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METHODOLOGICAL APPROACHES FOR COST–EFFECTIVENESS AND COST–UTILITY ANALYSIS OF INJURY PREVENTION MEASURES

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Methodological approaches for cost–effectiveness and cost–utility analysis of injury prevention measures

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ABSTRACT

Economic evaluation plays an increasing role in prioritising the implementation of the treatment and prevention of both unintentional and intentional injuries. Policy-makers and decision-makers generally need information about the effectiveness of an intervention in relation to its costs to assess whether an intervention provides good value for money. A review of the literature has shown that few methodologically robust and comparable studies have been undertaken in the field of injury prevention. This document has been written to provide step-wise guidance on the use of standardized methods to conduct cost-effectiveness and cost-utility analyses on injury prevention interventions, thereby contributing to a larger body of such evidence. The added value of this guide is that it links general guidelines on economic evaluation studies to a step-by-step guide for performing economic evaluation studies of injury prevention interventions. It focuses on the specifics of health outcomes and costs in injury prevention. It is hoped that the framework provided in this document will assist public health experts, researchers and policy-makers who are interested in estimating the cost–effectiveness and cost–utility of injury prevention programmes. The use of this document will hopefully contribute to increasing the evidence base of economic evaluations of injury prevention programmes in the European Region.

Keywords

Injury – economics

Injuries – prevention and control

Violence – Prevention and control

Costs – effectiveness and utility analysis

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Contents

Abbreviations

DALY	Disability-Adjusted Life-Year
ICD	International Classification of Diseases
QALY	Quality-Adjusted Life-Year
WHO	World Health Organization
WHO-CHOICE	WHO project on providing cost–effectiveness information: Choosing Interventions that are Cost–Effective

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Executive summary

Since the problem of injuries is great and heterogeneous and since resources are scarce, methods are needed for making optimal choices in policies to prevent injuries. Economic evaluation studies give insight into the potential changes in costs and population health resulting from a specific intervention or a combination of interventions. In many countries, economic evaluation plays a role in decision-making on reimbursement or the implementation of a specific intervention. Policy-makers and decision-makers generally need information about the effectiveness of an intervention in relation to its costs to assess whether an intervention provides good value for money.

The usefulness and quality of future economic evaluation studies on preventing injury may be largely expanded by developing an extensive common core of basic methodological choices that will make these studies more supportive in choosing between alternative interventions. Efforts to sort out some of the finer methodological challenges in both the cost and effectiveness elements of studies economically evaluating injury prevention interventions will lead to more uniformity in reporting. Examples include using a common perspective (societal perspective), common cost categories in all analyses, standardized measurement of health effects and discounting, which facilitates comparison between interventions. Further, reporting of the methods applied and data collection should be more transparent. In addition, using methods in accordance with the methods used for other public health issues would enhance the value of economic evaluation studies for injury prevention measures. This would enable policy-makers to base their decisions on objective information to maximize the effectiveness of their injury prevention policy in terms of health outcomes and efficient allocation of resources. Only then can economic evaluation be used for setting priorities: comparing with other public health issues and comparing within the domain of injuries.

The overall aim of this WHO project is to provide step-wise guidance according to standardized methods to contribute an increased evidence base of cost–effectiveness and cost–utility interventions for preventing injury. The added value of this guide is that it links general guidelines on economic evaluation studies to a step-by-step guide for performing economic evaluation studies of injury prevention interventions in particular. It therefore zooms in on the specifics on health outcomes and costs in injury prevention.

The report provides a general framework for public health experts, policy-makers and researchers interested in conducting studies that can estimate the economic burden of injuries. It is intended to assist countries in estimating the cost–effectiveness and cost–utility of injury prevention programmes. It is hoped that this guidance will support a growing number of scientific analyses of the economic effects of injuries and, ultimately, result in additional prevention programmes and lives saved.

This guidance has six main stages:

1. defining the study design (conceptual model)
2. estimating the health effects of the intervention
3. estimating the costs of the intervention
4. calculating the incremental cost–effectiveness ratio
5. analysing data and adjusting for timing and uncertainty
6. reporting the results of cost–effectiveness and cost–utility analysis.

1. Introduction

1.1 Background

Injury has been widely recognized as a major public health problem and is the leading cause of death and illness among children in high-income countries (1,2). In addition, it is the leading cause of disability throughout the world, with great numbers of people having physical, mental and functional limitations as a result of their injuries (3,4). The operational definition of physical injury is based on the WHO definition: the damage caused by the acute transfer of energy, whether physical, thermal, chemical or radiant, that exceeds the physiological threshold or by the deprivation of a vital element (5). Injuries can be unintentional, such as those caused by road traffic injuries, burns or scalds, falls, poisoning and drowning or submersion, or they can be intentional. Intentional injuries can be caused by violence, which is the intentional threat or use of physical force against oneself, another person or community that results in injury, death, mental harm, maldevelopment or deprivation. Injury is related to many diverse causes and social activities, such as transport, work, violence, recreation and sports and the home situation. Violence can be interpersonal (intimate partner violence, youth violence, child maltreatment or elder abuse), self-directed (suicide or self-harm) or collective (war).

The injury problem is large and heterogeneous (6,7) regarding external causes, type of injury, severity, age patterns and opportunities for prevention. Injuries range from frequent minor injuries such as superficial injuries) to rare major injuries (such as polytrauma). As a consequence, injuries result in a wide array of individual patterns of use of health services and functional outcome. Choices must be made in setting priorities for injury prevention and allocating scarce resources between alternative uses (8). For example, should more resources be allocated to programmes for preventing falls among older people, programmes for promoting water safety among children or programmes for preventing violence among adolescents? Within preventing falls, should more resources be allocated to reducing the current rate of falls by screening the older people who have fallen and visit the emergency department (high-risk population) or to providing an information campaign for everyone older than, for example, 55 years (low-risk population). Methods are therefore needed for making the most optimal choices in injury prevention policies.

An injury prevention measure can lead not only to avoiding injury, disability, death and associated health care costs but also to reducing property damage, loss of productivity and the pain and suffering resulting from injuries (9). Decision-makers want to know whether injury prevention interventions are worth implementing and whether the benefits from already implemented interventions have been worth their costs (9).

During the first phase of the project, a literature review was performed to assess the quality and comparability of economic evaluation studies on injury prevention measures (Polinder S et al. Systematic review and quality assessment of economic evaluation studies of injury prevention interventions. Submitted) (10). This literature search gave an overview of the results of the economic evaluation of injury prevention measures and of current methods used to economically evaluate injury prevention.

The review concluded that cost–effectiveness studies on injury prevention measures differ greatly in method, especially how they measure and valuate the economic and health effects of injuries. The lack of a common core of basic methodological choices currently limits the comparability of studies, even studies on the same injury prevention programme. The interpretation and comparability of the economic evaluation studies reviewed is further hampered because the perspective of the analysis, the intervention being analysed, the target population, the time horizon and the assumptions used in developing any models are often not clearly defined.

1.2 Rationale for estimating the cost–effectiveness of injury prevention measures

Economic evaluation comparatively analyses the costs and effects of two or more alternative interventions (11). The primary aim of health economic evaluation studies is evaluate the outcomes and costs of interventions designed to improve health. In addition, they can play a key role in setting priorities for injuries compared with other public health issues and compared within the domain of injuries. This will guide policy-makers in making decisions based on objective information to maximize the cost–effectiveness of their injury prevention policy in health outcome per monetary unit spent (11). The cost–effectiveness of interventions increasingly needs to be demonstrated, and this needs to be considered in formulating and implementing handbooks with guidelines for practice (11–13). Decision-makers generally recognize the usefulness and need for published economic evaluations. Nevertheless, the actual use and knowledge of economic analysis are limited in injury prevention.

Setting priorities in the heterogeneous field of injury prevention urgently requires economic evaluation studies according to a state-of-the-art method. Improving the quality and comparability of economic evaluation studies in injury prevention makes them more useful in supporting choices between alternative interventions. Further, the use of economic evaluation studies for injury prevention measures will gain value if the methods are in accordance with the methods used for other public health issues. Developing and applying harmonization procedures that enable improvements in methods and enhanced comparability of economic evaluation studies in injury prevention are therefore strongly recommended. This publication presents a methodological approach for conducting economic evaluation studies on injury prevention measures.

1.3 Aim and objectives

This guidance on cost–effectiveness and cost–utility analysis of injury prevention measures aims to support countries in the WHO European Region in conducting cost–effectiveness analysis on injury prevention measures using a standardized methodological framework and to make the results of countries' economic evaluation studies as comparable as possible.

The overall aim of this project is to provide step-wise guidance according to standardized methods to contribute to increasing the evidence base on cost–effectiveness interventions for injury prevention.

This publication provides a simple set of guiding principles for estimating the cost–effectiveness of injury prevention measures. The guidance is practical and presented using a step-by-step approach. Given the data limitations most countries face, the publication identifies a minimum set of data required to produce general estimates of cost–effectiveness. In some settings, obtaining even the minimum set of data may require creative and innovative solutions.

What is the added value of this publication for economic evaluation studies specific to injury prevention measures? This publication links general guidelines on economic evaluation studies to a step-by-step guide for measuring the cost–effectiveness and cost–utility analysis of injury prevention measures in particular.

People with injuries differ from people with other diseases, since the severity varies substantially. Injuries therefore result in a wide array of individual patterns of use of health services and functional outcome. The guidance for estimating the costs and effects of the intervention is therefore particularly based on earlier European projects on injury aimed at developing standardized methods of quantifying costs and disability effects resulting from injuries in Europe: EUROCOST (14), APOLLO (15) and INTEGRIS (16). Box 1.1 briefly describes these European projects.

Box 1.1. The EUROCOST, APOLLO and INTEGRIS projects

EUROCOST: a surveillance-based assessment of the medical costs of injury in Europe (2000–2004) *(17)*

The aim of the EUROCOST project was to enhance the effective use of current European and national injury surveillance systems for policy-making by adding information on the medical costs of injury. The objectives were to harmonize the available data on injury incidence and related use of health care in all participating countries, to estimate the medical costs of injury using a uniform method in those countries and to explore the causes of international differences.

This project developed a uniform method to calculate the direct medical costs of injury and applied it to 10 European Union (EU) countries. This method enabled the medical costs of injury to be calculated by sex, age, external cause and type of injury for each country and the EU as a whole. Moreover, due to several harmonization procedures, meaningful international comparisons of injury incidence and costs can be made. Further, the medical costs of injury at the EU level were estimated.

APOLLO Work Package 2.1: economic consequences of injury (2005–2008) ***(18,19)***

Within the Burden of Injuries Work Package of the APOLLO project on strategies and best practices for reducing injuries, the methods developed in the EUROCOST project were used to support EU countries in calculating the direct health care costs of injury by developing a manual, guidelines and web tools.

An instrument to calculate the direct health care costs of injury was developed to be implemented with the most common standardized hospital-based data sets in the EU, the hospital discharge data (for all injuries) based on the International Classification of Diseases (ICD) and the EU Injury Database data based on the International Classification of External Causes of Injury (emergency department data for home and leisure injuries). The web tools were developed to analyse, harmonize, aggregate and merge hospital-based data for the calculation of direct health care costs. A manual with guidelines explains the methods for analysing hospital-based surveillance data and describes the collection, harmonization and analysis of data on injury incidence and related use of health care and costs.

Finally, the project provided information about the indirect costs of injury. Guidelines on calculating productivity costs due to injuries were developed, and basic data requirements for estimating lost productivity were described.

INTEGRIS Work Package 5: injury disability indicators (2008–2009) ***(20)***

The major goal of Work Package 5 of the INTEGRIS project was to produce a state-of-the-art report on how to assess the disability component of the burden of injury and to propose a method for linking existing injury-related disability information to the INTEGRIS data set. The first aim, the theoretical framework, was to make an inventory of available methods for assessing the disability component of the burden of injury, specifying the data needed (the incidence and prevalence of injury and disability weights and duration). The second aim was to review applications at the international and/or country level to assess the disability component of the burden of injury (evaluation of best practices). The final aim was to complete tables with injury-specific disability weights that can be applied to the INTEGRIS incidence data set. Further, an overview was presented of currently available disability weights for injury consequences that were derived with panel studies.

The guidelines for the study design, analysis of data and reporting of cost–effectiveness and cost–utility analysis results are embedded in existing guidelines, such as *Making choices in health: the WHO guide to cost–effectiveness analysis (12) and the Manual for estimating the economic costs of injuries due to interpersonal and self-directed violence (21)*. This report was especially written to help countries to maximize insight into the costs and effectiveness of injury prevention measures for injury-specific public health problems.

The report provides a general framework for public health experts and researchers interested in conducting studies that can estimate the economic burden of injuries. The primary target audience of this report includes public health agencies, policy-makers and researchers specializing in injury prevention. The guidance should especially provide a general framework for injury prevention experts and researchers working at local, national and international institutions such as city health councils, national public health institutions and focal points for violence and injury prevention. It is hoped that this guidance will support a growing number of scientific analyses of the economic effects of injuries and ultimately result in additional prevention programmes and lives saved.

2. General concepts and conceptual framework

2.1 Injury

The first issue is defining injury. This is not a trivial issue, as Langley & Brenner demonstrated recently *(22)*. Even if the injury is detected through a health care setting, the definition of injury, classifications and inclusion criteria can differ. An international scientific debate is taking place about several methodological data issues related to determining the incidence of injury *(22–27)*. The operational definition of physical injury is based on the WHO definition, defined as relatively sudden discernible effects due to body tissue damage from energy exchanges or ingestion of toxic substances but not due to medical adverse events, and obtained from health care settings *(28)*. This is equivalent to ICD-9 external causes E800–E999, excluding E870–E876, E878–E879, E930–E949, and ICD-10 codes V01–Y98 minus Y40–Y89.

An injury is the damage caused by the acute transfer of energy, whether physical, thermal, chemical or radiant, that exceeds the physiological threshold or deprives the body of a vital element *(5)*. Injuries can be unintentional, such as those caused by road traffic, burns or scalds, falls, poisoning and drowning or submersion, or they can be intentional. Intentional injuries can be caused by violence, which is the intentional threat or use of physical force against oneself or another person or community that results in injury, death, mental harm, maldevelopment or deprivation. Violence can be interpersonal (intimate partner violence, youth violence, child maltreatment or elder abuse), self-directed (suicide or self-harm) or collective (war). Injuries can range from frequent minor injuries (such as superficial injuries) to rare major injuries (polytrauma). Injuries thus result in a wide array of individual patterns of use of health services and functional outcome. This heterogeneity puts specific demands on data sources for measuring and valuating the incidence, functional outcome and costs of injury in a national and international context.

The leading causes of injury death in the WHO European Region are self-directed violence, road traffic injuries, poisoning, interpersonal violence, drowning, falls and thermal injuries. The pattern for non-fatal injuries varies somewhat, and the leading cases are home and leisure injuries, road traffic injuries, self-directed violence and poisoning.

2.2 Injury prevention measures

Injuries are prevented through interventions aimed at breaking the chain of events that lead to an injury *(8)*. Injury prevention aims to reduce the incidence of injuries and their severity and thereby their costs. Prevention strategies or interventions can be classified as primary, secondary or tertiary prevention.

Primary prevention involves interventions aimed at preventing the likelihood of disease and injury. It also includes interventions that reduce the likelihood and severity of a disease or injury, such as alcohol control and regulation of motorcycle helmet use.

Secondary prevention involves interventions that can provide early detection of a disease and thereby provide early treatment and a better prognosis, such as diagnostic procedures at an emergency department.

Tertiary prevention involves suitable interventions to reduce the likelihood of disability and prolonged sequelae from the disease or injury, such as increasing the efficiency of the emergency department in a hospital.

2.3 Economic evaluation

The primary aim of economic evaluation studies is to evaluate the outcomes and costs of interventions, such as interventions designed to improve health. Economic evaluation comparatively analyses the costs and effects of two or more interventions *(11)*. Generally, a new intervention is compared with usual health care, which can be the standard intervention or no intervention at all. The outcome of economic evaluation is expressed as a ratio of costs (C) in relation to effects (E):

$$\frac{C_{new} - C_{usual\ health\ care}}{E_{new} - E_{usual\ health\ care}}$$

This ratio is called the incremental cost–effectiveness ratio: the difference in costs between the new and the old intervention is divided by the difference in effects between the new and old intervention.

There are four forms of economic evaluation of interventions: cost–minimization analysis, cost–effectiveness analysis, cost–utility analysis and cost–benefit analysis *(11)*. Table 2.1 summarizes the characteristics of the different types of economic evaluation, which are described in more detail below.

Table 2.1. Characteristics of the different types of economic evaluation

Method	Costs	Effects	Evaluation question
Cost–effectiveness analysis	Monetary units	Natural units (life-years gained, burns prevented, etc.)	Comparisons of interventions with same objective
Cost–utility analysis	Monetary units	Utility and QALYs or DALYs	Comparison of interventions with different objectives
Cost–benefit analysis	Monetary units	Monetary units	Are the benefits worth the costs?
Cost–minimization analysis	Monetary units	The effects are not measured, since they are considered to be equal	Least-cost comparisons of programmes with the same outcome

2.3.1 Cost–effectiveness analysis

Cost–effectiveness analysis expresses the effects of interventions in naturally occurring units, such as deaths, illnesses or burns prevented, and the costs of these interventions in monetary units. Cost–effectiveness analysis aims to provide information about the relative efficiency of alternative interventions that serve the same goal. The outcome of such analysis is a ratio that reproduces cost differences in relation to differences in the effectiveness of this intervention compared with other interventions that serve the same goal *(11)*. Thus, studies that describe cost–effectiveness analysis need to contain effect outcomes and the costs of intervention and should compare these to the costs and effects of alternatives that serve the same goal. Cost–effectiveness analysis is the most straightforward type of economic evaluation to account for differences in outcome.

The main advantage of cost–effectiveness analysis is that measuring benefits in natural units simplifies the analysis and is often more intuitive for users of the study. The disadvantages are the inability to compare efficiency assessments across interventions that produce different outcomes and the need to focus on a single outcome of an intervention even when an intervention generates several distinct benefits *(29)*.

2.3.2 Cost–benefit analysis

Only cost–benefit analysis can formally determine how much more or how much less of society's resources should be allocated to pursuing a goal. Cost–benefit analysis expresses the costs and benefits of an intervention in monetary units. The outcome can be reported in two ways: as net monetary gain or loss or as a ratio of benefits and costs. Cost–benefit analysis aims, like cost–effectiveness analysis, to directly compare diverse interventions *(30)*. Thus, studies that describe cost–benefit analysis need to contain the monetary effect outcomes of an intervention and the monetary costs of an intervention and should compare these to the benefits and costs of alternative interventions.

The main practical problem with cost–benefit analysis is valuating benefits, such as saving lives or relieving pain, in money units.

Cost–benefit analysis can incorporate the widest range of effects across the widest range of interventions and programmes (both inside and outside the health sector) but is often controversial because it requires valuating the benefits, including death and disease, in monetary terms *(29)*.

2.3.3 Cost–utility analysis

Cost–utility analysis is a form of cost–effectiveness analysis to calculate the cost per unit of utility (units that relate to a person's well-being). The most commonly used units of utility are quality-adjusted life-years (QALY) and disability-adjusted life-years (DALY). The outcome measure of cost–utility analysis is a ratio that represents the number of QALYs or DALYs gained as a result of the intervention and the cost in monetary units of this intervention *(11,31)*. Like all types of economic analysis, cost–utility analysis aims at comparing the intervention with other types of intervention. Thus, a study that describes cost–utility analysis needs to include cost in monetary units and utility in units (such as QALYs) and should compare the cost utility of an intervention to other interventions. Cost–utility analysis can be used to decide the best way of spending a given treatment budget or the health care budget as a whole. Cost–utility analysis is therefore broader than cost–effectiveness analysis but is a variant of that approach. Compared with cost–effectiveness analysis, a key disadvantage is the considerable increase in the complexity of assessing outcomes.

2.3.4 Cost–minimization analysis

Cost–minimization analysis is performed when the health effects of the alternatives are known or assumed to be equal. In this case, the decision simply revolves around the costs. Only the costs need to be analysed, and the least costly alternative is the most efficient. However, few interventions are actually equally effective. Evidence must be available to support the claim that outcomes are the same.

Cost–minimization analysis has limited use because it can only compare alternatives with the same outcomes *(32)*. Further, cost–minimization analysis is rarely an appropriate method of analysis even when sampled data on costs and effects are available *(33)*. The methods used in cost–minimization analysis are therefore not explained further here.

2.4 General concept: settings versus types of injury

Calculating the costs and effects of injury prevention programmes requires using data on both the nature of the injury and the mechanism or external cause. The use of health care and the disability resulting from specific injuries defined by external causes (such as road crashes and unintentional falls) depend on the types of injury they cause. Unintentional falls, for example, may result in head injuries, hip fractures and other injuries. These three types of injury, all caused by falls, have different economic and health effects. A multifaceted programme for preventing falls will reduce all three types of injuries, whereas hip protectors will only reduce the number of hip fractures and may even lead to increases in other types of injuries.

The setting and the type of injury are not competing but are both part of one integrated approach. A prerequisite for conducting cost–effectiveness and cost–utility analysis of injury prevention measures is using data sets on the incidence of injury that contain information on both the external causes (such as falls, violence or road crashes) and diagnostic information on the type and anatomical location of the resulting injuries. An incidence-based approach should therefore be used for cost–effectiveness and cost–utility analysis, and costs and health effects should be calculated by type of injury. However, data sets with information on both the external cause and type of injury can be used to calculate and report the cost–effectiveness of programmes targeting specific external causes (such as the cost–effectiveness of programmes for preventing falls).

2.5 Conceptual framework – guidance

The conceptual framework of the guidance outlines the basic data requirements and calculations necessary to estimate the cost–effectiveness of injury prevention measures. Cost–effectiveness and cost–utility analysis of injury prevention measures starts from an injury-specific public health problem and a set of proposed preventive interventions. The cost and effectiveness of each of these alternative solutions are estimated, and the results for each potential solution are compared. The conceptual framework in Table 2.2 outlines crucial stages of analysis and steps to be taken for such an analysis.

Table 2.2. Conceptual framework: step-by-step guide for economic evaluation studies by main stage of analysis

Main stages of analysis	Steps to be taken
1. Study design	**1.1. Define the intervention, target population and injury population**
	1.2. Choose the form of economic evaluation
	1.3. Choose the perspective
	1.4. Define the implementation period and time horizon
	1.5. Choose primary or secondary data
	1.6. Primary data – choose data sources
	1.7. Differentiate cases by injury diagnosis
2. Estimating effects	**Cost–effectiveness analysis**
	2.1. Choose natural units
	2.2. Obtain data
	Cost–utility analysis – calculating DALYs
	2.1. Choose incidence data
	2.2. Choose an anatomical classification system
	2.3. Determine the proportion of short-term and lifelong effects
	2.4. Choose a set of disability weights
	2.5. Obtain mortality data
	2.6. Calculate the number of DALYs
	Cost–benefit analysis
	2.1. Choose monetary units
3. Estimating costs	**3.1. Identify the minimum data requirements**
	3.2. Measure the use of health care and other services
	3.3. Collect cost data
	3.4. Calculate costs
4. Incremental cost–effectiveness ratio	**4.1. Calculate the incremental cost–effectiveness ratio**
5. Adjusting for timing and uncertainty	**5.1. Discount costs and health effects**
	5.2. Perform sensitivity analysis

	5.3. Perform (probabilistic) uncertainty analysis
6. Reporting results	**6.1. Report the cost information**
	6.2. Report the effectiveness information
	6.3. Report the uncertainty results
	6.4. Report the incremental cost–effectiveness ratio

Based on the degree of specificity of the available data, however, researchers may wish to refine their cost–effectiveness and cost–utility analysis. The minimum data requirements outlined in Table 2.2 should therefore be used as a flexible framework allowing for further investigation and analysis if the data permit.

3. Study design

3.1 Introduction

Before undertaking an economic evaluation study, the analyst must decide on an overall approach to the study and on specific aspects of the study design. The early conceptualization and planning steps are essential for focusing the study on relevant research questions *(13)*. A conceptual model should be developed that describes the intervention and how it affects health outcomes. The model essentially describes the course of events with the intervention compared with the absence of the intervention. Further, the analyst must determine how to collect the data on costs and health effects. The tasks required for this step vary greatly depending on whether and to what extent the analysis will collect primary data, use existing data (such as performing secondary analysis on data from administrative databases or published reports) or estimate parameters using mathematical models. Finally, the analyst must develop the analytical methods to combine the information appropriately into cost–effectiveness and cost–utility analysis. Table 3.1 presents a step-by-step guide for defining the study design.

Table 3.1. Step-by-step guide for study design

STAGE 1. STUDY DESIGN	
Steps to be taken	**Modular approach**
1.1. Define the intervention, target population and injury problem	Always
1.2. Choose the type of economic evaluation	Cost–effectiveness analysis or cost–utility analysis
	Cost–benefit analysis
	Cost–minimization analysis (not in this guidance)
1.3. Choose the perspective	Societal
	Health care or insurance or individual
1.4. Define the implementation period and the time horizon for analysis	Long enough to capture all costs and effects
	Shorter time period
1.5. Choose primary or secondary data	Primary: randomized controlled trials
	Secondary: literature or existing databases
1.6. Primary data – choose data sources	
	Hospital discharge and emergency department data
	Health interview surveys, mortality data, etc.
1.7. Differentiate cases by injury diagnosis	39 injury groups (EUROCOST)
	Subsets of categories, alternative categories

3.2 Conceptual model of the study

The conceptual model serves as a guide to conducing economic evaluation analysis. Aspects of the conceptual model will affect the analyst's range of choice of input to the economic evaluation analysis and, to some extent, the methods for conducting the analysis. The conceptual model outlines the full range of events stemming from the intervention. Because it guides the analysis, it should be considered in great detail, including costs and effects at all levels of importance.

Step 1.1: define the intervention, target population and injury definition used

First of all, the research question being addressed should be clearly stated. The intervention must therefore be described accurately using all information that is essential to interpret the estimated costs and benefits *(12)*.

The definition of an intervention should include information on the setting where the intervention is delivered or undertaken (such as primary, secondary or tertiary prevention); the target population covered by the intervention; the time frame of the cost and effect data included; the extent of coverage of the target population; and any other important information.

The target population is the population for whom the programme is intended. Depending on the programme, this may be individuals of a given age and sex, living in a particular region, having a specific disease or having a certain risk profile or groups defined by combinations of these characteristics. The target population can dramatically affect the cost–effectiveness of an intervention.

Further, the definition of injury used should be clearly stated. There are many definitions of injury. The definition used clearly affects the number and type of disease conditions included and thereby the resulting burden of injury obtained.

Step 1.2: choose a type of economic evaluation

Before undertaking analysis, the analyst should determine the type or types of analysis that will best illuminate the subject of the study. Many forms of information can contribute to deciding whether to perform cost–effectiveness analysis, cost–utility analysis, cost–benefit analysis or cost–minimization analysis.

Step 1.3: choose a perspective

Economic evaluation can be undertaken from several perspectives. The broadest is the comprehensive societal perspective, which incorporates all costs and all health effects regardless of who incurs the costs and who obtains the effects. Other perspectives that can be used in economic evaluation include those of the public sector, the health care institution, the third-party payer and the individual person and his or her family *(13)*. The perspective for the analysis should be explicitly stated and justified.

The choice of the study perspective is an important methodological decision because it determines what costs and effects to count and how to valuate them. The appropriate perspective depends on the objective of the study. For studies addressing the broad allocation of resources, the societal perspective is recommended. The societal perspective includes all health care costs, social service costs, spillover costs on other social sectors such as education and costs paid for by individuals and their families *(13)*. This perspective assures that the analysis includes all resource costs, even when shifted among hospitals, insurers, individual users of health care and other parties – as is often the case in health care.

Decision-makers dealing with choices affecting organizations or specific interest groups may often wish to conduct economic evaluation from the narrower viewpoint of the entity of interest. Fortunately, performing economic evaluation from one perspective does not preclude using other perspectives as well. The preferred approach when a specific viewpoint is needed (such as that of a health care organization or the health care users and their families) is to conduct the economic evaluation and present the results both from the broad societal perspective and from the narrower perspective relating to the particular interests of the actor.

Step 1.4: define the implementation period and the time horizon for analysis

Many interventions have costs and benefits extending over several years. The time horizon over which costs and benefits are considered should be given. When possible, the time horizon should be long enough to capture all the differential effects of the options. This means that the costs and health effects related to the intervention should be followed for the duration of the lifetime of the beneficiaries.

3.3 Data

Step 1.5: choose primary and secondary data

As part of designing the economic evaluation study, analysts must decide what types of data to include in the analysis. Analysts can collect primary data on costs, effects and health status. Secondary data obtained from studies in the literature, from databases or from other sources of existing data can be used instead of primary data or in addition to them.

Ideally, data on the costs and effects of an intervention should both be collected using the same properly designed primary study. The most common and preferred primary research design is a randomized controlled trial. Relevant information on health-related quality of life, preferences for states of health and loss of time can be collected along with data on costs and effectiveness.

However, this ideal is frequently not feasible for economic evaluation. When a primary study is not possible, costs and effectiveness data can be gathered from separate primary or secondary sources.

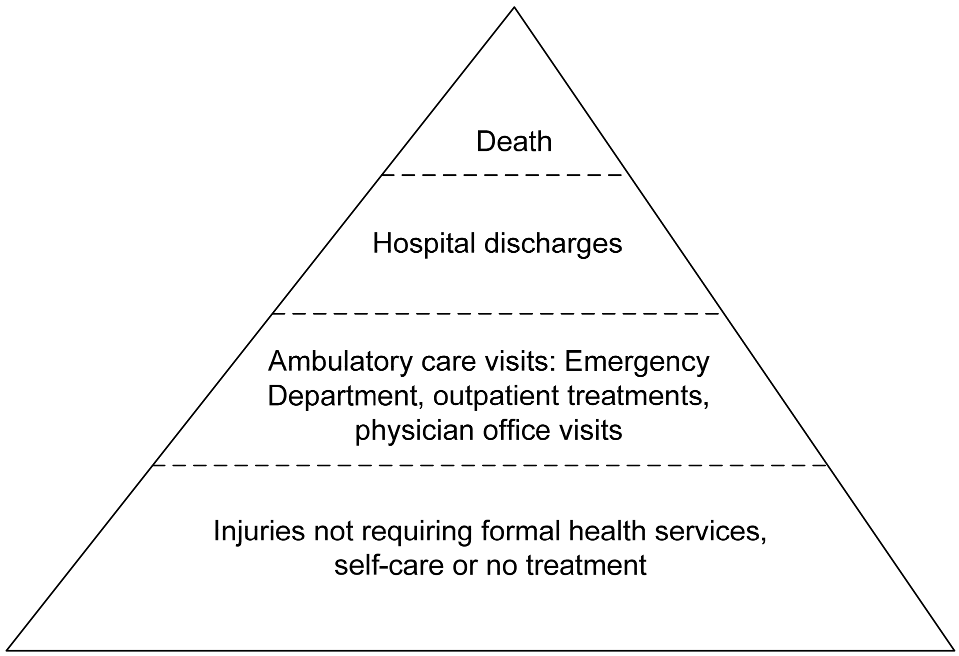
When data are gathered from separate sources, analysts generally rely on decision models to combine the information into a structure based on the conceptual model.

Decision modelling has been defined as a systematic approach to decision-making under uncertainty. In the context of economic evaluation, a decision analytical model uses mathematical relationships to define a series of possible effects that would flow from a set of alternative options being evaluated. Based on the input into the model, the likelihood of each effect is expressed in terms of probabilities, and each effect has a cost and an outcome. The expected cost and expected outcome of each option being evaluated can thus be calculated. For a given option, the expected cost (outcome) is the sum of the costs (outcomes) of each effect weighted by the probability of that effect. *Decision modelling for health economic evaluation (34)* has more information about decision modelling.

Step 1.6: find data sources (select injury cases)

Several data sources can be used for the collecting and estimating costs and effects. The incidence of injury is most often derived from hospital data systems. Routinely collected hospital-based injury incidence data are available at the national, subnational and local levels. They can be distinguished into emergency department–based injury surveillance systems, hospital discharge registries and trauma centre or trauma network registries. From the perspective of causal and comparative research, hospital-based incidence data have several limitations *(28,35,36)*. Hospital-based data on the incidence of injury, however, are very useful for quantifying the economic or health burden of a disease or type of injury at the population level *(37–39)*. Nevertheless, hospital-based incidence data do not cover all injuries in the population, as reflected by the surveillance pyramid (Fig. 3.1). This surveillance pyramid is hypothetical and does not necessarily reflect the distribution of the proportions of injuries between the different levels. Theoretically, one initial decision in studies quantifying disability at the population level is which sources of incidence data are to be used: thus, which level or levels of the surveillance pyramid will be considered.

Fig. 3.1. Surveillance pyramid for the effects of injuries



Hospital discharge data and emergency department data are recommended for selecting injury cases, since the patient and injury characteristics required to assess the costs and the disability component of injuries are well documented among these data systems.

This section further stresses the importance of sound epidemiological data on both injury incidence and injury effects that have to be linked in calculating the burden of injury.

Injury incidence data are difficult to interpret and even more difficult to compare between countries with vastly different health care administrations. A comprehensive flow diagram for injury occurrence and acute health care was produced to give insight into the health care use of people with injuries. This is shown in Annex 1, with points indicating where incident cases could theoretically be captured in emergency departments, hospital discharge registries and mortality statistics.

The recent guidelines on conducting community surveys on injuries and violence produced by WHO shows clearly how variation in content, coverage, classification, definition and coding between countries means that current surveys cannot be compared "unless standardized definitions and survey methods are used" *(40)*. In addition, breaking down costs by anatomical injury requires common systems of injury classification, but these are rarely found in self-completed survey data. Consequently, coded injury data from administrative systems in each country are preferred.

In surveys, severity is often defined based on attending health care for the injury, usually carried out by a physician, or a period of restricted activity. Neither of these is a reliably objective measure of severity. There is growing literature on the effect of non-injury factors on attendance at an emergency department or admission to hospital.

The diagram shows the complexity of the patient flows and how these might affect injury registration at the three levels (emergency department, hospital discharge registries and mortality statistics). Information on all flows is not necessary for each study. Nevertheless, considering whether each type of patient flow exists is crucial to interpreting cost–effectiveness.

3.3.1 Injury incidence data

Calculating the costs and effects of injury prevention programmes requires using data on both the type or nature of the injury and the mechanism of the injury or external cause. The use of health care and disability resulting from specific injury mechanisms or external causes (such as road crashes or unintentional falls) depends on the types of injuries they cause. Unintentional falls, for example, may result in head injuries, hip fractures and other injuries. These three types of injuries, all caused by falls, have different economic and health effects. A multifaceted programme for preventing falls will reduce all three types of injuries, whereas hip protectors will only reduce the number of hip fractures and may even lead to increases in other injuries. Costs and health effects should therefore be calculated by type of injury in the cost–effectiveness and cost–utility analysis. In conclusion, the setting and the type of injury are not competing but are part of one integrated approach *(41)*.

One approach to determining the incidence of injury is to measure the lifetime cost–effectiveness of injury prevention measures that occurred during a specific period, such as one year; this is an incidence-based approach. Using this bottom-up approach typically requires counting all new injuries that occurred during a year and estimating the costs and effects of these injuries during that year and beyond. Lifetime estimates are generally derived from counts of new injury-related deaths and injuries seen at hospitals and emergency departments within a specified period, although the same technique could also be applied to all existing injuries, both old and new.

Another approach is to estimate the costs and effects of injuries for a given period, typically a year, regardless of when the injuries first occurred. This approach is called the prevalence-based approach. These estimates usually rely on a top-down approach by determining, for example, the proportion of annual budgets and expenditure that can be attributed to injuries.

The choice of approach depends on the economic question the study sets out to answer. Further, most countries' injury surveillance systems record incidence data more accurately than prevalence data, especially in identifying the cause of injury and intent. For these reasons, adopting a bottom-up approach that assesses the incidence of injury within a specific period of one year and the associated lifetime economic effects is recommended.

Step 1.7: differentiate cases by injury diagnosis (anatomical classification)

Anatomically classifying the injury by location and type is a key variable in calculating the nonfatal burden of injury. Functional effects of injury, both temporary and permanent, vary greatly depending on the location and types of injury. The literature has consistently shown that injuries to the head, spine and lower extremities have the greatest effect on health-related quality of life *(39,42–45)*. Moreover, the type of injury highly influences the patterns of effects and recovery. Within the group of people with injuries to the lower extremities, for example, people with fractures (and hip fractures in particular) have more severe effects than people with other types of injuries *(39,43,46)*.

The location and types of injury are better predictors of functional effects than systems for rating injury severity (such as the Abbreviated Injury Severity Scale and Injury Severity Score) that were developed for predicting mortality risk. Many studies have shown the association between the Abbreviated Injury Severity Scale or Injury Severity Score and functional effects to be lacking or weak *(42,44,47)*. This means that a classification system used for linking hospital-based incidence data to functional effects preferably includes both the injury location and the types of injury.

3.3.2 Existing types of anatomical classification by location and type of injury

Economic evaluation studies of specific well-defined interventions require disaggregating incidence data by injury group *(21)*. Breaking down the types of treatment required by type of injury sheds further light on the types of injury that incur the highest cost–effectiveness. This can help policy-makers and practitioners set priorities by identifying specific areas where targeted interventions could be implemented.

There are several anatomical classification systems. This section presents the ICD, the Barell Injury Diagnosis Matrix and the EUROCOST groups as examples of anatomical injury group classification systems.

3.3.2.1 International Classification of Diseases

The ICD is the international standard diagnostic classification for all general epidemiological and many health management purposes and clinical use. It is used to classify diseases and other health problems recorded on many types of health and vital records, including death certificates and health records. In addition to enabling the storage and retrieval of diagnostic information for clinical, epidemiological and quality purposes, these records also provide the basis for compiling national mortality and morbidity statistics. The ICD-10 has 22 chapters, including a chapter on injury and poisoning and other external causes, which provides very detailed information on injury diagnoses by location and type of injury *(48)*.

The full ICD cannot be used for linking incidence and disability data, since there are no empirical data on injury-related disability by ICD code. However, the ICD coding is more valid than EU Injury Database–specific injury coding *(49)*.

3.3.2.2 Barell Injury Diagnosis Matrix

The Barell Injury Diagnosis Matrix, Classification by Body Region and Nature of the Injury (50) is a product of the International Collaborative Effort on Injury Statistics. The Matrix is based on data coded according to the ICD-9 Clinical Modification and not on data directly obtained from injured people. *Injury Prevention* published a complete discussion of the Matrix, including guidelines for use and data analysis (51). The Matrix has three levels of anatomical location that distinguish 5, 9 and 36 separate injury locations, respectively. Injury at each location can be assigned a type in the following 12 categories: fracture, dislocation, sprains and strains, internal injury, open wound, amputations, blood vessels, contusion or superficial, crush, burns, nerves and unspecified.

In principle, the Matrix is promising for linking incidence and disability data. However, the Matrix has not yet been used in studies obtaining data on injury-related disability. Linking injury-related disability with the cells of the Matrix will therefore be difficult and possible to a limited extent only. In addition, due to lack of detailed information, the Matrix is difficult to use for classifying injuries in emergency department surveillance systems.

3.3.2.3 EUROCOST injury diagnosis classification scheme

The EUROCOST model offers a third potentially useful injury grouping by location and type. The EUROCOST classification *(17)* was originally developed to define a set of homogeneous patient groups from the perspective of health care use. Nevertheless, it has been successfully implemented in two European studies assessing both the costs and health burden of injuries *(38,39)*. Annex 2 *(14)* identifies 39 injury groups that are then regrouped into 10 broader categories (see Table 3.2). A major advantage is related to its use in both patient follow-up studies and in panel studies to assess injury-related disability. For this reason, incidence and disability data can largely be linked when using the EUROCOST model. Further, the EUROCOST classification can easily be operationalized in both the EU Injury Database and hospital discharge registration systems *(28)*. Table 3.3 gives an example of the use of the EUROCOST groups for calculating the costs of injury-related hospital admissions in Europe *(28)*.

Table 3.2. Major injury groups in the EUROCOST model

INJURY GROUP	ICD-10 CODES
Head and facial injury (excluding eye injury)	S06.0, S02.0–S02.1, S02.7, S02.9, S06.1–S06.9, S04.0–S04.9
	S07.1–S07.9, T02.0, T04.0, S01.0, S08.0, S02.2–S02.6, S02.8
	S01.1–S01.9, S08.1–S08.9, S09.2
Eye injury	S01.1, S05.0–S05.9
Injuries to vertebral column, spine, internal organs, and rib or sternum fractures	S12.0–S12.7, S12.9, S13.0–S13.3, S13.6
	S22.0–S22.1, S23.0–S23.1, S23.3, S29.0
	S32.0–S32.2, S33.0–S33.2, S33.5–S33.7, T02.1
	T03.0–T03.1, T08, T09.2
	S13.4, S14.0–S14.1, S24.0–S24.1, S34.0–S34.1, S34.3, T06.1, T09.3
	S26.0–S26.9, S27.0–S27.9, S29.7, S36.0–S36.9
	S37.0–S37.9, S39.6–S39.9, T06.5, S22.2–S22.4, S22.8–S22.9
Upper extremity injury (excluding nerves)	S42.0–1, S42.7–S42.9, S42.2–S42.3
	S42.4, S52.0–S52.4, S52.7–S52.9
	S52.5–S52.6, S62.0–S62.1, S62.2–S62.8
	S43.0–S43.7, S53.0–S53.4, S63.0–S63.7
	S45–S49, S55–S59, S65–S69, T04.2
	T05.0–T05.2, T11.4–T11.9
Lower extremity injury	S32.3–S32.8, S72.0–S72.2, S72.3, S72.7–S72.9
	S72.4, S82.0–S82.2, S82.4, S82.7–S82.9
	S82.3, S82.5–S82.6, S83.0–S83.7
	S92.0–S92.9, S93.0–S93.9
	S15.1, S75–S79, S85–S89, S95–S99, T04.3
	T05.3–T05.5, T06.3, T13.4–T13.9, T14.5
Superficial injury, including contusions and open wounds	S00, S10, S20, S30, S40, S50, S60, S70, S80, S90, T00
	T09.0, T11.0, T13.0, T14.0

	S11, S21, S31, S41, S51, S61, S71, S81, S91, T01
Burns	T20–T32
Poisoning	T36–T65
Foreign body	T15–T19
Other and unspecified injury	S14.2–S14.4, S24.2, S44, S54, S64, T11.3, S73.0–S73.1
	S34.2–S34.8, S74, S84, S94, T13.3
	… and other codes

Source: Polinder et al. *(14)*.

Table 3.3. Example of cost estimation of injury-related hospital admissions in Europe for the EUROCOST injury groups

Injury group	Cost per capita[a]		Incidence		Mean cost per injury	
	€	Rank	Per 1000 population	Rank	€	Rank
Fracture, hip, pelvis or femur shaft	10.92	1	2.3	1	5530	1
Fracture, knee or lower leg	2.46	2	0.9	5	3504	4
Skull-brain injury	1.66	3	1.2	3	2822	7
Superficial injury	1.16	4	0.9	6	1312	23
Vertebral column or spinal cord	1.11	5	0.5	13	3305	5
Fracture, ankle	1.03	6	0.5	10	2636	9
Other and unspecified injury	0.91	7	1.1	4	2327	11
Fracture, upper arm	0.74	8	0.3	17	2818	8
Open wounds	0.67	9	0.8	7	1949	14
Poisoning	0.61	10	1.7	2	1370	22
Fracture, wrist	0.59	11	0.8	8	1374	21
Fracture, elbow or forearm	0.59	12	0.6	9	1726	16
Dislocated, sprained or strained knee	0.56	13	0.4	15	1727	15
Burns	0.54	14	0.2	18	4065	2
Internal organ injury	0.39	15	0.2	19	2865	6
Fracture, rib, sternum	0.34	16	0.2	20	2126	13
Complex soft tissue injury, upper extremity	0.30	17	0.4	14	1440	17
Fracture, foot or toes	0.30	18	0.2	24	2514	10
Open wounds	0.29	19	0.5	12	1165	25
Complex soft tissue injury, lower extremity	0.29	20	0.2	22	3535	3
Facial fractures	0.27	21	0.5	11	1379	20
Fracture, hand or finger	0.21	22	0.4	16	1131	26
Sprained or strained ankle or foot	0.20	23	0.1	25	1430	18
Sprained or strained shoulder or elbow	0.19	24	0.2	23	1225	24
Fracture, clavicle or scapula	0.14	25	0.1	26	2152	12
Eye injury	0.09	26	0.1	27	1391	19

Injury group	Cost per capita[a]		Incidence		Mean cost per injury	
Foreign body	0.09	27	0.2	21	1083	27
Sprained or strained wrist, hand or fingers	0.05	28	0.1	28	775	28

Source: Polinder et al. *(38).*

4. Estimating the health effects of the intervention

4.1 Introduction

This chapter examines issues related to estimating the denominator of the economic evaluation ratio: the health effects. The primary effect measures depend on the type of economic evaluation chosen and are naturally occurring units (cost–effectiveness analysis), utility-based outcome measures (cost–utility analysis) and valuating outcomes in monetary terms (cost–benefit analysis). Table 4.1 provides an overview of the specific effect measures and data needed for each economic evaluation method.

Table 4.1. Step-by-step guide for estimating effects

STAGE 2: ESTIMATING EFFECTS	
Modular approach	**Choices to be made**
Cost–effectiveness analysis	
2.1. Choose natural units	Generic: injuries prevented and years of life gained Injury-specific: falls prevented
2.2. Obtain data	
Cost–utility analysis – calculate DALYs	
2.1. Choose incidence data	
2.2. Choose anatomical classification system	
2.3. Determine the proportion of short-term and lifelong effects	
2.4. Choose a set of disability weights[a]	
2.5. Obtain mortality data	
2.6. Calculate the number of DALYs	
Cost–benefit analysis	
2.1. Choose monetary units	

[a]Disability information can be derived from measures of health status or from the Global Burden of Disease study or the Integrated Burden of Disease Study.

4.2 Cost–effectiveness analysis – estimating effects

The effect measure of a cost–effectiveness analysis consists of the difference in population health with an intervention compared with the effect of no intervention (the net health effect). In relation to injury prevention and control interventions, two types of outcomes representing health gains can be distinguished: generic outcomes, such as injuries prevented and life-years gained, and injury-specific outcomes, such as falls prevented. Data on the health effects of interventions ideally come from randomized controlled trials or systematic reviews of studies.

Cost–effectiveness analysis expresses the effects of interventions in naturally occurring units, such as deaths, illness or burns prevented (Table 4.1). The main sources of data ideally need to be obtained from a systematic review that, if done well, will ensure a low probability of obtaining a biased estimate of the overall effectiveness of an intervention. Through data pooling, meta-analysis done as part of a systematic review can also increase the power to detect a difference in the effectiveness of interventions. Data pooling can also be used to explore questions of whether the effectiveness of interventions differs across population groups (effect modification) by analysing these groups.

The summary measure of efficacy can be risk differences or relative risk for outcomes that are expressed as proportions (case fatality or incidence proportions) or effect size for outcomes that are expressed as continuous variables, such as measures of disability or functioning. A relative risk is a measure of how much more likely an outcome is among individuals in a group given an intervention versus a group not given an intervention. A relative risk of 1 means that the intervention is not efficacious for the outcome being measured.

An effect size is a standardized difference. It is the difference in means of the two groups being compared expressed in terms of standard deviation shifts:

(mean of group 1 – mean of group 2)/standard deviation.

An effect size of 0 means that the groups do not differ, whereas an effect size of 1 means that 88% of the control group would rank below the average person in the experimental group (assuming normal distributions).

Box 4.1: CEA and CUA – examples of effect outcomes

METHOD	EFFECTS	EXAMPLES
CEA	Natural units	e.g. deaths, life years gained, amount of injuries prevented (e.g. number of burns prevented, number of hip fractures prevented), number of violence injuries averted.
CUA	Unit of utility	quality-adjusted life years (QALY) or disability-adjusted life years (DALY)

4.3 Cost–utility analysis – estimating effects

This section explains stepwise how to link routinely collected hospital-based injury incidence data with information on injury-related disability. Analysts performing cost–utility analysis are recommended to express population effectiveness in terms of DALYs, although measures such as QALYs could also be used.

Burden of disease studies quantify the health status of a population and frequently use DALYs. DALYs integrate the impact of mortality along with morbidity and disability so they can be considered at the same time *(52,53)*, simplifying comparisons between population subgroups.

The World Bank introduced the DALY in 1993, and it has gained wide adherence since the Global Burden of Disease study used it in 1996 *(53,54)*. The DALY aggregates mortality (expressed in years of life lost) and morbidity (expressed in years lived with disability) into a single figure and is calculated as:

$$\text{DALY} = \text{years of life lost} + \text{years lived with disability}$$

The number of years of life lost represents the time lost due to premature mortality and is calculated using the following formula:

$$\text{Years of life lost} = \Sigma\, d_l \times e_l$$

where d is the number of fatal cases due to health outcome l in a certain period, and e is the expected individual life span at the age of death.

The number of years lived with disability represents the healthy time lost while living with a disease or disability and is calculated using the following formula:

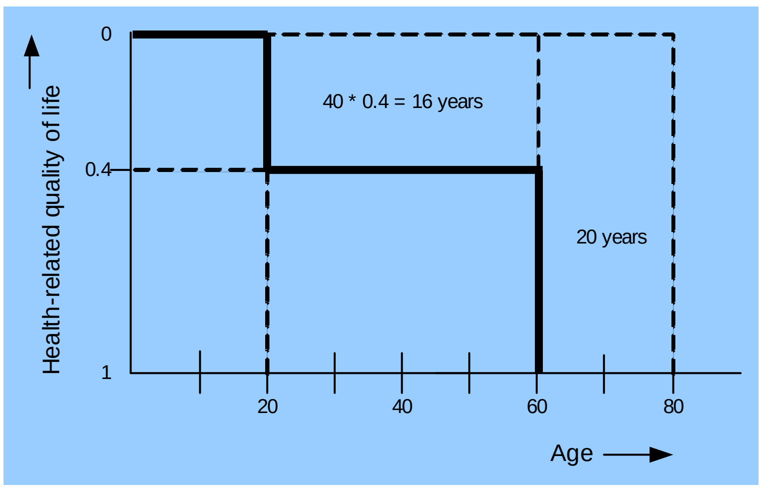
$$\text{Years lived with disability} = \Sigma\, n_l \times t_l \times \text{DW}_l$$

Where *n* is the number of cases with health outcome *l*, *t* the duration of the health outcome and DW the disability weight assigned to health outcome *l*.

Box 4.2 provides a theoretical example.

Box 4.2. Theoretical example of health-related quality of life

The theoretical example represents the DALY calculation of one life history. A healthy woman sustains a lifelong severe disability (such as paraplegia) in a road crash, decreasing her health-related quality of life from 1.0 to 0.6. She dies from kidney failure at age 60 years. For the period between 20 and 60 years, we calculate 40 years times 0.4 = 16 years lost because of decreased health-related quality of life. If we assume a life expectancy of 80 years, she lost 20 years because of premature mortality. In this life history, 36 DALYs are lost. By combining all life histories in a population, population health can be described in terms of DALYs lost.



Source: Mackenbach & van der Maas *(55)*.

Note: for interventions that alter life expectancy, the number of years of life saved by an intervention should be estimated by using a population model.

Step 2.1: choose incidence data

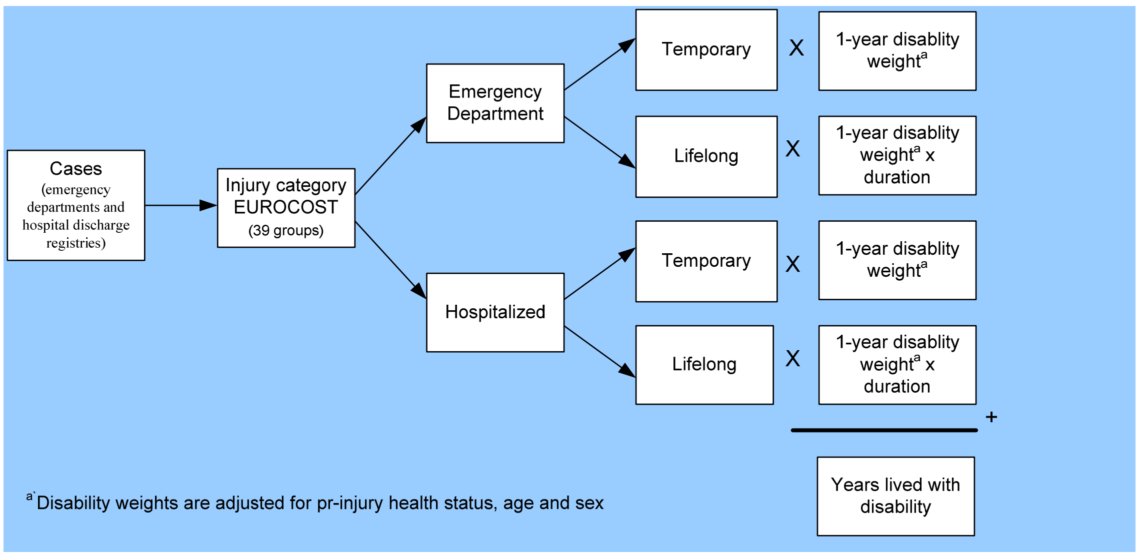
Injury data may be retrieved from several sources. Assessing the disability component of injuries requires being able to divide the incident cases into homogeneous groups for the expected health effects. These groups may be constructed based on the characteristics of the injured people, such as age, sex, location of the injury, type of injury and admission to hospital. Using incidence data from emergency departments and hospital discharge registries is recommended, since these characteristics are well documented among these hospital-based data systems and avoid underestimating the disability component of injury.

In conclusion, calculating disability (years lived with disability, the disability component of the DALY) requires:

- incidence: data on the annual number of cases in a population a year; often only data on the registered cases and in some cases supplementary data from population studies are available; and
- the age distribution of the cases.

Fig. 4.1 shows a conceptual model of the DALY calculation.

Fig. 4.1. Conceptual model for calculating the number of years lived with disability using the recommended approach



Source: Haagsma et al. *(16)*.

Box 4.3 gives an example of how disability can be calculated.

Box 4.3: Example of disability calculation

For example, an injury patient with skull-brain injury treated at the ED has a disability weight of 0.090, whereas for hospitalized patients the disability weight is 0.241. We assume that there are 1500 incident cases with skull-brain injury, of which 1,000 were treated at the ED and 500 admitted to hospital. Of the ED cases 13% (130) and of the HDR cases 23% (115) skull-brain injury suffer from lifelong consequences. The disability weight for these lifelong consequences is 0.323. The age distribution of the cases indicated that the average duration of life long consequences is 15 years for ED cases and 20 years for HDR cases.

Calculation:

YLD short term ED:	1,000 * 0.090 =	90
YLD short term HDR:	500 * 0.241 =	121
YLD long term ED:	130 * 0.323 * 15 =	630
YLD long term HDR:	115 * 0.323 * 20 =	743
		______+
		1,584 YLD

Step 2.2: which anatomical classification system?

Linking the hospital-based incidence data with disability information requires using an anatomical classification system that can link each group to a disability weight and can differentiate all groups with emergency department and hospital discharge registry data. Because functional injury effects highly depend on the location and type of injury, the anatomical classification system preferably includes both. The ICD, the Barell Injury Diagnosis Matrix and the EUROCOST injury diagnosis classification schemes comply with this requirement, as described earlier in step 1.7. Assessment of these three anatomical classification systems showed that the ICD and Barell Injury Diagnosis Matrix have limited capacity to link with information on injury-related disability and that they have limited use in linking to emergency department systems. The EUROCOST classification, in contrast, has been used in both follow-up studies of injured people and panel studies to assess injury-related disability and has proven to be feasible in emergency department systems *(16)*. Using the EUROCOST classification is therefore recommended for calculating the burden of injury. The recoding tables from Annex 2 can be used for recoding ICD-10 to EUROCOST. Some countries use the ICD-9. In this case, the tables for converting ICD-9 to EUROCOST from the EUROCOST reports may be used.

Step 2.3: proportion of injuries with short-term and lifelong effects

Calculating the disability within a certain injury group requires having information about the proportion of injuries with short-term and lifelong effects.

Information on the duration of the disabilities has to be gathered, and the proportion of cases with lifelong disability has to be determined. Long-term follow-up data may be used to assess the duration and/or proportion of injured people with lifelong disability. Another option is to use the proportions of lifelong disability per injury category that were predefined by the Global Burden of Disease study *(56)*.

Step 2.4: choose a set of disability weights

The next step is to link the injury diagnosis to the disability weight of temporary and lifelong effects.

Disability weights reflect the health effects of an injury or disease and have a value that ranges from 0 (worst possible state of health) to 1 (full health). Disability weights may be adopted from existing sets, such as the set of disability weights derived for the Global Burden of Disease study or the set of disability weights produced in the Netherlands *(57–59)*.

The Global Burden of Disease disability weights were calculated at the request of WHO. The Global Burden of Disease study determined a comprehensive set of short-term (first year after injury) and lifelong sequelae *(60)*. Annex 3 provides an overview of Global Burden of Disease disability weights for injuries. It is assumed that people not admitted to the emergency department only had short-term disability. For people who were hospitalized, the Global Burden of Disease study formulated injuries with lifelong disability for at least a predefined proportion of the total number of people admitted (skull-brain injury, 15%; spinal cord injury, 100%; injury of the nerves, 100%; amputations of the lower and upper extremities, 100%; fractured hip, 5%; and fractured femur shaft, 5%) *(61)*. The Global Burden of Disease weights and our data sources were compatible for 33 injury groups, as shown in Table 4.2.

Table 4.2. Overview of disability weights and duration of the state of health for injuries in the Global Burden of Disease study for the EUROCOST injury groups

Injury groups	Global Burden of Disease disability weight	Duration of disability (years)
1. Concussion	0.020[b]	–
2. Other skull-brain injury	Short term 0.359–0.431 – lifelong 0.350[b]	0.107 – lifelong 15%[b]
3. Open wound, head	0.108	0.024
4. Eye injury	0.004[a]	–
5. Fractured facial bones	0.233	0.118
6. Open wound, face	0.108	0.024
7. Vertebral column fractures, dislocations, sprain or strain	0.266	0.140
8. Whiplash, neck sprain, distortion of cervical spine	0.094[a]	–
9. Spinal cord injury	0.725	100% lifelong
10. Internal organ injury	0.208	0.042
11. Fracture of rib or sternum	0.199	0.115
12. Fracture of clavicle or scapula	0.153–0.137	0.112
13. Fracture of upper arm	0.153–0.137	0.112
14. Fracture of elbow or forearm	0.153–0.137	0.112
15. Fracture of wrist (including carpal bones)	0.100	0.112
16. Fracture of hand or fingers	0.100	0.070
17. Dislocation, sprain or strain of	0.074	0.035

shoulder or elbow		
18. Dislocation, sprain, or strain of wrist, hand or fingers	0.064	0.035
19. Injury of nerves, arm or hand	0.064	100% lifelong
20. Amputation, upper extremity	0.102–0.165	100% lifelong
21. Fracture of pelvis	0.247	0.126
22. Fracture of hip	Short term 0.372 – lifelong 0.272	0.139 – lifelong 5%[e]
23. Fracture of femur shaft	Short term 0.372 – lifelong 0.272	0.139 – lifelong 5%[e]
24. Fracture of knee or lower leg	0.196	0.090
25. Fracture of ankle	0.196	0.096
26. Fracture of foot	0.077	0.073
27. Dislocation, sprain or strain of knee	0.064	0.035
28. Dislocation, sprain or strain of ankle or foot	0.064	0.035
29. Dislocation, sprain or strain of hip	0.074	0.035
30. Injury of nerves, leg or foot	0.064	100% lifelong
31. Amputation, lower extremity	0.300	100% lifelong
32. Superficial injury (including contusions)	0.005[a]	—
33. Open wounds	0.108	0.024

Sources: Polinder et al. *(62,63)* and Murray & Lopez *(58)*.

[a]Disability weights from the Netherlands *(57)*. Because most people with eye injury in industrialized countries have only minor temporary problems, the assumption of the Australian burden of disease study was adopted, which used the short-term disability weight of open wounds for eye injury. [b]A proportion of the injured people has lifelong sequelae. The others have short-term disability.

A second option is to use states of health reported by the people with injuries, which are converted into disability weights using multi-attribute utility instruments such as the EQ-5D™ *(64)*. An important distinction is that the disability weights obtained using multi-attribute utility instruments are generic, which means that, in contrast to the Global Burden of Disease and disability weights from the Netherlands, they do not include disease-specific symptoms but measure the state of health with generic attributes only, such as mobility and pain *(65)*.

Using the Polinder multi-attribute utility instrument disability weights *(16)* is recommended, since these disability weights are based on EQ-5D™ data from a large number of injured people. Because of their constraints in measuring temporary health states, the multi-attribute utility instrument disability weights are less appropriate for short-term injury effects *(65)*. For certain injury groups, the Haagsma disability weights were therefore appended to the multi-attribute utility instrument disability weights; these disability weights have been derived in such a way that the time constraints for temporary states of health have been alleviated *(57)*.

Table 4.3 presents the recommended disability weights by type of injury that can be linked to hospital data systems on hospitalized and non-hospitalized injured people. The multi-attribute utility instrument disability weights presented in these tables have been adjusted for the age and sex of the people with injuries.

Table 4.3. Mean one-year disability weights of temporary injury effects per EUROCOST injury group, stratified by emergency department and hospital discharge registry

Injury group	Acute phase		Lifelong effects
	Emergency department	Hospital discharge registries	
Concussion	0.015	0.100	0.151
Other skull-brain injury	0.090	0.241	0.323
Open wound, head	0.013	0.209	–
Eye injury	0.002	0.256	–
Fracture, facial bones	0.018	0.072	–
Open wound, face	0.013	0.210	–
Fracture, dislocation, sprain or strain of vertebrae or spine	0.133	0.258	–
Whiplash, neck sprain or distortion of the cervical spine	[a]	[a]	[a]
Spinal cord injury	[a]	0.676	[a]
Internal organ injury	0.103	0.103	–
Fracture of rib or sternum	0.075	0.225	-
Fracture of clavicula or scapula	0.066	0.222	0.121

Injury group	Acute phase		Lifelong effects
	Emergency department	Hospital discharge registries	
Fracture of upper arm	0.115	0.230	0.147
Fracture of elbow or forearm	0.031	0.145	0.074
Fracture, wrist	0.069	0.143	0.215
Fracture, hand or fingers	0.016	0.067	0.022
Dislocation, sprain or strain of shoulder or elbow	0.084	0.169	0.136
Dislocation, sprain or strain of wrist, hand or fingers	0.027	0.029	–
Injury of nerves of upper extremity	[a]	[a]	–
Complex soft tissue injury of upper extremity	0.081	0.190	0.166
Fracture of pelvis	0.168	0.247	0.182
Fracture of hip	0.136	0.423	0.172
Fracture of femur shaft	0.129	0.280	0.169
Fracture of knee or lower leg	0.049	0.289	0.275
Fracture of ankle	0.096	0.203	0.248
Fracture of foot or toes	0.014	0.174	0.259
Dislocation, sprain or strain of knee	0.109	0.159	0.103
Dislocation, sprain or strain of ankle or foot	0.026	0.151	0.125
Dislocation, sprain or strain of hip	0.072	0.309	0.128
Nerve injury, lower extremity	[a]	[a]	–
Complex soft tissue injury, lower extremity	0.093	0.150	0.080
Superficial injury (including contusions)	0.006	0.150	–
Open wound	0.013	0.093	–
Burns	0.055	0.191	–
Poisoning	0.245	0.245	–
Multi-trauma	[a]	[a]	[a]
Foreign body	0.044	0.060	–
No injury after examination	–	–	–

Injury group	Acute phase		Lifelong effects
	Emergency department	Hospital discharge registries	
Other and unspecified injury	0.111	0.212	–

Source: Haagsma et al. *(16)*.

0: full health; 1: worst possible state of health.

The boxes shaded grey are the Haagsma disability weights.

[a]For these injury categories, EQ-5D™ data were missing or very limited (*n* < 10).

Several injury categories do not cause lifelong disability, such as open wounds. This is indicated with "–".

The burns injury group only includes people with relatively mild burn injuries. People with severe burn injuries are treated at specialized burn units, for which no data are available.

Step 2.5: estimate the years of life lost due to mortality

Many measures have been developed to measure the stream of life lost due to death at different ages. These measures can be divided into four families: potential years of life lost, period expected years of life lost, cohort expected years of life lost and standard expected years of life lost *(12)*.

Potential years of life lost is the simplest measure of time lost due to premature death. A potential limit to life is chosen arbitrarily, and the duration of life lost due to a death is simply the potential limit to life minus the age at death. Potential years of life lost is criticized because deaths averted for people older than the arbitrarily chosen potential limit of life do not contribute to the burden of premature mortality. Using it as an indicator for cost–effectiveness analysis implies that there is no benefit to health interventions that reduce mortality over the potential limit to life. This is at odds with the values of most societies.

Period expected years of life lost is a popular alternative to potential years of life lost, where the duration of life lost is the local period of life expectancy at each age. In a period life table, life expectancy at each age is the estimated duration of life expected at each age if the current age-specific mortality patterns were to hold in the future. In period expected years of life lost, a population's current mortality level is being used as the "ideal" against which it is compared to calculate the burden of disease. Local life expectancy varies over time and across communities and thus the reference standards vary, creating peculiar findings at times for burden comparisons.

Cohort expected years of life lost: given past secular trends in mortality, the average individual alive today at any given age is likely to live substantially longer than period life expectancy at that age. In contrast to period life expectancy, cohort life expectancy is the estimated average duration of life a cohort would actually experience. Cohort life expectancy is substantially higher than period life expectancy. However, a disadvantage is that, if expected years of life lost is used as a measure of the burden of disease, a death in a high-income country in which life expectancy at each age is higher would be considered a greater burden than a death in a low-income country with a lower life expectancy.

Standard expected years of life lost: the advantages of an expectation approach in which every death contributes to the burden of disease and the equitable approach of potential years of life lost in which every death of a given age contributes equally to the calculation of the burden of disease can be combined by using a standard expectation of life at each age as the reference norm. The standard expected years of life lost method has been adopted for measuring the global burden of disease due to premature mortality. To define the standard, the highest national life expectancy observed was taken. This is not the approach used to measure DALYs averted by interventions, which requires different calculations.

WHO has adopted the standard expected years of life lost method for measuring the global burden due to premature mortality associated with different types of diseases. This uses the expectation of life at each age *x* based on some ideal standard to estimate the loss of years of life associated with a death *(12)*.

Step 2.6: calculate DALYs

After all information is gathered, the DALYs can be estimated (explained previously). DALY combines in one measure the time lived with disability and the time lost due to premature mortality:

$$\text{DALYs} = \text{years of life lost due to premature mortality} + \text{years lived with disability}$$

estimate the years lived with disability on a population basis, the number of disability cases is multiplied by the average duration of the disease and a weight factor that reflects the severity of the disease on a scale from 0 (perfect health) to 1 (dead). The basic formula (without applying social preferences) for one disabling event is:

$$\text{Years lived with disability} = I \times DW \times L$$

where:

I = number of incident cases

DW = disability weight

L = average duration of disability (years)

The years of life lost measure essentially corresponds to the number of deaths multiplied by the standard life expectancy at the age at which death occurs, and it can be rated according to social preferences (see below). The basic formula for calculating the years of life lost for a given cause, age or sex is:

$$\text{Years of life lost} = n \times L$$

where:

n = number of deaths

L = standard life expectancy at the age of death (in years)

The years of life lost basically corresponds to the number of deaths multiplied by the standard life expectancy at the age at which death occurs. The basic formula for years of life lost (without yet including other social preferences discussed below) is the number of deaths multiplied by the standard life expectancy at the age of death in years.

Table 4.4 gives an example of assessing DALYs from injury in six European countries.

Table 4.4. Example of assessing the burden of injury in six European countries

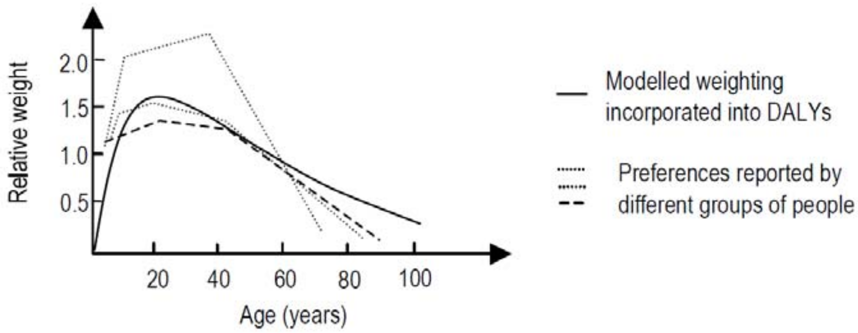
Country	Disability				Premature mortality	Burden of injury per 1000 people
	Years lived with disability				Years of life lost	DALYs
	Not admitted short term	Admitted short term	Admitted life long	Total		
Austria	0.2	0.2	7.7	8.2	17.1	25.3
Denmark	0.4	0.4	2.8	3.4	15.5	18.9
England	0.3	0.3	2.0	2.4	9.8	12.2
Ireland	0.1	0.1	4.1	4.3	15.3	19.6
Netherlands	0.2	0.2	2.8	3.1	9.4	12.6
Norway	0.3	0.3	2.6	3.2	14.1	17.2
Wales	0.3	0.3	2.1	2.5	9.8	12.3

Source: Polinder et al. *(62)*.

Additional step: calculating DALYs with discounting and age weighting

In the Global Burden of Disease study, a year of healthy life lived at younger and older ages was weighted lower than for other ages. In other words, the Global Burden of Disease study chose to valuate a year of life in young adulthood more highly than a year in old age or infancy. This choice was based on several studies that have indicated a broad social preference to valuate a year lived by a young adult more highly than a year lived by a young child or an older person *(58)*. Fig. 4.2 shows a general pattern of the valuating of health according to age.

Fig. 4.2. Relative value of a year of life lived by age: reported preferences and modelling



Source: adapted from Murray & Lopez *(58)*.

Not all such studies agree that younger and older ages should be given less weight, nor do they agree about the relative magnitude of the differences. For the purpose of cost–effectiveness analysis at the country level, individual analysts may choose whether to use age weighting. For example, WHO reports its cost–effectiveness results with age-weighting in its base case and without age weighting as part of the sensitivity analysis. Murray & Lopez *(58)* discuss the principles and techniques of age-weighting in more detail.

Studies have shown that people have preferences regarding the moment at which death or disability occurs *(58,66)*. People generally prefer a healthy year of life immediately, rather than in the future, if given the choice. DALYs measure the future stream of healthy years of life lost due to each incident case of disease or injury. It is thus an incidence-based measure rather than a prevalence-based measure. To estimate the net present value of years of life lost, a discount rate should be used for years of life lost in the future. With this discount rate, a year of healthy life gained 10 years from now is worth 24% less than a year gained now.

If both age-weighting and discounting are applied and the years between the event and the life expectancy are summed, the initially simple formulas for years of life lost and years lived with disability become more complicated (formula for a single death). These formulas have also been programmed into calculation spreadsheet templates for DALYs that are available at the WHO web site *(67)*.

4.4 Cost–benefit analysis – estimating effects

In cost–benefit analysis, the costs and effects are both expressed in monetary units. Effects are therefore measured in monetary units. For more information about measuring costs, see Chapter 4.

5. Estimating the costs of the intervention

5.1 Introduction

This chapter examines the theory and process of identifying, estimating and valuating the costs associated with the intervention. Estimating costs normally involves three steps: identifying cost categories, measuring utilization and valuation: determining the monetary costs per unit of utilization.

Any attempt to estimate the costs must recognize that injuries affect societies at all levels. Studies documenting the economic effects of injuries have therefore covered a broad range of costs affecting individuals and society as a whole. Distinguishing between direct and indirect costs is useful in categorizing the costs of injuries. The next sections describe the calculation of direct and indirect costs separately.

5.2 Identifying cost categories: direct and indirect costs

Distinguishing between direct and indirect costs is useful in categorizing the costs of injuries (Table 5.1). Direct costs arise directly from acts of injury and require actual payments by individuals, institutions and costs incurred by the health care system as a whole. They can be further divided into health care and non–health care costs. Direct health care costs generally include those for hospital treatment, outpatient visits, ambulance or other transport to hospital, physician fees, drugs and laboratory tests. Direct non–health care costs include, for example, child-care costs for a parent and transport costs to the hospital. Indirect costs refer to lost resources and opportunities resulting from injuries. Studies tend to focus on tangible costs such as reduced productivity or output by the injured person, which are usually calculated from average gross earnings and the amount of work time lost as a result of injuries. In some settings, incorporating the reduced productivity of a caregiver may be appropriate. Other tangible costs include lost investment in social capital (such as the education of the injured person), life insurance costs, reduced productivity and macroeconomic costs (such as a reduction in property values or foreign investment due to injuries).

Indirect costs also include intangible costs such as reduced quality of life. Quality of life includes many components, such as job opportunities, access to schools and public services and participation in community life. In the context of injuries, it is usually associated with health-related quality of life, which includes the pain and suffering, both physical and mental, that arise from injuries.

These guidelines consider the components that make up direct health care costs and productivity losses from the category of tangible costs as core requirements. Estimating the impact of injuries on quality of life and disaggregating costs by sex, age, intent, type of injury and mechanism are suggested as optional modules for further analysis.

The cost of providing health interventions should be included in the analysis, as should the resources used in seeking or obtaining an intervention, such as transport costs.

The perspective determines which cost categories should be included in the analysis. In a societal perspective, cost analysis preferably takes into account direct and indirect costs inside and outside the health care sector. Within the insurer and health care perspective, only direct health care costs need to be included. Methods for estimating both the resources and prices (unit costs) used should be given separately.

Table 5.1. Direct and indirect costs of injuries

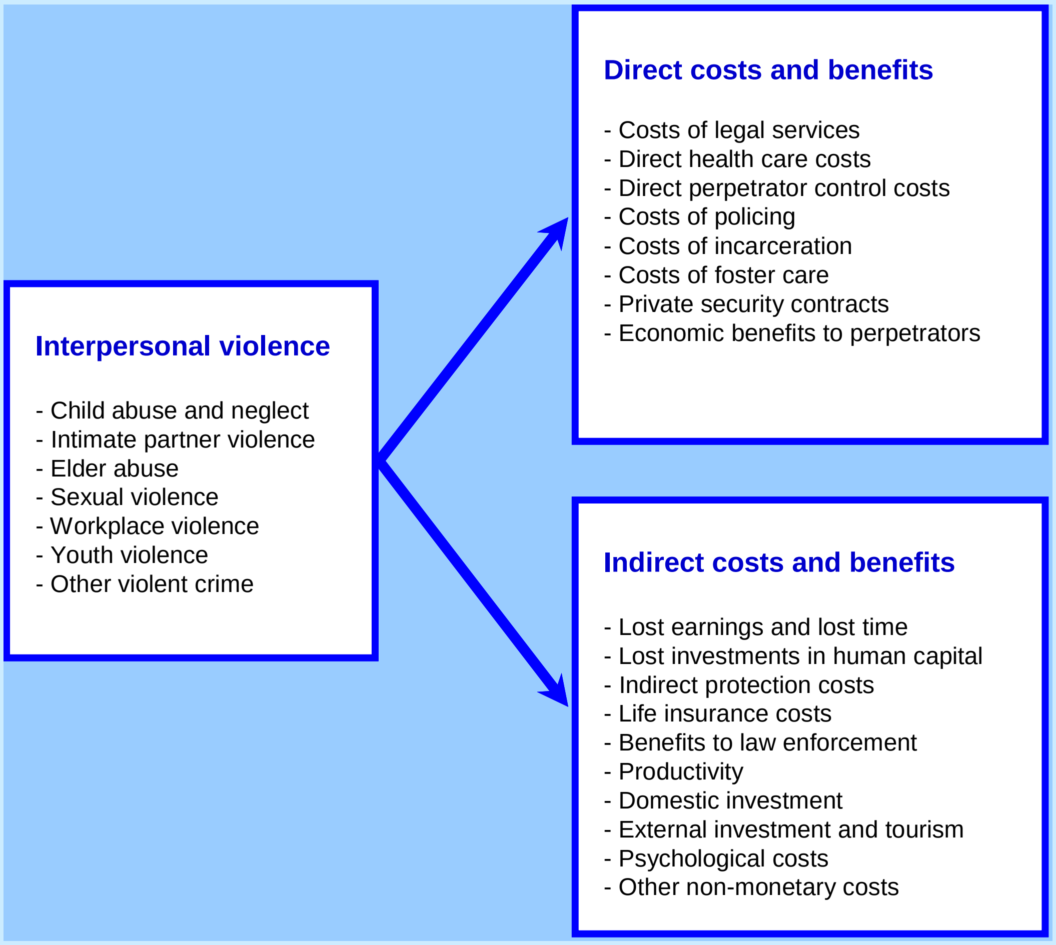
Cost category	Type of cost	Components	Disaggregation options
Direct	Health care	Hospital inpatient	By demographic group
		Hospital outpatient	By type of injury
		Transport or ambulance	By mechanism
		Emergency department	By intent
		Physician	
		Drugs and laboratory tests	
		Counselling	
		Rehabilitation services	
		Intervention	
	Non–health care	Legal services	
Indirect	Tangible	Loss of productivity	
	(non–health care)	Mortality costs	
	Intangible	Health-related quality of life	

The total costs sum the health care and non–health care direct costs and the tangible and intangible indirect costs.

Box 5.1 describes commonly used direct and indirect costs of interpersonal violence.

Box 5.1. Example of direct and indirect costs of interpersonal violence

The WHO report *The economic dimensions of interpersonal violence (68)* addresses methodological issues around the costing of violence. Studies documenting the economic effects of interpersonal violence have used a broad range of categories of direct and indirect costs.



The most commonly cited direct costs were health care and the costs of the judicial and penal systems – policing and incarceration. Indirect costs included the long-term effects of acts of violence on perpetrators and victims, such as lost wages and mental costs, also referred to as pain and suffering.

Source: Waters et al. *(68).*

The next sections describe the calculation of the intervention costs and direct and indirect costs separately. The direct and indirect costs are based on the general conceptual framework, as presented in Table 5.2.

Table 5.2. Step-by-step guide for estimating direct and indirect costs

Stage 3. Estimating costs	
Steps to be taken	**Modular approach**
3.1. Identify the minimum data requirements	
3.2. Measure health care utilization	Minimum data set Minimum + additional data
3.3. Collect cost data	Minimum data set Minimum + additional data
3.4. Calculate costs	

5.3 Intervention costs

All costs related to developing and performing an intervention should be included in the cost calculations. For example, costs for personnel, training staff, administration costs and costs for office space and materials should therefore be included. If the skills required to deliver an intervention are not available (or not yet available to the full extent necessary) in the country being studied, training costs to develop these skills should be included as part of the intervention costs.

5.4 Direct health care costs

This section is partly based on the *Manual for estimating the economic costs of injuries due to interpersonal and self-directed violence (21).*

Step 3.1: identify the minimum data requirements

The severity of an injury will partly determine its costs and therefore which data should be collected for health care utilization. Previous practice has shown that injuries can usefully be classified into three categories: fatal, serious and slight *(21).*

A fatal injury (*L1*) is one in which the person dies as a result of the incident within 30 days. Death registries, mortuary and hospital records, and coroner or medical examiner reports are consulted to obtain these data.

A serious injury (*L2*) is one that does not cause the person's death within 30 days but is serious enough for the person to be admitted to hospital as an inpatient. Hospital admission registries are the main source of data.

A slight injury (*L3*) is one that requires an emergency department visit but is not followed by hospital admission. The incidence of slight injuries can be derived from emergency department registries.

Other categories of injury severity, such as those that do not require hospital or emergency department treatment but require another form of outpatient care, and those for which no care is sought but for which loss of productivity may occur, are more difficult to quantify.

For each definition, the codes in parentheses (*L1*, *L2* and *L3*) refer to the costing equations in Table 5.3.

A distinction has been made between the minimum data necessary for calculating direct health care costs and more extensive calculation, which requires additional data. Where possible, all cost categories that may be either individually or collectively large enough to influence a decision should be included. In the initial phase of identifying cost categories, enumerating all resources consumed is helpful, even small ones and those difficult to valuate in monetary terms. Listing the elements comprehensively allows analysts to make a considered decision on whether each resource should be included. The perspective of the analysis is an important determinant of which resources should be identified and measured.

Step 3.2: basic data requirements: measuring health care utilization

The health care costs resulting from injuries arise from outpatient health care or hospital treatment (inpatient and outpatient) and the use of ambulances or other means of transport to hospital. Whether the source of information is a hospital data system or facility registries or a new patient survey, the following minimum health care data should be collected for people being treated for injury:

- the average length of stay in hospital (in days) for injuries;
- the percentage of emergency department visits due to injury that required transport (such as by ambulance); and
- the percentage of hospital admissions for serious injuries that are admitted through an emergency department.

Further, for fatal injuries the following information is needed:

- the percentage of injury-related deaths;
- the percentage of fatal injuries involving hospital admission; and
- the percentage of fatal injuries involving an emergency department visit.

Additional data include:

- the average number and list of all operations carried out;
- a list of all drugs given to patients during and after the stay;
- the average number of examinations (such as X-rays) carried out;

- the average number of blood transfusions;
- the average number and type of physicians consulted during the stay; and
- the average number of outpatient visits after leaving the facility.

The last two items in the list above may be requested from the personnel treating the person. If time allows, however, conducting follow-up interviews with people after they leave the facility would be preferable and more accurate.

Step 3.3: collect cost data

One of the most important inputs to a costing process is estimating the unit costs of services. The following unit costs should be gathered.

The minimum data include:

- the average cost per bed-day of hospital treatment, including hotel costs, physician fees, operations, blood transfusions, tests and examinations (such as X-rays) and drugs;
- the average unit cost for transport to the emergency department (such as the average unit cost incurred by ambulance services) per emergency department visit or hospital admission; and
- the average cost of health care in the emergency department per visit.

Further, for fatal injuries the following information is needed:

- the average cost of injury-related deaths.

Additional data include:

- the average hotel cost per bed-day: the total budget of the facility minus drugs, surgery and physicians divided by the number of beds;
- the costs of the various drugs used;
- the average cost per type of operation, examination and blood transfusion;
- the average cost per physician consultation; and
- the average cost per outpatient visit.

Most guidelines cover methods to estimate these unit costs, such as Drummond et al. *(13)*. Some of this information may be published by health ministries or be available from private health facilities. However, reliable estimates are not available for many countries. Although the long-term solution is to encourage appropriate costing studies in all settings, for short-term use, WHO-CHOICE *(69)* has developed models to predict country-specific unit costs, which is used to estimate the cost–effectiveness of health interventions by region *(70)*. Regional estimates of unit costs per bed day, outpatient visit, category of personnel, etc. are available for the 14 WHO subregions *(71)*. Prices should be adjusted to a common year using the gross domestic product deflator where possible. If this is not available, the consumer price index can be used *(12)*.

Step 3.4: calculate

Table 5.3 lists the required data and basic costing equations for calculating direct health care costs with the minimal data requirements.

Table 5.3. Direct health care costs – required data and basic costing equations

Severity of injury	Modular approach – required data	Basic costing equation
Fatal	*L1*, *K1*, *K2*, *M1*, *M2*, *M3*, *M4*, *M5*, *M6*, *M8*	$L1 \times [(K1 \times K2)] + (M1 \times M5) + (M2 \times M3 \times M4) + (M6 \times M8)]$
Serious	*L2*, *M1*, *M3*, *M4*, *M5*, *M6*, *M7*	$L2 \times [(M6 \times M7)] + (M1 \times M5) + (M3 \times M4)]$
Slight or minor	*L3*, *M1*, *M5*, *M6*	$L3 \times [(M6) + (M1 \times M5)]$

Source: Butchart et al. *(21)*.

L1: number of fatal injuries, as defined in step 3.1. *L2*: number of serious injuries, as defined in step 3.1. *L3*: number of slight injuries, as defined in step 3.1. *K1*: average cost of injury-related deaths. *K2*: percentage of injury-related deaths. *M1*: average unit cost for transport to the emergency department per emergency department visit or hospital admission = transport cost per emergency department visit or hospital admission. *M2*: percentage of fatal injuries involving hospital admission = number of hospital admissions per 100 fatal injuries. *M3*: average length of stay in hospital (in days) for injuries = hospital days/hospital admissions. *M4*: average cost per bed-day of hospital treatment = hospital costs/hospital days. *M5*: percentage of emergency department visits due to injury that required transport = number of emergency department visits requiring transport per 100 fatal, serious or slight injuries. *M6*: average cost of health care in the emergency department per visit = treatment cost per emergency department visit. *M7*: percentage of hospital admissions for serious injuries that are admitted through an emergency department = number of serious injuries admitted via an emergency department visit per 100 serious injuries. *M8*: percentage of fatal injuries involving an emergency department visit.

Table 5.4 presents an example from an article emerging from the review (Polinder S et al. Systematic review and quality assessment of economic evaluation studies of injury prevention interventions. Submitted) with an extensive cost calculation.

Table 5.4. Example of a cost calculation: absolute numbers and accumulated costs (in euros) for each category of use of health care resources and absence from work and total costs (in euros) per group based on completed cost diaries only. The aim of the study was to evaluate the cost–effectiveness of a proprioceptive balance board training programme for preventing ankle sprains in volleyball.

Type of use		Intervention (*n* = 17)		Control (*n* = 22)	
	Unit cost	Number	Cost	Number	Cost
Direct health care costs					
General practice (number of visits)	16.60	6	99.60	10	166.00
General practice (number of phone consultations)	8.17	1	8.17	1	8.17
Physical therapist (number of visits)	18.15	38	689.70	23	416.45
Sports physician (number of visits)	16.60	3	49.80	4	66.40
Medical specialist (number of visits)	40.85	7	285.95	1	40.85
Alternative therapist (number of visits)	27.20	–	–	2	54.40
Radiograph or cast	50.00	3	150.00	5	250.00
Emergency room (number of visits)	50.00	3	150.00	4	200.00
Drugs	–		36.94		75.15
Medical devices					
Tape (number of rolls)	3.00	9	27.00	13	39.00
Braces	67.89	5	339.45	–	–
Crutches (number of times rented)	15.00	1	15.00	1	15.00
Indirect costs					
Absenteeism from paid work (days)	–	41	3447.61	51	2629.51
Absenteeism from unpaid work (hours)	7.94	174	1381.56	655	5200.70
Total costs			**6680.78**		**9161.63**

Source: Verhagen et al. *(72)*.

Web-based tools

In recent years, web-based tools have been developed within the EU-funded APOLLO project to support EU countries in calculating the direct health care costs of injury. EU countries can apply the data tools for collecting, harmonizing and analysing data on injury incidence and related use of health care services and for calculating the costs themselves by using the guidelines and tools developed within the APOLLO project. These guidelines and tools have been made available on the EuroSafe web site *(19)*. Annex 4 describes the project and the tools in detail.

5.5 Indirect non–health care costs: productivity costs

Apart from direct health care costs, indirect non–health care costs are among the major economic effects of injury *(73,74)*. The indirect costs represent the economic effects of injuries resulting from loss of productivity, disability and death. On average, these represent more than half the total disease costs or total costs avoided through health care interventions *(75)*. Productivity costs can be defined as the costs associated with the loss and replacement of production due to illness, disability and premature death.

Step 3.1: identify the minimum data requirements

5.5.1 Choosing a valuation method: human-capital method, friction-cost method or willingness to pay

The first step in calculating productivity costs is to choose the valuation method to be used. There is no consensus yet on the most appropriate method of valuating productivity costs. There are currently three internationally known methods for valuation: the human-capital method, the friction-cost method and the United States panel method. This subsection briefly describes all three methods for calculating indirect costs. For more details of the debate concerning the valuation of productivity costs, see Koopmanschap et al. *(76)*, Brouwer et al. *(77)* and Drummond et al. *(78)*. Further, the APOLLO results web site *(79)* explains more extensively how to calculate indirect costs for people with injuries.

5.5.2 The human-capital method

Productivity costs, as defined by the human-capital cost approach, are estimated as the reduced future gross income due to mortality and/or morbidity *(80)*. Traditionally, the human-capital method has been used for measuring productivity costs. It is a simple and straightforward method measuring lost production using gross individual income. Neoclassical economic theory suggests that the marginal productive value of workers equals the wage. Regardless of how long the period of absence or disability is, the gross wage a person would have earned during the entire period of absence is taken to approximate lost production. Because continuous full employment is assumed here, absence from work will always lead entirely to productivity costs, and these costs may continue until retirement age.

5.5.3 The friction-cost method

The proponents of the friction-cost method observe that full employment is not always prevalent in many societies and try to estimate the actual productivity costs. If the unemployment rate in an economy is higher than the frictional unemployment (an unavoidable part of unemployment because labour demand and supply do not always match at each instant), then a sick person can often be replaced (after a while). The essence of the friction-cost method is that, in case of unemployment, absent workers will be replaced after an adaptation period (the friction period) and thus prevent further productivity costs *(76)*.

With respect to short-term sick leave, the proponents of the friction-cost method also state that the actual productivity costs could be somewhat lower than according to the human-capital method because *(81)*:

- marginal returns to labour diminish (the individual's marginal productivity is decreasing);
- production loss due to short-term sick leave can be counteracted by internal labour reserves;
- individuals can make up for part of the loss of production when they return to work; and
- non-urgent work tasks can be cancelled.

5.5.4 The United States panel method

The Panel on Cost–effectiveness in Health and Medicine, a nongovernmental panel convened by the United States Public Health Service, proposed calculating (most) productivity costs in terms of quality of life and not in monetary terms (as in the other two methods). The Panel felt that, when methods of measuring quality of life are silent concerning income, respondents will incorporate income changes related to productivity changes into their valuation of their state of health. Capturing them in monetary terms as well would therefore result in double counting. Most researchers, however, feel that this method has two main shortcomings. First, the relationship between productivity and income in many countries is quite weak, which makes calculating productivity costs by means of QALYs unreliable *(77)*. Second, Krol et al. *(82)* demonstrated that neither spontaneous differences in incorporating the effects of health on income nor explicit instructions on incorporating income yielded different valuations of the state of health. This suggests that QALY measures are insensitive to concerns regarding effects on income even when these are (explicitly) incorporated.

Some health economists prefer the friction-cost method over the human-capital method since it allows for disequilibrium in economies, such as unemployment *(77)*. However, other health economists are not convinced that the friction-cost method is a good alternative to the human-capital approach. A practical guide is therefore presented for estimating productivity costs according to both methods. Data availability is a key concern, since these guidelines are intended to be applicable in all European countries. The friction-cost method might be less appropriate for some countries, as it requires more data. Box 5.2 gives an example of the calculation of indirect costs using both methods.

Box 5.2. Example: indirect productivity loss costs (in millions of US dollars) of injuries by source of economic production loss and sex according to the human-capital method and the friction-cost method, Netherlands, 1988

	Human-capital approach		Friction-cost method	
	Males	Females	Males	Females
Short-term absenteeism	876	185	566	121
Traffic crashes	157	53	85	30
Occupational injuries	359	27	240	19
Sports injuries	162	32	113	23
Domestic injuries	136	54	93	37
Other injuries	53	19	35	12
Long-term work disability[a]	1169	179	2	0
Mortality	825	78	11	2
Traffic crashes	337	28	4	1
Non-traffic injuries[b]	114	5	2	0
Other injuries	374	45	5	1
Total indirect costs of injuries	2851	442	579	123

[a]No information is available for any specific injury category.

[b]No information is available for a breakdown into occupational injuries, sports injuries and domestic injuries.

The table provides information on the indirect costs of specific subcategories of injuries to males and females. The relative proportion of the specific subcategories of injuries in the indirect costs strongly depends on the method used. In the human-capital approach, road crashes are a major category. This is based on the high indirect costs of road traffic deaths, which often appear at younger ages. In the friction-cost method, the indirect costs are almost completely caused by short-term absenteeism. In this approach, occupational injuries are the main cause of indirect costs, and sports injuries rank second. This is because of the high frequency of these types of injuries among men in the labour force.

Source: van Beeck et al. (73).

Steps 3.2 and 3.3: measure health care utilization and collect cost data

This section outlines the basic data requirements and calculations necessary to generate an estimate of the loss of productivity (indirect costs) due to injuries according to both the friction-cost method and the human-capital method. Based on the degree of specificity of the available data, however, researchers may wish to refine their cost estimates. The minimal data requirements outlined below should therefore be used as a flexible framework allowing for further investigation and analysis if the data permit. Both the friction-cost method and the human-capital method require data on absence from paid work, reduced productivity at work without absence (presenteeism) and the incidence of disability and mortality. Collecting data on absence from work and disability by means of general statistics or employer registration is the easiest way of analysing injuries among individual people and/or workers. Data on presenteeism (and possibly absence from work) are normally collected by surveying patients and/or using the estimates of treating physicians. Box 5.3 gives an inventory of the availability of data sources on indirect costs of injury in Europe.

The basic data requirements for estimating lost productivity are as follows:

- national data on the incidence of disability and mortality, according to age, sex and, if possible, educational level (Inc);
- average age at death from injury (D1);
- average age at retirement or at which a person ceases to work (D2);
- the average number of days an injured person is unable to resume normal activities (at the hospital and recovering at home) (D3), collected by general statistics or employer registration and/or surveys of patients;
- the average wage rate per person per day (D4), derived from available age- and sex-specific wage data or national wage rates;
- the average value of production per person per day, by age and sex (D5);
- the costs of reduced production, measured by hours of reduced productivity (presenteeism) (Pr), collected by surveying patients (such as PRODISQ (Productivity and Disease Questionnaire) or Health and Labour Questionnaire);
- a discounting factor, Dr (see below), based on a discount rate of 3%, which should be applied to discount future costs on the principle that people value income in the present more than they do an equivalent amount in the future (further explained in Chapter 6);
- friction period (FP), the length of which is based on the average vacancy duration, preferably by education level, which requires statistics on completed vacancy duration or estimates of completed vacancy duration based on data on uncompleted vacancy duration and the number of vacancies;
- the elasticity (El) of annual labour time versus labour productivity, which is 0.8; and
- presenteeism (ill people who go to work but are less productive), which can be measured in several ways, such as PRODISQ's two visual analogue scales, one for the quantity of paid work and one for the quality (74); other questionnaires such as the Health and Labour Questionnaire (83) apply other methods to measure presenteeism.

Source: Butchart et al. *(21)* provide some of the basic data requirements.

Table 5.5 provides an overview of the data required for both the human-capital method and the friction-cost method.

Step 3.4: calculate costs

Table 5.5 provides the basic equation for calculating loss of production for both the human-capital and friction-cost methods.

Table 5.5. Loss of productivity: data required and basic cost equations for the human-capital and friction-cost methods

Severity of injury[a]	Data required	Basic costing equation
Human-capital method		
Fatal	*Inc*, *D1*, *D2*, *D4*, *Dr*[b]	*Inc* × 365 × *D4* × *Dr* × (*D1* – *D2*)
Nonfatal injury	*Inc*, *D3*, *D4*	*Inc* × *D3* × *D4*
Friction-cost method		
Fatal	*Inc*, *D5*, *FP*, *Pr*[d], *Dr*[b], *El*[c]	*Inc* × *FP* × (*D5* × *Pr*) × *Dr* × 0.8
Nonfatal injury	*Inc*, *D3*, *D5*, *FP*, *Pr*[d], *El*[c]	*Inc* × MAX(*D3*,*FP*) × (*D5* × *Pr*) × 0.8

Inc: incidence of morbidity and mortality of injury patients. [a]A fatal injury is one in which the person dies as a result of the incident within 30 days. [b]$Dr = 1/0.03 - 1/[0.03 \times (1.03)^{p2 - p1 + 1}]$. [c]Elasticity = 0.8. [d]Presenteeism is the factor for reduced productivity and can be established by means of the quality and quantity method. The respondents rate the quality and the quantity of their work on the last working day on a visual analogue scale. *Pr* = (quality/10) × (quantity/10).

Box 5.3. Inventory of available data sources on the indirect costs of injury in Europe

Collecting data on absence from work and disability by means of general statistics or employer registrations is easiest. Data on presenteeism (and possibly absence from work) should normally be collected by surveying injured people.

If no national general data statistics are available, some international web sites give information about (country-specific) statistics. The Eurostat web site *(84)* gives country-specific information on employment (employment rate by age and sex, average exit age and unemployment rate) and the labour market. Further, the web site of the Organisation for Economic Co-operation and Development *(85)* gives information on employment and salaries.

Example: overview of data availability in the Netherlands

An example is an overview of the available data in the Netherlands for calculating indirect costs due to injuries. In the Netherlands, the information on the absenteeism of people with injuries originates from the survey of injured people of the Dutch Injury Surveillance System. People in paid employment before the injury are asked several questions designed to provide insight into the likelihood of absenteeism, the duration of absenteeism measured in working days and the likelihood of resuming work.

National registration data can be used for mortality (Statistics Netherlands), long-term work disability (Mutual Medical Service) and short-term absenteeism (Statistics Netherlands). The table gives an overview of the available data in the Netherlands for calculating indirect costs.

Overview of data in the Netherlands for calculating indirect costs of injury

Cost element	**Data**	**Source**
Absence, paid labor	National registry	Statistics Netherlands
Absence, unpaid labor	Population survey	Statistics Netherlands
Long-term work disability	National registry	Mutual Medical Service
Mortality	National registry	Statistics Netherlands
Value of production loss because of fatal injuries	Lifetime earnings per person by age and sex	Statistics Netherlands
Value of market production loss because of non-fatal injuries	Average earning per worker by age and sex	Statistics Netherlands

CBS, Centraal Bureau voor de Statistiek (Statistics Netherlands); GMD, Gemeentelijke Medische Dienst (Mutual Medical Service).

6. Comparing costs and effects: computing the incremental cost–effectiveness ratio

6.1 Calculating the cost–effectiveness ratio

The basic core of any cost–effectiveness analysis is an incremental comparison of an intervention with a comparison programme. Here the term incremental is used to denote two aspects of appropriate comparisons in cost–effectiveness analysis. First, the comparison is always between two discrete alternatives. Second, the appropriate incremental comparisons for cost–effectiveness are sometimes between entirely different programmes and sometimes between different levels of intensity within the same programme (Box 6.1).

Box 6.1. Stage 4: calculating the incremental cost–effectiveness ratio

After the differences in costs and effects are estimated, these two outcomes should be jointly assessed to determine whether the data support the value for the costs of one of the interventions being evaluated. The costs and effects can be compared by calculating an incremental cost–effectiveness ratio.

The incremental cost–effectiveness ratio is defined as:

$$\text{Cost}A - \text{Cost}B = \Delta C$$

$$\text{Effect}A - \text{Effect}B = \Delta Q$$

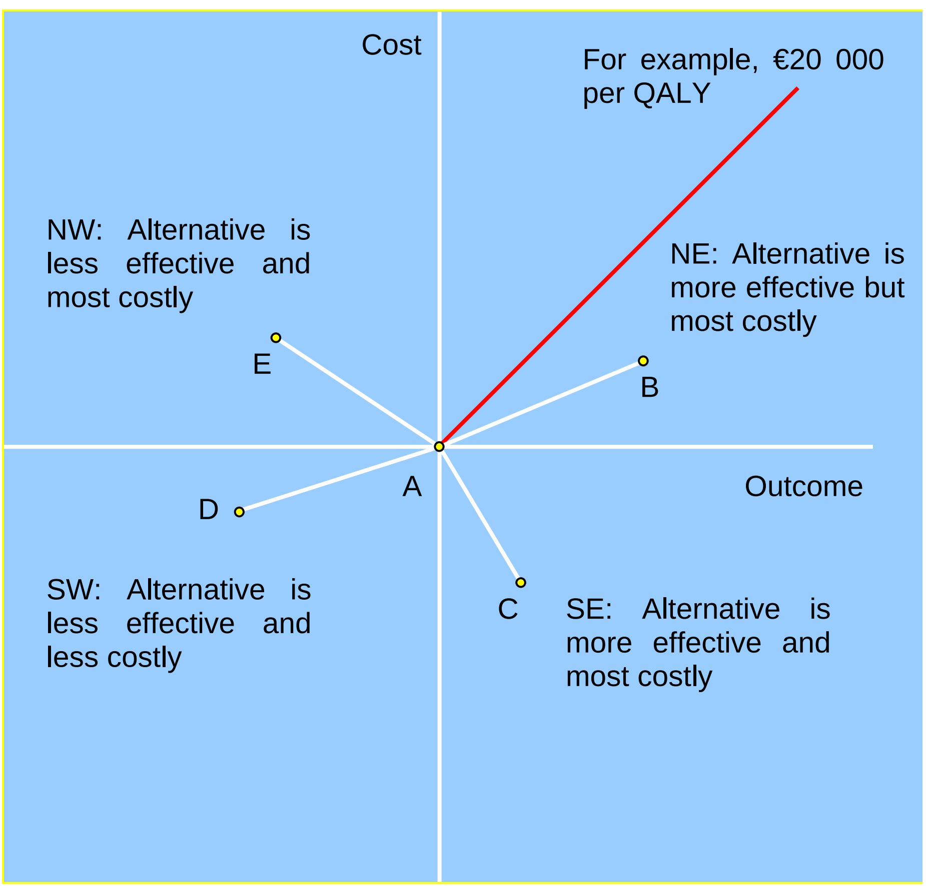
Where Cost_A is the arithmetic mean cost for intervention *A*; Cost_B is the arithmetic mean cost for intervention *B*; Effect_A is the arithmetic mean effect for intervention *A*; Effect_B is the arithmetic mean effect for intervention *B*; ΔC is the difference in cost; and ΔQ is the difference in effect.

Because of the number of calculations required, especially when multiple event pathways are involved, cost–effectiveness and cost–utility analysis are frequently carried out using computer spreadsheets, decision-analytical software or simulation software. Analysts can write their own software or use existing software that incorporates Monte Carlo simulation, state-transition models or decision-tree models *(13)*.

6.2 Incremental cost–effectiveness plane

The incremental cost and incremental effect can be represented visually using the incremental cost–effectiveness plane as represented in Fig. 6.1. The horizontal axis divides the plane according to incremental cost (positive above and negative below), and the vertical axis divides the plane according to incremental effect (positive to the right and negative to the left). This divides the incremental cost–effectiveness plane into four quadrants through the origin. Each quadrant has a different implication for the decision. If the incremental cost–effectiveness ratio for intervention *A* compared with intervention *B* is in the south-eastern quadrant, with negative costs and positive effects, intervention *A* would be more effective (better survival) and less costly than intervention *B*. Interventions in this quadrant are always considered cost–effective. If the incremental cost–effectiveness ratio is in the north-western quadrant, with positive costs and negative effects, intervention *A* would be more costly and less effective than intervention *B* (intervention *A* is more cost–effective than intervention *B*). Interventions in this quadrant are never considered cost–effective. If the incremental cost–effectiveness ratio is in the northeast quadrant, with positive costs and positive effects, or the south-western quadrant, with negative costs and negative effects, trade-offs between costs and effects need to be considered. These two quadrants represent the situation where intervention *A* may be cost–effective compared with intervention *B*, depending on the value at which the incremental cost–effectiveness ratio is considered good value for money.

Fig. 6.1. The incremental cost–effectiveness plane



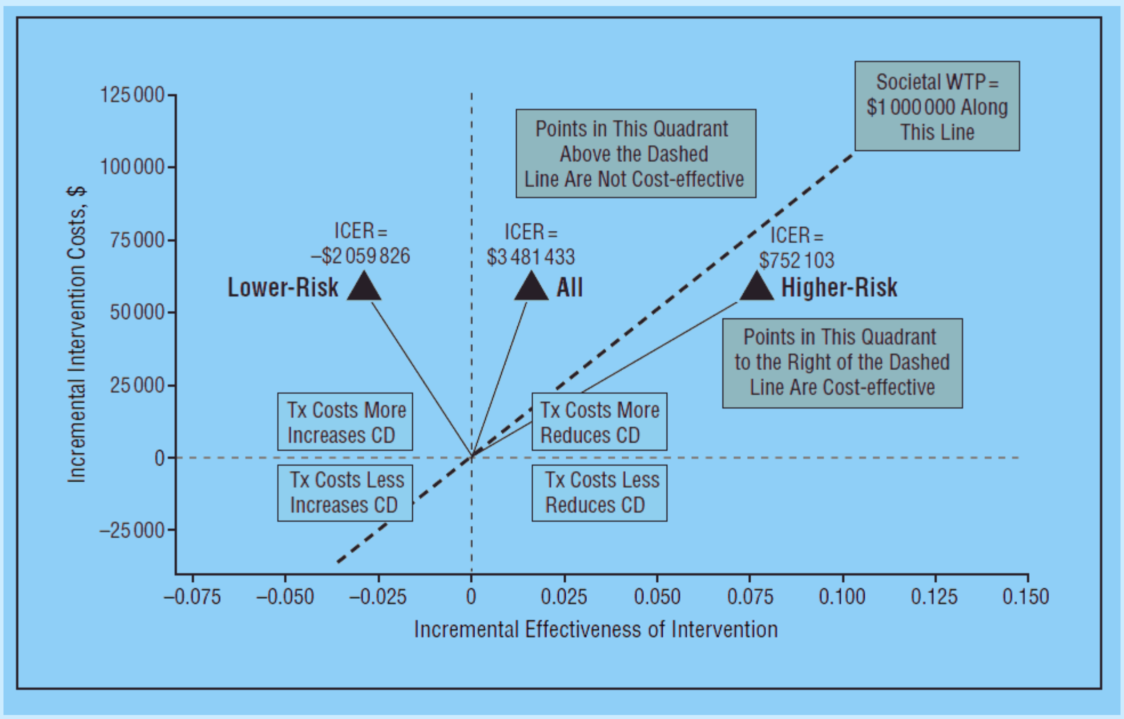
Box 6.1: Example – Use of incremental cost-effectiveness ratio plane

Aim of the study: To examine the cost-effectiveness of the Fast Track intervention, a multi-year, multi-component intervention designed to reduce violence among at-risk children.

Figure. Incremental cost-effectiveness ratios (ICERs) for Fast Track sample and subsamples (lower- and high-risk): incremental cost per case of conduct disorder (CD) averted. Each point represents the costs and effects of intervention/treatment (Tx) on the cost-effectiveness plane. The slope of the corresponding line is the incremental cost-effectiveness ratio. Effectiveness measure scaled such that the x-axis is the increase

in non disordered cases.

Figure Incremental Cost-Effectiveness Plane



Abbreviation: WTP, willingness to pay.

Using the so-called cost-effectiveness plane, the Figure provides a visual representation of the relationship between costs and effects. The figure plots these estimates for all youth in the study and for those at higher and lower risk as defined by behavior problems at baseline. The dashed lines at 0 (incremental) costs and no impact divide the plane into 4 quadrants. The vertical (dashed) line at 0 incremental effectiveness provides a threshold for whether or not the intervention is effective (reduces or increases conduct disorder). For each point, the slope of a line from that point to the origin equals the ICER. The willingness-to-pay line on this graph represents the limit for how much society is willing to pay in incremental intervention costs given a certain effect size of the intervention. Points to the right of that dashed line represent samples for which the intervention is cost-effective. The ICERs that fall in the area above the willingness-to-pay line but in the northeast quadrant represent samples for which the intervention is beneficial but not cost-effective.

Source: Can a Costly Intervention Be Cost-effective? An Analysis of Violence Prevention. Foster et. al (2006) (4)

6.3 Incremental cost–effectiveness threshold

The studies often made an adoption decision by comparing an intervention's cost–effectiveness ratio or net monetary benefit to a predefined standard (a maximum acceptable cost–effectiveness ratio or willingness to pay), such as €30 000 or €50 000 per QALY. In some research fields, there may be general agreement on the value of this maximum acceptable cost–effectiveness analysis ratio; in the injury field there is not.

Once the incremental cost–effectiveness ratio of a new intervention is calculated, the next question is when an intervention is considered cost–effective. In other words: when does an intervention present good value for money? The answer to these questions depends on the cost–effectiveness threshold used (Box 6.2) *(86)*. Different countries use different thresholds. In the United Kingdom, for instance, the National Institute for Health and Clinical Excellence uses a threshold value of £20 000 to £30 000 (about €24 000 to 36 000) per QALY *(87)*. In the Netherlands, a frequently cited threshold value is €20 000 per QALY *(88,89)*. However, it is argued that this threshold is too low and does not reflect societal preferences. In fact, reimbursement decisions on cancer drugs indicate that the actual threshold for health care is higher than €20 000 per QALY. Recently, the Council for Public Health and Health Care proposed a variable threshold, depending on the severity of the disease. The maximum value for this threshold was €80 000 per QALY.

Box 6.2. Example of a calculation of cost–effectiveness outcomes: characterizing the net cost and the quality of life effects associated with hip protector use among older people relative to no intervention

Base case results: cost–effectiveness per 500 000 population and implications

	Total net cost in millions of US dollars (1999)	Total net effectiveness		Implications for hip protector use[a]
		In lives	In QALYs	
Women (all)	(1 215)[b]	5 906	32 000	Recommend
65–74 years	(182)	579	4 000	Recommend
75–84 years	(553)	2 239	18,000	Recommend
85+ years	(480)	3 089	10,000	Recommend
Men (all)	(135)	5 962	(26 000)[c]	Do not recommend (US$ 6400 saved per QALY lost)
65–74 years	78	123	(25 000)	Do not recommend
75–84 years	(117)	1 429	(5 000)	Do not recommend (US$ 39 000 saved per QALY lost)
85+ years	(96)	1 109	4 500	Recommend (US$ 16 000 spent per QALY gained)

[a]Recommendation based on the following rationale.

- If the costs decline and QALYs increase, recommend.
- If the costs decline and QALYs decline, decide whether to recommend based on the cost–effectiveness ratio threshold of US$ 100 000 saved per QALY lost.
- If the costs increase and QALYs increase, decide whether to recommend based on the cost–effectiveness ratio threshold of US$ 100 000 spent per QALY gained.
- If the costs increase and QALYs decline, do not recommend.

[b]The total net costs are negative because the savings due to mortality and morbidity prevented exceeded the costs of hip protectors.

[c]The total QALYs are negative because the inconvenience of consistently wearing hip protectors exceeds the benefits in mortality and morbidity.

As seen in the table, use of hip protectors among women in this hypothetical cohort led to cost savings exceeding US$ 1.215 billion, 5906 fewer hip fracture–related deaths and 32 000 QALYs gained. The cost savings reflects the high incidence rate of hip fracture among this population and the low costs of the intervention. These cost savings and the QALY gains are particularly large during the decade from 75 to 84 years old due to the large number of women still alive in that group (409 000 at age 75 years versus 243 000 at age 85 years) and the much higher incidence rate of hip fracture in this age group. In fact, about half the costs saved and the QALYs gained due to hip protectors in this hypothetical cohort of women occurred during this age period (45% and 56%, respectively). Use of hip protectors among men led to an overall net cost savings of more than US$ 135 million, 5962 hip fracture–related deaths averted and a net loss of 25 000 QALYs. However, these findings differ as the cohort ages; hip protectors save costs only for men older

7. Analysis of data: adjusting for timing and uncertainty

7.1 Introduction

This chapter describes the adjustments for timing (discounting) and uncertainty (sensitivity analysis). Table 7.1 gives an overview of the research steps and the choices to be made.

Table 7.1. Step-by-step guide for adjusting for timing and uncertainty

Stage 5. Adjusting for timing and uncertainty	
Steps to be taken	**Modular approach**
5.1. Discounting costs and health effects	Discounting costs and effects by 3% annually
5.2. Sensitivity analysis	One-way and/or multi-way analysis[a]
	Search for plausible parameters[b], such as:
	• discounting: 0–6% cost and effects
	• cost–utility analysis: age weighting: yes or no
5.3. Probabilistic uncertainty analysis	Search for plausible parameters[b]

[a]The impact of uncertainty surrounding one parameter or around multiple parameters can be explored. [b]Plausible parameter: possible source of uncertainty.

7.2 Discounting

Step 5.1: discount costs and health effects

Discounting is the process of converting future values, such as costs or health effects, to their present values to reflect the belief that, in general, society prefers to receive benefits sooner rather than later and pay costs later rather than sooner. This discounting procedure gives less weight to future events.

Discounting future costs and health benefits is an issue of considerable debate. This debate concerns the arguments on why discounting is applied, the appropriate discount rate, the shape of the discount function and finding an objective measure for relevant differences between people over time.

The literature generally agrees about the need to discount costs and agrees somewhat about the likely value or range of the appropriate discount rate. There is less agreement about the need to discount health effects and, if so, whether the appropriate discount rate should be identical to that used for costs *(13,87,91)*. Given the current debates about discounting, the main emphasis should be on transparency in reporting the methods used.

Discounting future health and costs is a major issue because it can alter the results of economic evaluation studies considerably. Using a 5% discount rate implies that seven QALYs (gained) or DALYs (prevented) after 40 years are counted as about one QALY (gained) or DALY (prevented) this year. Likewise, discounting reduces the importance of the burden of diseases and injury among children relative to older people and might therefore result in morally unacceptable allocations between generations. In injury prevention, often focused on young people, the level of the discount rates can reduce the apparent net effectiveness of a programme dramatically. Proper justification of the discounting procedure is therefore required.

Making choices in health: the WHO guide to cost–effectiveness analysis (12) has more detailed information about the reasons for discounting costs and health effects.

The current guideline is to discount costs and effects at 3% in the base-case analysis *(12,87)*. The mechanics are straightforward. The discrete time formula for estimating the present value of any stream of costs is:

$$Cost_{present \cdot value} = \sum_{t=0}^{T} \frac{Cost}{(1+r)^t}$$

where r is the discount rate and t is the time period when the cost occurs. The appropriate rate of discount r is more controversial *(13)*.

7.3 Uncertainty in economic evaluation studies

Step 5.2: conduct sensitivity analysis

7.3.1 Three types of uncertainty

All estimates of costs and effects are subject to uncertainty, and the sources can be categorized in several ways *(13,92)*. This section describes three types of uncertainty: parameter uncertainty, model uncertainty and generalizability uncertainty *(12)*.

Parameter uncertainty arises for two reasons. The first is sample variation around estimates of the variables used to calculate a cost–effectiveness ratio, such as unit costs, adherence rates and the efficacy of an intervention. The second is because there is no agreement about the value judgements required for the cost–effectiveness and cost–utility analysis – the choice of the appropriate discount rate is an example *(13,92)*.

Model uncertainty relates to uncertainty around the appropriate functional form of a model used to estimate a particular parameter and the explanatory variables that should be included. For economic evaluation studies, this is most relevant when considering the joint effect of interventions on health. Trial data are often available for the effectiveness or efficacy of interventions undertaken singly but rarely for the joint impact of two or more interventions undertaken together. In this case, the joint impact needs to be modelled – most commonly assuming a multiplicative relationship between the effectiveness of the individual interventions – but this may not be the "truth" *(13)*.

The third type, generalizability uncertainty, relates to the need to extrapolate the results of studies. For example, clinical trials of a pharmaceutical product might have been undertaken in a low-risk patient group, but policy-makers need to know the cost–effectiveness of the product as the general population would use it. Further, costs might have been determined sometime in the past and need to be extrapolated to the present for the cost–effectiveness and cost–utility analysis.

7.3.2 Sensitivity analysis

This uncertainty is dealt with by using sensitivity analysis, which tests whether plausible changes in the values of the main variables affect the results of the analysis (Box 7.1). Uncertainty related to variables that carry value judgments should be subjected to one-way, and sometimes multi-way, sensitivity analysis.

Sensitivity analysis shows how varying parameters affects the cost–effectiveness ratio. With one-way analysis, each uncertain component of the evaluation is varied individually, while the others retain their base-case specifications to establish the separate effect of each component on the results. Multi-way sensitivity analysis involves varying two or more inputs at the same time and studying the effect on outcomes.

The analyst could choose to recalculate the cost–effectiveness ratio for a range of plausible values and identify whether the parameter could have a value at which the intervention would no longer be considered cost–effective. The important policy question then is the likelihood of the threshold value of the parameter occurring: the likelihood of the intervention not being less or more cost–effective than the alternative.

An alternative is to use analysis of extremes, in which the sensitivity analysis only includes the extremes of the range of plausible values, to determine whether the policy implications would change. If the intervention would be considered to be cost–effective even at the extremes, the analysis is said to be robust to changes in key assumptions.

Sensitivity analysis could be undertaken for any parameter used to construct the cost–effectiveness ratio. However, using probabilistic uncertainty analysis to explore the impact of variability in parameters that can be measured and for which there is an underlying probability distribution is preferable *(12)*. Sensitivity analysis is more relevant for variables that cannot be measured and for which there is no probability distribution. For cost–effectiveness analysis, this applies to the two key social choice variables: the discount rate and age weights. Neither parameter has a probability distribution. The base case for WHO-CHOICE includes age-weighting and a 3% discount rate for both costs and health effects. For sensitivity analysis, using analysis of extremes is recommended for these parameters. In the sensitivity analysis, testing the sensitivity of the results to a 0% discount rate for health effects and a 6% discount rate for costs is recommended. This involves recalculating all cost–effectiveness ratios in the absence of age-weighting and exploring the sensitivity of the results to a zero discount rate for health effects *(12)*.

Box 7.1. Example of sensitivity analysis

Aim of the study: to assess the cost–effectiveness of air bags for the driver and front passenger.

Methods: Future health effects and costs were discounted using a 3% annual discount rate. In sensitivity analysis, the outcomes were shown while using 5% and 0% discount rates.

Outcomes of the sensitivity analysis

Strategies	Total net cost (includes savings) per 10 million vehicles in millions of US dollars (1993)	Total effectiveness per 10 million vehicles, QALYs	Incremental cost per 10 million vehicles in millions of US dollars (1993)	Incremental effectiveness per 10 million vehicles, QALYs	Cos ef ct er s ra c in en nt U do ar pe in en nt Q L
Discounted results (3%)					
No air bags (manual lap-shoulder belts)	–1 357[a]	219 629	NA	NA	N
Driver's side air bag (plus manual restraints)	853	312 735	2 210	93 106	24 0

Step 5.3: conduct probabilistic uncertainty analysis

Sensitivity analysis has traditionally been used for uncertainty around the distribution of such parameters as unit costs, population effectiveness or initial incidence, but recently there has been interest in applying statistical methods to quantify the effect of these sources of uncertainty. The effect of uncertainty surrounding one parameter or around multiple parameters can be explored. For a decision-maker, the most important piece of information is whether the results are robust to all possible sources of uncertainty at the same time, and the statistical approaches therefore generally consider multiple sources of uncertainty simultaneously. However, the analyst reporting uncertainty around key parameters individually is often useful as a way of helping policy-makers understand the sources of the overall uncertainty.

The main application of this approach has been probabilistic uncertainty analysis using the method of bootstrapping. For one-way uncertainty analysis, repeated draws are performed from the distribution around each key variable to determine the probability distribution of the cost–effectiveness ratio. The number of draws should be sufficiently large to allow the estimated cost–effectiveness ratio to stabilize, usually a minimum of 1000. From this, 90% uncertainty intervals around the cost–effectiveness ratio can be generated using the simple percentile method, which involves omitting the lower and upper 5% of the estimates.

For multi-way uncertainty analysis, one draw is taken from the uncertainty range around each parameter simultaneously. The cost–effectiveness ratio is then estimated. This procedure is repeated a minimum of 1000 times, and the 90% confidence interval is calculated for the cost–effectiveness ratio, taking into account the variation around all parameters simultaneously.

Bootstrapping can be applied to sampled or non-sampled data. With sampled data, nonparametric bootstrapping is preferable: repeated draws can be taken from the sampled data with no need to specify a particular distribution. If sampled data are not available, the analyst needs to specify the upper and lower limits for each parameter to be used in the draws and the type of distribution that is likely to characterize the parameter. Analysis can be undertaken using a variety of standard statistical programmes—the analysis for WHO-CHOICE is based on @Risk 4.0 (Palisade Decision Tools).

So far the discussion has dealt with parameter uncertainty. Model uncertainty is more difficult to formally incorporate into cost–effectiveness and cost–utility analysis and is therefore not explored further here. Generalizability uncertainty can be incorporated in the same way as parameter uncertainty using probabilistic uncertainty analysis. The analyst must simply decide on the likely upper and lower limits of key parameters in the group or time period to which the results will be extrapolated.

For more detailed information, see *Making choices in health: the WHO guide to cost–effectiveness analysis (12)*.

8. Reporting the results of cost–effectiveness and cost–utility analysis

8.1 Introduction

Reports on the results of cost–effectiveness and cost–utility analysis must provide sufficient information to enable independent analysts to critically evaluate the estimates of the costs and effectiveness of the interventions studied. In addition, the analysts should be able to interpret the findings of the cost–effectiveness and cost–utility analysis and assess the possibility of generalizing them to their own decision-making context.

To enhance transparency and ensure accountability, all reports and all data input used in deriving the estimates, including assumptions, should be placed in the public domain. A report on cost–effectiveness and cost–utility analysis usually contains, or indicates sources for, a detailed description of the inputs and methods used to estimate the costs, effectiveness and cost–effectiveness ratios of the interventions studied. The checklist introduced by Drummond et al. *(11)* or a similar format may be used as a guide to analysts seeking to improve the quality of their study reports (Box 8.1).

Box 8.1. Checklist for assessing economic evaluation

- Was a well-defined question posed in answerable form?
- Were the competing alternatives described comprehensively?
- Was the effectiveness of the programmes or services established?
- Were all the important and relevant costs and effects for each alternative identified?
- Were costs and effects measured accurately in appropriate physical units?
- Were costs and effects valuated credibly?
- Were costs and effects adjusted for differential timing?

Source: Drummond et al. *(11)*.

Economic evaluation of interventions relies on the quality and transparency of the data collected. Any limitations in the quality of the data or in the description of it weaken any economic evaluation based on it. Reports on the results of cost–effectiveness and cost–utility analysis must provide sufficient information in the public domain to enable independent analysts and policy-makers to critically evaluate the validity of the estimates of the costs and effectiveness of the interventions studied.

This chapter outlines the key information to be reported with respect to the elements of cost–effectiveness and cost–utility analysis (Table 8.1).

Table 8.1. Step-by-step guide for reporting the results (stage 6: reporting results)

Steps to be taken	Modular approach
6.1. Reporting cost information	
6.2. Reporting effectiveness information	
6.3. Reporting uncertainty results	Providing information for each parameter
6.4. Reporting the incremental cost–effectiveness ratio	Presenting the information in a numerical form

8.2 Cost information

Step 6.1: report cost information

The main components of costs should be reported in a disaggregated form before being combined in a single index or ratio.

Reports should contain or discuss:

- information on the unit prices and quantities for the main factor inputs used to estimate programme costs, such as personnel, vehicles and office space;
- how the costs of care were estimated – for example, the cost per visit or bed-day and the costs of laboratory tests – and what assumptions were used, including questions of intervention coverage levels, capacity utilization, depreciation rates used to obtain capital costs;
- how productivity costs were estimated;
- whether the costs used in the study have face validity in terms of other costs reported in the literature, for example, and whether they were obtained from a sample of costs that are likely to be representative rather than based on a single observation;
- the results of sensitivity and uncertainty analysis; and
- space permitting (such as for web-based presentation of results), a detailed listing of the quantities and prices of the factor inputs used in the analysis .

Source: *Making choices in health: the WHO guide to cost–effectiveness analysis (12).*

Table 8.2 gives an example of how to present the costs in a scientific paper.

Table 8.2. Example of how to present costs: key unit costs in US dollars used to valuate the resources used measured in a trial to investigate the cost–efficacy of providing hip protectors and structured education in reducing hip fractures

Item of resource	Unit	Unit cost (US dollars)	Source
Resource use due to implementation of interventions			
Education material	Item	141	Invoice by the manufacturer
Nurses’ salary	Hour	21	Finance department of nursing homes in Hamburg, trade union for Germany’s service industry
Investigators’ salary	Hour	31	Finance department of the University of Hamburg
Travel expenses	Kilometre lump sum	0.2	
Hip protector	Item	40	Invoice by the manufacturer
Resource use due to hip fracture–related care:			
Physicians' consultation	Visit	27–39	Health insurance
Transport by ambulance	Event	283	
Hospital admission, days			
≤20	Lump sum	5342	
21–36	Lump sum	6621	
>36	Day	304	Finance department of the corresponding hospital
Inpatient rehabilitation	Day	131–220	
Outpatient physiotherapy	Lump sum per visit	24	Health insurance
Walking aid			
Wheelchair	Item	650	Health insurance, manufacturers
Rolling walker	Item	148	
Increased degree of disability			
From 0 to 1	Day	34	Germany’s social security code XI
From 0 to 2	Day	43	
From 1 to 2	Day	8.5	
From 2 to 3	Day	5.1	

Source: Meyer et al. *(94)*.

8.3 Effectiveness information

Step 6.2: report effectiveness information

Reports should contain or discuss:

- whether a systematic search for evidence on baseline epidemiology and effectiveness was undertaken, the criteria used for selecting sources, the assumptions made, etc.;
- quantitative documentation of the sources and assumptions used for:
  - (1) the main input variables in the analysis such as prevalence, incidence or remission rates and relative risk ratios, all of which should be reported for both the null and the intervention scenarios;
  - (2) how the effectiveness of each intervention was modelled, such as through a decrease in incidence, in duration, in remission or in mortality rates;
  - (3) other factors related to modelling health effects such as intervention coverage rates, adherence to medicines and follow-up visits and quality of services provided;
- the healthy years of life lived by the population under both the null and interventions scenarios and the difference between the two scenarios – representing the health gain of the intervention; and
- the results of sensitivity and uncertainty analysis.

Source: *Making choices in health: the WHO guide to cost–effectiveness analysis (12).*

8.4 Reporting uncertainty results

Step 6.3: report uncertainty results

To improve the usefulness of sensitivity and uncertainty analysis to decision-makers and analysts, an explanation should be provided for each parameter that has been varied. This should include the upper and lower limits used for probabilistic uncertainty analysis and the source(s) and the nature of the assumed distribution. Further, providing a summary of how uncertainty in each key variable separately affects the cost–effectiveness ratio is useful in understanding the source of overall uncertainty. This can be investigated formally using regression or correlation analysis of the simulation data, a feature contained in @Risk 4.0 (Palisade Decision Tools). The value of this is that it informs the analyst which uncertainty variable affects the cost–effectiveness ratio most and can guide researchers as to what future prospective research is the most beneficial in reducing uncertainty in the cost–effectiveness ratio *(12)*.

8.5 Reporting cost–effectiveness ratios

Step 6.4: report cost–effectiveness ratios

Reports should contain or discuss:

- both numerical and graphical documentation of cost–effectiveness ratios;
- cost–effectiveness ratios compared with the null for all interventions studied and incremental cost–effectiveness ratios for the interventions on the expansion path; and
- the expansion paths clearly identified either in tabular or graphical form for each set of inter-dependent interventions.

Source: *Making choices in health: the WHO guide to cost–effectiveness analysis (12)*.

The ultimate aim of an economic evaluation is to determine which option provides the best value for money. An incremental approach is generally adopted in which the additional costs that one alternative imposes over another are compared with the additional benefits provided.

9. Examples of economic evaluation by stages and steps

9.1 Example of cost–utility analysis: cost–utility of interventions to reduce falls among older women

The following is an example of an economic evaluation of interventions to prevent falls among older women in the Netherlands. This example is elaborated by using the step-by-step approach formulated in the guidance.

Unintentional falls are a major cause of injury and death among people older than 55 years and lead to high health care costs and disability.

Stage 1: study design

Step 1.1

The relationship between the health care costs and health effects of a multifactorial fall-reducing intervention by modelling incidence, mortality and trial results was investigated.

Multifactorial intervention, with screening on several risk factors followed by targeted intervention, is an effective measure when applied in a high-risk population: women 65 years and older with a history of falls presenting with a fall-related injury at an emergency department.

The model was used to compare the burden of unintentional fall injuries in two simulated older populations: one population receiving usual care and the other receiving multifactorial intervention. The target population was estimated by calculating the population-attributable risk *(95)* based on prevalence data for fall-related injuries and the relative risk of falling among people with a history of falls.

Step 1.2

Cost–utility analysis was performed.

Step 1.3

The cost–utility analysis was performed from a societal perspective.

Step 1.4

The implementation was simulated over a one-year period; the effects were calculated within a lifelong time horizon.

Steps 1.5 and 1.6

Both primary and secondary data were used for the analysis.

Primary data: injury data were extracted from 12 emergency department–based injury surveillance systems and a nationwide hospital discharge registry in the Netherlands. Injury-related mortality data were obtained from the Mortality Registry of Statistics Netherlands.

Secondary data: evidence on effectiveness of interventions was taken from a Cochrane review *(96)* indicating that multifactorial interventions for preventing unintentional falls among older people are effective.

Step 1.7

The following injuries are distinguished: skull-brain, arm fractures, hip fractures (including pelvic and femur shaft fractures), other lower extremity fractures and other injuries.

Stage 2: Estimating costs

Step 2.1

The direct health care costs with and without the intervention were estimated using the Dutch Burden of Injury Model *(97)*. The age- and injury-specific costs are based on the estimated health care supplied to the individual injured people.

Step 2.2

Health care utilization data were gathered from registry information (hospital discharge registries and emergency departments) and questionnaires administered among injured people sampled from the emergency department registry (*n* = 10 120).

Step 2.3

For each type of health service, the costs were determined per unit of volume that reflects real resource use. All unit costs were estimated according to national guidelines for health care costing *(98)*.

Step 2.4

The direct health care costs were calculated for five types of fall-related injuries in five-year age categories: head injuries, arm fractures, hip fractures, other lower extremity fractures and other injuries. The age- and injury-specific cost was multiplied by the number of prevalent injuries in the population of the Netherlands within each category.

The intervention costs were calculated by multiplying the assumed cost of €112.50 per individual measure with the estimated number of older people at risk.

Stage 3: estimate the effects

Step 3.1

The effect of the preventive measure was expressed as the number of injuries prevented and thus the number of lost DALYs prevented.

Step 3.2

Major risk factors for falls are a previous fall (a relative risk of 2.6 (95% confidence interval: 2.0–3.3 *(99)*), and the model basically assumed that the intervention was 50% effective *(100)*. The prevalence of fall-related injuries was derived from emergency department injury surveillance data. The age-specific population-attributable risk describes which part of the injured population suffered a fall injury in the past:

Population-attributable risk = prevalence × (relative risk – 1)/(prevalence × (relative risk – 1) + 1).

Step 3.3

Disability weights were estimated with data from the Dutch Burden of Injury Model.

Step 3.4

Mortality data were obtained from the Causes of Death Registry of Statistics Netherlands.

Step 3.5

Health care effects were expressed in DALYs, measured with mortality data (years of life lost) and information about disability (years lived with disability). The functional outcome and incidence of fall injuries were estimated with data from a national injury surveillance system and the national hospital discharge database *(6)*.

Table 9.1 shows the age-specific prevalence and mortality of fall-related injuries among older people in the Netherlands in 2008. The population-attributable risk in the reference population reflects the proportion of victims with a history of falls. Of all fall-related injuries in the surviving population, 3877 injuries were related to previous falls, and the direct health care costs were €32 million.

Table 9.1. Estimated prevalence, fatality and population-attributed risk among community-dwelling older women

	Prevalence in the total population	Prevalence and fatality in the community			Injuries related to previous falls with no intervention				
Age (years)	***n***	***n***	**Dead**	**Prevalence rate of injury**	**Relative risk**	**Population-attributable risk**	***n***	**Mean cost (in 1 000 €)**	**Cost (in 1 000 €)**
65–69	7 612	7 497	21	0.0211	2.6	3.3%	245	3.30	792
70–74	8 506	8 359	42	0.0268	2.6	4.1%	344	3.89	1 299
75–79	10 228	10 001	102	0.0376	2.6	5.7%	567	6.36	3 477
80–84	11 228	10 870	220	0.0547	2.6	8.0%	875	7.67	6 423
85–89	8 537	8 142	290	0.0816	2.6	11.5%	940	11.08	9 919
90–94	4 331	4 012	266	0.1177	2.6	15.9%	636	12.22	7 281
95–99	1 375	1 229	128	0.1756	2.6	21.9%	270	12.23	2 900
Total	51 817	50 110	1 069				3 877		32 091

Source: emergency department injury surveillance system, Dutch Burden of Injury Model, 2008.

Stage 4: present the results of the cost–utility analysis

Table 9.2 presents the results of intervention, assuming a 50% reduction in injuries.

The savings in direct health care costs were subtracted from the expenses for the intervention.

At the ages of 65–69 years, the cost is estimated to be €843 000 – €396 000 = €448 000, as the number of DALYs prevented was 55. The incremental cost–effectiveness ratio is calculated as €448 000/55= €8084 per DALY prevented.

The age-specific incremental cost–effectiveness ratio is calculated to be less than zero at the age of 75 years and older.

Table 9.2. Results of the cost–utility analysis of the multifactorial intervention among women 65 years and older

Age (years)	Injuries prevented (*n*)	Savings[a] (in 1 000 €)	Intervention cost (in 1 000 €)	Net cost[b] (in 1 000 €)	DALYs lost prevented	Incremental cost–effectiveness ratio (€ per DALY)
65–69	123	396	843	–448	55	8 084
70–74	172	650	940	–291	43	6 791
75–79	284	1 738	1 125	613	63	<0
80–84	437	3 211	1 223	1 989	117	<0
85–89	470	4 959	916	4 270	118	<0
90–94	318	3 641	451	3 350	108	<0
95–99	135	1 450	138	1 337	41	<0
Total	**1 939**	**16 045**	**5 637**	**10 821**	**547**	**<0**

[a]Savings in direct health care costs. [b]Intervention cost savings. [c]DALYs related to injuries prevented.

Stage 5: adjust for timing and uncertainty

The analysis was repeated using the lower and upper ranges of the confidence interval of the relative risk estimate on previous falls, 2.0 and 3.3 respectively. Thus, lower and higher ranges for population-attributable risk were calculated. Table 9.3 presents the results. The total savings were calculated respectively at €5.3 million and €16.7 million. As expected with a lower population-attributable risk, the incremental cost–effectiveness ratio for 65–74 years was estimated higher: between about €17 000 and €19 500 per DALY lost prevented.

For a higher population-attributable risk, the estimated incremental cost–effectiveness ratios were lower: €380 to €3599 per DALY lost prevented.

Table 9.3. Results of the sensitivity analysis of the cost–utility analysis results

	Relative risk = 2.0			Relative risk = 3.3		
Age (years)	**Cost (in 1 000 €)**	**DALYs**	**Euros per DALY**	**Cost (in 1 000 €)**	**DALYs**	**Euros per DALY**
65–69	–593	35	16 926	–282	78	3 599
70–74	–528	27	19 430	–23	60	380
75–79	15	40	–	1 313	88	–
80–84	847	76	–	3 237	163	–
85–89	2 550	77	–	6 097	162	–
90–94	2 129	72	–	4 604	146	–
95–99	875	28	–	1 789	54	–
Total	**5 265**	**356**	**–**	**16 734**	**752**	**–**

9.2 Example of cost–benefit analysis: cost–effectiveness of preventing bicycle-spoke injuries among children aged 2–5 years

The following is an example of an economic evaluation of an intervention to prevent bicycle-spoke injuries among children 2–5 years old by using spoke guards in the Netherlands. This example is elaborated by using the step-by-step approach formulated in the guidance.

Background

A bicycle-spoke injury is an injury of the foot, ankle and/or lower part of the leg caused by the entrapment of a person's foot between the frame of a bicycle and usually the spokes of its rear wheel *(101)*. Children 2–5 years old run the highest risk because they are more often transported on the back of the bike. Most of these injuries are considered preventable because child seats, spoke covers and even overcoat guards were not present at the time of the crash or injury *(101)*.

About 460 000 children 2–5 years old (57%) are transported at least once a week seated on a bicycle carrier *(102)*. Almost 1% of these children had a spoke injury and visited the emergency department per year. Observation of child transport in three cities in the Netherlands showed that more than half the children were not carried safely *(103)*.

The intervention included distributing information about risk and intervention related to spoke incidents to the parents of young children and offering spoke guards at the price of €5 per set.

Step 1: study design

Step 1.1

Estimating the relationship between the benefit and cost of a promotional campaign using spoke guards to prevent injuries.

Step 1.2

Cost–benefit analysis was performed.

Step 1.3

The cost–benefit analysis was performed from a health perspective.

Step 1.4

The implementation was simulated over a one-year period; the effects were calculated within a one-year period.

Steps 1.5 and 1.6

Both primary and secondary data were used for the analysis.

Primary data: injury data were extracted from 12 emergency department-based injury surveillance systems and a nationwide hospital discharge registry in the Netherlands. Injury-related mortality data were obtained from the Mortality Registry of Statistics Netherlands.

Secondary data: exposition data were derived from an observational study. The study describes the result of systematic observation of child transport in three locations in the Netherlands *(103)*.

Step 1.7

The following injuries are distinguished: lower extremity fractures, ankle sprain, wounds and superficial injuries.

Step 2: estimate the costs

Step 2.1

The direct health care costs with and without the intervention were estimated using the Dutch Burden of Injury Model *(97)*. The age- and injury-specific costs are based on the estimated health care supplied to the individual injured people.

Step 2.2

Health care utilization data were gathered from registry information (hospital discharge registries and emergency departments) and questionnaires were administered among injured people sampled from the emergency department registry (*n* = 10 120). The injured people responded to questions about their injury-related health care use, absenteeism and quality of life during the two years after their first emergency department visit.

Step 2.3

For each type of health service, we determined the costs per unit of volume that reflects real resource use. All unit costs were estimated according to the national guidelines for health care costing *(98)*.

Step 2.4

The direct health care costs were calculated for all bicycle spoke injuries among children.

The age- and injury-specific costs were multiplied by the number of injuries occurring in the population of the Netherlands within each category.

The intervention costs were calculated by multiplying the assumed cost of €5–15 per individual measure by the estimated number of children at risk.

Step 3: estimate the effects

Step 3.1

The effects of the preventive measure were expressed as the cost savings (or net benefits) of the reduction in bicycle spoke injuries among children.

Step 4: results of the cost–benefit analysis

The analysis basically assumed that the intervention was 0–10% effective. The incidence of bicycle spoke–related injuries was derived from emergency department injury surveillance data.

The total burden of spoke injuries among children 2–5 years old is estimated to be €2.06 million per year, a mean of €600 per injury. Other costs such as absenteeism of the parent were not included in the analysis.

The savings on direct health care costs were based on the number of injuries prevented multiplied by the mean direct health care cost (€600).

The cost of intervention included the cost of information products and distribution among child-care centres and bicycle dealers, €40 000, and the cost of spoke guards (percentage of the population for whom an injury was prevented times €5).

The analysis assumed that 50% of the children were not carried safely (*n* = 230 000). We calculated the prevention cost and the savings of direct health care costs for a 2.5–10% reduction in unsafe bicycle transport of children (Table 9.4).

Table 9.4. Results of cost-benefit analysis of measures preventing spoke injuries in the Netherlands

	Effect size				
Reduction in unsafe bicycle transport	0.0%	2.5%	5.0%	7.5%	10.0%
Number of children carried unsafely	230 000	225 000	220 000	215 000	205 000
Number of spoke injuries presenting at emergency departments	3 350	3 250	3 150	3 100	3 000
Savings in direct health care costs	0	€50 000	€100 000	€150 000	€200 000
Cost of safeguards	0	€29 000	€57 500	€86 000	€115 000
Cost of intervention	€40 000	€40 000	€40 000	€40 000	€40 000
Benefit–cost ratio	–	0.73	1.03	1.19	1.29

If 5% of the parents undertake preventive measures at the cost of €57 500, the savings on direct health care costs nearly equal the total prevention cost of €97 500 (= €57 500 + €40 000). The benefit–cost ratio is 1.03, the benefit of health care savings divided by the intervention cost. Assuming that 10% of the parents are willing to use the safeguards at the cost of €115 000, the estimated savings on direct health care costs exceeds the total cost of the intervention: €200 000 versus €155 000, a benefit–cost ratio of 1.29.

10. Generalizability of economic evaluation studies

Economic evaluation studies can guide resource allocation decisions by shifting resources away from the interventions that are costly in terms of the health gains they generate and towards interventions that provide better value for money.

10.1 Problems with generalizability

Policy-makers and programme managers must be aware that several factors can influence the results and therefore the transferability of economic evaluation studies. An issue that can affect generalizability is the fact that many economic evaluations are context-specific and cannot be used in other populations. Population characteristics (such as age, sex, ethnicity or risk factor behaviour) and environmental factors may predispose people to a particular injury problem. The costs and the effectiveness of the intervention will vary across populations, creating differences in cost–effectiveness outcomes. If possible, those evaluating an intervention that serves groups of people with different characteristics should calculate population-specific cost–outcome measures in addition to a total measure.

Second, the effectiveness of an intervention can depend on the scale of the intervention.

Third, the presence of other programmes can influence the cost–outcome results because of interactions between programmes.

10.2 The use of league tables

League tables that rank interventions in terms of their cost per unit of outcome are a tool that can be used to compare the efficiency of interventions *(8)*. League tables rank interventions in terms of their cost per unit of outcome, with the lowest cost per unit of outcome generally at the top of the league table and those with the highest cost per unit of outcome ranked at the bottom. Using league tables, policy-makers and programme managers can choose to provide the interventions higher up on the league table. In injury prevention and control, Vahidnia & Walsh *(104)* have constructed a league table for road safety interventions in the United States of America. Further, Miller & Levy *(105)* have presented cost–outcome measures across all injury causes for the United States of America (but not ranked).

The problems with generalizability do not invalidate the use of economic evaluation evidence as an important component of health care decision-making but necessitate a warning against simplistic approaches, such as constructing league tables that purport to rank a wide variety of health care programmes according to their efficiency. The appropriate use of economic evaluation evidence requires detailed consideration of the quality of the evidence along with thoughtfully assessing the threats to transferability to one's own setting and even, in some cases, recalibrating study results to fit better in the specific context of application (such as recalculating the cost–effectiveness, substituting prices relevant to one's own setting for those from the study setting) *(12,29)*.

The difficulty in generalizing context-specific cost–effectiveness and cost–utility analysis studies is institutionalized by the proliferation of multiple national and subnational guidelines for cost–effectiveness and cost–utility analysis practice, all using slightly different methods. International guidelines have not yet been developed *(12)*.

Further, when intervention packages are selected in a resource-constrained environment, interventions with the lowest cost per unit of health gain are not necessarily always the best choice *(8)*. Other alternatives may yield more benefits but at a slightly higher cost per unit of health gain. In addition, choosing interventions to address a problem requires weighing the overall size of the problem and the benefits per monetary unit invested. Interventions with lower benefits per monetary unit invested that address problems affecting a larger target population can prevent more injuries than those with higher benefits per monetary unit invested that affect a smaller target population.

10.3 Transferability of economic evaluation results

Most health technologies are evaluated in only a few countries. As a result, decision-makers often face the question of whether the results from studies in other countries can be transferred to their country or whether they need to ask for a new national study to be conducted. Due to monetary or time constraints, the second option is often not possible, leaving the decision-makers with the study results from other countries *(106)*. Assessing and improving the transferability of study results is therefore increasingly being recognized as an important research field. Welte et al. *(106)* developed a checklist for the transferability of study results to another country.

10.4 Barriers to using economic evaluation studies in decision-making

The barriers to using economic evaluation studies in health care decision-making are accessibility and acceptability. The accessibility of the research evidence including issues such as difficulty in interpretation, the aggregation of results, difficulty in accessing information, timeliness and shortage of relevant skills. The acceptability of the research evidence includes a whole range of barriers that prevent or provide negative incentives for implementing the findings of cost–effectiveness studies.

Making the information accessible requires that end-users be able to readily understand and interpret the results of the economic analysis. This is mainly concerned with how information is presented. Presentational issues are important for two aspects of the results of cost–effectiveness studies: base-case results and uncertainty around the base case. Particular difficulties are likely to exist in notions of the uncertainty in the results of analysis, primarily because policy-makers typically are not trained in research methods and are liable to misunderstand statistical representations of uncertainty.

For the information to be acceptable, economic analysis must provide information that end-users consider relevant, providing data on parameters that are likely to influence the decision of the policy-makers and that are appropriate to the decisions they face, taking into account relevant contextual factors.

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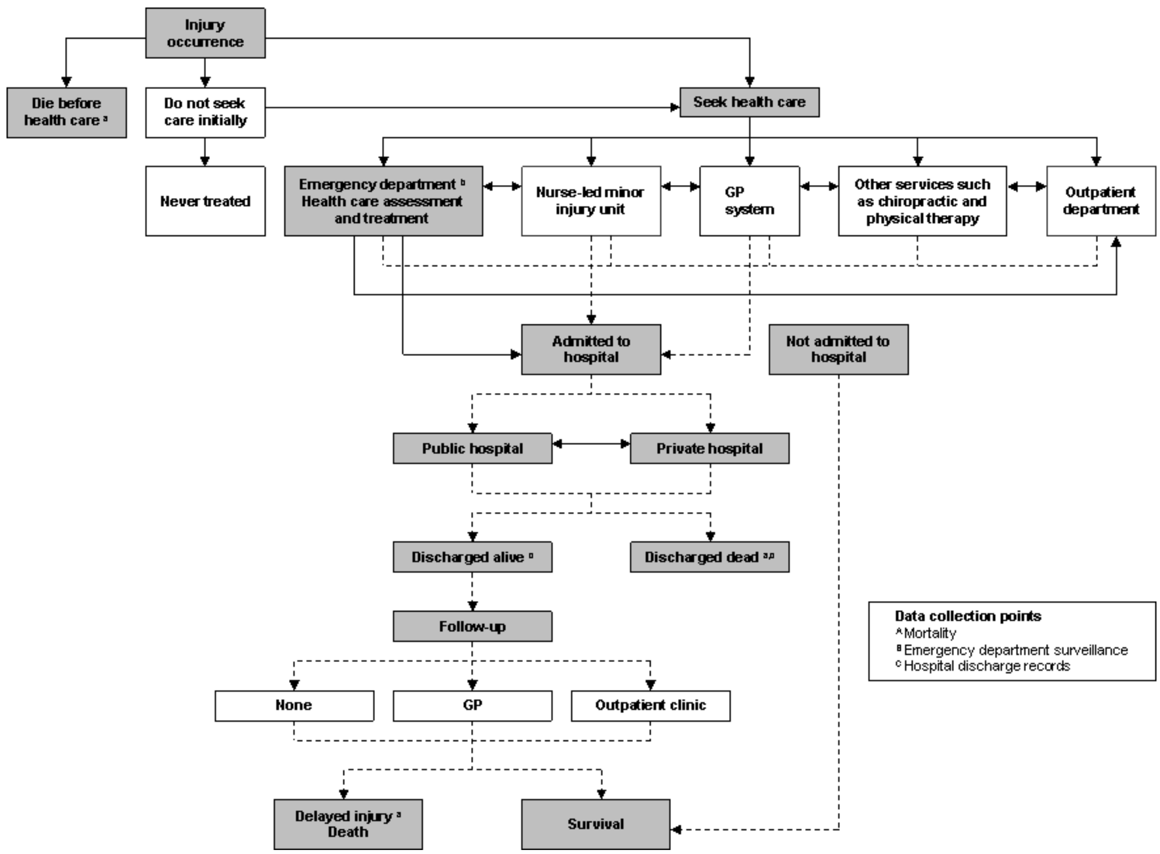
Annex 1. Health care flow diagram for acute injury



Source: Lyons *(1)*.

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Annex 2. EUROCOST injury groups

EUROCOST data set definition of injury groups according to the European Home and Leisure Accident Surveillance System (EHLASS) codebook *(1)* and ICD-9 and ICD-10 codes

Injury group	Type of injury	Part of body injured	ICD-9CM	ICD-10
Head				
1. Concussion	1	10	850	S06.0
2. Other skull-brain injury	2, 5, 8–9, 11	10, 11	800–801, 803–804, 851–854, 950–951	S02.0–1, S02.7, S02.9, S06.1–9, S04.0–9, S07.1–9, T02.0, T04.0
3. Open wound, head	4	11, 12	873.0, 873.1	S01.0, S08.0
Face				
4. Eye injury	1–99	13	870–871, 918	S01.1, S05.0–9
5. Fracture, facial bones	5, 6	14, 16	802	S02.2–6, S02.8
6. Open wound, face	4	14, 16, 18, 19	872, 873.2–9	S01.1–9, S08.1–9, S09.2
Vertebrae or spine				
7. Fracture, dislocation, sprain or strain	5–7	23, 32, 42	805, 839.0–5, 846, 847.1–9	S12.0–7, S12.9, S13.0–3, S13.6, S22.0–1, S23.0–1, S23.3, S29.0, S32.0–2, S33.0–2, S33.5–7, T02.1, T03.0–1, T08, T09.2
8. Whiplash, neck sprain or distortion of the cervical spine	7, 99	29	847.0	S13.4
9. Spinal cord injury	8	23, 32, 42	806, 952	S14.0–1, S24.0–1, S34.0–1, S34.3, T06.1, T09.3
Abdomen or thorax				
10. Internal organ injuries	1–99	33, 34, 41	860–869, 900–902, 926, 929	S26.0–9, S27.0–9, S29.7, S36.0–9, S37.0–9, S39.6–9, T06.5
11. Fracture, rib or sternum	5	31, 38–39	807.0–3, 809	S22.2–4, S22.8–9
Upper extremities				
12. Fracture, clavicle or scapula	5	50–51	810–811	S42.0–1, S42.7–9
13. Fracture, upper arm	5	52	812.0–3	S42.2–3
14. Fracture, elbow or forearm	5	53–54	812.4–5, 813.0–3, 813.8–9	S42.4, S52.0–4, S52.7–9

Injury group	Type of injury	Part of body injured	ICD-9CM	ICD-10
15. Fracture, wrist (including carpal bones)	5	55	813.4–5, 814	S52.5–6, S62.0–1
16. Fracture, hand or fingers	5	56–57	815–817	S62.2–8
17. Dislocation, sprain or strain, shoulder or elbow	6–7	51, 53	831–832, 840–841	S43.0–7, S53.0–4
18. Dislocation, sprain or strain, wrist, hand or fingers	6–7	55–57	833–834, 842	S63.0–7
19. Injury of nerves	8	50–59	953.0–1, 953.4, 955	S14.2–4, S24.2, S44, S54, S64, T11.3
20. Complex soft tissue injury	9–12	50–59	880.2, 881.2, 882.2, 883.2, 884.2, 885–887, 903, 927	S45–S49, S55–S59, S65–S69, T04.2, T05.0–2, T11.4–9
Lower extremities				
21. Fracture, pelvis	5	44	808	S32.3–8
22. Fracture, hip	5	60	820	S72.0–2
23. Fracture, femur shaft	5	61	821.0–1	S72.3, S72.7–9
24. Fracture, knee or lower leg	5	62–63	821.2–3, 822, 823	S72.4, S82.0–2, S82.4, S82.7–9
25. Fracture, ankle	5	64	824	S82.3, S82.5–6
26. Fracture, foot (excluding ankle)	5	65–66	825, 826	S92.0–9
27. Dislocation, sprain or strain, knee	6–7	62	836, 844	S83.0–7
28. Dislocation, sprain or strain, ankle or foot	6–7	64–66	837–838, 845	S93.0–9
29. Dislocation, sprain or strain, hip	6–7	60	835, 843	S73.0–1
30. Injury of nerves	8	60–69	953.2–3, 953.5, 956	S34.2–8, S74, S84, S94, T13.3
31. Complex soft tissue injury	9–12	60–69	890.2, 891.2, 892.2, 893.2, 894.2, 895–897, 904, 928	S15.1, S75–S79, S85–S89, S95–S99, T04.3, T05.3–5, T06.3, T13.4–9, T14.5
Minor external				
32. Superficial injury (including contusions): distinguish between contusions (2) and abrasions (3)	2–3	12–20,28–31, 38–40, 43–99	910–917, 919–924	S00, S10, S20, S30, S40, S50, S60, S70, S80, S90, T00, T09.0, T11.0, T13.0, T14.0
33. Open wounds	4	28–31, 38–40, 43–99	874–884 (excluding 880.2, 881.2, 882.2, 883.2, 884.2), 890–894 (excluding 890.2,	S11, S21, S31, S41, S51, S61, S71, S81, S91, T01

Injury group	Type of injury	Part of body injured	ICD-9CM	ICD-10
			891.2, 892.2, 893.2, 894.2)	
34. Burns	14–15	12–20, 28–31, 38–40, 43–99	940–949	T20–T32
35. Poisoning	13	10–99	960–989	T36–T65
36. Multi–trauma	–	–	Several combinations	Several combinations
Other injuries				
37. Foreign body	–	–	930–939	T15–T19
38. No injury after examination	97	10–99	–	–
39. Other and unspecified injury	All other combinations		807.4–6, 818–819, 827–829, 830, 839.6–9, 848, 953.8–9, 954, 957, 925, 959, 990–995	Other codes
Not included			905–909 (late consequences), 958 (early complications), 996–999 (medical complications)	

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Annex 3. Global Burden of Disease disability weights for injuries by age group

	Age (years)									
Short-term disability weights	Treated					Untreated				
Injury category	0–4	5–14	15–44	45–59	60+	0–4	5–14	15–44	45–59	60+
Fractured skull	0.431	0.431	0.431	0.431	0.431	0.431	0.431	0.431	0.431	0.431
Fractured face bones	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223
Fractured vertebral column	0.266	0.266	0.266	0.266	0.266	0.266	0.266	0.266	0.266	0.266
Fractured rib or sternum	0.199	0.199	0.199	0.199	0.199	0.199	0.199	0.199	0.199	0.199
Fractured pelvis	0.247	0.247	0.247	0.247	0.247	0.247	0.247	0.247	0.247	0.247

Fractured clavicle, scapula or humerus	0.153	0.153	0.136	0.136	0.136	0.153	0.153	0.136	0.136	0.136
Fractured ulna or radius	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180
Fractured hand bones	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
Fractured femur	0.372	0.372	0.372	0.372	0.372	0.372	0.372	0.372	0.372	0.372
Fractured patella, tibia or fibula	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271
Fractured ankle	0.196	0.196	0.196	0.196	0.196	0.196	0.196	0.196	0.196	0.196
Fractured foot bones	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077
Other dislocation	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074
Dislocation of shoulder, elbow or hip	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074
Sprains	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064
Intracranial injuries	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359
Internal injuries	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
Open wound	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108
Injury to eyes	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108
Crushing	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218
Burns <20%	0.158	0.158	0.158	0.158	0.158	0.156	0.156	0.156	0.156	0.156
Burns >20% and <60%	0.441	0.441	0.441	0.441	0.441	0.469	0.469	0.469	0.469	0.469
Burns >60%	0.441	0.441	0.441	0.441	0.441	0.469	0.469	0.469	0.469	0.469
Injured nerves	0.064	0.064	0.064	0.064	0.064	0.078	0.078	0.078	0.078	0.078
Poisoning	0.611	0.611	0.608	0.608	0.608	0.611	0.611	0.608	0.608	0.608

	Age (years)									
Long-term disability weights	**Treated**					**Untreated**				
Injury category	**0–4**	**5–14**	**15–44**	**45–59**	**60+**	**0–4**	**5–14**	**15–44**	**45–59**	**60+**
Fractured skull	0.350	0.350	0.350	0.350	0.404	0.410	0.410	0.410	0.419	0.471
Injured spinal cord	0.725	0.725	0.725	0.725	0.725	0.725	0.725	0.725	0.725	0.725
Fractured femur	0.272	0.272	0.272	0.272	0.272	0.272	0.272	0.272	0.272	0.272
Intracranial injuries	0.350	0.350	0.350	0.350	0.404	0.410	0.410	0.410	0.419	0.471
Injury to eyes	0.301	0.300	0.298	0.298	0.298	0.354	0.354	0.354	0.354	0.354
Amputated thumb	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165
Amputated finger	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102
Amputated arm	0.257	0.257	0.257	0.257	0.257	0.308	0.308	0.308	0.308	0.308
Amputated toe	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102
Amputated foot	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300
Amputated leg	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300
Burns <20%	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002
Burns >20% and <60%	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255

Burns >60%	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255
Injured nerves	0.064	0.064	0.064	0.064	0.064	0.078	0.078	0.078	0.078	0.078

Source: Mathers CD et al. *Global Burden of Disease in 2002: data sources, methods and results*. Geneva, World Health Organization, 2003 (http://www.who.int/healthinfo/paper54.pdf, accessed 1 September 2010).

Annex 4. Web tools to calculate the direct health care costs of injury

The injury field is very dynamic and heterogeneous. Priority-setting is therefore extremely important for policy-makers within this field to efficiently reduce the national burden of injuries. Priority-setting is preferably based on a set of reliable indicators of population health, including information on the health care costs of injury. Information about costs is an important supplement to epidemiological data, such as the incidence and mortality rates. Within the framework of the EUROCOST project, a uniform method to calculate the direct health care costs of injury was developed from 2001 to 2004 and applied to 10 EU countries (for more detail on the methods, see the published final reports on this project *(1,2)*). This method allows the direct health care costs of injury to be calculated by sex, age, external cause and type of injury at the country level and EU level. Moreover, due to several harmonization procedures, meaningful international comparisons of injury incidence and costs can be made.

In 2006, a project called Economic Consequences of Injury started as part of Work Package 2 of the EU-funded APOLLO project. This project elaborates on the EUROCOST project. The methods developed, including the steps to further harmonize the surveillance data, were used within the APOLLO project to support EU countries in calculating the direct health care costs of injury by making them available on the Internet. EU countries can apply the method (collection, harmonization and analysis of data on injury incidence and related use of health services and costs calculations) themselves by making use of guidelines and tools developed within the APOLLO project. These guidelines and tools have been made available on the EuroSafe web site *(3)*.

Methods to support EU countries in calculating the indirect costs of injury with uniform methods have also been explored and reported in the final report of the APOLLO project *(4)*. The final report describes approaches to measure and valuate productivity costs (indirect costs) arising as a result of injuries. A set of minimum data requirements necessary to generate estimates of these costs is provided (using the friction-cost and human-capital approaches). Because data for calculating productivity costs may not be available from existing sources in many countries, a systematic process is described for calculating productivity costs from a sample of relevant facilities.

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Economic evaluation plays an increasing role in prioritizing the implementation of the treatment and prevention of both unintentional and intentional injuries. Policy-makers and decision-makers generally need information about the effectiveness of an intervention in relation to its costs to assess whether an intervention provides good value for money. A review of the literature has shown that few methodologically robust and comparable studies have been undertaken in the field of injury prevention. This document has been written to provide step-wise guidance on the use of standardized methods to conduct cost-effectiveness and cost-utility analyses on injury prevention interventions, thereby contributing to a larger body of such evidence. The added value of this guide is that it links general guidelines on economic evaluation studies to a step-by-step guide for performing economic evaluation studies of injury prevention interventions. It focuses on the specifics of health outcomes and costs in injury prevention. It is hoped that the framework provided in this document will assist public health experts, researchers and policy-makers who are interested in estimating the cost–effectiveness and cost–utility of injury prevention programmes. The use of this document will hopefully contribute to increasing the evidence base of economic evaluations of injury prevention programmes in the European Region.

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