COST-EFFECTIVENESS ANALYSIS

LDI Health Economics and Management Workshop

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Outline

- Introduction to cost-effectiveness analysis (CEA)
- Cost-effectiveness study designs
- Cost-effectiveness methods overview
- Choice criteria for CEA

Outcomes Research

- Evaluates outcomes of medical therapies (potentially including costs) and their impacts on people, organizations, and society
- Therapies can include drugs, devices, procedures, or broader programmatic or system interventions
- Outcomes can include mortality, morbidity, functional status, mental well-being, other aspects of health-related quality of life, cost, etc.

Cost-Effectiveness Analysis

- Outcomes research specifically focused on economic value of therapies / delivery systems / behavioral interventions
- Multidisciplinary methods
  - Economics
  - Epidemiology
  - Medicine
  - Pharmacy
  - Decision sciences
  - Operations research
  - Statistics / biostatistics
  - Other social sciences

Economic Messages

- Therapy is good/bad value
- Budget impact
- Burden of illness
  - Often flag waving: “This disease is important…”
- Specific messages addressed depend in part on:
  - Disease and therapy under evaluation
  - Other therapies available to treat condition
  - Interest of regulatory bodies, providers, payers, and patients

Cost-Effectiveness Study Designs

Cost-Effectiveness Study Designs

- Clinical trials
  - Economic evaluation in clinical trials widespread
  - Little to no selection bias, but potential issues of generalizability
- Observational studies
  - Often more generalizable, but problems with selection bias
- Decision models
  - Often used to address pressing questions for which direct data are not available
  - Shares strengths and weaknesses of source data
  - Added uncertainties related to combining data from multiple sources and projection beyond the data

Decision Analysis Approaches

- Most frequently used healthcare decision analytic approaches
  - Decision trees
  - Markov models
- Can be used:
  - To analyze data from trial
  - To perform analyses that incorporate data from trial(s) plus observational data
  - (Most frequently) To perform analysis when trial data are unavailable

Cost-Effectiveness Methods Overview

Economic Evaluation Methods Overview

- Types of analyses
- Steps in economic evaluation
- Types of outcomes
- Perspective

Types of Analyses

Types of Analysis

- Cost identification
- Cost-effectiveness / cost-utility
- Cost-benefit
- Generally distinguished by:
  - Outcomes included: e.g., costs alone vs costs and effects
  - How outcomes are quantified: e.g., as money alone or as health and money

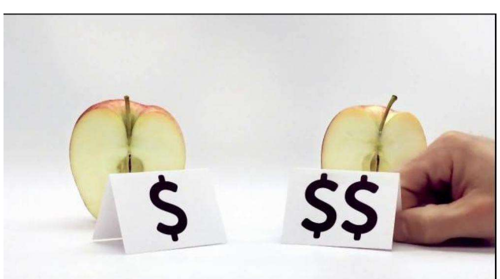
Cost Identification / Cost Minimization / Cost-Cost Analysis

Cost-Identification, etc.

- Estimates difference in costs between therapies, but not difference in other outcomes
- Commonly conducted when no difference observed in effectiveness
  - "As no statistical significant difference among the mean QALYs gained with the different [hormonal therapies] was detected (p = 0.12), CUA was replaced by a cost minimization analysis."

Lazarro et al. Archivio Italiano di Urologia, Andrologia. 2007:79:104-7

Appropriate Only When Therapies are Identical



Dish Network TV Spot, "Apples", 2015

Cost Identification ???

2016 Kia Rio, MSRP $14,165

Mercedes
2016 SLK, MSRP $47,925

Is failure to detect a difference same as a demonstration of equivalence?

Cost-Effectiveness Analysis

Cost-Effectiveness Analysis

- Estimates differences in costs and differences in outcomes between interventions
- Costs and outcomes measured in different units
- Costs usually measured in money terms; outcomes in some other units
- Incremental cost-effectiveness ratio

$$\frac{\text{Costs}_1 - \text{Costs}_0}{\text{Effects}_1 - \text{Effects}_0}$$

- Most used form of economic evaluation

Cost-Effectiveness A Relative Measure

- Cost-effectiveness is a *relative* measure; no program is "cost-effective" in abstract
  - Results meaningful in comparison with:
    - A predetermined standard
      - e.g., $50,000 per quality-adjusted year of life saved
    - Other accepted and rejected interventions (e.g., a league table)

What Is Maximum Acceptable WTP?

- US Gov't
  - EPA: 9.1 M / life (~222K / undiscounted YOLS)
  - FDA: 7.9 M / life (~176K / undiscounted YOLS)
  - DOT: 6 M / life (~133K / undiscounted YOLS)
- Australia: $AU 42K - 76K /YOLS
- Italy: €60,000/QALY
- Netherlands: €80 000/QALY
- Sweden: SEK 500,000 (€54,000) / QALY
- UK: £20 - 30K / QALY
- WHO report: 3 times GDP per DALY

Cost-Benefit Analysis

Cost-Benefit Analysis

- Estimates differences in costs and differences in benefits in same (usually monetary) units
- As with cost-effectiveness, requires a set of alternatives
- Net benefit is preferred cost-benefit result
  - $(\text{Benefit}_1 - \text{Benefit}_0) - (\text{Cost}_0 - \text{Cost}_0)$

Types Costs and Effects

Types of Costs

- Direct: medical or nonmedical
- Time costs: Lost due to illness or to treatment
- Intangible costs
- Types of costs included in an analysis depend on:
  - What is affected by illness and its treatment
  - What is of interest to decision makers
    - e.g., a number of countries' decision makers have indicated they are not interested in time costs

What Effectiveness Measure?

- Can calculate a ratio for any outcome
  - Cost per toe nail fungus day averted
- For cost-effectiveness ratios to be an informative, must know willingness to pay for outcome
  - In many jurisdictions, quality-adjusted life year (QALY) is recommended outcome of cost-effectiveness analysis

QALYS / DALYS

- Economic outcomes that combine preferences for both length of survival and quality into a single measure
- Help us decide how much to pay for therapies that:
  - Save fully functional lives/life years

    VS
  - Save less than fully functional lives/life years
    - e.g., heart failure drug that extends survival, but extra time spent in NYHA class III

    VS
  - Don't save lives/life years but improve function
    - e.g., heart failure patients spend most of their remaining years in class I instead of class III

Compare magnitude of difference in costs and outcomes and evaluate "value for costs"

How do we choose among multiple therapies?

Colorectal Cancer Screening

- Suppose 5 screening strategies have the following discounted costs and life expectancies:

Treatment	Cost	YOLS
S1 Sig Q10	1290	17.378
S2 Sig Q5	1535	17.387
S3 U+Sig, Q10	1810	17.402
S4 C, Q10	2030	17.396
S5 U+Sig, Q5	2035	17.407

Frazier AL, et al. JAMA. 2000;284:1954-61.

- What calculations might help us make a choice between them?

Mistake #1

- Divide a therapy's cost by its outcome; compare resulting ratios

Treatment	Cost		YOLS		C/Y
S1 Sig Q10	1290	÷	17.378	=	74.23
S2 Sig Q5	1535	÷	17.387	=	88.28
S3 U+Sig, Q10	1810	÷	17.402	=	104.01
S4 C, Q10	2030	÷	17.396	=	116.69
S5 U+Sig, Q5	2035	÷	17.407	=	116.91

- Sometimes mistakenly referred to as the average cost-effectiveness ratios

Guerra RL et al. Cost-Effectiveness of Routine Diagnostic Evaluation of Pulmonary TB

Treatment	Cost	#Correct Diagnoses	Cost/Correct Diagnosis
Rx	5368.47	74	72.55
Prevention	***5944,15***	***96***	***61.92***
Early Detection	5442.17	96	56.69

Dividing a Therapy's Costs by Its Effects is "Generally Uninformative"

	Cost	Effect	Ratio
Example 1			
Rx1	2,800	0.28	10,000
Rx2	5,800	0.29	20,000
Example 2			
Rx1	2,800	0.28	10,000
Rx2	11,200	0.56	20,000

Dividing a Therapy's Costs by Its Effects is "Generally Uninformative"

	Cost	Effect	Ratio
Example 1			
Rx1	2,800	0.28	10,000
Rx2	5,800	0.29	20,000
	(5,800-2,800) / (0.29-0.28) = 300,000		
Example 2			
Rx1	2,800	0.28	10,000
Rx2	11,200	0.56	20,000
	(11,200-2,800) / (0.56-0.28) = 30,000		

Mistake #2

- Calculate ratios for all therapies versus S1; compare resulting ratios

Treatment	Cost	ΔCost	YOLS	ΔYOLS	ACER
S1 Sig Q10	1290	--	17.378	--	--
S2 Sig Q5	1535	245	17.387	.009	27,222
S3 U+Sig, Q10	1810	520	17.402	.024	21,667
S4 C, Q10	2030	740	17.396	.018	41,111
S5 U+Sig, Q5	2035	745	17.407	.029	25,690

- Correctly referred to as average cost-effectiveness ratios

Average Cost-Effectiveness Ratio

- If these were the correct ratios, what should we conclude?

Treatment	Cost	ΔCost	YOLS	ΔYOLS	ACER
S1 Sig Q10	1290	--	17.378	--	--
S2 Sig Q5	1535	245	17.387	.009	27,222
S3 U+Sig, Q10	1810	520	17.402	.024	21,667
S4 C, Q10	2030	740	17.396	.018	41,111
S5 U+Sig, Q5	2035	745	17.407	.029	25,690

What is Good Value?

- The “cost-effective” strategy delivers the largest health outcome that we are still willing to pay for
- Why don’t the average ratios provide this information?

What's Wrong with the Average Cost-Effectiveness Ratio

Treatment	Cost	ΔCost	YOLS	ΔYOLS	ACER
S1 Sig Q10	1290	--	17.378	--	--
S3 U+Sig, Q10	1810	520	17.402	.024	21,667
S5 U+Sig, Q5	2035	745	17.407	.029	25,690

- 25,690 for U+Sig, Q5 gives credit for the 520 we are already spending and the .024 YOLs we are already receiving from S3
- Compared to S3, we are spending almost 50% more for S5 and receiving only about 20% more of the outcome

Incremental Cost-Effectiveness Ratio

- Basic idea for correct ratio: calculate ratio for S2 vs S1, S3 vs S2, S4 vs S3 and S5 vs S4

Treatment	Cost	ΔCost	YOLS	ΔYOLs	ICER
S1 Sig Q10	1290	--	17.378	--	--
S2 Sig Q5	1535	245	17.387	.009	27,222
S3 U+Sig, Q10	1810	275	17.402	.015	18,333
S4 C, Q10	2030	220	17.396	-.006	-36,667
S5 U+Sig, Q5	2035	5	17.407	.011	455

- But not always right

Problem 1

- Treatments must be correctly ordered

Treatment	Cost	YOLS
S1 Sig Q10	1290	--
S2 Sig Q5	1535	245
S3 U+Sig, Q10	1810	520
S4 C, Q10	2030	740
S5 U+Sig, Q5	2035	745

Frazier AL, et al. JAMA. 2000;284:1954-61.

- In this case they are

Problem 2

- Never want to spend more and obtain less outcome as in S4 vs S3. **S4 is strongly dominated by S3**

Treatment	Cost	Δ	YOLS	Δ	ICER
S1 Sig Q10	1290	--	17.378	--	--
S2 Sig Q5	1535	245	17.387	.009	27,222
S3 U+Sig, Q10	**1810**	**275**	**17.402**	**.015**	**18,333**
S4 C, Q10	**2030**	**220**	**17.396**	**-.006**	**-36,667**
S5 U+Sig, Q5	2035	225	17.407	.005	45,000

- S4 should be eliminated from consideration for adoption

Problem 3

- Don't want to buy less outcome for a higher cost per unit of outcome as in S2 vs S3: **S2 weakly dominated by S3**

Treatment	Cost	Δ	YOLS	Δ	ICER
S1 Sig Q10	1290	--	17.378	--	--
S2 Sig Q5	**1535**	**245**	**17.387**	**.009**	**27,222**
S3 U+Sig, Q10	**1810**	**275**	**17.402**	**.015**	**18,333**
~~S4 C, Q10~~	~~2030~~	~~220~~	~~17.396~~	~~-.006~~	~~S Dom~~
S5 U+Sig, Q5	2035	225	17.407	.005	45,000

Problem 3

- S2 should be eliminated from consideration for adoption
  - Must recalculate ratio for S3 vs S1

Treatment	Cost	Δ	YOLS	Δ	ICER
S1 Sig Q10	1290	--	17.378	--	--
~~S2 Sig Q5~~	~~1535~~	~~245~~	~~17.387~~	~~.009~~	~~W Dom~~
S3 U+Sig, Q10	1810	520	17.402	.024	21,667
~~S4 C, Q10~~	~~2030~~	~~220~~	~~17.396~~	~~-.006~~	~~S Dom~~
S5 U+Sig, Q5	2035	225	17.407	.005	45,000

Steps for Calculating ICER

- Step 1: Rank order therapies in ascending order of either costs or outcomes (final ordering of nondominated therapies unaffected by variable chosen)
  - Already correctly ordered by cost
- Step 2: Eliminate therapies that are strongly dominated (i.e., have increased costs and reduced effects compared with at least one other alternative
  - S4 is strongly dominated by S3
- Step 3: Compute incremental cost-effectiveness ratios for each adjacent pair of remaining outcomes (e.g., between options 1 and 2; between options 2 and 3; etc.)

Steps for Calculating ICER (2)

- If resulting ratios are ranked from lowest to highest, can skip to step 6. If not....
- Step 4: Eliminate therapies that are less effective (costly) but have a higher cost-effectiveness ratio than next higher ranked therapy (weakly dominated/extended dominance)
  - "S2 is weakly dominated by S3"; "eliminate S2 because of extended dominance by S3"

Steps for Calculating ICER (3)

- Step 5: Recalculate ratio for next higher ranked therapy vs next lower ranked therapy
  - E.g., S3 vs S1
  - Recalculated ratio will always be higher than original ratio, but can't be higher than weakly dominated ratio
    - E.g., 27,222 > 21,666 > 18,333
  - If resulting ratios still not ranked from lowest to highest, may need to repeat evaluation of weakly dominated therapies several times
    - After S2 is eliminated, ratios are ordered from lowest to highest
- Step 6: Identify acceptable ratio

Reduced Table

- Candidates for adoption include S1, S3, and S5

Treatment	Cost	Δ	YOLS	Δ	ICER
S1 Sig Q10	1290	--	17.378	--	--
S3 U+Sig, Q10	1810	520	17.402	.024	21,667
S5 U+Sig, Q5	2035	225	17.407	.005	45,000

- If W < 21667, adopt S1
- If W $\geq$ 21,667 and <45,000, adopt S3
- If W$\geq$ 45,000, adopt S5

Take Home Messages

- Decision making using cost-effectiveness ratios requires attention to incremental cost-effectiveness ratios
- To make decisions using these ratios, they must be compared to:
  - A predefined standard (i.e., an acceptability criterion) against which they can be compared (e.g., $50,000 per year of life saved might be considered largest acceptable ratio), or
  - Other accepted and rejected interventions (e.g., against league tables)