Cost-Effectiveness Analysis (CEA)

Marcelo Coca Perraillon

University of Colorado
Anschutz Medical Campus

Cost-Effectiveness Analysis
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Outline

- Focus on the denominator of ICER: measuring effectiveness/outcomes
- A brief detour on measuring health
- The cost-effectiveness plane
- How to use the ICER:
  - Distributing a budget
  - Interpreting the ICER and the notion of "thresholds"
- Calculating ICER with more than 1 alternative program

Big picture

- The last three lectures were about the cost side of EEs and the ICER
- One key message was that there are three guiding principles for deciding which costs to include: 1) **Perspective**, 2) **Time horizon**, and 3) **Relevance of costs** for the decision
- (**Department of Homework Corrections**: **Overhead costs are not sunk costs** although under certain circumstances they could be)
- Today we will talk about talk the **effectiveness side** and how both sides fit together
- When we talk about "effectiveness" we are really talking about health outcomes
- Therefore, we have to talk about how **health is measured**

Department of Definitions

- If outcomes are measured in "natural units," the old terminology was to call these type of studies cost-effectiveness analysis (CEA)
- In this terminology, "life years gained" are natural units
- If **quality of life** are used to adjust life years, then it was called cost-utility analysis (CUA)
- We also learned that both are also called cost-effectiveness analysis. Blame the older edition of your textbook for creating confusion
- I don't mind which one you use, but I need you to know about it because you may get confused when reading articles
- So...

Health measurement terms

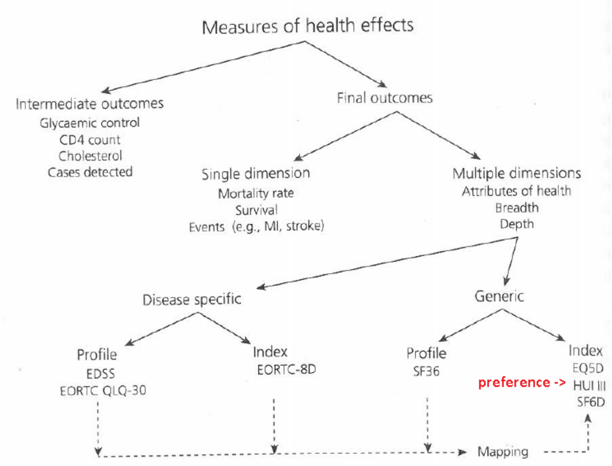
- There are many ways of **measuring** health and many ways of **classifying** measurements of health
- For the **purpose of this class**, we will use these terms:
  1. **Natural units**: cases detected, cases averted, episode-free days, events (strokes, MIs), blood pressure levels, *years of life gained*
  2. **Generic or disease-specific scales**: Hamilton depression scale, SF-6, SF-12 or SF-36
  3. **Preference based scales**:EQ-5D, SF-6D
- Note that natural units or preference-based scales can be generic or specific
- **Generic** scales measure “general” health status; **disease specific** scales measure health functioning considering factor that are specific to certain health conditions

Intermediate versus final outcomes

- Outcomes could also be classified as **intermediate** outcomes (cholesterol, blood pressure) or **final** outcomes (mortality, MI, strokes)
- **Intermediate outcomes**: Defined as an important/critical outcome that is related to another more important or final outcome
- The intermediate outcome is in the pathway to the final outcome
- **Final outcomes:** The outcome of interest or the end results in the pathway
- Think of diabetes: A1C (correlated with previous 3 months of glucose level) versus mortality or an amputation. Cholesterol levels and myocardial infarction
- The other way to think about intermediate outcome: **proxy** of what you want to measure. For example, TSH levels versus T3/T4 hormones

Helpful classification

- From Chapter 5 of your textbook



Big picture

- Any of the measures of health could be the measure of effectiveness in an economic evaluation
- $ICER = \frac{C_2 - C_1}{E_2 - E_1}$
- In the above equation, E could be CD4 counts, cholesterol, cases detected, SF-36 scores, life years, life years adjusted for quality
- The ICER would be in the units $\frac{\$}{E}$. So for example $\$1,000$ per case detected, or per life year or per cholesterol unit or quality adjusted life years
- **But there is a significant problem with using different metrics for outcomes**

Comparability

- Silly example to illustrate the problem. Since we are in Colorado: beer versus ski boots
- You do your mental calculation of the value of craft beer vs Coors light. Say \$3 versus \$6. So incremental cost is \$3. Because you are such a beer connoisseur you have your own quality scale (or maybe there is an App for that?). So in that scale the incremental quality is 1.5 units. ICER is then $\frac{\$3}{1.5} = \$2$ per unit of beer quality
- Now boots. New versus old model. About \$300 price difference. This time you have another scale that takes into account pain and lightness of the boot. Your ICER is $\frac{\$300}{50} = \$60$ per unit of boot quality
- Can you make a statement about the **relative cost-effectiveness of craft beer versus a new boot**? Of curse not. You would need to come up with beer quality to boot quality comparison

So how do we choose a measure of effectiveness?

- To do EEs, we want to use a measure of health that is **relevant** and **important** because costs will be compared to to this measure to make decisions about resource allocation
- A consensus measure is for sure **years of life gained**. One goal of health care is to extend life. Or put it differently, to extend life by avoiding "preventable" deaths
- (**Trivia**: Upper limit of life years in both the bible and science seems to be 120 years)
- On the other hand, **quality** and not just quantity is important
- Both years of life gained and quality-adjusted years of life gained (QALYs) are common measures of benefits in EEs
- In part because of **comparability** concerns we want to use a common metric

The importance of choosing a measure of benefit

- It is this search for **comparability** that has driven the field towards using QALYs
- But this complicates CEAs because often data on effectiveness cannot be translated easily into years of life gained
- Example: we conduct a screening program for diabetes or celiac in children. What can we measure? In about, say, two years, cases detected? (Yes) Complications averted? (Not all of them)
- Mostly **intermediate** outcomes $\rightarrow$ need to somehow simulate final outcomes
- This, in turn, has increased the use of modeling (trees,Markov models, microsimulation) to **link intermediate and final** outcomes (at the cost of adding more layers of assumptions)

Maximizing life-years gained (or any other outcome)

- Suppose we (society) wanted to **maximize years of life gained** given a budget constraint. And suppose that you have used **life years as the measure of effectiveness for every possible intervention**
- In other words, you have a fixed budget that you want to allocate among different alternatives in the most **efficient way** so as to maximize the unit of outcome, life years
- Theory tells us that we should order the alternatives from lowest ICER to highest
- Then, do the alternative with lowest ICER. If there is money left, do the alternative with second lowest ICER, and so on until you there is no more money left
- That procedure **maximizes life years gained given your budget**

Intermediate versus final outcomes

- Still, studies often use outcomes other than QALYs
- Some guidelines about intermediate versus final outcomes:
  1. Make case for intermediate outcome (i.e. argue it is important)
  2. Make sure that there is a strong link between intermediate and final outcome
  3. Ensure that any uncertainty surrounding the link is taken into account
- Example: In a screening study, cases detected is fairly relevant. But is there a strong link between cases detected and mortality or say, MI (final outcome)?
- But keep in mind that the problem remains: you can only compare studies if they use the same unit of outcome

Big picture again

- We are going to cover more about measuring quality of life or what economics call **preferences over health states** soon
- In doing so, we will briefly talk about some instruments like the SF-12
- But this is all for now about *measuring* health outcomes
- So we have the costs (last two classes) and we, sort of, have a measure of health outcomes after my super brief discussion of health measurement
- **How do they fit together?**

Incremental cost-effectiveness ratio (ICER)

- Once we have a measure of benefit we can calculate the ICER between alternatives
- As we saw before:

$$ICER = \frac{C_A - C_B}{E_A - E_B} = \frac{\Delta C}{\Delta E}$$

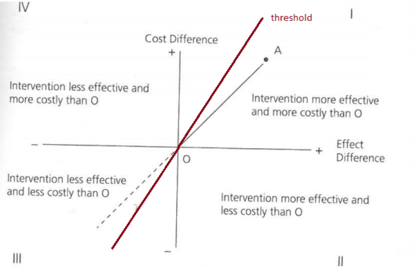
  C_i and E_i, where $i \in \{A, B\}$, are the costs and benefit measure of alternative i

- The result is the incremental cost **per unit of effectiveness**
- For example, one study found that the cost of counseling per smoking quit was $\$1,300$. So $\$1,300$ per case averted

the **concept of "dominance"**

- Suppose we calculate an ICER comparing a new intervention (B) to usual care (A)
- Easy cases:
  1. B is more expensive and less effective (prefer A) $\rightarrow$ A **dominates** B
  2. B is less expensive and more effective (prefer B) $\rightarrow$ B **dominates** A
- The **pure dominance** cases are simple decisions
- Not-so-easy cases:
  1. B is more expensive and more effective (**by far the most common case with new "technology"**)
  2. B is both less expensive and less effective (we don't like interventions that are less effective; we don't do EEs of them)

Cost-effectiveness plane



- The y-axis is the numerator of ICER; the x-axis is the denominator
- Note that the ICER is the slope of the line connecting O with A
- If we use a **threshold** to determine cost effectiveness, the threshold is also a line (red one here)
- Note signs: ICER is a ratio, so $-/+ = -$ and $-/- = +$

Several alternatives

- Now for something somewhat different: several alternatives
- We have been considering only two alternatives in most examples although we talked about screening programs (with multiple intensities)
- The cost-effectiveness plane can be a useful tool to think about another type of dominance: "**extended dominance**"
- Extended dominance comes up with multiple alternatives. Not the most common situation but worth it going over it

Example: Dealing with several alternatives

Intervention	Cost ($)	Effect (years)
1	$350	20
2	$1,500	27
3	$3,500	35

1. Organize interventions from least costly to most costly
2. Organize interventions in increasing order of effectiveness

Example

Intervention	Cost ($)	Effect (years)	ICER
1	$350	20	-
2	$1,500	27	$164
3	$3,500	35	$250

$$ICER_{2,1} = \frac{(1,500 - 350)}{27 - 20} = \$164$$

$$ICER_{3,2} = \frac{(3,500 - 1,500)}{35 - 27} = \$250$$

- Which one do we choose? It depends on how much the decision maker is willing to pay per year of life gained
- Note how comparisons are so important. If we knew that Intervention 2 is not viable, the $ICER_{3,1} = 210$ per life year

A more complex example from Drummond et al (2005)

Table 5.4 Cost per patient (*C*) and effectiveness per patient (*E*) for the available alternatives in each of three treatment strategies. (There are 1000 patients to be treated in each group.)

Treatment strategy I			Treatment strategy II			Treatment strategy III		
Alternative	***C***	***E***	**Alternative**	***C***	***E***	**Alternative**	***C***	***E***
A	100	10	F	200	12	K	100	5
B	200	14	G	400	16	L	200	8
C	300	16	H	550	18	M	300	12
D	400	19						
E	500	20						

From Karlsson and Johannesson (1996).

- Three different interventions: I, II, III
- Each intervention can be deliver in varying degrees of intensity
- There is a "do-nothing" (called O) alternative with \$0 cost and 0 benefits

A more complex example

Treatment strategy I		
Alternative	***C***	***E***
A	100	10
B	200	14
C	300	16
D	400	19
E	500	20

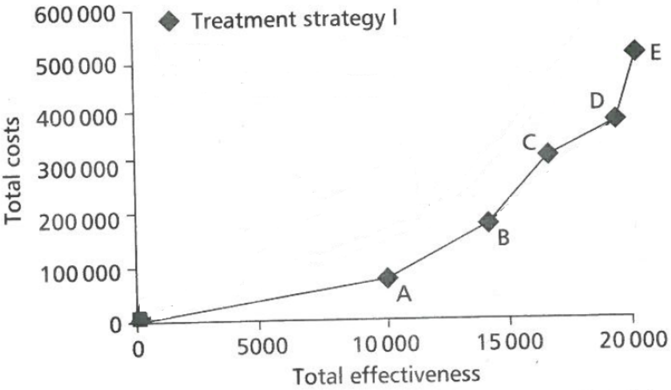
$$ICER_{A,O} = (100 - 0)/(10 - 0) = \$10$$
$$ICER_{B,A} = (200 - 100)/(14 - 10) = \$25$$
$$ICER_{C,B} = (300 - 200)/(16 - 14) = \$50$$
$$ICER_{D,C} = (400 - 300)/(19 - 16) = \$33$$
$$ICER_{E,D} = (500 - 400)/(20 - 19) = \$100$$

A more complex example

Treatment strategy I			
Alternative	ΔC	ΔE	$\Delta C/\Delta E$
A	100	10	10
B	100	4	25
C	100	2	50
D	100	3	33
E	100	1	100

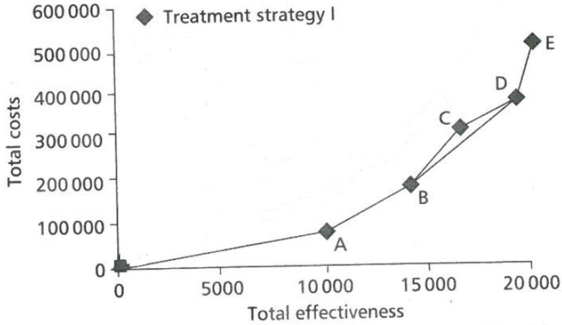
- Note that that $ICER_{B,A} = \$50 > ICER_{D,C} = \$33$

A more complex example



- ICER is the slope of the line
- This graph is for the 1,000 hypothetical patients
- C is a bit peculiar. You could draw a line from B to D that passes **below** point C

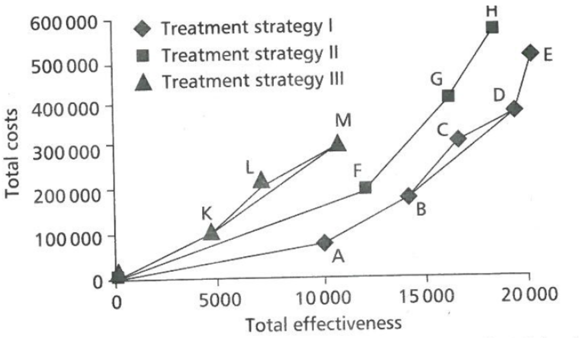
A more complex example



- $ICER_{D,B} = (400 - 200)/(19 - 14) = 40$
- In other words, we could eliminated C from consideration because it is (extended) dominated
- **Extended dominance**: ICER for a given alternative is higher than that of the next, more effective alternative

A more complex example

- You can repeat the same analysis for the other treatment strategies



Things to take into account

- Not common to have multiple alternatives; screenings programs are an exception. Do we screen once a year? Twice? Every three years?
- Be careful when reading articles because some authors place costs on the x-axis and effectiveness on the y-axis (then ICER is the inverse)
- Note that in this example we are comparing each treatment sequentially because it follows the decision, much like the stool test example
- The alternatives have different intensities; by the time you have a table like 5.4, several dominated alternatives have been eliminated
- We want to compare an alternative to the next best alternative

Next classes

- Measuring quality of life in cost-effectiveness studies (or cost-utility)
- Then back to measuring health and, more important, the concept of thresholds
- After Spring break, we start with modeling using decision trees and Markov models. All a lot of fun (in the nerdy connotation of fun, of course)