COST-EFFECTIVENESS ANALYSIS

Health Economics Introductory Workshop
Leonard Davis Institute of Health Economics

Sponsored by Janssen Pharmaceuticals, Inc.

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Outline

- Introduction to cost-effectiveness analysis (CEA)
- Choice criteria for CEA

Cost-Effectiveness Analysis (I)

- Estimates costs and outcomes of intervention
- Costs and outcomes expressed in different units
  - If outcomes aggregated using measures of preference (e.g., quality-adjusted life years saved), referred to as cost utility analysis
- Most used form of economic analysis

Cost-Effectiveness Analysis (II)

- Results meaningful:
  - If there exists a predefined standard (i.e., a threshold, or maximum acceptable cost-effectiveness ratio, or an acceptability criterion) against which they can be compared
    - e.g., $50,000 per year of life saved might be considered the threshold, or
  - Compared with other accepted and rejected interventions (e.g., against league tables)

Cost-Effectiveness "History"

- $/Life saved
- $/Year of life saved (YOL)
- $/Quality adjusted life year saved (QALY)
- ??? US Congress and outlawing QALYs ???

Cost-Effectiveness Ratios

- Cost-effectiveness ratio

$$\frac{\text{Costs}_1 - \text{Costs}_2}{\text{Effects}_1 - \text{Effects}_2}$$

- A ratio exists for every pair of options
  - 1 option (case series), no ratios calculated
  - 2 options, 1 ratio
  - 3 options, 3 ratios (option 1 versus option 2, option 1 versus option 3, and option 2 versus option 3)
- In "efficient" selection algorithm, don't necessarily calculate all possible ratios

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

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 quite right

Problem 1

- 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 2

- 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 2

- 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 (2)

- 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

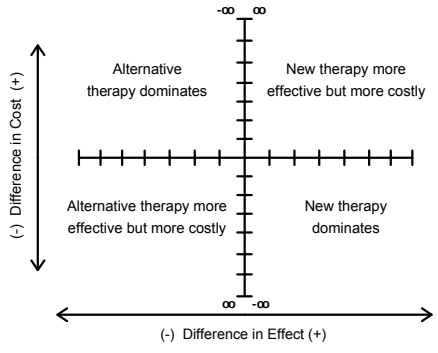
Treatment	Cost	Δ	YOLS	Δ	ICER
S1 Sig Q10	1290	--	17.378	--	--
S3 U+Sig, Q10	1810	520	17.402	.024	21,667
S5 U+Sig, Q5	2035	225	17.407	.005	45,000

- If W < 21667, adopt S1
- If W ≥ 21,667 and <45,000, adopt S3
- If W≥ 45,000, adopt S5

Simultaneous Comparison

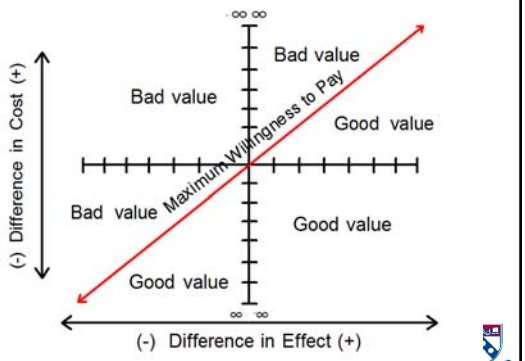
- Description of selection algorithm may suggest a path through different options, with adoption of lower cost/ effect pairs before adoption of higher cost/effect pairs
- Not true
  - Selection algorithm is simply step-by-step procedure that simultaneously compares all options

Cost-Effectiveness Plane



- Axes
- Origin
- Average ratios
- Incremental ratios

Good and Bad Value



What Is Maximum Acceptable Ratio?

- 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

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)