Cost-effectiveness Analysis

- Cost-effectiveness analysis seeks to address the question of value in health care
- Value is the balance between what we spend and what we get
  \[ \text{Value} = \frac{\text{Quality}}{\text{Cost}} \]
- CEA combines both cost and effectiveness into a single, useful measure

Rationale for Economic Evaluation

- What it is:
  - A way of establishing value for money spent on health care technology
  - An approach to assessing efficiency
- What it is not:
  - NOT a way to save money
  - Many interventions that are "cost-effective" are more costly
Why Should You Care?

- Economic evaluations are increasing in prevalence in the literature
- Economic evaluation is a young field and the quality of publications is variable
- Economic terms are misunderstood or used too loosely
- Resources used are not available for other uses

The Cost Perspective

- What is cost?
- Importance of perspective
  - Societal
  - Health care provider
  - Payor
  - Patient

Cost-Effectiveness Analysis

- Comparison of 2 or more interventions
- Costs are measured in monetary units
- Outcomes are measured in natural units (e.g., patients surviving, years of life saved, infection avoided)

\[ C_1 \quad E_1 \quad C_2 \quad E_2 \]
Cost-Effectiveness Analysis

- Where do we get $C_1$, $E_1$, $C_2$, and $E_2$?
  - Retrospective data
  - Decision analysis
  - Clinical trials
- In Decision Analysis they come essentially from solving the model twice:
  - Once for costs
  - Once for outcomes
- Compute the Incremental Cost-effectiveness Ratio

Incremental Cost-effectiveness Ratio (ICER)

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

Example:

$$\frac{12,000 - 5,000}{6.2 - 5.7} = \frac{7,000}{0.5} = 14,000$$
What is Cost-effective?

- Interventions whose ICER is below the ceiling WTP threshold of the decision maker
- Standard for declaring an intervention “Cost-effective”
  - Often cited as $50,000 per quality adjusted life year (QALY)

Reference ICERS

<table>
<thead>
<tr>
<th>Treatment</th>
<th>ICER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cholesterol testing and diet therapy</td>
<td>280</td>
</tr>
<tr>
<td>Advice from GP to stop smoking</td>
<td>390</td>
</tr>
<tr>
<td>Heart pacemaker implantation</td>
<td>1,420</td>
</tr>
<tr>
<td>Hip replacement</td>
<td>1,520</td>
</tr>
<tr>
<td>Coronary artery bypass graft</td>
<td>2,700</td>
</tr>
<tr>
<td>Kidney transplant</td>
<td>9,060</td>
</tr>
<tr>
<td>Breast cancer treatment</td>
<td>7,480</td>
</tr>
<tr>
<td>Heart transplant</td>
<td>10,110</td>
</tr>
<tr>
<td>Continuous ambulatory peritoneal dialysis</td>
<td>25,630</td>
</tr>
<tr>
<td>Neurosurgery for brain tumour</td>
<td>139,040</td>
</tr>
</tbody>
</table>


Limitations

- Only interventions whose outcomes are measured in equivalent units can be compared
Cost-Utility Analysis

- Just like Cost-effectiveness analysis
- Only one outcome measure: QALYs
- Most North American health economists do not make a distinction between cost-effectiveness analysis and cost-utility analysis
- Most European health economists do

Quality Adjusted Life Years

- One year of life in perfect health is not the same as one year of life with some disability or morbidity
- QALYs adjust survival time to account for the quality of the time
- QALY = utility \times Year of life
- This puts years of life with discomfort/disability into equivalent years of perfect health

Utility

- Measure of patient preference for health states
- A common unit with which to compare interventions with widely divergent outcomes
  - 1 = Perfect health
  - 0 = Death
- Larger numbers are better
### Reference Utilities

<table>
<thead>
<tr>
<th>Disability</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>No disability</td>
<td>1</td>
<td>0.995</td>
<td>0.99</td>
<td></td>
</tr>
<tr>
<td>Slight social disability</td>
<td>0.99</td>
<td>0.986</td>
<td>0.973</td>
<td></td>
</tr>
<tr>
<td>Severe social disability and/or slight impairment of performance at work</td>
<td>0.964</td>
<td>0.95</td>
<td>0.932</td>
<td></td>
</tr>
<tr>
<td>Slight impairment of performance at work</td>
<td>0.98</td>
<td>0.972</td>
<td>0.96</td>
<td></td>
</tr>
<tr>
<td>Very severe social disability and/or slight impairment of performance at work</td>
<td>0.964</td>
<td>0.956</td>
<td>0.942</td>
<td></td>
</tr>
<tr>
<td>Severe social disability and/or slight impairment of performance at work</td>
<td>0.964</td>
<td>0.956</td>
<td>0.942</td>
<td></td>
</tr>
<tr>
<td>Confined to chair or to wheelchair</td>
<td>0.875</td>
<td>0.845</td>
<td>0.68</td>
<td>0</td>
</tr>
<tr>
<td>Confined to bed</td>
<td>0.677</td>
<td>0.564</td>
<td>0</td>
<td>-1.486</td>
</tr>
<tr>
<td>Unconscious</td>
<td>-1.028</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Quality Adjusted Life Years

- Example: Assume that a patient lives 5 years on dialysis. Then she receives a kidney transplant and lives five more years and dies of unrelated causes. How many QALYs?
- Assume utility for dialysis is .6 and utility for life with a functioning kidney transplant is .95.
- Total QALYs are: $5 \times .6 + 5 \times .95 = 7.75$

### Why the ICER not the ACER

- ACER is Average Cost-Effectiveness Ratio

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Cost</th>
<th>QALYs</th>
<th>ACER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5000</td>
<td>5</td>
<td>1000</td>
</tr>
<tr>
<td>2</td>
<td>6000</td>
<td>6</td>
<td>1000</td>
</tr>
</tbody>
</table>
Why the ICER not the ACER

- According to this, the strategies are equivalent
- But RELATIVE TO WHAT?
  - A strategy that costs nothing and yields no benefits
  - i.e., doing nothing
- Does not allow direct comparison

\[
ACER = \frac{C_1}{E_1} = \frac{C_1 - 0}{E_1 - 0}
\]

1000 Hypothetical Patients

Strategy 1
- Costs $5,000 \times 1000 = $5,000,000
- Gets you 5 \times 1000 QALYs
- Or $1000 per QALY (ACER)

Strategy 2
- Costs $6,000 \times 1000 = $6,000,000
- Gets you 6 \times 1000 QALYs
- Or $1000 per QALY (ACER)

But gets you 1000 MORE QALYs for $1,000,000

ICER = $1000 per QALY

Strategy 2 is far superior!

Probabilistic Sensitivity Analysis

- Model parameters are probability distributions
- Take draw from each parameters distribution and roll the tree back
  - This approximates the joint distribution of the ICER
  - Also allows us to account for uncertainty
- Allows us to asks the probability that the intervention is cost-effective for a given WTP threshold
Probabilistic Sensitivity Analysis

\[ \lambda = 0 \]

\[ \Pr(\text{cost-effective}) = 10\% \]
Probabilistic Sensitivity Analysis

Pr(cost-effective) = 86%

λ = 400

ΔE

ΔC

Probabilistic Sensitivity Analysis

Pr(cost-effective) = 99%

λ = 1,100

ΔE

ΔC

Cost-Effectiveness Acceptability Curve

Probability (CER ≤ μ)

Willingness-to-Pay

ΔE

ΔC
Homework

• Read the