Valuing Nonfatal Health Risk Reductions in Global Benefit-Cost Analysis

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Preface and Acknowledgements

The Bill and Melinda Gates Foundation (BMGF) is supporting the development of guidelines for the economic evaluation of investments in health and development, particularly in low- and middle-income countries ("Benefit-Cost Analysis Reference Case: Principles, Methods, and Standards," grant number OPP1160057). These guidelines will supplement the existing international Decision Support Initiative (iDSI) reference case, which provides general guidance on the overall framework for economic evaluation as well as specific guidance on the conduct of cost-effectiveness analysis.

This working paper is part of a series of methods papers and case studies being conducted to support the extension of the reference case to include benefit-cost analysis. The methods papers were reviewed by selected experts, posted online for public comment, discussed in a November 2017 workshop at Harvard University, then finalized. Although these papers will provide the basis for the benefit-cost analysis reference case guidance, the reference case may ultimately deviate from their recommendations in some cases.

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More information on the project is available at https://sites.sph.harvard.edu/bcaguidelines/.

Executive Summary

In the context of benefit-cost analysis, the approach for valuing nonfatal risk reductions and other policy outcomes is grounded in two basic assumptions. The first is that each individual is the best judge of his or her own welfare. This principle, often referred to as "consumer sovereignty," means that values should be based on the preferences of those affected by a policy. The second is that these preferences are represented by an individual's willingness to exchange income to achieve a beneficial outcome. Presumably, an individual's willingness to pay (WTP) for a nonfatal risk reduction or other desired improvement indicates that he or she values that outcome at least as much as the other things that money could buy.

The first step in valuing nonfatal risk reductions is to review the WTP literature to determine whether studies of reasonably high quality are available that are applicable to the risk and population of concern. Presumably, this WTP accounts for both the pecuniary effects of the risk change (e.g., out-of-pocket medical expenses and earnings) and the non-pecuniary effects (e.g., pain and suffering and other quality of life impacts). WTP is expected to vary depending on characteristics of the risk reduction, such as its duration and severity, and the characteristics of those affected, such as income, age, and baseline health status.

For nonfatal risk reductions, relatively few WTP studies are available. Thus often the main challenge faced by analysts is to determine how to best value these risk changes in the absence of WTP estimates. Typically, two approaches are used either alone or in combination. The first involves applying an estimate of averted costs, often referred to as the cost of illness (COI). The cost of illness includes both direct and indirect costs that may be avoided if incidence is reduced. Direct costs typically include per case expenditures for medical treatment; indirect costs typically include productivity losses associated with reduced work time. Other costs may also be considered, such as travel, food, and lodging associated with seeking treatment. Such costs may be incurred by the ill or injured individual, his or her household or family members, or third parties such as government agencies, private insurers, or donor organizations. One advantage of the averted cost approach is that it relies on data that are reasonably accessible in most cases and can be easily understood by decision-makers and other stakeholders. The sum of these costs likely understates the value of reducing the risk, because it excludes the nonpecuniary effects of the health improvement.

The second approach involves applying monetized estimates of quality-adjusted life years (QALYs) or disability-adjusted life years (DALYs). Although QALYs and DALYs differ in concept and application, both are nonmonetary measures that integrate morbidity and mortality. Mortality is quantified by the change in length of life, typically measured as life years gained or lost. Morbidity is expressed as a fraction of each year of life lived, using a zero-to-one scale. QALYs and DALYs use reverse scales, however. A year of life lived in full health is equivalent to a QALY score of 1.0 but a DALY score of zero. Illnesses or injuries that have relatively mild effects are scored higher on the QALY scale and lower on the DALY scale than more severe conditions. Years of life gained or lost can then be added to years of life lived in impaired health to determine the total impact of the condition.

The value per QALY or DALY is frequently approximated using an estimate of the value per statistical life year (VSLY). The VSLY in turn is typically derived from a population-average estimate of individual WTP to reduce one's own mortality risks, expressed as the value per statistical life (VSL), often by dividing VSL by the (discounted) expected life years remaining for an individual at the mean age of the population studied. This approach is based on several strong assumptions, including that (1) the VSLY is constant; (2) the VSLY is equivalent to the value per QALY or DALY; and (3) the value per QALY or DALY is constant. However, both theory and an increasing number of empirical studies suggest that the value per QALY or DALY will vary depending on whether it measures a change in life expectancy or a change in health, and on factors such as the duration and severity of the health condition. More work is needed to develop a valuation function that better reflects how individuals' WTP per QALY or DALY varies depending on these and other attributes.

One question that arises when WTP or monetized QALY or DALY estimates are used for valuation is whether they include the full social welfare costs of the health condition. This is in part a question of what costs are included or excluded in the underlying WTP study, or in the valuation measure used to monetize QALYs or DALYs. While the appropriate treatment of averted costs often needs to be determined on a case-by-case basis, it seems reasonable to assume that costs incurred by the individual are likely to be included in the WTP or monetized QALY or DALY estimates, and hence should not be added to avoid double-counting. Similarly, it seems reasonable to assume that costs incurred by third parties are excluded from the WTP or monetized QALY or DALY estimates, and hence should be added. These are real resource costs that should be included to more completely address the effect of the condition on social welfare. The appropriate treatment of costs incurred by household or family members is more uncertain. However, the opportunity costs associated with caregiving provided outside of the health care system often should be added to estimates of WTP or monetized QALYs or DALYs.

The options for valuing nonfatal risk reductions are summarized in Figure ES.1 below. The options vary in how they estimate value from the perspective of the affected individual; each also includes an estimate of the impacts on costs that would otherwise be incurred by third parties. The types of impacts included as third-party costs will vary depending on the health condition and on the approach used for valuation. Costs incurred by members of the household or family as well as society at large may be at times be added to the estimates of impacts on the ill or injured individual.

Figure ES.1. Options for Valuing Nonfatal Risk Reductions

Option 1	Option 2	Option 3	Option 4
WTP estimates + third party averted costs	QALYs or DALYs monetized using a valuation function + third party averted costs	QALYs or DALYs monetized using a constant VSLY + third party averted costs	Individual + third party averted costs
• Consistent with the benefit-cost analysis framework • High quality, applicable WTP estimates often unavailable	• Accounts for quality of life impacts as well as averted costs • Valuation function needs further development to better approximate WTP	• Accounts for quality of life impacts as well as averted costs • Valuation approach requires strong assumptions	• Relies on easily accessible data • Excludes quality of life impacts

While option 1 is clearly preferred, it often cannot be implemented given gaps in the available research. Option 2 appears to be the second best choice, since it encompasses both the pecuniary and nonpecuniary effects of the risk change and uses a valuation function to approximate individual WTP. However, while work is underway on such a valuation function, it is not yet at a point where it is suitable for application in global benefit-cost analyses. Options 3 and 4 each have significant drawbacks. Option 3 involves the use of strong assumptions to value quality of life impacts, while option 4 excludes these impacts from consideration.

Given the available data, in the near-term, we recommend that analysts begin by searching the literature to determine whether reasonably high quality, suitable estimates of WTP are available. Averted costs not included in the WTP estimate (e.g., that would otherwise be incurred by third parties) may be added. If WTP estimates are not available, analysts should sum the averted costs incurred by the affected individual, household or family members, and third parties to estimate the value of nonfatal risk reductions, recognizing that this sum likely understates this value. If the results have significant implications for the analytic conclusions, then analysts should conduct sensitivity analysis using monetized QALYs or DALYs. In this case, the value of the monetized QALYs or DALYs should replace the estimate of costs incurred by the individual to avoid double-counting. Over the long run, more work on a valuation function for QALYs and DALYs should be a high priority.

More specifically, analysts should proceed as follows.

1) **Conduct a criteria-driven review of the WTP literature.** This review should apply the benefit transfer framework to determine whether estimates of reasonable quality are available for health risks similar to those associated with the policy. This review should include four steps:
    a. Describe the policy outcome;
    b. Search the literature;
    c. Review studies for quality and applicability; and (if suitable estimates are available),
    d. Transfer the estimate(s).

2) **Estimate averted costs, distinguishing between costs incurred by the affected individual, household or family members, and third parties.** These costs should be reported as follows:
    - When WTP estimates are used for valuation, add costs averted by the policy that are not counted elsewhere in the analysis, especially if these costs are expected to be significant.
    - When WTP estimates are not available, sum the costs incurred by the individual, the household and family members, and third parties and use the results for valuation, recognizing that this sum is expected to understate the value of the risk reduction.

3) **Conduct sensitivity analysis using monetized estimates of the change in QALYs or DALYs, if WTP estimates are not available.** In cases where WTP estimates are not available and averted costs are used to estimate the value of nonfatal risk reductions, conduct sensitivity analysis that replaces the estimates of costs incurred by the individual with estimates of monetized QALYs or DALYs. The monetary value per QALY or DALY should be a constant VSLY derived from the VSL estimates used to value mortality risk reductions. Such analysis may not be necessary if increasing the estimates of the value of nonfatal risk reductions is unlikely to affect the decision.

4) **Address uncertainty:** Assess uncertainties in the estimates both qualitatively and quantitatively; e.g., by conducting sensitivity or probabilistic analysis, discussing the quality of the evidence, and indicating the implications for decision-making.

Over the long term, more research on the value of nonfatal risk reductions is needed.

1) **Compile a global database of WTP studies and detailed guidance on benefit transfer.** Greater access to WTP research and information on its quality is needed to support the valuation of nonfatal health risk reductions in low- and middle-income countries.

2) **Further develop a valuation function for QALYs and DALYs.** A valuation function, based on the results of WTP per QALY or DALY studies, is likely to more accurately reflect the value of QALY or a DALY than the application of a constant value discussed above.

3) **Conduct additional research on WTP for nonfatal risk reductions:** More research is needed on the value of nonfatal risk reductions in high- as well as low- and middle-income settings. Because any individual study will have advantages and limitations, ideally a research program would be developed that includes the application of a variety of research methods to a range of risks and populations.

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1.0 Introduction

The approach for valuing nonfatal health risk reductions in benefit-cost analysis, regardless of whether they are associated with illness, injury, or another form of disability, is very similar to the approach for valuing mortality risk reductions. In both cases, estimates of individual willingness to pay (WTP) are the most appropriate approach for valuation, given the underlying conceptual framework. The main difference relates to the lack of high quality valuation research for many nonfatal conditions. Given the multitude and diversity of these effects, this deficiency is perhaps unsurprising; a large research program would be needed to provide valid and reliable estimates for all the potential effects of concern. The challenge is thus to determine how to best value these risk changes when estimates of individual WTP of reasonable quality are not available. This paper explores this challenge and evaluates approaches for addressing it.

This paper is one in a series of methods papers which will ultimately be used to develop guidance on the conduct of benefit-cost analysis in global health and development. Information on the overall project, the benefit-cost analysis framework and related normative assumptions, and on the role of benefit-cost analysis in decision-making, is provided in our scoping report (Robinson et al. 2017). This paper supplements and complements a separate paper on the valuation of mortality risk reductions (Robinson, Hammitt, and O'Keeffe 2018). More information is provided on the project website (https://sites.sph.harvard.edu/bcaguidelines/).

This introductory chapter provides a brief overview of concepts and methods related to estimating individual WTP. In the next chapter, we focus on developing proxy measures when WTP estimates are not available. These proxies include estimates of averted costs (often referred to as the costs of illness or COI), alone or in combination with estimates of health-adjusted life year gains or losses; i.e., quality-adjusted life years (QALYs) and disability-adjusted life years (DALYs), valued in monetary terms. The concluding chapter summarizes our findings and recommendations.

1.1 General Framework

In benefit-cost analysis, the starting point for valuing nonfatal health risk reductions is typically an estimate of the change in the likelihood of illness, injury, or other disability in a defined time period for those individuals affected by the policy.[1] This risk change can be aggregated over the affected population to calculate the expected number of statistical cases the policy averts. The term "statistical" is used to emphasize that the number and identities of cases cannot be known in advance; most policies reduce the risk incurred by the affected population rather than preventing identifiable cases with certainty. For example, if a policy decreases the risk of a specific illness by 1 in 10,000 in a given year for each of 10,000 individuals, it averts one statistical case of that illness (10,000 * 1/10,000 = 1).

[1] In this and other papers prepared for this project, we use the term "policy" generically to refer to all types of programs and interventions that may be the focus of a benefit-cost analysis.

Consistent with the benefit-cost analysis framework, the value of these risk reductions is based on individuals' willingness to trade-off spending on other goods and services for reductions in their own risks; i.e., the marginal rate of substitution between wealth and the probability of not suffering the specified health effect.[2] Presumably, individual WTP accounts for both the pecuniary effects of the risk change (including avoided out-of-pocket medical expenses and earnings losses) and the non-pecuniary effects (including averted pain and suffering and other quality of life impacts).[3]

These values are likely to vary across individuals (e.g., due to their income, age, or baseline health status) and also across types of health risks (e.g., due to their severity and duration). For example, the value of a chronic condition with lifelong effects, such as blindness, is likely to be quite different from the value of an acute condition with relatively short-lived effects, such as a minor fracture. Similarly, a health effect that occurs when one is very young may be valued differently than the same effect if it occurs when one is middle-aged or elderly. As is the case for mortality risk reductions and other outcomes, these values are likely to vary depending on income as well as on the characteristics of the society, such as cultural mores and the quality and accessibility of the health care system.

Averted costs that would otherwise be incurred by third parties can be added to these estimates, as long as they are not included elsewhere in the analysis, to more completely account for the impacts of the risk reductions on social welfare.[4] The next chapter discusses these costs in more detail. They may include, for example, the costs of medical treatment covered by government programs, private insurance, or donor organizations and of caregiving provided outside of the health care system (e.g., by family and friends).

For risks that accrue throughout a population, the value of the risk reduction is equal to the sum of each member of the population's WTP for the risk reduction he or she experiences. This sum can be divided by the total number of cases averted to estimate the average value per statistical case (VSC) within that population. For example, if a population of 10,000 is willing to pay, in the aggregate, $600,000 in a given year for a risk reduction expected to result in 10 fewer illnesses in that year, mean VSC would be

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[2] Estimates of willingness to accept compensation (WTA) are also consistent with the benefit-cost analysis framework. However, WTP is estimated more frequently in empirical research and typically used to value improvements from the status quo.

[3] For a more technical, theoretical exploration of this framework, see Harrington and Portney (1983). These impacts are not necessarily additive; see Hunt et al. (2016) for discussion of potentially counterbalancing effects.

[4] As discussed in our scoping report (Robinson et al. 2017), we suggest including those impacts (and any offsetting savings) associated with implementing the policy in the cost analysis, and those impacts that are an outcome of the policy (e.g., changes in health risks) in the benefits analysis. This requires carefully distinguishing between the types of medical costs included in each analytic component. For example, for a policy that provides tuberculosis vaccinations, the costs associated with delivering the vaccine would be included in the cost analysis, and the cost-savings associated with the resulting reduction in disease incidence would be included in the benefit analysis. In the latter case, only the medical costs paid by third parties would be included in the benefit estimates to avoid double-counting what is included in the WTP estimate.

$60,000 ($600,000 divided by 10 cases). VSC can also be defined for an individual as the marginal rate of substitution between money and risk, typically estimated by dividing WTP for a small change in risk by the risk change. For example, if an individual is willing to pay $6.00 for a 1 in 10,000 reduction in his or her risk of incurring a particular illness in the current year, his or her VSC is $60,000 ($6 WTP ÷ 1 in 10,000 risk change).

1.2 Valuation Approaches

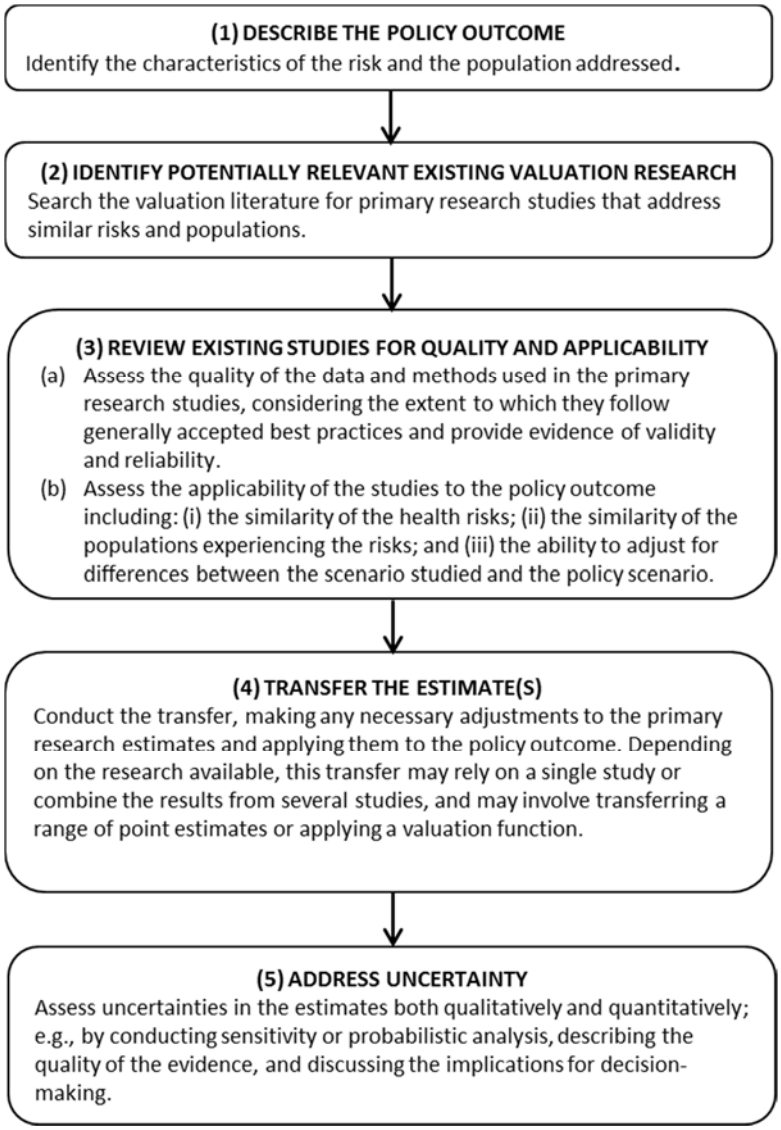
As is the case for mortality risk reductions, estimates of individual WTP for nonfatal health risk reductions are generally derived using stated- or revealed-preference methods. Stated-preference methods typically employ survey techniques to ask respondents about their WTP for an outcome under a hypothetical scenario, while revealed-preference methods infer the value of nonmarket goods from observed behaviors and prices for related market goods.[5,6]

Because conducting new primary research using either method requires substantial time and expense, typically analysts rely on existing valuation studies. This approach is referred to 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. Similar to the approach used to estimate almost any parameter in policy analysis, such transfers involve carefully reviewing the literature to identify high-quality studies that are suitable for application in a particular context and clearly addressing the implications of related uncertainties. In some cases, these uncertainties may have relatively little effect on the conclusion that a policy is, or is not, cost-beneficial. In other cases, these uncertainties may have a more profound effect. Figure 1 illustrates this framework.

[5] Experiments may also be used to examine these values. This method typically involves asking individuals to make choices in an artificial (laboratory) environment. While these choices may have real consequences (e.g., involve monetary exchanges), the extent to which they are likely consistent with decisions made in real-world environments is often unclear.

[6] Johnston et al. (2017) provide recent best practice guidance for stated preference research; Freeman et al. (2013) discuss the wider range of nonmarket valuation methods. However, these and other texts generally focus largely on the conduct of such studies in high income countries.

Figure 1. Benefit Transfer Process



Guidance on implementing this framework is provided several texts and articles. However, this guidance is often focused the application of the available research in high income countries. Analysts will need to adapt the guidance to reflect the policy context, the importance of the estimates to the overall results, and the time and resources available. Some potentially useful references include Söderqvist and Soutukorva (2006) and Johnston et al. (2015).

The benefit transfer approach is similar to the framework for systematic review used in health care. This framework is discussed in detail in Institute of Medicine (2011), which evaluates and synthesizes standards for these reviews. However, these standards may best be viewed as aspirational even in high

income countries. They require investing substantial time and resources and are not tailored to the issues that arise in benefit valuation.

More generally, benefit transfer requires significant judgment on the part of the analyst, given the complexity of the issues, the limited number of studies available, and the lack of consistent reporting standards for valuation research. As a result, careful documentation of the approach and discussion of its limitations is essential.

The logical starting places for benefit transfer are previously-completed literature reviews. We are not aware of a recent, comprehensive review of the global valuation literature for nonfatal risks, unfortunately. For nonfatal illnesses, respiratory and cardiovascular conditions associated with air pollution appear to have been subject to more study than other conditions; see, for example, Hunt and Ferguson (2010) and Hunt et al. (2016). For acute effects, a meta-analysis by Van Houtven et al. (2006) lists 17 stated preference studies from nine countries published from the late 1970s through the early 2000s. The European Chemicals Agency (ECHA, 2016) reviews several studies of health effects associated with chemical exposures, including skin sensitization, kidney failure and kidney disease, fertility and developmental toxicity, and cancer. For injuries, most WTP studies bundle a range of injuries into a few categories. For example, Viscusi and Aldy (2003) identify 40 wage-risk studies globally that define the nonfatal risk variable as either the overall injury rate, the rate for injuries severe enough to result in a lost workday, or the rate of lost workdays. For effects on children, Gerking and Dickie (2013) and Alberini et al. (2010) review related studies. Many of these reviews are relatively old and do not focus on values directly applicable to low- and middle-income countries.

Because estimates of WTP are the most appropriate valuation measure for benefit-cost analysis, analysts should first review the literature to determine whether WTP estimates of reasonable quality are available for the nonfatal risks of concern, applying the benefit transfer framework. Given the limited number of studies available, analysts are likely to need to adjust the results of this research to be applicable to the policy and population of concern. Such tailoring may include, for example, adjusting an estimate from a high-income country to a lower-income setting.[7]

[7] The relationship between WTP and income is not as well-studied for nonfatal risk reductions as for mortality risk reductions, and hence is uncertain (see Robinson and Hammitt 2015 for discussion). As a default, analysts may wish to assume that WTP changes in proportion to income; i.e., an income elasticity of 1.0. This means that the ratio of the value of the risk reduction to income is constant. Robinson, Hammitt, and O'Keeffe (2018) discuss the concept and use of income elasticities in more detail.

We expect that, in many cases, analysts will not be able to identify a high-quality WTP study that addresses a reasonably similar risk and population, in which case they will need to use proxy measures. Thus in the remainder of this paper we focus on the development of these proxies. Because of the diversity of the health effects likely to be considered and the gaps in the research literature, this paper focuses on concepts and criteria that analysts should apply in developing estimates, rather than recommending specific values.

2.0 Methods for Approximating Individual Willingness to Pay

Because it is often difficult to identify WTP studies of reasonable quality that are applicable to the nonfatal risks and populations addressed by a particular benefit-cost analysis, analysts frequently use other measures as proxies. Typically, two approaches are used either alone or in combination. The first involves applying an estimate of averted costs, often referred to as the direct and indirect costs of illness (COI). Such estimates are incomplete measures of value because they do not address pain and suffering and other quality of life impacts. To address these nonpecuniary effects, analysts often estimate the monetary value of the change in QALYs or DALYs associated with the risk reduction. We discuss the application of each approach below.

Regardless of whether WTP estimates or these proxy measures are used, the results should be accompanied by appropriate characterization of uncertainty and discussion of its implications for the analytic conclusions; i.e., the likelihood that the benefits of the policy will exceed its costs. For example, for many policies, the estimate of net benefits may be dominated by the value of mortality risk reductions and may not be significantly affected by the value placed on nonfatal risk reductions. In other cases, uncertainty in the latter values may substantially affect net benefits.

2.1 Averted Costs

Averted costs refer to changes in the real resource costs associated with incurred cases of illness, injuries, or other conditions. Such estimates are often used to compare the costs of different health conditions or of alternative treatments for a particular condition. These costs are frequently referred as "cost of illness" (COI) estimates, and typically include direct medical costs and indirect productivity losses. We use the term "averted costs" to emphasize that, in the context of benefit valuation, we are generally interested in decreases in these costs. In addition, costs other than those associated with medical care and productivity may be included if they are affected by the policy. Such costs may relate, for example, to expenditures on transportation and lodging while seeking medical care, on processing reimbursement claims, or related to the reallocation of leisure time, as well as other impacts.

Direct medical costs typically include expenditures for services from physicians and other health care providers, medication, hospital stays, rehabilitation, and other treatment-related activities. Indirect costs associated with lost productivity may stem from absence from work or from decreased productivity while at work, and may include other costs such as those associated with idling assets or training replacement workers. Productivity losses may also include decreases in unpaid work, such as household services, agricultural labor for household consumption, or volunteer efforts. While losses in leisure time are not normally included in COI studies, they may be considered in benefit-cost analysis. Those affected are likely to experience a welfare gain if the policy allows them to reallocate time from relatively unpleasant activities (such as caring for an ill relative) to more pleasant or productive activities (such as paid or unpaid work or recreation).

The estimation of these costs is discussed in detail elsewhere, and hence not addressed in this paper. In particular, to supplement the iDSI Reference Case guidance (Wilkinson et al. 2016), medical cost

estimation is being addressed in ongoing work by iDSI and the Global Health Cost Consortium (Vassall et al. 2017) as well as others.[8] As part of this benefit-cost analysis reference case guidance project, related issues are discussed in two separate papers; one on the valuation of changes in time use (Whittington and Cook 2018), and one on economy-wide modeling (Strzepek et al. 2018).

Averted costs include several components: those that accrue to an individual who would have become ill or injured in the absence of the policy, those that accrue to his or her family or household, and those that accrue to society at large. For example, costs may include medical expenses paid out-of-pocket by the ill individual, or by others such as the government, insurers, or donor organizations. In addition to productivity losses that accrue to the ill or injured individual, averted costs may include lost productivity associated with caregiving incurred outside of the health care system; e.g., by friends or family.[9]

The relationship of these costs to estimates of individual WTP is somewhat uncertain. The extent to which they are included in particular WTP estimates will depend in part on the design of the study. For example, respondents to a stated preference survey may be instructed to include or exclude certain impacts; researchers may be able to control for different types of costs in a revealed preference study. Costs that accrue to the individual are more likely to be included in the WTP estimates while costs that accrue to third parties are more likely to be excluded. Whether costs to the individual's household or family are included may be more uncertain. Regardless, review of individual WTP studies is needed to explore the treatment of these costs. This assessment is further complicated by uncertainty regarding the extent to which individuals consider these costs in their decision-making, regardless of whether the WTP study addresses them explicitly.

Conceptually, individual WTP is expected to exceed the costs that accrue to the individual, because -- as noted earlier -- an individual's WTP reflects effects on wellbeing in addition to the costs he or she incurs (see Harrington and Portney 1985 for more discussion). Difficulties in measurement may mean, however, that estimated costs are more or less than individual WTP despite this expectation.[10] For example, ideally estimates of medical costs averted would reflect marginal costs per case, but often only data on average costs are available. For lost productivity, wage rates are often used to estimate values, but whether they are equivalent to the associated opportunity costs is uncertain. In addition, what wage rates to use, and whether and how to include taxes, employer-paid benefits, and other employment-related costs is subject to debate. The valuation of losses in unpaid productive time, such as that used for household tasks, raises additional challenges. Measurement is complicated in part because prices

[8] For more information on these initiatives, see: http://www.idsihealth.org/knowledge_base/the-reference-case-for-economic-evaluation/ and https://ghcosting.org/.
[9] Care provided by employees of the health care system is included in the medical cost component.
[10] These challenges can be significant in high income settings; see, for example, Baxter, Robinson, and Hammitt (2017) and Robinson, Rein, and Hammitt (2017) for issues related to U.S. practices. Both data availability and the functioning of markets in low- and middle-income countries raise additional challenges.

may not be a good measure of opportunity costs. In many countries, health care and labor markets are significantly distorted.

The allocation of costs between the individual, household or family members, and third parties will vary depending on the characteristics of the society, its health care system, and its labor markets, as well as the characteristics of the health conditions and the individuals affected. Thus this allocation should be examined within the context addressed by a particular policy. For example, countries differ significantly in the extent to which they provide health insurance and sick leave or workers compensation. In general, review of individual WTP studies is needed to explore what the estimates do, and do not, include, so as to avoid double-counting. Where the inclusion or exclusion of particular types of averted costs is uncertain, this uncertainty should be explicitly addressed in the analysis.

If the underlying WTP studies do not directly address the treatment of these costs, it generally seems reasonable to assume that the costs that accrue to the individual are included in the WTP estimates. Double-counting may result if such costs (e.g., averted out-of-pocket medical costs and productivity losses) are added. Whether costs borne by household or family members are included is more uncertain, and analysts may wish to explore the extent to which including these costs significantly affects the benefits estimates. Third party costs borne by society at large are typically not included in WTP estimates, so may be added. These costs reflect expenditures of real resources and should be included to better represent the total societal impact of the risk reduction.

Although averted costs also can be added to WTP estimates for mortality risk reductions, they may be more significant for nonfatal risk reductions for several reasons. First, the available evidence suggests that individual WTP for mortality risk reductions is much larger than individual WTP for nonfatal risk reductions, often by orders of magnitude. Any additional averted costs may be small in comparison and have little impact on the analytic results. In contrast, for some nonfatal conditions, the magnitude and duration of such costs may be relatively large in comparison to the effects captured in the WTP estimates. In addition, and perhaps most importantly, in the case of mortality risks costs are delayed rather than averted, since we all die eventually. While such costs may change if the individual dies from a cause other than that addressed by the policy, the value of this change may be relatively small compared to the WTP estimate for mortality risk reductions.

2.2 Monetized QALYs and DALYs

QALYs and DALYs differ in concept and application, but both translate the impact of nonfatal health effects into a life year measure, so that the years of life lived in different health states or lost to premature fatality can be combined into a single indicator. Such estimates are relatively plentiful and easily accessible, addressing a wide range of health conditions. Our concern in this paper is with the use of these measures to estimate individual WTP for nonfatal risk reductions. We first provide a brief overview of the construction of QALYs and DALYs, referencing other sources for more information. We then describe their monetary valuation.

2.2.1 Estimating QALYs and DALYs

The QALY is a nonmonetary measure that integrates the duration and severity of various health conditions.[11] QALYs are widely used to rank and prioritize public health programs, analyze the cost-effectiveness of health policy and medical treatment decisions, and compare health status across individuals or population groups. In these contexts, QALYs are generally not assigned a monetary value, but monetization is needed to apply these estimates in benefit-cost analysis.[12]

QALYs are derived by multiplying the amount of time an individual spends in a health state by a measure of the associated health-related quality of life (HRQL). HRQL is measured using a scale anchored at zero and one, where one corresponds to full health and zero corresponds to a state that is as bad as dead (values cannot be greater than one but may be less than zero for states judged to be worse than dead). Once HRQL is determined for a particular health state, it is then multiplied by the duration of that state to estimate the associated QALYs.

HRQL can be estimated directly or indirectly. Direct methods include the standard gamble, time tradeoff, and visual analog scale, administered in individual interviews or surveys. Indirect methods typically apply one of several generic HRQL indices, examples of which include the EQ-5D, the Health Utilities Index (HUI), and the Quality of Well-Being (QWB) scale. Each employs a classification system with several dimensions to describe health as well as a scoring system based on population surveys to estimate the associated HRQL. These indices have the advantage of standardizing the approach for describing health states. The results will vary, however, depending on which index is applied, given differences in the attributes they include and in the scoring functions. Each approach has advantages and limitations, which should be explored in the context of a particular analysis.

QALYs are not entirely consistent with the conceptual framework for valuation in benefit-cost analysis, which focuses on measuring overall welfare rather than solely health. Their construction is based on the assumption that how individuals value health states is independent of the duration of the state, the age at which it is experienced, the individual's remaining life expectancy, and his or her wealth and income (see Hammitt 2002, 2013).

The DALY is a similar measure that is commonly used in global health. It was developed by researchers associated with the World Bank and World Health Organization (WHO) as a generic measure of the

[11] For more information, including discussion of criteria to be considered in selecting among the available estimation methods and estimates, see Institute of Medicine (2006), Drummond et al. (2015) and Neumann et al. (2016a). A comprehensive database of cost per QALY studies is available in the Cost Effectiveness Analysis Registry maintained by the Center for Evaluation of Value and Risk in Health at Tufts Medical Center (www.cearegistry.org).

[12] Valuation is implicit in any decision that affects spending on health. In cost-effectiveness analysis, these values may be represented by monetary thresholds, that are compared to the cost-effectiveness ratio to determine whether an intervention is worth implementing.

global burden of disease (Jamison et al. 1993, Murray and Lopez 1996) and is often used when estimating the cost-effectiveness of health-related interventions.[13]

DALYs use a scale that inverts the QALY scale. They are framed as the loss from full health associated with disability, rather than as the gain associated with improved health. For nonfatal effects, the disability is measured as a value between zero (for full health) and one (equivalent to dead). For example, a health condition assigned a disability weight of 0.2 is equivalent to 80 percent of a year in full health. In contrast, for QALYs, a condition equivalent to 80 percent of a year in full health would be represented by HRQL of 0.8. The disability weight is multiplied by the duration of the condition to calculate years lived with disability (YLDs). For fatal effects, each year of life lost (YLL) is assigned a value of 1.0 DALY.

The methods for estimating DALYs rely on a set of standardized weights which were originally derived from judgments by medical experts and are now derived from population surveys (Murray et al. 1996, Salomon et al. 2012, Salomon et al. 2015). The discounting method used, the weighting of different age groups, and the assumptions regarding life expectancy have also evolved over time and vary across analyses (Fox-Rushby and Hanson 2001, Sassi 2006, Salomon 2014). Analysts using these approaches should be clear about the source of the disability weights and about the assumptions used in their analysis, as well as the limitations of the approach and associated uncertainties.

There has been some debate over whether DALYs are intended to solely measure health or to measure welfare more generally. In recent iterations of the DALY weights, the researchers have been clear that the intent is to measure health alone (Salomon et al. 2012). Thus DALYs are also not entirely consistent with the framework for benefit-cost analysis, which focuses on overall welfare.

2.2.2 Valuing QALYs and DALYs

The monetary value of a QALY or a DALY is often based on an estimate of the value per statistical life year (VSLY). Because few empirical studies directly estimate VSLY, it is typically derived from an estimate of VSL, often by dividing that VSL by the expected (discounted) life years remaining for an individual at the mean age of the population studied.[14] This VSLY is then multiplied by the change in QALYs or DALYs

[13] A comprehensive database of cost per DALY studies is available in the Global Health Cost-Effectiveness Analysis Registry maintained by the Center for Evaluation of Value and Risk in Health at Tufts Medical Center (http://healtheconomics.tuftsmedicalcenter.org/ghcearegistry/); see Neumann et al. (2016b) for more discussion.

[14] Alternatively, VSL could be divided by expected future QALYs for the average member of the population to estimate a constant value per QALY (see, for example, U.S. Department of Health and Human Services 2016). This approach yields a larger value, because HRQL is expected to decline with age. (Dividing instead by future life years essentially averages future health over these years.) To implement this approach, estimates of HRQL by year of age are needed for the population of concern.

to estimate the value of the risk reduction.[15] The VSLY concept, its derivation, and its application in global health and development is discussed in more detail in the methods paper on mortality risk reductions (Robinson, Hammitt, and O'Keeffe 2018).[16]

Using these VSLY estimates to value QALYs or DALYs is based on several simplifying assumptions. The first is that VSLY is constant. Both theory and empirical research suggest that this is not the case. Both VSL and VSLY are likely to depend on the characteristics of the population affected (such as income, age, life expectancy, and health status), the characteristics of the risk (such as whether it is associated with an injury or an acute or chronic illness, or is viewed as voluntary or controllable), and the physical and social characteristics of the society (such as the quality of its health-care system and cultural attitudes). In addition, theory suggests that VSLY will decrease as the quantity of life years remaining declines (Hammitt 2013).

Additional assumptions are that the value of a QALY or DALY is both constant and equivalent to this VSLY. An increasing body of scholarship as well as theory suggests that this assumption does not hold.[17] In particular, several studies suggest that individual WTP per QALY depends on the severity and duration of the health condition as well as other factors. Simple economic models suggest that marginal and average WTP per QALY should decrease with the magnitude of the QALY gain, but they provide little guidance about the magnitude of the decrease. Empirical estimates of average WTP per QALY gained suggest it decreases quite sharply with QALYs.

For example, Hammitt and Haninger (2017) elicit WTP per QALY for 38 nonfatal health conditions of varying severity and duration in the U.S. They find that the estimated elasticity of WTP with respect to the QALY loss is about 0.15. Estimating the elasticity of WTP separately for severity and duration leads to values of about 0.3 to 0.4 for severity and about 0.1 for duration. Hammitt (2017b) compares direct estimates of WTP with estimates based on multiplying the expected change in QALYs by a constant. Compared with the direct WTP estimates, the estimates based on multiplying QALYs by a constant are much smaller for acute illnesses, are comparable for mild illnesses of long duration (40 years), and are much larger for severe illnesses of long duration.[18] This work suggests that WTP per QALY is a decreasing function of the magnitude of the QALY gain, although the rate of decrease seems implausibly large (e.g., WTP seems implausibly insensitive to the severity and duration of impaired health). The value of a DALY, although less studied, is likely to vary for similar reasons.

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[15] For example, if the VSLY calculated for a particular country is $20,000, and the QALY gain associated with the risk reduction was 0.3 QALYs, then the monetary value would be $6,000 ($20,000 * 0.3).

[16] At times discounted expected life years are approximated by the present value of a series of years with length equal to life expectancy. See Jones-Lee et al. (2015) for more discussion of this approximation, and Claxton (2018) for more discussion of discount rates.

[17] See the meta-analyses and reviews in Johnson et al. (1997), Van Houtven et al. (2006), and Ryen and Svensson (2015) as well as the studies listed in the appendix to this paper for more information.

[18] In Hammitt (2017b), the constant value per QALY is calculated by dividing VSL by future QALYs rather than future life years.

A more complicated valuation function, based on the results of WTP per QALY studies such as those cited above, is likely to reflect the value per QALY or DALY more accurately than a constant value. Such a function can adjust the value to reflect the characteristics of the health effect, and possibly also the characteristics of those affected. Work is now underway to develop such a function for QALYs and to determine the extent to which QALY and DALY estimates for similar health effects are consistent. This work is being undertaken by the authors under a separate project; the work on the consistency of QALYs and DALYs is being undertaken by the Neumann et al. team at Tufts Medical Center as part of its Global Health Cost-Effectiveness Analysis Registry project. In the interim, valuation using a constant value per QALY or DALY appears to be the most feasible and reasonable approach.

Determining the extent to which estimates of averted costs should be added to the monetized QALY or DALY estimates raises several complicated issues that are not easily resolved. When QALYs or DALYs are used to value nonfatal risk reductions, some costs that accrue to the individual are presumably included in the estimate used for monetization – i.e., in the VSL estimate from which the monetary value of a QALY or DALY is derived. However, the direct and indirect costs associated with a fatal condition likely vary significantly from those associated with a nonfatal condition as well as across nonfatal conditions.[19] In addition, in the QALY literature, there has been substantial debate about whether productivity losses that accrue to the affected individual are included in the QALY measure. Recent U.S. guidance suggests that adding such losses may result in double-counting (Neumann et al. 2016a). Similarly, as discussed in the methods paper on valuing mortality risk reductions (Robinson, Hammitt and O'Keeffe 2018), VSL estimates are likely to include effects on individual earnings, although theory suggests that the relationship is complex (Hammitt 2017a).[20]

Given these uncertainties, analysts may wish to follow the same approach as discussed earlier for adding averted costs to WTP estimates. In other words, they would assume that monetized QALY or DALY estimates include direct and indirect costs borne by the individual but not by third parties. Hence third party costs may be added. The appropriate treatment of costs incurred by household or family members is again more uncertain, and analysts may wish to explore the extent to which including these costs significantly affects the benefits estimates. However, the opportunity costs associated with caregiving provided outside of the health care system can often be added.

Monetized QALYs or DALYs merge nonmonetary measures of health status with monetary estimates of individuals' willingness to exchange income (which could be spent on other things) for the change in health represented by these measures. It approximates the effect of changes in health on overall welfare, consistent with the conceptual framework for benefit-cost analysis. However, more work is

[19] In addition, an individual may be less concerned about reducing medical costs incurred when he dies than for a nonfatal illness.

[20] The productivity loss associated with a year of life lost (and embedded in the VSL measure) may not be proportional to the productivity loss associated with a particular illness, injury, or other disability.

needed to further develop this function. Some issues to be addressed include the extent to which WTP estimates vary depending on the approach used to estimate QALYs or DALYs; for example, on which of the direct elicitation or generic indices are used in the case of QALYs. In addition, these values may vary depending on the characteristics of the population; for example, without more research, the extent to which these values vary across countries due to cultural and other factors is unclear. Finally, research that estimates the value of particular dimensions of HRQL (such as each of the dimensions included in the generic indices such as the EQ-5D) may aid in developing more robust estimates.

3.0 Summary and Recommendations

Ideally, in benefit-cost analysis the value of changes in nonfatal risks would be derived from estimates of individual WTP, that indicate the extent to which those affected by the policy are willing to exchange income for a reduction in their own risks. Presumably this WTP accounts for both the pecuniary effects of the risk change (e.g., out-of-pocket medical expenses and earnings) and the non-pecuniary effects (e.g., pain and suffering). These values will vary across individuals and across types of risks.

Because primary research is lacking on individual WTP for reducing many types of nonfatal risks, analysts often apply other measures to approximate these values. Such proxy measures include estimates of averted costs and monetized QALYs and DALYs.

Averted costs include both the direct and indirect costs of illness that may be avoided if incidence is reduced. Such costs include, for example, expenditures for medical treatment and productivity losses associated with reduced work time. These costs may be incurred by the individual, their family or household, or by the government, insurers, or other third parties.

QALYs and DALYs are non-monetary measures that represent the effects of illness or injury on longevity and quality of life. They differ in concept and application, but both translate the impact of nonfatal health effects into a life-year measure, so that the years of life lived in different health states or lost to premature fatality can be combined into a single indicator. Their value is typically estimated based on a VSLY. The VSLY in turn is typically derived from an estimate of individuals' WTP to reduce their own mortality risks (i.e., the VSL), often by dividing VSL by the (discounted) life expectancy of an individual at the mean age of the population studied.

When WTP estimates or monetized QALYs or DALYs are used for valuation, one question is whether to add averted costs to these estimates. Because these estimates reflect how an individual values changes in his or her own health, it seems reasonable to assume that they exclude costs borne by third parties. These costs may include direct medical costs that are averted as a result of the policy, as well as the opportunity costs associated with caregiving outside of the health care system. Adding these costs more fully accounts for the impacts of the risk reduction on social welfare.

3.1 Near-Term Recommendations

In the near-term, analysts should begin by searching the literature to determine whether reasonably high quality, suitable estimates of WTP are available. Otherwise, they should apply estimates of averted costs, recognizing that these costs may understate the value of the risk reduction. Monetized DALYs or QALYs should be used in sensitivity analysis, if including these estimates could significantly affect the analytic conclusions.

More specifically, analysts should proceed as follows.

1) **Conduct a criteria-driven review of the WTP literature.** This review should apply the benefit transfer framework, to determine whether estimates of reasonable quality are available for health risks similar to those associated with the policy. This review should include four steps.
    a. *Describe the policy outcome:* Determine the characteristics of the risks and populations to be addressed by the policy options.
    b. *Search the literature:* Identify potentially relevant valuation research
    c. *Review studies for quality and applicability:* Assess the quality of the data and methods used, considering the extent to which they follow generally accepted best practices and provide evidence of validity and reliability. Also assess the applicability of the studies to the policy outcome including: (i) the similarity of the health risks; (ii) the similarity of the populations experiencing the risks; and (iii) the ability to adjust for differences between the scenario studied and the policy scenario, such as income or age.
    d. *Transfer the estimate(s):* If applicable WTP estimates of reasonable quality are available, conduct the transfer, making any necessary adjustments to the primary research estimates. These may include, for example, adjusting for differences in the income level of the country where the country was conducted and the country addressed by the benefit-cost analysis. This transfer may rely on a single study or combine the results from several studies, and may involve transferring a range of point estimates or a valuation function that tailors the estimate to the policy outcome.

2) **Estimate averted costs, distinguishing between costs incurred by the affected individual, household and family members, and third parties.** These costs should be reported as follows:
    - When WTP estimates are used for valuation, add costs averted by the policy that are not counted elsewhere in the analysis, especially if these costs are expected to be significant. These additional costs are likely to include medical costs paid by third parties, such as government programs, private insurance, or donor organizations. They are also likely to include the opportunity costs of caregiver time, when such caregiving is provided by household members or friends outside of the formal health care system. Generally costs borne by the individual are included in the WTP estimate so should not be added.
    - When WTP estimates are not available, sum the costs incurred by the individual, the household and family members, and third parties, and use the results for valuation -- recognizing that this sum is expected to understate the value of the risk reduction. Costs incurred by the individual should include out-of-pocket medical expenditures and productivity losses, as well as other costs if significant.

3) **Conduct sensitivity analysis using monetized estimates of the change in QALYs or DALYs, if WTP estimates are not available.** In cases where WTP estimates are not available and averted costs are used to estimate the value of nonfatal risk reductions, sensitivity analysis should be conducted that replaces the estimates of costs incurred by the individual with estimates of monetized QALYs or DALYs. Such analysis may not be necessary if increasing the estimates of the value of nonfatal risk

reductions is unlikely to affect the decision; e.g., if nonfatal risk reductions represent an insignificant share of total benefits or if the relative rankings of the policy options are not likely to be altered. These values should be developed as follows:

a. *Estimate the change in QALYs or DALYs attributable to the policy:* The selection of a QALY or DALY measure should follow the iDSI Reference Case methodological specifications and reporting standards, and also take into account the benefit transfer considerations noted in the WTP discussion above, including both the quality and applicability of the available estimates.
b. *Estimate the monetary value:* In the near-term, the monetary value per QALY or DALY should be derived from the VSL estimates used to value mortality risk reductions, applying the approach recommended for estimating VSLY recommended in the separate methods paper on these values (Robinson, Hammitt, and O'Keeffe 2018). This approach should be replaced by a valuation function that better represents individuals' WTP for changes in QALYs or DALYs when available.

4) **Address uncertainty:** Assess uncertainties in the estimates both qualitatively and quantitatively; e.g., by conducting sensitivity or probabilistic analysis, discussing the quality of the evidence, and indicating the implications for decision-making.

3.2 Long-Term Recommendations

Over the long term, more research on the value of nonfatal risk reductions is needed. Additional work on a valuation function for QALYs and DALYs would be particularly useful.

1) **Compile a global database of WTP studies and detailed guidance on benefit transfer.** Greater access to WTP research and information on its quality is needed to support the valuation of nonfatal health risk reductions in low- and middle-income countries. Such access could be provided by developing a database of studies that is easy to search and update, provides information on the advantages and limitations of each study, and includes the data needed to select studies for application in particular contexts. The usefulness of these data would be enhanced by the creation of detailed guidance on the conduct of benefit transfers, tailored for application in low- and middle-income countries. These data and guidance can also aid in identifying and prioritizing data gaps and limitations to be addressed by future research.

2) **Further develop a valuation function for QALYs and DALYs.** A valuation function, based on the results of WTP per QALY or DALY studies, is likely to more accurately reflect the value of QALY or a DALY than the application of a constant value. Work is now underway to develop such a function for QALYs and to determine the extent to which QALY and DALY estimates for similar health effects are consistent. More effort is needed, however, to further develop this function for application in low- and middle-income settings, to extend it to reflect the differences between QALYs and DALYs, and to determine the implications for how QALYs and DALYs are estimated.

3) **Conduct additional research on WTP for nonfatal risk reductions:** More research is needed on the value of nonfatal risk reductions in high- as well as low- and middle-income settings. Because any individual study will have advantages and limitations, ideally a research program would be developed that includes the application of a variety of research methods to a range of risks and populations. This program could be designed, for example, to develop base values for a subset of nonfatal risks of concern in selected settings, as well as adjustment factors for applying these values to other risks and other populations. It could also include the conduct of more research on WTP per QALY and per DALY to support refinement of the valuation function described above.

In conclusion, this paper provides recommendations for valuing nonfatal risk reductions that can be implemented based on the research now available. It also identifies areas in need of more research. In the near-term, it recommends that – when WTP estimates are not available – analysts rely on estimates of averted costs. Because these estimates exclude nonpecuniary effects and are expected to understate the value of these risk reductions, analysts should conduct sensitivity analysis using monetized QALYs and DALYs when the results are likely to be useful for decision-making. This latter approach merges nonmonetary measures of health status with monetary estimates of individuals' willingness to exchange income (which could be spent on other things) for the change in health represented by these measures. Over the longer term, more research on individual WTP for nonfatal risk reductions is needed.

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(Includes links for publications that are freely available online.)

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Appendix: Willingness to Pay per QALY Studies

In the table below, we list examples of studies that estimate WTP per QALY for nonfatal health effects, ordered by date of publication. These studies are diverse, using different methodologies as well as addressing different health outcomes and approaches to estimating QALYs. In Chapter 2, we discuss the use of this research to estimate the value of a QALY. We have not found studies that estimate the value of a DALY in our reviews to-date; however, work is now underway to explore the consistency of QALY and DALY estimates for different conditions.

Study	Country
Zethraeus (1998)	Sweden
Gyrd-Hansen (2003)	Denmark
Byrne et al. (2005)	U.S.
King et al. (2005)	U.S.
Lieu et al. (2008)	U.S.
Pinto-Prades et al. (2009)	Spain
Bobinac et al. (2010)	Netherlands
Haninger and Hammitt (2011)	U.S.
Prosser et al. (2011)	U.S.
Zhao et al. (2011)	China
Bobinac et al. (2012)	Netherlands
Bobinac et al. (2014)	Netherlands
Gyrd-Hansen and Kjaer (2012)	Denmark
Gyrd-Hansen et al. (2012)	Denmark
Robinson et al. (2013)	Netherlands, U.K., France, Spain, Sweden, Norway, Denmark
Shiroiwa et al. (2013)	Japan
Thavorncharoensap et al. (2013)	Thailand
Pennington et al. (2015)	Netherlands, U.K., France, Spain, Sweden, Norway, Denmark
Andersson et al. (2015)	Sweden
Gao et al. (2015)	China
Ahlert et al. (2016)	Germany
Hammitt and Haninger (2017)	U.S.
Lim et al. (2017)	Malaysia