Cost-Benefit Analysis in the study of the effectiveness of health programs

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Abstract

Ensuring proper access to health services is a critical problem faced by contemporary health systems. Health reforms indicate new directions for health policies and implement new tools to support decision-making on the financing of health care services, guaranteeing both the specific health benefits for the patients, as well as economic benefits for the system, emphasising the importance of these problems. Some of these tools are the methods and techniques of economic evaluation of health programs which are a part of a group of cost and benefits analyses. Cost-benefit analysis (CBA) is one of the evaluation methods that can be successfully used in healthcare for efficient allocation of limited resources. The main purpose of cost-benefit analysis may be either establishing the most valuable set of benefits, or determining the lowest possible cost at which certain benefits are achieved.

The aim of the article is to present a cost-benefit techniques and their possible applications in healthcare. In discussion, the theoretical aspects of the use of that technique were described, while mentioning the relations of CBA with other methods of health needs assessments, for instance: the willingness to pay. Theoretical considerations were also supported by empirical examples of healthcare programs evaluations with the use of cost-benefit analyses.

Keywords: evaluation of health care, cost-benefit analysis, willingness to pay.
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1. Introduction

The purpose of conducting economic evaluation in health care is an attempt to determine the preferences of society for a certain program/therapy in relation to the adopted health policy alternatives. From the point of view of achieving high productivity, economic evaluation of healthcare services should be carried out always, even in the absence of comparative alternatives. It should be emphasized that the lack of comparative alternatives does not exclude the possibility of evaluation, although in such a situation health program can only be described, not assessed from the point of view of the medical and economic efficiency. The core of the economic evaluation is the act of choice in the process of decision making.

Dissemination of the theory of economics of the public sector led to perception of health in terms of an economic good (Suchecka, 2010). Hence, by making evaluation of health, economists try to measure health in monetary terms, which greatly facilitates any comparative

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analyses. Often, however, such an approach is considered by patients/society as quite controversial, while subjective valuation of health/life sets an unspecified limit and any of this evaluation below the unlimited value is unacceptable.

Conducting economic evaluations, however, has to answer the fundamental question: how much of scarce resources should be allocated to saving lives and maintaining a good health level. Limited resources in the health sector force decision-makers to make choices and to conduct economic evaluation based on the finite values of health (Brent, 2003). Making choices clearly explains why a certain evaluation can be accepted as "best", even though there might appear some serious objections. This happens often because some of the decisions/choices must be adopted in order to conduct comparative analyses and identifying directions for further changes in the financial policy of the health sector entities.

2. Methods of economic evaluation

Before the economic evaluation is conducted, an assessment of the effectiveness of a medical technology or a health program should be made – at this point any suggestions made by specialists in the field of medicine concerning these interventions are crucial. Especially in the healthcare sector, for the purpose of comparing the effectiveness of alternative treatments, including in the evaluation, for instance, a range of demographic factors such as: age, sex, as well as a disease agent may not be a good practice, as there is a small number of healthcare interventions that lead to the consistent results for all patients undergoing these interventions. Recognition of individual differences in the process of conducting economic evaluation of the program is a key element. Indicated differences, in fact, determine the outcome of the evaluation. For example, one can quote here an example of a drug, which in spite of its higher effectiveness in curing a specific disease, is not recommended due to the pharmacological studies revealing numerous side effects.

When comparing programs, one should consider 4 types of relations between costs and health effects (Fig. 1). It is obvious that when an intervention cheaper and more effective (upper left quarter), uneconomical would be to choose an expensive and less effective option (lower right quarter). However when this comparison is not so legible (considering the costs and benefits levels), the economic evaluation is necessary.
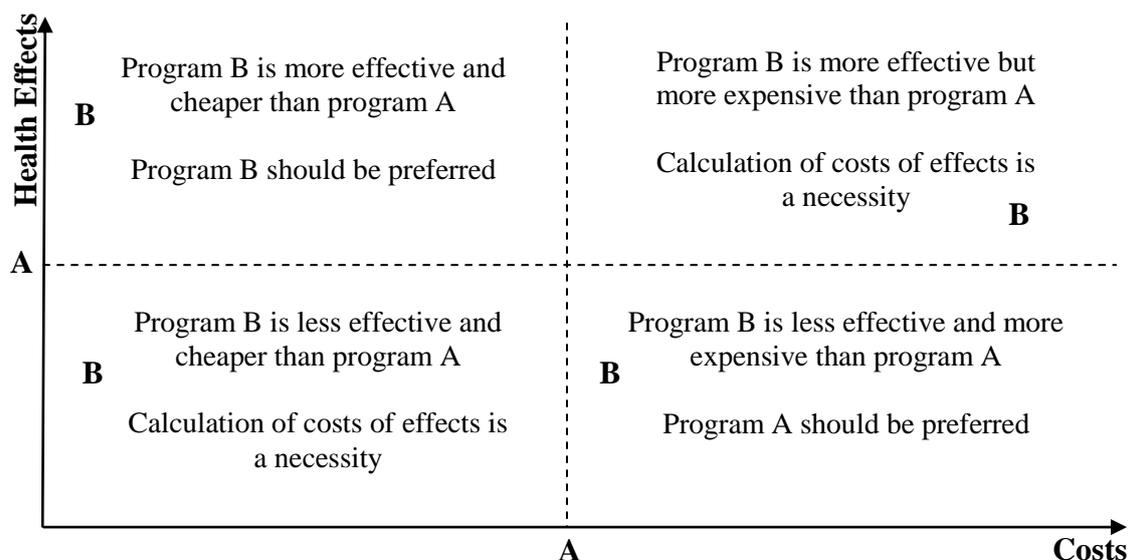
Fig. 1. Relations between A and B alternatives.

Healthcare program uses entry resources − the inputs, such as: labor, capital, etc. and transforms those resources into results − the outputs. To aggregate input data, usually with market prices, a valuation of labor and capital inputs is made. This approach allows to assess the total amount of resources consumed in the health intervention. The total amount of the inputs can be further considered as costs and expressed in monetary units. In contrast, the results of medical intervention can be expressed in different: direct or indirect measure units. Most often as a direct measure unit, a result of the diagnostic test or a successful operation/treatment is accepted (the positive effects of medical interventions).

In a broader sense, the outputs' measure reflects the intervention's certain level of utility, reflecting the satisfaction from achieved effects. The most commonly used measure in the economic evaluation of health programs/medical technology, which expresses satisfaction is a QALY (indicating the level of achieved satisfaction from gained life years). Structure of this measure enables expressing gained benefits, in the same monetary units as cost.

Taking into account costs and results − Cost-Consequences, in advanced methods of economic evaluation of health programs, in accordance with the aim of the analysis, three basic types of these analyses may be indicated. In literature, three main types of economic evaluation are proposed:

- Cost-Benefit Analysis (CBA),
- Cost-Effectiveness Analysis (CEA),
- Cost-Utility Analysis (CUA).

Moreover, as an optimization criterion cost minimization (CM) is additionally assumed.

2.1. Cost-Benefit Analysis – CBA

The characteristic that distinguishes the CBA method from the rest is that the resulting benefits, as well as costs, are expressed in monetary units (Brent, 2003; Haefeli et al., 2008; Ovretveit, 1998; Suchecka, 2010; Zweifel et al., 1997). In this case, the so called costs of the intervention are the inputs (resources). A situation, in which the benefits of a medical intervention (B_1) outweigh its costs (C_1), should be considered as a positive outcome of such evaluation. This means that the considered program is profitable, both from health and economic reasons. This relationship can be expressed as follows:

$$B_1 > C_1. \tag{1}$$

Applying the CBA to economic evaluation, transitional stage effects should be also taken into account. The main objective of the transitional phase is to determine the effects of the intervention (E_1) expressed in monetary units. Estimating the benefits can occur in two stages: in the first stage the effect of the proposed intervention should be evaluated, and then a certain P_1 monetary value should be assigned, so benefits further could be described as: $B_1 \equiv E_1 \cdot P_1$. Then the criterion of cost-effectiveness can be defined as follows:

$$E_1 \cdot P_1 > C_1. \tag{2}$$

The equation (2) above indicates that when it comes to determining the border, to which it is possible to incur the costs of a medical intervention, the ratio of costs-benefits can be expressed as a condition for the decision-making situation within budget constraint:

$$\frac{E_1 \cdot P_1}{C_1} > 1. \tag{3}$$

In practice it is possible to consider the following three situations:
- $B_1/C_1 > 1$ – achieved benefits outweigh cost and program is beneficial for he recipient;
- $B_1/C_1 = 1$ – benefits balance costs incurred during implementation of specyfic strategy;
- $B_1/C_1 < 1$ – achieved benefits in monetary values are lower in comparison with amount of incurred costs.

In case of budget constraint, the CBA method also takes into account the optimality criterion in the Pareto's sense (incurring costs on one health program makes it impossible to incur them to finance a second) or maximization criterion (Suchecka, 2010, p. 74).

When considering the implementation of alternative health program, achieved benefits can be expressed as B_2 (in monetary terms $B_2 \equiv E_2 \cdot P_2$) and the costs of this intervention as C_2. However, the criterion of cost-benefit ratio greater than unity is insufficient. In such situation,

it is desirable that ratio of benefits to costs for the alternatives satisfies the following inequality:

$$\frac{E_1 \cdot P_1}{C_1} > \frac{E_2 \cdot P_2}{C_2}. \tag{4}$$

The fulfillment of this criterion ensures that while making a choice between compared interventions, selecting the first program, more benefits (in monetary terms) to costs are achieved than it would be possible to gain when accepting the second intervention.

2.2. Cost-Effectiveness Analysis – CEA

In the evaluation of alternative health programs in the CBA, it is assumed that the benefits are expressed in fixed prices at the P_1 and P_2 levels. It is possible to repeal of this assumption and cost-effectiveness analysis – CEA can be used (Brent, 2003; Melnikow et al., 2013; Ovretveit, 1998; Suchecka, 2010; Zweifel et al., 1997). This method allows to focus on the results achieved: E_1 and E_2, without determining their prices. In the classic approach, the CEA admits the presence of budget constraint, which means that alternative health program cannot be considered separately. However, the effects of alternative treatments must be of the same kind. Thus, it is possible to compare two treatments of headache or two methods of diagnosing cancer, but it is not possible to contemplate the obtained effects of the interventions against headache and cancer diagnosis at the same time.

Therefore, the main objective of the CEA is the choice of a program, which provides a fixed effect unit at the lowest cost. Under CEA conditions, the second intervention is more cost-effective than the first treatment, when:

$$\frac{C_1}{E_1} < \frac{C_2}{E_2}. \tag{5}$$

Assuming an opposite situation – effects to cost ratio, then a better alternative would be the one which results in a greater number of the effects from a fixed cost unit:

$$\frac{E_1}{C_1} < \frac{E_2}{C_2}. \tag{6}$$

It is easy to observe that the inequality (6) above resembles to profitability criterion for CBA, with the limitation that the analysis of the CEA does not include pricing of effects. It could also be assumed that, in principle, the CEA is a special case of CBA. It should be noted, however, that the requirements of the application of the CEA are more rigorous, because the results achieved from two analysed interventions must be exactly the same, which further indicates that even the quality of the effects of comparable programs must be identical.

2.3. Cost-Utility Analysis - CUA

As it was pointed out earlier, in analysis of the CEA, the only difference between the achieved and identically defined effects E_1 and E_2 is their quantity. If there is a need to compare quite different effects (headache-pain relief versus precise, diagnostic test for cancer) without unwanted pricing effects, then outputs should be expressed in the same unit of measurement. This type of issues can be solved with the cost-utility analysis – CUA (Brent, 2003; Lairson et al., 2014; Ovretveit, 1998; Suchecka, 2010; Zweifel et al., 1997).

In this approach, the individual QALY (Quality Adjusted Life Year) is taken for the unit of achieved effects from the proposed intervention/program. According to this concept, each healthcare intervention allows patient to live longer (more life years) or to have a healthier life (better quality of life). Aspirin can alleviate headache improving the quality of life of a patient and accurate diagnostic tests, providing they lead to actions such as prevention, which minimizes the risk of death, can add the years of life of the patient. In determining the appropriate value of QALY, it is necessary to establish the number of years of life that someone is willing to give up in order to live a life with higher quality.

Adoption of a QALY unit as a measure of general effect from the intervention, which is at the same time program's profitability level, makes this method quite similar to the results for CEA. Therefore, the analysis of the costs and utilities may be considered as a unique case of the cost-effectiveness analysis:

$$\frac{QALY_1}{C_1} < \frac{QALY_2}{C_2}.$$

(7)

So, in given example, the second intervention would be better than the first one.

In conclusion, it should be noted that the analysis of the costs and effectiveness (CEA) and the analysis of costs and utility (CUA), in practice, differs from the cost-benefit analysis (CBA). CBA is based on the principle that patients are accustomed to purchase goods on the market at a given price, and are not used to purchase QALY units and therefore are unaware of the process of obtaining QALYs at the lowest possible cost.

3. Cost-Benefit Analysis – application

Prerequisites for application of the economic evaluation methods in healthcare are many, but why should the method of the costs and benefits be used in these analyses? The answer to this question is quite complex. Many publications proved that CBA ought to be the foundation of the public policy. In this context, the cost-benefit analysis is most useful, as it provides a consistent framework for decision-making, specifying when a health intervention is

desirable. When considering, for instance, the rate reduction for the provision of subsidized medicine or the introduction of a supportive system for patients with disease X, CBA method is most suitable.

CBA approach enables a better reflection of social preferences and needs, than the market itself, or the political decisions. Especially in healthcare, this analysis should be used instead of other types of economic evaluation, since it is one of the few methods that permits to identify whether the intervention is worthwhile or not, and at the same time, socially desirable compared to an alternative use of the same amount of funds (Hong et al., 2010; Ovretveit, 1998).

The issue of the use of funds undoubtedly heads towards their effective allocation. Formally, the concept of efficient allocation of resources could be defined as the state of the economy in which it is not possible for one person to gain in the decision-making process without the loss for someone else – in this scenario the allocation of resources is Pareto optimal (Drummond et al., 2003; Scarborough and Bennett, 2012). In the analysis of the cost-benefit, the most valued set of benefits is determined by the maximum value (amount of money), which the patient is willing to pay for products/services to which he or she is entitled to.

As a result, this specifies the conditions for productivity levels, which are necessary to achieve allocation efficiency, so that each benefit is produced at the lowest possible cost, in relation to the actual production and that each sale price is equal to the marginal cost of production of the goods. In this context, allocation efficiency is maximized when the patient's satisfaction achieved from the last unit of the service is exactly equal to its cost of production.

Let us consider the cost of the health program for breast cancer prevention research and the cost of medical intervention in 3 randomly selected clinics of the Mazowieckie (MAZ), Slaskie (SL) and Podlaskie (PD) voivodships. Relevant information is presented in Table 1 below.

In each of the analysed regions, the benefits derived from the use of preventive interventions outweigh the cost of a situation when health program is not applied. Analysing the relation of cost of non-compliance procedures (as a result of the health program) to the cost of proper medical intervention in the case of advanced disease, the best results are achieved in the Podlaskie voivodships, where the benefits outweighed the cost of treatment approximately 5 times. Positive results, however, could have been caused by numerous factors, which this analysis did not consider.

Specification	MAZ	SL	PD
Total costs of intervention [thous. PLN]	565.94	60.99	12.06
Average cost of intervention [thous. PLN]	9.20	9.00	9.50
Given number of benefits for intervention [thous.]	61.52	6.78	1.27
The average cost of treatment [thous. PLN]	31.40	29.2	44.1
Granted benefits without the intervention	18.02	2.09	0.27
The costs of non-compliance procedure for the benefits provided [thous. PLN]	1931.57	197.89	55.96
Ratio of non-compliance procedure to the application of intervention	3.41	3.24	4.64

Table 1 Costs of breast cancer treatment and the costs of the benefits provided without medical intervention for randomly selected clinics and provinces.

Consider another example, where there are 4 health programs possible to choose. For every program the amounts of costs, benefits and net benefits are known (Table 2 above). As an example above showed, it is possible to compare interventions when comparing costs and benefits – in this case Cost/Benefit Ratio (CBR) can be used.

Program	Costs	Gross Benefits	Net Benefits	Return on Investment	Costs/Benefits Ratio
I	100000	102000	2000	2.00%	1.02
II	20000	30000	10000	50.00%	1.50
III	320000	370000	50000	15.63%	1.16
IV	105000	100000	-5000	-4.76%	0.95

Table 2 Cost-Benefit Analysis for 4 hypothetic health programs.

When CBR>1, then every 1 PLN invested in program, provides more than 1 PLN of benefits – in that situation the intervention is profitable. To assess the beneficial effects of the program, it is possible to use the return on investment rate (ROI). ROI indicates percentage of the capital return after investing in the program. In this case, looking at the example above, the highest return on investment rate is achieved by the II intervention (the CBR also indicate this program as most beneficial).

It is also possible to calculate (on the basis of data in Table 2) the incremental cost-benefit ratios to decide, which of the comparable program produces more benefits (results are presented in Table 3 below).

Health program	I	II	III	IV
I	N/A	1.11	0.82	-2.50
II	1.11	N/A	0.88	1.21
III	0.82	0.88	N/A	0.80
IV	-2.50	1.21	0.80	N/A

Table 3 Incremental Costs-Benefits Ratios for 4 health interventions.

As it turned out the highest positive health effect of one program compared to another is achieved by the II option when compared with the IV. The less beneficial program was the fourth one when comparing with the I.

Applications of CBA and the results interpretation depends on the comparison perspective. If it should be made from the perspective of manager, who is responsible for managing of the institution, one should select interventions which produce the highest amounts of net benefits. If the analysis would be made from the perspective of a senior consultant, the choice of interventions may vary. It is true that II program not generates the highest net benefits, but in this case the rate of return amounted to 50%, but the program required the least amount of capital invested – this option is most desired by the senior consultant, but not preferred for a hospital manager.

Conclusion

Examples showed how health program/intervention can be rated for the most efficient decision-making and dealing with the resulting costs. CBA method has a much greater range of applications than other described methods of economic evaluation. Not only it allows evaluating the health procedure, but thanks to its usage, it is possible to support better resource allocation due to more accurate reflection of social preferences.

By the use of CBA it is possible to evaluate various health programs, which have different health effects (for instance, breast cancer prevention, screening blood test for cholesterol level), comparing cost-benefit ratios (CBR) and/or the net benefits. Worth remembering is the fact that the cost-benefit analysis enables to switch the results of clinical trials into monetary values, which sometimes discourages its use. As examples showed while conducting the cost-

benefit analysis, its results can be interpreted from different perspectives. Concluding, should also be considered, while making any decision in health care: an advantage for patient can be a burden to others.

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