The results of GCEA can be used to guide policy in a number of ways. This section provides an overview of these options with reference to WHO-CHOICE, the database on costs and effects of interventions that WHO has established using GCEA. However, the policy uses are also relevant to other types of CEA.

7.1 Global dissemination of new interventions

Some new technologies and approaches to improving health are rapidly disseminated and adopted. Others take a longer time to be accepted. The former group includes technologies that improve the health of people who can afford to purchase them or who have the ability to demand the service in other ways. The latter group includes interventions aimed largely at poor people. GCEA can identify interventions that are potentially very good buys but which are not currently used, either because they are new or because they have not been widely adopted.

Once an intervention has been identified as cost-effective, it can be promoted at an international and national level, shortening the lag time between development and adoption of the technology. For example, the analysis on micronutrient supplementation and fortification undertaken by WHO-CHOICE showed that these interventions were cost-effective in all regions (see www.who.int/evidence/cea). But while vitamin A supplementation has been promoted actively by international agencies and some governments, zinc supplementation has lagged behind and many countries are still not providing this intervention. Reduction of the salt content in processed foods has been shown to be an efficient way of reducing the risk of cardiovascular events, but governments have only recently begun to think about how to encourage this type of action. Information from CEA can help to ensure that new or under-
used interventions are used more rapidly. The corollary is that it can also help to discourage the use of inefficient technologies that are widely used.

7.2 National Priority Setting

7.2.1 Priority Setting at the Programme Level

GCEA is particularly suited to identifying a set of the most cost-effective interventions that can be used by decision-makers to improve the performance of their health systems. Unlike earlier work on sectoral CEA, WHO-CHOICE has evaluated sets of interventions at different coverage levels and in different combinations. This accounts for non-linearities in cost-functions and for any interactions in the impact of interventions being undertaken simultaneously. Groups of interventions that are interrelated are evaluated together in a cluster, as discussed in Section 2.

The first use is to set priorities within any set of interrelated interventions. This was illustrated in Section 2.2 where a hypothetical example from TB was used to illustrate how an expansion path can be calculated for the set of interrelated interventions and the most appropriate mix chosen for any given level of resources. An example relating to the prevention of cardiovascular disease through reducing blood pressure and cholesterol levels is found in Part Two of this volume, reproducing work originally reported in *The Lancet* (136). There it is shown that secondary prevention based on the identification and treatment of elevated blood pressure alone, or of elevated levels of cholesterol alone, are not on the expansion path in any subregion. They are less cost-effective than interventions which first identify the overall risk individuals have of suffering a cardiovascular event in the next 10 years, then identified individuals at risk with the combination of a cholesterol lowering agent, a blood pressure-reducing agent and aspirin.

CEA within a group of interrelated interventions is a powerful tool even where there is uncertainty. Often it is very clear that one intervention is both less costly and more effective than another option, for all combinations of assumptions. The analysis can also show which interventions are very costly ways to improve health within any set.

The use of this type of information in identifying potential improvements in the efficiency of the health system is demonstrated in Figure 7.1, which illustrates the maximum gain in health that could be derived if the most efficient set of interventions were chosen to improve child health for any given level of resource use. The “frontier” that is depicted has been developed from an analysis of interventions
versus childhood pneumonia and diarrhoea, and zinc and vitamin A deficiency in one epidemiological subregion of Africa characterized by high adult and high child mortality (called AFRO-D—for a description of WHO-CHOICE and the definition of epidemiological subregions, see Annexes A and G respectively). The gain in healthy life expectancy (HALE) is given on the y-axis (obtained by transforming the DALYs averted by the interventions to HALE gain) and resource use or costs on the x-axis. 

Figure 7.1 Maximum possible health gains from selected child health interventions, AFRO-D

The costs of the current set of interventions used in AFRO-D and the associated gains in HALE were then estimated, represented by point X. This implies that it would be possible for countries in AFRO-D to reallocate the resources currently devoted to interventions focusing on children under the age of five years in a way that would achieve more health than is currently the case. This can be done, for example, by increasing the provision of micronutrients, particularly zinc but also vitamin A, either through fortification or supplementation.

7.2.2 Priority setting at the sectoral level

The potential improvement of efficiency is even greater if a sectoral approach is taken and all interventions are considered together. Figure
7.2 represents the efficiency of a health system in the production of overall health. The x-axis denotes the inputs used to achieve health improvements. The y-axis represents the level of health. Line \( L \) represents the minimum health level that would be observed in the absence of a health system or the absence of any health expenditure—it is not zero because people would still be alive even if the health system did not exist. Line \( M \) represents the maximum level of health that could be achieved for any given level of resources, or the production frontier for the system as a whole, as opposed to the case of Figure 7.1 which represented only the frontier for interventions focusing on child health. It reflects the fact that increasing expenditure is associated with increasing health.

**Figure 7.2** Health system efficiency and cost-effectiveness

Country A is observed to provide a set of interventions resulting in the costs and health level of point \( e \). Efficiency is usually defined as the level of actual goal attainment divided by the maximum that would have been possible for the resources available. In this case, because some level of health would exist even if no resources were spent (e.g. line \( L \)), it is defined as the health gain achieved above the minimum possible \( (L) \), divided by the maximum health gain that would have been possible for those inputs (also above the minimum). Efficiency at \( e \) is the distance from line \( L \) to \( e \) in a vertical direction, divided by the distance from \( L \) to \( M \) at that point. Efficiency at \( g \) is \( \frac{Lg}{LM} \). Assuming all other variables contributing to health are held constant, countries below line \( M \) are producing less health than is possible for their given level of resources.

Inefficiencies in the production of health may derive from two sources: problems with technical efficiency—how an intervention is delivered—and problems with allocative inefficiency—which set of interventions is
provided. If a spontaneous vaginal delivery at a health facility utilizes seven days of in-patient stay, but the same health outcomes could have been obtained with an in-patient stay of 48 hours or less, or even a home birth, there is technical inefficiency. A given health gain is obtained at a higher than necessary cost. If several magnetic resonance imaging devices have been purchased and placed in health facilities within walking distance of each other, resulting in under-utilization of those devices, there is again technical inefficiency. The same benefits of MRI technology could have been obtained through selective placement of the machines in referral facilities, at lower cost.

Allocative efficiency traditionally is used to describe the optimal mix of inputs (such as capital, labour and supplies) to a production process, given their respective prices. As interventions are inputs to the production of health, allocative efficiency requires choosing the most cost-effective mix of interventions for any set of resource constraints. Country A operating initially at point e could improve health by spending more—moving to g, for example. The alternative would be to change the mix of interventions it is providing. It could have reallocated existing resources from cost-ineffective to cost-effective interventions, gaining more health for the same resources, e.g. moving to point f. If it has additional resources to invest, by choosing a more cost-effective mix of interventions and spending more, it could move from point e to h.

This illustrates how GCEA can help decision-makers to assess and potentially improve the performance of their health systems in terms of one goal, the level of health. It indicates which sets of interventions provide the highest “value for money” and helps policy-makers choose the interventions and programmes which maximize health for the available resources. In principle, GCEA could also be used to define the overall frontier M for the entire health sector. This would require information on the entire set of intervention options but, at least in theory, it is a way of assessing the efficiency of the overall system—similar to the situation depicted in Figure 7.1 but for the entire sector.

7.3 Reimbursement and Financing Decisions

Related to the uses described above, GCEA can also be used to guide or re-examine financing decisions. It can help inform decisions on whether to fully reimburse, subsidize, or refuse to cover the costs of providing a service. It could be used to decide the extent or frequency of coverage—for example, for screening programmes. This provides valuable information for a health insurance scheme covering all types of health interventions, or a component of the health system such as a hospital. On the grounds of efficiency, it can be argued that there should be no attempt to provide cost-ineffective interventions. This type of use of CEA is becoming increasingly common—for example, the Pharmaceutical Benefits Advisory Committee in Australia takes cost-effectiveness into
account when making decisions on which new drugs will be publicly reimbursed. The National Institute for Clinical Excellence in the United Kingdom has also used cost-effectiveness information in providing guidance for the use of new drugs in the National Health Service.

7.4 Research and Development Priorities

WHO-CHOICE has analysed approximately 200 interventions at a subregional level. An immediate research need is to expand the number of interventions in the database and to contextualize the results to as many countries as possible. Analysts in countries can contribute to both activities by contacting the WHO-CHOICE project team.

GCEA can be used to estimate the contribution of interventions, or combinations of interventions, to decreasing the burden of disease. If it is shown, for example, that all combinations of cost-effective interventions together have a relatively small impact on the total burden of a particular disease or risk factor, research into new ways of reducing this burden is required. Interventions targeting child under-nutrition illustrate this. They are relatively costly and not very effective. Research to improve the effectiveness of current technologies, to reduce their costs, or to develop new technologies is warranted.

A variation of this theme is that technologies may exist but there may be system-wide constraints which prevent them being used. For example, access to skilled midwives is a cost-effective way to reduce maternal mortality, but there might be a shortage of skilled midwives that prevent this intervention being scaled-up to high levels of coverage. It is critical for decision-makers to know if a high disease burden is due to the lack of cost-effective intervention options, or if it is due more to health system constraints.

The final possibility is that a cost-effective intervention exists but is not widely used. Research is needed to determine why this is the case—it may, for example, be related to cost, or perhaps providers or members of the community are not convinced that it is effective—and to examine how it can be used more widely.

7.5 Goals and Functions of Health Systems

Cost-effectiveness analysis focuses on the improvements in health that result from different choices about how health resources should be used. It is important to remember that improving health is only one goal of health systems. According to the WHO framework of health systems performance assessment, there are five indicators of the three intrinsic social goals to which the health system contributes: namely, improving the level and distribution of health, improving the level and distribution of responsiveness and ensuring that the financial burden of paying for the health system is distributed fairly (137) (see Table 7.1).
This means that the results of CEA should not be used formulaically. Cost-effectiveness provides information on how current resources and any new resources could be allocated to obtain the greatest possible improvement in population health. This enters the policy debate and decision-makers then must weigh the costs of changing the intervention mix and the impact of different mixes against other goals of the health system. In fact, CEA at the sectoral level is probably most powerful when it is used to classify interventions into broad groups. In the first round of WHO-CHOICE three categories were used—those that are: very cost-effective, cost-effective, and not cost-effective. Policy-makers would be encouraged to choose from the first set, and to avoid the third, other things being equal, but they would also need to assess the impact of any proposed mix of interventions on poverty and other types of inequality, for example.

To illustrate, in Figure 7.1 the intervention combination nearest the upper right corner includes targeted provision of supplementary food to infants. This combination cannot be considered cost-effective for the available resources. However, even if it exceeds the threshold of what is considered to be cost-effective in that setting, countries in the region might opt to provide it on equity grounds because under-nutrition has a disproportionately high burden in the poor. At the same time, having identified that there is no cost-effective intervention against under-nutrition, policy-makers could also recommend setting aside research funds to determine how to decrease the costs or improve the effects of the interventions, or even fund a research programme with the intent to discover a different technology altogether.

### 7.6 Ethical issues

A number of ethical issues may arise when using CEA for health care resource prioritization. For example, how can concerns for equity or justice be incorporated in decision-making in addition to the concerns for efficiency and benefit maximization? And, should all QALYs or DALYs count equally regardless of the age of the recipient of the health benefit?

<table>
<thead>
<tr>
<th>Goal</th>
<th>Level</th>
<th>Distribution</th>
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<tbody>
<tr>
<td>Health</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Responsiveness</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Fair financing</td>
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<td>X</td>
</tr>
</tbody>
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Table 7.1  WHO health system performance framework
Another question is what priority should be given to the sickest or worst off? Since many of the issues are relevant to GCEA as well as to other forms of CEA, the interested reader is referred to an overview in Part Two on ethical issues in CEA and for a more thorough discussion, to *Fairness and Goodness: Ethical Issues In Health Resource Allocation* (138).
ANNEX E. DALYs TO MEASURE BURDEN OF DISEASE

DALYs are the sum of years of life lost (YLLs) and years of life lived with disability (YLDs). A variety of measures have been developed to measure the stream of life lost due to death at different ages. These measures can be divided into four families: potential years of life lost, period expected years of life lost, cohort expected years of life lost and standard expected years of life lost (139).

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

- **Period expected years of life lost.** A popular alternative to PYLL is to calculate period expected years of life lost (PEYLL), where the duration of life lost is the local period life expectancy at each age. In a period life table, life expectancy at each age is the estimated duration of life expected at each age if the current age-specific mortality patterns were to hold in the future. In PEYLL, a population’s current mortality level is being used as the “ideal” against which it is compared in order to calculate the burden of disease. Over time and across communities, local life expectancies vary and thus the reference standards vary, creating at times, peculiar findings for burden comparisons.

- **Cohort expected years of life lost.** Given past secular trends in mortality, the average individual alive today at any given age is likely to live substantially longer than period life expectancy at that age. As distinct from period life expectancy, cohort life expectancy is the estimated average duration of life a cohort would actually experience. Cohort life expectancy is substantially higher than period life expectancy. However, a disadvantage is that if expected years of life lost are used as a measure of the burden of disease, a death in a rich country where life expectancy at each age is higher would be considered a greater burden than a death in a poor country with a lower life expectancy. If burden of disease assessments were to influence resource allocation this could lead to counter-intuitive and inequitable conclusions.

- **Standard expected years of life lost.** The advantages of an expectation approach where every death contributes to the burden of disease, and the equitable approach of PYLL where every death of a given age contributes equally to the calculation of the burden of disease, can be combined by using a standard expectation of life at each age as the
reference norm. For measuring the global burden of disease due to premature mortality, the SEYLL method has been adopted. To define the standard, the highest national life expectancy observed was taken. Based on the observation that Japanese females achieve a period life expectancy at birth higher than 82 years, the standard expectations were based on model life table which has a life expectancy at birth for females of 82.5 years. Note that this is not the approach used to measure DALYs averted by interventions which requires a different calculus. Details are found in Section 4.
ANNEX F. MEASURING INTERVENTION BENEFIT AT THE POPULATION LEVEL

In Section 4.1.7, it was claimed that a population model is often necessary to measure intervention benefit accurately. It is therefore necessary to relate the kind of measure deriving from such a model (see Section 4.2) to the other standard measures of benefit that satisfy the general criteria established in the foregoing parts of Section 4.1.

For example, under appropriate assumptions, changes in healthy years lived (HYL) are equal to changes in DALYs. To see this, consider Figure F.1. Area A (dark grey) represents the population number surviving in equivalent full health under the baseline scenario, i.e. where there is no intervention. This area is analogous to the area under the lower line in Figure 4.1 (Section 4.1.7), except that here non-fatal health effects are also considered: “equivalent full health” means that the survivorship curve forming the upper boundary of Area A has been adjusted for time spent in states less than perfect health (see Section 4.1.2). While a standard survivorship curve typically represents the percentage surviving at a given age, here the absolute number surviving at a given time is shown. For simplicity, only the population alive at time \( t = 0 \) is depicted, i.e. there are no births or other entrances.

Now suppose that an intervention is introduced and that Area B (light grey) represents the increment experienced by the population when that intervention is implemented at time \( t = 0 \). It is clear that this area represents the intervention effect, or intervention benefit, measured at population level. On the stated assumptions, Area B in the above diagram

**Figure F.1** The area below the health-adjusted survival curve (A), the benefit (B) resulting from a given intervention, and the loss (C) relative to a normative goal
is denominated in units of HYL. The area under the survivorship curve after the intervention consists of the sum of Area A and Area B. Area B can be measured as the difference of the integrals of the two survivorship curves (100). Both Area A and Area B belong to the type of measure that demographers denote as belonging to the “health expectancy” family (140).

Now assume that in Figure F.1 the population members alive at a given time have different ages, i.e. they do not all belong to the same birth cohort, and further assume that the survivorship curves shown in Figure F.1 are adjusted for the average societal values attached to life lived at different ages, using a system of age-specific weights (see Section 4.1.6). Finally, assume that time discounting is also represented in the figure at a constant rate of 3%. On these assumptions, Area B is denominated in age-weighted, discounted HYL.

Area C (white) represents a loss in population health, where “loss” is measured relative to a particular reference standard. Here the reference standard is the vertical line drawn at time $t = 100$. A vertical line is used for purposes of illustration, although another reference standard could be used, such as the age-specific life expectancy of a particular population, which is the approach is used for calculating the YLL component of DALYs (see Section 4.1.7 and Annex E). Note that “loss” is by definition measured above the survivorship curve, and is therefore a “health gap” measure (2). Although the reference standard in Annex Figure F.1 is only a vertical line representing death at an arbitrary point in time, Area C can be thought of as measuring a particular kind of DALY (i.e. one in which the reference standard is simpler than an idealized survivorship curve).
In any case, once a reference standard is chosen, Area C is fully determined by the curve forming the upper boundary of Area B. Area C represents DALYs in a population in which the intervention was implemented at time \( t = 0 \); if the intervention is not implemented, DALYs are measured by the sum of Area B and Area C, as shown in Figure F.2.

It is therefore evident that Area B represents the same quantity of intervention benefit, whether benefit is measured in terms of DALYs or HYLs. This is because intervention benefit is not measured “above” or “below” the curve but is measured as the difference between two survivorship curves. For the equivalence to hold exactly, it is only necessary to ensure that changes in DALYs/HYLs are calculated using the same assumptions, namely, with the same discount rate and the same set of age weights and health state valuations.