Quantifying environmental health effects

Gezondheidsraad **President**
Health Council of the Netherlands

To the Minister of Housing, Spatial Planning and the Environment

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Dear minister,

At the end of 2002, your predecessor asked the Health Council for advice on various aspects of the Health and Environment Action Programme. In response, the Council produced two advisory reports: *Environmental Health: Research for Policy* (2003) and *Gezondheid en milieu: beoordelingskader beoordeeld* (2004, not available in English). In 2005, the Council also reviewed the European Environment and Health Action Plan in the light of its Dutch equivalent. The report that I am now presenting for your consideration – *Quantifying environmental health effects* – forms the final part of the Council's advice regarding the Action Programme.

The advisory report has been drawn up by the Standing Committee on Health and Environment, to which several additional experts were appointed to assist deliberations on this topic. The draft report was reviewed by the Standing Committee on Medical Ethics and Medical Law and by a number of external experts.

I have today also submitted copies of the advisory report to the Minister of Health, Welfare and Sport and, for information purposes, to the Minister of Social Affairs and Employment.

Yours sincerely,
(signed)
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Quantifying environmental health effects

to:

the Minister of Housing, Spatial Planning and the Environment

the Minister of Health, Welfare and Sport

No. 2007/21E, The Hague, October 16, 2007

The Health Council of the Netherlands, established in 1902, is an independent scientific advisory body. Its remit is “to advise the government and Parliament on the current level of knowledge with respect to public health issues...” (Section 22, Health Act).

The Health Council receives most requests for advice from the Ministers of Health, Welfare & Sport, Housing, Spatial Planning & the Environment, Social Affairs & Employment, and Agriculture, Nature & Food Quality. The Council can publish advisory reports on its own initiative. It usually does this in order to ask attention for developments or trends that are thought to be relevant to government policy.

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This report can be downloaded from www.healthcouncil.nl.

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Contents

Executive summary

How can levels of disease burden (and avoidable disease burden) be estimated?

One of the main objectives of environmental policy in the Netherlands is to contribute to improved public health. One way of doing this is to reduce harmful effects such as exposure to particulate matter or noise. To be able to decide the best way of achieving an improvement, information is needed about the scale of health impairment experienced by the public at large and how this can be affected by intervention. There are various metrics for quantifying health impairment. Three are discussed here.

A commonly used term in the healthcare sector is the QALY (*quality-adjusted life year)*, which is used to determine the health benefits obtainable from medical services. A QALY represents a year's living in full health. Years lived in less than perfect health are translated into healthy years. A medical service can be rated in terms of the number of QALYs gained, making it possible to compare the various options against each other in terms of effectiveness. Estimating the costs for each option per QALY gained then allows the costs to be taken into account when making decisions about the allocation of resources.

For some time now, environmental policy has been using a related metric, the DALY (*disability-adjusted life year*). A DALY represents a year in full health that is retained. Unlike QALY calculations, for which the starting point is the state of health before intervention, DALY calculations are based on an achiev-

able standard lifespan. The QALY and DALY are also substantially in agreement about the way in which health gains (or avoidable disease burden) are estimated.

Finally, there is a third method for expressing avoidable disease burden numerically, namely in monetary terms. In this instance, the burden of disease is expressed as a monetary value rather than in terms of a specially developed metric.

In this advisory report, a Committee of the Health Council of the Netherlands has evaluated these three metrics in terms of their applicability to environmental policy and for the setting of priorities in particular.

DALY suitable in many cases

The Committee believes that QALY and DALY can be used for comparing the impact of various environmental factors on health. Moreover, they can be used for comparing the extent to which measures can restrict those effects. This could also be combined with a cost per QALY gained or DALY avoided.

On top of that, the alternative – expressing the burden of avoidable disease as a monetary amount – creates opportunities for comparison with other types of impacts of a measure: the impact on the natural environment, mobility, the economy and so forth. The burden of disease can then be included in a social cost-benefit analysis of environmental measures. This is an analysis of all the favourable (benefits) and unfavourable (costs) effects, irrespective of who is affected, in which the costs and benefits are expressed (where possible) in monetary terms.

Whether the burden of disease is expressed in QALYs/DALYs or monetary units is important for ordering environmental factors by the extent to which they impair health. However, it is not possible to determine which metric is a better representation of the normative ‘reality’. This is because both types of metric rely on people’s valuations of lifespan and health, and changes to them. The Committee’s preference is for the QALY and DALY concept when setting priorities based on health-based considerations. The principal reason for this is that the concept was specifically developed to quantify health and any changes to it.

Monetary units are preferable when it is necessary to compare an avoidable burden of disease with the other effects of specific measures or social activities. They come into their own, for example, in decision-making about projects involving e.g. infrastructure and spatial planning.

There are no fundamental methodological differences between the QALY and the DALY that make either one clearly more suitable than the other for application in environmental policy. Moreover, they seem to produce the same sequence when environmental questions are ranked by their burden of disease

(although that observation is based on just a single study). Because of the way practices (including international practices) in environmental fields have developed, the Committee prefers the DALY to the QALY for use in these areas.

When environmental problems are ranked according to the burden of disease expressed in monetary units, a different sequence is obtained. As there are no direct studies into the relationship between the burden of disease in DALYs and in monetary units, the Committee proposes that such research should be carried out. The results of such a study could provide greater insights into the opportunities for integrating DALYs into cost-benefit analyses. It would then be possible to combine the benefits of both methods.

Taking background information about the figures into account

In theory, the number of DALYs could be used to indicate the magnitude of the environmentally-related burden of disease (and avoidable burden of disease). The costs per DALY avoided can then also be determined if necessary. The number of DALYs can give an indication of the scope of the harm to health in the general population due to an environmental factor (such as particulate matter), making clear what proportion of this can be avoided through a specific measure (e.g. particulate filters for cars). It is important to be aware that the figures are not all equally solidly based.

The limited validity of the numbers is primarily related to the normative choices that are inherent in the application of the DALY concept. An example of this is the way it deals with the time that elapses before any health impairment becomes manifest. In general, people prefer immediate results. The estimated burden of disease in DALYs can take this into account: effects that appear immediately (such as asthma attacks) are weighted more heavily than effects that are only anticipated in ten or twenty years' time (such as mortality due to cancer). This relationship can however be modified; the extent to which this is done is a matter of choice. However, that choice does have implications for policy. If late effects are given a lower weighting, measures that only have a longer-term impact will score relatively unfavourably.

The second reason why a figure is not definitive is that there may be differences in the solidity of the data upon which estimates of the burden of disease in DALYs are based. In some cases, for example, evidence of a harmful effect of an environmental factor may be restricted to animal studies. The figure for the burden of disease is less reliable in such a case than if it was supplemented by data from human epidemiological studies. Another example is that health impairment occurring in the shorter term can be determined more accurately than health

impairment that becomes manifest in the longer term. This is something else not shown in the results for the estimation of the burden of disease.

The Committee believes that the burden (and avoidable burden) of disease expressed as a single figure is not informative enough for balanced decision-making about the environmental policy that is to be implemented. Its opinion is that background material needs to be included that provides insights into the quality of the data used and the choices that were made during the calculations, such as the demarcation of 'health impairment' (e.g. whether or not to include hindrances due to environmental factors such as noise), plus the relative weightings of early and long-term health impairment as described above.

This does not mean that the numbers do not provide any useful information; it is merely something that has to be taken into account. Using simpler metrics (such as the probability of mortality) would be of limited use, because the data on exposure and effects which is used for these metrics is largely the same. Moreover, important information about impacts on health is then left unused.

The additional information should ensure that the figures do not start leading lives of their own and that we do not lose sight of the principal characteristics of the burden of disease to which they refer. This information must be weighted increasingly heavily as the questions or measures that are being compared with one another diverge further. That is the only way to produce a meaningful comparison that can contribute to a carefully considered ranking of problems and prioritisation of measures.

Sensitivity analyses must furthermore be provided along with estimates of disease burden (and avoidable disease burden) wherever possible. A sensitivity analysis provides more than just insights into the consequences of the uncertainties and value judgements: it also shows the relative importance of individual variables.

Research to further improve the validity of the DALY

Further research could reduce the uncertainties that are inextricably linked to application of the DALY in the environmental field. Both the characteristics of the DALY approach and the underlying data about exposure and effect are determining factors for the reliability of the estimates of the burden of disease. Progress can be made in the DALY method by, for example, increasing the reliability of the estimates for the duration of relevant health conditions.

The underlying data has a major influence on the estimate. After all, the figure cannot be more reliable than the data on which it is based. However, there are often shortcomings in the data. Examples are the risks due to hormone disrupters

and nano-materials. The burden of disease due to either of these cannot currently be determined. It is therefore desirable that further investment should be made in gathering more and better data about exposure and effect. Consideration should also be given here to multiple exposures and to interactions between environmental factors. The interactions of environmental factors with other factors that affect health (such as social and economic factors) also require further exploration. Given that application of all three metrics is based on the same data about exposure and effects, such improvements will have a positive effect on the estimates of the burden of disease from all three methods.

This two-pronged approach (improving the actual DALY method and gathering better basic data) will contribute to further increases in the reliability of the figures. This will allow health-based environmental policy to be strengthened still further.

Chapter 1

Introduction

1.1 Background

Core values of environmental policy

For some decades, the core values underpinning Dutch environmental policy have been health, safety and sustainability.[1,2] This advisory report focuses particularly on the protection of human health. The exposure limits applied with a view to affording such protection are based on the highest levels of exposure that may reasonably be expected to induce no adverse health effects, or on the highest levels of exposure associated with a specified (small) additional mortality risk. Dutch environmental policy also incorporates the ALARA principle: the principle that exposure to potentially hazardous environmental influences should be kept as low as reasonably achievable.

A few years ago, the then State Secretary of Housing, Spatial Planning and the Environment (VROM) initiated a programme of policy modernisation known as Coping Rationally With Risks,[3-5] which led to greater emphasis being placed on the ALARA principle. Hence, for example, it was made clear Legionella control measures were required only where there was a high risk of infection. The objective of the policy realignment was to ensure that the cost burden associated with risk control was kept within reasonable bounds.

The need for a way of measuring avoidable disease burden

In order to apply the ALARA principle responsibly, it is important to be able to reliably estimate the extent of environmental factors' adverse influence on human health (for convenience referred to in this advisory report simply as 'environmental health effects') and the extent to which countermeasures are likely to be effective. Such estimates can be made using metrics that take account of both the number of people affected by a given factor and the seriousness of the health impairment that they suffer, as reflected in, for example, prematurity of death.

Such a metric is already used in medicine: the QALY (quality-adjusted life year). The QALY is widely utilised to support decisions regarding the prioritisation of treatments and services. It is therefore pertinent to consider whether this indicator could also be used in the environmental policy domain. Other metrics might also be useful, one being the DALY (disability-adjusted life year). Indeed, the DALY, which is related to the QALY, is already employed as an environmental policy tool.

The former State Secretary of VROM asked the Health Council to consider how the QALY might be used in the environmental policy domain and what value should be attached to a QALY. The State Secretary's request for advice, including a summary of the background to it, is presented in Appendix A. In view of the close relationship between the QALY and the DALY, it was felt appropriate to take the DALY into consideration as well. Another metric whose usefulness as an environmental policy tool warrants assessment is avoidable disease burden expressed in monetary units.

This advisory report seeks to establish the extent to which the three metrics might profitably be used to compare the influence on health of various environmental factors and to forecast how (and at what cost) possible countermeasures are likely to mitigate such influence. Could the metrics be useful, for instance, in answering questions such as: Which is likely to reduce disease burden the most, action to prevent air pollution, or action to prevent noise pollution? Is pollution-related health impairment best tackled by limiting vehicle speeds or by subsidising the fitment of particle filters to existing diesel vehicles? What effect would a combination of measures have? Clarity regarding the extent to which environmental factors influence health and regarding the effectiveness of possible countermeasures can aid policy-related decision-making.

1.2 The Committee

This advisory report is the work of a permanent committee of experts made up of members of the Health Council: the Standing Committee on Health and Environment. For the task of compiling this report, a number of additional experts were co-opted onto the committee. This enlarged body is referred to below simply as 'the Committee'. The actual text of the report was prepared by a subcommittee, which included the co-opted experts. The membership of the full Committee and of the subcommittee is specified in Appendix B.

The draft report was reviewed by the Standing Committee on Medical Ethics and Medical Law and by several external experts, who are also listed in Appendix B.

1.3 Scope

Selection of metrics for assessment

This advisory report is concerned with three metrics that can be used to quantify the influence of environmental factors on health and the effect of intervention measures. The first two metrics are the QALY and the DALY, both of which quantify the disease burden avoidable by intervention in terms of life prolongation and health improvement.

There are two other QALY-related metrics of health benefit, which could in principle also be used for the intended purpose. These are the healthy years equivalent (HYE) and the saved young life equivalent (SAVE) (see the Health Council background study on cost-utility analysis[6]). Both were developed for use in the medical domain, but have yet to enter widespread use, possibly because they are perceived as cumbersome. These indicators are not therefore assessed in this advisory report.

Nor does the report deal with life expectancy indexes, such as healthy life expectancy or health-adjusted life expectancy (HALE). Because life expectancy is the product of all health determinants collectively, it is probably not sufficiently sensitive as a tool for quantifying the effect of individual determinants with relatively little influence, such as environmental factors.

Also outside the scope of the report are *semi*-quantitative indicators of health benefit, such as the scores attributed in the context of City and Environment Health Effect Screening, a test applied to local spatial plans, such as traffic man-

agement plans and residential development plans, with a view to gauging their probable impact.

The report does, however, consider another quantitative metric of life prolongation and health improvement and compare it with the QALY and DALY: avoidable disease burden expressed in monetary units. With this metric, the health effect of environmental measures can be quantified simply in euros. The Committee has considered this indicator, because it enables the comparison of attainable health benefit with the other effects of environmental measures, such as effects on nature or agriculture.

Questions addressed

Within the scope defined above, the Committee has addressed the following questions:

- What can be achieved by calculating the health effects of environmental measures in terms of QALYs and cost per QALY?
- What can be achieved by calculating the health effects of environmental measures in terms of DALYs and cost per DALY?
- What can be achieved by calculating the health effects of environmental measures in terms of monetary units?
- How suitable is each of the candidate metrics as a tool for the prioritisation of environmental measures?
- What is required in order to make the candidate metrics more useful as environmental policy tools?

In answering these questions, the Committee has elaborated upon the content of three recent Health Council publications relating to the medical domain, in which reservations were expressed regarding use of the QALY.[6-8] The publications in question were an advisory report on the composition of the basic health care benefit package, a related background study report on cost-utility analysis* and a horizon-scanning report on the ethical aspects of cost-utility analysis.

In this advisory report, the Committee is concerned primarily with the national government. Effects are considered at the societal level: all the consequences of an environmental intervention measure, both positive and negative, are taken into account, regardless of who the beneficiaries or disadvantaged parties are. Furthermore, in recognition of the communal and preventive nature of

* Cost-utility: a special variant of the efficiency criterion ‘cost-effectiveness’ (cost per unit of health benefit), i.e. the cost per QALY gained.

environmental policy, the Committee has examined the relevant issues from the communal viewpoint. Hence, aspects of the QALY that relate to decisions regarding individual patients are not examined.

The product of the Committee's analysis is an appraisal of a) the suitability of the three metrics for use in the quantification of avoidable disease burden in the context of environmental policy, and b) the best way to make use of the metrics.

1.4 Structure of the report

In chapter 2, the Committee considers how useful the QALY and the DALY can be as tools for quantifying the health effects of environmental policy measures. chapter 3 is devoted to an examination of the potential for using monetary units in the same way. By providing insight into the way these tools work and their potential in the context of environmental policy, chapters 2 and 3 cover the first three questions set out above. In chapter 4, the Committee goes on to consider how useful each of the three instruments can be in the prioritisation of environmental measures, and what conditions must be fulfilled to enable them to be used to full advantage; the content of chapter 4 is therefore a response to the final two questions. Finally, in chapter 5, the Committee summarises its main conclusions and makes a number of recommendations.

Chapter 2

The suitability of the QALY and the DALY

In this chapter, the Committee begins by examining the methodological issues surrounding use of the QALY for the quantification of health effects. This necessarily entails frequent reference to the domain where this metric is mainly used: the health care sector. The Committee then makes a similar examination of the DALY methodology, before considering the implications of applying the QALY and DALY methodologies in the context of environmental policy and making a number of related observations. The chapter concludes with an appraisal of the suitability of the two metrics for the quantification of health effects in environmental policy.

2.1 Methodological considerations

2.1.1 QALY calculations in the health care sector

A generally valid metric

Health benefit can take the form of longer life and/or better health during life ('health-related quality of life'). These two forms of health benefit can be expressed in terms of a single unit that incorporates them both: the quality-adjusted life year (QALY). By expressing health benefit in this way, it is possible to quantify the benefit of a particular measure to an individual, to a group (e.g. people who have a particular condition), or to the population as a whole.

In the health care sector, the QALY is used to quantify health and health benefit and as a component of cost-utility expressions (expressions of cost per QALY gained). Health benefit and cost-utility data are then used to compare and prioritise medical services. The QALY is an attractive expression of health benefit and cost-utility is an attractive expression of cost-effectiveness (efficiency) because both are universally applicable: they enable the comparison of very different services. This is not the case with many other indicators of health benefit.

The Health Council has recently highlighted certain matters associated with the use of the QALY and cost-utility expressions, which had not previously received a great deal of attention.[6-8] The Council has also assessed the implications of the relevant matters for the use of these indicators to inform decision-making on the allocation of scarce resources in the health care sector. The relevant observations and advice from the Council's earlier publications are summarised below.

Assumptions underpinning the calculations

One QALY is a year spent in full health, or two years spent in a state of health that is considered 'half as good as full health', and so on.

In order to express health benefit in QALYs, health statuses are 'weighted' by assigning a factor reflective of the extent to which the status is considered to detract from a sufferer's quality of life. The weighting factor is usually a figure between 0 and 1, where 0 represents death or a health status no better than death, and 1 represents full health*. The health benefit of an intervention measure to patients with a given condition is calculated by subtracting the weighting factor for patient's status before intervention from the weighting factor for his/her status after intervention, and multiplying the result by the number of patients affected and the number of years they may be expected to spend in improved health.

This approach is based upon a number of normative assumptions. It is assumed, for example, that life expectancy and health-related quality of life can be reflected in a single expression and that the health benefit to several (or numerous) people may be aggregated. It is also assumed that health and health benefit are in fact quantifiable, i.e. expressible in numeric terms, and that a

* In the series comatose, asthmatic, discomforted, for example, the weightings increase. It is worth noting that not all conditions fall in the range 0 to 1: some conditions are regarded as worse than death, and are accordingly assigned negative weighting factors.

QALY has the same value to any recipient, regardless of his/her age and health status before and after treatment.

In addition, use of the QALY requires various methodological choices to be made. It is necessary to decide, for example, how the relevant health statuses should be defined and how they should be assessed: by paired comparison or individual appraisal (e.g. based on a score out of ten). A decision also has to be made as to who should make the assessment: patients, health care practitioners, or a cross-section of the general population.

Implications for the outcome

The decisions made regarding how health statuses should be defined and assessed influence the weighting factors assigned to them and therefore the number of QALYs attainable through intervention. It is not clear, however, how reliable the various alternatives are, or how comparable the results obtained using them are. The choice of assessor-group also influences the weighting factor assigned to a status, but the theoretical and practical significance of differences between the assessments made by different groups remains uncertain.

Furthermore, use of the QALY has a systematic influence on the way health benefit from a service is distributed across the population. Older people, for example, stand to gain fewer QALYs from life-prolonging treatments than younger people, and fewer QALYs can be won by treating people who are chronically ill than by treating people who are relatively healthy. This means that a quantification of attainable health benefit expressed in QALYs, or a statement of cost per QALY, will tend to make a treatment or service that predominantly benefits the young and (relatively) healthy appear more worthwhile than one whose main beneficiaries are older or chronically ill people.

Various technical means of correcting for this systematic distribution bias have been put forward. One is an alternative method for assessing the seriousness of a status: instead of respondents being asked to choose between two hypothetical forms of health benefit without regard for who the beneficiaries are, they should be asked to take the profile of the beneficiary group into consideration. Another option involves correcting for the age of the beneficiary. This could be done by, for example, applying an age group-specific correction factor, or a correction factor that is stepped according to the recipient’s age. Either of these methods would influence the apparent distribution of health benefit.

Cost determination

In order to calculate the cost per QALY of a care sector intervention, it is necessary not only to quantify the health benefit in QALYs, but also to determine what the intervention costs. This implies making certain decisions about what costs should and should not be attributed to the intervention. In this context, distinction should be made between direct and indirect costs, each of which may be subdivided into medical and non-medical items.

Direct costs include not only the costs of prevention, diagnosis, treatment, rehabilitation and nursing, but also the cost of travelling to and from the treatment location. Indirect costs are costs that are related to the disease or treatment, but not a primary consequence of it. Under this heading come the cost of providing medical care to a person during the extra years of life that are won for him/her and productivity costs (the cost of lost paid or unpaid output and the cost of providing cover for someone who is unable to work or has died).

Such costs are by no means always or all taken into account when an intervention is costed. Indirect costs are particularly liable to be ignored or only partially accounted for. To complicate matters, there are various methods for estimating the individual cost items, while valuations are sometimes made on an average basis and sometimes on a marginal basis. An average cost is obtained by dividing the total cost by the number of procedures performed, whereas a marginal cost calculation is based on the cost of an additional procedure.

In this context too, therefore, decisions need to be made that can significantly influence the outcome of the calculation process. If, for example, productivity costs are included, services that benefit non-working members of the population, such as the elderly and children, appear less beneficial than those that benefit people in work. If, on the other hand, such costs are disregarded, that would be to the disadvantage of the very people whose productivity has to cover the cost of providing medical services.

Time factor correction

Calculation of the cost per QALY requires a further decision to be made, regarding the extent to which the health benefits and costs attributable to an intervention should be corrected to take account of when they arise. Some benefits and costs arise immediately following an intervention, while others follow after a significant interval. Generally speaking, people wish to secure the benefit of an intervention (e.g. improved health) as soon as possible, while deferring any undesirable consequences (costs) as long as possible. To reflect these prefer-

ences, both health benefits and costs are discounted over time, i.e. the later they arise, the lower their value is deemed to be. Discounting is achieved by reducing the basic values by an annual percentage, known as the discount rate. Thus, if the discount rate is 4 per cent, a thousand QALYs secured ten years after intervention are worth the same as 680 QALYs secured immediately*.

The discount rate applied to health benefits may or may not be the same as that applied to costs. Therefore, another decision has to be made, which has a bearing on the conclusions reached regarding the cost-utility ratios of medical services. If equal discount rates are applied, interventions whose benefit is not felt for some years, such as public health care initiatives, appear to have a relatively unfavourable cost-utility ratio: the benefit is devalued by its deferment, while the cost is incurred at the time of intervention. Thus, vaccination programmes (disease prevention) and public information campaigns designed to encourage healthy lifestyles (health promotion) seem to be relatively poor value for money. In other words, the individual preference for short-term effects is at odds with an approach that also accords importance to societal interests, such as protection against long-term effects and responsibility towards future generations.

If a lower discount rate is applied to health benefits than that applied to costs, the cost-utility ratios of preventive measures look more favourable. The lower the health benefit discount rate, the greater this effect becomes. If, for example, a discount rate of 2 per cent were applied, the thousand QALYs secured ten years after intervention would be worth the same as 820 QALYs secured immediately.

Suitability for use in health care

When providing advice in the past, the Health Council therefore concluded that health benefit and cost-utility were not easily operationalised criteria, despite the encouraging progress made in terms of making them suitable for use in health care. Not only was the quantification of health benefit and cost-utility regarded as problematic by the Council, but it was also felt that additional considerations needed to be taken into account when considering the allocation of care budgets, such as the fair distribution of health benefits across the population.

In what situations and in what way can the expression of health benefit in QALYs and expressions of cost-utility best be used to inform decision-making concerning the prioritisation of medical services? The Council did not consider it desirable to base prioritisation decisions purely on such expressions across the

* The discount factor is $1/(1+s)^t$), where s=0.04 and t=10.

health care spectrum. Rather it saw these metrics as tools for use within well-defined fields of care, such as the prevention of cardiovascular disease.

Within such fields problems and considerations are similar and the relevant knowledge and experience needed for decision-making is not unduly wide-ranging. Furthermore, interpretation tends to be less problematic where there is less diversity in the medical conditions and care services being compared. That is certainly the case when what one is seeking to determine is at what stage of a condition's development it is best to provide a given service. QALYs can be very useful when assessing whether surgery is best undertaken early or late in the development of prostate conditions, for example, or deciding when cholesterol synthesis inhibitors should be prescribed in order to minimise the risk of coronary heart disease developing.

The Council also concluded that a transparent decision-making process was a necessary precondition for the application of health benefit and cost-utility as criteria in the prioritisation of medical services. Prioritisation decisions needed to take account of other considerations as well, including the availability of funds, practical issues such as the existence of thresholds and limits for the two criteria, moral and ethical questions such as the fair distribution of health benefit, and legal issues.

Debate regarding the use of health benefit (expressed in QALYs) and cost-utility (expressed as cost per QALY) as indicators to guide the allocation of resources in health care has continued unabated since the Council's earlier publications. One notable recent contribution was the report by the Council for Public Health and Health Care.[9] The relationship between the health benefit discount rate and the cost discount rate also continues to be discussed (see, for example, [10,11]).

2.1.2 DALY calculations in environmental policy

Related approach

The disability-adjusted life year (DALY) is a similar concept to the QALY, developed in the 1990s. The DALY was introduced by the WHO and the World Bank for use in the Global Burden of Disease (GBD) Project. These organisations wanted a way of measuring the disease burden on a given population and monitoring change in that burden over time. Since then, it has been used to calculate the contributions made by major causes of disease burden, such as malnutrition, inadequate vitamin intake, overweight, air pollution and smoking. Detailed examinations of the DALY can be found in several survey reports.[12-14]

To date, the DALY has been more widely used as an environmental policy support tool than the QALY, primarily with a view to determining the extent to which disease burden is attributable to environmental factors. A number of reports have been published on use of the DALY in the environmental policy domain.[15-19]

How the DALY differs from the QALY

The QALY and the DALY are related concepts, but they differ in their perspective. This is reflected in the fact that the values attached to the two extreme states of health – full health and death – are inverted. Full health is represented by a weight of 0 (the absence of disease burden), while death has a weight of 1, when calculating DALYs.

Another more fundamental difference is that the QALY takes the current situation as its starting point, while the DALY uses a reference point in the future: 'standard life expectancy'. The extent to which a person's actual life falls short of this standard – in its length, or its quality, or both – is then calculated. This implies, of course, that the level of disease burden expressed in DALYs depends partly on what the standard life expectancy is deemed to be.

The QALY and the DALY also differ in a number of less salient respects relating to matters such as the assessors and the valuation of health status. DALY values are less subject to assessor-related variation or variation attributable to the method used to determine the weighting factors than QALY values are. At least, that was the case in the GBD Project and the associated analyses, in which the assessors were health care practitioners and weighting factors were determined using a particular method that took fairness into account*.

Originally, the QALY and DALY methods also differed in their approach to age correction. The first DALY estimates published incorporated only standard, evenly distributed age correction factors. This approach has since been abandoned, however (see, for example, [20,21]).

In the health care sector, it is normal to quantify effects in terms of health benefit, expressed in QALYs, while in the environmental policy domain it is more normal to use avoidable disease burden, expressed in DALYs. The latter approach reflects the collectivist perspective of that domain and the fact that the reference point for the estimates is an objective: a life expectancy that is consid-

* The weighting factors are not determined by hypothetical health improvements in their own right, but by comparing the improvements in different groups.

ered attainable. The QALY terminology reflects an individualised, curative perspective, whose point of reference is the person's health status at the outset.

2.1.3 Conclusions regarding the QALY and DALY methodologies

There are no fundamental methodological differences between the QALY and the DALY that make the one a better tool for use in the environmental policy domain than the other. The Committee sees the DALY and the QALY as related concepts. The DALY may be thought of as the mirror image of the QALY, since it measures health lost, rather than health gained. Consequently, the methodological observations made regarding the QALY are equally valid in relation to the DALY.

2.2 Suitability for use in the environmental policy domain

The next step is to consider how the basic QALY and DALY concept might be used in the environmental policy domain. In this subsection, the Committee considers what scope there is for using these metrics in the same way that they are used in the health care sector.

The environmental and health care policy domains differ insofar as determining the disease burden that can be prevented by an intervention measure is usually more difficult in the environmental domain than in the health care sector. This is due to two important characteristics of the issues addressed in each case.

2.2.1 Characteristics of health issues in the environmental policy domain

Health benefit is less directly felt

Environmental policy measures have a less direct effect on disease burden than health care intervention measures, particularly curative intervention measures. In the health care sector, health benefit is obtained by providing medical treatment and other forms of care to people who are sick. In the environmental policy domain, by contrast, intervention is not direct or individualised, but indirect and collectivist, entailing measures that improve the quality of the environment and thus help to protect the health of the population. This indirect, preventive approach is more akin to that used in the public health care sector. Consequently, it is harder to quantify avoidable disease burden in the environmental policy domain.

Issues have a greater time span and greater geographical spread

Another important difference is that the health issues addressed in the environmental policy domain typically have a greater time span and a greater geographical spread than those addressed in health care. This too makes it harder to establish how much disease burden can be avoided.

1 Greater time span

The health benefits of curative interventions are usually felt sooner than the benefits of collectivist preventive interventions, such as the measures typically taken in the environmental policy and public health care domains. It will be decades, for example, before a structural reduction in chlorofluorocarbons (which deplete the ozone layer), or a structural reduction in exposure to carcinogenic substances results in lower levels of disease burden. Furthermore, the effects of environmental policy measures tend to span several generations. The two examples given above illustrate this point: the health benefits of both would be felt by many future generations. In this respect, environmental measures resemble public health care intervention measures, such as vaccination and the provision of lifestyle advice.

Although the benefits of environmental measures are more likely to be deferred than the benefits of curative intervention measures, some do reduce short-term disease burden as well. The suppression of particulate pollutants in the atmosphere has been found to reduce premature mortality almost immediately, for example; lower levels of particulates and ozone can also bring about a speedy decline in the number of asthma-related emergency hospital admissions.[22-24]

Because of the extended time horizon, the discount rate applied has a greater influence on apparent disease burden reduction in the environmental policy domain than in the care sector. Furthermore, the longer a reduction in disease burden is deferred, the greater the uncertainty as to how sizeable the reduction is likely to be; cause and effect become harder to correlate as they become more removed from one another in time. Consequently, estimates of avoidable disease burden are more uncertain in the environmental policy domain than in the care sector.

Uncertainty regarding and deferment of disease burden reduction make it harder to decide what time horizon and discount rate are most appropriate for use in the calculation purposes. If a lower discount rate is used, disease burden avoidable in the more distant future will be accorded greater weight, but –

because the avoidable burden is harder to quantify with confidence – the total disease burden estimates will be less reliable.

2 Greater geographical spread

Their multi-generational significance is not the only characteristic that distinguishes environmental health issues from health care issues. They also tend to be geographically international. This necessitates the coordination of policy within the EU or in a broader international context, as with action on particulates and climate change. The scale of such issues makes the estimation of avoidable disease burden particularly complex: what forms of adverse health effect are involved, how many QALYs or DALYs are associated with the factor in question, where can QALYs be gained or DALYs avoided, and when?

2.2.2 Implications for the disease burden estimation

Quantifying disease burden (and therefore avoidable disease burden) in the environmental policy domain is comparatively difficult because of the indirect manner in which disease burden is prevented, the time span of the issues and their geographical spread. Quantification also implies insight into the effectiveness of a measure. The differences between the environmental policy domain and the care sector are reflected in the data from which the disease burden related to environmental factors has to be calculated.

Effect determination

The first step is to establish a correlation between a given environmental factor and one or more health effects. In the health care sector, it is usually possible to draw upon data from experimental and observational (epidemiological) research with human subjects. Where environmental factors are concerned, experimental research with human subjects is rarely possible, however, or open to important ethical objections.[25] Consequently, the kinds of data that support evidence-based care sector interventions tend to be lacking in the environmental sector.

The scientific basis for health protection measures in the environmental policy domain is nearly always obtained from experimental research with animals or with cells and tissues *in vitro*, and/or from observational research.

Such observational research as there has been has often provided no basis for conclusions about the health effects associated with a given environmental factor – because the subjects are simultaneously exposed to more than one environmen-

tal factor, for example. Furthermore, even if epidemiological studies suggest that the existence of a causal relationship is plausible, such studies may not contribute to quantification of the disease burden (in QALYs/DALYs or in another unit). The reason being that, in many cases, the level of exposure associated with the health effect is not known. Retrospective estimation is often not possible or not sufficiently reliable. Because of the lack of adequate epidemiological data in this domain, data from animal experiments or *in vitro* research are often used. So environmental health conclusions regarding causal relationships tend to be based on sundry combinations of data of various types, obtained from various sources, including epidemiological and toxicological research.

One drawback of this is that the disease burden associated with environmental factors often has to be calculated from observations that are not easy to interpret. In this domain, findings from research into relevant health problems or conditions, such as respiratory conditions, are by no means always available. This makes it necessary to draw on data from research into variables that have no direct correlation to disease burden, but merely provide an indication of it. Such variables are typically referred to as 'health indicators'.[26] Examples from epidemiological research include the number of hospital admissions (e.g. in connection with respiratory complaints) and the number of people that report annoyance (e.g. caused by noise or unpleasant odours). Typical health indicators provided by animal research include early biological changes, such as increased organ weights or tissue enzyme levels. However, it is not always clear what the health significance of such observations is, or to what extent findings from animal research are transferable to people. As a result, it is difficult to establish whether there is a link between an environmental factor and health.

Quantitative association between exposure and effect

The estimation of disease burden requires not only the demonstration of a causal relationship, but also the quantification of an exposure-response curve. In other words, it is necessary to know how the response (the number of exposed people exhibiting a given health indicator, such as the development of respiratory complaints) changes under the influence of increasing exposure to the environmental factor in question. The definition of exposure-response curves is similarly dependent on various types of data drawn from sources such as epidemiological and toxicological research.

The determination of exposure

In addition to the above-mentioned qualitative and quantitative data regarding the relation between an environmental factor and its health effects, a third (and, again, quantitative) body of information is needed in order to estimate the associated disease burden. Namely, information about the level of exposure or, more precisely, about the distribution of exposure within the population: how many people are exposed to the factor, and in what concentration. Exposure may be estimated using measurements and/or modelling, and demographic data. However, the estimates thus obtained are often quite rough.

2.2.3 Examples from the environmental policy domain

Sometimes, the available data are so sketchy that they do not support any conclusions regarding the existence of a causal relationship between an environmental factor and health problems in the population. This is the case, for example, with substances that cause hormonal disruption. The Health Council has previously reported that it is not clear whether exposure to such substances is involved in the increasing incidences of breast, testicular and prostate cancer.[27] Measured in QALYs/DALYs, the impact of these diseases is very significant, but it is far from certain how much of the disease burden is attributable to hormone disrupters.

Another example is the possible link between environmental factors and cancer in children. Cancer is relatively uncommon in children, but the length of the illness in those that do develop it, and the youth of those that die from it, mean that the QALYs/DALYs scores per case are very significant. Again, though, it is not clear what influence environmental factors have, or what proportion of the disease burden they are responsible for. Both of these questions are among the issues addressed by SCALE (*Science, Children, Awareness, Legal instruments, Evaluation*), the European Commission's strategy for reinforcing EU policy in the field of health and environment and the basis for the European Environment and Health Action Plan 2004-2010.[28-31]

Less profound gaps also exist in scientific understanding of the influence of environmental factors on health. In some cases, for example, there may be evidence indicating that a causal relationship is plausible and there may be sufficient data to estimate the associated disease burden. However, it may not be apparent from the outcome how strong the evidence for causality is. This implies that the data are not directly comparable, even with similar risks, which differ in relatively few regards. This is illustrated by the following example.

According to the WHO's International Agency for Research on Cancer, benzene has been shown to be carcinogenic in humans; by contrast, evidence that ethylene oxide and polycyclic aromatic hydrocarbons may also possess carcinogenic properties comes only from animal research. The Agency accordingly classifies benzene as 'carcinogenic to humans' and the other two substances as 'probably carcinogenic to humans'. DALY scores have been calculated for all three substances.[32] The figures for benzene are more reliable than those for the two other substances, because they are based on stronger evidence. This fact is not apparent, however, simply from the data.

It may also be that the disease burden calculated for a given environmental factor consists partly of short-term effects and partly of long-term effects. The short-term effects of exposure to an environmental factor will usually be easier to quantify than the long-term effects. So the QALY/DALY scores for short-term effects are more reliable. So DALY estimates of the effects of exposure to particulates sometimes involve combined short-term and long-term data, and sometimes relate only to the short term.[19]

The problem is that reliable data on the long-term effects of environmental factors are scarce, particularly where effects other than raised mortality risk are concerned. In the case of particulates, there have been recent developments, however: it has been demonstrated that in children there is a correlation between low lung capacity and living in an area with high traffic density.[33,34]

2.2.4 Observations regarding (avoidable) disease burden calculations

Estimates of (avoidable) disease burden always involve a degree of uncertainty, which derives from variability and gaps in scientific knowledge. In addition, the calculated values depend to a significant extent on the choices that are necessarily made when implementing the concept.

The influence of how health impairment is defined

As indicated above, estimation of the avoidable disease burden attributable to an environmental factor involves making a choice regarding the discount rates to be applied (as also happens in the care sector) and – where a DALY calculation is involved – regarding standard life expectancy. However, a third choice also has to be made: about what does and does not constitute health impairment. The need to make this choice is not specific to the environmental policy domain, but its influence on the estimated disease burden can be considerable.

It is difficult to say what phenomena may reasonably be deemed forms of health impairment. Accepted definitions of health offer little assistance in this regard, because of their breadth. According to the most widely quoted definition, that given by the WHO, health is a state of complete physical, mental and social wellbeing, and not merely the absence of disease or infirmity.[35] This definition has been criticised in many quarters, since it implies that almost no one may consider themselves truly healthy. In several recent reports, the Health Council has observed that other such positive definitions of health, albeit narrower biomedical definitions, are also open to operationalisation in a variety of ways.[8,36,37]

Any demarcation between health and ill health has to be based on a number of value-based choices. Medical conditions that fall on the borderline between health and ill health include, for example, onychomycosis and a light cold. Where one draws the line has implications for the estimation of what can be achieved by a given form of intervention. Perhaps the most obvious example of this in the environmental policy domain is nuisance caused by noise or unpleasant odours. Noise can cause annoyance, sleep disturbance or hearing damage.[38,39] All three have implications for quality of life, each to a greater degree than the former. Methodologically speaking, it is quite possible when calculating disease burden to take account not only of hearing damage, but also of sleep disturbance and annoyance. Indeed, in a recent report, the Health Council sought to approximately quantify the disease burden attributable to serious sleep disturbance,[39] while researchers at the RIVM have attempted to quantify the burden associated with annoying noise.[19] The inclusion of annoyance in the calculation of noise-related disease burden, has a considerable influence on the outcome because, although its seriousness weighting may be low, annoyance is very common, and therefore generates a high QALY/DALY score. It has recently been estimated, for example, that traffic noise-related disease burden in the form of premature death (as the end-point of a causal chain in which it is preceded by stress, high blood pressure and cardiovascular disease) averages 420 DALYs per million people in the Netherlands.[19] However, the disease burden including not only premature death, but also (serious) annoyance and sleep disturbance, has been put at 2300 DALYs per million people: more than five times as much.

It will be apparent, therefore, that what one includes within the definition of health impairment has a major influence on one’s disease burden calculation. Nevertheless, the implications of the definition adopted can be made transparent by specifying the contribution of each health effect to the overall QALY/DALY score.

The influence of variability

The estimation of disease burden in QALYs or DALYs involves the application of weighting factors, which associate a particular quality of life with a defined health effect. The variability of the weighting factors determines the influence that they have on the reliability of the outcome. Again, this is not specific to the calculation of disease burden in the environmental policy domain, but it is particularly relevant, as the example below illustrates.

Low DALY weighting factors – indicative of a low degree of medical seriousness and slight quality-of-life impairment – tend to exhibit a fairly large standard deviation in absolute terms (see, for example, [21]). This has significant implications, for example, for the calculation of the disease burden associated with noise: the combination of a low, less precisely defined weighting factor and a large number of affected individuals yields a disease burden figure for noise-related nuisance that is quite substantial, but with a wide margin of uncertainty.

Other points need to be taken into account

The disease burden avoidable through the implementation of environmental policy measures is not always distributed evenly across the population. The impact of a given measure may vary from one population group to the next. Everyone is exposed to particulates and ozone, for example, but reducing the concentrations of these substances would not affect everyone in the same way. Older people would benefit most from lower particulate levels, which would mean less risk of sudden death for the elderly.[40,41] By contrast, young people, who tend to be more physically active, would benefit more from a lower ozone concentration, since this would cut the risk of acute asthma.[42] Uneven benefit distribution patterns need to be considered on a case-by-case basis.

2.3 Conclusion

QALYs and DALYs can be used to quantify (avoidable) disease burden. Although the two metrics differ in their perspective, they are essentially similar concepts, applied in a similar fashion. Either may be used to estimate the disease burden associated with environmental factors, to compare the potential effectiveness of various means of reducing disease burden, and to shed light on the cost of implementing such measures.

The similarity between these two metrics is such that methodological observations may be made that are valid in both domains. For example, normative

decisions have to be made concerning matters such as the discount rate to be applied and the definition of health impairment, which have a considerable influence on the outcome of the quantification process. Furthermore, health impairment is often difficult to measure, and allowance has to be made for the uncertainty associated with variability and gaps in scientific knowledge.

Estimates of (avoidable) disease burden expressed in QALYs or DALYs, and of cost per QALY/DALY, require qualification. They say nothing, for example, about the strength of the evidence for a causal relationship between intervention and effect, or about their own reliability. Such matters need to be borne in mind when assessing the value of these metrics.

The Committee is of the view that the issues highlighted above are of greater significance when the metrics are employed in the environmental policy domain than when they are used in the health care sector. The environmental policy domain has two characteristics that complicate the estimation of avoidable disease burden. First, estimated values are less certain, partly because the effects of intervention are normally indirect and often substantially deferred.

Consequently, the quantification of (avoidable) disease burden in QALYs or DALYs and of cost per QALY or DALY is not very reliable in this policy domain. Furthermore, it would be inappropriate to base environmental policy decisions on such quantitative criteria alone. Issues such as the overall cost of disease burden avoidance and the distribution of benefit across the population need to be separately taken into account. The more dissimilar the health issues and intervention measures under consideration are, the more weight should be attached to such other criteria.

It should also be recognised that (avoidable) disease burden dominates decision-making less in the environmental policy domain than it does in the health care sector. While the avoidance of disease burden may be the primary objective in both spheres, environmental policy is intended to additionally take account of the effects – both positive and negative – for the economy, mobility, nature and so forth. Decision-making in this domain also seeks to reflect public opinion on the relevant issues and the perceived threat level. In these respects, the environmental policy domain resembles the public health care sector more than the therapeutic care sector.

Insofar as the health implications of a policy decision need to be taken into account, the QALY and DALY are in principle suitable tools for quantifying the disease burden associated with an environmental factor, the disease burden avoidable by the implementation of a given measure and – where cost data are available – the cost per unit of avoided disease burden. However, it is important

to recognise that QALY-based and DALY-based quantitative expressions are not uniformly reliable, their reliability being dependent on the research data from which they are calculated. Furthermore, one should not lose sight of the fact that the outcome of a QALY or DALY calculation is always influenced by certain normative choices inherent to the calculation process.

Chapter 3

The suitability of monetary units

It is also possible to quantify (avoidable) disease burden in terms of its monetary or economic cost, i.e. its cost in euros. In this chapter, the Committee considers how avoidable disease burden expressed in euros might be used for the prioritisation of environmental measures.

This chapter accordingly begins with an examination of the established methods for estimating avoidable disease burden in monetary units. The Committee also considers how the monetary cost of avoidable disease burden may be incorporated into an efficiency criterion. The chapter ends with the Committee's conclusions regarding the suitability of this form of expression for use in the environmental policy sector.

3.1 Methodological considerations

The Committee is not aware of any academic publications in which the potential of quantifying health effects in monetary terms has been assessed, in the way that use of the QALY in the care sector has been assessed. The Committee's appraisal is therefore based on a small number of guidebooks and other publications, in which the various methods for calculating monetary values are explained and their merits examined.[43-49] Among the publications considered is an OECD-commissioned survey of cost-benefit analysis in the environmental policy domain, which appeared last year and includes an outline of recent developments.[49]

3.1.1 *Estimating value on the basis of individual preferences*

Method

Various changes in people's circumstances can be measured in economic terms: consumption or non-consumption of goods, provision or use of services, response to community activities or to government measures intended to mitigate the undesirable effects of such activities. A change in an individual's circumstances may be positive or negative to a greater or lesser degree. In welfare economics, the degree of change is measured by calculating its economic value. This is done on the basis of two related concepts, borrowed from market research. Willingness to pay is an expression of the maximum economic value that a person places on a change to his or her circumstances (i.e. the most that the person is prepared to pay to secure a positive change or to avoid a negative change). Willingness to accept is an expression of the minimum economic value that a person places on a change to his or her circumstances (i.e. the least that the person is prepared to take in return for going without a positive change or accepting a negative change). The points of reference are therefore the person's circumstances before and after the change under evaluation, e.g. the effect of an environmental intervention measure.

Monetary units therefore differ from QALYs and DALYs in terms of the breadth of their potential field of application. While QALYs and DALYs are specifically for the quantification of health and changes in health status, monetary units can be used to quantify a wider spectrum of changes. Nevertheless, in the context of this advisory report, what we are concerned with is the use of monetary units to place a value on the avoidance of disease burden (in the form of reduced life expectancy, impaired (health-related) quality of life, or a combination of the two).

Willingness to pay for the avoidance of disease burden and willingness to accept avoidable disease burden may be ascertained in two ways: by asking people what they would prefer in a given hypothetical situation (stated-preference approach) or by analysing their market behaviour and asking them questions about the variables that influence such behaviour (revealed-preference approach). An example of a willingness-to-pay question from the environmental policy domain is how much extra a person is willing to pay for a home in a traffic-calmed residential district. A relevant willingness-to-accept question might be what sum a person would consider reasonable as compensation for a change in local traffic management arrangements that resulted in more noise.

Quantification on the basis of stated preference

There are various ways of getting people to express their preferences, as a basis for calculating the monetary value of (avoidable) disease burden. One of the direct enquiry methods, contingent valuation, is particularly well established in Anglo-Saxon countries. Several contingent valuation techniques are used: posing direct open questions, posing sequences of questions and asking the respondent to choose between pairs of options (the dichotomous choice technique).

The other methods for determining willingness to pay or willingness to accept are based on indirect quantification. The leading indirect methods are conjoint measurement (also known as choice modelling), welfare evaluation and wellbeing evaluation; of these, conjoint measurement is the most widely used. Like dichotomous choice contingent valuation, this method involves asking the respondent to choose between two options.

In conjoint measurement, the respondent is asked to put a series of cards in order of preference. The options on the cards might be various hypothetical descriptions of the environment, for example. They cover various alternatives for each characteristic of the situation. One of them is a sum of money. The others are, for example, various garden or balcony options, parking facilities, public transport access levels, levels and frequencies of noise, levels of accommodation charge, etc. Several protocols are available to the researcher for interpreting the order that the respondent places the cards in. From the order of preference that the respondent applies, it is possible to deduce what he or she is willing to pay (or willing to accept as compensation) for the item on the cards that the researcher is interested in – a given level of reduction in noise, for example.

In welfare evaluation and well-being evaluation, respondents are not asked to makes choices, but to rate their income situation or well-being on a (qualitative or quantitative) scale. In welfare evaluation, respondents rate their income situation (by scoring it on a scale or assigning it to a category) and the researcher determines a value for the item under investigation by linking the rating to variables that are relevant to the respondent (see, for example, [50]). In well-being evaluation, respondents are asked to rate their well-being on a scale of 1 to 10. In addition, questions are asked about all sorts of well-being determinants, including health and income. The researcher then relates the respondent's well-being to the determinants (see, for example, [43,51,52]).

The latter two methods are less widely used and are not mentioned in the OECD survey.[49]

Quantification on the basis of revealed preference

The best-known method of using revealed preference to place a monetary value on (avoidable) disease burden is the so-called hedonistic price method. There are two variants of this method. One is based on the price of goods, the other on earnings. The price of a house, for example, is a function of several variables, including the number of rooms, the presence of a garden and the noisiness of the surroundings. From the price difference between houses in a quiet street and those in a noisy street, it is possible to calculate people's willingness to pay for quiet residential surroundings. This approach is known as the property value method.

The second, also commonly used, method is based on compensatory wage differentials. Using this method, a monetary value may be placed upon a given risk of dying or suffering an accident. This is done by establishing how much more a worker needs to be paid in order to induce him or her to accept a certain risk, or how much lower wages are where a given risk is absent. The former is a means of estimating willingness to accept, and the latter of willingness to pay. The willingness to accept an occupational health risk is reflected in higher pay, while the willingness to pay for the avoidance of risk is reflected in lower pay. Examples of willingness to accept include 'danger money' and shift allowances.

Finally, there is a technique based on 'averting behaviour' and 'defensive expenditure'. In this technique, the economic value of non-market goods is calculated from the price of market goods or substitute non-market goods. Spending on acoustic insulation, for instance, is indicative of what people are prepared to pay for quiet homes. An example of averting behaviour is staying indoors during episodes of smog; the time devoted to the averting behaviour provides a basis for assigning a monetary value to the avoidance of respiratory complaints. The method therefore involves asking people about how they spend their time, so as to establish, for example, whether the factor under investigation persuades them to spend more time working (indoors) or less time working (outdoors). It may also be that spending more time indoors results in lower medical expenditure in connection with respiratory complaints.

3.1.2 Estimating the value of collective preferences

There is another method for expressing (avoidable) disease burden in monetary terms. The basis of this method is revealed preference at the group level; its rationale is that the euro-value of (avoidable) disease burden can be calculated from the expense that the state and the public are willing to incur in order to

attain a given level of health. In other words, the focus of this method is combined personal and collective expenditure in the form of medical expenses, loss of productivity and loss of income.

Unlike the methods referred to in the previous subsection, which entail the direct estimation of (avoidable) disease burden in monetary units, this method involves derivation of the monetary value of (avoidable) disease burden from its cost. The cost data are therefore used in a manner that differs from that described above. In the methods previously considered, (avoidable) disease burden was expressed in specially constructed units (QALYs or DALYs), and the cost figure was divided by the quantitative expression of (avoidable) disease burden.

As indicated in chapter 2, there are various methods of estimating the costs associated with disease burden. However, the cost of medical care and lost productivity are not a direct reflection of a person's well-being or the level of inconvenience or annoyance he or she experiences. It is not therefore possible to express the entire spectrum of relevant phenomena in monetary terms, as one can with willingness to pay or willingness to accept.

3.1.3 *From the monetary expression of (avoidable) disease burden to cost*

(Avoidable) disease burden expressed in monetary units can be used to calculate the efficiency of a given form of intervention, just as a QALY-based or DALY-based expression can. The methodology used with a monetary expression is somewhat different, however. With a QALY-based or DALY-based expression, efficiency is calculated by determining the cost per unit. When monetary units are used, a more general calculation is made, with the negative effects (cost) of a measure being deducted from its positive effects (benefit).[53-55] In this approach avoided disease burden is one of the benefits.

The aim of a cost-benefit analysis is to monetarise possible effects, to discount them and finally to combine the data to give a single figure: the balance of the costs and benefits. Once more, therefore, the issue of discounting enters the picture. Effects that cannot (sensibly) be expressed in monetary terms have to be recorded separately. Examples include the visual impact of noise screens and the aforementioned distribution of (avoided) disease burden across the population. Ultimately, such non-monetarisable effects have to be weighed up against the sum of the monetarised effects by policy/decision-makers.

In other words, this approach to the expression of efficiency, like those previously considered, is characterised by the influence of normative values. In this advisory report, we are concerned with the effects of a measure on society as a

whole: social cost-benefit analysis. This is therefore the term employed in the remainder of this advisory report.

3.2 Suitability for use in the environmental policy domain

3.2.1 Characteristics of quantification in monetary terms

Comparison and combination with non-health effects is possible

The quantification of avoidable disease burden in monetary units is attractive for environmental policy purposes, because it enables avoidable disease burden to be weighed up against other – positive or negative – effects of a given measure, such as the ecological impact. This method of quantification therefore makes social cost-benefit analysis possible, taking account of the various implications of a measure (of which the avoidance of disease burden is just one). However, decision-makers should not lose sight of effects that are not quantifiable in monetary terms.

Different quantification methods offer various possibilities

A wide range of techniques exist for quantifying environment-related (avoidable) disease burden in monetary units on the basis of individual and collective preferences. Not all of the methods can be used to quantify all types of effect, however. The cost estimation method, for example, takes no account of nuisance (see 3.1.2).

The methods available for monetarising avoidable disease burden vary more than the available DALY/QALY application techniques. In their variety, they reflect the wide scope for applying monetary valuation. This diversity increases the potential for customisation, but also necessitates greater care in the collection and interpretation of data. The methodological diversity means that monetary valuations of avoidable disease burden tend to be less comparable than QALY/DALY-based data, although the comparability in a given case depends on the actual degree of heterogeneity in the origin of the data sets concerned.

Furthermore, a monetary value can be based upon more than avoidable disease burden alone; it can also reflect the cause of the disease burden. Depending on the study design, it is possible to, for example, separately monetarise the avoidable disease burden attributable to all lung cancer, smoking-induced lung cancer and asbestos exposure-induced lung cancer. This feature of the methodology makes its outcomes situation-specific and to a significant extent determines

the scope for using data originally gathered for a different purpose, for example. The operational significance of this cannot be defined in general terms.

The Committee is unaware of any survey articles that have sought to identify differences between previously published monetary estimates of environment-related disease burden, or to explain those differences, as has been done for DALY-based estimates of environment-related disease burden.

Choosing between the available methods

Each of the available methods of quantifying the health effects of environmental factors in monetary terms has its strengths and its weaknesses. Methods based on stated preference, for example, are flexible and lend themselves to application in many different fields. Contingent valuation is the most popular of these methods.

However, the direct nature of the questions used in contingent valuation introduces various forms of bias, such as a bias towards strategically or socially preferable answers. Furthermore, the way that the questions are worded and the nature of the background information given to respondents are liable to influence the results. Another drawback of contingent valuation is that it makes significant demands in terms of respondents' ability to comprehend the data and questions, and to retain an overview and recognise the significance of their answers (in financial and other terms). In addition, the questions relate to hypothetical situations and the answers given have no consequences for the respondents. This too can influence the outcome.

With the other stated-preference methods, the question that the researcher is investigating is made less clear. As a result, such methods introduce less bias. Generally speaking, keeping the issue under investigation hidden from the respondent makes a study more labour-intensive for the researcher. On the other hand, stated-preference studies tend to have the advantage of being relatively respondent-friendly.

The application of revealed-preference techniques produces results that depend to a considerable extent on the researcher's knowledge of or ability to predict the variables that determine respondent behaviour. Furthermore, the results may not be very representative, because they will inevitably reflect the views of a particular group. Noise-attenuating purchases, such as double glazing, are more likely to be made by people who are particularly sensitive to noise, for example. Nevertheless, revealed-preference methods have the advantage of avoiding the bias involved in, say, contingent valuation.

For a more detailed examination of the pros and cons of the various methods, the reader is referred to the cited publications. However, one significant point

receives relatively little attention in those publications: the scope for rational application of the willingness-to-accept principle. Willingness to pay and willingness to accept are both wealth-dependent, but wealth influences each variable in a different way. Willingness to pay increases with the wealth of the respondent, but is limited by disposable income. Willingness to accept, by contrast, has no upper limit, although the more wealthy a person is, the greater the financial inducement necessary to persuade him or her to accept something undesirable. In practice, researchers usually adopt the willingness-to-pay formula. Within the scientific community, it is generally acknowledged that economic values tend to be significantly overstated when willingness to accept is used as the basis of valuation.

The Committee shares this view, but is reluctant to therefore dismiss valuation on the basis of willingness to pay. There are situations when this method of valuation is appropriate and does not produce unrealistically high values. Sensible valuation by this method does, however, require that willingness to accept is determined by an indirect method, such as well-being evaluation. Using the latter method, research has been done to establish the amount of compensation needed to secure the acceptance of air traffic noise among people living near to Amsterdam's Schiphol airport. The findings indicate that no more than 2.3 per cent of net income is required.[56]

Broadly speaking, the Committee's earlier observations regarding the uncertainties, assumptions and value-based choices that underpin the quantification of (avoidable) disease burden in QALYs/DALYs apply equally to the quantification of such burden in monetary units. Consider, for example, the significance of the chosen valuation method, and the size of the discount rate applied.

3.3 Conclusion

As with the use of QALYs/DALYs, the less correspondence that exists in terms of (avoidable) disease burden between the issues or measures that one wishes to compare, the more important it is that the euro value of disease burden (and the outcome of any social cost-benefit analysis) is not viewed in isolation, but in conjunction with other matters associated with (avoidable) disease burden, such as the fairness of distribution and the practicability of the policy under consideration.

The most flexible approach, which would in principle allow the monetarisation of all the health effects relevant in the context of this advisory report, is the determination of willingness to pay or willingness to accept by asking people about their preferences. In terms of the valuation method that underpins it, the

latter approach is the most like QALY-based or DALY-based quantification, which often entails the application of weighting factors determined on the basis of statements of preference. Partly for this reason, the Committee prefers this approach for the estimation of (avoidable) disease burden in monetary units. Although the willingness-to-accept approach does not always result in unduly high valuations, the absence of any limitation on the values it yields makes it less attractive than a methodology based on willingness to pay. Of these two alternative methods for monetarising (avoidable) disease burden, the Committee has therefore chosen to assess the merits of willingness to pay (based on stated preference) as a policy support tool against those of the QALY/DALY.

Chapter 4

Choice of method and application in the environmental policy domain

In the previous two chapters of this report, the Committee examined two ways of estimating (avoidable) disease burden: quantification in QALYs or DALYs and quantification in monetary units. The respective methodologies were described and the potential value of each approach in the environmental policy domain was considered. The next question that arises is when each method can best be used to compare the health effects of environmental factors and, possibly in conjunction with cost considerations, to support the prioritisation of measures with the potential to mitigate such effects. This question is addressed below, along with various practical application issues.

4.1 Choosing an appropriate quantification method

4.1.1 Conclusions of the methodological assessment

In principle, the monetary quantification and quantification in QALYs/DALYs have similarly wide fields of application. The two approaches can utilise the same exposure and effect data for the estimation of the (avoidable) disease burden.

One key difference is that the QALY and DALY are metrics that have been developed specially for the expression of health and changes in health status, while monetary units are less specific. In methodological terms, this implies that

an effect quantified in euros is the product of a calculation that includes a greater number of variables than an effect quantified in QALYs or DALYs.

The QALY/DALY concept is based on the assumption that preferences concerning lifespan and quality of life depend only on avoidable disease burden, rather than the personal characteristics of the effected individual, such as his/her age, his/her health before or after intervention, and the cause of his/her diminished quality of life. An expression of disease burden in terms of willingness to pay does take account of such determinants, and of the respondent's financial circumstances. Lung cancer has been used as an example to illustrate that, while the cause of the disease burden can influence the study outcome, this influence can be mitigated by good study design. Provided that this is done, there is no difference between monetary quantification and DALY/QALY-based quantification*.

With the QALY and the DALY, it is also assumed that the value attached to a given health status depends partly on when that status will come about (now or later) and on the person's health status before and after that time. No such assumptions are made in willingness-to-pay calculations, although the study set-up can be adjusted to take account of factors such as those referred to.

Another inherent feature of the calculations is that disease burden in QALYs or DALYs is proportional to its duration**: if a condition lasts for five times as long, it is deemed to impose five times the disease burden. Avoidable disease burden expressed in monetary units also increases with the duration and seriousness of the conditions responsible for the burden, but the relationship is not necessarily linear.

Furthermore, with the QALY/DALY concept, the weighting factor and the duration of a given health status are assumed to be independent. This assumption does not underlie willingness to pay.

The QALY/DALY concept is risk-neutral. In other words, nine assured healthy life years yield a similar QALY/DALY figure as a 90 per cent chance of ten healthy life years combined with a 10 per cent chance of immediate death. Hence, life expectancy (the individual perspective) and the chance of a given life expectancy (the collective equivalent) are interchangeable. No such assumption underpins the monetary quantification of disease burden.

What do these considerations imply for the methodological assessment of the two approaches to quantification? The identified differences mean that QALY-based and DALY-based methods produce outcomes that necessarily have a less

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* There are agreements about the valuation methods, which in principle enable health statuses to be valued on a cause-independent basis.

** Unless age correction is applied.

heterogeneous background and are therefore more comparable. What falls within the definition of avoidable disease burden in monetary units is more dependent on the research design (whether factors such as the cause of the disease burden and timing are taken into account) than what falls within the corresponding definition when QALYs or DALYs are used. When data previously collected in another context are used, it is possible to compensate by analysing the particular research questions that relate to the relevant variables. Furthermore, so-called 'benefit transfer' techniques can be used to correct for context (see, for example, [57,58]). No corresponding techniques exist for correcting QALY/DALY calculations, but correction is less important with such calculations.

The Committee concludes that application of the QALY/DALY concept produces outcomes that have a less heterogeneous background than willingness-to-pay calculations. Nevertheless, it is possible to compensate for heterogeneity in the latter type of calculation by adapting the study design.

4.1.2 *Conclusions regarding suitability for use in the environmental policy domain*

Practical application

The methodological differences between the two quantification methods mean that it is not possible to conclude that either method is a superior means of estimating the disease burden associated with environmental factors or the disease burden avoidable by the implementation of control measures. Both entail valuation, and there is no standard for comparison, so it is not possible to say that one reflects the normative 'reality' better than the other.

However, the choice of avoidable disease burden quantification method is important for the prioritisation of environmental policy. That much is apparent from the only study that the Committee is aware of, in which environmental factors have been ranked, on the basis of various metrics of disease burden.[59,60] Notably, all the data relate to environment-related disease burden in the Netherlands. According to the US research team, the size of the analysis was limited by the available data. Using previously published data, the team was able to calculate the disease burden associated with five environmental factors in the Netherlands, expressed in four different quantitative units. The environmental factors in question were airborne particulates, ozone, lead in drinking water, traffic noise and UV radiation. Ranking was on the basis of disease burden quantified in QALYs, DALYs, euros (calculated by a mix of methods) and mortality. The results are presented in table 1. It will be seen that the various factors' ranking positions

depend on the unit in which burden is quantified, and that the rankings fall into two distinct groups.

When disease burden is expressed in DALYs and QALYs, the order of the five factors is almost the same; the only difference is that noise and particulates exchange positions. However, when the burden is expressed in monetary units or in terms of mortality risk, the five factors come out in a quite different order. This dichotomy is a consequence of the position occupied by noise, and the proportion of disease burden attributable to mortality and nuisance.

When burden is quantified in terms of mortality or in monetary units, noise occupies a relatively low position in the list, because these expressions take relatively little account of nuisance. However, when burden is quantified in QALYs or DALYs, nuisance has a major effect on the outcome (see chapter 2). According to the authors, the difference between the QALY order and the DALY order is due to the low and relatively uncertain DALY weighting factor for nuisance, in combination with the large number of people who experience nuisance.

What is the value of such data? The literature provides some insight into this matter. The weighting factors used for the DALY calculations, for example, come from a single source, whereas those used for the QALY calculations come from several. For the monetarisation of disease burden, data were included that had been obtained using various methods. Hence, the comparability of the outcomes is at least compromised by the heterogeneity of the calculation methods.

In the Committee's view, this emphasises the need to exercise caution when interpreting the results. The findings are meaningful only in conjunction with background information concerning the basis of the figures.

Table 1 Ranking of five environmental factors by their impact on the health of the Dutch population, as quantified using various metrics of disease burden.[59,60]

Environmental factor	Metric			
	DALYs	QALYs	Euros	Mortality
Particulate Matter	1	2	1	1
Ozone	4	4	2	2
Lead in drinking water	3	3	5	5
Noise	2	1	3	3
UV radiation	5	5	4	4

Relationship between QALYs, DALYs and monetary units

In view of the influence that the choice of quantification method has on the ranking of issues, a more general question arises concerning the translatability of disease burdens figures expressed in QALYs/DALYs and in euros. Greater insight into the interrelationship might make it possible in the future to translate the avoidable disease burdens expressed in QALYs/DALYs into euro figures for inclusion in the social cost-benefit analysis of environmental measures.

Most relevant scientific literature contains data expressed in terms of cost per QALY (or another unit of avoidable disease burden), rather than individual willingness to pay per QALY, even though the latter is, in this context, theoretically more appropriate and more significant. Little is known about individual willingness to pay per QALY. One meta-analysis of the relationship between the QALY and willingness to pay has been published,[61] which sought to correlate published disease burden data expressed in monetary units and in QALYs. The results indicate that (individual, stated-preference) willingness to pay per QALY is not constant. As one might expect, though, willingness to pay does increase as the seriousness and duration of the avoidable health problems increase. The relationship was determined by the meta-analysis of average data from various studies.

In the Committee's view, the non-linear nature of the relationship raises questions about both metrics. The data are derived from various sources. Furthermore, the willingness to pay figures were obtained using several of the techniques for determining stated preference – the approach that is most consistent with the QALY concept – described in chapter 3. This source of variation makes interpretation of the analysis results difficult. The researchers sought to compensate by applying various methodological constraints. A more targeted, direct study of the relationship between the two metrics could in the future provide valuable information.

4.1.3 Conclusion

Choosing between QALYs/DALYs and monetary units

Whatever metric and whatever efficiency criterion one uses to support decision-making in the environmental policy domain – the cost per QALY/DALY, or the outcome of a social cost-benefit analysis based on willingness to pay – limits are ultimately imposed by the available financial resources. Nevertheless, the Committee believes that certain options are preferable, depending on the policy issue under consideration.

Despite the uncertainty that surrounds the estimation of disease burden and avoidable disease burden, the Committee would prefer to see the QALY/DALY concept used for defining environmental policy priorities in circumstances where the public health implications are the primary focus. The main reasons for this preference are that this concept is specific to health and changes in health status and that it depends upon a relatively straightforward weighting method for health status valuation. The hypothetical judgement that respondents must make when considering questions about their willingness to pay is difficult, because it involves weighing up health against prosperity, whereas QALY- or DALY-associated weighting factors are based upon the comparison of different health statuses (see chapter 2).

Quantification in monetary units may nevertheless be preferable in certain cases, such as the assessment of spatial and infrastructure projects, where avoidable disease burden needs to be weighed up against other considerations, including the ecological impact and economic impact, in a social cost-benefit analysis. So, for example, the expression of health effects in monetary terms might be very helpful when considering whether the space-saving and noise-reduction benefits of routing a section of railway line justify the additional cost.

Choosing between the QALY and the DALY

Thus far, the QALY and the DALY have been referred to together, since they are related concepts. However, it is pertinent to consider whether one is preferable to the other, in terms of its suitability for use in the context of environmental policy.

In the Netherlands and elsewhere, the DALY is the predominant unit used for the quantification of avoidable disease burden within the environmental policy domain. In view of the minor nature of the differences that exist between the DALY and the QALY, the Committee considers it pragmatic to go on using the DALY for the comparison of issues and the prioritisation of measures in this field, in the interests of continuity.

In the context of such an approach, it is to a degree possible to make use of data collected by standardised methods, such as the application of weighting factors. There is, for example a Dutch set of mutually aligned, DALY-linked weighting factors for many different health statuses.[21,62,63] Nationally or internationally standardised working methods are also considered desirable by the National Institute of Public Health and the Environment (RIVM).[32]

The Committee supports the RIVM's call for generally accepted solutions to methodological problems, but emphasises that the standardisation of environment-related (avoidable) disease burden estimation would not result in a process

free of difficult choices. Even if the estimation of (avoidable) disease burden were a standardised process, all related issues would need to be taken into account, including the distribution of benefit and the reliability of the data.

4.2 Implementation in environmental policy

4.2.1 Establishing when application is possible and helpful

One point to take into account is that, with the DALY, it is theoretically possible to make an adequate estimate of (avoidable) disease burden, but such an estimate cannot in practice be made in all cases.

Sometimes the necessary data simply are not available. This is the case with nano-materials, for example.[64] Very little is known about the nature of these materials' health effects, let alone their extent. It is similarly very difficult to quantify the disease burden associated with hormone disrupters and childhood cancer, whether in DALYs or otherwise.

In other cases, only part of the disease burden can be quantified. The skin cancer burden associated with UV radiation can be estimated, for example, but other forms of disease burden associated with this factor cannot; there are insufficient data, for instance, to allow the quantification of UV radiation's contribution to skin aging or immune system suppression.[32] UV radiation is a special case anyway, since exposure to it also has positive effects as well (due to the stimulation of vitamin D production). Insofar as such effects might be quantifiable, they would need to be set off against the negative effects.

4.2.2 Background information about burden figures needs to be taken into account in prioritisation

In the context of balanced environmental policy decision-making, an (avoidable) disease burden figure on its own is not sufficiently informative. The Committee believes that every such figure should be accompanied by information about the quality of the source data and the underlying assumptions and choices, such as the applied definition of health impairment, discount rate, etc. The more heterogeneous the issues and measures to be compared, the more importance should be attached to this background information. This would allow the relevant characteristics of the (avoidable) disease burden to be taken into account in the decision-making process. The health-based comparison of issues and measures cannot form a meaningful basis for prioritisation without such an approach.

The Committee would like to see all disease burden estimates accompanied by a standard set of qualifying data concerning the population group, the strength of the scientific evidence for a causal relationship between the environmental factor and an adverse health effect, the quality of the basic calculation input data (exposure-response relationship and exposure distribution), the underlying models, the exposure or exposure reduction to which the figure relates and the time horizon and discount rate applied. An indication should also be given of the health effects that cannot be expressed in DALYs, so that qualitative allowance for them may be made.

In view of the difficulty of defining health impairment, the Committee believes that it would be helpful if disease burden were reported separately for each health indicator or group of health indicators, such as nuisance and mortality. Each such figure should be accompanied by a reliability statement. The quality of the estimates of an environmental factor's short and long-terms health effects would then be immediately apparent.

The quality of a DALY estimate of environment-related (avoidable) disease burden depends on the quality of the underlying data. Also important are DALY-specific elements, such as the duration of the quality-of-life reduction and the weighting factor applied. The relatively large variability of DALY-associated weighting factor values assigned to more minor conditions has already been highlighted (see 2.2).

Where all these matters are concerned, further research could improve the estimation of environment-related (avoidable) disease burden expressed in DALYs. Much could be improved in terms of the availability of data on exposure to and the effects of environmental factors. Where such research is concerned, the Committee considers the maintenance, expansion and (international) harmonisation of systems for monitoring health and exposure to environmental factors in the Netherlands, as previously recommended by the Health Council, to be very important.[26,65] Such systems include sources of data on disease and causes of death, such as registers of diagnostic data associated with hospital admissions and discharges.

Efforts should also be made to improve the measurement and modelling of exposure, with a view to ascertaining more precisely how many people are exposed, and to what extent. The ultimate linkage of exposure and effect data requires the collection of data on a sufficiently detailed scale. In this context, geographical information systems warrant attention, because of the opportunities they afford for linkage at the postcode level.[66]

4.2.3 *Making allowance for scale differences*

Environmental health issues vary in their geographical scope and require responses that vary correspondingly in their scale. Climate change is a global issue, while lead in drinking water is national or regional and soil pollution is local.

In principle, the scale of an issue has no bearing on whether the related effects can be measured in DALYs. The factors that determine whether disease burden can be estimated and how reliable any such estimation is, come under two headings: those that relate to the underlying exposure and effect data, and those that relate to the calculation of a DALY figure from those data. Factors of the former kind are specific to the issue, whereas factors in the second group are not. Indeed, the DALY-specific components of the estimation, such as the weighting factors and the duration of the health impairment, can be approximated in isolation from the issue. The underlying data are only partially scale-specific. The exposure-response relationship, for example, is specific to the environmental factor and can be used in the estimation of the avoidable disease burden at the local or national level.

Although the scale of an issue should not influence the usefulness of the DALY as a policy support tool, it does have practical implications. Differences in scale can complicate the comparison of issues and the prioritisation of measures. For example, climate change and lead in drinking water differ in too many ways for the avoidable disease burden associated with each in the Netherlands to be meaningfully compared, the Committee believes. There is simply too little correspondence in the geographical and temporal spread of the two issues. Where climate change is concerned, the disease burden avoidable through intervention cannot be quantified with nearly as much confidence.[67] Furthermore, climate change is a much more politically complex question, requiring international action and having important consequences other than health effects, such as changes to an area's agricultural options and an increased risk of flooding.

Scale therefore influences the comparison of issues and the prioritisation of intervention measures. Issues that differ in scale are harder to compare, and this has to be taken into account.

4.2.4 *Broad-based assessment is necessary*

As indicated earlier, the Committee believes that prioritisation should be supported by broad-based assessment. The Scientific Council for Government Pol-

icy has coined the phrase ‘wicked problems’ to describe persistent and new problems, such as the consequences of global change and the risks associated with nano-materials.[68] It is characteristic of such issues that any associated disease burden, whether quantifiable or not, plays a relatively minor role in decision-making, because other considerations – such as the acceptability of change and the scale of the problem – predominate.

In this context, it is illustrative to consider the comparison between lead in drinking water and UV radiation. It is possible to estimate the DALYs associated with exposure to lead, leading to intellectual impairment in children. It is also possible to calculate a DALY figure for the health implications (premature death from skin cancer) attributable to exposure to UV radiation. However, it is not possible to decide which issue should take priority solely on the basis of such information. It is within the Dutch government’s power to phase out lead water pipes, and such a move would have an immediate effect. By contrast, action to close the hole in the stratospheric ozone layer (or at least to prevent it widening) would require international cooperation and would yield benefits only in the long term. Furthermore, unlike action on the lead problem, measures intended to address the ozone issue have implications in other fields, such as ecology and possibly agriculture.

The significance of DALY figures in such broad-based assessments is inevitably more minor.

4.2.5 *DALYs should be used where the scale is comparable*

Where action on particulates, noise and lead in drinking water is concerned, for example, health protection is the primary aim in all cases and information regarding the avoidable disease burden in DALYs can be useful for the prioritisation of intervention measures on a similar scale (national or local). The general rule set out earlier nevertheless applies: avoidable disease burden figures should be compared only in conjunction with background information.

When assessing alternative ways of addressing a given issue, comparison is relatively straightforward, since of course one is dealing with the same health effect in each case. So, for example, DALY data can readily be utilised to assess the relative merits of lower speed limits and the subsidisation of diesel particle filter retro-fitting as means of reducing exposure to particulates. Similarly, comparison can be made between measures such as noise barrier erection and double glazing subsidisation as means of cutting noise-related nuisance.

Chapter 5

Conclusions and recommendations

5.1 Conclusions

The choice between QALYs/DALYs and monetary units

The QALY and the DALY can be used to compare the influence of environmental factors on health. They can also be used as criteria for the prioritisation of measures designed to mitigate such influences, possibly in combination with the cost per QALY gained or DALY avoided.

The alternative, the expression of (avoidable) disease burden as a sum of money, additionally allows for health effects to be compared and/or combined with other effects, such as the effect on nature, mobility, the economy, etc. This opens the way for including (avoidable) disease burden in a social cost-benefit analysis. There are various ways of calculating the monetary value of (avoidable) disease burden; of these, the Committee believes that the most suitable method for comparison with QALYs/DALYs is the determination of willingness to pay in combination with valuation techniques that theoretically allow all health effects to be expressed in monetary terms (through questioning regarding preferences). The principles that such techniques are based on have many parallels with the valuation methods used for the estimation of (avoidable) disease burden in QALYs and DALYs.

From the only reported study in which various indicators of disease burden were used to sort environmental factors on the basis of their effect on health, it is

apparent that it makes a significant difference to the outcome whether one expresses disease burden in QALYs/DALYs or in monetary units. However, it is not possible to say that one valuation method reflects the normative 'reality' better than the other, since both are based upon the value that people attach to life expectancy and health, and to change therein. The Committee would prefer to see the QALY/DALY concept used for prioritisation on the basis of health considerations. There are two reasons for this preference. First, the concept was specifically developed for the quantification of health and changes in health status. Second, quantification in QALYs/DALYs involves a more straightforward valuation step (see chapter 4). Quantification in monetary units is preferable when the object is to compare avoidable disease burden with the other effects of intervention measures or social activities. So, for example, monetarisation is a valuable decision-support tool for the evaluation of proposed infrastructural or spatial planning projects.

The choice between QALYs and DALYs

There are no fundamental methodological differences between the QALY and the DALY that make the one inherently more suitable for use in the environmental policy domain than the other. Furthermore, the one study that compared them found that, when used to rank environmental health factors, they produced almost identical outcomes. The Committee is reluctant to draw firm conclusions from a single study, however; so it cannot be said that in practice it makes little or no difference which of the two is employed. Nevertheless, the findings of the study referred to are consistent with the conceptual similarity between the QALY and the DALY. Therefore, since the DALY is more firmly established in (international) environmental policy analysis, the Committee sees it as the preferable unit for use in this field.

The significance of a numeric expression of (avoidable) health burden

A DALY figure is in principle an appropriate expression of the size of the (avoidable) disease burden associated with an environmental factor. An expression of cost per avoided DALY is also of value. However, when using such numeric expressions, it is important to bear in mind that they are not all equally reliable. This is partly because of the normative choices inherent to application of the DALY concept, and partly because the data from which such expressions are derived are themselves variable in their reliability.

That is not to say that such numeric expressions are of no value, but that certain considerations need to be taken into account when using them for policy development and analysis. It is worth noting that little is to be gained from using simpler metrics, such as mortality risk, instead, since any such indicator will inevitably derive from broadly the same data on exposure and effect. Furthermore, a simpler metric is liable to overlook certain important health effects.

Environmental policy decisions naturally need to take account of matters other than disease burden in DALYs, avoidable disease burden in DALYs and cost per avoided DALY. Considerations such as the overall cost of the avoided disease burden and the distribution of avoided DALYs across the population need to be addressed separately. The more heterogeneous the issues or measures under examination are, the more weight needs to be attached to such considerations.

In the Committee's view, a single (avoidable) disease burden figure is not on its own a sufficiently informative basis for balanced environmental policy decision-making. Such an expression needs to be accompanied by background information about (the quality of) the underlying data and underlying choices, such as what constitutes health impairment and what the discount rate should be. The qualification of disease burden figures would help to ensure that they did not acquire inappropriate status and that the central characteristics of the disease burden to which they relate were not overlooked. The more heterogeneous the issues or measures under examination are, the more weight such information should carry. Without such information, no meaningful comparison of issues and measures can be made as a basis for the rational ranking of issues and prioritisation of intervention measures.

5.2 Recommendations

5.2.1 Use of DALYs in environmental policy

The Committee recommends that, for the purpose of environmental policy prioritisation, disease burden should be expressed in DALYs, and that monetary units should be used when the (avoidable) disease burden associated with a measure or social activity needs to be compared or aggregated with other effects, such as the effect on agriculture. It is further recommended that, for the purpose of decision support, expressions of avoidable disease burden should be used in association with qualifying information regarding the characteristics of the quantified burden. This would allow the degree of heterogeneity exhibited on various relevant dimensions by the measures under examination to be taken into account.

An estimate of the number of DALYs avoidable should, in the Committee's view, be accompanied by the following information as a matter of course:

- The nature of the health impairment involved (broken down by health indicator or by group of health indicators, for example mortality and nuisance)
- The subpopulation affected
- The strength of the evidence for a causal relationship between the relevant environmental factor and health impairment
- The quality of the underlying data
- The calculation models used
- The exposure reduction
- The time horizon and the discount rate
- The health effects that cannot be expressed in DALYs.

A statement of cost per DALY should be accompanied by similar information, plus a statement of the uncertainties inherent to the calculation and the cost assumptions.

Prudent environmental policy decisions need to take account of various criteria other than avoidable disease burden (e.g. the effectiveness of measures, the cost per DALY, availability of resources, fairness, social acceptance, etc). The more heterogeneous the issues involved are, the more important it is to take account of the characteristics and the more weight other considerations should carry. The Committee believes that the relationship between the choices made and the outcome should be made apparent.

It is also recommended that estimates of avoidable disease burden should be accompanied by sensitivity analyses. As well as providing insight into the significance of inherent uncertainties and underlying value judgements, a sensitivity analysis would indicate how much influence each variable had on the ultimate estimate. In view of the difference in reliability between estimates of short-term effect and estimates of long-term effect, the Committee recommends separate analyses for each.

The Committee considers it desirable to seek standardisation and international harmonisation, and regards these goals as consistent with the approach described above.

5.2.2 *Further research*

The Committee also recommends that further research be conducted or commissioned with a view to reducing the uncertainties inherent to application of the DALY in the environmental policy domain. Of particular importance is work to

reduce the relatively large standard deviation in low DALY-associated weighting factors, such as the weighting factor for noise-related nuisance. Low-seriousness phenomena often affect large numbers of people and therefore account for a considerable disease burden, but the standard deviation in the weighting factors is such that the quantification of that burden is comparatively uncertain. Better estimates of the durations of various medical conditions, such as asthma and raised blood pressure would also be helpful.

The Committee would additionally like to see targeted direct research into the correlation between (avoidable) disease burden expressed in DALYs and disease burden expressed in monetary units, calculated from willingness to pay, as reflected in stated preference. Such research would be useful because the data analysed to date have been obtained from a variety of sources and have been collected for other purposes. The results of such research could shed light on the scope for the integration of DALY figures into cost-benefit analysis.

The reliability of the disease burden estimates used in the analysis of environmental health issues is determined by the characteristics of the DALY approach and the underlying exposure and effect data. The Committee therefore recommends investing to generate more and better data. It considers the maintenance, expansion and (international) harmonisation of systems for monitoring health and exposure to environmental factors in the Netherlands, as previously recommended by the Health Council, to be very important.[26,65] The Committee particularly wishes to see the retention of important sources of data on disease and causes of death, such as registers of diagnostic data associated with hospital admissions and discharges.

Better-quality exposure data, from which it can be ascertained how many people experience exposure and at what levels, is also seen as desirable by the Committee. To this end, there is a need to improve exposure measurement and modelling.

The ultimate linkage of exposure and effect data requires the collection of data on a sufficiently detailed scale. In this context, the Committee recommends making greater use of geographical information systems, because of the opportunities they afford for linkage at the postcode level.

Other fields in which the Committee would like to see further research include the health implications of exposure to combinations of environmental factors and the role of interaction between various environmental factors and between environmental factors and other health-influencing factors, such as socio-economic status.

The Committee believes that this twin-track approach (improvement of the DALY-method itself and the generation of better basic data) is necessary to

reduce the uncertainty that exists regarding the disease burden avoidable by reducing exposure to environmental factors. In addition, the Committee proposes that the knowledge available regarding (individual) environmental health effects should periodically be analysed and interpreted, with a view to increasing the reliability of the data. Knowledge synthesis of this kind could also stimulate the generation of new and better data. Thus, the generation, synthesis and application of knowledge could be cyclically integrated, strengthening the health-related scientific basis of environmental policy at each step.

References

1 Omgaan met risico's. De risicobenadering in het milieubeleid. Tweede Kamerstukken, vergaderjaar 1988-1989, 21137 nr. 5. Den Haag: Sdu.

2 Regering. Een wereld en een wil: werken aan duurzaamheid. Vierde Nationaal Milieubeleidsplan (zie brief aan de Tweede Kamer van 13 juni 2001, kamerstuk 27801, nr. 1). Den Haag: Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer; 2001. Internet: http://www.vrom.nl/pagina.html?id=2706&sp=2&dn=1076 geraadpleegd 4-7-'07.

3 Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer. Achtergronddocument bij de nota ‘Nuchter omgaan met risico's. Beslissen met gevoel voor onzekerheden’. 2004.

4 Staatssecretaris van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer. Nuchter omgaan met risico's. Beslissen met gevoel voor onzekerheden. Brief aan de Tweede Kamer van 30 januari 2004.

5 Milieu- en Natuurplanbureau. Nuchter omgaan met risico's. Bilthoven: Rijksinstituut voor Volksgezondheid en Milieu; 2003: rapport nr 251701047/2003.

6 de Neeling JND. Kostenutiliteitsanalyse. Den Haag: Gezondheidsraad; 2003: publicatie nr A03/01.

7 Dondorp WJ. Ethische aspecten van kostenutiliteitsanalyse. In: Signalering ethiek en gezondheid 2005_Gezondheidsraad. Den Haag: Gezondheidsraad; 2005: publicatie nr 2005/07.

8 Gezondheidsraad. Contouren van het basispakket. Den Haag: Gezondheidsraad; 2003: publicatie nr 2003/02.

9 Raad voor de Volksgezondheid en Zorg. Zinnige en duurzame zorg. Zoetermeer: Raad voor de Volksgezondheid en Zorg; 2006.

10 Brouwer WB, Niessen LW, Postma MJ, Rutten FF. Need for differential discounting of costs and health effects in cost effectiveness analyses. BMJ 2005; 331(7514): 446-448.

11 van Hout BA. Discounting costs and effects: A reconsideration. Health Economics 1998; 7: 581-594.

12 Murray CJL, Salomon JA, Mathers CD, Lopez AD, (Eds.). Summary measures of population health. Concepts, ethics, measurement and applications. Genève: WHO; 2002.
13 Murray CJL, Lopez AD, eds. The global burden of disease; A comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected tot 2020. Global burden of disease and injury series, vol. 1. Cambridge, MA: Harvard School of Public Health on behalf of the World Health Organization and the World Bank; 1996.
14 Murray CJL, Acharya AK. Understanding DALYs (disability-adjusted life years). J Health Econ 1997; 16(6): 703-730.
15 de Hollander AEM. Assessing and evaluating the health impact of environmental exposures. Thesis. University of Utrecht; 2004.
16 Prüss-Üstün A, Mathers C, Corvalán C, Woodward A. Introduction and methods: assessing the environmental burden of disease at national and local levels (WHO Environmental Burden of Disease Series, No. 1). Genève: WHO; 2003.
17 Smith KR, Corvalan CF, Kjellstrom T. How much global ill health is attributable to environmental factors? Epidemiology 1999; 10(5): 573-584.
18 de Hollander AEM, Melse JM, Lebret E, Kramers PGM. An aggregate public health indicator to represent the impact of multiple environmental exposures. Epidemiology 1999; 10(5): 606-617.
19 Knol AB, Staatsen BAM. Trends in the environmental burden of disease in the Netherlands. Bilthoven: RIVM; 2005: rapport nr 500029001/2005.
20 Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJL, (Eds.). Global burden of disease and risk factors. New York: The World Bank and Oxford University Press; 2006.
21 Melse JM, Essink-Bot ML, Kramers PG, Hoeymans N. A national burden of disease calculation: Dutch disability-adjusted life-years. Dutch Burden of Disease Group. Am J Public Health 2000; 90(8): 1241-1247.
22 Brunekreef B. A tale of six cities. Am J Respir Crit Care Med 2006; 173(6): 581-582.
23 Laden F, Schwartz J, Speizer FE, Dockery DW. Reduction in fine particulate air pollution and mortality: Extended follow-up of the Harvard Six Cities study. Am J Respir Crit Care Med 2006; 173(6): 667-672.
24 Friedman MS, Powell KE, Hutwagner L, Graham LM, Teague WG. Impact of changes in transportation and commuting behaviors during the 1996 Summer Olympic Games in Atlanta on air quality and childhood asthma. JAMA 2001; 285(7): 897-905.
25 Zwiers RAA. Bestrijdingsmiddelen, cosmetica, verf: de bescherming van proefpersonen in blootstellingsonderzoek. In: Gezondheidsraad, Signalering ethiek en gezondheid 2004_Gezondheidsraad. Den Haag: Gezondheidsraad; 2004.
26 Gezondheidsraad. Gezondheid en milieu: mogelijkheden van monitoring. Den Haag: Gezondheidsraad; 2003: publicatie nr. 2003/13.
27 Gezondheidsraad. Hormoonontregelaars in de mens. Rijswijk: Gezondheidsraad; 1997: publicatie nr 1997/08.

28 Europese Commissie. Een Europese strategie voor milieu en gezondheid. Mededeling van de Commissie aan de Raad, het Europees Parlement en het Europees Economisch en Sociaal Comité. 2003: COM(2003)338.

29 Europese Commissie. Mededeling van de Commissie aan de Raad, het Europees Parlement en het Europees Economisch en Sociaal Comité: Het Europees actieplan voor milieu en gezondheid 2004-2010 [COM(2004) 416, deel I]. 2004. Internet: http://ec.europa.eu/environment/health/pdf/com2004416.pdf.

30 Europese Commissie. Commission staff working document. Document accompanying the Communication from the Commission to the Council, the European Parliament and the European Economic and Social Committee 'Mid term review of the European environment and Health Action Plan 2004-2010 {COM(2007)314 final}'. Technical annexes. 2007: SEC(2007) 777.

31 Europese Commissie. Communication from the Commission to the Council, the European Parliament and the European Economic and Social Committee. Mid term review of the European Environment and Health Action Plan 2004-2010. 2007: COM(2007) 314 final.

32 Knol AB, van Kempen EEMM, Staatsen BAM. The environmental burden of disease using the DALY approach. Differences explored. Advisory report to the Netherlands Environmental Assessment Agency (MNP). Bilthoven: National Institute for Public Health and the Environment; 2006.

33 Gauderman WJ, Vora H, McConnell R, Berhane K, Gilliland F, Thomas D ***et al***. Effect of exposure to traffic on lung development from 10 to 18 years of age: a cohort study. Lancet 2007; 369(9561): 571-577.

34 Sandstrom T, Brunekreef B. Traffic-related pollution and lung development in children. Lancet 2007; 369(9561): 535-537.

35 WHO. Definition of health. Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19-22 June, 1946; signed on 22 July 1946 by the representatives of 61 States (Official Records of the World Health Organization, no. 2, p. 100) and entered into force on 7 April 1948. New York: WHO; 1948.

36 Gezondheidsraad. Gezondheid en milieu: Kennis voor beleid. Den Haag: Gezondheidsraad; 2003: publicatie nr 2003/20.

37 Health Council of the Netherlands: Committee on the Health Impact of Large Airports. Public health impact of large airports [Grote luchthavens en gezondheid]. The Hague: Health Council of the Netherlands; 1999: Publication nr 1999/14.

38 Gezondheidsraad. Geluid en gezondheid. Den Haag: Gezondheidsraad; 1994: publicatie nr 1994/15.

39 Gezondheidsraad. Over de invloed van geluid op de slaap en de gezondheid. Den Haag: Gezondheidsraad; 2004: publicatie nr 2004/14.

40 Fischer P, Hoek G, Brunekreef B, Verhoeff A, van Wijnen J. Air pollution and mortality in The Netherlands: are the elderly more at risk? Eur Respir J Suppl 2003; 40: 34s-38s.

41 Zeka A, Zanobetti A, Schwartz J. Short term effects of particulate matter on cause specific mortality: effects of lags and modification by city characteristics. Occup Environ Med 2005; 62(10): 718-725.

42 McConnell R, Berhane K, Gilliland F, London SJ, Islam T, Gauderman WJ ***et al***. Asthma in exercising children exposed to ozone: a cohort study. Lancet 2002; 359(9304): 386-391. Lancet 2002; 359: 896.

43 Baarsma BE. Monetary Valuation of Environmental Goods: Alternatives to Contingent Valuation [Proefschrift]. Amsterdam: Universiteit van Amsterdam. Tinbergen Institute Research Series, nr 220; 2000.

44 Freeman III AM. The measurement of environmental and resource values. Theory and methods. Washington, D.C.: Resources for the Future; 1993.

45 Haab TC, McConnell KE. Valuing environmental and natural resources. New horizons in environmental economics. Cheltenham, Northampton: Edward Elgar; 2002.

46 McConnell KE. Indirect methods for assessing natural resource damages under CERCLA. In: Kopp RJ, Smith VK, editors. Valuing natural assets. Washington, D.C.: Resources for the Future; 1993: 153-196.

47 Mitchell RC, Carson RT. Using surveys to value public goods: the Contingent Valuation method. Washington, D.C.: Resources for the Future; 1989.

48 Pearce DW, Howarth A. Technical report on methodology: cost benefit analysis and policy responses. Bilthoven: RIVM; 2000: rapport nr 481505 020.

49 Pearce D, Atkinson G, Mourato S. Cost-benefit analysis and the environment. Recent developments. Paris: OECD; 2006.

50 Groot W, Maassen van den Brink H, Plug E. Money for health: the equivalent variation of cardiovascular diseases. Health Econ 2004; 13(9): 859-872.

51 Groot W, Maassen van den Brink H. A direct method for estimating the compensating income variation for severe headache and migraine. Soc Sci Med 2004; 58(2): 305-314.

52 van Praag BMS, Ferrer-i-Carbonell A. How to find compensations for aircraft noise nuisance. In: Happiness quantified: a satisfaction calculus approach. New York: Oxford University Press; 2004: 219-238.

53 Ministerie van Verkeer en Waterstaat. Aanvullingen op de Leidraad overzicht effecten infrastructuur: een samenvatting. Den Haag: Ministerie van Verkeer en Waterstaat; 2004.

54 Eijgenraam CJJ, Koopmans CC, Tang PJG, Verster ACP. Evaluatie van infrastructuurprojecten. Leidraad voor kosten-batenanalyse. Den Haag: Ministerie van Verkeer en Waterstaat/Ministerie van Economische Zaken; 2000.

55 Ministerie van Verkeer en Waterstaat, Ministerie van Economische Zaken. Risicowaardering. Aanvulling op de leidraad OEI. 2004.

56 van Praag BMS, Baarsma BE. Using happiness surveys to value intangibles – the case of airport noise. Economic Journal 2005; 115(500): 224-246.

57 Brouwer R, Bateman IJ. Benefits transfer of willingness to pay estimates and functions for health-risk reductions: a cross-country study. J Health Econ 2005; 24(3): 591-611.

58 Ready R, Navrud S, Day B, Dubourg R, Machado F, Mourato S ***et al***. Benefit transfer in Europe: how reliable are transfers between countries? Environmental & Resource Economics 2004; 29: 67-72.

59 Hofstetter P, Hammitt JK. Human health metrics for environmental decision support tools: Lessons from health economics and decision analysis. Washington DC: EPA; 2001: EPA/600/R-01/104.

60 Hofstetter P, Hammitt JK. Selecting human health metrics for environmental decision-support tools. Risk Anal 2002; 22(5): 965-983.

61 van Houtven G, Rousu M, Yang J-C, Pringle C, Wagstaff W, DePlatchett J. Valuation of morbidity losses: meta-analysis of Willingness-to-Pay and health status measures. Research Triangle Park, NC, USA: RTI Health, Social, and Economics Research; 2003.

62 Stouthard MEA, Essink-Bot ML, Bonsel GJ. Disability weights for diseases. A modified protocol and results for a Western European region. European Journal of Public Health 2000; 10: 24-30.

63 Stouthard MEA, Essink-Bot M-L, Bonsel GJ, Barendregt J, Kramers PGN, van de Water HPA ***et al***. Wegingsfactoren voor ziekten in Nederland. Amsterdam: AMC; 1997.

64 Gezondheidsraad. Betekenis van nanotechnologieën voor de gezondheid. Den Haag: Gezondheidsraad; 2006: publicatie nr 2006/06.

65 Gezondheidsraad. Europees Actieplan Milieu en Gezondheid 2004-2010. Den Haag: Gezondheidsraad; 2005: publicatie nr 2005/03.

66 Passchier WF, Briggs DJ, Caratti P, Guski R, Casteleyn L, de Hoog K ***et al***. Healthy airports (2). A set of indicators for comparing environmental health performance of airports in Europe. Maastricht: Universiteit Maastricht, Department of Health risk analysis and toxicology; 2004. Internet: http://www.icis.unimaas.nl/Projects/Airport/downs/main_2_b_lit.pdf.

67 Milieu- en Natuurplanbureau. Bresser AHM, Berk MM, van den Born GJ, van Bree L, van Gaalen FW, Ligtvoet W ***et al***. Effecten van klimaatverandering in Nederland. Bilthoven: MNP; 2005: rapport nr 773001034.

68 Wetenschappelijke Raad voor het Regeringsbeleid. Naar nieuwe wegen in het milieubeleid. Den Haag: Sdu Uitgevers; 2003: rapport nr 67.

69 Minister van Volksgezondheid, Welzijn en Sport. Gezondheid en Milieu. Opmaat voor een beleidsversterking. Den Haag: SDU Uitgevers; 2001: Tweede Kamer der Staten-Generaal, vergaderjaar 2001-2002, 28089, nr 1.

70 Helsinki Declaration on Action for Environment and Health in Europe, 1994. Copenhagen, Denmark: World Health Organization, Regional Office for Europe; 1994. Internet: http://www.who.dk/AboutWHO/Policy.

71 Minister van Volksgezondheid, Welzijn en Sport; Minister van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer. Actieprogramma Gezondheid en Milieu. Uitwerking van een beleidsversterking. 2002.

72 Minister van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer; Minister van Volksgezondheid, Welzijn en Sport. Eerste voortgangsrapportage van het Actieprogramma Gezondheid en Milieu. 2004.

73 Minister van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer. Actieprogramma gezondheid en milieu. Eindrapportage. Den Haag: Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieu; 2006.

74 Gezondheidsraad. Gezondheid en milieu: beoordelingskader beoordeeld. Den Haag: Gezondheidsraad; 2004: publicatie nr 2004/03.

75 van Bruggen M, Fast T. Beoordelingskader Gezondheid en Milieu. Bilthoven: Rijksinstituut van Volksgezondheid en Milieu; 2003: rapport nr 609026003/2003.

Annexes

Annex **A**

Request for advice

The policy document *Gezondheid en milieu: opmaat tot een beleidsversterking* (Health and Environment: Towards a Reinforcement of Policy), which the Minister of Health, Welfare and Sport and the Minister of Housing, Spatial Planning and the Environment presented to the lower house of the Dutch parliament several years ago, describes a strategy for giving added impetus to policy in the field of health and environment.[69] The document formed the Dutch *National Environmental Health Action Plan* (NEHAP), which the Netherlands had committed itself to producing as part of its WHO undertakings.[70] The *Environmental Health Action Plan: Implementing more powerful policy* was subsequently produced as a vehicle for implementation of the NEHAP.[71-73]

At the request of the then State Secretary for Housing, Spatial Planning and the Environment, the Health Council produced two advisory reports on that programme, each addressing certain issues identified by the State Secretary. The reports in question were '*Environmental Health: Research for Policy*' (2003) and *Gezondheid en milieu: beoordelingskader beoordeeld* (not available in English, 2004).[36,74] The first report consisted of a survey of priority topics for further research and scientific (re)assessment, with a view to improving understanding of the influence that environmental factors have on human health. The second contained the Council's appraisal of the *Beoordelingskader Gezondheid en Milieu* (Framework for Decision Making in the Field of Environment and Health): a checklist intended for use as a tool in assessment of the health-based, economic and social characteristics of environmental health issues, which may

have policy implications.[75] The Council also analysed the *European Environment and Health Action Plan* in order to place its Dutch counterpart in an international context (2005).[65]

However, the reports referred to above left one of the State Secretary's original questions unanswered: that concerning the quality-adjusted life year (QALY), a metric of health benefit that was already widely used to inform decision-making regarding medical services and treatments. What the State Secretary wanted to know was whether QALY data or expressions of cost per QALY gained could be used in the prioritisation of environmental measures.

The President of the Health Council promised the State Secretary that the Council would address this question in a separate document. In the meantime, he provided the State Secretary with a background study commissioned by the Council in connection with its report on the contours of the basic health care benefit package, which was felt to be of value in the context of the matter at hand.[6] The advisory report now before you makes good on the Council's earlier promise. The full text of the State Secretary's request for advice and the response of the President of the Health Council are reproduced below.

The request for advice of 9 December 2002, reference DGM/SAS/2002085338, was as follows:

The fourth National Environmental Policy Plan (NMP4, June 2001) made it clear that, without a change in policy, the Netherlands was in due course liable to be confronted with various health problems that are not yet presently apparent to any significant extent. It was also indicated that public safety and the quality of the human environment threaten to deteriorate. The Council for Public Health and Health Care (RVZ) produced the August 2001 advisory report entitled *Gezondheidsrisico's voorzien, voorkomen en verzekeren* (Predicting, Preventing and Insuring Against Health Risks), which contained an analysis of the public health threats likely to face Dutch society over the coming decades and the ways in which that would result in more appropriate responses to these threats.

On the basis of the environment-related health risks identified in the NMP4 and the RVZ report, together with the recommendations contained in the Health Council's advisory report *Ongerustheid over lokale milieufactoren* (Local Environmental Health Concerns, April 2001), the then Minister of VWS drew up a policy document entitled *Gezondheid en Milieu, opmaat voor een beleidsversterking* (Health and Environment: Towards a Reinforcement of Policy). This was presented to the Lower House of Parliament in November of last year. In this document, environmental factors are ranked on the basis of the extent to which their adverse effects on health can be quantified and how they are perceived by the public. This approach was elaborated in the *Actieprogramma Gezondheid en Milieu, uitwerking van een beleidsversterking* (Environmental Health Action Plan: Implementing more pow-

erful policy) that the last Minister of VROM submitted to the Lower House on 25 April this year. I have included a copy of this document for your information.

The Action Programme identifies thirty-six points requiring action over the next five years. The first action point is consultation with your Council regarding certain elements of the Action Programme. I am therefore writing to ask the Health Council to accordingly advise me and my colleague, the State Secretary for Health, Welfare and Sport. The Advisory council for research on spatial planning, nature and the environment (RMNO) will also be asked to give recommendations about appropriate elements of the Action Programme.

Among other things, the Action Programme indicates that research into the relationship between environment and health requires fresh impetus. It also identifies a number of themes that are regarded as important in relation to the assessment of health risks and in the context of which gaps in knowledge exist. These themes are arranged in order of significance (Appendix II, 2.3.2). The themes were selected primarily on the basis of the TNO report *Milieu en Gezondheid 2001* (Environment and Health 2001), subject to the omission of themes that are adequately covered by projects and programmes already in progress. An Environment and Health Research Programme that sets out a phased timetable and priorities for environmental health research should have been formulated before the end of 2002. Against this background, I ask the Health Council to provide recommendations regarding the following matters:

- Do the proposed themes adequately cover the existing gaps in knowledge regarding environment and health?
- The identification of priorities for research in the Netherlands, given the knowledge that is available in this country and elsewhere and taking account of existing research programmes and expertise here and abroad. In this context, I suggest that you consider the involvement of experts from RGO circles.

When formulating your advice, I would like you to consider the extent to which the results of the research would contribute to insight into the risks of adverse health effects and the health benefits potentially attainable, the easing of public anxiety, and the cost and feasibility of further research. I would specifically also like you to take account of the cost per additional quality-adjusted life year in order to perform an initial priority ranking.

Your analysis should also take into account the extent to which the research is likely to yield results that are of practical value within the period covered by the Action Programme.

The Action Programme also addresses the question of monitoring. I assume that this matter is to be dealt with in the advisory report you are currently preparing on the identification and monitoring of health risks associated with environmental factors.

In the interests of transparent decision-making regarding environment-related health effects, an assessment framework is being developed that is to include criteria pertinent to the assessment process. A draft checklist has been produced in which these criteria are grouped in five general categories. The checklist is not intended as a scientific decision-support instrument, but as an aid that

facilitates the illumination and discussion of matters that are pertinent to assessment of the nature and necessity of intervention options for which views amongst stakeholders differ. It is not only scientific, but also policy-related and social, criteria that play a role here

- I ask the Health Council to make a scientific appraisal of the draft checklist, to highlight anything regarded as an omission and to make such proposals as the Council sees fit regarding the improvement and/or further development of the checklist. Both technical and behavioural-scientific matters are of relevance in this regard.

I would be grateful if the Health Council could provide me with an advisory report on the closure of gaps in knowledge and the prioritisation of research topics by the end of this year. I appreciate that the formulation of recommendations regarding the other matters referred to in my questions will require more time and I will therefore be grateful to receive a report on such other matters by the summer of 2003. In view of the importance of this topic, I hope that the Health Council is able to make allowance for the preparation of such a report in its work programme for 2003.

Yours sincerely,
[signed]
B.A. van Geel
State Secretary for Housing, Spatial Planning and the Environment

On 3 February 2003 and under reference no. U221/WP/mk/720, the President of the Health Council replied to the State Secretary as follows:

In your 9 December 2002 letter, cited above, you posed a number of questions to the Health Council in connection with the development of your policy (and that of the Minister of VWS) concerning Environment and Health. I am please to inform you that, following discussions with your staff and in anticipation of your request, the Council has already begun deliberation of the matters referred to. I anticipate being able to respond in the short-term (i.e. by April 2003) to your questions regarding the themes set out in the Environment and Health Action Programme. However, I fear it will not be possible (within that time-scale) to use the gain or loss in terms of quality-adjusted life years (QALYs) or other such units to measure the likely impact of options within (or possibly outside) the said themes. Various expert members of the Council have stressed to me that the use of such units requires further consideration. I will arrange for an advisory report on this topic to be prepared in the short-term. I expect that the preparation of that report could make good use of the findings of a study commissioned by the Health Council in connection with the very recently published advisory report on the contours of the basic health care benefit package. A copy of that study is enclosed.

The last question you posed related to the assessment framework. I am aware that the RIVM is currently in the process of refining that framework. I will therefore ask the RIVM to indicate when the framework is likely to be ready for appraisal by the Health Council, since I do not feel it would be efficient to prepare an advisory report on the framework while it is still under development. You may rest assured that I will make preparations to ensure that a report can be quickly prepared.

Yours sincerely,
[signed]
Professor JA Knottnerus

Annex **B**

The Committee

This advisory report was compiled by the entire Subcommittee on the Quantification of Environmental Health Effects and the Standing Committee on Health and Environment.

Membership of the Subcommittee on the Quantification of Environmental Health Effects:

- Professor F.A. de Wolff, Emeritus Professor of Clinical and Forensic Toxicology, Amsterdam, *chairman*
- Professor R. Bal, Professor of Health Policy and Management, Institute of Health Policy and Management, Erasmus Medical Centre, Rotterdam
- Dr. J.J. van Busschbach, psychologist, Erasmus Medical Centre, Rotterdam
- Dr. G. van Donselaar, philosopher, University of Amsterdam
- Dr. H.F.G. van Dijk, Health Council, The Hague, *adviser*
- Dr. A.E.M. de Hollander, Public Health Status and Forecasting Project Leader, RIVM, Bilthoven
- Professor B.A. van Hout, Professor of Medical Technology Assessment, Julius Centre for Health Science and Primary Medicine, University Medical Centre, Utrecht
- Dr. H.M.E. Miedema, psychologist, TNO Built Environment and Geosciences, Delft
- Dr. P.W. van Vliet, Health Council, The Hague, *secretary*

Membership of the Standing Committee on Health and Environment:

- Professor J.A. Knottnerus, Health Council, The Hague, *chairman*
- Professor A. Bast, Professor of Human Toxicology, University of Maastricht
- Dr. C.J.M. van den Bogaard, VROM Inspectorate, Ministry of Housing, Spatial Planning and the Environment, The Hague, *adviser*
- Dr. J.S.M. Boleij, Director of the Board for the Authorisation of Pesticides, Wageningen (until 1 January 2007)
- Dr. C.A. Bouwman, Health Council, The Hague, *adviser*
- Professor B. Brunekreef, Professor of Environmental and Occupational Health, Utrecht University
- Professor M.H.W. Frings-Dresen, Professor of Occupational Health, Academic Medical Center, Amsterdam
- Dr. H.S. Hiemstra, Ministry of Social Affairs and Employment, The Hague, *adviser*
- Dr. A.E.M. de Hollander, Public Health Status and Forecasting Project Leader, RIVM, Bilthoven
- Professor D. Kromhout, Vice-President of the Health Council, The Hague
- Dr. R.M. Meertens, psychologist, Maastricht University
- Dr. H.M.E. Miedema, psychologist, TNO Built Environment and Geosciences, Delft
- Professor G.J. Mulder, Emeritus Professor of Toxicology, Oegstgeest
- Dr. W.R.F. Notten, TNO Built Environment and Geosciences, Delft, *vice-chairman*
- Professor W.F. Passchier, Professor of Risk-Analysis, Maastricht University
- Professor W. Seinen, Professor of Toxicology, Utrecht University (until 1 January 2007)
- Professor T. Smid, Professor of Occupational Health and Safety, VU University, Amsterdam (from 1 April 2007)
- J.A. Verspoor, Ministry of Housing, Spatial Planning and the Environment, The Hague, *adviser*
- Professor M. de Visser, Vice-President of the Health Council, The Hague
- Dr. F. Woudenberg, psychologist, Public Health Service Amsterdam (from 1 April 2007)
- A. Wijbenga, Executive Director of the Health Council, The Hague, *adviser*
- Dr. J.H. van Wijnen, physician, toxicologist/epidemiologist, Amsterdam
- Professor F.A. de Wolff, Emeritus Professor of Clinical and Forensic Toxicology, Amsterdam
- Dr. P.W. van Vliet, Health Council, The Hague, *secretary*

The following experts were also consulted:

- Dr. B.E. Baarsma, economist, SEO Economic Research, Amsterdam
- Dr. R. Brouwer, environmental economist, Institute for Environmental Studies, VU University, Amsterdam
- Professor W.N.J. Groot, Professor of Health Economics, Maastricht University
- Professor M.W. Hofkes, Professor of Economics and Sustainable Development, VU University, Amsterdam

The Health Council and interests

Members of Health Council Committees are appointed in a personal capacity because of their special expertise in the matters to be addressed. Nonetheless, it is precisely because of this expertise that they may also have interests. This in itself does not necessarily present an obstacle for membership of a Health Council Committee. Transparency regarding possible conflicts of interest is nonetheless important, both for the President and members of a Committee and for the President of the Health Council. On being invited to join a Committee, members are asked to submit a form detailing the functions they hold and any other material and immaterial interests which could be relevant for the Committee's work. It is the responsibility of the President of the Health Council to assess whether the interests indicated constitute grounds for non-appointment. An advisorship will then sometimes make it possible to exploit the expertise of the specialist involved. During the establishment meeting the declarations issued are discussed, so that all members of the Committee are aware of each other's possible interests.

Annex **C**

Glossary

DALY

disability-adjusted life year, an indicator of lifespan and health-related quality of life, in the context of which quality of life is expressed using a weighting factor of between 0 (full health) and 1 (death or a health status deemed to be no better than death).

Health indicator

a variable for measuring change associated with a health problem.

Monitoring

the periodic measurement, analysis and interpretation of indicators of environmental factors that are relevant to health or indicators of health problems that are attributable to environmental factors.

QALY

quality-adjusted life year, an indicator of lifespan and health-related quality of life, in the context of which quality of life is expressed using a weighting factor of between 0 (death or a health status deemed to be no better than death) and 1 (full health).

Social cost-benefit analysis

an analysis of all the positive effects (benefits) and negative effects (costs) of a social activity, felt by any party or group in society and expressed in monetary terms wherever possible.

Weighting factor

a value between 0 and 1, used to correct life years for health-related quality of life.

Willingness to accept

an expression of the minimum economic value that a person places on a change to his or her circumstances (i.e. the least that the person is prepared to take in return for going without a positive change or accepting a negative change).

Willingness to pay

an expression of the maximum economic value that a person places on a change to his or her circumstances (i.e. the most that the person is prepared to pay to secure a positive change or to avoid a negative change).