Introduction to Economic Evaluation of Healthcare

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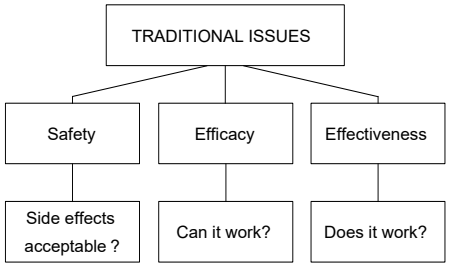
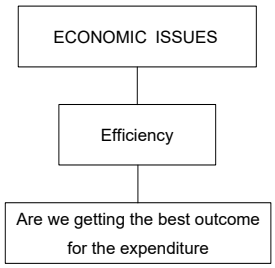
Epi 550

February 21, 2020

Evaluation of Medical Care (I)



Evaluation of Medical Care (II)



Principles of Economic Assessment

- Rules exist for assessing costs and benefits
- Assumptions are made explicit
- As a result:
  - There is consistency of approach
  - It is clear what is included and excluded from calculations

Scarcity

- Resources are limited
- Choices must be made
- When a resource is used, opportunity to use it for something else is lost
- Value of a resource in its best alternative use is its "opportunity cost"

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

Who is Listening?

Not the U.S. Congress

"The Patient-Centered Outcomes Research Institute . . . 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"

The Patient Protection and Affordable Care Act

Is Some Use in US

- NIH expert guideline panels and Environmental Protection Agency can and do use
- Chambers et al.: Lack of an estimate of cost-effectiveness associated with a decreased likelihood of Medicare coverage decisions
- Medicaid, Vaccines for children (But not formally)
- Aspinall et al.: Veterans Health Administration "has emphasized use of cost-effectiveness data, especially for newer, costly drugs."
- Neuman and Bliss: 12% of FDA DDMAC warning letters between 2002 and 2011 cite health economic violations

But Not All Agencies

- Medicare and Medicaid prohibited from consideration of costs and cost-effectiveness in recommendations and policies (but use informally)
- ACIP and USPSTF prohibited

Medicare's Coverage Policy

- So far, inclusion of economic considerations limited to:
  - If new technology is worse, don't cover no matter what the cost
  - If new technology is no better and costs more, don't cover
  - If new technology is possibly better but possibly not, don't cover unless it costs less
  - If new technology is definitely better, always cover

Others

- AMCP Guidance for Submission of Clinical and Economic Evaluation Data to Support Formulary Listing in U.S. Health Plans and Pharmacy Benefits Management Organizations
- Cost effectiveness analysis (never cost benefit) used in other countries (UK, Canada, Australia, etc.) to suggest/determine what will be paid for under a (nearly) free single insurance plan. The plan either pays in full or pays nothing

Economic Evaluation Methods Overview

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

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 ???

2020 Kia Rio, MSRP $15,850

Mercedes
2019 SL, MSRP $91,995

When's Cost-Minimization Appropriate?

- When purchase price is only consideration
- What other considerations might be appropriate?
  - Other costs
    - Expected lifetime maintenance cost
    - Expected lifetime gasoline cost
    - Expected lifetime cost of future cars
  - Total mileage
    - Quality-adjusted mileage
  - WOW factor!
  - Time/opportunities lost due to car being serviced
  - Etc.

ORIGINAL ARTICLE

ONLINE FIRST

Immediate Adenoidectomy vs Initial Watchful Waiting Strategy in Children With Recurrent Upper Respiratory Tract Infections

An Economic Evaluation

Chantal W. B. Boonacker, PhD; Maaike T. A. van den Aardweg, MD; Pieter H. Bivos, MSc; Arno W. Hoes, MD, PhD; Anne G. M. Schilder, MD, PhD; Maroesha M. Rovers, PhD

JAMA Otolaryngol. 2013;139:129-33.

Clinical Report:

van den Aardweg MTA, et al. Effectiveness of adenoidectomy in children with recurrent upper respiratory tract infections: open randomised controlled trial. BMJ. 2011;343:d5154 doi: 10.1136/bmj.d5154.

Cost-Identification Example

	Adenoidect	WW	Diff	95% CI
URTI episodes	7.86	7.89	-.03	-1.72 to 1.76
URTI days	66.25	67.2	-.95	-10.5 to 4.5
Severe episodes	3.97	3.54	.42	-.63 to 1.52
Severe days	48.49	46.2	2.28	-15.6 to 20.2
School absence	1.75	1.9	-.15	-.78 to .48
Cost (Median)	$1995	$1215	$780	(NR)

van den Ardweg MTA, et al.
Boonacher CWD, et al.

Conclusion: Adenoidectomy Vs Watchful Waiting

"...in children selected for adenoidectomy for recurrent URTIs, immediate adenoidectomy results in an increase in costs, whereas it confers no clinical benefit over an initial watchful waiting strategy?"

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

Problems With Cost Identification

- Old version
  - If two therapies' effects are identical, adopt cheaper of two
    - Effect maximization corollary: If two therapies' costs identical, adopt more effective of two
- New version
  - Generally can't conclude two therapies are identical
    - At most fail to reject null hypothesis
  - Cost-minimization analysis unlikely to be appropriate

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

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

- NEVER compare:

$$\frac{\text{Costs}_1}{\text{Effects}_1} \quad \text{VS} \quad \frac{\text{Costs}_0}{\text{Effects}_0}$$

Addiction
RESEARCH REPORT
doi:10.1111/j.1360-0443.2010.03001.x

Cost-effectiveness of extended buprenorphine–naloxone treatment for opioid-dependent youth: data from a randomized trial

Daniel Polsky[1], Henry A. Glick[1], Jianing Yang[2], Geetha A. Subramaniam[3]*, Sabrina A. Poole[4] & George E. Woody[5]

Buprenorphine/Nalaxone: Opioid Addicted Youth

- The data *

	Cost	Opioid Free Year
Usual Care	9210	0.319
Bup/Nal	9293	0.589

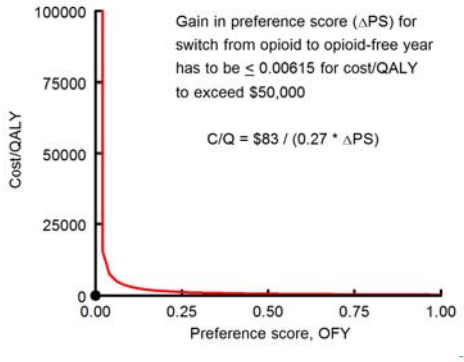
- Cost-effectiveness ratio

$$\frac{9293 - 9210}{0.589 - 0.319} = \frac{83}{0.27} = 307$$

95% CI, Dominates to 21,100/OFY

* 1-year results Polsky et al., Cost-effectiveness of extended buprenorphine-nalaxone… Addiction. 2010;105:1616-24

Almost Surely Good Value



Cost-Effectiveness 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 Value W?

- Can calculate a ratio for any outcome
  - e.g., Cost per opioid-free day
- To be informative, must know willingness to pay
  - Differs by outcome
    - If 50k-100k per QALY, doesn't mean it's 50k-100k per opioid-free year
  - Can differ among decision makers
  - Can differ for single decision maker based on on other features of decision problem
    - E.g., NICE
      - Less than 24 months of life expectancy and therapy offers at least 3 extra months
      - Licensed/indicated for small patient populations

What Is US Maximum WTP?

- No general agreement on 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)
  - Cost/QALY thresholds, recent review of CEA for 36 precision medicine interventions (2010-2018)
    - $50,000, N=10
    - $100,000, N=12
    - $50,000 to $100,000, N=2
    - $100,000 to $150,000, N=1
    - Other=3
    - Unstated, N=8

Cost-Utility Analysis

- Costs and Outcomes measured in different units AND outcomes expressed in units of utility (e.g., QALYs)
- Referred to either as a fourth type of analysis or as a subset of cost-effectiveness analysis

Choosing Among Alternative Interventions

	Effects	
Costs	A < B	A > B
A > B	B Dominant	Incremental Cost-Effectiveness Analysis
A < B	Incremental Cost-Effectiveness Analysis	A Dominant

Dominance and Choice

- Old version: Calculate cost-effectiveness ratios only when one therapy cost more and is more effective
  - Other outcomes indicate either dominance (e.g., cost less and does more) or a toss-up (e.g., equal cost and effect)
- New version: Omit calculation of cost-effectiveness ratios only when one therapy costs significantly less and is significantly more effective (i.e., significantly dominates the alternative)
  - e.g., when one therapy is significantly more effective but its cost-savings are not significant, the resulting CI for the CER may indicate we can't be confident that value of two therapies' differs

League Table Cost per QALY

Intervention	Ratio (US $*)
CABG for Left Main CAD	4,200
Neonatal Intensive Care (Birthweight 1-1.499 kg)	4,500
Neonatal Intensive Care (Birthweight .500-.999 kg)	31,800
CABG for Single Vessel Disease	36,300
School TB Testing Program	43,700

* 1983 value Source: Torrance, 1986

Cost-Benefit Analysis

Cost-Benefit Analysis (I)

- Estimates differences in costs and benefits in same units
  - Usually money, but any common unit possible
- As with cost-effectiveness, requires a set of alternatives
- Net benefit (preferred)

$$(Benefit_1 - Benefit_2) - (Cost_1 - Cost_2)$$

- Alternative: Benefit-cost ratio (typically not preferred)

$$\frac{(Benefit_1 - Benefit_0)}{(Cost_1 - Cost_0)}$$

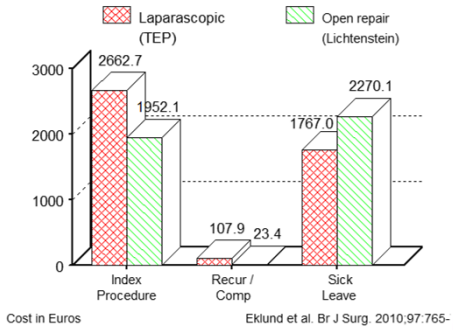
Original article

Long-term cost-minimization analysis comparing laparoscopic with open (Lichtenstein) inguinal hernia repair

A. Eklund[1], P. Carlsson[2], A. Rosenblad[3], A. Montgomery[4], L. Bergkvist[1] and C. Rudberg[1] for the Swedish Multicentre Trial of Inguinal Hernia Repair by Laparoscopy (SMIL) study group

[1]Department of Surgery, Central Hospital, Västerås, [2]Centre for Medical Technology Assessment, Linköping University, Linköping,[3]Centre for Clinical Research, County of Västmanland, Uppsala University, Uppsala, and [4]Malmö University Hospital, Malmö, Sweden
Correspondence to: Dr. A. Eklund, Department of Surgery, Central Hospital, 721 89 Västerås, Sweden (e-mail: arne.eklund@ltv.se)

Cost-Benefit Analysis, Inguinal Hernia Repair



Eklund et al. Br J Surg. 2010;97:765-

"Net benefit": (2662.7+107.9+1767.0)-(1952.1+23.4+2270.1) = -292 (p=.02)

Net Monetary Benefit (NMB)

- Composite measure (part cost-effectiveness, part cost benefit analysis), usually expressed in dollar terms, derived by rearranging cost-effectiveness decision rule:

  $$W^* > \Delta C / \Delta Q$$

  where W^* = maximum willingness to pay (e.g., 50,000 per QALY)
- NMB routinely (but not necessarily) expressed on cost scale, known as net monetary benefit (NMB)

  $$(W \times \Delta Q) - \Delta C$$
- Particularly important for statistical evaluation of cost-effectiveness analysis
  - e.g., sample size; direct statistical testing by use of patient-level data; etc.

CBA VS NMB

- Principal difference between CBA and NMB is in how willingness to pay is estimated
  - When estimated at the individual level, and ideally, when principles of welfare economics are employed, use of WTP yields CBA
  - When calculated as a decision maker's rule of thumb (e.g., 50,000 or 100,000), use of W yields NMB, a simple transformation of CEA

Types of Analysis Review

Review

- Investigators compared 2 treatments, "LessCost" and "MoreCure"
- Found that "LessCost" was less expensive and recommended its adoption by physicians
  - 1000 vs 1200
- What type of economic analysis are investigators carrying out?
- Do you agree with their conclusion?

Example 2

- Investigators compared 2 treatments, “LessCost” and “MoreCure.” Observed the following:

	MoreCure	LessCost	Difference
Cost	1200	1000	200
Benefit	3000	1500	1500

- Authors concluded that MoreCure is net beneficial.
- What type of economic analysis are investigators carrying out?
- Do you agree with their conclusion?

Example 3

- Investigators compared 2 treatments, “LessCost” and “MoreCure.” Observed that MoreCure cost 200 (1200 vs 1000) more than LessCost and provided 0.03 additional QALYs (35.13 vs 35.1)

$$\frac{200}{0.03} = 6667$$

- Authors recommended that MoreCure was good value for cost
- What type of economic analysis are investigators carrying out?
- Do you agree with their conclusion?

Cost-Effectiveness / Cost-Benefit Study Designs

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 tool
  - Decision trees
  - Markov models
- Can be used:
  - To analyze data from trial
    - Sometimes trial data can be analyzed directly
  - To perform analyses that incorporate data from trial(s) plus observational data
  - (Most frequently) To perform analysis when little or no trial data are available (e.g., reported changes in blood pressure or cases averted)

Decision Trees

- "Models" that use a horizontal tree-like structure to organize thoughts and data about problems (e.g., treatment decisions) and their consequences
- Characterized by decisions, chances, and outcomes
- Results based on probabilities and outcome "rewards"
- Time usually not directly modeled in decision trees

Markov Models

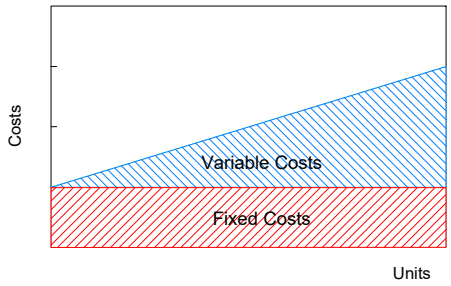
- Repetitive decision trees used for modeling conditions that have events that may/do occur repeatedly over time
  - e.g., Cycling among heart failure classes or screening for colorectal cancer
- Use of Markov models simplifies presentation of tree structure
- Markov models explicitly account for timing of events

Types of 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

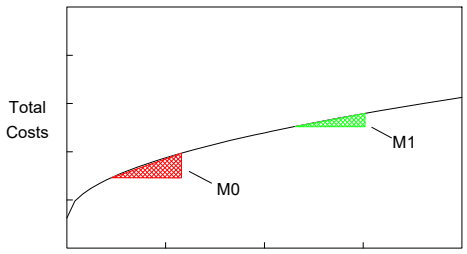
Direct Cost



Marginal Cost (I)

- Costs incurred in providing an extra unit of service, or savings realized by providing one less unit
- Calculation unaffected by fixed costs

Marginal Cost (II)



Marginal Versus Average Cost

- Suppose that:

Total drug costs	=	$50
Total doses	=	10
Average cost / dose	=	5

- Suppose, however that:

9 doses	=	$49
10 doses	=	$50
Marginal cost of 10th dose	=	$1

Cost Estimation

- Standard economic assumption
  - Purchase price = cost
- Health care (particularly U.S.)
  - Purchase price ≠ cost or there is no price to observe
- Difference relates to:
  - Health care consumers not having adequate information
  - High levels of insurance
  - Regulation
  - Hospital internal costing policies; free care
  - Economies of scale / fixed costs

Cost Estimation Paradox

- Evaluation most difficult when it is most needed
  - Markets don't exist and costs are hard to determine
- Easiest when it is needed least
  - Markets exist and costs are observable

Indirect Cost (I)

- Human capital approach
  - Advantages
    - Easy to measure
    - Assess actual gains / losses in productivity
  - Disadvantages
    - Not theoretically correct measure
    - Poor proxy for "Willingness to Pay" (although in some common situations may be a lower bound)
    - "Undervalues" anyone not earning a wage

Indirect Cost (II)

- Willingness to pay approach
  - Advantages
    - Theoretically correct measure
  - Disadvantages
    - Function of ability to pay
    - May be difficult to measure in practice

What Effectiveness Measure

- As previously noted, 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

- Economic outcome that combines 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 functioning
    - e.g., heart failure patients spend most of their remaining years in class I instead of class III

QALY Scores

- QALY or preference scores generally range between 0 (death) and 1 (perfect health)
  - E.g., health state with a preference score of 0.8 indicates that year in that state is worth 0.8 of year with perfect health
  - There can be states worse than death with preference scores less than 0

Prescored Health State Classification Instruments

- Dominant approach for QALY measurement uses prescored health state classification instruments
  - Indirect utility assessment
- Rather than reporting their own preferences for their health, participants' report their functional status across a variety of domains
- Preference scores derived from scoring rules that usually have been developed from (sometimes small) samples from general public

Point of View / Perspective

Point of View / Perspective

- Society
- Patient
- Payor (e.g., insurance company, employer)
- Provider (e.g., hospital)

Study Perspective

- Economic analyses should adopt 1 or more "perspectives"
- Perspective helps identify services that should be included in the analysis and how services should be costed out
  - e.g., patient out-of-pocket expenses may be excluded from insurer perspective
  - Not all payments may represent costs from the societal perspective

Sensitivity Analysis

- Demonstrates dependence/independence of a result on a particular assumption
- Identifies critical values of variables
- Identifies uncertainties requiring further research

Discounting

Discounting

- Costs and benefits incurred now are greater than those with a similar nominal value incurred later
- Future costs and benefits must be expressed in terms of present value

$$PDV = \sum_{T=0}^{N-1} \frac{C_T}{(1+r)^T}$$

Discounting: an Example

- Assume that a program costs $1,000 this year and for next 2 years

$$PDV = \frac{1000}{1.03^0} + \frac{1000}{1.03^1} + \frac{1000}{1.03^2}$$

i.e., PDV = 1,000 + 970.87 + 942.60

Hence, PDV = 2,913.47

Issues in Discounting

- What is appropriate discount rate for costs?
- Should monetary costs and non-monetary outcomes be discounted at same rate?

Distributional Issues

	Program 1	Program 2
Net Cost	250,000	250,000
Net Effect	10 Years	10 Years
C/E Ratios	25,000	25,000
# of Patients who Benefit	1	5

Features in Health Economic Analysis

- Consistent application of rules
- Marginal costs
- QALYS (and other measures of preference)
- Perspective
- Discounting

Objectives of Health Economic Assessments

- Economic assessments of health care aim at demonstrating most efficient use of available resources, not cuts in expenditures