Health Economics

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Week – 08

Lecture 40- Principles of Economic Evaluation: Cost-effectiveness Analysis (CEA)

Welcome friends once again to our NPTEL MOOC module on Health Economics. We are presently explaining week 8 on the Theory and Principles of Economic Evaluations. We have already discussed principles in two lectures, and this is our third explanation of the principles of economic evaluation. We are trying to give you all the details possible to understand the principles of economic evaluation. The previous two lectures taught us about the least performed economic evaluation principles: CCA and CMA. CCA stands for cost consequence analysis, and CMA stands for cost minimization analysis. Also, we discussed about the three most performed methods. These are CBA (cost-benefit analysis), CEA (Cost-effectiveness analysis), and CUA (cost-utility analysis). We will be discussing that, but most important one is CBA. In each of these (i.e., CCA, CMA, and CBA), we discussed their definitions, objectives, features, and use of this principle and their respective examples, advantages, and disadvantages.

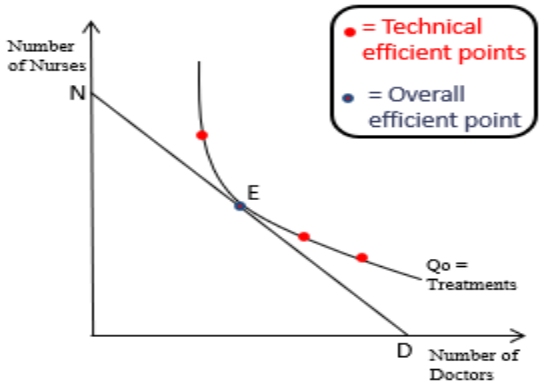
In the next two lectures, we will learn the remaining two most performed complete economic evaluations, that is (as I already said) cost-effectiveness analysis (CEA) and cost-utility analysis (CUA). We will start with the CEA (in detail). Then, in the next one, we will introduce the last method. Economists recognize that health economics involves some costs and benefits that can be measured, but not in monetary terms. These are often called incommensurable items, such as hospital service (where measuring patient satisfaction is the most important direction).

Some others (cost and benefits) are known or suspected to exist but cannot be qualified at all; they are called intangible items. For example- someone is dealing with mental illness issues, where it is purely intangible and difficult to measure. This is where the CBA fell short, which led to the development of a few other economic evaluation principles that are highly performed in health economics evaluation. They are called CEA (cost-effectiveness analysis) and CUA (cost-utility analysis).

Starting with CEA, we will compare it with the CBA method we discussed earlier and find out why this differs. In terms of their definition, CEA is a form of comparative economic analysis that evaluates two or more policy alternatives in terms of their relative cost and outcomes (we are here also referring to the same author, Turner et al., 2021). Here, the outcomes are measured in a single natural unit, for example- life years gained, number of disease cases, etc. As stated earlier, the rationale behind this method is that it is difficult to

measure benefits in terms of money, similar to cost (like we did in CBA). In practice, comparing costs and benefits in different units is not straightforward.

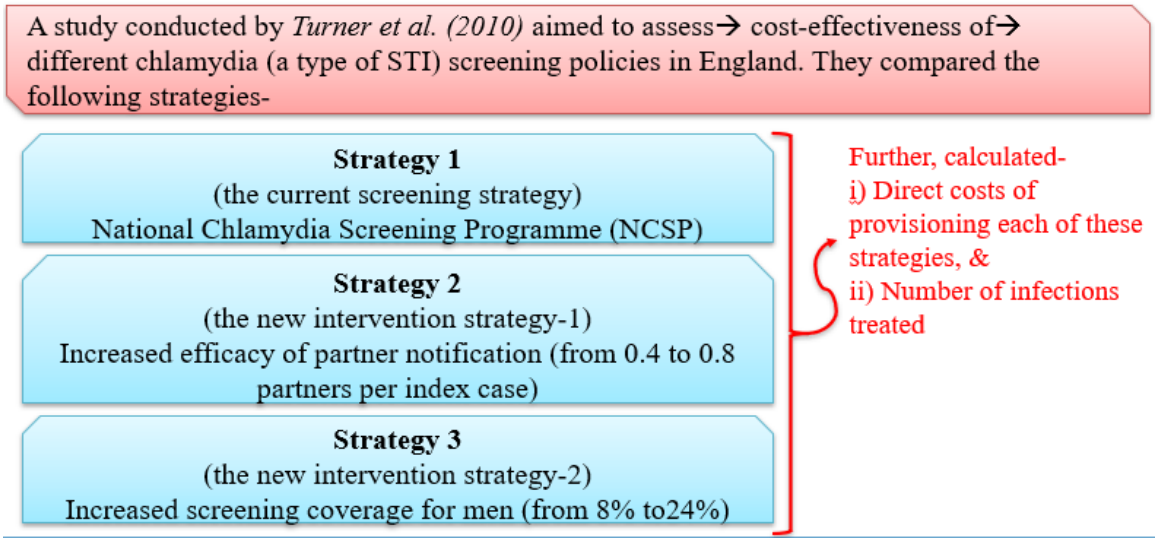
So, is there any theoretical basis for such a comparison? Yes, the answer is yes because the theory of production efficiency provides a theoretical basis for this comparison. Then, what is this theory of production efficiency? We will be discussing here. We already addressed some of these directions in unit number 3, where we discussed the isoquant curve that shows a mapping of the inputs to produce the same output (different combinations of input to produce the same output). Usually, this is measured in physical units. Another vital factor is the iso-cost curve, which shows different combinations of inputs that can be afforded given a budget. This is usually measured in monetary units. Even in our efficiency chapters, we have highlighted some of these concepts. This diagram shows the isoquant and iso-cost are also used-



In the efficiency chapters, especially in unit number 10, we will discuss technical efficiency points, how it is measured, and the different methods. However, the fundamentals of this can be explained through the efficiency frontier, which can be projected through the isoquant and iso-cost lines, especially isoquant, which is the benchmark. So, isoquant identifies technically efficient points. These are the points at which the maximum output can be produced given the inputs, which is basically the efficient frontier. The iso-cost identifies the allocative efficiency. In the above diagram, it is across N and D; you can just see starting from N till D.

So, N-D is the line (you can have a check). This gives a set of input prices, and basically, in this efficiency point, the answer is that for a given set of input prices, it is impossible to produce extra without extra cost. That is the best, or, the minimum most cost point. Overall, at point E (due to the cost and allocative and technical efficient points), you will find the overall efficient point (this is tangential to the point of both curves), which is defined as E and forming the equilibrium. Hence, it is theoretically well established that even though not straightforward, comparing cost and benefits in different units is possible. Moreover, similar to the theory, CEA also tries to identify where more benefit can be generated given the intervention cost or how lower cost can be achieved for the same benefit.

However, in practice, there are many situations where we wish to compare alternative interventions. However, it is not possible to keep either cost or benefit constant. In this case, the solution that economists suggest is a 'cost-effectiveness ratio' with the implication that lower is better. We will understand this with appropriate examples. Suppose we are concerning the study by Turner et al. (2012) that assesses the cost-effectiveness of different Chlamydia screening policies in England. It is referring to the policies for healthcare. They compare the following three strategies. The current screening strategy is basically called NCSP (National Chlamydia Screening Program). The second one is the increased efficacy of partner notification, and finally, the third intervention is increased screening coverage for men. Both of these interventions are compared to the current NCSP program.



So, the first intervention strategy is increasing or increasing partner notifications' efficacy. The partner notification will be increased from 0.4 to 0.8 partners per index case. In another intervention, screening is increased for men from 8 percent to 24 percent (this is as per the author's calculation, we are just citing for better clarification). Further, this is calculated for direct costs of provisioning each strategy and the number of infections treated.

We will now see the computed direct costs and the number of infections

Cost per infection treated (Cost-benefit ratio) with each strategy is show below-

Strategy	Total Cost (£ million)	Cost per infection treated (£)
NCSP	46.26	506
Increased partner notification	49.57	449
Increased screening for men	69.17	528

Conclusion by Turner et al. (2010)-
Increasing the efficacy of partner notification was cost-effective, but increasing the screening for men was not → as compared to NCSP.

Even **instead of a simple** cost-effectiveness ratio **(CER)**, when the authors **used incremental** cost-effectiveness ratio **(ICER)**, that is-

$\blacktriangle C / \blacktriangle B = (Cost_A - Cost_B) / (Benefit_A - Benefit_B)$

Additional cost per unit of health gain

Each strategy's cost-benefit ratio can be used to compute the infection treatment cost. We already have the computed values shown. For the NCSP program, the total cost and the cost per infection treated are mentioned above (in million pounds). The increased partner notification's total cost and the cost per infection treated is also given. The screening specifications for men are also mentioned in this example. Now, as per Turner et al.'s (2010) conclusion, increasing partner notification's efficacy was cost-effective.

You can just check this. The total cost for increasing partner notification is 449, which is less than NCSP, but the cost of increasing the screening for men is much higher than that of NCSP.

Instead of a simple cost-effectiveness ratio (CER), the results were really interesting when the authors used the incremental cost-effectiveness ratio (ICER). We are going to just show it to you, where the incremental CER is basically-

$$\frac{\Delta C}{\Delta B} = \frac{Cost_A - Cost_B}{Benefit_A - Benefit_B}$$

This represents the additional cost per unit of health gain. You can just see the results. The same example is in the first table is presented below

The results of the study changed as shown below-

Strategy	Total Cost (£ million)	Total infections treated
NCSP	46.26	91, 438
Increased partner notification	49.57	1,10,306
Increased screening for men	69.17	1,31,113

Comparison	Incremental Cost	Incremental Effect	ICER
Increased partner notification versus NCSP	3.31	18,868	175
Increased screening for men versus NCSP	22.19	39,675	559

Conclusion- Even ICER suggests → partner notification is more cost-effective

In the second table, we are just trying to find out about ICER and other details. The first row of the second table basically compares increased partner notification with NCSP. And the second row shows the comparison between increased screening for men versus NCAP. So the incremental cost or the change basically means change from the absolute number, i.e., $\Delta C = 49.57 - 46.27 = 3.3$

You will find the change here is presented as 3.31. Similarly, the second row, the increamental cost is-

$$\Delta C = 69.17 - 46.27 = 22.19$$

So you will find the incremental change. The incremental effect is also presented here. You can also find out the total infection treated and the differences. The changes are quite important here. The results of ICER also suggest that partner notification is more cost-effective. You can see, especially for the partner notification, that their incremental cost is less than that of the screening for men.

So now, let us answer this example as well. If intervention A costs 10,000 rupees, the effect is that it extends life by 5 years, while in intervention B, the cost is 8000 rupees, and life is extended by 4 years. What is the incremental cost-effectiveness ratio (ICER) for intervention A compared to intervention B? So, these are the options-

A. $10,000 per life year gained.

B. $8,000 per life year gained.

C. $2,000 per life year gained.

D. $40,000 per life year gained.

You can just see and tell which option is correct. You can try solving this yourself, and I will just clarify and give you certain hints. We know that it has to be answered through $\frac{\Delta C}{\Delta B}$.

So, this is, $\frac{\Delta C}{\Delta B} = \frac{(C_1 - C_0)}{(B_1 - B_0)} = \frac{10{,}000 - 8{,}000}{5-4} = \frac{2{,}000}{1} = 2000$

Applying the formula, we know that the incremental life extended by $5 - 4 = 1$ years, so the effect is 1. Hence, in the denominator, you will find 1. Meanwhile, for the numerator, the difference is 2,000. So, the answer would be derived accordingly. So, 2,000 divided by 1, it will be 2,000. You can check the different options, using other points and applying them to the formula: $C_1 - C_2/B_1 - B_2$, as per your convenience. The starting point you take should follow in both cases accordingly.

Can you also answer this question, which is a little different? Let us see- The cost of intervention A is 5,000, which leads to 50 life years of gain. Intervention B costs 4,000, resulting in 45 life years of gain. Now, accordingly, calculate the cost-effectiveness ratio (CER). But note that now the difference is not incremental. It is only a cost-effectiveness ratio. So, calculate CER for both interventions and determine which is more effective. In the previous example, we discussed ICER. In this case, it is CER. So, there are all these options-

I. CER for Intervention A = $100 per life year gained,
CER for Intervention B = $88.89 per life year gained.
Intervention B is more cost-effective.

II. CER for Intervention A = $88.89 per life year gained,
CER for Intervention B = $100 per life year gained.
Intervention A is more cost-effective.

III. CER for Intervention A = $5,000 per life year gained,
CER for Intervention B = $4,000 per life year gained.
Intervention B is more cost-effective.

IV. CER for Intervention A = $4,000 per life year gained,
CER for Intervention B = $5,000 per life year gained.
Intervention A is more cost-effective.

We can find out which one would be more relevant. So, CER for intervention A is cost per life gained, which means-

$$\frac{Cost_A}{Life\_Gained_A} = \frac{5000}{50} = 100$$

$5,000 divided by 50, it is $100 per life year gain. So, 100 we have calculated in this case. And, CER for intervention B will be of course-

$$\frac{Cost_B}{Life\_Gained_B} = \frac{4000}{45} = 88.89$$

4,000 divided by 45. So, that is precisely around $88.89 per life years gain. Hence, out of these two comparisons, you can see that intervention B is more effective because its cost is lower.

In the second option, let us see what really happens. So far as CER is concerned for case A, the figures are reversed, and I think they may not be correct. Similarly, other options are in front of you, and you can find out which is the correct option. I have just given certain hints to it for this question; you can find others. In the query lecture, we will have a live session where you can raise your voice.

We will present here some of the limitations of the CEA model. It is already mentioned that CEA measures health consequences in a single natural unit, which we have just seen, like cases avoided or life years gained. However, it is difficult to compare studies investigating interventions that target different diseases or stages of healthcare, as health consequences will be expressed in different units. This is really limiting its potential use for informing policymakers.

Moreover, choosing and comparing even between different units of measurement of effect is difficult to specify. This limitation can be understood by an example. Suppose we have a comparison that involves a treatment that prevents heart disease. There are different

scenarios associated to it. First, a treatment that prevents heart disease. Second, one out of every 20 cases of the heart disease, a person suffers a heart attack. And half of those who suffer a heart attack die, leading to an average loss of 5 years of life. We are giving multiple pieces of information at this moment. Fourth, the treatment cost is £50,000 to prevent 20 cases. So, what different results do we get here under the CEA assumption that health consequences are a single natural unit? This requires some mathematical calculations and that goes like this-

Money per Case Prevented:
CER = £50,000 (Cost) / 20 (Cases Prevented) = £2,500 per case prevented. This ratio indicates the cost required to prevent one case of heart disease.
Money per Heart Attack Prevented:
CER = £50,000 (Cost) / 1 (Heart Attack Prevented) = £50,000 per heart attack prevented. This ratio measures the cost of preventing one heart attack.
Money per Death Averted:
CER = £50,000 (Cost) / 0.5 (Deaths Averted) = £100,000 per death averted. This ratio quantifies the cost to avert one death.
Money per Life Saved:
CER = £50,000 (Cost) / (0.5 * 5) (Years of Life Saved) = £20,000 per life saved. This ratio indicates the cost of saving one year of life. Can these results be obtained using ICER

See the above results, there are a variety of computations possible. In the first case, when we want to compute money per case prevented, the cost is £50,000 for preventing 20 cases). Which results in £2,500 per case prevented. To calculate it, we divided £50,000 by 20. The resulting ratio indicates the cost required to prevent one case of heart disease.

We can also compute the money per heart attack that is prevented. In that case, that will be £50,000 for one heart attack prevention. As, £50,000 is required to treat 20 patients, but along 20 one suffers a heart attack. So, we calculate £50,000 divided by one potential heart attack case. This ratio measures the cost of preventing one heart attack.

Another calculation that can be undertaken to understand this question is money per death averted. So, we know that 50 percent, i.e., half of those who suffer a heart attack, die. So, 50 percent are death cases. To compute it, we divide £50,000 by 0.5. The results show that it would cost around £ 1lakh per death averted. The cost for this is 1 lakh. Hence, this ratio quantifies the cost to avoid one death.

Another computation can be money per life saved. In this case, for per life saved, we know that we have an average life loss of 5 years. The death aversion rate is 0.5, and only half of them are averted. So, for computing years of life saved, we devide the cost of treatment for

20 patients by the product of years of life lost, and aversion rate. The resulting amount is £20,000 per life saved. This ratio indicates the cost of saving one year of life.

We did some mathematical computations and saw different results. Different measures of effect can lead to different interpretations. Let us break down each of these calculations and their implications. We will explain once again what these cases are and how they can be clearly interpreted based on the results we just computed. Starting with £2500 per case prevented- this ratio represents the cost required to prevent one case of heart disease. It is a useful measure if the focus is on preventing the cases of the disease regardless of their severity. This basically focuses on preventing cases.

The second one is the ratio, which quantifies the cost of preventing one heart attack. It is relevant when the primary concern is preventing heart attacks, especially if they are life-threatening. The third one is related to £1 lakh per death averted, where the focus on the severe outcomes that is death and measures the cost of preventing it. The last one, which is £20,000 per life saved,evaluates the cost of savinge one year of life. It considers the broader perspectives of saving years of life rather than specific events.

So, this particular example concludes that the choice of measure of effect is critical in CEA, especially when comparing interventions for the same disease. For example, Suppose one intervention is better at preventing non-fatal heart attacks while another is better at preventing fatal attacks. In that case, the choice of effect measure is crucial yet practically difficult to answer.

This difficulty led to the development of a specific form of CEA (which we already stated), i.e., in short, called cost-utility analysis or CUA. Other forms of CEA are also available, like distribution CEA or extended CEA, which are used for priority setting. So, if you are interested, you can see the cited references, which will be useful for your reading.

So, let us clarify what we dealt in this lecture and explain once again in short. Although the cost-benefit analysis is the most widely used method across different sectors, the CEA is most widely used in healthcare. You can just note that this is most widely used in healthcare. Under CEA, outcomes are measured in a single natural unit. The theory of production efficiency provides a basis for CEA. This tends to compare the costs and benefits of different units. Cost-effectiveness ratio helps in deciding the best policy intervention.

There are two important limitations as well. First, it is difficult to choose the best measure of effects as the effects can be measured in different ways. Second, we cannot compare the interventions for two different health issues.

Issues in CEA led to the development of cost utility analysis or CUA. So, in the next class, we will discuss the CUA, i.e., its features, the thumb rules for CUA with specific examples, and those used in practice.

These are the readings. I think, it will be useful. We have mentioned Turner et al., with specific page numbers. You can also follow it. We have also given article links (or DOA files), which I think With this, I think I should stop here.

I look forward to your participation. Thank you.