Introduction to Economic Evaluation – Part II

May 18, 2011
Outline

• Overview of BCA, CEA, and CUA

• Measuring outcomes for use in economic evaluations
  – BCA - $
  – CEA – natural units
  – CUA - QALYs

• Examples of BCA/CEAs of tobacco control programs
What EE Method to Use?

Ex: Health vs. Defense
Benefits = $
BCA

Ex: Cancer screening vs. Smoking cessation
Benefits = QALYs
CUA

Ex: Nicotine patch versus behavior therapy to prevent smoking
Benefits = Cases
CEA
Systematic Review of EE Evidence in Tobacco Control

Benefit-cost Analysis (BCA)

- A method used to compare costs and benefits of an intervention
  - where all the costs and benefits are standardized or valued in *monetary terms*.

- Provides a single value:
  - Net Benefits: NB (Benefits – Costs)
Quantify Benefits - BCA

• Human Capital or Cost-of-Illness (COI) approach
  – Typically includes medical costs and productivity losses averted
  – Productivity losses based on wages
    • Undervalues women, children, and the elderly

• Willingness-to-Pay (WTP) or Contingent-valuation surveys
  – e.g., how much is society willing to pay to reduce the annual mortality risk associated with secondary smoke
Example

• Mudharri, US EPA, 1994
  – BCA of a national smoke-free law for all public building with 10+ persons entering per week
  – Costs
    • Implementation of the restriction, construction and maintenance of smoking lounges, and enforcement.
  – Benefits - HUMAN CAPITAL APPROACH
    • Savings on medical expenditures by averting heart disease, the value of lives saved, costs averted by reduced smoking-related fires, and productivity improvements.
  – The net present benefit to society was between $42 and $78 billion, and this range was based on high and low estimates of costs and benefits.
Cost-effectiveness Analysis (CEA)

• Measures both the costs and outcomes, but assures that all of the outcomes are measured in the same metric across all alternatives.
  – The outcome of interest is the only relevant outcome for both strategies
    • cost per quit
    • cost per smoking days prevented
    • cost/life saved
    • Cost per life-year saved
CE Never in Isolation

• Compared to what?
  – A single option can never be "cost effective"; the term *requires* a comparison to another specific alternative
    • another intervention or option
    • do nothing (which has its own stream of costs and outcomes)
    • Status quo (which may be doing nothing)

• Choice of comparator
  – always use best available alternative intervention
  – always include most widely used intervention
Average, Marginal, and Incremental C/E Ratios

• Average C/E ratio (ACER)
  – ratio of costs to outcomes for a single program

• Marginal C/E ratio (MCER)
  – ratio of additional costs to outcomes obtained from one additional unit of an intervention

• Incremental C/E ratio (ICER)
  – ratio of additional costs to outcomes obtained when one program is compared with the next least effective program
Average C/E Ratio - Strategy A

Cost Strategy A

Outcome Strategy A
Marginal C/E Ratio - Strategy A

Cost Strategy A’ - Cost Strategy A

Outcome Strategy A’ - Outcome Strategy A
Incremental C/E Ratio - Strategy B

Cost Strategy B - Cost Strategy A

Outcome Strategy B - Outcome Strategy A

Costs include:
program costs – (medical costs + productivity losses averted*)
• Different actions are indicated in the different quadrants
• CEA analysis is only useful when there is a TRADEOFF between cost and outcomes
Quantify Outcomes — CEA

• Intermediate outcomes:
  – Reduced cigarette smoking
  – Decreased hypertension

• Final outcomes:
  – Increased disability-free days
  – Increased # of life years (LYs) or life expectancy
  – Increased health-related quality of life (HRQoL)
CEA Caveat

• Outcomes cannot be combined; they must be considered separately. Consider one or two of the most important measures.

• Number of summary measures depends on number of outcomes chosen.
  – If A and B are the most important, then:
    • Cost/outcome A (cost per 1% increase in smoking days).
    • Cost/outcome B (cost per 1% reduction in hypertension).

• **Translation for policy-makers can be difficult.**
THE EFFECTIVENESS AND COST-EFFECTIVENESS OF TELEPHONE COUNSELING AND THE NICOTINE PATCH IN A STATE TOBACCO QUITLINE

Hollis, McAfee, Fellos, et al
Tobacco Control
2007; 16(S1): i53-i59
Tobacco Quitlines Overview

• Quitlines are telephone-based tobacco cessation services that help tobacco users quit.
• In this particular intervention, counselors, with motivational interviewing training, follow computer driven scripts providing
  – Caring
  – Motivation
  – Quitting strategies
• Participants offered referrals, mailed “quit kits”, and given information on pharmacotherapy options.
Study Overview

• Comparison of the cost-effectiveness of three protocols
  – Intensive: multiple and longer calls
  – Moderate: multiple calls
  – Single brief call
• Three protocols further divided into 2 groups each
  – Offered free nicotine patches (NRT)
• Part of an RCT
• Outcome:
  – 30 days of abstinence at 12-month follow-up
Study Overview

• Perspective: State program
• 5 methods compared to the brief, no NRT option provided
• Costs:
  – Training
  – Counselors time
  – Administrative and technical support
  – Facility space
  – Supplies
Results

Table 3  Smoking cessation and cost effectiveness

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>No NRT offer</th>
<th></th>
<th>NRT offer</th>
<th></th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Brief (n=872)</td>
<td>Moderate (n=718)</td>
<td>Intensive (n=720)</td>
<td>Brief (n=868)</td>
<td>Moderate (n=715)</td>
</tr>
<tr>
<td>Abstinence* 6 months (%)</td>
<td>10.2</td>
<td>10.7</td>
<td>13.1</td>
<td>16.8</td>
<td>21.3</td>
</tr>
<tr>
<td>Abstinence* 12 months (%)</td>
<td>11.7</td>
<td>13.8</td>
<td>14.3</td>
<td>17.1</td>
<td>20.1</td>
</tr>
<tr>
<td>Cost/participant (SD), 2004$</td>
<td>$67 ($20)</td>
<td>$107 ($33)</td>
<td>$132 ($57)</td>
<td>$193 ($79)</td>
<td>$242 ($92)</td>
</tr>
<tr>
<td>Incremental cost/quit† (range), 2004$</td>
<td>NA</td>
<td>$1912</td>
<td>$2640</td>
<td>$2467</td>
<td>$2109</td>
</tr>
</tbody>
</table>

*Abstinent from all forms of tobacco for 30 days or more at follow-up.
†Incremental cost per additional quit relative to brief/no NRT arm. Ranges calculated using standard deviations and 12-month abstinence.

• Example of how CE Ratios calculated:
  – Comparing No NRT/Moderate to No NRT/Brief
    • \( \frac{($107 - $67)}{(.138 - .117)} = $1905 \) (table shows $1912)
  – Comparing NRT/Intensive to No NRT/Brief
    • \( \frac{($2112 - $67)}{(.212 - .117)} = $2138 \) (table shows $2112)
Limitations

• Outcomes relied on self-reports
• Outcomes not collected beyond one year
• No placebo NRT included (increased outcomes could be due to increased expectancy of quitting)

• Average CE ratios (compared to No NRT/brief) included in analysis, rather than incremental CE ratios
# Incremental CE Ratios

<table>
<thead>
<tr>
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<th>Effects at 12 months</th>
<th>Costs</th>
<th>Inc CE Ratio</th>
</tr>
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<tbody>
<tr>
<td>No NRT/Brief</td>
<td>11.7</td>
<td>67</td>
<td>--</td>
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<td>13.8</td>
<td>107</td>
<td>1905</td>
</tr>
<tr>
<td>No NRT/Intensive</td>
<td>14.3</td>
<td>132</td>
<td>5000</td>
</tr>
<tr>
<td>NRT/Brief</td>
<td>17.1</td>
<td>193</td>
<td>2179</td>
</tr>
<tr>
<td>NRT/Moderate</td>
<td>20.1</td>
<td>242</td>
<td>1633</td>
</tr>
<tr>
<td>NRT/Intensive</td>
<td>21.1</td>
<td>268</td>
<td>2600</td>
</tr>
</tbody>
</table>

1. Order interventions by increasing effectiveness.
2. Eliminate programs where effectiveness increases, but costs decrease (“dominance”)
3. Calculate incremental CE ratios – comparing each program to next least effective program
4. Eliminate programs where “extended dominance” occurs – that is, there is the CE ratio does not increase with increasing effectiveness
## Incremental CE Ratios

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<td>242</td>
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<td>NRT/Intensive</td>
<td>21.1</td>
<td>268</td>
<td>2600</td>
</tr>
</tbody>
</table>

Example of how incremental CE ratio calculated:
- comparing NRT/Moderate to No NRT/Moderate

\[
\text{($242 - $107) - (.201 - .138) = $2143}
\]
Example of Extended Dominance

- No NRT/Intensive
- NRT/Moderate
- NRT/Brief
- No NRT/Brief
- No NRT/Moderate

Anything in this area is "cheaper and better" than No NRT/Intensive
OR
No NRT/Intensive is "more expensive and worse" than any strategy between A and B.
Sub-variant of CEA

• Cost-Utility Analysis - CUA
  – measures outcomes in terms of the value (utility) placed on the outcome, not the outcome itself
  – requires an ability to place numeric comparisons of various outcome states
  – We all know that life in different health states is not valued equally:
    • a year of life in full health
    • a year of life after a stroke
    • a year of life in severe pain
    • a year of life with lung cancer
Cost-Utility Analysis — CUA

• Compares costs and benefits, where benefits = # of life years saved *adjusted* for loss of quality.

• Combines length and quality of life.

• Compares disparate outcomes in terms of utility.
  – Quality-adjusted life years (QALYs).
  – Disability-adjusted life years (DALYs).

• Derives a ratio of cost per health outcome.
  – $/QALY or $/DALY.
When Is CUA Used?

• When quality of life is **the** important outcome.
• When the program affects both morbidity and mortality.
• When programs being compared have a wide range of outcomes.
• When one of the programs being compared has already been evaluated using CUA.
• Utilities, or preference weights, are:
  – A quantitative approach for describing preferences for quality of life.
  – Typically based on a 0 to 1 scale, where:
    • 0 = death.
    • 1 = perfect health.
Time Trade-Off

Utility

U(healthy) = 1.0

U(Lung cancer) = ?

Dead

0 12 20 Years

healthy

lung cancer
Valuation of Benefits in a CEA: Combining Length of Life with Quality of Life

LENGTH OF LIFE (Years)

QUALITY OF LIFE (weights)

1.0

birth death

without intervention

with intervention

without intervention

death death’
NOTE: Incremental C/E Ratio for CUA

Cost Strategy B - Cost Strategy A

Outcome Strategy B - Outcome Strategy A

Costs include:

program costs – (medical costs + productivity losses averted*)
COST-EFFECTIVENESS OF A SCHOOL-BASED TOBACCO-USE PREVENTION PROGRAM

Wang, Crossett, Lowry, Sussman, & Dent
Archives of Pediatric Adolescent Medicine
2001; 155: 1043-1050
Project Toward No Tobacco Use (TNT)

- School-based education program for juniors and seniors
- Teaches refusal skills, awareness of social misperceptions about tobacco use, and misconceptions about physical consequences
- Designated by the CDC as a Program That Works
- Three types of curricula: physical consequences, informational social influence, and normative social influence
Efficacy Trial

• Students randomly assigned to 1 of 4 curricula: the three mentioned on previous slide and a “usual care” curriculum

• 2-year follow-up found that each of the three curricula were effective, all 3 used in a combined fashion for the CEA
Programmatic Costs

- Collected retrospectively
- Only direct costs included at a program perspective

Table 1. Intervention Costs

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Cost, $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training of health educators</td>
<td></td>
</tr>
<tr>
<td>2 Health educators received</td>
<td>$2400</td>
</tr>
<tr>
<td>$10/h for 15 d (120 h) of training</td>
<td></td>
</tr>
<tr>
<td>2 Health educators received the training</td>
<td>$1680</td>
</tr>
<tr>
<td>at a fee of $56/d for 15 d (120 h) of training</td>
<td></td>
</tr>
<tr>
<td>Subtotal</td>
<td>$4080</td>
</tr>
<tr>
<td>Teaching</td>
<td></td>
</tr>
<tr>
<td>2 Health educators taught at 4 schools each for</td>
<td></td>
</tr>
<tr>
<td>10 d (80 h) for $10/h</td>
<td>$6400</td>
</tr>
<tr>
<td>for $10/h</td>
<td></td>
</tr>
<tr>
<td>2 Health educators taught 2-d (16-h) booster</td>
<td>$1280</td>
</tr>
<tr>
<td>sessions at 4 schools each for $10/h</td>
<td></td>
</tr>
<tr>
<td>Subtotal</td>
<td>$7680</td>
</tr>
<tr>
<td>Materials</td>
<td></td>
</tr>
<tr>
<td>2 Teacher manuals at $45 per manual</td>
<td>$90</td>
</tr>
<tr>
<td>1234 Student manuals at $3.69 per manual</td>
<td>$4553</td>
</tr>
<tr>
<td>Subtotal</td>
<td>$4643</td>
</tr>
<tr>
<td>Total</td>
<td>$16,403</td>
</tr>
</tbody>
</table>

*Values provided by the Project Toward No Tobacco Use evaluation study group.
Outcome Steps

1) Estimation of the number of established smokers prevented
2) Estimation of the number of life years (LYs) saved and QALYs saved
3) Estimation of the lifetime medical costs saved
Established Smokers Prevented

- Smoking progression model
- Divided the students at 2-year follow-up into nonsmokers, experimenters, and established smokers
- Used probabilities from a natural history on smoking (from a national sample) to model the movement of individuals among the three states
- Students modeled from age 14 to age 26, assumed that smoking would likely not be initiated after this age
LYs Saved

- Used estimates of life expectancy from the National Health Interview Survey and National Mortality Followback Survey
- Example:
  - Life expectancy of a never smoker is…
    - 2 years longer than a former smoker
    - 3.5 years longer than a light smoker
    - 14.2 years longer than a heavy smoker
  - Discounted (from 26 to end of LE) at an annual rate of 3% to
    - 0.26 discounted LYs
    - 0.47 discounted LYs
    - 2.13 discounted LYs, respectively
  - Weighted average (based published distributions of smokers) of discounted LYs: 31.7%*0.26 + 52.3%*0.47 + 16%*2.13 = 0.67 LYs
    - 0.67 LYs represents the discounted LYs saved per established smoker prevented (comparing never smoker to weighted average of “other” smoker types)
QALYs Saved

• Used published estimates for conversion of LYs to QALYs for smokers

• Example:
  – 1.31 LYs saved per quitter estimated as 2.34 QALYs saved for men aged 25 to 29 years

• From JAMA 1997 (Cromwell et al) - 1.57 QALYs saved is equivalent to 1 LY saved
  – What does this mean?
    • If you don’t smoke – for every addl year of life gained, you also gain ½ a year adjusted for quality of life gains.
Medical Costs Saved

• Used published estimates for medical expenditures associated with becoming a smoker versus not becoming a smoker

• Example:
  – A male smoker spends $8,638 more than a never smoker for medical care
  – A female smoker spends $10,119 more than a never smoker for medical care
Results

- Incremental CE Ratios compared to “no smoking” curriculum
- CEA including medical care costs saved (base, worst, and best case at right) is negative due to overall cost savings
- **NOT RECOMMENDED** to report negative CE ratios

Table 4. Results From Base-Case and Multivariate Sensitivity Analyses*

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Base Case</th>
<th>Worst Case</th>
<th>Best Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention cost, $</td>
<td>16 403.00</td>
<td>36 563.00</td>
<td>16 403.00</td>
</tr>
<tr>
<td>Established smokers prevented, No.</td>
<td>34.9</td>
<td>19.7</td>
<td>51.0</td>
</tr>
<tr>
<td>Medical care cost saved, $</td>
<td>327 139.50</td>
<td>160 991.50</td>
<td>478 329.00</td>
</tr>
<tr>
<td>Discounted LYs saved</td>
<td>23.3</td>
<td>13.2</td>
<td>34.1</td>
</tr>
<tr>
<td>Discounted QALYs saved</td>
<td>36.6</td>
<td>20.7</td>
<td>53.6</td>
</tr>
<tr>
<td>Cost per LY saved, $</td>
<td>-13 316.50</td>
<td>-9426.80</td>
<td>-13 538.70</td>
</tr>
<tr>
<td>Cost per QALY saved, $</td>
<td>-8 481.80</td>
<td>-6 004.40</td>
<td>-8 623.40</td>
</tr>
<tr>
<td>Cost per LY saved (excluding medical care costs saved), $</td>
<td>702.90</td>
<td>2 770.10</td>
<td>480.80</td>
</tr>
<tr>
<td>Cost per QALY saved (excluding medical care costs saved), $</td>
<td>447.70</td>
<td>1 764.40</td>
<td>306.20</td>
</tr>
</tbody>
</table>

*LY indicates life year; and QALY, quality-adjusted life year.
Limitations

• Retrospective estimation of costs
• Number of established smokers prevented modeled rather than directly measured
• One source of data available for probabilities of smoking progression
• No consideration of continued effectiveness of TNT beyond 2-year follow-up
• Did not account for all of the costs of smoking to society
Where to Get QALY Weights?

<table>
<thead>
<tr>
<th>Source</th>
<th>Examples</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literature</td>
<td>■ Individual studies &lt;br&gt;■ CUA databases – Tufts***</td>
<td>■ Lack of comparability</td>
</tr>
<tr>
<td>Indirect measures</td>
<td>■ Beaver Dam study, QWB &lt;br&gt;■ Joint US-Canadian health survey included HUI &lt;br&gt;■ MEPS included EQ-5D US</td>
<td>■ Only common diseases &lt;br&gt;■ No severity levels</td>
</tr>
<tr>
<td>Direct measures</td>
<td>■ Expert panel &lt;br&gt;■ Special sample survey</td>
<td>■ Expense &lt;br&gt;■ Time &lt;br&gt;■ Representation</td>
</tr>
</tbody>
</table>

***https://research.tufts-nemc.org/cear4/default.aspx
## Smoking Related Utilities

<table>
<thead>
<tr>
<th>Smoking Classification</th>
<th>Age</th>
<th>Male Utility</th>
<th>Female Utility</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Smoker</td>
<td>40-44</td>
<td>0.82</td>
<td>0.83</td>
<td></td>
</tr>
<tr>
<td>Smoker</td>
<td>75-79</td>
<td>0.67</td>
<td>0.61</td>
<td></td>
</tr>
<tr>
<td>Never Smoker</td>
<td>18-19</td>
<td>0.93</td>
<td>0.92</td>
<td></td>
</tr>
<tr>
<td>Smoker</td>
<td>18-19</td>
<td>0.91</td>
<td>0.89</td>
<td></td>
</tr>
</tbody>
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Final Comments

- Economic evaluation (EE) methods are valuable to decision making and for setting policy.

- For practitioners and evaluators, these skills are necessary because the DEMAND for these analyses is growing.
Thank You!

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