COST-EFFECTIVENESS ANALYSIS

and

SAS Health User Group

11 April 2014
Disclaimer

These views are my view and not the view of the people or place with whom I work.
Overall Objectives

- Economic evaluation 101
- CEA and SAS in action
Outline

- Why do economic evaluation?
- What is economic evaluation?
- How to estimate cost-effectiveness?
- How to estimate cost-effectiveness in SAS?
Biggest “BANG”

For Your “BUCK”
Health Care: Medications, Devices, ...
Factors to Consider

- Cost
- What you will get (e.g., outcome, effect)
- Budget
What is Economics?

- **Objective and Constraints**

- **Objective**
  - Maximize profit, patients treated, quality of care, etc.

- **Constraints**
  - Limited money, time, people, space, machines, etc.
Scarcity and Tradeoffs

2011-2012 Program Expense

- Education and social services (59%)
- Health (41%)

Source: Ontario Ministry of Finance
Scarcity and Tradeoffs

2011-2012 Program Expense

- Education and social services (59%) - Health (41%)
- Education and social services (30%) - Health (70%)

Source: Ontario Ministry of Finance
Why Do Economic Evaluation?

- Health care resources = scarce
- Therefore,
  Choices must be made.
Old School Methods

- What we did last time
- Gut feelings
- Educated guesses
Outline

- Why do economic evaluation?
- What is economic evaluation?
- How to estimate cost-effectiveness?
- How to estimate cost-effectiveness in SAS?
Economic Evaluation = a Tool

- A technique that objectively compares 2 or more treatments
- Considers both cost and effect simultaneously
Different Types of Economic Evaluation

- Cost Benefit Analysis (CBA)
- Cost Utility Analysis (CUA)
- Cost Effectiveness Analysis (CEA)
- Cost Minimization Analysis (CMA)
- Budget Impact Analysis
Different Types of Economic Evaluation

- Cost Benefit Analysis (CBA)
- Cost Utility Analysis (CUA)
- Cost Effectiveness Analysis (CEA)
- Cost Minimization Analysis (CMA)
Different Types of Economic Evaluation

- Cost Benefit Analysis (CBA)
- Cost Utility Analysis (CUA)
- Cost Effectiveness Analysis (CEA)
- Cost Minimization Analysis (CMA)
The Importance of Effect (Outcome)

CBA  Outcomes in $$$

CUA  QALY (quality-adjusted life years), Q and q

CEA  Natural unit (e.g., number of falls, pain level)

CMA  0 (no outcome)
Perspective
Perspectives in Health Care

Patients

Society

Hospital

Government

Caregivers

Industry

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• Cost
• Effect
• Perspective
Statistically, what economic evaluation is about?

- **NOT** about hypothesis testing
- Creating a cost-effectiveness estimate
- Characterizing the uncertainty of the estimate
Statistically, what economic evaluation is about?

- **Estimates**
  - Incremental Cost-Effectiveness Ratio (ICER)
  - Incremental Net Benefit (INB)

- **Uncertainty**
  - Cost-Effectiveness Acceptability Curve
  - Fieller’s Theorem Confidence Interval
  - Confidence Ellipse
Outline

- Why do economic evaluation?
- What is economic evaluation?
- **How to estimate cost-effectiveness?**
- How to estimate cost-effectiveness in SAS?
Cost-Effectiveness Estimate - ICER

- Incremental Cost-Effectiveness Ratio (ICER)
  - One approach
  - To compare COST and EFFECT between 2 groups
  - ICER = EXTRA cost for 1 more unit of outcome (effect)

\[ \Delta C / \Delta E \]

\[ ICER = \frac{C_{TX} - C_{UC}}{E_{TX} - E_{UC}} \]
General Decision Rules

- What you want > your budget
  - SAY **NO**
  - 🙁

- What you want < your budget
  - SAY **YES** or BUY
  - 😊
General Decision Rules

- **ICER > WTP**
  - Not cost-effective
  - 😞

- **ICER < WTP**
  - Cost-effective to invest
  - 😊
Compared to UC, is TX cost-effective?

- **ICER = Extra cost for 1 unit of effect**

- **Cost-effective:**

  \[ \frac{\Delta C}{\Delta E} < \text{WTP} \]
Outline

- Why do economic evaluation?
- What is economic evaluation?
- How to estimate cost-effectiveness?
- How to estimate cost-effectiveness in SAS?
How to estimate ICER in SAS?

- 3 approaches to estimate ICER
- means
- ttest
- regression (simple linear regression)
## Data

<table>
<thead>
<tr>
<th>ID</th>
<th>TX</th>
<th>COST</th>
<th>EFFECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>$100</td>
<td>90</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>$200</td>
<td>80</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>$300</td>
<td>70</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>$600</td>
<td>40</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>$500</td>
<td>30</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>$400</td>
<td>45</td>
</tr>
</tbody>
</table>

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```
PROC MEANS DATA=example;
   TITLE 'Means of cost and effect by treatment group';
   VAR cost effect;
   BY tx;
RUN;
```

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>cost</td>
<td>3</td>
<td>450.00000000</td>
<td>50.00000000</td>
<td>400.00000000</td>
<td>500.00000000</td>
</tr>
<tr>
<td>effect</td>
<td>3</td>
<td>25.00000000</td>
<td>5.00000000</td>
<td>20.00000000</td>
<td>30.00000000</td>
</tr>
</tbody>
</table>

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<tr>
<td>effect</td>
<td>3</td>
<td>70.00000000</td>
<td>10.00000000</td>
<td>60.00000000</td>
<td>80.00000000</td>
</tr>
</tbody>
</table>
\[
\text{ICER} = \frac{C_{TX} - C_{UC}}{E_{TX} - E_{UC}} = \frac{200 - 450}{70 - 25} = \frac{\Delta C}{\Delta E} = \frac{-250}{45} = -5.6
\]
The procedure used to perform the t-test is shown in the image:

```plaintext
PROC TTEST DATA=example;
   TITLE 'Means of cost and effect by treatment group';
   VAR cost effect;
   CLASS tx;
RUN;
```

The output shows the mean and standard deviation for each treatment group:

<table>
<thead>
<tr>
<th>tx</th>
<th>N</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Std Err</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3</td>
<td>450.0</td>
<td>50.0000</td>
<td>28.8675</td>
<td>400.0</td>
<td>500.0</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>200.0</td>
<td>100.0</td>
<td>57.7350</td>
<td>100.0</td>
<td>300.0</td>
</tr>
<tr>
<td>Diff (1-2)</td>
<td>250.0</td>
<td>79.0569</td>
<td>64.5497</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The ICER (Incremental Cost-Effectiveness Ratio) is calculated as follows:

ICER = \frac{200 - 450}{70 - 25} = \frac{ΔC}{ΔE} = \frac{-250}{45} = -5.6
Cost $\rightarrow$ Diff (1-2) = $\Delta C$

Effect $\rightarrow$ Diff (1-2) = $\Delta E$

$\text{ICER} = \frac{\Delta C}{\Delta E}$

$= -250 / 45$

$= -5.6$
PROC REG DATA = example;
TITLE 'SLR: cost by treatment group';
MODEL cost = tx;
RUN; QUIT;

The REG Procedure
Model: MODEL1
Dependent Variable: cost

Number of Observations Read 6
Number of Observations Used   6

Analysis of Variance

Source            DF    Sum of Squares    Mean Square    F Value    Pr > F
Model              1     93750           93750          15.00    0.0179
Error              4     25000           6250.00000     
Corrected Total    5     118750          

Root MSE 79.05694    R-Square 0.7895
Dependent Mean 325.00000  Adj R-Sq 0.7368
Coeff Var 24.32521

Parameter Estimates

| Variable | DF | Parameter Estimate | Standard Error | t Value | Pr > |t|   |
|----------|----|-------------------|----------------|---------|-------|-----|
| Intercept| 1   | 450.00000         | 45.64355       | 9.86    | 0.0006|
| tx       | 1   | -250.00000        | 64.54972       | -3.87   | 0.0179|
proc reg

- MODEL cost = tx;
  - Coefficient of TX dummy = ΔC

- MODEL effect = tx;
  - Coefficient of TX dummy = ΔE

- ICER = ΔC/ΔE
Compared to UC, is TX cost-effective?

- ICER

- Cost-effective:
  \[ \text{ICER} < \text{WTP} \]
Summary 1

- Why do economic evaluation?
  - Scarcity → having to make choices

- What is economic evaluation?
  - A tool to help us compare 2 or more treatments
  - Consider both COST and EFFECT simultaneously

- What is cost-effectiveness?
  - Cost; Effect; Willingness-to-pay; Perspective
  - ICER < WTP
Summary 2

- How to estimate cost-effectiveness?
  - ICER, INB

- How to estimate cost-effectiveness in SAS?
  - means, ttest, reg

- CEA is about
  1. Estimation: **ICER**, INB
  2. Uncertainty: CEAC, Ellipse, CI
THANK YOU

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