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Systematic Literature Review

How Much Is a Human Life Worth? A Systematic Review

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ABSTRACT

Objectives: To systematically review studies eliciting monetary value of a statistical life (VSL) estimates within, and across, different sectors and other contexts; compare the reported estimates; and critically review the elicitation methods used.

Methods: In June 2019, we searched the following databases to identify methodological and empirical studies: Cochrane Library, Compendex, Embase, Environment Complete, Informit, ProQuest, PubMed, Scopus, and Web of Science. We used the Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines for reporting and a modified Consolidated Health Economic Evaluation Reporting Standards checklist to assess the quality of included studies.

Results: We identified 1455 studies, of which we included 120 in the systematic review. A stated-preference approach was used in 76 articles, with 51%, 41%, and 8% being contingent valuation studies, discrete-choice experiments, or both, respectively. A revealed-preference approach was used in 43 articles, of which 74% were based on compensating-wage differentials. The human capital approach was used in only 1 article. We assessed most publications (87%) as being of high quality. Estimates for VSL varied substantially by context (sector, developed/developing country, socio-economic status, etc), with the median of midpoint purchasing power parity–adjusted estimates of 2019 US$5.7 million ($6.8 million, $8.7 million, and $5.3 million for health, labor market, and transportation safety sectors, respectively).

Conclusions: The large variation observed in published VSLs depends mainly on the context rather than the method used. We found higher median values for labor markets and developed countries. It is important that health economists and policy-makers use context-specific VSL estimates. Methodological innovation and standardization are needed to maximize comparability of VSL estimates within, and across, sectors and methods.

Keywords: revealed preference, stated preference, systematic review, value of statistical life, VSL, willingness to pay.

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Introduction

Value of a Statistical Life

The monetary valuation of a statistical life is used in a broad range of policy areas, including environmental, transport, and health economics. However, assigning a monetary value to a human life is inherently difficult and even seen as unethical.[1] Nevertheless, the monetary value of a statistical life (VSL) is often used for evaluating policies that aim to reduce mortality risks such as compulsory safety devices in cars, health interventions, or clean air policies. To determine whether a proposed policy is worthwhile and provides good value for money, policymakers often use a cost-benefit analysis framework where both costs and benefits of an intervention are monetized and compared with each other. Therefore, any assessment of a policy that changes mortality risks requires an estimate of how society values a statistical life in monetary terms.[2]

The distinction between a statistical life and a human life is crucial. Generally, economic research and policy evaluation aims at eliciting the VSL. A common misconception is that the VSL expresses the value for which an individual would trade their life.[3] It does not. The VSL identifies how people value a small reduction in mortality risk. For instance, if each individual is willing to pay $1 to reduce the risk of dying by 1 in 1 000 000, then a population of 1 million individuals would be willing to pay $1 million to save 1 statistical life – the VSL is $1 million. Even though valuation tasks in surveys/experiments are generally framed as a change in the participant's own mortality risk, the objective is to elicit the VSL because it is unlikely that the participant's life will be saved owing to the intervention considered. Closely related to the concept of a VSL, the value of a statistical life-year (VSLY) represents the value of one additional year of life. One of the benefits of using VSLY estimates instead of VSL estimates is that the age of individuals benefiting from an intervention is taken into account when performing an economic evaluation. As such, a higher value would be placed on the life of a child than the life of an elderly person owing to the difference in remaining life expectancy.

Methods for Eliciting the VSL

Several methods have been used to elicit the VSL. Broadly, these can be grouped into 2 categories: revealed- and stated-preference methods. Revealed-preference studies observe the behavior of individuals in a market and analyze market decisions for hazardous goods (eg, cigarettes, risky jobs) or safety devices (eg, smoke detectors). The most common revealed-preference approach is to estimate the VSL based on compensating-wage differentials, that is, risk premiums workers demand for engaging in risky occupations such as mining.[4] To elicit the VSL from observed labor market transactions, hedonic-wage models are used to control for job and worker characteristics other than incomes and occupation-related risks. In such a model, the equilibrium wage observed in the market is regressed on the mortality risk to reveal the trade-off between the prevailing wage rate and an incremental increase in the risk level, allowing the derivation of the VSL implied by this trade-off.[5] A major limitation of these models is that VSL estimates are based on the working-age population and often only male workers.[6]

Researchers using the stated-preference approach do not analyze observed behavior of individuals in a market; rather they ask individuals hypothetical questions to elicit their VSL. Stated-preference methods are more varied in their approach, but generally comprise variations of contingent valuation (CV) studies or discrete-choice experiments (DCEs). Because participants are asked to place a monetary value on a given reduction in mortality risk hypothetically, stated-preference studies allow researchers to elicit the VSL from commodities that are not traded in a market or in cases where it is not possible to observe transactions under specific conditions.[7] For example, stated-preference methods have been used to value public goods (eg, improved air quality)[8] or private non-market goods (eg, reduced mortality or morbidity risk).[9] In CV studies, respondents are directly asked how much they are willing to pay for a given mortality-risk reduction phrased around a specific disease or a specific population (eg, children). In DCEs, respondents are required to make trade-offs among various scenarios/choice sets. Typically, each participant is asked to state their preferred choice between 2 or 3 scenarios. These scenarios are described by a small number of attributes/characteristics (typically no more than 8) where each attribute can take on different levels/qualities. If a cost attribute is included in the choice sets, the trade-offs participants make in the selection of their preferred choice can be analyzed using the theory of the marginal rate of substitution to qualify their willingness-to-pay (WTP) and thus the value they place on a statistical life.[7]

Another method used to value a statistical life, although rarely used nowadays, is the human capital approach, which determines the VSL as the present value of the expected future income stream of an individual. This approach only considers material losses because it only values lost production[2]; however, individuals value not only production/consumption but also life itself. In contrast to the WTP/willingness-to-accept approach (eg, compensating-wage differentials), which captures both material and immaterial components of the VSL, the human capital approach ignores the value individuals or society place on life apart from earnings and any reductions in VSL owing to pain and suffering. Additionally, the human capital approach is inappropriate for estimating the VSL of children and elderly who are not part of the labor market. Owing to its simplicity, this approach continues to be occasionally used in low-resource settings and developing countries.[10]

Review Articles, Meta-analyses, and Gaps in the Literature

There have been numerous literature reviews,[11-16] meta-analyses,[4,17-33] and discussion articles[2,34-47] on the topic of the VSL, likely owing to the controversial ethical nature of assigning a monetary value to a life and the wide range of published estimates. Appendix Table 1 (in Supplemental Materials found at https://doi.org/10.1016/j.jval.2021.04.003) summarizes the previously published reviews and meta-analyses with a focus on the period from 2009 to 2019. Most studies are restricted to a specific context, such as only including estimates for high-income countries and occupational risk. Here, "context" refers to the sector investigated (ie, health, environment, safety), the specific topic (eg, air pollution, cancer), the population group (ie, socioeconomic status, age, gender), and other relevant characteristics (eg, private or government/public intervention). While meta-analyses typically are used to combine VSL estimates from various studies or to calculate the income elasticity of the VSL,[17,18,21-23,28,31] literature reviews and discussion articles are more diverse. However, only a few of these[12,31,34,36] describe the methods used for VSL elicitation and none provide a detailed overview of how common the various methods are in different sectors and countries and specific estimates obtained. Given that cost-benefit analyses become increasingly common – not only in the environmental, safety, and transportation sectors but also in healthcare – there is a need for researchers to understand the different types of methods available for VSL elicitation.

Objectives

Despite the multitude of different approaches to elicit the VSL, to the best of our knowledge, there is no comprehensive review of available methodologies and their frequency of application within, and across, different sectors and obtained estimates. Therefore, the objective was to systematically review studies eliciting monetary VSL estimates within, and across, different sectors and other contexts; compare the reported estimates; and critically review the elicitation methods used. We also highlight recent methodological developments and areas for future research.

Methods

Systematic Review of Methodological and Empirical Studies

We performed a systematic review of publications to identify the methods used for the elicitation of the VSL. The systematic review followed the established Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement[48] and the PRISMA Extension for Scoping Reviews (PRISMA-ScR).[49] Our review was pre-registered in the Open Science Framework Registry. The registration can be found at https://osf.io/d26ts.

Identification of Studies

We searched the following databases in June 2019 for peer-reviewed, full-text, accepted publications written in English and published from 2009 to June 2019: Cochrane Library, Compendex, Embase, Environment Complete, Informit, ProQuest, PubMed (which contains the MEDLINE database), Scopus, and Web of Science. We also cross-checked all reference lists of identified studies for additional relevant publications. Review articles, conference presentations, and abstracts were excluded.

Selection of Studies for Inclusion

To be eligible for the systematic review, a publication had to be either an original research study presenting methodologies used for the elicitation of the VSL or an original research study applying such methods to a specified research question. This excluded (1) articles simply using VSLs in the analysis without eliciting them, (2) articles that merely estimate relative values (eg, the VSL of a 20-year-old is worth 3 times as much as the VSL of an 80-year-old person), and (3) articles using methods based on another country's or region's estimate such as the value transfer method or meta-regression analysis to estimate the VSL, which are often used in the context of developing countries.[50] In addition, any other studies applying methods that can be used to elicit VSL estimates, but not reporting these estimates, were excluded. For instance, some studies analyzed a specific relationship between the VSL and a variable and only reported on its relative influence on VSL values.

Screening of titles and abstracts was performed by the primary author to determine eligibility. All publications identified as not meeting the eligibility criteria were additionally checked by the secondary author. In a second step, potentially eligible full publications were screened in full by the primary author with excluded publications additionally reviewed by the secondary author. Any disagreement between the reviewing authors was resolved by consensus.

Search Terms

The search terms used to identify publications are listed in Table 1. Boolean AND and OR commands were used to combine the different concepts such as approach and focus in Table 1. Appendix 2 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2021.04.003 includes the full electronic search strategy employed. The search strategy was developed in consultation with an academic librarian. We used equivalent search strategies in all databases, applying no further limits to the search other than the ones described earlier (eg, years considered).

Information Extraction and Synthesis

The primary author extracted relevant information and subsequently classified all publications according to the elicitation methods used (ie, human capital, revealed- or stated-preference approach) and the sector (ie, environment, health, labor market, safety or transportation safety). The specific context for VSL elicitation (as defined earlier) was also extracted because evidence is accumulating that suggests that individuals value mortality-risk reductions differently depending on the context, particularly depending on how much a certain risk is perceived as dreadful (eg, cancer vs accident) and controllable (eg, COVID-19 vs flu).[36,51-53] The following information was extracted for all publications: authors, year of publication, country, sector, risk context, nature of risk/scenario, method used, sample including year, sample size, and range of reported VSL estimates inflated to 2019 purchasing power parity (PPP) US dollars using conversion rates published by the Organisation for Economic Co-operation and Development.[54-56] The range of reported mean estimates for the VSL, where available, was extracted including mean estimates of population subgroups (eg, by income or risk aversion). If a publication did not report mean VSL estimates, median values were extracted, or whichever values were reported.

For revealed-preference studies, we further extracted information on the data source for the risk variable and the mean annual fatality risk, average income level (only for studies based on compensating-wage differentials), and whether nonfatal risk and workers' compensation were included in hedonic-wage models because this information is required to assess revealed-preference studies. Furthermore, we collected data on the risk change valued in stated-preference studies and the attributes together with their levels of DCEs.

Because our primary objective was to compare VSL estimates obtained with different methods and for different contexts, we were unable to use advanced meta-analytical methods. This follows guidance by the US Environmental Protection Agency Work Group on VSL Meta-analyses,[57] which recommends separate analyses for vastly different methods and contexts, such as CV and hedonic-wage studies. Because we focus on a broad range of different approaches and novel elicitation methods in a diverse set of contexts, it was not appropriate to split up these studies in few meta-analysis datasets. Instead, we calculated an overall VSL estimate based on the following method: For each study, we extracted information on the lowest and highest mean VSL estimate reported. We then calculated the midpoint as the average of the lowest and highest mean estimates. Finally, we determined the median value of midpoints across all studies, which represents our overall VSL estimate. We used the median, rather than the mean, value to prevent bias from outliers. In addition to the overall estimate for all studies, we calculated separate estimates by sector – environment, health, labor market, safety, and transportation safety – following the same procedure.

Quality Assessment of Eligible Studies

We assessed the quality of studies included in the review based on a modification of the Consolidated Health Economic Evaluation

Table 1. Search terms.

Additional descriptor	Approach/outcome	Focus
Economic	Value	Value of a statistical life
Economical	Valuation	Value of statistical life
Monetary	Elicit	VoSL
	Elicitation	VSL
	Method	Statistical life year
	Methods	VSLY
	Compensating-wage differential	Value of a prevented fatality
	Human capital	Value of prevented fatality
		VPF

VoSL indicates value of statistical life; VPF, value of a prevented fatality; VSL, value of a statistical life; VSLY, value of a statistical life-year.

Reporting Standards (CHEERS) checklist[58] to account for the different methodological approaches used and the lack of a single standardized method for quality assessment. The modified version of the CHEERS checklist has 21 items, and each item was scored either 0 or 1. Studies with a score of less than 12 were considered to be of poor quality, those with a score of 12 to 16 of moderate quality, and those with a score of more than 16 of high quality.

Results

Figure 1, the PRISMA flow diagram, summarizes the results of the search strategy. In total, 120 studies met the inclusion criteria. The details of each study are included in Appendix Tables 3 and 4 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2021.04.003. Table 2 provides a complete list of all databases searched including number of search results.

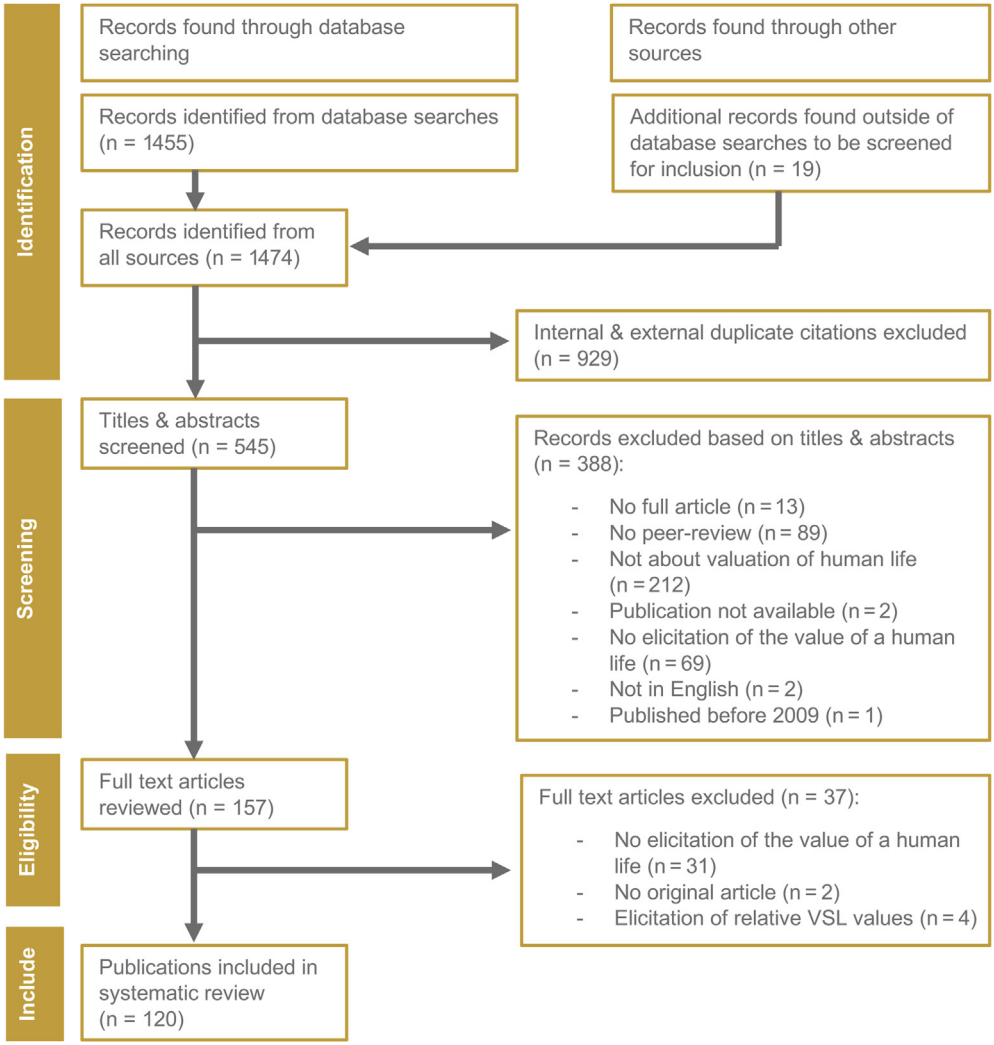
In total, we identified 43 revealed-preference studies,[5,59-100] of which three-fourths (n = 32) applied a hedonic-wage model to elicit the VSL based on labor market data. Most publications (63%, n = 76) elicited VSL estimates using stated-preference methods with roughly an equal split between CV studies[9,101-144] and DCEs.[51,104,106,109,119,134,141,145-174] In addition, 7 studies presented novel methods with the aim of improving existing methodologies to produce better VSL estimates. Only 1 study,[175] which investigated the value Russians place on a statistical life, applied the human capital approach.

Study Characteristics

The characteristics and VSL estimates of the 43 revealed-preference, 76 stated-preference, and 1 human capital studies meeting our inclusion criteria are summarized in Appendix Tables 3 and 4 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2021.04.003. The studies were published relatively evenly across the 11-year period considered, with an average of 10.9 publications per year.

Of the 120 included studies, 77 (64%) estimated VSL for a developed country with 38 (32%) and 34 (28%) of all publications conducted for a European or North American country, respectively. Studies for developing countries were mainly conducted for Asian countries, representing 29% of all included publications (n = 35). Most of the studies were conducted on transportation safety (n = 41, 34%), labor markets (n = 35, 29%), and health sectors (n = 31, 26%).

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) flow diagram.



VSL indicates value of a statistical life.

Table 2. Databases searched for systematic review.

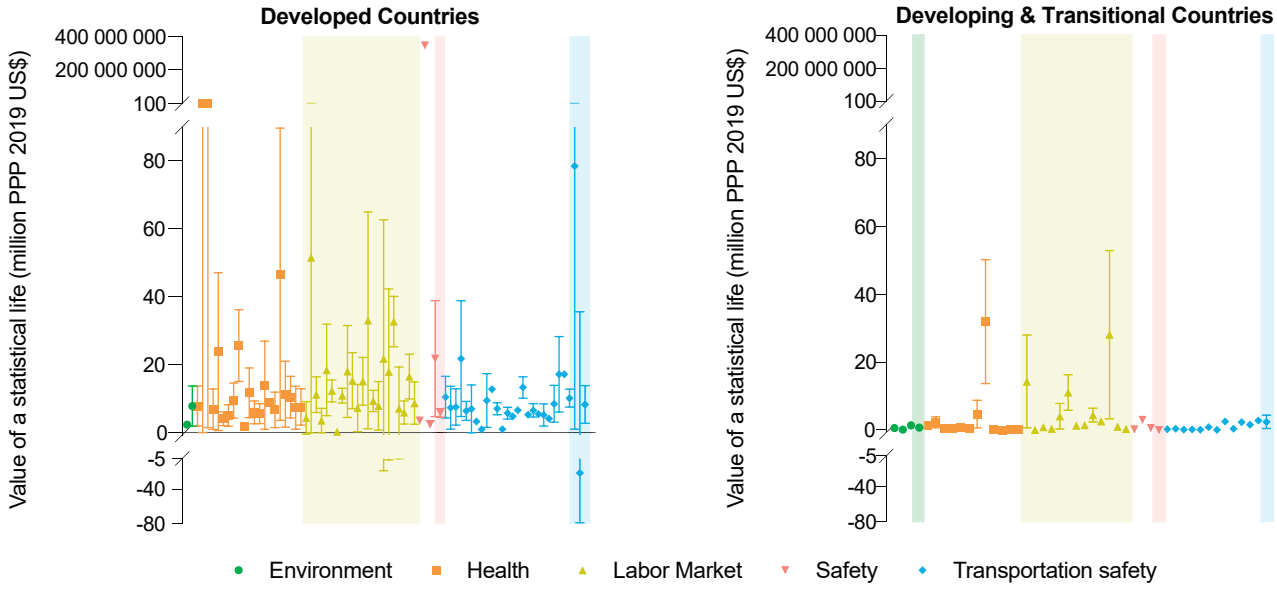
Database	Description	Number of search results (number of unique results after removing duplicates*)
Cochrane Library	Collection of databases containing evidence to inform healthcare decision making	1 (0)
Compendex	Broadest and most complete engineering literature database	100 (69)
Embase	Multi-purpose biomedical database covering international literature	102 (90)
Environment Complete	Database for environmental studies from top journals	129 (52)
Informit	Collection of over 100 databases covering a wide range of subjects	13 (5)
ProQuest	World's largest multi-disciplinary collection of databases for scholarly journals, working articles, etc	574 (202)
PubMed	Database mainly comprising MEDLINE	129 (20)
Scopus	World's largest abstract and citation database of peer-reviewed literature in science, technology, medicine, social sciences, and arts and humanities	202 (44)
Web of Science	Broad database covering sciences, social sciences, and arts and humanities	205 (43)

*The number of unique results is calculated as the total number of search results within a database minus any duplicates within the same database (internal duplicates) and minus any duplicates from other databases (external duplicates).

The elicitation of VSL estimates was far more prevalent (n = 117, 98%) than elicitation of VSLY estimates (n = 12, 10%); 9 studies (8%) estimated both. Obtained estimates using revealed-preference methods ranged from less than $0 to $156.012 million for developed countries and from $952 to $52.892 million for developing countries. Likewise, stated-preference studies yielded VSL estimates ranging from less than $0 to $47.116 million (with 3 outliers reporting values of more than $475 million) and from less than $0 to $8.779 million (with 1 outlier reporting a maximum value of $50.213 million), respectively. Seven studies (6%; 6 studies for developed countries) additionally reported separate VSL estimates for children, which ranged from $416 216 to $38.336 million (with 1 outlier of more than $2 billion) and from $804 514 to $5.062 million for developed and developing countries, respectively, indicating that individuals place a substantially higher value on a child's life as opposed to an adult life. Comparing estimates of children with those of adults within a single study shows that estimates were up to 4.66 times higher when parents were asked to value their children's rather than their own lives. We were not able to assess whether this difference is caused by their longer life expectancy because none of the included studies reported VSLY estimates separately for children. Comparing VSL estimates for children and adults across studies showed that several studies reported higher VSL estimates for adults than the highest reported child VSL estimate (excluding 1 outlier of more than $2 billion). This might have been caused by different methods and contexts.

Overall, we found overlapping ranges for VSL estimates among sectors (Fig. 2). However, the range of VSL estimates reported in health and labor market studies was generally greater than the range reported for other sectors. Across the 3 sectors of health,

Figure 2. Reported range for the value of a statistical life (2019 purchasing power parity US$).



PPP indicates purchasing power parity.

labor market, and transportation safety, the median of the midpoint VSL estimates was $6.8 million, $8.7 million, and $5.3 million, respectively (Table 3), indicating that VSL estimates are significantly different across sectors. The higher magnitude of labor market estimates compared with all other sectors may be caused by the propensity for VSL estimates to be derived using revealed-preference methods. It is possible that both the sector and the use of revealed-preference methods contributed to the higher estimates. However, in the safety and transportation safety sectors, revealed- and stated-preference methods resulted in very similar estimates (Table 3) suggesting that people might have a generally higher VSL in the labor market as opposed to other sectors. When excluding studies assessed as being poor to medium quality, median of midpoint VSL estimates across sectors increased between 9% and 44% for developing countries whereas those for developed countries remained largely unchanged.

Quality Assessment

Overall, the quality score ranged from 5 to 21 (mean 18.40; median 19) indicating that studies were generally of good quality. However, there were some differences in quality between the 2 subgroups of studies (revealed-preference studies: mean 19.14; median 19; stated-preference studies: mean 17.97; median 19). While only 1 revealed-preference study was of medium quality, 20% (n = 15) of stated-preference studies were of poor or medium quality (Fig. 3).

A major factor complicating the direct comparison of studies and the reported VSL and VSLY estimates was the failure to report the dates of the estimated values. To overcome this weakness of included studies, we assigned the currency valuation of the year the sample was drawn or, if no year was reported, the year of publication to convert and inflate all estimates to PPP-adjusted 2019 US dollars.

Discussion

Our comprehensive and systematic review identified 120 studies presenting or applying elicitation methods for the VSL. Of these, 63% applied stated-preference methods, 36% revealed-preference methods, and 1% (1 study) a human capital approach. The median of the midpoint of reported VSL estimates across studies was found to be $6.8 million, $8.7 million, and $5.3 million for health, labor market, and transportation safety sectors, respectively. These medians of midpoint estimates provide a better understanding of the general magnitude of estimates, which often vary substantially within studies. However, these overall VSL estimates are only indicative. They should not be used for economic valuations in a particular country for which no alternative VSL estimates exist. Various studies have developed benefit transfer functions[18,26,33] that can be used to infer a VSL for a particular country, for which no local estimates exist, based on VSL estimates for other countries, gross domestic product per capita, and other characteristics.

Although we attempted to also compare VSL estimates of studies with different levels of quality, this comparison had a major limitation: The modified CHEERS checklist that we used for quality assessment measures primarily "reporting," rather than "methodological," quality. This might be interpreted as implying that studies that report well are also of good methodological quality. This assumption is not the most innocuous to make but it does not seem unreasonable. Therefore, our comparison should not be seen as conclusive evidence that study quality does not have a major impact on VSL estimates for developed countries.

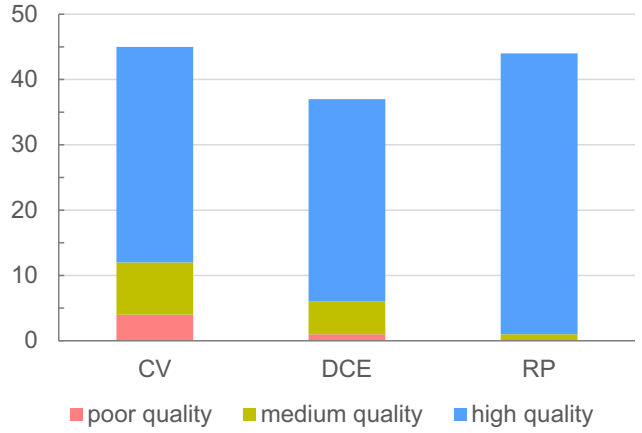
Of 120 included studies, only 2 reported quality-adjusted life year (QALY) estimates[93,143] and 9 studies reported VSLY estimates[73,82,95,115,127,128,130,157,165] (Appendix Tables 3 and 4 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2021.04.003), all of which were for developed countries with only 1 exception. Reported QALY values ranged from $61 000 to $7.6 million, whereas VSLY estimates ranged from $13 000 to $796 000 (approximately $10 000-$613 000 per QALY assuming a utility weight of 0.77 for the general population[176]). Several assumptions would need to be accepted to convert VSL estimates to QALY or VSLY estimates: First, one would have to assume that the VSL is the sum of the discounted VSLY for each remaining year of life where each year is valued equally (ie, the VSLY is age-independent; unless there is evidence for a different relationship between age and the VSLY in the population of interest) such as in Chanel, Luchini.[130] Second, it would require an assumption about the remaining life expectancy of individuals. Third, for conversion to QALYs, an additional assumption about the average utility weight for each life-year is required. Compared with common QALY thresholds of up to $100 000,[177-179] we found that the VSL literature often reports VSL(Y) estimates that are likely to fall above this threshold when being converted according to the method described earlier. This indicates that individuals value a statistical life more highly than what is currently assumed in health technology assessment (HTA). However, HTA bodies might have to predominantly use lower thresholds than the societal valuation given fixed healthcare budgets. As a consequence, these lower

Table 3. Median of the midpoint of reported value of a statistical life (VSL) estimates in included studies.

Sector	Overall (no. studies)	Developed countries (*no. studies)	Developing countries (*no. studies)	Stated-preference studies (*no. studies)	Revealed-preference studies (*no. studies)	Human capital approach (*no. studies)
Environment	$1 062 630 (6)	$5 146 850 (2)	$680 489 (4)	$1 381 201 (5)	NA (0)	$744 058 (1)
Health	$6 770 534 (33)	$8 989 328 (21)	$580 663 (12)	$6 770 534 (33)	NA (0)	NA (0)
Labor market	$8 740 231 (35)	$11 784 289 (22)	$1 430 105 (13)	NA (0)	$8 740 231 (35)	NA (0)
Safety	$3 010 740 (9)	$7 075 108 (5)	$409 110 (4)	$3 010 740 (7)	$2 942 773 (2)	NA (0)
Transportation safety	$5 335 248 (41)	$7 075 108 (28)	$403 798 (13)	$5 335 248 (37)	$5 383 706 (4)	NA (0)
All sectors	$5 716 830 (116)	$8 342 027 (73)	$858 599 (42)	$5 185 402 (74)	$7 940 006 (41)	$744 058 (1)

NA indicates not available.
*No. studies indicates the number of studies on which the calculations for the median of the midpoint estimates are based. The number of studies considering all sectors is not necessarily equal to the sum of studies across the single sectors owing to some studies reporting VSL estimates for multiple sectors.

Figure 3. Quality of included studies (score based on modified CHEERS checklist).



CHEERS indicates Consolidated Health Economic Evaluation Reporting Standards; CV, contingent valuation; DCE, discrete-choice experiment; RP, revealed-preference study.

thresholds rather reflect opportunity costs of displaced treatments, rather than societal valuation.[180]

A recently proposed framework by Lakdawalla and Phelps[181] to better align the current HTA approach with economic analysis of other domains also provides insights for the apparent disconnect between VSL(Y) and QALYs. The foundation of HTA methods is to compare the incremental cost per unit of health gain (measured as utility) with a societal WTP threshold for a unit gain in health. Implicitly, it is assumed that the incremental value of health is invariant to severity of illness and also does not consider risk aversion over health. Not accounting for diminishing returns to health leads to overvaluation of treatments of low-severity illnesses and undervaluation of treatments of very high-severity conditions. Reflecting Lakdawalla and Phelps's[181] arguments, by accounting for the diminishing returns and baseline level of illness, severity-adjusted WTP per QALY may be more in line with published VSL estimates.

The results of our systematic review show that the VSL in monetary terms continues to be of interest to economists and policymakers. In addition, the development of novel methods in recent years[60,61,116,146,148,152,156] highlights the continued relevance of these estimates for informing investment decisions and the need of continuously refining existing methodologies. Hypothetical bias in stated-preference studies continues to pose a challenge for the external validity of obtained results. Methods such as well-designed DCEs or properly incentivized economic experiments are aimed at minimizing the impact of hypothetical bias.[182-185] Furthermore, it is important to ensure that participants comprehend the type of risk to be valued and its magnitude. Evidence shows that stated-preference studies tend to lack scope sensitivity which, for example, is likely the result of participants not being able to evaluate the difference between a 1 in 100 000 and a 1 in 1 000 000 risk reduction.[186] The type of risk evaluated also plays a crucial role as evidenced, for instance, by the commonly assumed cancer premium. Dread of a particular type of mortality risk (eg, cancer)[36,51] and the inability to control risk (eg, terrorist attack, COVID-19) seem to cause higher VSL estimates.[52,53] This was also visible in the median of midpoint VSL estimates extracted from studies included in this systematic review: Stated-preference studies with a cancer context had a median of midpoint estimates of $6.956 million compared with $3.350 million for non-cancer studies.

Aside from differences across sectors in which VSL estimates are elicited, different VSLs result from population heterogeneities, particularly in income. In addition to determining whether, for instance, a child should be valued the same as an adult or an elderly individual, it is important to determine how a child not yet conceived should be valued relative to a baby that has already been born. Determining which approach – a universal VSL or multiple values – is the most adequate is a normative question. However, it ultimately determines which methods should be used to elicit the VSL given that approaches considering age and income heterogeneity would be redundant if a mean VSL estimate for the whole population is desired. Furthermore, it is unclear whether simply discounting the value of mortality-risk reductions for future generations to a present value at a specific discount rate[187] is in line with society's preferences.

Even though methods for eliciting the VSL are established and have been used for many years, our systematic review indicates that there are only few studies eliciting child VSL estimates and that there remains a lack of methods to value a life that has not yet been created. This is despite many technologies exclusively targeting children and fertility treatments, such as in vitro fertilization, being expensive technologies now accounting for the birth of approximately 5% of children in most developed countries.[188] To the best of our knowledge, there is only 1 study that attempted to calculate monetary estimates for the value of a statistical baby conceived through in vitro fertilization. Neumann and Johannesson[189] provide estimates for the ex ante and ex post WTP for a statistical baby of $3 164 000 and $325 000 (inflated to PPP-adjusted 2019 US dollars), respectively, in a feasibility study. Other studies have used stated-preference methods to value certain aspects of fertility treatment, but these have not been designed to value a baby born from fertility treatment.[190-192] Considering that the evaluation of medical interventions using a cost-benefit framework becomes increasingly more common, there is a need to address the lack of VSL estimates for children and estimates for the value of a statistical baby.

Conclusions

VSL estimates are an important contribution to inform investment decisions, policy analyses, and cost-benefit analyses. Although there is substantial literature reporting monetary VSL estimates for different countries and different sectors which we have described here, there is currently a lack of VSL estimates for children and future lives. Because VSL estimates vary by context and in particular across sectors, it is important to consider context-specific VSL estimates, rather than 1 overarching average VSL estimate.

Methodological innovation and standardization are needed to maximize comparability of VSL estimates, particularly as cost-benefit analyses are increasingly used to inform public policy and investment decisions.

Supplemental Materials

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REFERENCES

1. Davis DS. Is life of infinite value? *Kennedy Inst Ethics J*. 2001;11(3):239–246.
2. Wijnen W, Wesemann P, de Blaeij A. Valuation of road safety effects in cost–benefit analysis. *Eval Program Plann*. 2009;32(4):326–331.
3. Viscusi WK. How to value a life. *J Econ Finance*. 2008;32(4):311–323.
4. Majumder A, Madheswaran S. Meta-analysis of value of statistical life estimates. *IIM Kozhikode Soc Manag Rev*. 2017;6(1):110–120.
5. Qin X, Li L, Liu Y. The value of life and its regional difference in China. *China Agric Econ Rev*. 2013;5(3):373–390.
6. Cropper M, Hammitt JK, Robinson LA. Valuing mortality risk reductions: progress and challenges. *Annu Rev Resour Economics*. 2011;3:313–336.
7. Mangham LJ, Hanson K, McPake B. How to do (or not to do)... designing a discrete choice experiment for application in a low-income country. *Health Policy Plan*. 2009;24(2):151–158.
8. Wardman M, Bristow AL. Traffic related noise and air quality valuations: evidence from stated preference residential choice models. *Transp Res D Transp Environ*. 2004;9(1):1–27.
9. Hammitt JK, Herrera-Araujo D. Peeling back the onion: using latent class analysis to uncover heterogeneous responses to stated preference surveys. *J Environ Econ Manage*. 2018;87:165–189.
10. Kuchyňa P. Problems associated with value of life. *Procedia Econ Fin*. 2015;25:378–385.
11. Clough P, Guria J, Bealing M. *Approaches to Valuing Injury and Mortality Risk in Transport Assessments*. Wellington, New Zealand: NZ Transport Agency; 2015.
12. Cropper L, Sebnem MS. *Valuing Mortality and Morbidity in the Context of Disaster Risks*. Washington, D.C.: The World Bank; 2009.
13. Hein L, Roberts P, Gonzalez L. Valuing a statistical life year in relation to clean air. *J Environ Assess Policy Manage*. 2016;18(4):1–24.
14. Hultkrantz L, Svensson M. The value of a statistical life in Sweden: a review of the empirical literature. *Health Policy*. 2012;108(2-3):302–310.
15. Robinson LA, Hammitt JK, O'Keeffe L. Valuing mortality risk reductions in global benefit-cost analysis. *J Benefit Cost Anal*. 2019;10(Suppl 1):15–50.
16. Nelson JP, Kennedy PE. The use (and abuse) of meta-analysis in environmental and natural resource economics: an assessment. *Environ Resour Econ*. 2009;42(3):345–377.
17. Bellavance F, Dionne G, Lebeau M. The value of a statistical life: a meta-analysis with a mixed effects regression model. *J Health Econ*. 2009;28(2):444.
18. Dekker T, Brouwer R, Hofkes M, Moeltner K. The effect of risk context on the value of a statistical life: a bayesian meta-model. *Environ Resour Econ*. 2011;49(4):597–624.
19. Doucouliagos C, Stanley TD, Giles M. Are estimates of the value of a statistical life exaggerated? *J Health Econ*. 2012;31(1):197.
20. Doucouliagos H, Stanley TD, Viscusi WK. Publication selection and the income elasticity of the value of a statistical life. *J Health Econ*. 2014;33:67–75.
21. Kluve J, Schaffner S. The value of life in Europe - a meta-analysis. *Sozialer Fortschr*. 2008;57(10/11):279–287.
22. Kochi I, Hubbell B, Kramer R. An empirical Bayes approach to combining and comparing estimates of the value of a statistical life for environmental policy analysis. *Environ Resour Econ*. 2006;34(3):385–406.
23. Lindhjem H, Navrud S, Braathen NA, Biausque V. Valuing mortality risk reductions from environmental, transport, and health policies: a global meta-analysis of stated preference studies. *Risk Anal*. 2011;31(9):1381–1407.
24. Majumder A, Madheswaran S. Compensating wage differential and value of statistical life: a meta-analysis. *Indian J Lab Econ*. 2017;60(4):527–548.
25. Masterman CJ, Viscusi WK. The income elasticity of global values of a statistical life: stated preference evidence. *J Benefit Cost Anal*. 2018;9(3):407–434.
26. Milligan C, Kopp A, Dahdah S, Montufar J. Value of a statistical life in road safety: a benefit-transfer function with risk-analysis guidance based on developing country data. *Accid Anal Prev*. 2014;71:236–247.
27. Organisation for Economic Co-operation and Development. *Mortality Risk Valuation in Environment, Health and Transport Policies*. Paris and Washington, DC: Organization for Economic Co-operation and Development; 2012.
28. U.S. Environmental Protection Agency, National Center for Environmental Economics. *Valuing Mortality Risk Reductions for Environmental Policy: A White Paper*. Washington, D.C.: U.S. Environmental Protection Agency; 2010.
29. Viscusi WK. *The role of publication selection bias in estimates of the value of a statistical life*. Cambridge, Massachusetts: National Bureau of Economic Research, Inc.; 2014.
30. Viscusi WK. Best estimate selection bias in the value of a statistical life. *J Benefit Cost Anal*. 2018;9(2):205–246.
31. Viscusi WK, Aldy JE. The value of a statistical life: a critical review of market estimates throughout the world. *J Risk Uncertain*. 2003;27(1):5–76.
32. Viscusi WK, Masterman C. Anchoring biases in international estimates of the value of a statistical life. *J Risk Uncertain*. 2017;54(2):103–128.
33. Viscusi WK, Masterman CJ. Income elasticities and global values of a statistical life. *J Benefit Cost Anal*. 2017;8(2):226–250.
34. Abelson P. Establishing a monetary value for lives saved: issues and controversies. https://www.pmc.gov.au/sites/default/files/publications/Working_paper_2_Peter_Abelson.pdf. Accessed August 5, 2020.
35. Adler MD, Hammitt JK, Treich N. The social value of mortality risk reduction: VSL versus the social welfare function approach. *J Health Econ*. 2014;35:82–93.
36. Alberini A. Measuring the economic value of the effects of chemicals on ecological systems and human health. https://www.oecd-ilibrary.org/docserver/9dc90f8d-en.pdf?expires=1619890479&id=id&accname=guest&checksum=D4C9AA9C2E00D524527B4C3BDCA474C9. Accessed June 11, 2019.
37. Chambers J, Campbell M. Pricing the priceless child: measuring the benefit of saving children's lives. *New Zealand Sociol*. 2016;31(5):73–87.
38. Courard-Hauri D, Lauer SA. Taking "all men are created equal" seriously: toward a metric for the intergroup comparison of utility functions through life values. *J Benefit Cost Anal*. 2012;3(3):Article 3.
39. Grüne-Yanoff T. Mismeasuring the value of statistical life. *J Econ Methodol*. 2009;16(2):109–123.
40. Hammitt JK, Robinson LA. The income elasticity of the value per statistical life: transferring estimates between high and low income populations. *J Benefit Cost Anal*. 2011;2(1):1–29.
41. Laxminarayan R, Jamison DT, Krupnick AJ, Norheim OF. Valuing vaccines using value of statistical life measures. *Vaccine*. 2014;32(39):5065–5070.
42. Robinson LA, Hammitt JK. Research synthesis and the value per statistical life. *Risk Anal*. 2015;35(6):1086–1100.
43. van Wee B, Rietveld P. Using value of statistical life for the ex ante evaluation of transport policy options: A discussion based on ethical theory. *Transportation*. 2013;40(2):295–314.
44. Viscusi WK. The heterogeneity of the value of statistical life: introduction and overview. *J Risk Uncertain*. 2010;40(1):1–13.
45. Viscusi WK. What's to know? Puzzles in the literature on the value of statistical life. *J Econ Surv*. 2012;26(5):763–768.
46. Kip Viscusi W. Reference-dependence effects in benefit assessment: beyond the WTA-WTP dichotomy and WTA-WTP ratios. *J Benefit Cost Anal*. 2015;6(1):187–206.
47. Viscusi WK. Pricing lives: international guideposts for safety. *Econ Rec*. 2018;94:1–10.
48. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: the PRISMA statement. *BMJ*. 2009;339:b2535.
49. Tricco AC, Lillie E, Zarin W, et al. PRISMA Extension for scoping reviews (PRISMA-ScR): checklist and Explanation. The PRISMA-ScR statement. *Ann Intern Med*. 2018;169(7):467–473.
50. Yaduma N, Kortelainen M, Wossink A. Estimating mortality and economic costs of particulate air pollution in developing countries: the case of Nigeria. *Environ Resource Econ*. 2013;54:361–387.

51. Alberini A, Ščasný M. Context and the VSL: evidence from a stated preference study in Italy and the Czech Republic. *Environ Resour Econ*. 2011;49(4):511–538.
52. Robinson LA, Hammitt JK, Aldy JE, Krupnick A, Baxter J. Valuing the risk of death from terrorist attacks. *J Homeland Sec Emerg Manag*. 2010;7(1). Article 14.
53. Robinson LA, Sullivan R, Shogren JF. Do the benefits of COVID-19 policies exceed the costs? Exploring uncertainties in the age-VSL relationship [published online March 16, 2020]. Risk Anal. https://doi.org/10.1111/risa.13561.
54. Purchasing power parities (PPP). Organization for Economic Co-operation and Development. https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm. Accessed October 29, 2019.
55. Inflation (CPI). Organization for Economic Co-operation and Development. https://data.oecd.org/price/inflation-cpi.htm. Accessed October 29, 2019.
56. PPP conversion factor, private consumption (LCU per international $). The World Bank. https://data.worldbank.org/indicator/PA.NUS.PRVT.PP. Accessed October 29, 2019.
57. Allen E, Becker BJ, Berlin JA, et al. Report on the EPA Work Group on VSL Meta-Analyses (2006). United States Environmental Protection Agency. https://www.epa.gov/environmental-economics/report-epa-work-group-vsl-meta-analyses-2006. Accessed June 13, 2019.
58. Husereau D, Drummond M, Petrou S, et al. Consolidated Health Economic Evaluation Reporting Standards (CHEERS) statement. *BMJ*. 2013;346:f1049.
59. Parada-Contzen MV. The value of a statistical life for risk-averse and risk-seeking individuals. *Risk Anal*. 2019;39(11):2369–2390.
60. Schaffner S, Spengler H. Using job changes to evaluate the bias of value of a statistical life estimates. *Resour Energy Econ*. 2010;32(1):15–27.
61. Evans MF, Schaur G. A quantile estimation approach to identify income and age variation in the value of a statistical life. *J Environ Econ Manag*. 2010;59(3):260–270.
62. Guo X, Hammitt JK. Compensating wage differentials with unemployment: evidence from China. *Environ Resour Econ*. 2009;42(2):187–209.
63. Polat S. Wage compensation for risk: the case of Turkey. *Saf Sci*. 2014;70:153–160.
64. O'Brien J. Age, autos, and the value of a statistical life. *J Risk Uncertain*. 2018;57(1):51–79.
65. Viscusi W, Gentry E. The value of a statistical life for transportation regulations: a test of the benefits transfer methodology. *J Risk Uncertain*. 2015;51(1):53–77.
66. Rohlfs C, Sullivan R, Kniesner T. Reducing risks in wartime through capital-labor substitution: evidence from World War II. *J Risk Uncertain*. 2016;52(2):163–190.
67. Tsai W-J, Liu J-T, Hammitt J. Aggregation biases in estimates of the value per statistical life: evidence from longitudinal matched worker-firm data in Taiwan. *Environ Resour Econ*. 2011;49(3):425–443.
68. Kniesner TJ, Viscusi WK, Ziliak JP. Policy relevant heterogeneity in the value of statistical life: new evidence from panel data quantile regressions. *J Risk Uncertain*. 2010;40(1):15–31.
69. Scotton CR, Taylor LO. Valuing risk reductions: incorporating risk heterogeneity into a revealed preference framework. *Resour Energy Econ*. 2011;33(2):381–397.
70. Vitaliano DF. A profit function approach to wage-risk differentials. *Int J Econ Bus*. 2019;26(2):217–231.
71. Guardado JR, Ziebarth NR. Worker investments in safety, workplace accidents, and compensating wage differentials. *Int Econ Rev*. 2019;60(1):133–155.
72. Mardones C, Riquelme M. Estimation of the value of statistical life in Chile and extrapolation to other Latin American countries. *Lat Am Res Rev*. 2018;53(4):815–830.
73. Munro A. Economic valuation of a rise in ambient radiation risks: hedonic pricing evidence from the accident in Fukushima. *J Reg Sci*. 2018;58(3):635–658.
74. Zan H, Scharff RL. Regional differences in the value of statistical life. *J Consum Policy*. 2017;40(2):157–176.
75. León G, Miguel E. Risky transportation choices and the value of a statistical life. *Am Econ J Appl Econ*. 2017;9(1):202–228.
76. Rohlfs C, Sullivan R, Kniesner T. New estimates of the value of a statistical life using air bag regulations as a quasi-experiment. *Am Econ J Econ Policy*. 2015;7(1):331–359.
77. Kniesner TJ, Viscusi WK, Ziliak JP. Willingness to accept equals willingness to pay for labor market estimates of the value of a statistical life. *J Risk Uncertain*. 2014;48(3):187–205.
78. Parada-Contzen M, Riquelme-Won A, Vasquez-Lavin F. The value of a statistical life in Chile. *Empirical Econ*. 2013;45(3):1073–1087.
79. Benkhalifa A, Lanoie P, Ayadi M. Estimated hedonic wage function and value of life in an African country. *Econ Bull*. 2013;33(4):3023–3031.
80. Goucher J, Horrace WC. The value of life: real risks and safety-related productivity in the Himalaya. *Labour Econ*. 2012;19(1):27.
81. Rohlfs C. The economic cost of conscription and an upper bound on the value of a statistical life: hedonic estimates from two margins of response to the Vietnam draft. *J Benefit Cost Anal*. 2012;3(3):1–37.
82. Miyazato N. Estimating the value of a statistical life using labor market data. *Jpn Econ*. 2011;38(4):65.
83. Shanmugam KR. Discount rate for health benefits and the value of life in India. Econ Res Int. 2011;2011:1-5. https://downloads.hindawi.com/archive/2011/191425.pdf. Accessed June 11, 2019.
84. Hintermann B, Alberini A, Markandya A. Estimating the value of safety with labour market data: are the results trustworthy? *Appl Econ*. 2010;42(9):1085.
85. Liou JL. Effect of income heterogeneity on valuation of mortality risk in Taiwan: an application of unconditional quantile regression method. *Int J Environ Res Public Health*. 2019;16(9):1620.
86. Gentry EP, Viscusi WK. The fatality and morbidity components of the value of statistical life. *J Health Econ*. 2016;46:90–99.
87. Lavetti K. The estimation of compensating wage differentials: lessons from the deadliest catch. *J Bus Econ Stat*. 2020;38(1):165–182.
88. Benkhalifa A. Compensating wage differentials for workplace accidents: evidence for union and non-union workers in Tunisia. *J Econ Coop Dev*. 2016;37(4):1–20.
89. Deleire T, Khan S, Timmins C. Roy model sorting and nonrandom selection in the valuation of a statistical life. *Int Econ Rev*. 2013;54(1):279–306.
90. Kniesner TJ, Viscusi WK, Woock C, Ziliak JP. The value of a statistical life: evidence from panel data. *Rev Econ Stat*. 2012;94(1):74–87.
91. Rafiq M, Shah MK, Nasir M. The value of reduced risk of injury and deaths in Pakistan—using actual and perceived risk estimates. *Pak Dev Rev*. 2010;49(4):823–836.
92. Cole MA, Elliott RJR, Lindley JK. Dirty money: is there a wage premium for working in a pollution intensive industry? *J Risk Uncertain*. 2009;39(2):161–180.
93. Aiken DV, Zamula WW. Valuation of quality of life losses associated with nonfatal injury: insights from jury verdict data. *Rev Law Econ*. 2009;5(1):293–310.
94. Li S. Traffic safety and vehicle choice: quantifying the effects of the 'arms race' on American roads. *J Appl Econ*. 2012;27(1):34–62.
95. Lakdawalla DN, Sun EC, Jena AB, Reyes CM, Goldman DP, Philipson TJ. An economic evaluation of the war on cancer. *J Health Econ*. 2010;29(3):333–346.
96. Hersch J, Viscusi WK. Immigrant status and the value of statistical life. *J Hum Resour*. 2010;45(3):749–771.
97. Kochi I, Taylor LO. Risk heterogeneity and the value of reducing fatal risks: further market-based evidence. *J Benefit Cost Anal*. 2011;2(3):1–28.
98. Scotton CR. New risk rates, inter-industry differentials and the magnitude of VSL estimates. *J Benefit Cost Anal*. 2013;4(1):39–80.
99. Kremer M, Leino J, Miguel E, Zwane AP. Spring cleaning: rural water impacts valuation, and property rights institutions. *Q J Econ*. 2011;126(1):145–205.
100. Kochi I. Endogeneity and estimates of the value of a statistical life. *Environ Econ*. 2011;2(4):17–31.
101. Liu WG, Zhao SC. The value of a statistical life in road safety: findings from a contingent valuation study in Dalian, China. Paper presented at: Proceedings of the 1st International Conference on Transportation Information and Safety; June 30-July 2, 2011; Wuhan, China. https://ascelibrary.org/doi/abs/10.1061/41177(415)134. Accessed June 11, 2019.
102. Svensson M. The value of a statistical life in Sweden: estimates from two studies using the "Certainty Approach" calibration. *Accid Anal Prev*. 2009;41(3):430–437.
103. Balmford B, Bateman IJ, Bolt K, Day B, Ferrini S. The value of statistical life for adults and children: comparisons of the contingent valuation and chained approaches. *Resour Energy Econ*. 2019;57:68–84.
104. Bockarjova M, Rietveld P, Verhoef ET. Valuation of flood risk in the Netherlands: some preliminary results. https://edepot.wur.nl/314050. Accessed June 11, 2019.
105. Chaturabong P, Kanitpong K, Jiwattanakulpaisarn P. Analysis of costs of motorcycle accidents in Thailand by willingness-to-pay method. *Transp Res Rec*. 2011;2239(1):56–63.
106. Šliupas T, Pakalnis A. Estimation of Socio-Economic Cost of Road Accidents in Lithuania: Willingness-to-Pay Approach (WTP). Proceedings of 21st International Scientific Conference: Transport Means 2017. Juodkrante, Lithuania; 2017.
107. Mon EE, Jomnonkwao S, Khampirat B, Satiennam W, Ratanavaraha V. Willingness to pay for mortality risk reduction for traffic accidents in Myanmar. *Accid Anal Prev*. 2018;118:18–28.
108. Lee SH, Kang HG. Integrated framework for the external cost assessment of nuclear power plant accident considering risk aversion: the Korean case. *Energy Policy*. 2016;92:111–123.
109. Flügel S, Veisten K, Rizzi LI, de Dios Ortúzar J, Elvik R. A comparison of bus passengers' and car drivers' valuation of casualty risk reductions in their routes. *Accid Anal Prev*. 2019;122:63–75.
110. Yang Z, Liu P, Xu X. Estimation of social value of statistical life using willingness-to-pay method in Nanjing, China. *Accid Anal Prev*. 2016;95(B):308–316.
111. Mofadal AI, Kanitpong K, Jiwattanakulpaisarn P. Analysis of pedestrian accident costs in Sudan using the willingness-to-pay method. *Accid Anal Prev*. 2015;78:201–211.
112. Leiter AM. Age effects in monetary valuation of reduced mortality risks: the relevance of age-specific hazard rates. *Eur J Health Econ*. 2011;12(4):331–344.
113. Liao CH, Liu JT, Pwu RF, You SL, Chow I, Tang CH. Valuation of the economic benefits of human papillomavirus vaccine in Taiwan. *Value Health*. 2009;12(Suppl 3):S74–S77.

114. Krüger NA, Svensson M. The impact of real options on willingness to pay for mortality risk reductions. *J Health Econ*. 2009;28(3):563–569.
115. Desaigues B, Ami D, Bartczak A, et al. Economic valuation of air pollution mortality: a 9-country contingent valuation survey of value of a life year (VOLY). *Ecol Indic*. 2011;11(3):902–910.
116. Finkel AM, Johnson BB. The limits of self-interest: results from a novel stated-preference survey to estimate the social benefits of life-prolonging regulations. HeinOnline. https://heinonline.org/HOL/LandingPage?handle=hein.journals/envlnw48&div=21&id=&page=. Accessed June 11, 2019.
117. Lee YJ, Lim YW, Yang JY, Kim CS, Shin YC, Shin DC. Evaluating the PM damage cost due to urban air pollution and vehicle emissions in Seoul, Korea. *J Environ Manage*. 2011;92(3):603–609.
118. Blomquist GC, Dickie M, O'Conor RM. Willingness to pay for improving fatality risks and asthma symptoms: values for children and adults of all ages. *Resour Energy Econ*. 2011;33(2):410–425.
119. Adamowicz W, Dupont D, Krupnick A, Zhang J. Valuation of cancer and microbial disease risk reductions in municipal drinking water: an analysis of risk context using multiple valuation methods. *J Environ Econ Manag*. 2011;61(2):213–226.
120. Svensson M. Precautionary behavior and willingness to pay for a mortality risk reduction: searching for the expected relationship. *J Risk Uncertain*. 2009;39(1):65–85.
121. Nunthasen K, Nunthasen W. Value of a statistical life of agrochemicals use paddy farmers. *Adv Sci Lett*. 2018;24(4):2320–2323.
122. Hoffmann S, Krupnick A, Qin P. Building a set of internationally comparable value of statistical life studies: estimates of Chinese willingness to pay to reduce mortality risk. *J Benefit Cost Anal*. 2017;8(2):251–289.
123. Roldós MI, Corso P, Ingels J. How much are Ecuadorians willing to pay to reduce maternal mortality? Results from a pilot study on contingent valuation. *Int J MCH AIDS*. 2017;6(1):1–8.
124. Mohamed HA. Estimation of socio-economic cost of road accidents in Saudi Arabia: willingness-to-pay approach (WTP). *Adv Manag Appl Econ*. 2015;5(3):43–61.
125. Wang H, He J. Estimating the economic value of statistical life in China: a study of the willingness to pay for cancer prevention. *Front Econ China*. 2014;9(2):183–215.
126. Hoffmann S, Qin P, Krupnick A, et al. The willingness to pay for mortality risk reductions in Mongolia. *Resour Energy Econ*. 2012;34(4):493–513.
127. Cameron M, Gibson J, Helmers K, Lim S, Tressler J, Vaddanak K. The value of statistical life and cost–benefit evaluations of landmine clearance in Cambodia. *Environ Dev Econ*. 2010;15(4):395–416.
128. Ortiz RA, Markandya A, Hunt A. Willingness to pay for mortality risk reduction associated with air pollution in São Paulo. *Rev Bras Econ*. 2009;63(1):3–22.
129. Viscusi WK, Huber J, Bell J. Assessing whether there is a cancer premium for the value of a statistical life. *Health Econ*. 2014;23(4):384–396.
130. Chanel O, Luchini S. Monetary values for risk of death from air pollution exposure: a context-dependent scenario with a control for intra-familial altruism. *J Environ Econ Policy*. 2014;3(1):67–91.
131. Ghadi M, Török Á, Tánczos K. Study of the economic cost of road accidents in Jordan. *Period Polytech Transp Eng*. 2018;46(3):129–134.
132. Alolayan MA, Evans JS, Hammitt JK. Valuing mortality risk in Kuwait: stated-preference with a new consistency test. *Environ Resour Econ*. 2017;66(4):629–646.
133. Morisugi M, Mori R, Sakamoto N, Nakajima K, Ohno E. Option price model and evaluation of time saving effect for emergency patient of heat stroke. Paper presented at: World Conference on Transport Research; July 10-15, 2016; Shanghai, China. https://www.sciencedirect.com/science/article/pii/S2352146517305744. Accessed June 11, 2019.
134. Le H, Van Geldermalsen T, Lim WL, Murphy P. Deriving Accident Costs Using Willingness-to-Pay Approaches - A Case Study for Singapore. https://trid.trb.org/view/1138215. Accessed June 11, 2019.
135. Gerking S, Dickie M, Veronesi M. Valuation of human health: an integrated model of willingness to pay for mortality and morbidity risk reductions. *J Environ Econ Manag*. 2014;68(1):20–45.
136. Chanel O, Chichilnisky G. Valuing life: experimental evidence using sensitivity to rare events. *Ecol Econ*. 2013;85:198–205.
137. Hammitt JK, Haninger K. Valuing fatal risks to children and adults: effects of disease, latency, and risk aversion. *J Risk Uncertain*. 2010;40(1):57–83.
138. Ohno E, Morisugi M, Kyophilavong P, Sao H. Measurement of value of statistical life by evaluating diarrhea mortality risk due to water pollution in Laos and Vietnam. Paper presented at: 52nd Congress of the European Regional Science Association: "Regions in Motion - Breaking the Path"; August 21-25, 2012; Bratislava, Slovakia. https://www.econstor.eu/handle/10419/120620. Accessed June 11, 2019.
139. Andersson H, Lindberg G. Benevolence and the value of road safety. *Accid Anal Prev*. 2009;41(2):286–293.
140. Mahmud M. On the contingent valuation of mortality risk reduction in developing countries. *Appl Econ*. 2009;41(2):171–181.
141. Abdallah NM, El Hakim AS, Wahdan AH, El Refaeye MA. Analysis of accidents cost in Egypt using the willingness-to-pay method. *Int J Traffic Transp Eng*. 2016;5(1):10–18.
142. Andersson H, Hammitt JK, Lindberg G, Sundström K. Willingness to pay and sensitivity to time framing: a theoretical analysis and an application on car safety. *Environ Resour Econ*. 2013;56(3):437–456.
143. Haninger K, Hammitt JK. Diminishing willingness to pay per quality-adjusted life year: valuing acute foodborne illness. *Risk Anal*. 2011;31(9):1363–1380.
144. Leiter AM, Pruckner GJ. Proportionality of willingness to pay to small changes in risk: the impact of attitudinal factors in scope tests. *Environ Resour Econ*. 2009;42(2):169–186.
145. Liu W, Zhao S. The value of statistical life in road traffic based on logit model. *J Transp Syst Eng Inf Technol*. 2013;13(1):137–141.
146. Rouwendal J, de Blaeij A, Rietveld P, Verhoef E. The information content of a stated choice experiment: a new method and its application to the value of a statistical life. *Transp Res B Meth*. 2010;44(1):136–151.
147. Carlsson F, Daruvala D, Jaldell H. Value of statistical life and cause of accident: a choice experiment. *Risk Anal*. 2010;30(6):975–986.
148. Andersson H, Hole AR, Svensson M. Valuation of small and multiple health risks: A critical analysis of SP data applied to food and water safety. *J Environ Econ Manag*. 2016;75:41–53.
149. Niroomand N, Jenkins GP. Estimating the value of life and injury for pedestrians using a stated preference framework. *J Saf Res*. 2017;62:81–87.
150. Guignet D, Alberini A. Can property values capture changes in environmental health risks? Evidence from a stated preference study in Italy and the United Kingdom. *Risk Anal*. 2015;35(3):501–517.
151. Mouter N, van Cranenburgh S, van Wee B. Do individuals have different preferences as consumer and citizen? The trade-off between travel time and safety. *Transp Res A Policy Pract*. 2017;106:333–349.
152. Cameron TA, DeShazo JR. Demand for health risk reductions. *J Environ Econ Manage*. 2013;65(1):87–109.
153. Niroomand N, Jenkins GP. Estimating the value of life, injury, and travel time saved using a stated preference framework. *Accid Anal Prev*. 2016;91:216–225.
154. Tekesin C, Ara S. Measuring the value of mortality risk reductions in Turkey. *Int J Environ Res Public Health*. 2014;11(7):6890–6922.
155. Ščasný M, Alberini A. Valuation of mortality risk attributable to climate change: investigating the effect of survey administration modes on a VSL. *Int J Environ Res Public Health*. 2012;9(12):4760–4781.
156. Rheinberger CM, Schläpfer F, Lobsiger M. A novel approach to estimating the demand value of public safety. *J Environ Econ Manag*. 2018;89:285–305.
157. Rheinberger CM. A mixed logit approach to study preferences for safety on alpine roads. *Environ Resour Econ*. 2011;49(1):121–146.
158. Alberini A, Ščasný M. Exploring heterogeneity in the value of a statistical life: cause of death v. risk perceptions. *Ecol Econ*. 2013;94:143–155.
159. Cameron TA, DeShazo JR, Stiffler P. Demand for health risk reductions: a cross-national comparison between the U.S. and Canada. *J Risk Uncertain*. 2010;41(3):245–273.
160. Huang D, Andersson H, Zhang S. Willingness to pay to reduce health risks related to air quality: evidence from a choice experiment survey in Beijing. *J Environ Plan Manag*. 2018;61(12):2207–2229.
161. Antoniou C, Kostovasilis K. How may external information affect traffic risk perception? *J Transp Saf Sec*. 2017;9(3):347–368.
162. Reynaud A, Manh-Hung N. Valuing flood risk reductions. *Environ Model Assess*. 2016;21(5):603–617.
163. Antoniou C. A stated-preference study of the willingness-to-pay to reduce traffic risk in urban vs. rural roads. *Eur Transp Res Rev*. 2013;6(1):31–42.
164. Hensher DA, Rose JM, Ortúzar JdD, Rizzi LI. Estimating the willingness to pay and value of risk reduction for car occupants in the road environment. *Transp Res A*. 2009;43(7):692–707.
165. Grisolia JM, Longo A, Hutchinson G, Kee F. Comparing mortality risk reduction, life expectancy gains, and probability of achieving full life span, as alternatives for presenting CVD mortality risk reduction: a discrete choice study of framing risk and health behaviour change. *Soc Sci Med*. 2018;211:164–174.
166. Gyrd-Hansen D, Kjaer T, Seested Nielsen J. The value of mortality risk reductions. Pure altruism - a confounder? *J Health Econ*. 2016;49:184–192.
167. Alberini A, Ščasný M, Guignet D, Tonin S. Cancer values of prevented fatalities (VPFs), one size does not fit all: the benefits of contaminated site cleanups in Italy. *J Air Waste Manage Assoc*. 2012;62(7):783–798.
168. Alberini A, Ščasný M. The benefits of avoiding cancer (or dying from cancer): evidence from a four-country study. *J Health Econ*. 2018;57:249–262.
169. Hensher DA, Rose JM, Ortúzar JD, Rizzi LI. Estimating the value of risk reduction for pedestrians in the road environment: an exploratory analysis. *J Choice Model*. 2011;4(2):70–94.
170. Chestnut LG, Rowe RD, Breffle WS. Economic valuation of mortality-risk reduction: stated preference estimates from the United States and Canada. *Contemp Econ Policy*. 2012;30(3):399–416.
171. Yusof MFM, Nor G, Mohamad NA. Malaysian value of statistical life for fatal injury in road accident: a conjoint analysis approach. *J Soc Transp Traffic Stud*. 2013;2(2):30–40.
172. Veisten K, Flügel S, Rizzi LI, de Dios Ortúzar J, Elvik R. Valuing casualty risk reductions from estimated baseline risk. *Res Transp Econ*. 2013;43(1):50–61.
173. González RM, Román C, Amador FJ, et al. Estimating the value of risk reductions for car drivers when pedestrians are involved: a case study in Spain. *Transportation*. 2018;45(2):499–521.

174. Zhang J, Adamowicz W, Dupont DP, Krupnick A. Assessing the extent of altruism in the valuation of community drinking water quality improvements. *Water Resour Res*. 2013;49(10):6286–6297.
175. Porfiriev B. Evaluation of human losses from disasters: the case of the 2010 heat waves and forest fires in Russia. *Int J Disaster Risk Reduc*. 2014;7:91–99.
176. Norman R, Church J, van den Berg B, Goodall S. Australian health-related quality of life population norms derived from the SF-6D. *Aust N Z J Public Health*. 2013;37(1):17–23.
177. Our Principles. National Institute for Health and Care Excellence. https://www.nice.org.uk/about/who-we-are/our-principles. Accessed February 10, 2021.
178. George B, Harris A, Mitchell A. Cost-effectiveness analysis and the consistency of decision making: evidence from pharmaceutical reimbursement in Australia (1991 to 1996). *Pharmacoeconomics*. 2001;19(11):1103–1109.
179. Neumann PJ, Cohen JT, Weinstein MC. Updating cost-effectiveness–the curious resilience of the $50,000-per-QALY threshold. *N Engl J Med*. 2014;371(9):796–797.
180. Vallejo-Torres L, García-Lorenzo B, Castilla I, et al. On the estimation of the cost-effectiveness threshold: why, what, how? *Value Health*. 2016;19(5):558–566.
181. Lakdawalla DN, Phelps CE. Health technology assessment with diminishing returns to health: the generalized risk-adjusted cost-effectiveness (GRACE) approach. *Value Health*. 2021;24(2):244–249.
182. Dixit VV, Ortmann A, Rutström EE, Ukkusuri SV. Experimental economics and choice in transportation: incentives and context. *Transp Res C Emerg Technol*. 2017;77:161–184.
183. Harrison GW, Rutström EE. Experimental evidence on the existence of hypothetical bias in value elicitation methods. *Handbook of Experimental Economics Results*. 2008;1:752–767.
184. Hoyos D. The state of the art of environmental valuation with discrete choice experiments. *Ecol Econ*. 2010;69(8):1595–1603.
185. Fifer S, Rose J, Greaves S. Hypothetical bias in stated choice experiments: is it a problem? And if so, how do we deal with it? *Transp Res A Policy Pract*. 2014;61:164–177.
186. Robinson LA, Hammitt JK. Valuing reductions in fatal illness risks: implications of recent. *Res Health Econ*. 2016;25(8):1039–1052.
187. Jones-Lee M, Chilton S, Metcalf H, Nielsen JS. Valuing gains in life expectancy: clarifying some ambiguities. *J Risk Uncertain*. 2015;51(1):1–21.
188. Adamson GD, de Mouzon J, Chambers GM, et al. International Committee for Monitoring Assisted Reproductive Technology: world report on assisted reproductive technology, 2011. *Fertil Steril*. 2018;110(6):1067–1080.
189. Neumann PJ, Johannesson M. The willingness to pay for in vitro fertilization: a pilot study using contingent valuation. *Med Care*. 1994;32(7):686–699.
190. Musters AM, de Bekker-Grob EW, Mochtar MH, van der Veen F, van Mello NM. Women's perspectives regarding subcutaneous injections, costs and live birth rates in IVF. *Hum Reprod*. 2011;26(9):2425–2431.
191. Ryan M. Should government fund assisted reproductive techniques? A study using willingness to pay. *Appl Econ*. 1997;29(7):841–849.
192. van den Wijngaard L, Rodijk ICM, van der Veen F, et al. Patient preference for a long-acting recombinant FSH product in ovarian hyperstimulation in IVF: a discrete choice experiment. *Hum Reprod*. 2015;30(2):331–337.