Volume 5 • Number 4 • 2002
VALUE IN HEALTH

Conditions for the Near Equivalence of Cost-Effectiveness and Cost-Benefit Analyses

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ABSTRACT

The equivalence of cost-effectiveness analysis (CEA) and cost-benefit analysis (CBA) has been vigorously debated in the health economic literature. In this paper we review and refine the conditions for the equivalence of CEA and CBA. The previously stated conditions require that 1) each individual's willingness to pay (WTP) per quality-adjusted life year (QALY) is constant and does not vary with the magnitude of QALY gains, and 2) the WTP per QALY is identical for every individual in society. Based on mathematical programming formulations of CEA and CBA, we note that condition 2 can be replaced with two other conditions, which together are less restrictive than the requirement that every individual have the same WTP per QALY. Even with this less restrictive set of conditions, CEA and CBA are unlikely to be equivalent under real world conditions. When CEA and CBA do lead to different resource allocation decisions, the most appropriate framework for health economic analysis depends on the perspective regarding distribution issues. We also examine the equivalence of two different definitions of CEA provided in the literature and discuss the problems that could arise when there are multiple optima.

Keywords: cost-benefit analysis, cost-effectiveness analysis.

Introduction

The distinctions between cost-effectiveness analysis (CEA) and cost-benefit analysis (CBA) have been vigorously debated in the health economic literature [1,2]. The metric for decision making in CEA is the ratio if the incremental cost to incremental effectiveness, measured in quality-adjusted life years (QALYs). On the other hand, the metric in CBA is the net benefit, defined as the difference between the incremental benefits and incremental costs.

Phelps and Mushlin [1] argue that the two analyses are equivalent and that decisions made about medical resources using CE analysis are wholly analogous to those using CB analysis. This implies that analyses using CEA and CBA should result in identical allocation of health-care resources and that the only distinction between CEA and CBA is in the measurement of health benefits.

An alternate approach to examining the distinction between CEA and CBA was provided by Donaldson [2] and was based on the question that the analyst was attempting to answer, rather than what was being measured. According to his definition, the objective of CEA is to determine the least costly way to achieve a goal, while the objective of CBA is to determine whether the goal is worth achieving. Based on these definitions, he argues that the near equivalence between the two methodologies is a fallacy, since they do not address the same allocation question.

A third point of view on the distinction between CEA and CBA was provided by Johannesson [3], in which he argued that CEA could be viewed as a subset of CBA. Furthermore, CEA and CBA would be equivalent if: 1) the willingness to pay (WTP) per unit of effectiveness is constant; and 2) this WTP is the same for everyone.

In this paper, we attempt to shed some light on these seemingly contradictory assertions in the health economic literature. In reality, the alternative approaches described above overlap substantially and differ from one another mostly in the definitions of CEA and CBA. The objectives of the paper are:

1. to formulate CEA and CBA as optimization problems using a mathematical programming framework;

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2. to derive conditions under which the different formulations are equivalent;
3. to examine whether these conditions of equivalence are likely to hold under real-world conditions;
4. to examine the choice of the most appropriate methodology for health economic analysis when CEA and CBA are not equivalent.

Definitions of CEA and CBA

In this section, we will focus on allocation of resources for health interventions. We derive formulations for CEA and CBA from the perspective of a societal decision maker whose task it is to choose the optimal set of health-care interventions that will maximize societal well being. Ideally, such allocation of health-care resources will occur in the context of allocating the entire societal budget, where decisions regarding not only health-care spending, but also regarding allocation of resources for education, the environment and public works, have to be made. We will address health economic analysis and its focus on allocation of resources for health interventions and will refer to the problem of societal resource allocation only when it has a bearing on the choice of methodology for health economic analysis.

We first define "I" potentially overlapping subgroups within a given society. Individual members of a subgroup are assumed to suffer from the same medical condition, to be in identical health states, with the same expected response to treatments for that condition and of the same socioeconomic category. This does not imply that all individuals in a subgroup have identical response to treatment, or identical preferences for health outcomes. It implies only that though individual responses to treatment may vary, characteristics such as age, gender, disease duration, and comorbidity are not used as distinguishing features between members of the subgroup in terms of their expected response to available treatments, or the willingness to pay for improvements in health outcomes. Note that one individual can belong to more than one subgroup if he/she suffers from more than one medical condition.

Let J(i) be the finite set of medical interventions available to treat individuals in subgroup i. If two drugs, say A and B, and their combination (A + B) are available to treat a given subgroup, these would be considered to be three different interventions. Similarly, different dosages of the same drug would be considered to be different interventions. Note that the absence of, or no treatment, is an option that should be included in J(i) for any subgroup i. The objective of the societal decision maker is to assign one and only one intervention from J(i) for each individual in a subgroup i. The framework is such that the decision maker can assign different interventions for different individuals within a given subgroup. It may not be logical for the societal decision maker to treat certain patients in a subgroup differently from others given that the individuals are indistinguishable in terms of their expected response to each intervention. However, this could indeed happen for certain formulations of the CEA problem, as will be demonstrated.

We further define the variables used to formulate CEA and CBA as optimization problems. Let N_i be the number of individuals in subgroup i. In view of the decision maker's objective to assign each patient in a subgroup to one and only one intervention, the decision maker must determine the number of individuals N_{ij} ($0 \le N_{ij} \le N_i$) in subgroup i to be treated with each intervention j ($\in J(i)$), such that $\Sigma_{j \in J(i)} N_{ij} = N_i$. This constraint ensures that each patient is treated with one and only one intervention. The allocation of individuals to different interventions in CEA depends on the QALY gain (Q_{ij}) and cost (C_{ij}) for a random individual in subgroup i treated with intervention j. In the CBA framework, the benefit provided by the intervention is measured not only in terms of QALYs, but also in terms of the WTP (W_{ij}) for intervention j, of a random individual in subgroup i. One can use the monetary amount that an individual is willing to pay per QALY to examine the equivalence of CEA and CBA. Let ν be the WTP per QALY of a randomly chosen individual in the society and ν_i, the WTP per QALY of a randomly chosen individual in subgroup i. The distribution of ν_i could differ from that of ν if the subgroup i is different from the overall population in terms of WTP per QALY. Note that the difference between W_{ij} and ν_i is that W_{ij} is the WTP for the QALY gain from intervention j, while ν_i is the WTP for one QALY.

Of the two methodologies under discussion, CEA is more widely used in health economic analysis. The CEA decision rule as described by Johannesson and Weinstein [4] is to treat every individual in each subgroup with the intervention that has the highest incremental cost-effectiveness ratio below a threshold value V, after eliminating interventions ruled out because of simple or extended dominance. The threshold value V corresponds to the monetary value that society places on a unit of effectiveness or one QALY, for instance. In this framework the objective of the decision maker is to allocate