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Abstract

In health economics, cost-effectiveness is defined as maximized health benefits for a given health budget. When there is a private alternative to public treatments, care must be taken when using costeffectiveness analysis to decide what types of treatments should be included in the public program. The correct benefit measure is in this case the sum of health benefits to those who would not be treated without the public alternative and the cost savings to those who would otherwise choose private treatment. In the socially optimal ranking of treatments to be included in the public health program, treatments should be given higher priority the higher are costs per treatment for a given ratio of gross heath benefits to costs.

1 Introduction

What treatments should be included in a public health system? This is a fundamental question in any country that has a public health system. As a method to help answer this question, an obvious candidate is standard cost-benefit analysis. A very rough description of this method is the following: One first calculates the benefits of a potential treatment, measured in money units. These benefits are then be compared with the costs of the treatment. If benefits exceed the costs, the treatment ought to be included in the public health program.

Much can be said about simple cost-benefit analyses of the type sketched above. In particular, many health economists have been sceptical to applying traditional cost-benefit analysis to the health sector. A main reason given for this scepticism is that the analysis requires the calculation of a monetary value of health benefits. In particular, this means that one must put a money value on life. Several health economists have been critical to this both for ethical and computational reasons.

An alternative to traditional cost-benefit analysis is so-called cost-effectiveness analysis.[1] Cost-effectiveness is defined as the minimum cost for a given health benefit, or equivalently, maximal health benefits for given expenditures on health care. More precisely, one ranks all treatments according to the ratios between health benefits and costs, and treatments for which this ratio is above some threshold should be included in the public health program. The threshold is determined by the budget, which is assumed to be exogenously given.[2]

Cost-effectiveness analysis is not without problems. First, this type of analysis does not give any guidance to the decision of how large the public health budget should be, this decision is simply assumed to be exogenously set by the policy-makers. Second, to be able to perform a cost-effectiveness analysis, one needs an aggregate measure of health benefits for each individual. A typical measure that is used is QALYS, or *Quality Adjusted Life Years*. It is well known in the literature that QALYs and most other aggregate health indicators can only represent a person's preference orderings over

[1] In the present article I use the term "cost-effectiveness analysis" in a broad sense that also includes what some health economists call "cost-utility analysis". See Hurley (2000) for a further discussion.

[2] For a further discussion of cost-effectiveness analysis see e.g. Weinstein and Stason (1977), Johannesson and Weinstein (1993), Garber and Phelps (1997) and Garber (2000).

life years and health quality of each life year in special cases.[3] Finally, even if one has a correct measure of aggregate health benefits at the individual level, it is not obvious that there is any justification for taking a simple sum over these benefits over all persons for making a social evaluation.[4]

In the current paper all of the objections above concerning cost-effectiveness are ignored. Instead, the focus is on the consequence of a private alternative to public treatment: In most of the literature that discusses how a public health budget should be allocated across potential medical interventions, it is explicitly or implicitly assumed that the health interventions that are not funded by the public budget are not carried out. This may be a good assumption for treatments such as heart surgery or cancer treatment. However, for many treatments there is a private alternative to public treatment. The private alternative may be potential in the sense that it is only relevant if the treatment is not offered by the public system, or it may exist in parallel with the public alternative, e.g. due to waiting time for public treatment. Examples of treatments that typically are offered outside the public system, at least if not offered by the latter, are surgical sterilization, assisted fertilization, cataract surgery and dental care. Comparing different countries that all have a predominantly public health system, one will find that countries differ with respect to what is covered by the public system and what is not. In the countries where a treatment of the above type is not offered by the public system, this treatment will typically be offered by the private sector.

In standard cost-effectiveness analysis, the health benefits that enter the calculation for a particular treatment is the health benefit for all those who get treatment in the public sector. However, this is a measure of *gross* health benefits, and does not measure the true health effect of including a treatment in the public program if part of the public treatment simply is a shift from private to public treatment. To measure the true health effect of including a treatment in the public program one would have to calculate *net* health benefits, i.e. the net increase in total (private plus public) treatments as a consequence of including the treatment in the public program. Intuitively, one might expect hat the true benefit measure in a cost-effectiveness analysis should be net health benefits as described above. This is, however, not the case. To see why not, consider the following simple example. There are two

[3] See e.g. Broome (1993), Mehrez and Gafni (1989), Culyer and Wagstaff (1993), Bleichrodt and Quiggin (1999) and Gafni et al. (1993).

[4] See e.g. Harris (1987), Wagstaff (1991), Nord (1994), Olsen (1997) and Dolan (1998).

treatments A and B with the same cost per treatment. If both are included in the public program, there will be the same number of treatments for A as for B, so that total costs are the same for these two. Gross health benefits are higher for A than for B, and everyone would rather be without B than without A. If only one of these two treatments are to be included in the public program, it is therefore reasonable that this should be A. However, this might not be the result of a cost-effectiveness analysis using net health benefits: It might be the case that if B is not offered publicly, very few people would choose B privately. The net health benefits of B are therefore almost as high as the gross benefits. On the other hand, if A is not offered publicly, almost everyone might instead choose A privately, since A is valued higher than B. The *net* health benefits of A may therefore be very low, even though the *gross* health benefits are high. Ranked by the ratio between net health benefits and costs, B may therefore seem better than A.

From the discussion above, it is thus clear that neither gross nor net health benefits should be used in a cost-effectiveness analysis when there is a private alternative to public treatment. To find out what the correct benefit measure is in this case, I us a simple model where maximizing the sum of some aggregate measure of health benefits for a given budget is socially optimal (as defined by standard welfare economics and given the budget constraint) provided there is no alternative to public treatment. I then show that when a private alternative to public treatment is introduced, the benefit of including a treatment in the public program is the sum of the net health benefits and the cost savings patients get from getting public instead of private treatment. In order to add these two benefit components one is thus forced to make a monetary valuation of the net increase in health benefits. The paper shows that when this is correctly done, the social optimum (given the public health budget) no longer implies that the public health system should maximize gross or net health benefits for the given public health budget. A comparison is also given between the socially optimal priority ranking and the standard cost-effective ranking of different treatments.

The rest of the paper is organized as follows. In Section 2 the basic model is introduced, and I derive the correct benefit-cost ratio to be used in a cost-effectiveness analysis. Sections 3 and 4 point out some important differences between the cases with and without a private alternative. Some concluding remarks are given in Section 5.

2 Cost-effectiveness with and without a private alternative

There are n mutually exclusive potential illnesses, where each person gets illness j with probability π_j (formally, we let one of the "illnesses" represent perfect health, so that the probabilities add up to one). There are H persons in the economy, and the utility loss of person h in the case of illness j is ℓ_j^h. Illness j may be perfectly cured with a treatment that costs c_j. The average utility loss if illness j is left untreated is denoted ℓ_j, i.e. $\ell_j = \frac{1}{H}\sum_h \ell_j^h$, and ℓ_j may be interpreted as the (average) health benefit of giving treatment for illness j. With this framework, traditional cost-effectiveness analysis would rank all treatments according to the ratios $\frac{\ell_j}{c_j}$, and include in the public health program all treatments for which this ratio between health benefits to costs exceeds some threshold. The threshold is determined by the exogenously given health budget.

Let the utility level of person h be $u(y^h)$ if this person is treated for any illness he/she gets, where y^h is this person's income. The function u is assumed to be increasing and strictly concave. According to the notation above, this person's utility is $u(y^h) - \ell_j^h$ if he/she gets illness j and is untreated. Assume that if the public health system doses not offer treatment for illness j, one can get private treatment at the price c_j (i..e. the same as the cost would be for public treatment). If treatment for illness j is not offered by the public heath system, person h thus has the choice between the utility levels $u(y^h) - \ell_j^h$ and $u(y^h - c_j)$ if he/she gets illness j.

From the assumptions above, it follows that the expected utility of person h is (when I is the set of treatments that are included in the public health program)

$$v^h = \sum_{i\in I} \pi_i u(y^h) + \sum_{i\notin I} \pi_i \max\left[u(y^h) - \ell_j^h, u(y^h - c_j)\right] \tag{1}$$

At the level of the aggregate economy, π_j is the proportion of the population that gets illness j. The budget constraint of the public health system is therefore given by

$$\sum_{i\in I} \pi_i H c_i \leq T \tag{2}$$

where T is the exogenous budget. The cost C_j of including treatment j in the public heath program is the increase in the left hand side of (2) such an inclusion gives, i.e.

$$C_j = \pi_j H c_j \tag{3}$$

The benefit B_j of including treatment j in the public heath program is the increase in $\sum_h v_h$ such an inclusion gives. Defining P_j as the set of persons that choose private treatment for illness j if this treatment is not offered by the public health system, it thus follows from (1) that

$$B_j = \pi_j \left\{ \sum_{h \notin P_j} \ell_j^h + \sum_{h \in P_j} \left[u(y^h) - u(y^h - c_j) \right] \right\} \tag{4}$$

The first sum in this expression is the health benefits of those who would not be treated unless the treatment was offered publicly. The second sum is the cost savings of those who would choose and pay for private treatment if the treatment was not offered publicly.

We define the surplus from private treatment by

$$s_j^h = u(y^h - c_j) - \left[u(y^h) - \ell_j^h \right] = \ell_j^h - \left[u(y^h) - u(y^h - c_j) \right] \tag{5}$$

The set of persons that choose private treatment for illness j if this treatment is not offered by the public health system (P_j) is given by the set of persons that have a positive value of s_j^h. Inserting (5) into (4) gives

$$B_j = \pi_j \left[\sum_h \ell_j^h - \sum_{h \in P_j} s_j^h \right] \tag{6}$$

We wish to maximize $\sum_h v_h$ subject to the budget constraint (2). The solution to this problem is found by ranking all treatments according to the benefit-cost ratios $\frac{B_j}{C_j}$, and including in the public health program treatments in the order of declining ratios until the budget is exhausted. From the equations above the ratios $\frac{B_j}{C_j}$ are given by (remembering the definition $\ell_j = \frac{1}{H} \sum_h \ell_j^h$)

$$\frac{B_j}{C_j} = \frac{\ell_j}{c_j} \left[1 - \frac{1}{H \ell_j} \sum_{h \in P_j} s_j^h \right] \tag{7}$$

If there were no private alternative, the term in square brackets in (7) would simply be one, and we would be back to the standard cost effectiveness analysis based on the ratios $\frac{\ell_j}{c_j}$. The ratios $\frac{\ell_j}{c_j}$ are important also for the case when a private alternative exists. However, in this case there are other factors than the ratios $\frac{\ell_j}{c_j}$ that matter in addition. With a private alternative the term in square bracket is less than one, since $s_j^h > 0$ for all those who choose private treatment if treatment is not offered by the public health system. We therefore have the following important result: If there are treatments that for some reason are not offered by the private sector, such treatments should be given higher priority as a candidate for inclusion in the public health program than treatments that have the same ratio $\frac{\ell_j}{c_j}$ of gross health benefits to costs but are offered by the private sector.

3 Size matters

Consider two illnesses/treatments j and k. In the absence of a private alternative, we know that j should be ranked higher than k if either ℓ_j is higher than ℓ_k or c_j is lower than c_k. In both cases the benefit-cost ratio is higher for j than for k. When there is a private alternative to private treatment, it is no longer obvious that this is true. Although the ratio $\frac{\ell_j}{c_j}$ is higher than the ratio $\frac{\ell_k}{c_k}$, it does not follow directly from (7) that $\frac{B_j}{C_j} > \frac{B_k}{C_k}$, since the term in brackets also will differ between the two treatments. However, we show in the Appendix that the benefit-cost ratio defined by (7) is in fact higher for j than for k if either $\ell_j^h > \ell_k^h$ for all h or if $c_j < c_k$. For treatments differing in this way, there is thus no difference between the present case and the case of no private alternative. However, there is an important difference between the two cases: When there is no private alternative, it is *only* the ratios $\frac{\ell_j}{c_j}$ that matter for the ranking. When there is a private alternative, the term in brackets in (7) is also of importance for the benefit-cost ratio, and thus for the ranking. In particular, consider the case where j and k have the same ratios between gross health benefits and treatment costs, i.e. $\frac{\ell_j}{c_j} = \frac{\ell_k}{c_k}$. If there were no private alternative for any of these treatments, they would be ranked equally in a cost-effectiveness analysis, i.e. either both or none would be offered by the public system if cost-effectiveness analysis was the criterion used in the decision. When there is a private alternative this is no longer generally true. It is shown in the Appendix that the term in square brackets in (7) is higher for higher costs per treatment for a given ratio between gross health benefits and treatment costs. This means that one can no longer simply rank treatments by their benefit-cost ratios, the cost per treatment is also an important factor to take into consideration. In particular, it follows that $\frac{B_k}{C_k} > \frac{B_j}{C_j}$ if $c_k > c_j$ and $\frac{\ell_k}{c_k} = \frac{\ell_j}{c_j}$, i.e. the treatment with the highest cost per treatment gets the highest priority in the cost-effectiveness ranking. It may therefore be the case that the cost-effectiveness analysis leads one to include treatment k in the public health program, but leave out treatment j, even though $\frac{\ell_j}{c_j} = \frac{\ell_k}{c_k}$.

The intuition behind the result that "size matters" is as follows. Consider a proportional increase in health benefits and treatment costs. Even if the money costs increase proportionally with the health benefits, the *utility* cost increases more than proportionally with the health benefits, due to the concavity of the utility function. Since health benefits are measured in utility units, costs rise more than proportionally with health benefits when both are measured in utility units. The private alternative therefore becomes less attractive as health benefits and treatment costs increase, which in turn implies that public treatment should be given higher priority.

4 Heterogeneity matters

If there were no private alternative for any treatments, it would only be the average health benefit ℓ_j that would matter in a cost-effectiveness analysis, and not the distribution of ℓ_j^h across the population. This is no longer true when there is a private alternative, since the term in square brackets in (7) may depend on this distribution. The importance of heterogeneity is analyzed in Hoel (2005) for the special case in which income is the same for everyone. In particular, a comparison is given between two illnesses j and k that have identical average health benefits and treatment costs, i.e. $\ell_j = \ell_k = \ell$ and $c_j = c_k = c$. If preferences are more heterogeneous for k than for j in the sense that the distribution of ℓ_k^h is a mean preserving spread of the distribution of ℓ_j^h (in the terminology of Rothschild and Stiglitz (1970)), treatment k should be given lower priority as a candidate for inclusion in the public health program than treatment j. While this is an interesting result, it is not valid as a general result for the case when income differs across persons. To see this, consider the case of a two person economy, where only one person (number 1) chooses to be treated privately if the treatments j and k are not offered publicly. For this case it follows from (7) that

$$\frac{B_j}{C_j} = \frac{\ell}{c}\left[1 - \frac{1}{2\ell}s_j^1\right] \tag{8}$$

and

$$\frac{B_k}{C_k} = \frac{\ell}{c}\left[1 - \frac{1}{2\ell}s_k^1\right] \tag{9}$$

The only difference between these two ratios is thus the terms s_j^1 and s_k^1. Since we are assuming that preferences are more heterogeneous for k than for j, it must be the case that $|\ell_k^1 - \ell_k^2| > |\ell_j^1 - \ell_j^2|$. If $y^1 \leq y^2$, it must be the case that $\ell_k^1 - \ell_k^2$ and $\ell_j^1 - \ell_j^2$ are both positive, since it is person number 1 who chooses private treatment although number 2 has at least as high income as number 1. When $\ell_k^1 - \ell_k^2$ and $\ell_j^1 - \ell_j^2$ are both positive, it follows from $|\ell_k^1 - \ell_k^2| > |\ell_j^1 - \ell_j^2|$ that $\ell_k^1 > \ell_j^1$, which in turn implies $s_k^1 > s_j^1$, see (5). From (8) and (9) it thus follows that $\frac{B_k}{C_k} < \frac{B_j}{C_j}$, i.e. k is given lower priority than j. However, from the reasoning above it is clear that if we instead had $y^1 > y^2$, we cannot exclude the possibility that $\ell_k^1 - \ell_k^2$ and $\ell_j^1 - \ell_j^2$ are both negative, i.e. private treatment is chosen by the "rich" person, and not by the person who gets the largest utility loss in the absence of treatment. If $\ell_k^1 - \ell_k^2$ and $\ell_j^1 - \ell_j^2$ are both negative, it follows from $|\ell_k^1 - \ell_k^2| > |\ell_j^1 - \ell_j^2|$ that $\ell_k^1 < \ell_j^1$, which in turn implies $s_k^1 < s_j^1$, see (5). From (8) and (9) it thus follows that $\frac{B_k}{C_k} > \frac{B_j}{C_j}$ in this case i.e. k is given *higher* priority than j. In this example more heterogeneous thus leads to higher priority in the public system.

In the last example above there was a negative correlation between income and utility loss in the case of illness. The case where these two variables are uncorrelated is discussed in more detail in the Appendix. It is shown that in this case the result derived in Hoel (2005) is valid: If preferences are more heterogeneous for k than for j (as defined in the Appendix), k should be given lower priority in the public system than j. The intuition for this result is as follows: Treatment k has more health benefits than treatment j for persons with a large utility loss for both illnesses, but less health benefits than treatment j for the persons with a small utility loss for both illnesses.

But the persons with a large utility loss for both illnesses are in any case going to be treated, so for these the benefits of public treatment are their cost savings, which are identical for k and j. Since the persons with a small utility loss for both illnesses get less health benefits from treatment k than for j, k should be given lower priority.

5 Conclusions

The preceding analysis has shown that the existence of a private alternative has important consequences for the ranking of treatments in a cost-effectiveness analysis. An important result is that treatments that for some reason are not offered by the private sector should be given higher priority as a candidate for inclusion in the public health program than treatments that have the same ratio of average gross health benefits to costs, but are offered by the private sector. A second important result is that for a given ratio of average gross health benefits to treatment costs, lower priority should be given to a treatment the lower is the cost per treatment. Finally, the degree of heterogeneity of preferences is of importance, but without knowledge about the correlation between preferences and income we cannot say how the ranking of treatments is affected by this heterogeneity.

A Appendix: Proofs of results in Sections 3 and 4

The benefit-cost ratio given by (7), henceforth denoted β_j, can be written as

$$\beta_j = \frac{\ell_j}{c_j} - \frac{1}{c_j H} \sum_h \max(0, s_j^h) \tag{10}$$

Consider first the case of $c_j = c_k (= 1$ for convenience) and $\ell_j^h > \ell_k^h$ for all h. From (10) it follows that

$$\beta_j - \beta_k = \ell_j - \ell_k + \frac{1}{H} \left[\max(0, s_k^h) - \max(0, s_j^h) \right] \tag{11}$$

Moreover, from (5) we have $s_k^h - s_j^h = \ell_k^h - \ell_j^h < 0$, implying

$$\max(0, s_k^h) - \max(0, s_j^h) \geq s_k^h - s_j^h = \ell_k^h - \ell_j^h \tag{12}$$

where the inequality is strict if $s_k^h < 0$ and $s_j^h > 0$ for at least one person. Combining (11) and (12) and remembering the definition of $\ell_j = \frac{1}{H}\sum_h \ell_j^h$ we thus get

$$\beta_j - \beta_k \geq \ell_j - \ell_k + \ell_k - \ell_j = 0 \tag{13}$$

where the inequality is strict unless the same persons choose private treatment for both illnesses j and k if they are not provided publicly (i.e. unless s_k^h and s_j^h have the same sign for all persons). Higher gros health beneifts thus leads to a higher ranking of the treatment.

Consider next the case of an illness for which (ignoring the subscript for notational convenience) $\ell^h = \alpha^h c$ where the parameters α^h are constant and $\frac{1}{H}\sum_h \alpha^h = 1$(implying $\ell = 1$). Using (10) and (5) we have

$$\beta = 1 - \frac{1}{H}\sum_h \max\left[0, \alpha - \frac{u(y^h) - u(y^h - c)}{c}\right] \tag{14}$$

From the concavity of the function u it follows that the fractions in the square brackets are larger the larger is c. The whole terms in square brackets are thus lower the higher is c, so that β is higher the higher is c. Higher cost per treatment thus leads to a higher ranking of the treatment, for given ratios between gross health benefits and costs.

A partial increase in treatment costs can be considered as a combination of a proportional increase in health benefits and costs and a reduction in health benefits. It therefore follows from the results above that a treatment should be given lower priority the higher are costs per treatment (for given health benefits).

Consider finally the consequences of preferences becoming more heterogeneous. Consider an illness for which (ignoring the subscript for notational convenience) $\ell = c(= 1$ for convenience), and let $\ell^h = 1 + \mu\sigma^h$ where $\frac{1}{H}\sum_h \sigma^h = 0$ and $\mu > 0$. The higher μ is, the more heterogeneous are people with respect to utility loss of an untreated illness. Combining (11) and (12) gives us

$$\beta = 1 - \frac{1}{H}\sum_h \max\left[0, 1 + \mu\sigma^h + u(y^h - c) - u(y^h)\right] \tag{15}$$

If there is no correlation between y^h and σ^h, the average value of the σ^hs for those who choose private treatment if treatment is not provided publicly (i.e. those who have $1+\mu\sigma^h+u(y^h-c)-u(y^h)>0$) will be positive. For his case an increase in μ will increase the terms in square brackets, i.e. reduce β. In other words, the more heterogeneous the utility losses of an untreated illness are, the lower priority should public treatment of this illness be given.

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