Decision Analysis: an Overview

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Spring 2014
What will you learn?

- Why to use decision analysis
- Different types of decision analysis
- Jargon → definitions
- The difference between cost-effective and cost-saving
Why engage in decision analysis?

- Have to choose between funding different interventions
  - limited resources

- There is generally no clear “right” answer of the best intervention to fund

- Logical, transparent, quantitative way to weigh the pros and cons of each intervention
  - Make an informed decision
Weighing the pros and cons of a decision

Not all “pros” and “cons” are equal:

- Consequences of pro/con
- Probability of pro/con
  - Variation in probability
Pros and cons

- **Option A:**
  - 80% probability of cure
  - 2% probability of serious adverse event

- **Option B:**
  - 90% probability of cure
  - 5% probability of serious adverse event

- **Option C:**
  - 98% probability of cure
  - 1% probability of treatment-related death
  - 1% probability of minor adverse event
Opportunity costs

- Choosing one option means forgoing another
  - Due to funding
  - Due to resources

Example:
  - Tuberculosis directly-observed therapy versus Promatora-based breast-feeding campaign
  - Cap-and-trade versus carbon tax
Variation

- In medicine/healthcare, we have a lot of variation!

  - Variation:
    - application of intervention (if it is non-pharmacological)
    - adherence to intervention
    - response to intervention

  - Sampling error (uncertainty)
Recap, Why to use Decision Analysis

- Allocation of limited resources
- Each intervention has pros and cons
- Each intervention is different:
  - Condition/population
  - Cost
  - Health outcome
- And we are know there is uncertainty around much of our estimates of pros, cons, costs and health outcomes
Advantages of Decision Analysis

- Evaluates each intervention using the same measure(s)

- Compare results using the same metric:
  - Costs
  - Cost per Life Year Saved
  - Cost per Quality-Adjusted Life Year
Decision Analysis can be applied to…

- Drugs
- Procedures
- Health programs
- Screening
- Vaccines
- Reimbursement decisions
- Etc.
Types of decision analysis
Types of decision analysis

- Cost-effectiveness analysis
- Cost-benefit analysis
- Budget impact analysis
Cost-Effectiveness Analysis (CEA)

Costs : Health effects

Health effects can be anything:

- Life-Years Saved
- Cases of Cancer Avoided
- Etc
CEA and ICERs

- Cost-Effectiveness Analyses compare the impact of 2 or more interventions

- Result is an Incremental Cost-Effectiveness Ratio (ICER)
  \[
  \text{ICER} = \frac{\text{Cost}_B - \text{Cost}_A}{\text{Health Effect}_B - \text{Health Effect}_A}
  \]
Cost-Utility Analysis

- A particular form of cost-effectiveness analysis
- Health Effect is a Quality-Adjusted Life Year (QALY)
  QALY is derived from Utility
CEA versus CUA

Both compare 2 or more interventions

<table>
<thead>
<tr>
<th>Method</th>
<th>Cost-Effectiveness Analysis</th>
<th>Cost-Utility Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome</td>
<td>Δ Cost / Δ Health Effect</td>
<td>Δ Cost / Δ QALY</td>
</tr>
</tbody>
</table>
QALYs and Utilities

- QALY = # of years of life * Utility of life

Example:
- Utility = 0.8
- # of years of life lived = 5
- QALY = 0.8 * 5 = 0.40
Utilities

- Preference for health
  - Not just a measure of health!

- Combine:
  - Health state a person is in
  - Valuation of health state

- Conventionally range from 0-1
  - 0 = death
  - 1.0 = perfect health

- More info in Dr. Sinnott’s upcoming HERC lecture
## Utility Calculations

<table>
<thead>
<tr>
<th>Variable</th>
<th>Jane’s health (0-1)</th>
<th>Jane’s valuation (sum to 1)</th>
<th>Joe’s health (0-1)</th>
<th>Joe’s valuation (sum to 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADL</td>
<td>0.8</td>
<td>0.15</td>
<td>0.12</td>
<td>0.8</td>
</tr>
<tr>
<td>Exercise</td>
<td>0.2</td>
<td>0.40</td>
<td>0.08</td>
<td>0.2</td>
</tr>
<tr>
<td>Mental Clarity</td>
<td>0.4</td>
<td>0.40</td>
<td>0.16</td>
<td>0.4</td>
</tr>
<tr>
<td>Emotional well-being</td>
<td>0.9</td>
<td>0.05</td>
<td>0.045</td>
<td>0.9</td>
</tr>
<tr>
<td>Total</td>
<td>---</td>
<td>1.0</td>
<td><strong>0.405</strong></td>
<td>---</td>
</tr>
</tbody>
</table>

Note: The values in bold are the final utility scores.
Utility $\rightarrow$ QALY

- Jane’s utility is 0.405
  - Jane lives for 10 years
    - $0.405 \times 10 = 4.05$ QALYs
  - Jane lives for 12 years
    - $0.405 \times 12 = 4.86$ QALYs

- Joe’s utility is 0.595
  - Joe lives for 10 years
    - $0.595 \times 10 = 5.95$ QALYs
  - Joe lives for 5 years
    - $0.595 \times 5 = 2.975$ QALYs
Advantages of Utilities/QALYs

- Incorporate morbidity and mortality into a single measure

- Allows for comparison across disparate strategies
  - Newborn screening versus prostate cancer treatment
  - Early childhood education versus community health centers
ICERs in a Cost-Utility Analysis

ICER = \( \frac{\text{Cost}_B - \text{Cost}_A}{\text{QALY}_B - \text{QALY}_A} \)

If ICER < $50,000/QALY, is generally considered cost-effective

– More on this later
ICERs in a CUA, Example

ICER = \( \frac{\text{Cost}_B - \text{Cost}_A}{\text{QALY}_B - \text{QALY}_A} \)

<table>
<thead>
<tr>
<th></th>
<th>Program A</th>
<th>Program B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention</td>
<td>Mobile text messaging for medication adherence</td>
<td>Diabetes care coordinator</td>
</tr>
<tr>
<td>Cost</td>
<td>$40,000</td>
<td>$150,000</td>
</tr>
<tr>
<td>QALYs</td>
<td>25</td>
<td>35</td>
</tr>
</tbody>
</table>

\[
\text{ICER} = \frac{$150,000 - $40,000}{35 - 25} = \frac{$110,000}{10} = $11,000
\]

Cost-Effective
Cost saving

- Cost-effective ≠ cost-saving!!

<table>
<thead>
<tr>
<th>Cost-Saving</th>
<th>Cost-Effective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost less, provides greater health</td>
<td>Costs more, provides proportionally more health</td>
</tr>
<tr>
<td></td>
<td>Costs less, provides proportionally less health</td>
</tr>
</tbody>
</table>
Cost-Effective

- Program B costs more than Program A, but Program B provides proportionally more health benefit than Program A

Proportional?
- ICER is < Willingness to Pay Threshold
Willingness to Pay (WTP)

- U.S. – Often $50,000/QALY
  - Willing to pay *up to* $50,000 for one additional QALY

- Arbitrary, heavily criticized
  - Not an empirically-derived threshold
Thresholds for WTP

- Panel on Cost-Effectiveness in Health and Medicine does not endorse any WTP threshold

- NICE (U.K.) does not have an explicit threshold for reimbursement
  - Recommended results are presented using WTP of £20,000 and £30,000
Cost-Benefit Analysis
Cost-Benefit Analysis

- Costs and Effects are expressed entirely in dollar terms
  - Convert health effect $\rightarrow$ cost

Incremental Benefit (cost) – Incremental Costs = Net social benefit

- If Net social benefit is positive, then program is worthwhile
Assigning a dollar value to life

- **Willingness to Pay (WTP)**
  - Examine revealed WTP or elicit WTP
  - Framing effects, loss aversion, age-related effects, varying levels of disposable income

- **Human Capital Approach**
  - Use projected future earnings to value a life
  - Assumes an individual’s value is entirely measured by formal employment.
    - Children?
    - Retired people?
    - Pay differential between men and women, different races
Cost-Benefit Analysis in Healthcare/Medicine

- Very rarely used:
  - Problems with assigning a dollar value to life
  - Problems with evaluating quality of life
Budget-Impact Analysis
Budget Impact Analysis

- Estimate the financial consequences of adopting a new intervention.

- Usually performed in addition to a cost-effectiveness analysis
  - CEA: does the intervention provide good value?
  - BIA: can we afford it?
BIA, example

Drug A has an ICER of $28,000 per QALY compared with Drug B. It is cost-effective.

Drug B costs $70,000.

Therefore, Drug A costs $98,000. There are 10,000 people eligible for Drug A, resulting in a total cost of $980 million dollars.
BIA tells us

- The true “unit” cost of the intervention
- The number of people affected by the intervention
- To give us an understanding of the total budget required to fund the intervention
## CEA versus BIA

<table>
<thead>
<tr>
<th></th>
<th>CEA</th>
<th>BIA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Purpose</strong></td>
<td>Does this intervention provide high value?</td>
<td>Can we afford this intervention?</td>
</tr>
<tr>
<td><strong>Outcome</strong></td>
<td>Cost and health outcomes</td>
<td>Cost</td>
</tr>
<tr>
<td><strong>Size of Population</strong></td>
<td>Not explicitly considered</td>
<td>Explicitly Considered</td>
</tr>
</tbody>
</table>

More info in Dr. Sinnott’s upcoming BIA lecture
Approaches to Decision Analysis
Methods for decision analysis

- Modeling

- Measurement alongside a clinical trial
# Types and Methods for Decision Analysis

<table>
<thead>
<tr>
<th></th>
<th>Measurement alongside a clinical trial</th>
<th>Modeling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost-Effectiveness Analysis</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Cost-Benefit Analysis</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Budget Impact Analysis</td>
<td></td>
<td>x</td>
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</table>
Measurement alongside a trial

- “Piggyback” onto an existing RCT

- Collect extra information from patients enrolled in the trial
  - Cost (based on utilization)
  - Utilities
  - (Efficacy and AEs are already being collected)
Modeling

- No real-world experiment exists

- Build a mathematical framework to understand the relationship between inputs and outputs

- Build model structure in software, populate it with inputs (from literature). Run model to derive outputs

- You decide on the boundaries of the analysis
  - Time frame, population, interventions of interest
## Modeling versus Measurement

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Modeling</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Treatments considered</strong></td>
<td>• Only the ones in the RCT (which may include placebo)</td>
</tr>
</tbody>
</table>
| **Advantage** | • Design case-report forms  
• Individual-patient data (subgroup analysis)  
• Utilities may be more accurate (treatment and health condition specific) | • Don’t need to wait for a trial to be funded to do your analysis |
| **Disadvantage** | • Short time frame – will still have to project beyond the trial  
• Will not provide all of your inputs  
• Utilities come from patient perspective, rather than community | • Inputs need to come from similar studies on your population of interest |
Cost-effectiveness Analysis for Resource Allocation
How is CEA used for decision making?

- Ex-US: Used by NICE (U.K.), PBAC (Australia), CADTH (Canada) for regulatory/market access purposes

- US: Medicare has historically not used cost-effectiveness to drive coverage decisions, ACA prohibits this

“(e) The Patient-Centered Outcomes Research Institute established under section 1181(b)(1) shall not develop or employ a dollars-per-quality adjusted life year (or similar measure that discounts the value of a life because of an individual’s disability) as a threshold to establish what type of health care is cost effective or recommended. The Secretary shall not utilize such an adjusted life year (or such a similar measure) as a threshold to determine coverage, reimbursement, or incentive programs under title XVIII.”

(d) In GENERAL, Part D of title XI of the Social Security
U.S. Cost-Effectiveness Analysis

- Pharmaceutical companies – international markets
- Academia
- Veterans Health Administration

- NOT used by FDA or CMS
Summary

- 3 major types of decision analysis:
  - Budget Impact Analysis
  - Cost-Benefit Analysis
  - Cost-Effectiveness Analysis
    - Cost-Utility Analysis
      - QALYs, a measure of morbidity and mortality

- Operationalize your decision analysis:
  - Measurement alongside a clinical trial, or
  - Modeling

- Cost-effective ≠ cost-saving!
Resources: Decision Analysis and CEA


Questions?

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