Cost-Effectiveness Analysis (CEA)

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Cost-Effectiveness Analysis
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We’ll talk about adding benefits to the cost side of EEs
We’ll follow your textbook convention and call CEA studies that measure benefits in “natural units”
How do we measure benefits?
Calculating ICER
Cost-effectiveness plane
Distributing a budget
Interpreting ICER
Net benefits
Examples
The first lecture was an intro to all the topics we’ll cover this semester

The last two lectures were about the details of the cost side of EEs

The main lesson was that there are three guiding principles: 1) **Perspective**, 2) **Time horizon**, and 3) **Relevance of costs** for the decision

EEs are about allocating resources among alternatives by comparing costs with benefits

Now we are going to talk about the **benefits side** and how both sides fit together

Reminder: (benefits = effects) ≠ effectiveness
There are many ways to **measure** health and many ways to **classify** measurements of health.

- If benefits or consequences are measured in “natural units, then cost-effectiveness analysis (CEA).
- If quality of life or preferences are used, then cost-utility analysis (CUA).
- We also learned that both are also called cost-effectiveness analysis.
For the **purpose of this class**, we will use:

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-12, SF-36,
3. **Preference based**: EQ-5D, SF-6D

Sometimes classified as **intermediate** outcomes (cholesterol, blood pressure) or **final** outcomes (mortality, MI, strokes)

**Generic** scales measure “general” health status; **disease specific** scales measure health functioning considering factors that are specific to certain health conditions
Measurement

Measures of health effects

Intermediate outcomes
- Glycaemic control
- CD4 count
- Cholesterol
- Cases detected

Final outcomes
- Single dimension
  - Mortality rate
  - Survival
  - Events (e.g., MI, stroke)
- Multiple dimensions
  - Attributes of health
  - Breadth
  - Depth

Disease specific
- Profile
  - EDSS
  - EORTC QLQ-30
- Index
  - EORTC-8D

Generic
- Profile
  - SF36
- Index
  - EQ5D
  - HUI III
  - SF6D

Mapping
Warning: textbook confusion

- Your textbook, on page 124, talks about quality of life scales
  1. Specific measures (disease or age)
  2. General health profiles
  3. Preference-based measures

- The confusion is that many people would not agree that 1) and 2) are “quality” of life scales

- And what is called “quality” in CEA, as in quality-adjusted life years, should be called preferences
To do EEs, we want to use a measure of health that is relevant and important because costs will be compared to this measure to make decisions about allocating resources.

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.

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.

But in CEA there is also another major concern: comparability.

If different interventions have different measures of benefits, we can’t compare ICERs. Or, if an intervention is cost-effective using one measure of benefit but not cost-effective using another, what are we supposed to do?
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 to extra years of life.

Example: we conduct a screening program for diabetes or celiac in children. What can measure? In about, say, two years, cases detected? (Yes) Complications averted? (No)

Mostly intermediate outcomes → need to somehow simulate final outcomes.

This, in turn, has increased the use of modeling (trees, microsimulation) to link intermediate and final outcomes (at the cost of adding more layers of assumptions).
Your textbook has some suggestions about intermediate versus final outcomes. Paraphrasing:

1. Make case for intermediate outcome (clinical or value)
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

Again, point 3 is implicitly arguing for decision models (the topic of three lectures after Spring break)
Incremental cost-effectiveness ratio (ICER)

- Once we have a measure of benefit we can calculate the ICER among alternatives.
- Reminder:

\[
\text{ICER} = \frac{C_1 - C_2}{E_1 - E_2} = \frac{\Delta C}{\Delta E}
\]

\(C_i\) and \(E_i\) are the costs and effectiveness measure of alternative \(i\).

- The purpose is to compare the incremental costs to the incremental benefits.
- The result is the incremental cost per unit of benefit.
We have ICER comparing alternative B to usual care, A. Now what?

Easy cases:
1. B is more expensive and less effective (prefer A) $\implies$ A dominates B
2. B is less expensive and more effective (prefer B) $\implies$ B dominates A

Not-so-easy cases:
1. B is more expensive and more effective
2. B is both less expensive and less effective
Example

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

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Cost ($)</th>
<th>Effect (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$350</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>$1,500</td>
<td>27</td>
</tr>
<tr>
<td>3</td>
<td>$3,500</td>
<td>35</td>
</tr>
</tbody>
</table>
Example

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Cost ($)</th>
<th>Effect (years)</th>
<th>ICER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$350</td>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>$1,500</td>
<td>27</td>
<td>$164</td>
</tr>
<tr>
<td>3</td>
<td>$3,500</td>
<td>35</td>
<td>$250</td>
</tr>
</tbody>
</table>

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

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

Which one do we choose? It depends on how much the decision maker is willing to pay per year of life gained (we’ll come back to that in the next two classes)
A more complex example from your textbook

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.)

<table>
<thead>
<tr>
<th>Treatment strategy I</th>
<th>Treatment strategy II</th>
<th>Treatment strategy III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative</td>
<td>C</td>
<td>E</td>
</tr>
<tr>
<td>A</td>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td>B</td>
<td>200</td>
<td>14</td>
</tr>
<tr>
<td>C</td>
<td>300</td>
<td>16</td>
</tr>
<tr>
<td>D</td>
<td>400</td>
<td>19</td>
</tr>
<tr>
<td>E</td>
<td>500</td>
<td>20</td>
</tr>
</tbody>
</table>

From Karlsson and Johannesson (1996).

- Three different interventions: I, II, III
- Each intervention can be delivery in varying degrees of intensity
- There is a "do-nothing" (called O) alternative with $0 cost and 0 benefits
A more complex example from your textbook

<table>
<thead>
<tr>
<th>Treatment strategy</th>
<th>Alternative</th>
<th>C</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>100</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>200</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>300</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>400</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>500</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

\[ ICER_{A,O} = \frac{(100 - 0)}{(10 - 0)} = \$10 \]
\[ ICER_{B,A} = \frac{(200 - 100)}{(14 - 10)} = \$25 \]
\[ ICER_{C,B} = \frac{(300 - 200)}{(16 - 14)} = \$50 \]
\[ ICER_{D,C} = \frac{(400 - 300)}{(19 - 16)} = \$33 \]
\[ ICER_{E,D} = \frac{(500 - 400)}{(20 - 19)} = \$100 \]
A more complex example from your textbook

<table>
<thead>
<tr>
<th>Treatment strategy</th>
<th>Alternative</th>
<th>ΔC</th>
<th>ΔE</th>
<th>ΔC/ΔE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>100</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>100</td>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>100</td>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>100</td>
<td>3</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>100</td>
<td>1</td>
<td>100</td>
</tr>
</tbody>
</table>

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

- $\text{ICER}_{D,B} = (400 - 200)/(19 - 14) = 40$

- 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 from your textbook
Some things to take into account

■ Be careful when reading articles because some authors place costs on the x-axis and benefits on the y-axis

■ Note that in this example we are comparing each treatment sequentially because it follows the decision, much like the stool test example

■ In general, we want to compare an alternative to the next best alternative
Suppose that you wanted to maximize years of life gained given a budget constraint.

Order the alternatives from lowest ICER to highest:
- A (10), F (17), K (20), B (25), M (25), D (33), G (50), H (75), E (100)

Then, spend the money on A. If money left, on F, and so on.
Threshold line: the max the decision maker is willing to pay for a unit of effect (we will talk about how to come up with that threshold in the next two classes)

Decision rule: if $ICER_{A,O} < R_T$ or $\Delta C/\Delta E < R_T$
Problems with ICER

- ICER has some problems, some of which are easier to understand
- One is that a ratio of two negative numbers is positive, so ratios in quadrant III and quadrant I are positive but have very different meanings (not a big problem)
- Ratios do not provide a clear idea of the size of the programs (not a big problem either)
- It is not trivial to calculate the confidence interval of ratios (this is a big problem if you have individual-level data)
- Because of the CI problem, Stinnett and Mullahy (1998) proposed an alternative to ICER: **Net Health Benefits (NHB)**
The idea of NHB is based on basic algebra:

- The decision rule is $\Delta C/\Delta E < R_T$
- Same as $R_T \Delta E - \Delta C > 0$
- $R_T \Delta E - \Delta C$ is called the **net monetary benefit**
- If net momentary benefit is positive, the intervention is cost-effective
- Nothing magical about this, just a re-arrangement. **But it does change the measurement units**
- $(R_T \times \Delta E)$ is $\$$
- And we just opened a can of worms because this raises questions about the meaning of the threshold and the equivalence between CEA and **cost-benefit** analysis
Net Health Benefits

- We can keep doing algebra to rearrange the decision rule \( \frac{\Delta C}{\Delta E} < R_T \):

\[ \Delta E - \frac{\Delta C}{R_T} > 0, \] which is called the Net Health Benefit

- So now the decision rule is that the incremental gain in effect has to be greater than the incremental cost over the threshold value, which makes the comparison in terms of effects, not money.

- For NHB to be positive, the health gain has to be greater than that of investing the same resources in an alternative with the cost-effectiveness ratio of \( R_T \).

- And this opens another can of worms...

- Is the threshold \( R_T \) the opportunity cost or the price that the decision maker puts on a unit of effect?
So why are we doing algebra?

- I did it because:
  1. This is a good way to introduce the big ideas about a threshold value
  2. Your textbook explanation is not so great

- Stinnett and Mullahy (1998) did it because the rearrangement transforms the decision rule based on ICER into a linear function for which building CIs is straightforward

- In practice, there is no clear threshold $R_T$ so results are shown as a function of several possible values for $R_T$
Next class we will talk more about measuring health

We will start talking about measuring preferences so we can finally get to QALYs

ICER can be calculated with QALYs as a measure of benefit