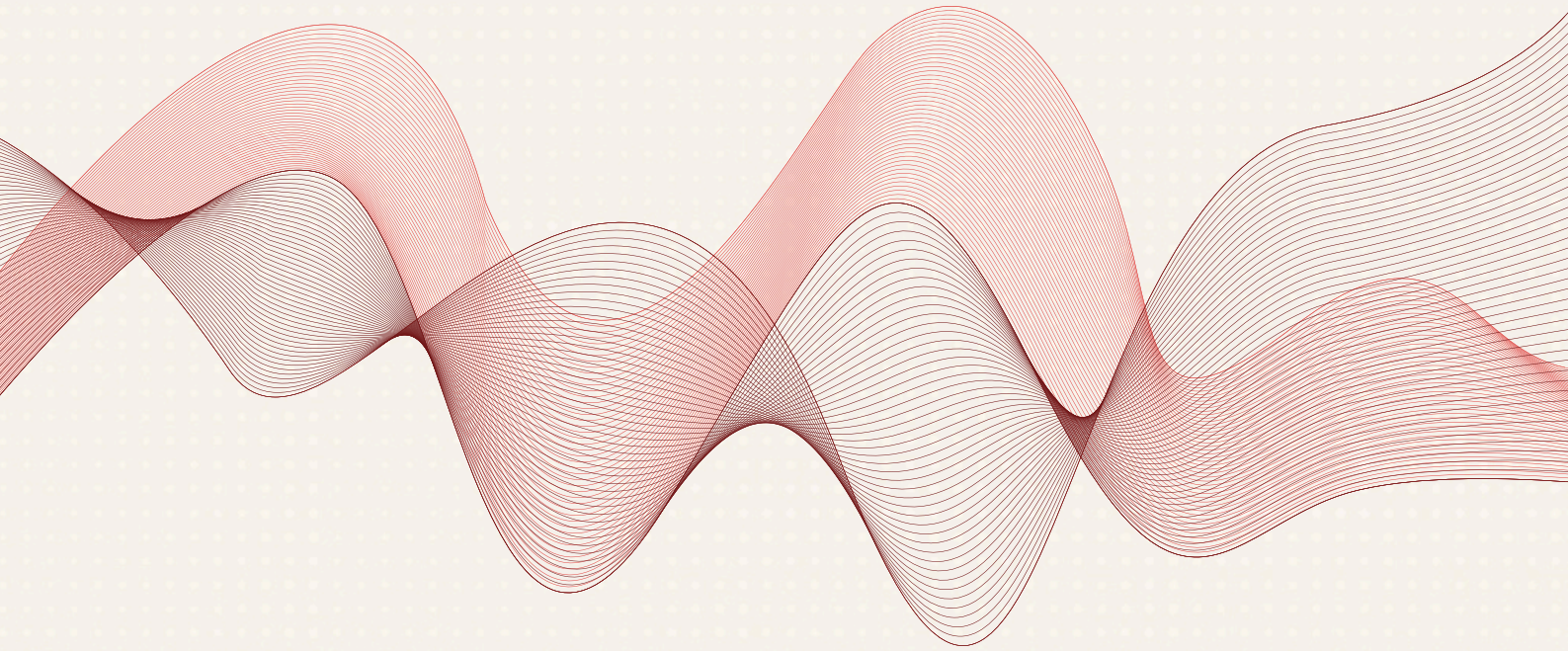

Disease Control Priorities, Fourth Edition
Volume 3, Interventions Outside the Health Care System

Guidelines for Consistent and Comparable Economic Evaluation to Support Prioritization

Lisa A. Robinson (Harvard University)
James K. Hammitt (Harvard University; Toulouse School of Economics
Brad Wong (Mettalytics)

Working Paper 15, June 2024

DCP4 Disease Control Priorities
economic evaluation for health

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June 2024

Correspondence to: Lisa A. Robinson (robinson@hsph.harvard.edu)

Note: This guidance is subject to change. It is an initial review draft; comments are welcome. It will be reviewed by our Technical Working Group and by the lead authors of the chapters in this volume, then finalized.

The draft is written in the past tense, given that it will eventually be included in Volume 3 along with the completed analyses. However, the assumptions and approaches it describes are preliminary proposals developed for consideration by reviewers, which will be revised to reflect their input.

Preface

Since the early 1990s, researchers involved in the Disease Control Priorities (DCP) effort have been evaluating options to decrease disease burden in low- and middle-income countries. This working paper was developed to support the Fourth Edition of this effort. It is posted to solicit comments and feedback, and ultimately will be revised and published as part of the DCP4 series.

DCP4 will be published by the World Bank. The overall DCP4 effort is led by Series Lead Editor Ole F. Norheim, Director of the Bergen Centre for Ethics and Priority Setting. Core funding is provided by the Norwegian Agency for Development Cooperation and the Norwegian Research Council. Lisa A. Robinson (Harvard University) and Brad Wong (Mettalytics) are the Co-Lead Editors for DCP4 volume 3, "Interventions Outside the Health Care System." More information on the project is available at: https://www.uib.no/en/bceps/156731/fourthedition-disease-control-priorities-dcp-4.

Acknowledgements

We thank Ole F. Norheim for his helpful advice and comments on earlier drafts of this working paper, and members of the project team for many useful discussions. We also thank participants in the BCEPS International Symposium 2024 for their insightful feedback. This chapter builds on the 2019 *Reference Case Guidelines for Benefit-Cost Analysis in Global Health and Development*, and we are grateful to the many contributors to that effort. Additional comments are welcome; please address correspondence to Lisa A. Robinson (robinson@hsph.harvard.edu).

Contents

Abstract

Interventions implemented outside the health care system contribute significantly to public health, often addressing the root causes of impairment and drawing on varied sources of support and resources. However, deciding which interventions to prioritize is a difficult task, given the numerous possibilities within and across policy sectors. While benefit-cost analysis and other forms of economic evaluation can aid in informing these decisions, three major implementation challenges must be addressed to support prioritization. The first relates to differences in impacts across contexts. An intervention that provides large positive net benefits in one country or region may provide much smaller, or even negative, net benefits elsewhere, and vice-versa. Yet it is not possible to assess every intervention in every possible context. The second relates to differences in methods. If dissimilar approaches, assumptions, or parameter values are used to estimate the costs and benefits of alternative investments, it is challenging to disentangle the extent which the results are driven by differences in methods rather than differences in impacts. Third, while conventional benefit-cost analysis is well-established and widely used, providing important and useful information, it has known limitations. Perhaps most importantly, it typically does not address issues of equity, i.e., the distribution of costs and benefits across disadvantaged and advantaged groups. This chapter summarizes the approaches used to address these challenges in this third volume of Disease Control Priorities, Fourth Edition, "Interventions Outside the Health Care System."

1.0 Introduction

The overall goal of the Disease Control Priorities, Fourth Edition (DCP4) effort is to summarize, produce, and help translate economic evidence into better priority setting for universal health coverage and for intersectoral and international action for health, focusing on low- and middle-income countries. In this third volume, we consider interventions undertaken outside the health care system. These interventions may address, for example, environmental, transportation, occupational, nutritional, behavioral, and other risks, including climate change. They may involve implementing regulations, developing targeted taxes, fees, or subsidies, or directly funding goods and services.

The aim is to:

- Aid decision-makers in comparing interventions implemented within and across policy sectors so as to identify those likely to yield the largest net improvements in health and welfare, including prioritization of policies within the purview of individual government ministries as well as across ministries and other local, national, and international organizations.
- Encourage the use of resources, legal authority, and political interests beyond those available to the health care sector to address challenging public health problems more effectively.

To compare and prioritize interventions undertaken outside of the health care sector, this volume relies primarily on conventional benefit-cost analysis (BCA). Conventional BCA has several strengths as well as limitations. It is well-established and widely used to evaluate interventions outside of the health care sector that significantly affect public health. It is familiar to policy analysts and decision-makers working in these sectors, and its application eases comparison of the analytic results in this volume to other analytic work.

Conventional BCA is designed to promote the efficient allocation of resources, recognizing that resources are limited. Investment in any policy imposes opportunity costs, precluding the use of the same resources for other, potentially more cost-beneficial, purposes. It encourages thoughtful, evidence-based assessment of alternative investments.

Conventional BCA incorporates well-developed approaches for estimating the value of non-health benefits. As discussed in the previous chapter of this volume, cost-effectiveness analysis (CEA) is commonly used to evaluate interventions within the health care sector.[1] CEA typically relies on non-monetary effect measures such as changes in expected deaths, quality-adjusted life years (QALYs), or disability-adjusted life years (DALYs). While impacts not included in these effect measures may be netted out of the cost estimate in calculating cost-effectiveness ratios, typically the primary focus is on maximizing health improvements within a fixed budget. In contrast, the resources available to support

[1] Robinson and Hammitt (2024), "Economic Evaluation for Health Priority-Setting: Cost-Effectiveness Analysis and Benefit-Cost Analysis Primer." DCP4 Working Paper 3. https://www.uib.no/en/bceps/156731/fourth-edition-disease-control-priorities-dcp-4.

interventions outside of the health care sector are typically not limited to an identified ministry or budget. Associated costs may be funded by imposing requirements on industry or other organizations through regulation, by creating targeted taxes, fees, or subsidies, or by direct investment of government or donor funds.

Applying BCA to support prioritization requires addressing three challenging methodological issues.

1. **The effects of interventions vary depending on the context**, due to the numerous cultural, socio-economic, geographic, and other variables that influence their impacts. Analysis conducted for a particular country, or for a particular location within that country, may lead to substantially different conclusions than an analysis conducted elsewhere. Analysis conducted at a broad scale, whether national, regional, or international, may mask important differences in impacts across specific locations.
2. **Inconsistent methods can obscure differences in impacts**, given the challenges of distinguishing the effects of varying assumptions and parameter estimates from the effects of the intervention itself. While conventional BCA provides a well-established and widely used conceptual framework for economic evaluation, the details of its implementation vary.
3. **Conventional methods rely on specific conceptions of individual and social welfare**, which may not fully address impacts of concern to decision-makers. Innovative work now underway provides opportunities to supplement conventional BCA with methods that rely on broader conceptions of welfare, and, most importantly, evaluate the distributional equity of impacts across advantaged and disadvantaged groups.

This chapter tackles these challenges, first discussing the approach for addressing the effects of context, then summarizing guidance designed to encourage consistent application of conventional BCA. This guidance discusses assessing distributional equity within the conventional framework. Our approach for supplementing these analyses using innovative approaches is summarized separately.[2]

[This paragraph discusses sections that are now being developed.] In the following chapter of Section I, we describe the process we followed to identify the policy sectors that are the focus of our work. The subsequent sections then address each policy sector in turn. For each sector, the section begins with an overview of the risks and the problems of concern, then summarizes the findings of the available literature that evaluates the potential impacts of interventions to address these concerns. Based on that review, the authors identify a subset of interventions that are expected to yield large net benefits within that policy sector, and apply the methods discussed in this chapter to consistently evaluate and compare their effects. The overview chapters within the following sections thus provide information on the possible impacts of a large number of interventions within that sector. The chapters that follow that

[2] See Ferranna, Hammitt, Robinson (2024).

overview within each section then provide the results of assessing a subset of sector-specific interventions that are most likely to substantially improve health and welfare, using consistent methods. In the current chapter, we focus on methods that are applied in these analyses of selected high impact interventions within each sector.

2.0 Comparability across Contexts

The goal of this project is to aid low- and middle-income countries in identifying interventions that are likely to lead to the largest net improvements in health and longevity. Given that there are over 100 countries classified as low- or middle-income economies by the World Bank, it is not possible to assess every intervention in every context.[3] Yet at the same time, determining how to prioritize decisions within individual countries requires information on local impacts.

This trade-off between generality and specificity permeates the analysis, affecting the predictions of baseline (without intervention) conditions as well as the estimates of the likely changes in these conditions attributable to the intervention. It also affects the parameter estimates used throughout the analysis. The latter include both cross-cutting socio-economic data applicable to most interventions (such as data on population size and per capita income) and intervention-specific data, such as the distance to the nearest water source in the case of interventions that require access to clean water.

As noted earlier, for each policy sector we begin with a literature review to identify those interventions likely to have the largest net benefits, then conduct BCAs using a consistent approach for a small subset of the interventions most likely to have the greatest net benefits.

In these analyses, one option is to use global or regional averages for the parameter estimates; a second option is to use estimates specific to the particular setting. The first approach has the advantage of simplicity, but has important disadvantages. The use of averages obscures important differences across countries, making it difficult to determine which interventions are likely to be most cost-beneficial in a particular location or setting. To be salient to a particular setting, generally context-specific estimates are needed. The second option has the advantage of producing relevant estimates for the specific context, but the disadvantage of not providing estimates relevant to the same intervention implemented elsewhere.

[3] For a list of countries in each income group, see: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups. For fiscal year 2024, the World Bank defines low-income economies as those with gross national income (GNI) per capita of $1,135 or less in 2022; lower middle-income economies are those with a GNI per capita between $1,136 and $4,465; upper middle-income economies are those with a GNI per capita between $4,466 and $13,845; high-income economies are those with a GNI per capita of $13,846 or more. All values are reported in U.S. dollars, calculated using the World Bank Atlas method, as described here: https://datahelpdesk.worldbank.org/knowledgebase/articles/378832-what-is-the-world-bank-atlas-method. The methods used to convert currencies across countries for the analyses conducted for this volume are explored later in this chapter.

For several reasons, we focus on location-specific analyses, while giving careful thought to both the selection of the locations and the extent to which the results are likely to hold in other locations and settings. Our overarching concern is that the results will be both useful and used in near-term policy decisions, which argues for a location-specific approach. In addition, we lack the resources to complete *de novo* analyses; rather, in the sections that follow, the authors build on previously completed work which is typically location specific.

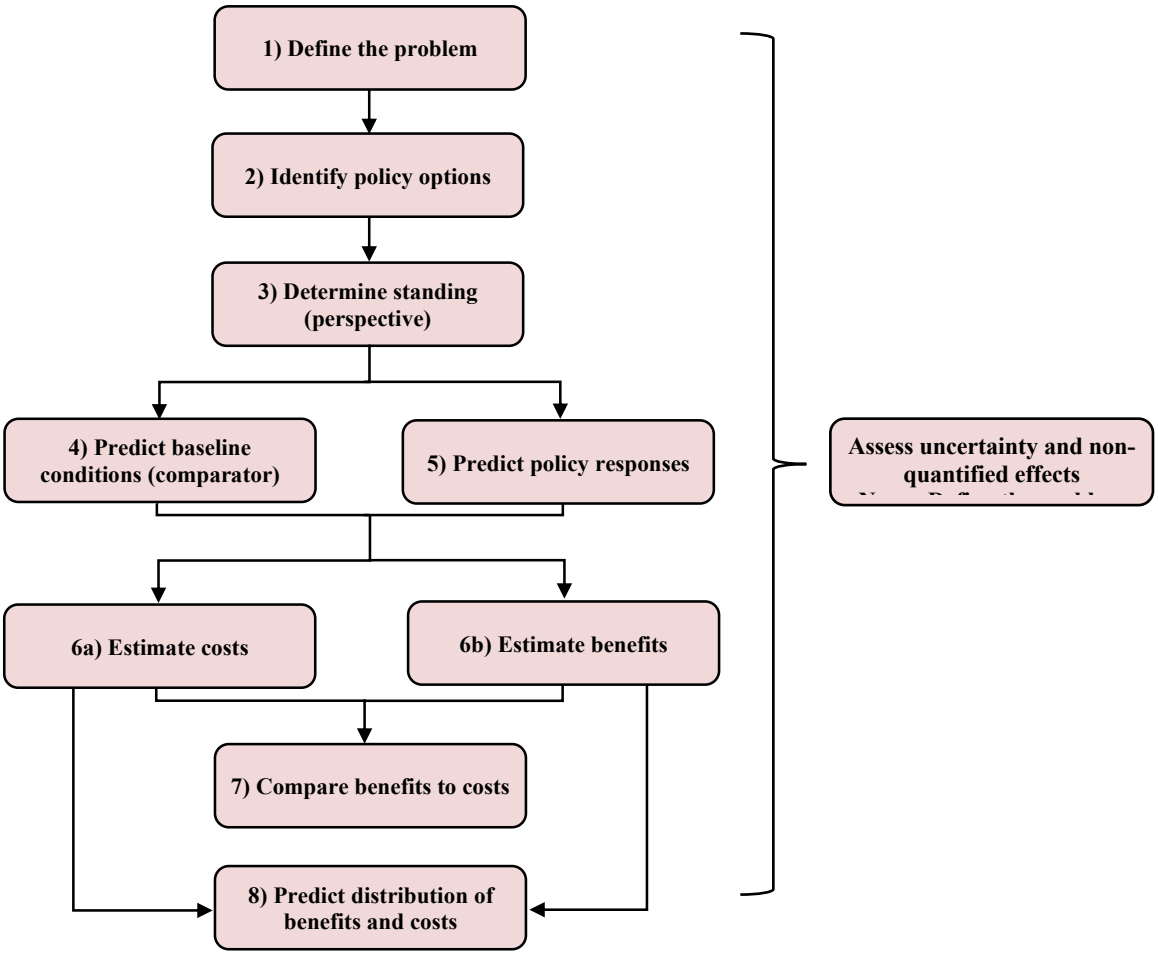
We attempt to mitigate the disadvantages of this approach by (1) relying on locations that are likely to be reasonably representative of many other locations, rather than analyzing impacts in locations with comparatively unique attributes; and (2) identifying the parameters that drive the results of each BCA and discussing the implications for other locations. As a perhaps overly simple example, if we evaluate an intervention that is expected to have large net benefits in a densely populated region, we might discuss the likely change in the net benefits if the intervention was implemented in a more sparsely populated area – if population density is an important driver of the net benefits. Similarly, if we evaluate an intervention in an arid region, we might discuss the likely outcomes of implementing it in a more humid area. The introductory chapter for each policy sector discusses how these issues were handled within that sector in more detail.

3.0 Conventional BCA: General Approach

As introduced in the prior chapter and discussed in detail in the *Reference Case Guidelines* (Robinson et al. 2019), economic evaluation typically includes seven basic components; distributional analysis is a desirable eighth component, as illustrated in Figure 1.[4] While shown as if it were a sequential process, in reality these steps are iterative. As analysts acquire additional information and review their preliminary findings, they often revise earlier components to reflect improved understanding of the issues. Each component requires consideration of uncertainty as well as non-quantified effects; approaches for addressing uncertainty and non-quantified effects are discussed in Chapter 8 of the *Reference Case Guidelines* and are not repeated in this chapter.

[4] See Robinson and Hammitt (2024) for the working paper version of the prior chapter.

Figure 1. Economic Evaluation Components



Listing all potential impacts of the policy, both positive and negative, is an important initial step. It is often useful to map the links between the policy and these impacts as a decision tree or logic model to illustrate the likely relationships. Screening analysis, which relies on easily accessible information and simple assumptions, is also frequently useful. It provides preliminary insights into the direction and magnitude of effects, aids in determining which effects are likely to most significantly contribute to net benefits, and identifies where additional research is most needed to reduce uncertainty in the estimates of net benefits.

As noted above, the previous chapter introduces these components, which are discussed in detail in the *Reference Case Guidelines.* Our focus in this chapter is on the application of those guidelines to the analyses conducted for this DCP4 volume. In this section, we discuss general principles. In the following section, we discuss approaches for estimating key parameter values.

The first three components in Figure 1 involve clarifying and communicating the context for the analysis. Component 1, define the problem, establishes the starting point for identifying potentially cost-beneficial interventions and the likely consequences of those interventions,

both positive and negative, desirable and undesirable. The introductory chapters to each of the following sections describe this step for the policy sectors considered in this volume.

Component 2, identify policy options, involves reviewing feasible and potentially cost-beneficial alternatives and deciding which to subject to detailed evaluation, based on the results of previous work supplemented by simple screening analysis as needed. This component is also addressed in the introductory chapters of the following sections, which describe the results of our scoping review of the relevant benefit-cost analysis literature.

Component 3, determine who has standing (perspective), refers to identifying whose benefits and costs count. In this volume, the analyses are conducted from the societal perspective, including impacts on all those who may be significantly affected by the costs or benefits of the policy. Affected individuals may include who reside or work outside of the geographic area that is the target of the intervention, e.g., beyond the borders of the locality or country of concern. These external impacts are included in the analysis if significant. Analysts then report both the total costs and benefits of the intervention and the disaggregate results within and outside of the area of concern, to aid decision-makers in weighing these consequences. For example, both national and international impacts may be reported if significant.

The next two components often pose the greatest difficulties. Both involve prediction: baseline conditions in the case of Component 4 and policy responses in the case of Component 5. In each case, the goal is to be as realistic as possible.

Under Component 4, the analyses in this volume rely on a "without intervention" baseline. Analysts project future conditions in the absence of the interventions of concern, taking into account expected changes in the population, the economy, and other factors that may influence the effects of the intervention. Appendix C of this chapter identifies the data sources used for common variables of concern, such as current and future population and income levels.

Under Component 5, predicting the impacts of an intervention in comparison to this baseline can be very difficult. No intervention is likely to be 100 percent effective and many have consequences that may be unanticipated without careful investigation. It is important to distinguish between the initial action or requirement, subsequent events, and the ultimate outcomes or consequences. For example, if a program funds an informational campaign intended to improve health, the information will likely reach only a subset of the intended recipients, and only a portion of the recipients will likely change their behavior.

One challenge is ensuring that changes likely to occur under the baseline are not inappropriately attributed to the policy; another is exploring the causal pathway that links the policy to the outcomes of concern. Although randomized controlled trials (RCTs) are typically considered the preferred source for predicting policy impacts, they are not available for many interventions, often consider contexts and time horizons that differ in significant

respects from the context and time frame under consideration, and may only address a short time period or a subset of the outcomes of interest for the analysis.

Other options include quasi-experiments, which rely on data on differences between populations in which a policy has and has not been implemented. Quasi-experiments apply statistical methods to estimate likely policy impacts, controlling for other influencing factors. Observational studies are also often useful. Where data on likely impacts are limited or unavailable, approaches such as logic models that illustrate the (often hypothetical) chain of causes and effects may be useful.

The starting point for estimating policy impacts is often a systematic review, which may be supplemented by meta-analysis, expert elicitation, or other forms of research synthesis. Regardless, analysts must clearly report the data and calculations used to predict impacts and their limitations as well as the justification for the approach, and assess the impact of key uncertainties.

As described above, this fifth component focuses on the physical impacts of the policy; the expected number and types of individuals and organizations affected and the likely outcomes they will experience, including counts of expected deaths and cases of illnesses or injuries averted.

Component 6, estimate costs and benefits, involves monetary valuation of the impacts. The *Reference Case Guidelines* discuss the conceptual framework for valuation and the methods used in detail. Conventional BCA is based in economic-welfare theory, focusing on opportunity costs. This framing recognizes that devoting resources (e.g., labor and materials) to producing a particular set of goods and services means that fewer resources are available to invest in producing other things. To estimate the value of these opportunity costs, conventional BCA relies on the preferences of those affected. The idea is that each individual is the best or most legitimate judge of their own welfare; the approach respects individual autonomy and avoids being paternalistic.

Whether a consequence is categorized as a "cost" or "benefit" is arbitrary and varies across BCAs. As long as the sign is correct (positive or negative), the categorization of an impact as a cost or a benefit will not affect the estimate of net benefits. However, it will affect the comparability of benefit-cost ratios (BCRs) as well as total costs and total benefits across analysis.

Consistent with the *Reference Case Guidelines* and other guidance, in this volume we follow the same intuition that underlies a production function: costs are the inputs or investments needed to implement and operate the policy – including real resource expenditures such as labor and materials, regardless of whether these are incurred by government, private or nonprofit organizations, or individuals. Benefits are the outputs or outcomes of the policy, i.e., changes in factors that affect welfare such as reduced risk of death, illness, or injury.

Under this framework, counterbalancing effects are assigned to the same category as the impact they offset. For example, "costs" might include expenditures on improved technology as well as any cost-savings that result from its use; "benefits" might include the reduction in disease incidence as well as any offsetting risks. For example, chemicals used to remove contaminants from drinking water may lead to adverse reactions among some individuals.

The seventh component involves comparing costs and benefits. As part of this calculation, future-year impacts are discounted to reflect time preferences and the opportunity costs of investments made in different periods. This discounting reflects the general desire to receive benefits early and to defer costs, as discussed in more detail in Chapter 3 of the *Reference Case Guidelines*. The discounting approach used in this volume is discussed in the next section.

The principal summary measure in conventional BCA is net benefits (benefits minus costs). In this volume, we also report the BCR to provide additional insights and aid prioritization. However, these ratios are insensitive to the magnitude of the impacts; an intervention with small net benefits have a larger benefit-cost ratio than an intervention with very large net benefits. Thus these ratios are not sufficient for choosing which of several competing interventions to implement. Additional information on presenting and summarizing the results is provided in Chapter 9 of the *Reference Case Guidelines*.[5] The introductory section of this volume summarizes the results across the interventions assessed and discusses the implications.

The eighth component, estimate the distribution of impacts, is an essential supplement to the summary measures reported under Component 7. Understanding who gains and who losses is important to decision-makers and other stakeholders. Most texts and guidance documents, including the *Reference Case Guidelines*, recommend that, at minimum, analysts provide descriptive information on the distribution of the costs, benefits, and net benefits across advantaged and disadvantaged groups. However, this requirement is often ignored. In the next section, we provide more detailed guidance on estimating parameter values for specific analytic components, including distributional analysis.

4.0 Conventional BCA: Approach for Estimating Selected Parameter Values

While the 2019 *Reference Case Guidelines* provide the foundation for the approach to conventional BCA followed in this volume, some updates and adjustments were needed to tailor them to the DCP4 context. In this section, we discuss the approach for estimating key parameter values, focusing on those relevant to many of the analyses in this volume. The

[5] In addition to the guidelines in this chapter, the authors of the analyses contained in this volume were asked to use a common outline to present their analyses and a standard table to summarize the results, to ease comparison across analyses.

discussion is relatively brief, supplementing rather than repeating the *Reference Case Guidelines*.

This discussion is split into four sections. First, we discuss issues related largely to the timing and the location of the impacts, which are covered in more detail in Chapter 3 of the *Reference Case Guidelines.* These include determining the time frame covered by the analysis, adjusting values for inflation, converting values across currencies, and discounting to reflect time preferences.

Second, we discuss outcomes that typically require the use of nonmarket valuation methods, including valuing mortality risk reductions, valuing nonfatal risk reductions, and valuing changes in time use. These methods may also be needed to value impacts on the natural and constructed environment, as discussed in the context of specific interventions assessed later in this volume. The approaches for nonmarket valuation and for transferring values across contexts are discussed in more detail in Chapter 2 of the *Reference Case Guidelines*; values for specific outcomes are discussed in *Guidelines* Chapters 4, 5, and 6.

Third, we discuss estimating costs. Cost estimation is not discussed in detail in *the Reference Case Guidelines*. Instead we supplement the discussion in this chapter in Appendix A, which discusses costing in more detail. Fourth, we discuss estimating the distribution of the impacts. The *Reference Case Guidelines* provide a general overview of distributional analysis. Here we provide more detailed guidance. Appendix B provides a compendium of the equations used in estimating values; Appendix C provides the data sources used for common, cross-cutting parameter estimates.

4.1 Adjusting for differences in timing and currencies

Building on the discussion in Chapter 3 of the *Reference Case Guidelines*, below we describe the assumptions we use regarding the analytic time frame, inflation adjustments, currency conversions, and discounting to reflect time preferences.

Analytic time frame: In this volume, analysts use the year 2026 as the time when policy is first implemented and the costs and/or benefits of the intervention begin to accrue. For many if not most interventions, benefits lag behind costs, i.e., the beneficial consequences of costs incurred in year 1 may not begin to accrue until year 2 or later. Each analysis in this volume covers a long enough period for both its costs and benefits to fully manifest. For many policies, a 10-to-20-year time horizon suffices. Shorter periods are used if the policy is expected to end sooner or if the costs and benefits reach a steady state earlier rather than continuing to noticeably change over time. In a few cases, a longer time horizon is necessary, because the impacts of the intervention continue to change farther into the future.

The time horizon for assessing the intervention should not be confused with the time horizon for assessing the impact on an individual. For each year that the intervention is implemented, the analysis considers the lifetime consequences for those individuals affected in that year.

For example, several interventions reduce the risk of experiencing a chronic illness that has lifetime effects. The present value of these future effects is taken into account in estimating the value of reducing the incidence of new cases of that illness in each year.

Adjusting for inflation: In this volume, all monetary amounts are updated to 2024 values, using the inflation indices identified in Appendix B and the equations provided in Appendix C. Inflation refers to increases in prices throughout the economy. If there is inflation, the quantity of goods one can purchase per monetary unit (e.g., for $1.00) decreases over time. Conversely, deflation means that the amount one can buy increases. We use the term "currency year" rather than "base year" when discussing the treatment of inflation, to avoid confusion with the "base year" referenced when discussing discounting. Once monetary values are adjusted to currency year 2024, all estimates are reported in real terms, without consideration of future inflation.

Converting values across currencies: Currency conversations pose challenging issues in the context of this volume. Because the analyses are location-specific, one could argue that the local currency should be used to reflect conditions in that area. However, we also want to be able to compare across interventions, which argues for the use of a common currency. Two frequently used conversion methods for such comparisons are: (1) market exchange rates and (2) purchasing power parity. The first reflects market demand and supply for different currencies, often measured in U.S. dollars. The second is an index designed to represent what money can purchase in different economies, measured in international dollars. In the country of concern, an international dollar would buy a comparable quantity of goods and services as a U.S. dollar would buy in the United States.

As discussed in the *Reference Case Guidelines*, when values are transferred across countries, whether purchasing power parity or market exchange rates should be used depends on what is being valued. For benefit values estimated using nonmarket valuation methods as well as other inputs or outcomes that are not traded outside the local context, purchasing power parity should be used to convert values to the local currency. For market inputs that are traded outside the local context, market exchange rates should be used.

Total benefits and total costs should be converted from the local currency to internationally comparable units. To facilitate comparison to the results for analyses conducted in other contexts, total costs and total benefits also should be converted to U.S. dollars based on market exchange rates or to international dollars using purchasing power parity. In this volume, to ease comparison of the results across countries, we rely on purchasing-power parity for these conversions. The exchange rate and its source should be reported, so that the estimates can be easily converted into other currencies as needed.

When an analysis relies on cost or benefit values originally estimated in another currency in a prior time period, analysts must also determine how to sequence the inflation adjustments and the currency conversions. Because the sequencing of these calculations may affect the results,

in this volume analysts first inflate values in the original currency and then convert the resulting value into the target currency.

Discounting to reflect time preferences: Discounting allows comparison of real benefits and costs that accrue in different time periods. There are two interrelated reasons why values are not weighted equally over time. One is the opportunity cost of capital; money received now can be invested in exchange for receiving more money later; future obligations can hence be satisfied by investing a smaller amount of money now. The second reason is people generally prefer to receive benefits early and to pay costs later, which is part of the reason why interest rates are typically positive.

In this volume, each analysis begins by reporting the undiscounted costs, benefits, and net benefits that accrue each year, beginning in the year in which the intervention is first implemented (assumed to be 2026). These yearly impacts are illustrated in a bar chart or similar graphic. In addition to reporting data needed for subsequent calculations, this illustration aids decision-makers and other stakeholders in understanding the timing of the policy impacts.

To reflect the effects of timing, each analysis then presents both the net present value and the annualized value of the impacts. The net present value calculation coverts the values in every year to a corresponding present value in the base year (i.e., 2026), using a discount factor to reflect the impact of timing. The annualized value is the constant annual amount that has the same present value, if maintained for the same number of years as the initial stream of impacts. In other words, annualization spreads the costs, benefits, and net benefits equally over the time period, taking the discount rate into account. The underlying concepts and calculations are discussed in detail in Chapter 3 of the *Reference Case Guidelines*, the relevant equations are also included in Appendix B of this chapter.

The most difficult component of these calculations is determining the appropriate discount rate. Consistent with the overall BCA framework, these rates should reflect the preferences of the individuals affected. These preferences in turn reflect economic conditions, cultural characteristics, and other factors. This framing suggests that context specific discount rates are appropriate, estimated in this volume as a constant annual rate equal to 1 plus 1.4 times the projected near-term gross domestic product (GDP) per capita growth rate, based on Haacker, Hallett, and Atun (2020).[6] The authors also report their results using a common 5 percent discount rate, again based on Haacker, Hallett, and Atun (2020). Some authors explore the effects of alternate rates on their analytic results. For the subset of interventions assessed over time horizons greater than 30 years, the authors also consider the effects of using rates that decrease over time.

[6] This approach is discussed in more detail in the *Reference Case Guidelines* Chapter 3 and is often referenced as "Ramsey" discounting. Haacker, Hallett, and Atun (2020) update and refine the *Guidelines* estimates based on date from low- and middle-income countries.

4.2 Estimating nonmarket values

While many costs and some benefits can be valued using market prices, several outcomes require the use of nonmarket methods for valuation. As discussed in Chapter 2 of the *Reference Case Guidelines*, these methods include stated preference studies, revealed preference studies, and experiments. Stated preference studies typically employ survey techniques to ask respondents about their willingness to exchange income for the outcome of concern. Revealed preference studies rely on observed market behavior to estimate the value of related nonmarket goods, using statistical methods to separate the value of the outcome of concern (e.g., changes in morbidity risks) from other attributes (e.g., the time and discomfort associated with using safety equipment). Experiments combine aspects of both types of studies; the researcher controls the scenario but it may involve the exchange of real money for real (rather than hypothetical) goods or services. Each type of study has advantages and limitations. The value transfer framework (see *Guidelines* Chapter 2) is typically followed to assess available studies for quality and suitability and synthesize the results for application to the outcome of concern.

Below, we provide specific recommendations for selected outcomes assessed in this volume, focusing on those that are addressed in many, if not most, of the analyses. These methods may also be used to value other impacts, such as effects on the natural and constructed environment. Default values relevant to individual policy sectors are discussed later in this volume.

Valuing mortality risk reductions: Given the focus on improving public health, all of the interventions assessed in this volume aim at least in part to improve longevity, decreasing the risk of dying in each year. The value of these risk reductions is usually expressed as the value per statistical life (VSL). This terminology is widely misunderstood. VSL is *not* the value that the analyst, the government, or the individual places on saving an identified life with certainty. Instead, it reflects individuals' willingness to exchange their own money for a small change in their own risk, such as a 1 in 10,000 decrease in the chance of dying in a specific year. This individual willingness to pay (WTP) can be divided by the risk change to estimate VSL. To estimate the associated benefits, VSL is then multiplied by the expected reduction in the number of deaths each year attributable to the intervention.

As discussed in the *Reference Case Guidelines* as well as Robinson, Hammitt, and O'Keeffe (2018, 2019), ideally the value of mortality risk reductions is derived by evaluating and synthesizing multiple high-quality studies that address the population affected by the policy. However, few high-quality studies are available for low- and middle-income countries. Hence in this volume, the analyses rely on estimates extrapolated from U.S. values. U.S. studies of the value of mortality risk reductions are plentiful and have been extensively reviewed. In some cases, the authors of the analyses in this volume explore the sensitivity of their results to other estimates.

More specifically, the primary VSL estimates for the country of concern are extrapolated as follows.

1. **Base value:** The estimates start with a base U.S. ratio of VSL to gross national income (GNI) per capita based on purchasing power parity. The *Reference Case Guidelines* rely on a U.S. VSL-to-GNI per capita ratio of 160; inspection of updated U.S. estimates suggests that this ratio is still appropriate.[7]
2. **Income elasticity:** For the primary VSL estimate, an income elasticity of 1.5 is used to extrapolate from the U.S. to the target country, based on that country's estimated GNI per capita; see the *Reference Case Guidelines* and Appendices B and C for more details on these data and calculations.[8] The authors also report the results using a sensitivity analysis that relies on the same base value and an income elasticity of 1.0, given the substantial uncertainty associated with this extrapolation that results from the lack of empirical research.
3. **Income growth:** VSL estimates for the base year are adjusted for expected growth in real GNI per capita over time in the target country, using the same approach as in the base year and the data sources identified in Appendix C.

It is important to keep in mind that these estimates reflect the willingness of individuals in each country to exchange their own income for small changes in their own mortality risks in a defined period.[9] It seems nonsensical, if not impossible, for individuals in lower income economies to expend the same amount on these small risk changes as an individual in a high-income economy, given other essential needs. For example, the current U.S. VSL suggests that the average member of the population would spend over $1,000 for a 1 in 10,000 risk change in the current year, roughly 1.6 percent of their income. Yet total annual income for the average individual in low-income countries is often less than $1,000. Using the same VSL for these countries as for the U.S. implies that residents would spend all of their money to reduce their risks by this small amount.

For policies that disproportionately affect the very young or the very old, the authors also conduct sensitivity analyses using value per statistical life year (VSLY) estimates derived from the VSL estimates as a rough proxy. This constant VSLY is calculated by dividing the population-average VSL by undiscounted future life expectancy at the average age of the adult population in that country.[10] The analysts rely on the age that is equivalent to one-half

[7] For 2022, the U.S. Department of Health and Human Services (HHS) VSL estimate was $12.3 million in 2022 dollars (U.S. HHS 2021, 2023). The U.S. GNI per capita was $77,950 (The World Bank, "GNI per capita, PPP (current international $)," as viewed December 2023. https://data.worldbank.org/indicator/NY.GNP.PCAP.PP.CD.)

[8] If this approach yields a target country value of less than 20 times GNI per capita, then 20 times GNI per capita is instead used. Note that this approach is designed for application to low- and middle-income countries; smaller elasticities are likely appropriate when extrapolating across high-income countries. The elasticity is also dependent on the base VSL. A different elasticity may be appropriate if a different VSL is used as the starting point.

[9] Ferranna, Hammitt, and Robinson (2024) discusses alternatives that address the limitations of this approach.

[10] While it is common to discount future life expectancy at the same rate as applied to money values elsewhere in the analysis, we do not do so in this case. It is unclear whether such discounting is appropriate. Individuals may discount their own life years at a smaller rate; future life years also count less because the probability of

of life expectancy at birth to approximate this average age if needed. VSLY is then multiplied by the expected life year gain attributable to the policy. The result is that the value of risk reductions that accrue to young children are higher, and the value of risk reductions that accrue to the elderly are lower, than the value of risk reductions that accrue to an adult of average age. This sensitivity analysis is not needed if the average age of those affected is the same as the average for the population; in that case applying this VSLY approach would lead to the same result as applying the population-average VSL.

Many find the use of VSLY estimates appealing because they match the intuition that the value of mortality risk reductions should decrease as one ages, given that one has fewer expected remaining life years. However, it is not clear that this intuition is correct. The use of a constant VSLY is not consistent with empirical research or theory (see, for example, Robinson et al. 2021 and Hammitt 2023). Monetary measures reflect the trade-off between income, which tends to increase then decrease over the lifecycle, and mortality risk reductions – not simply the number of expected life years remaining. Hence in this volume VSLY is used only for sensitivity analysis.

Valuing nonfatal risk reductions: The conceptual framework and general approach for valuing nonfatal health risk reductions is the same as for valuing mortality risk reductions. The major challenge relates to the wide variety of illnesses and injuries that may be of interest, which differ significantly in severity, duration, and other characteristics. Studies of individual WTP are available for only a subset of these diverse risks, even in high-income countries.

When suitable WTP estimates of adequate quality are not available, analysts typically approximate these values using estimates of averted costs (often referred to as the cost of illness, COI) alone or in combination with estimates of the change in QALYs or DALYs valued in monetary terms.[11] In this volume, analysts use estimates of averted costs as a proxy when WTP estimates are not available. When the value of nonfatal risk reductions substantially influences the BCA results, authors may also explore the sensitivity of their results to the use of monetized QALYs or DALYs. More information on the application of these approaches is provided in Chapter 5 of the *Reference Case Guidelines*.

Valuing changes in time use: How individuals use their time, regardless of whether it involves paid or unpaid work or leisure, is often affected by policies that aim to improve health and longevity. Changes in time use may be categorized as either a cost or a benefit, depending on whether the change contributes to implementation of a policy (a cost) or is

remaining alive decreases with age. In addition, discounting flattens the relationship between the value of reducing risk and age, making it more similar to the alternative of using the same VSL for all ages. More generally, regardless of the discounting approach, assuming VSLY is constant provides only a rough proxy for the effects of age and life expectancy.

[11] WTP measures as well as the use of monetized QALYs or DALYs as proxies typically include costs paid by the individual, as well as the nonpecuniary effects of the risk change (e.g., reduced pain and suffering). Averted costs paid by third parties should hence be added to these measures to more fully account for the value of the risk change. See *Reference Case Guidelines* Chapter 5 for more discussion.

among its outcomes (a benefit). For market (paid) work time, compensation for similar individuals in similar occupations generally provides a reasonable estimate of these values, including compensation paid directly to the employee and any employer paid taxes and benefits.

As discussed in more detail in Chapter 6 of the *Reference Case Guidelines*, estimating these values can be difficult for some countries because of limited data availability and the prevalence of work outside the formal labor market; one potential source is the World Bank Living Standards Measurement Survey.[12] As for other parameter values, the data source used and related uncertainties should be reported along with the results.

For nonmarket work and leisure, data from nonmarket valuation studies are typically needed. In the absence of studies relevant to the policy context, estimates of compensation received by the worker (net of any taxes or employer paid benefits) provide the starting point for developing a range of values. In this volume, consistent with the recommendations in Chapter 6 of the *Reference Case Guidelines*, changes in nonmarket work and leisure time are valued using 50 percent of this compensation as a central estimate. If the value of nonmarket time significantly affects the estimates of net benefits, the authors may also examine the implications of sensitivity analysis using 25 percent and 75 percent of after-tax wages.

4.3 Estimating costs

The *Reference Case Guidelines* do not discuss the estimation of costs in detail, although the same general principles apply as when estimating benefits. Value is again based on the concept of opportunity costs; costs are incurred when resources (labor, materials, etc.) are used for one purpose and hence cannot be used for another purpose. Typically, market prices are used for costing with some exceptions. Note that in calculating net benefits, transfers between persons or groups that do not affect the total resources available to society do not necessarily need to be included. However, in this volume these transfers are estimated because they affect the results of the distributional analysis discussed below. More information on costing is provided in Appendix A.

4.4 Estimating the distribution of the impacts

Conventionally, BCA focuses on economic efficiency, comparing an intervention's costs and benefits to estimate its net effects. There is widespread agreement, however, that information on how impacts are distributed across disadvantaged and advantaged individuals is also needed to support sound decisions.

In this volume, to supplement the conventional BCA, analysts at minimum estimate the distribution of benefits, costs, and net benefits across income quintiles and age groups. Age in this case acts a rough proxy for baseline health and remaining life expectancy, both of which typically decline as one grows older. Some authors also consider other measures of relative

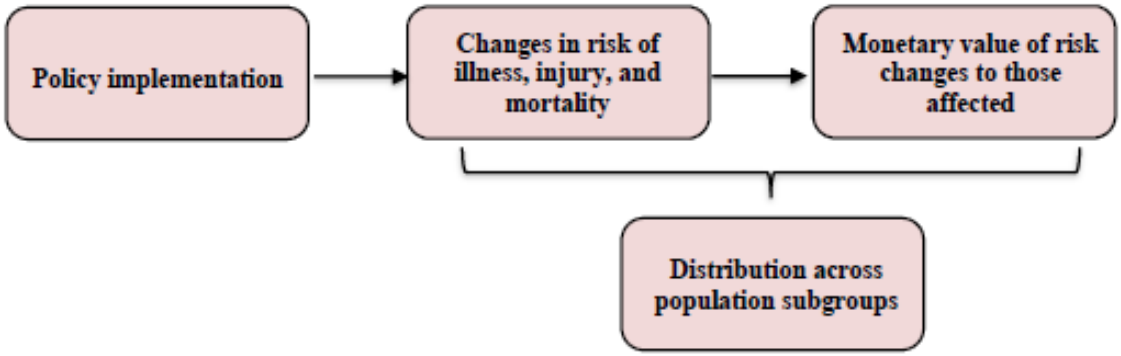
[12] See: https://www.worldbank.org/en/programs/lsms.

disadvantage that are particularly important in the context of the intervention being assessed. The results of the distributional analysis are reported as monetary values as well as in physical terms, i.e., as the expected number of individuals who accrue costs and/or benefits of various amounts.[13]

As discussed in more detail in Chapter 7 of the *Reference Case Guidelines*, this process is often less complicated for benefits than for costs. Figure 2 illustrates the process for benefits, using health outcomes as an example. A process similar to that illustrated in the figure is followed for other benefit categories.

[13] This section describes the approach to distributional analysis that accompanies the conventional BCA, relying on the same underlying conceptual framework. Approaches that go beyond this conventional framework, including social welfare analysis and alternatives, are discussed elsewhere in this volume.

Figure 2. Distribution of Health Benefits

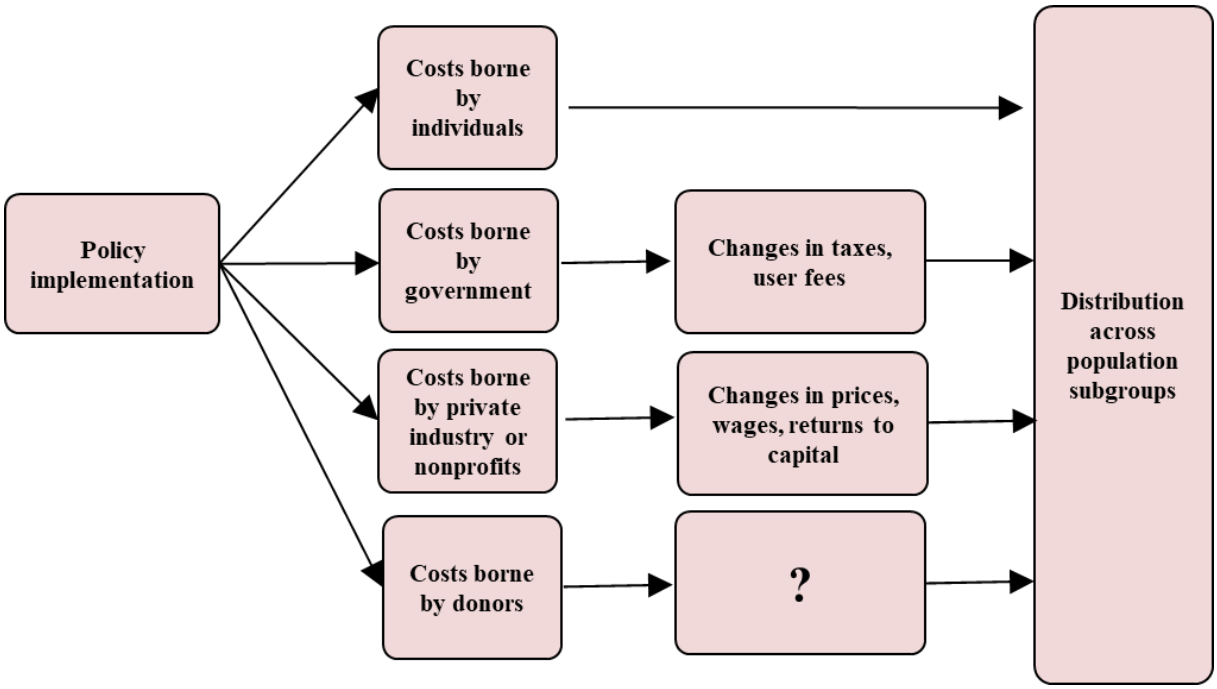


The research used to predict overall policy impacts (such as the risk assessment and disease modeling) may provide data on the distribution of the risk changes. Otherwise, analysts rely on other sources to develop assumptions and explore the implications of associated uncertainties. In the absence of more refined data, analysts at times simply assume that the change in risk is distributed evenly across the individuals affected and examine the implications of associated uncertainties. Once the expected number of averted statistical cases is estimated, the next step is to estimate the monetary value of these risk reductions. For fatal and nonfatal risks, the conventional BCA relies on population-average values. For the distributional analysis, these values are adjusted for the income levels of those affected. These subpopulation estimates rely on the same approach as the population-average values, but substitute subgroup income estimates for the population-average estimates.

In the case of costs (and off-setting savings, including transfers), analysts are typically interested in the effects of monetary expenditures on the disposable income of the groups of concern. If costs are borne directly by individuals, the main challenge is determining how the costs are distributed across those who belong to different groups. If costs are borne initially by the government, industry, donors, or other organizations, assessing the effects on individuals requires additional steps.

For government programs, the analyst first needs to estimate how the costs translate into changes in taxes or user fees or are otherwise financed, then estimate the incidence of these taxes or fees. For programs funded by nonprofit or for-profit organizations, the analyst must determine how costs are allocated among owners, workers, and consumers. This allocation will be affected by how the costs translate into changes in unit prices (which have both income and substitution effects on consumer expenditures), in wages paid to employees, and in returns to capital that accrue to owners. Costs paid by external donors (e.g., aid from foreign governments or foundations) raise other issues. In the short-term, donor-financed costs may have little or no direct impact on the income or wealth of members of the target population. However, the donor agency may be interested in estimating how these costs would be distributed if the policy were instead funded using in-country resources. Figure 3 illustrates this process.

Figure 3. Distribution of Costs



Often, organizations will finance the costs of the interventions through more than one pathway, for example, both raising prices and reducing wages in the case of a regulation affecting industry. It may be difficult to separate the effect of the intervention from the effects of other factors that influence an organization's operations. To continue the example, an industry may raise prices or decrease wages because of the combined effects of the regulation, other government policies, changes in the costs or availability of labor or materials, or changes in their market competition. In some cases, it is infeasible to estimate the distribution of costs given these complexities, and analysts use simple defaults, such as assuming costs are allocated equally across members of the affected population. In this case, careful exploration of the implications of uncertainty is essential.

Once costs and benefits are estimated for members of each group of concern, they are combined to determine the net effects. In this volume, the results are expressed as net benefits for each group of concern, supplemented by benefit-cost ratios.

5.0 Summary and Conclusions

The goal of the DCP4 project is to summarize, produce, and help translate economic evidence into better priority setting to improve health and longevity in low- and middle-income countries. This third volume considers interventions undertaken outside the health care system. Evaluating and prioritizing these interventions requires addressing three methodological challenges: (1) the effects of interventions differ across contexts, but it is not possible to assess every intervention in every possible context; (2) consistent methods are needed so that differences in methods do not obscure differences in impacts; and (3) while

conventional BCA provides a well-established and widely used conceptual framework for economic evaluation, it does not address concerns about distributional equity.

The previous sections of this chapter address these challenges, first discussing the approach for addressing the effects of context, then summarizing guidance on the consistent application of conventional BCA, including addressing the distribution of impacts using the conventional framework. Supplemental analyses using innovative approaches to assess individual and societal welfare, including distributional equity, are discussed elsewhere in this volume. The key recommendations in this chapter are summarized in Figure 4 below.

Figure 4. Summary of Key Guidelines

Comparability Across Contexts (Section 2.0)
• Analyses address implementation of interventions within a particular context, and discuss likely effects of implementation in other contexts.
General Approach (Section 3.0)
• Analyses address those problems and policies most likely to lead to substantial improvements in health and longevity as well as overall welfare (net benefits).
• Analyses are conducted from a societal perspective, including impacts on all those who may be significantly affected by the costs or benefits of the policy.
• The predicted baseline is as realistic as possible, reflecting without intervention conditions over the time horizon considered in the analysis.
• The predicted impacts of the intervention are as realistic as possible, reflecting careful assessment of the available evidence on the causal links to the policy.
• Impacts are categorized as costs if they relate to the implementation of the policy; impacts are categorized as benefits if they relate to the outcomes of the policy.
• The results are summarized as net benefits and as benefit-cost ratios, accompanied by assessment of the implications of uncertainties and non-quantified effects.
• The analyses also report physical measures of impacts (number of organizations and individuals affected, expected deaths, injuries or illnesses averted, etc.)
• The distribution of costs, benefits, and net benefits across advantaged and disadvantaged groups are also estimated.
Approach for Parameter Values (Section 4.0)
• The time horizon for the analysis assumes implementation will begin in 2026 and extends until costs and benefits fully manifest (typically 10 to 20 years in the future).
• All monetary values are adjusted for inflation to the year 2024, and not inflated further.
• All monetary values are converted to international dollars based on purchasing power parity.
• Analytic results are reported undiscounted as well as discounted using (i) a country specific rate of 1+1.4*GDP per capita growth and (ii) a common rate of 5 percent; declining rates are used in cases where the time horizon exceeds 30 years. Sensitivity analyses using alternative rates are reported at the discretion of the authors.
• The values of mortality risk reductions are estimated using a base U.S. VSL of 160 times GNI per capita and income elasticities of 1.5 and of 1.0. Sensitivity analyses using alternative values are reported at the discretion of the authors.
• The values of nonfatal risk reductions are estimated based on WTP studies if applicable high-quality studies are available; otherwise, these values are estimated based on averted costs. Sensitivity analyses using monetized QALYs or DALYs are reported at the discretion of the authors.
• Changes in time use are valued using data on total compensation for market (paid) work time, and 50 percent of earnings for nonmarket time and leisure, with sensitivity analysis when the value of this time significantly affects the analytic results.
• Costs are estimated based on market prices, with adjustment if needed to more accurately reflect opportunity costs. Transfers are included in the estimates, to support the distributional analysis.
• The distribution of costs, benefits, and net benefits across advantaged and disadvantaged groups is estimated, at minimum considering the distribution across income quintiles and across age groups.

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Appendix A: Estimating Costs

The *Reference Case Guidelines for Benefit-Cost Analysis in Global Health and Development* (Robinson et al. 2019) provide the foundation for the guidance contained in the main text of this chapter. However, the 2019 *Guidelines* do not discuss costing in detail. Hence this appendix provides supplementary guidance on estimating costs. It focuses on crosscutting concepts and best practices applicable to many, if not all, of the interventions assessed in this volume. Costs specific to particular types of interventions are discussed in the sections that address each policy sector.

As noted in the main text, in this volume we define costs as including the inputs or investments needed to implement and operate a policy – including real resource expenditures such as labor and materials, regardless of whether they are incurred by the government, private or nonprofit organizations, or individuals. Benefits are the outputs or outcomes of the policy, such as the reduced risk of death, illness, or injury. Within this framework, counterbalancing effects are assigned to the same category as the impact they offset. For example, "costs" might include expenditures on improved technology as well as any cost-savings that result from its use.

A.1 Conceptual Framework

The framework for estimating costs is based on the same fundamental concepts as the framework for estimating benefits. Costs are derived from the value of foregone opportunities; once a resource is used to implement a policy, it cannot be used for another purpose. The value of a resource is based on its best, or most welfare-enhancing, alternative use. In other words, the analysis aims to estimate the full social costs associated with the intervention.

This definition differs from the concept of accounting costs (i.e., actual expenses plus depreciation of capital equipment). It includes the use of all resources regardless of whether they are accompanied by a monetary transaction. For example, the cost of volunteer (unpaid) labor is estimated by the opportunity costs associated with the use of that time, as discussed in the main text of this chapter as well as in more detail in *Guidelines* Chapter 6.

In many cases, market prices can be used for costing. In these cases, market prices are simply multiplied by the quantity of the goods or services used to implement and operate the policy. There are two major exceptions to this practice, however. The first is when market prices are either non-existent (as in the case of unpaid labor) or do not accurately account for the effects of resource use on societal welfare. For example, the effects of pollution emissions on welfare are typically not incorporated into market prices. Externalities such as these are considered if they will be significantly affected by a policy; for example, if the policy is likely to increase the production and hence emissions from polluting industries. In such cases, nonmarket valuation methods are needed, as summarized in the main text of this chapter and discussed in more detail in *Guidelines* Chapter 2. Alternatively, market prices may be smaller

than social costs when goods are subsidized, as is sometimes true for food and fuel. The second major exception is if a policy is likely to lead to significant changes in market prices. In this case, partial or general equilibrium models may be used to estimate the effect on supply and demand in the associated market, as discussed later in this appendix.

Finally, in conventional benefit-cost analysis (BCA), transfers need not necessarily be considered as long as they do not lead to behavioral changes. Transfers are monetary payments between persons or groups that do not affect the total resources available to society. They are a benefit to recipients and a cost to payers, with zero net effect. For example, some types of taxes, fees, and surcharges can be categorized as transfer payments. However, transfers are essential to the analysis of distributional impacts, so are included in the analyses in this volume.

As discussed in *Guidelines* Chapter 2 as well as the main text of this chapter, enacting an intervention does not necessarily mean it will be enforced or will alter behavior in the way expected. Therefore, before estimating costs, analysts should first consider the extent to which the intervention is likely to lead to behavioral change, if at all. They should also consider whether the intervention is likely to lead to unintended consequences, such as an increase in the use of informal channels to circumvent the intervention. Analysts must take care to ensure that they do not attribute costs to the intervention that would be incurred in the absence of the policy. For example, if a community expects to install latrines regardless of whether a particular sanitation policy is implemented, the costs of those latrines should not be attributed to the policy.

A.2 Approaches for Estimating Costs

We first review two methodologies for estimating costs when an intervention does not affect market supply and demand conditions: micro-costing and gross-costing. We then address the use of partial or general equilibrium models when market conditions are affected. We conclude by discussing two additional issues: the treatment of transfers and marginal excess tax burden.

A.2.1 Estimating Costs

Typically, costs include some that are fixed and some that are variable over the short- or longer-run. Fixed costs do not depend on the quantity of goods or services provided, such as those associated with renting property or paying the salaries of individuals involved in overhead functions rather than in directly providing services. In the near term, it may not be possible to adjust these costs, although they may be more flexible in the longer term. Variable costs depend on quantity, e.g., on the number of beneficiaries. For example, the costs of providing nutritional supplements depends on how many people are served.

Costs can also be subdivided into capital or operations and maintenance costs. Capital costs generally refer to those associated with purchasing equipment, acquiring buildings or land, and other inputs that are not immediately consumed in the process of producing a good or

providing services. Operations and maintenance costs include those associated with labor, materials, and other resources required to operate and maintain capital equipment and to provide the products or services.

Costs may be estimated using micro-costing or gross-costing approaches, which vary primarily in terms of the level of aggregation. Which approach is most appropriate depends on the nature of the intervention and the extent to which data of each type are available.

Micro-costing involves listing and costing every input used to deliver a good or service.[14] The process starts with the detailed identification of all resources required for implementation, such as the amount and types of paid personnel, equipment, utilities, infrastructure, volunteer time, and travel. Unit costs are assigned to each input based on market prices or nonmarket valuation. The total cost of the intervention is estimated as the sum of the inputs multiplied by their unit costs.

Data for micro-costing studies can come from a variety of sources. Information about the inputs required for an intervention can be obtained from operating procedure manuals, direct observation, passive data collection devices, or interviewing those implementing the policy. Unit cost data can be obtained from purchase catalogues, historical accounting and administrative data, surveys, or personal transaction diaries. When using historical program expenditures, care is required to translate accounting information into data relevant for the costing exercise. Accounting information is not always categorized in a way that is useful for economic evaluation of individual interventions. For example, costs that may be distinct from an analytical perspective, such as wages for frontline staff and wages for management, both may be included in the "wages" category for accounting purposes. Accounting protocols also include non-cash items such as depreciation that require careful consideration when estimating opportunity costs for the purpose of economic evaluation.

Gross-costing involves estimating the costs of an intervention using information that is not highly disaggregated, such as summing totals for high-level accounting categories like wages, infrastructure, and equipment. In the *ex-ante* analyses that are the focus of this volume, gross-costing involves taking a unit cost from a previous costing exercise of the same or similar intervention and transferring that value to the new context. For example, an analyst might estimate the cost of a road at $200,000 per km. Applying that value to a proposed road that is 50 km long generates a cost estimate of 50 km*$200,000 = $10,000,000. This example assumes that the cost per unit is constant.

However, the cost function may be more complex. In many cases it is more appropriate to assume some form of fixed or upfront cost plus a variable cost. This pattern is often seen in programs that seek to change behavior including promotion campaigns, enforcement

[14] Micro-costing is sometimes referred to as ingredients-based costing. Activity-based costing is a particular type of micro-costing where an intervention's costs are categorized by distinct activities that comprise the complete intervention.

campaigns, or subsidies, such as a community-led total sanitation program that encourages the construction of toilets, or a conditional-cash transfer program that encourages school enrollment. In these examples the program might have an upfront cost that is fixed regardless of the number of people served, or fixed once the target population is set. However, the response to the program influences subsequent costs in a variable manner. In this case, an analyst needs estimates of the fixed cost and the variable cost (per unit), and also of the response rate for the intervention.

Another complexity is the need to account for economies or diseconomies of scale. In some cases, it is reasonable to assume that unit costs change as coverage increases. If there are synergies in implementation, unit costs fall with increasing coverage. If there are diminishing marginal returns, unit costs rise with increasing coverage. Cost functions can include both phenomena, for example, they may be 'S' shaped.

Analyst judgement is required when using any value transfer approach.[15] Costs may vary substantially depending on context. It is often useful to survey the literature and identify multiple estimates, carefully assessing which most closely represent the implementation scenario under consideration. A cost function that formally and quantitatively accounts for differing characteristics of each implementation context might be useful and more accurate. For example, such a function might be developed by using a meta-analytic approach.

Moreover, even when the analyst is satisfied that a unit cost or cost function is relevant for the analytical context, care must be taken when transferring estimates because there might be differences in the reporting of costs across studies. Some common reporting differences that require adjustment include:

- Differences in units, e.g., cost per beneficiary vs. cost per household. Costs must be converted to the same unit as the analytical context before being adopted.
- Differences in currency or year or both. Costs must be converted to the same currency and inflated to the same year using the approaches discussed in Chapter 3 of the *Guidelines* as summarized in the main text of this chapter.
- Differences in discount rate. If the timing of the costs was reported, the analyst can re-estimate costs using the discount rate applied in this volume (see main text of this chapter as well as *Guidelines* Chapter 3.) If not, it may not be possible to precisely estimate costs by transferring values across studies.

Regardless of which approach is used, changes in real costs need to be projected into the future, over the time horizon covered by the analysis. In some cases, data are available on the likely trend in those costs; in other cases, analysts need to carefully evaluate and explain how they estimate the extent to which costs will change over time.

[15] See the discussion of value transfer in Chapter 2 of the *Guidelines* for more information on the factors to consider when relying on estimates from other studies.

A.2.2 Accounting for Market Impacts

The preceding section assumes that the intervention will not significantly affect the overall quantity of goods produced or market prices. If this assumption does not hold, partial or general equilibrium modeling may be needed to more precisely estimate social costs.[16] These models address responses to price changes, i.e., changes in consumer and producer surplus. Consumer surplus is the benefit that consumers receive when they are able to purchase products for less than the maximum they are willing to pay; producer surplus is the difference between the revenue producers receive and their cost of production. When an intervention increases production costs, the market price is likely to increase, inducing consumers to reduce their consumption and producers to reduce production. The cost of the intervention includes both the direct costs and the "deadweight loss" associated with the reduction in output; however, this deadweight loss is often small enough to be ignored.[17]

When an intervention affects a single market or a small number of unconnected markets, partial equilibrium analysis provides a useful tool for estimating welfare changes. Analysts use information about the quantity and price of goods produced without the intervention, the costs of the intervention, and elasticities of supply and demand to estimate the equilibrium output with the intervention and the resulting net changes in consumer and producer surplus. At times, the effects of the intervention may be large enough to affect multiple, interconnected markets, the national economy, or the regional or international economy. In this case, general equilibrium analysis is often used to estimate impacts. General equilibrium models are complex and generally require a significant amount of data and substantial expertise.

A.2.3 Treatment of Transfers

As introduced above, transfers are the movements of resources between parties, such as cash payments, that do not affect the overall resources available to society nor impact the net benefits of an intervention. However, transfers may influence behavior or have additional implications for health and welfare. These impacts on behavior are often the primary motivation for interventions that involve transfers.

It is important to explicitly report the size of a transfer and the parties involved for two reasons. The first is to support distributional analysis, which requires a clear accounting of who bears the costs and who receives the benefits of an intervention (see main text and *Guidelines* Chapter 7). The second is to aid government decision-making, given that the ability of governments to raise taxes or borrow is constrained. A cash transfer program drawn from the government's budget, or from donors or lenders, likely diverts funds that otherwise would be used for other purposes.

A.2.4 Marginal Cost of Taxation

[16] These approaches are discussed in more detail in many texts and guidance documents, such as Boardman et al. (2018).
[17] For a more detailed overview and discussion of consumer and producer surplus, see Appendix B of HHS (2016).

When taxes are raised to finance an intervention, they have distortionary effects on resource allocation that may be important in some cases. For example, taxes on wages provide a disincentive for working and may lead more people to stay out of the labor force. These distortionary effects result in a deadweight loss, i.e., a loss to society that results from inefficient market operations. At times, analysts explicitly include the marginal cost of taxation when estimating the impacts of raising money for a government program. This is usually assessed as a percentage mark up on costs per dollar of investment.

This approach is often not feasible for low- and middle-income countries when data limitations preclude adequate estimation of this marginal cost. Decisions about whether to include these costs need to be made on a case-by-case basis. If included, analysts should separately report costs with and without the adjustment, to ease comparison with other interventions funded by taxation.

This adjustment primarily relates to spending resources to implement an intervention that provides goods or services. Governments may also impose taxes on specific goods and services to influence behavior, such as increasing taxes on tobacco. These interventions generate costs as well as benefits for members of society that are considered, even if the government budget impact is minimal.

Appendix B: Equation Compendium

See Section 4 of the main text as well as the 2019 *Reference Case Guidelines* for more information on these variables and calculations.

1. Adjusting for inflation and converting currencies

$$\text{Target value}_{\text{currency year}} = \text{reference value}_{\text{original year}} * (1 + \text{cumulative inflation}_{\text{reference country}}) * \text{currency conversion rate}_{\text{currency year}}$$

(equation 1)

Note: Cumulative inflation is the inflation between the original year and the currency year. 1 + cumulative inflation is equal to the product of (1 + annual inflation rate) for each year between the original year and the currency year. When an index is used to adjust for inflation, the formula is: Cumulative inflation = $(\text{index}_{\text{year b}} / \text{index}_{\text{year a}})$

2. Discounting for time preferences

If:

- V = value in year (0)
- FVt = future value in the year (t) when the benefit or cost accrues
- NPV = net present value in the base year (year 0) of benefits and costs combined across all time periods
- r = the discount rate
- t = the number of years in the future (measured from the base year) when the cost or benefit accrues
- n = the number of years included in the analysis

Then the discount factor for costs or benefits that accrue in year t is: $1/(1+r)^t$

The present value of a future cost or benefit that accrues in year t is: $PV = FV(1/(1+r)^t)$

The net present value for a stream of future benefits and costs is:

$$NPV = V + (FV_{t=1} /(1+r)) + (FV_{t=2} /(1+r)^2) + (FV_{t=3} /(1+r)^3) \ldots (FV_{t=n} /(1+r)^n)$$

(equation 2)

3. Valuing changes in mortality risks

$$VSL_{\text{target}} = VSL_{\text{reference}} \times (\text{Income}_{\text{target}} / \text{Income}_{\text{reference}})^{\text{elasticity}}$$

(equation 3)

$$VSLY_{\text{target}} = VSL_{\text{target}}/LE_{\text{average age}}$$

(equation 4)

4. Valuing changes in nonfatal risks

$$\text{Preferred approach: } \text{Value}_{\text{per case}} = \text{WTP}_{\text{case}} + \text{Averted costs}_{\text{third parties}} \quad \text{(equation 5)}$$

$$\text{Default proxy: } \text{Value}_{\text{per case}} = \text{Averted costs}_{\text{individual+third parties}} \quad \text{(equation 6)}$$

$$\text{Sensitivity analysis: } \text{Value}_{\text{per case}} = (\text{VSLY}_{\text{target}} \times \text{DALYs}) + \text{Averted costs}_{\text{third parties}} \quad \text{(equation 7)}$$

5. Valuing market and nonmarket time

$$\text{Value}_{\text{market time}} = \text{Compensation}_{\text{employee}} + \text{Fringe benefits}_{\text{employer paid}} + \text{Taxes}_{\text{employer paid}} \quad \text{(equation 8)}$$

$$\text{Value}_{\text{nonmarket time}} = \text{Compensation}_{\text{employee}} \times \text{Adjustment}_{\text{factor}} \quad \text{(equation 9)}$$

Note: Employer fringe benefits and taxes may be zero in some settings, e.g., for work outside of the formal labor market.

Appendix C: Data Sources for Common Socio-Economic Variables[18]

To ensure comparability, the benefit-cost analyses included in this volume require use of consistent data sources and methods to the extent feasible. In this appendix, we list the data sources used for cross-cutting parameters applicable to most analyses. Data sources related to specific policy sectors or interventions were selected by the subject matter experts conducting those analysis and are referenced in the relevant chapter.

These cross-cutting parameters, along with the sources used for historical time series and future projections, are presented below. We selected these sources because they are well-established and widely used, provide internally consistent estimates across countries, and cover most if not all low- and middle-income countries over time. The project team provided analysts with spreadsheets that report these data for all years and all countries covered by the analyses included in this volume.

Note to reviewers: The table reflects data available as of February 2024, which for most parameters are through 2022. Hence the table assumes that all analyses will be conducted in 2022 dollars. We expect to update this table to reflect 2023 data once they are available. In most analyses, impacts are projected 10 or 20 years into the future, with some exceptions as discussed in the main text and in Chapter 3 of the *Reference Case Guidelines for Benefit-Cost Analysis in Global Health* (Robinson et al. 2019).

Table A.1. Sources for cross-cutting data elements

Parameter [a]	Historical data (through 2022)	Future projections (2023 onwards)[b]
GNI (current US$ or Int$)	WDI database: • Current US$: https://data.worldbank.org/indicator/NY.GNP.MKTP.CD • Current Int$: https://data.worldbank.org/indicator/NY.GNP.MKTP.PP.CD	N/A
GNI (constant 2022 US$ or Int$)	Calculated from WDI data using GDP deflator[c] • GNI in constant 2015 US$ (https://data.worldbank.org/indicator/NY.GDP.MKTP.KD) • GNI in constant 2017 Int$ (https://data.worldbank.org/indicator/NY.GNP.PCAP.PP.KD)[c]	• Time series derived from implied growth rates from SSP2 "middle-of-the-road scenario." • International Institute for Applied Systems Analysis[d] https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=welcome
GNI per capita (Current US$ or Int$)	WDI database: • Current US$: https://data.worldbank.org/indicator/NY.GNP.PCAP.KD • Current Int$: https://data.worldbank.org/indicator/NY.GNP.PCAP.PP.CD	N/A
GNI per capita (constant 2022 US$ or Int$)	Calculated from WDI using GDP deflator[c]	GNI in constant 2022$ divided by projected population

[18] We thank William Garcia (University of Washington) for helping to draft this appendix.

Parameter [a]	Historical data (through 2022)	Future projections (2023 onwards)[b]
	• GNI per capita in constant 2015 US$: https://data.worldbank.org/indicator/NY.GNP.PCAP.KD • GNI per capita in constant 2017 INT$: https://data.worldbank.org/indicator/NY.GNP.PCAP.PP.KD	
Inflation[c]	WDI database. • Consumer Price Index (2010=100), https://data.worldbank.org/indicator/FP.CPI.TOTL • GDP deflator, base year varies by country https://data.worldbank.org/indicator/NY.GDP.DEFL.ZS	N/A[b]
Population	UNWPP 2022: https://population.un.org/wpp/Download/Standard/Population/	UNWPP 2022: https://population.un.org/wpp/Download/Standard/Population/
Life Expectancy	UNWPP 2022: https://population.un.org/wpp/Download/Standard/Mortality/	UNWPP 2022:[f] https://population.un.org/wpp/Download/Standard/Mortality/
Exchange rates	WDI database: • Local currency unit per US$: https://data.worldbank.org/indicator/PA.NUS.FCRF • PPP conversion factors, GDP (Int$) https://data.worldbank.org/indicator/PA.NUS.PPP	N/A[g]

Abbreviations
N/A = not applicable.
GNI = gross national income
GDP = gross domestic product
Int$ = international dollars
PPP = purchasing power parity
SSP2 = Shared Socioeconomic Pathways 2 (2016 revision, Delink et al. 2017)
UNWPP = United Nations World Population Prospects
US$ = U.S. dollars
WDI = World Development Indicators (https://databank.worldbank.org/source/world-development-indicators)

Notes
a. See *Guidelines* Chapter 3 for more discussion of Int$ and US$.
b. All values are adjusted for inflation and real changes to a common currency year (2022). Values for future years are adjusted only for real changes in value, not for predicted inflation.
c. See *Guidelines* Chapter 3 for more discussion of the use of CPI and GDP deflators to estimate inflation.
d. SSP2 provides projected real GDP for every country at 5 year-intervals. We apply cubic splines to split 5-year GDP projected levels into yearly values from 2020 to 2100 and calculate yearly growth rates from yearly GDP levels. Annual growth rates are applied to 2022 GNI for future projections.
e. The projected growth rates are applied to the last year of available data in the historical series to project a time series of GNI in constant 2022 dollars.
f. Future population and life expectancy projections for 2023-2100 are available for different fertility scenarios. We adopt the medium-variant scenario.
g. All values are converted to 2022 Int$ using the methods outlined in *Guidelines* Chapter 3. Future projections are then estimated in Int$.