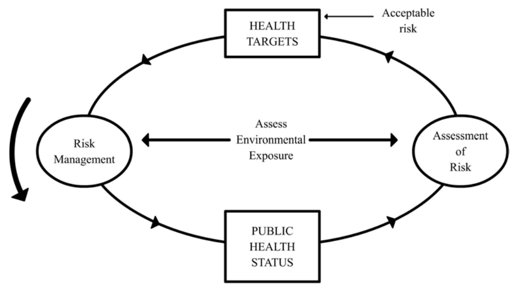

15

Economic evaluation and priority setting in water and sanitation interventions

Guy Hutton

There is always a need to weigh up costs against benefits and in doing so one of the more difficult problems is to come up with a monetary measure for different benefits. This chapter examines some of the instruments available to guide priority-setting and their use in assessing water and sanitation interventions.

15.1 INTRODUCTION

The discipline of economics essentially deals with the allocation of scarce resources amongst competing alternatives, with the aim of maximising an outcome of interest (e.g. profit, health or social welfare). In the health arena, policy makers and programme managers are constantly faced with economic

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decisions: how to spend a limited budget and have the biggest impact on health? The technique of economic evaluation can contribute to these decisions by providing information on the costs and benefits of alternative interventions, summarising information in a cost-effectiveness or cost-benefit ratio. In addition to the information it provides economic evaluation helps to bring elements of transparency and objectivity to policy making.

Water and sanitation interventions provide an interesting but challenging application of economic principles to resource allocation issues. The challenge is partly that economic evaluation guidelines were developed to evaluate health interventions provided by core health services, with a focus on health sector costs and benefits. However, like many environmental interventions aimed at improving or sustaining health, water and sanitation interventions are different in that:

- they are more likely to be regulatory in nature (such as the meeting of quality criteria)
- they involve cross-sector collaboration and are often financed by non-health agencies (Varley *et al*. 1998)
- they provide large non-health benefits (such as time saving, increasing amenity etc.) which are important to consider (Hutton 2000)
- they are less amenable to controlled trials to evaluate effectiveness (due to confounding factors, for example Blum and Feachem 1983)
- different studies have reported wide ranges of effect (Esrey *et al*. 1985) leading to difficulties in generalising results between different settings.

The implication of these aspects is that appropriate methods for evaluating water and sanitation interventions have remained underdeveloped, and subsequently there are few published studies that have dealt with the economics of water and sanitation interventions in a comprehensive or satisfactory way (Hutton 2000).

Another particular challenge faced in implementing water and sanitation interventions in developing countries is that the expenditure patterns required to meet current guidelines and standards are unrealistic in many developing countries (WHO 1997). This requires many resource-poor countries to make choices over which quality standards they should meet using a risk-benefit or economic evaluation approach, since meeting some quality standards may be less expensive and/or have a larger health effect than others. However, again, there is remarkably limited evidence on the cost-effectiveness of water and sanitation interventions to make these choices (Hutton 2000).

Therefore, the overall aim of this chapter is to assess the applicability of a recently developed and widely supported economic evaluation framework to appraise alternative water and sanitation interventions, and make recommendations for those wishing to conduct economic evaluations in this area.

15.2 ECONOMIC EVALUATION FRAMEWORK

15.2.1 Outline of economic evaluation framework

The past two decades have experienced a proliferation in published economic evaluations in the medical literature, reflecting the increasing importance of economic aspects of medical interventions in resource allocation decisions (Elixhauser *et al.* 1993, 1998; HEED 2000; Walker and Fox-Rushby 2000). Economic evaluation guidelines such as those put forward by Drummond *et al.* (1997) have played an important part in improving the quality of such evaluations, albeit gradually (Adams *et al.* 1992; Baladi *et al*. 1998). More recently, the use of the economic evaluation framework recommended by guidelines has been linked both formally and informally to the peer review process for publishing articles, and has been used by funding bodies of health-care research in allocating research funds. For example, the *British Medical Journal* (BMJ) commissioned an Economic Evaluation Working Party to put together a series of critical elements for journal reviewers and editors to use when deciding whether to publish economic evaluations (Drummond and Jefferson 1996). Also, the *New England Journal of Medicine* published a series of articles with recommendations produced by the United States Panel on Cost-Effectiveness in Health and Medicine (Gold *et al*. 1996; Weinstein *et al.* 1996). Currently the World Health Organization (WHO) is designing its own cost-effectiveness guidelines (Murray *et al.* 2000).

The main purposes of these economic evaluation guidelines are to increase consistency and to allow comparison of the results of different studies, as well as to clarify the methodological choices that can be made at various stages of the evaluation for those less familiar with the economic evaluation framework. The economic evaluation framework recommended by the BMJ is summarised in Box 15.1 (Drummond and Jefferson 1996) and consists of three main stages, namely: study design, data collection, and data analysis and interpretation of results.

Box 15.1. Summary of BMJ economic evaluation guidelines (reproduced, with permission, from Drummond and Jefferson 1996)

Study design

(1) Study Question

–The economic importance of the research question should be outlined.
–The hypothesis being tested, or question being addressed, in the economic evaluation should be clearly stated.
–The viewpoint(s) – for example, health care system, society – for the analysis should be clearly stated and justified.

(2) Selection of alternatives

–The rationale for choice of the alternative programmes or interventions for comparison should be given.
–The alternative interventions should be described in sufficient detail to enable the reader to assess the relevance to his or her setting – that is, who did what, to whom, where, and how often.

(3) Form of evaluation

–The form(s) of evaluation used – for example, cost minimisation analysis, cost-effectiveness analysis (CEA) – should be stated.
–A clear justification should be given for the form(s) of evaluation chosen in relation to the question(s) being addressed.

Data collection

(4) Effectiveness data

–If the economic evaluation is based on a single effectiveness study – for example, a clinical trial – details of the design and results of that study should be given – for example, selection of study population, method of allocation of subjects, whether analysed by intention to treat or evaluable cohort, effect size with confidence intervals.
–If the economic evaluation is based on an overview of a number of effectiveness studies, details should be given of the method of synthesis or meta-analysis of evidence – for example, search strategy, criteria for inclusion of studies in the overview.

(5) Benefit measurement and valuation

–The primary outcome measure(s) for the economic evaluation should be clearly stated – for example, cases detected, life years, quality-adjusted life years (QALYs), willingness to pay.
–If health benefits have been valued, details should be given of the methods used – for example, time trade off, standard gamble, contingent valuation – and the subjects for whom valuations were obtained – for example, patients, members of the general public, health care professionals.
–If changes in productivity (indirect benefits) are included they should be reported separately and their relevance to the study question discussed.

(6) Cost data
-Quantities of resources should be reported separately from the prices (unit costs) of those resources.
-Methods for the estimation of both quantities and prices (unit costs) should be given.
-The currency and price date should be recorded and details of any adjustment for inflation, or currency conversion, given.

(7) Modelling
–Details should be given of any modelling used in the economic study – for example, decision tree model, epidemiology model, regression model.
–Justification should be given of the choice of the model and the key parameters.

Analysis and interpretation of results
(8) Adjustment for timing and costs of benefits
–The time horizon over which costs and benefits are considered should be given.
–The discount rate(s) should be given and the choice of rate(s) justified.
–If costs or benefits are not discounted an explanation should be given.

(9) Allowance for uncertainty
–When stochastic data are reported details should be given of the statistical tests performed and the confidence intervals around the main variables.
–When a sensitivity analysis is performed details should be given of the approach used – for example, multivariate, univariate, threshold analysis – and justification given for the choice of variables for sensitivity analysis and the ranges over which they are varied.

(10) Presentation of results
–An incremental analysis – for example, incremental cost per life year gained – should be reported, comparing the relevant alternatives.
–Major outcomes – for example, impact on quality of life – should be presented in a disaggregated as well as an aggregated form.
–Any comparison with other health care interventions – for example, in terms of relative cost-effectiveness – should be made only when close similarity in study methods and settings can be demonstrated.
–The answer to the original study question should be given; any conclusions should follow clearly from the data reported and should be accompanied by appropriate qualifications or reservations.

Current evaluation guidelines recommend presentation of incremental cost-effectiveness (i.e. current care versus the best alternative). However, there is increasing support for presentation of average cost-effectiveness ratios as well (Murray *et al.* 2000), where alternatives are compared with the costs and consequences of a do-nothing alternative (i.e. no intervention). Economic evaluation guidelines distinguish between studies relating to decisions of programme managers in the short term, which should use marginal costs, and those relating to national policy, which should use average costs (Drummond and Jefferson 1996).

15.2.2 Implications of economic evaluation framework for water and sanitation interventions

As already mentioned, when applied to water and sanitation interventions, there is a risk that the current economic evaluation guidelines are not comprehensive in scope, as they may be confined to include only those interventions typically delivered by core health services, with an emphasis on curative treatment. As outlined earlier, environmental health interventions differ from core health services. It is for these reasons that selective primary health-care interventions, such as those suggested in the influential article by Walsh and Warren (1980) contain limited environmental health interventions, and those included appeared much less cost-effective than most curative measures. Attempts have recently been made to formulate essential national packages of services in developing countries; however, few contained environmental health interventions. Exceptions included that proposed by Jha *et al.* (1998) which included the construction of pit latrines and safe water provision as part of a package of 40 health interventions in Guinea, although this intervention turned out to be considerably less cost-effective than the treatment of diarrhoea. However, Varley *et al.* (1998) argued that environmental health interventions to prevent diarrhoea can compete with other means of controlling diarrhoea, such as oral rehydration therapy, once the non-health benefits are taken into consideration.

Therefore, the special nature of environmental health interventions in general, and water and sanitation interventions in particular, should be considered when applying current economic evaluation guidelines to estimate cost-effectiveness. Before these issues raised above are discussed further, a review of literature on economic aspects of water and sanitation interventions is presented and discussed briefly, to act as a backdrop to the discussion of issues in the following section.

15.3 ECONOMIC STUDIES IN WATER AND SANITATION

A brief search was made of electronic databases using key words and researchers in this area contacted to identify articles on the economics of water supply and sanitation. The purpose of the search and review was not to compare the actual cost-effectiveness of alternative water and sanitation interventions, but instead a more important first step was to summarise the range of studies conducted to date, and comment on methodological approaches and study quality. Twenty-four studies were located on the economics of water and sanitation interventions, and these are summarised in Table 15.1. Three main types of study are classified in the table: those evaluating cost-effectiveness or cost-of-illness of water and sanitation interventions; those measuring willingness to pay (WTP) for water and sanitation interventions; and those measuring WTP, cost and cost-effectiveness of water quality improvement.

None of the studies estimated cost-effectiveness of water and sanitation interventions using primary data from a single setting, and only four studies considered both the costs and consequences of at least two alternatives, thus meeting the criteria for a full ‘economic evaluation’ (see Box 15.1). The most comprehensive study was that by Varley *et al.* (1998) who modelled the cost-effectiveness of water and sanitation interventions in a hypothetical city in a developing country, using secondary data from a variety of sources and a number of assumptions. Phillips (1993) discussed the potential cost-effectiveness of hand-washing to prevent diarrhoea, and used published studies of effectiveness data to build a plausible picture of procedures and resource use, and hence of cost-effectiveness. Briscoe (1984) discussed methodological issues in evaluating the cost-effectiveness of water and sanitation interventions, presenting data to support the hypothesis that water and sanitation interventions can compete with oral rehydration in terms of cost-effectiveness in reducing the incidence of diarrhoeal diseases. Very few published studies measured the actual costs of water and sanitation services, and those that did (such as Varley *et al.* 1998) used available data that were often transferred from other countries.

Generally the studies assessing the water market focused on the demand side, measuring willingness to pay of actual or potential customers and identifying options for cost recovery. Most willingness to pay studies measured either (a) the value to consumers of improvements in the availability and quality of drinking water or (b) the value to consumers of improvements in the quality of surface water (rivers, lakes or coastal waters) for amenity uses. Most WTP studies used the contingent valuation method (see later) to identify the potential demand curve for improved water supply and quality, and many of these also identified current water markets and compared them with WTP (Whittington *et al.* 1990a,b). Franceys (1997) also discussed several options for private sector participation in the provision of water and sanitation facilities, using case studies taken from both developed and developing countries.

In conclusion, the literature reviewed covered several economic aspects of water supply, water quality and sanitation interventions, including costs, cost-effectiveness, willingness to pay, and cost-of-illness. However, few studies measured the costs and benefits of alternative interventions to provide policy makers with the information to choose the most efficient intervention from the viewpoint of society or the health sector. Generally, it would seem that there has been inadequate attention to economic issues in water and sanitation interventions.

Table 15.1. Cost-effectiveness, cost-of-illness or willingness to pay studies on water and sanitation services

Reference	Study aim and country	Costs included	Benefits included
Cost-effectiveness or cost-of-illness studies			
Briscoe (1984)	Review of cost-effectiveness of water supply	R: HS	R: MOR
Harrington *et al.* (1989)	Costs of a waterborne disease outbreak (USA)	P: HS, PT	P: COI
Paul and Mauskopf (1991)	Methodology for cost-of-illness studies	None	R: COI
Philips (1993)	Review of diarrhoea control (LDCs)	S: HS	S: CDA
WASH (1993)	COI of cholera epidemic (Peru)	None	P: COI
Varley *et al* (1998)	CE of WS interventions (LDCs)	S: HW/SW	S: CDA, DALY
Willingness to pay (WTP) studies on water supply and sanitation services			
Boadu (1992)	WTP for water piped to households (Ghana)	None	P: WTP
Whittington *et al.* (1990a)	WTP for water from village standposts (Haiti)	None	P: WTP
Whittington *et al.* (1990b)	WTP for water piped to households (Nigeria)	S: PIP	P: WTP
Whittington *et al.* (1990c)	WTP for water – vendor/kiosk/wells (Kenya)	None	P: WTP
Whittington *et al.* (1991)	WTP for improved piped water supply (Nigeria)	P: VE, HW	P: WTP
Darling *et al*. (1992)	WTP for sewerage facilities (Caribbean)	None	P: WTP
Whittington *et al.* (1993)	Time to think in WTP valuations (Nigeria)	None	P: WTP
Hanley (1989)	WTP for reducing nitrate level of water (UK)	None	P: WTP
North and Griffin (1993)	Water supply and house prices (Philippines)	None	P: WTP
Whittington *et al.* (1993)	WTP for improved WS services (Ghana)	P: HW	P: WTP

Reference	Study aim and country	Costs included	Benefits included
Willingness to pay, cost and cost-effectiveness studies on water quality improvement			
Dixon *et al.* (1986)	Industrial waste water disposal (Philippines)	S: IND	None
Hanley (1989)	Costs of reducing nitrate pollution (UK)	P: IND	None
Hanley and Spash (1993)	Review of CB of controlling nitrate pollution	R: PC	R: WTP, CAV
Kwak and Russell (1994)	WTP to stop contaminating river water (Korea)	None	P: WTP
WHO (1994)	Review of cost recovery approaches for WS	S: GOV	None
Giorgiou *et al.* (1996)	WTP to improve bathing water quality (UK)	None	P: WTP
Day and Mourato (1998)	WTP to improve river water quality (China)	None	P: WTP
Machado and Mourato (1999)	WTP to improve bathing water quality (Portugal)	None	P: WTP

Abbreviations: CE – cost-effectiveness; WS – water and sanitation; WTP – willingness to pay; LDCs – less developed countries; CB – cost-benefit. ***Data type***: P – primary data; R – review; S – secondary data. ***Costs included***: HS – health service; PT – patient; PC – pollution control; GOV – government; VE – private vendors; IND – industry; HW – hardware; SW – software. ***Benefits included***: MOR – morbidity and mortality; COI – cost-of-illness; CAV – costs averted; CDA – cases and deaths averted; DALY – disability-adjusted life years saved.

This highlights the need for an economic framework that is specific to water and sanitation interventions, but which still allows comparison of economic efficiency with other health interventions. Therefore, the rest of this chapter focuses on issues where greater clarification and agreement are needed.

15.4 ISSUES IN APPLYING THE ECONOMIC EVALUATION FRAMEWORK TO WATER AND SANITATION INTERVENTIONS

This section examines the issues arising through application of the economic evaluation guidelines to the water and sanitation field.

15.4.1 Study viewpoint: benefit inclusion

Berman (1982) points out that cost-effectiveness comparisons tend to undervalue interventions that provide important outcomes other than the one being considered, and are thus particularly inappropriate where programmes produce a broad mix of benefits. Water and sanitation interventions are a good example of health-related programmes with a broad mix of benefits. For example, WASH (1993) argued that:

…benefits analysis related to water supply and sanitation projects should include measurement of direct economic benefits, such as increased time availability when water is more conveniently located, commercial benefits (reflected in infrastructure improvement leading to increased investment and other opportunities) and health benefits, both direct in terms of avoided medical expenses and indirect in terms of productivity gains due to reduced morbidity.

Several categories of potential benefit arising from water and sanitation interventions are identifiable; Postle 1997). These are summarised in Table 15.2.

There are two main questions that follow from identifying the beneficiaries of water and sanitation interventions. The first question concerns which benefits should be included in the economic evaluation. The second question concerns identifying the main beneficiaries of an intervention and whether they would be willing to contribute to cost recovery.

15.4.1.1 Deciding which benefits to include

The answer to the first question invariably depends on the viewpoint of the policy maker (or those conducting research), whether representing a single ministry or government department, consumers, industry, or society as a whole.

While economic evaluation guidelines support a societal perspective (a view endorsed by Philips (1993) for water and sanitation interventions) the division of budgets between different government ministries or departments means that there are few incentives to estimate an overall 'societal' cost-effectiveness ratio, unless government departments work together in implementing and funding water and sanitation interventions. For example, in a purely health sector analysis, only the health gains and impact on medical costs would be included. This means that many of the non-health benefits are likely to be of less interest to the health ministry, despite empirical evidence to demonstrate the many benefits of water supply (for example, Briscoe 1984; Whittington 1990a,b,c, 1991).

There has also been some discussion surrounding which health benefits to include in the evaluation of water and sanitation interventions. Citing examples from Berman (1982) and Briscoe (1984), Feachem (1986) writes that:

> …special difficulties are inherent in applying cost-effectiveness analysis to interventions having multiple benefits, and water and sanitation interventions present these difficulties in an extreme form. In addition to their impact on diarrhoea rates among young children, these interventions may avert diarrhoea in other age groups, reduce the incidence of other infectious diseases and have a variety of benefits unrelated to health.

The implication of this view is that other studies (for example Varley *et al.* 1998 who modelled the cost-effectiveness of water and sanitation interventions on diarrhoeal incidence in under-fives) will have underestimated the overall health benefits and thus the true cost-effectiveness of water and sanitation interventions.

Another influence on benefit inclusion is the availability of data and ease of data collection or benefit valuation (see later). At the planning stage of the study, some idea is required of where the greatest data deficiencies or uncertainties lie, and which should first be addressed. Many of the data listed in Table 15.2 may already be available from routine sources such as government records. Other data, such as information on individual productivity, avertive expenditures and time saved, and recreational use or non-use values, however, will need special collection efforts. While it is recognised that data cannot necessarily be collected on all the beneficiaries in Table 15.2, lack of data should not be used to justify the exclusion of important benefits from the cost-effectiveness ratio.

Table 15.2. Categorisation of benefits to society of water and sanitation interventions

Benefit to	Type of benefit	Code
Health sector	Reduction in current costs due to health intervention: materials such as oral rehydration therapy and antibiotics, staff time	Med-cost-avert
	Savings in poison control centre costs	Med-cost-avert
	Reduction in future costs (fewer cases, less severe cases)	Med-cost-avert
Third party payer	Reduction in payouts to health-care providers	Med-cost-avert
Patient[1]	Reduced morbidity and mortality	Health benefit
	Increased life expectancy	Health benefit
	Increased health-related quality of life	Health benefit
	Reduced direct costs of attending care (out-of-pocket expenses)	Med-cost-avert
	Reduced future medical or social care costs	Med-cost-avert
	Increased productivity or capital formation activities such as less time off work and school and increased efficiency while at work or school	Prod -loss-saved
	Reduced risk avertive expenditures such as money cost (capital, recurrent) and time input	Avert-exp-saved
Family or carers of patient	Reduced time caring (back to work)	Prod -loss-saved
	Reduced out-of-pocket payments for medical care	Med-cost-avert
	Reduced risk avertive expenditures (see above)	Avert-exp-saved
Industry	Direct economic value of high quality water such as irrigation water for crops, fishery production, and sea ecosystems	Other-not-health
	Reduced sick leave of employees (paid sick leave, lost production)	Other-pay-avert
	Reduced medical expenses	Med-cost-avert
	Reduced avertive expenditures	Avert-exp-saved
Other government ministries	Reduced running costs or maintenance	Other-pay-avert
	Reduced avertive expenditures	Avert-exp-saved
All consumers	Reduced running costs or maintenance	Other-pay-avert
	Non-health benefits such as increased convenience of a good water supply, increased amenity (laundry, recreational uses), and non-use values (option, existence, bequest)	Other-not-health

Codes: Med-cost-avert: medical costs averted; Avert-exp-saved: avertive expenditure saved; Prod-loss-saved: production loss saved; Other-pay-avert: other payments averted; Other-not-health: other benefits not related to health impact.

[1] The patient is the person who would have been ill in the absence of environmental health intervention.

15.4.1.2 Identifying beneficiaries for cost recovery purposes

In addressing the second question, that of identifying means of cost recovery, there has been considerable work and advancement of methods in this area. For example, Whittington and others have shown that even poor people are willing to pay significant amounts for improved water supply. Also, Franceys (1997) presented examples showing how the private sector can become involved in water and sanitation provision.

Table 15.2 shows that there are many different agencies that may be willing to pay for the identified health services that avoid either tangible (real health and economic losses suffered) or intangible (non-use value) costs. One approach, the 'cost of illness' (COI) approach, has been found to be useful in identifying the size of the tangible costs, which approximates the overall willingness to pay to avoid the illness. As Mills (1991) notes, the inclusion of cost-of-illness aspects has tended to blur the distinction between cost-effectiveness analysis and cost benefit analysis. However, questions may be raised over the relevance of identifying WTP if it is not technically correct to include non-health benefits in the cost-effectiveness ratio. On the other hand, if benefits can be measured and used as evidence that there are options for cost recovery, cross-sector collaboration may be facilitated for the reason that interested parties are less concerned about projects being under-funded.

The importance of averting the indirect economic impacts that result from poor water supply and sanitation was illustrated in a study by Paul and Mauskopf (1991) on the impact of the cholera epidemic in Peru. In this epidemic, it was estimated that three-quarters of the economic costs were from indirect productivity losses due to morbidity (US$2.6m) and mortality (US$93.9m), as well as the macroeconomic impact of loss of exports (US$8.1m), tourism (US$15.4m) and domestic production (US$26.9m). Out of a total economic loss of US$200m, it was estimated that only US$53m was met by the health sector in terms of treatment of cholera cases and public education campaigns. Therefore, these data suggest that other beneficiaries, such as consumers, industry and other government departments, would be willing to pay to prevent such an outbreak from happening again.

In addition to these short-term costs associated with illness, WASH (1993) recognised longer term impacts of water and sanitation interventions, such as changes in population pressures through decreased mortality, and changes in physical capital formation through savings rates and school attendance.

One of the problems of cost recovery is that often not all the benefits are realised instantaneously, whereas significant costs may need to be recovered in the short term. This budget constraint means that while many agents may show willingness to pay for water and sanitation interventions in hypothetical surveys, few may be willing to pay for the benefits before they occur.

15.4.2 Study viewpoint: cost inclusion

This section discusses which environmental health intervention costs should be included in economic evaluations under a variety of viewpoints. Table 15.3 lists the range of agencies that may incur costs in relation to water and sanitation interventions. Several questions are raised in relation to cost inclusion, although not all are discussed here:

- What do water and sanitation facilities cost in different settings?
- Which costs do economic evaluation guidelines recommend to include?
- What proportion of costs fall within and outside the health sector?
- What is the possible impact of the inclusion/exclusion of non-health sector costs on the cost-effectiveness ratio?
- To what extent should the health sector be interested in funding non-health sector costs? Conversely, to what extent should the other agents be interested in funding health sector costs?
- Given the range of agencies funding water and sanitation interventions, which costs should be included in the cost-effectiveness ratio?

Without access to primary data sources, the first question is particularly difficult to answer, due to the lack of cost information provided in the medical literature (see Table 15.1), despite the WHO booklet outlining issues in financial management of water supply and sanitation (WHO 1994). While Varley *et al.* (1998) estimated ‘hardware costs’ of US$72 per household per year, and ‘software costs’ of US$3 per household per year, there was no indication of how these costs may vary with bulk purchase, location or quality. However, these data do suggest that a high proportion of water and sanitation cost consists of hardware costs, which are traditionally not paid for by the health sector.

Regarding the second question, costs included in the cost-effectiveness ratio in a purely health sector analysis should be costs met by the health sector. This view is supported by Varley *et al.* (1998) who recommended that the cost of water and sanitation interventions should be included in the health programme budget. This approach is justified in that it yields results that are useful for allocating health programme resources. On the other hand, Briscoe (1984) suggests including the full costs of water and sanitation activities, but subtracting from this figure the amount that users are willing to pay (thus giving the net cost to the providing agency).

Table 15.3. Categorisation of costs of water and sanitation health interventions

Cost borne by	Type of cost[1]
Health sector	Health education outreach and media
	Research costs such as epidemiological study and economic evaluation
	Monitoring and surveillance
Industry	Compliance with emissions regulations[2]
Agriculture	Change in land use following water management
Local council	Waste disposal services
	Water treatment activities
Other government/ public sector	Check compliance with regulations
	Providing clean water and water quality maintenance (e.g. finding new sources)
	Laying water and sewerage pipes (pipes, latrines, digging equipment, labour)
	Repairs to hardware
	Water treatment activities
	Education activities
Consumers	Compliance with waste disposal regulations
	Increased prices passed on by industry
	Charges for sewerage and water facilities

[1] Costs related as well as unrelated to the water and sanitation intervention (in both the initial and extended life span). Note that some of the costs attributed to certain agencies may in fact be met by other agencies in the first column.
[2] Regulations can have two principal types of effect. The first is when a regulation applies at the local level only. In this case it imposes costs on a producer, causing it either to earn less profit, to pay lower wages, or to go out of business. The second is when a regulation applies at the entire industry level. In this case costs are passed on to consumers in a higher price, or companies attempt to cut costs to keep prices stable.

The problem with the approach recommended by current economic evaluation guidelines is that it implicitly assumes a zero cost for non-health programme resources used for water and sanitation interventions. Thus it is unlikely to make optimal use of society's resources allocated to these interventions. For this reason, WASH (1993) states that:

> …comprehensive analysis of the economic effects of water supply and sanitation services have to include cost analysis components, such as construction costs, costs related to community organisation and participation, training, and ongoing operations and maintenance.

15.4.3 Valuation of benefits in monetary units

Economic evaluation guidelines recommend the use of economic value, wherever possible. Market prices are usually a good measure of economic value. However, the two problems faced in many economic evaluations are:

- Market values do not represent economic value, because there are some distortions present in the market such as monopoly, subsidy or taxes. The presence of any of these means that prices do not reflect the 'true' market rate. If the divergence of price with economic value is suspected to be substantial, then adjustments are recommended. For example, the profit element in medical charges could be subtracted if profit margins are known.
- The market values are not available to represent economic value. This is more of a serious problem, as it requires the use of other methods to value willingness to pay, and considerable controversy remains over optimal valuation methods.

Therefore, this section aims to identify the strengths and weaknesses of the different methods for valuing different types of benefit using the willingness to pay (WTP) method. The four methods for valuing willingness to pay identified in the economic literature (Hanley and Spash 1993; Postle 1997) are:

- market price
- household production function
- revealed preference
- contingent valuation.

The approaches are described briefly, and advantages and disadvantages discussed, in the following sections, while Table 15.4 summarises the different methods according to the benefits examined.

15.4.3.1 Market price of goods and activities

Market prices are used to value the costs or benefits associated with changes in environmental quality. This includes the 'cost of illness' approach discussed earlier, or the 'replacement costs' approach which values the damage to assets using market prices. This approach assumes that market price represents the economic value, and that there are no taxes and subsidies.

Essentially, market prices can be used for those changes in activity where markets exist. For example, changes in medical costs can be estimated by aggregating the unit costs of those services for the numbers of services saved.

Market prices are also used in the 'human capital' approach, where human life and time spent ill or recovering from illness are valued using future expected earnings. The calculation uses approximations of the value of the increased productivity of individuals through fewer days lost from work or days with restricted activity. For a person who dies prematurely, the lost productivity estimate is often given as the stream of earnings that the person would have earned if he or she had not died. The human capital approach can also be applied to time saving not associated with health, such as the economic value of reduced water collection time.

Table 15.4. Recommended methods of valuation for benefits of environmental health interventions

	Method of measuring willingness to pay[1]			
Type of benefit	Market value	Household production	Revealed preference	Contingent valuation
Health-related benefits				
Improved quality of life				✓
Improved life expectancy				✓
Medical costs avoided	✓			(✓)
Reduced time spent in care	✓			(✓)
Reduced travel expenses to care	✓			(✓)
Reduced avertive expenditure		✓	(✓)	(✓)
Increased productivity	✓			(✓)
Reduced sick leave	✓			(✓)
Benefits not related to health				
Increased competitiveness	✓			(✓)
Reduced running costs	✓			(✓)
Reduced emergency services	✓			(✓)
Increased convenience	✓		(✓)	✓
Increased amenity	(✓)	(✓)	(✓)	✓
Non-use option value[2]			(✓)	✓
Non-use existence value[2]			(✓)	✓
Non-use bequest value[2]			(✓)	✓

[1] See text for description of methods; ✓ = preferred method(s); (✓) = second best method(s); blank = no method available. [2] See text for explanation.

The human capital approach is perhaps the most difficult and controversial aspect of valuing health effects (Freeman III 1993). The most serious shortcoming of the human capital approach is that it does not provide information about what the individual would be willing to pay to obtain a given reduction in the probability of loss of life (Fisher 1981). Also, it does not measure the net contribution to society, it ignores non-market activities important to individuals, and the loss of leisure time or activities. Also, there is considerable uncertainty about the number of days or years that individuals actually take off work (Hanley and Spash 1993). Therefore, if used, this method must be applied with caution, and interpreted appropriately.

15.4.3.2 Household production function

The production function method may be applied either to private sector companies producing goods or services, or to households producing services that generate positive utility. For example, a household may react to water contamination by either purchasing water treatment equipment or by boiling water, both of which involve changes in expenditure patterns and the use of time. This behaviour is called mitigative behaviour, or avertive expenditure. The value of an improvement in water quality can be inferred directly from reductions in averting expenditure (Courant and Porter 1981). However, avertive expenditure may not capture all aspects of a benefit, it may overstate the benefit, and it is not widely applicable, but is instead specific to occasions when individuals change their activities to prevent an outcome. It requires surveys of individual behaviour, and results are likely to be highly setting-specific due to the many contextual factors that affect human behaviour (e.g. norms, income, risk perception etc.).

Another approach, the ‘travel cost’ method, has also been shown to be a useful method for measuring the value associated with environmental benefits, such as recreational benefits of water, although it has not been used to value health benefits. The travel cost method also suffers from weaknesses, such as whether a journey is made for reasons other than simply the environmental benefit.

15.4.3.3 Revealed preferences

The revealed preference method (also called ‘hedonic pricing') seeks to find a relationship between the levels of environmental services (such as a water supply), and the prices of the marketed goods (houses). Most studies found in the literature used regression analysis to identify this relationship. Several problems exist with this method, including large sample size requirements, omitted variable bias, multi-colinearity, wrong choice of functional form, not recognising market segmentation, not accounting for impact of expected environmental goods, and not meeting restrictive assumptions of the model (Hanley and Spash 1993).

Another application of the revealed preference method is the valuation of incremental morbidity or mortality risks by identifying wage differentials due to risk differences. The theory is that workers have to be paid a premium to undertake jobs that are inherently risky (or disagreeable) and this information can be used to estimate the implicit value individuals place on sickness or premature death associated with the job. Thus it measures, albeit inaccurately, an implicit willingness to pay for reductions in risk of death, or willingness to accept increases in the risk of death. However, it has limited applicability to water and sanitation interventions, and has several weaknesses (Hanley and Spash 1993).

15.4.3.4 Contingent valuation

In this method, the public is asked to value non-market goods within a hypothetical market. The contingent valuation method enables economic values to be estimated for a wide range of commodities not traded in markets, such as health and public goods (for example, clean air and scenery). The technique is now widely accepted by resource economists, following a great deal of empirical and theoretical refinements in the 1970s and 1980s (Hanley and Spash 1993). The contingent valuation method works directly by soliciting from a sample of consumers their willingness to pay for an improvement in the level of environmental service flows (or willingness to accept compensation) in a carefully structured hypothetical market. Bids are then obtained from the consumers, bid curves estimated, and the data aggregated to estimate the market demand curve.

There are several advantages of the contingent valuation method over other valuation techniques:

- It can take into account non-use values, such as the utility individuals derive from the existence of environmental goods, even if they do not use it. Non-use is divided into option value (the possibility that the person may want to use it in the future), existence value (the person values the fact that the environmental good exists, irrespective of use), and bequest value (the person wants future generations to enjoy it).
- It can be designed to include only the variables or characteristics of the market relevant to the objective of the study. For example, it can be designed to include only willingness to pay for health effects, or it can include productivity effects, expenditure averted, etc.
- It allows individuals to consider the true cost to themselves of a particular injury or illness. Results have been shown to be repeatable, both in terms of similarity in results across different settings, but also using a test-retest methodology. Whittington *et al.* (1990a) have found contingent valuation methods to be an appropriate instrument to elicit valuations in a very poor, illiterate population in Haiti, where reasonable, consistent answers were provided.

There are also several potential problem areas associated with this method, including bias, protest bids, the lack of verification procedures, and research cost.

15.4.3.5 Conclusions

In conclusion, market valuations are the best valuation method (if available) because they use existing prices and behaviour and are therefore generally valid. However, when markets do not exist, market behaviour must be extracted from surrogate or proxy markets, or from questionnaires. In general, the contingent valuation method is preferable to revealed preference as it is more reliable and questionnaires can be adapted to answer primary objectives. The household production approach is the least applicable, in that it only values averting expenditures or activities in relation to their health benefits.

While the general concept of willingness to pay is widely accepted by economists, there still exist several methodological problems associated with conducting these studies, whichever elicitation method is used:

- They assume rational individuals.
- They assume people are well informed about the choices they make.
- They assume a well functioning market.
- Through aggregating values, the preferences of the many are remorselessly outweighing the preferences of the few. This is especially problematic when the majority of people are ill informed.
- Under the cost-benefit analysis system, intrinsic value exists only in humans and not in animals, plants and other natural resources. Therefore cost-benefit analysis is anthropocentric, and only 'values' non-human entities when humans themselves value them. Put another way, an environmental good that does not enter at least one person's utility function or at least one private company's production function will have no economic value (Hanley and Spash 1993). Field (1997) suggests a 'stewardship value', related to the desire to maintain the environment for the continued use of all living organisms.

15.4.4 Discounting future costs and benefits

The economic evaluation guidelines state that the time horizon of the economic evaluation should be long enough to capture all the differential effects of the alternative options, and recommend discounting of future costs and benefits occurring during different time periods to their present value. The rationale for discounting is based on the observation that individuals discount the future, because:

- they may expect to be richer in the future
- there is risk attached to investment
- people prefer present to future consumption.

Economic evaluation guidelines also argue that monetary values and health outcomes should be discounted at the same rate. According to Weinstein *et al.* (1996) future health effects should be discounted at the same rate as future costs because people have opportunities to exchange money for health, and vice versa, throughout their lives. Therefore, failure to discount health effects will lead to inconsistent choices over time.

Table 15.5 shows how the net present value of future income streams is reduced with higher discount rates. For example, for the age group 20–24 years, use of a 10% discount rate reduces future income streams to a third of those at 2.5%. The table also shows how the net present value of income of children is very small at higher discount rates, as they will not become productive for many years. These data therefore illustrate the potential impact on future events of discount rates, whether they are costs or benefits (costs saved, health gain), and has implications for the relative cost-effectiveness of health interventions that have costs and benefits in different time periods.

Table 15.5. Net present value of future income streams (no specified currency) for different age groups and discount rates (from Landefield and Seskin 1982)

	Discount rate		
Age group	2.5%	6%	10%
1–4 years	405,802	109,368	31,918
20–24 years	515,741	285,165	170,707
40–44 years	333,533	242,600	180,352
65–69 years	25,331	21,807	18,825

Therefore, how should the discount rate be chosen, and should the same discount rate be applied to all health interventions, and to costs and benefits? Weinstein *et al.* (1996) suggest that a convention is needed for choosing the discount rate in order to achieve consistency across analyses. They argue that theoretical considerations suggest that the real discount rate should be based on time preference, the difference in value people assign to events occurring in the present versus the future. This is reflected in the rate of return on riskless, long-term securities, such as government bonds, which empirical evidence shows to be in the vicinity of 3% per annum. Rates of between 0% and 7% are recommended in the sensitivity analysis.

Discussion surrounding the discount rate and its role in economic evaluation has been given considerable attention by those working in environmental projects, and is of key interest in projects both related and unrelated to health. Baldwin (1983) argued in the context of rural water supply projects, 'the process of discounting removes from consideration a higher and higher proportion of values that fall in the future'. Therefore, the comparison of cost-effectiveness ratios of water and sanitation interventions with curative interventions leaves the former disadvantaged because curative interventions have more immediate effect. Also, the bulk of the costs of water and sanitation interventions are incurred early in the life of the project. Therefore, a positive discount rate reduces the relative costs of low technology curative interventions.

A number of solutions have been suggested but it is clear that there is no single alternative solution for the choice of discount rate that would not attract severe criticisms. Therefore, analysts and decision makers should be aware of the extent to which discount rates make environmental health interventions with high short-term costs and high long-term effects less cost-effective compared with other health interventions.

15.4.5 Dealing with uncertainty

The issue of uncertainty and how to deal with it plays an important role in cost-effectiveness analysis, particularly for water and sanitation interventions. Uncertainty stems from a lack of information about the consequences of a given action (data uncertainty), a lack of agreement in methods (model uncertainty), or uncertainty in the degree to which data can be transferred across settings (generalisability) (Briggs *et al.* 1994). Data uncertainty can include uncertainties in measurement, future values, scientific uncertainties (e.g. cause-effect relation), or the timeframe over which costs and benefits occur (Postle 1997). Model uncertainty can include methods for measuring economic value, the discount rate, and which costs and benefits are included, and have already been discussed in detail. Uncertainty associated with generalisability involves whether cost-effectiveness values from one setting (whether at the village, town, or country level) are applicable in another setting and, if not, whether adjustments can be made to make better predictions. These issues are discussed below for both effectiveness and costs.

15.4.5.1 Effectiveness of water and sanitation interventions

Briscoe (1984) argues that, 'an assessment of the likely impact of water supply and sanitation programmes on health is far more problematic than the assessment of other components of primary health care which operate more directly on the causes of disease'. There are several reasons why uncertainty in the effectiveness of water and sanitation interventions may be greater than for many other types of health intervention. First, evaluating health effects from a change in the natural or human environment is more difficult to do using controlled experiments such as the randomised controlled trial (Luken 1985), and therefore many assumptions are usually required in estimating health benefit. Blum and Feachem (1983) list methodological problems of previous epidemiological studies in measuring the impact of water and sanitation investments on diarrhoeal diseases. These included: lack of adequate control; sample size of one in cluster randomisation studies; confounding variables not controlled for; health indicator recall bias; poor health indicator definition; failure to analyse by age; failure to record facility usage; and failure to analyse by season. Subsequently larger confidence intervals exist around health effects for water and sanitation interventions than for curative activities, which tend to have more high-quality studies of effect performed (as evidenced by the weight of evidence in reviews of epidemiological evidence such as collected by the Cochrane Collaboration).

Second, there is substantial variability in dose–response relationship, and therefore the effectiveness of water and sanitation interventions. Machado and Mourato (1999) discussed the problems in identifying a dose–response relationship when considering the health risks of different levels of coliforms and streptococci, due to variability in levels between location, different weather conditions/times of day, and characteristics of person (gender, age, health condition, hygiene), all of which affect vulnerability to polluted water. This raises the need for subgroup analysis, to better understand dose–response relationships for specified conditions.

Third, due to the lack of evidence on causes of variability in dose–response relationships, it makes generalisations of effectiveness data between settings a highly uncertain process. For example, Hanley and Spash (1993) argue that the benefit of controlling nitrate pollution depends on percolation rates through groundwater, which are highly locale-specific. This raises serious questions about the appropriateness of taking effectiveness data from reviews of studies. For example, Varley *et al*. (1998) used a review of 65 studies to generate a plausible range for the minimum effectiveness of water and sanitation interventions in a hypothetical city in the developing world. However, actual effect may fall anywhere within that range. In this case, it may be better to use the results of the best quality study that was conducted in similar conditions to the setting of interest, thus reducing the range of effectiveness and therefore cost-effectiveness.

15.4.5.2 Costs of water and sanitation interventions

As argued earlier, there is limited primary data in the published medical literature on the costs of water and sanitation interventions. The published cost-effectiveness studies identified have largely used secondary data sources, thus increasing the degree of uncertainty in cost-effectiveness ratios. The implications are that researchers and policy makers using these cost-effectiveness studies to plan services are using outdated or inappropriate cost data.

Therefore, two measures are recommended. The first measure is the use of sensitivity analysis to quantify the impact of uncertainty in costs on the overall cost-effectiveness ratio. Thus the cost-effectiveness ratio is presented as a range as opposed to a point estimate. For example, Luken (1985) suggests the use of worst case and best case scenarios for estimating the costs of compliance with regulations. However, this approach does not attach probabilities to different outcomes, which may be important for policy makers to weigh up the risks of taking certain actions.

The second measure is improving access for researchers and policy makers to cost information, via the internet, local and international organisations, and published cost data in the medical literature. These costs should be both comprehensive (i.e. include all aspects of water and sanitation interventions) and detailed, thus providing data on the costs of different types and specifications of the required materials and equipment.

15.5 CONCLUSIONS

The economic evaluation guidelines (Drummond and Jefferson 1996) presented in this chapter are recognised to be important in that they reflect consensus among mainstream health economists and they increase consistency and comparability between cost-effectiveness ratios for a wide range of health interventions. However, several limitations or disadvantages were discussed in this chapter when applying these guidelines to water and sanitation interventions. These included uncertainty about which costs and benefits to include in the cost-effectiveness ratio, and the choice of discount rate for future costs and effects. Also, the advantages and disadvantages of different benefit valuation methods need to be understood fully by those undertaking such research, and this chapter provided a brief discussion of issues. There are a number of characteristics of water and sanitation interventions that make them particularly difficult to estimate cost-effectiveness with any degree of certainty, including the lack or poor quality of current evidence on costs and effects, and uncertainty associated with generalising cost-effectiveness across settings.

This chapter highlights the problems associated with placing an economic value on water-related interventions. Clearly, however, in terms of adapting international guidelines to national regulations such a valuation should play an important role in the process if standards are to be cost-effective and appropriate to local circumstances. It is, perhaps, the role of future guidelines to provide standardisation and guidance on how such a valuation should be achieved.

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