Introduction to Cost-Effectiveness Analysis

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RSNA Clinical Trials Methodology Workshop

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Fred Hutch Cancer Center

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Financial Disclosure

- Research grant: GE Healthcare

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Learning Objectives

- Describe how decision analysis may improve clinical decision making
- Review cost-effective analysis as a specific type of decision analysis and illustrative example
- Discuss cost-effectiveness analysis in the context of resource allocation decision-making

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Why is Clinical Research Important to Radiology?

- Radiology currently occupies a central position in the critical pathway of diagnosis and management
- Given the financial burdens facing the US healthcare system, payers now have higher standards for the quality and quantity of evidence required to justify the adoption of new services
  - Benefit in terms of patient outcomes
  - Estimates of the magnitude of costs
- Implementation of new imaging into clinical practice will increasingly hinge on the successful conduction of research on a scale and with a level of rigor not seen in the past

JH Thrall; Radiology 2007; 243: 5-9.

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How to define the benefit of a diagnostic test?

Levels of Clinical Efficacy

1.	Technical	"How good is the image?"
2.	Diagnostic accuracy	"Can you tell normal from abnormal?"
3.	Diagnostic thinking	"Is the patient more/less likely to have disease?"
4.	Therapeutic	"Has clinical management changed?"
5.	Patient Outcome	"Has length or quality of life improved?"
6.	Societal	"Is this worth doing? Is it cost-effective?"

Fryback DG and Thornbury JR. Med Decis Making 1991; 11: 88-94.

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Is this diagnostic test worth doing?

- Implicit acknowledgment
  - Resources are limited
  - Resources are being allocated

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Resources are limited

It is ***not*** possible to provide *all* of the potentially beneficial health care services to *all* people

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Clinical Decision Making

Life is short; the Art is long; opportunity fleeting; experience delusive; *judgment difficult.*

--Hippocrates

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Clinical Decision Making

- Judgment traditionally based on
  - Experience
  - Accumulated knowledge
- Complicated by
  - Complexity
  - Uncertainty
  - Competing values and objectives

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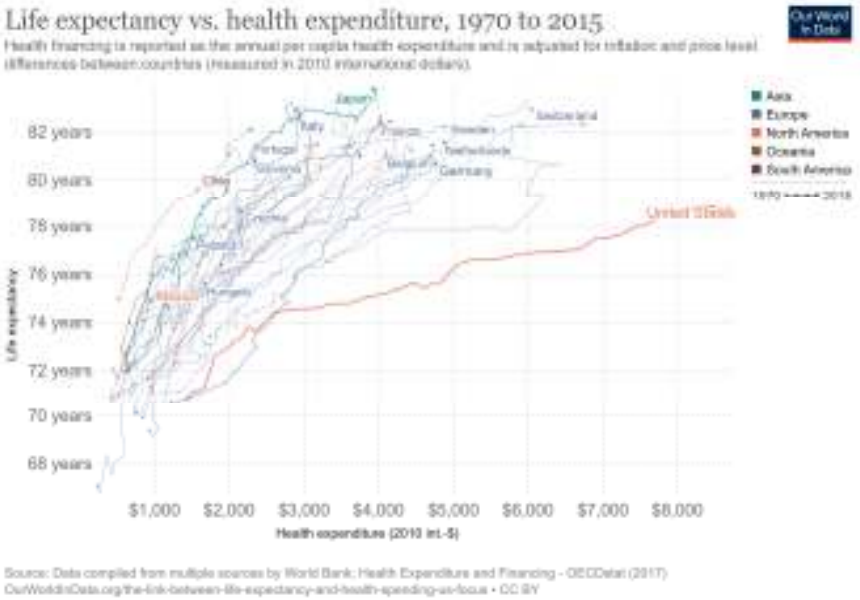

Not only is judgment difficult, there is evidence we are not doing it well!

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How can we make better decisions?

- New knowledge/new technologies → New choices
- How these choices are made is as important to their ultimate effect on health as the knowledge and technologies themselves.
- *Central premise: If we can make better choices, we can obtain better health.*
- Decision science and decision analysis provide methods and a formal process for evaluating decisions to identify choices in line with goals and values of decision makers

https://www.ahrq.gov/professionals/education/curriculum-tools/population-health/russell.html

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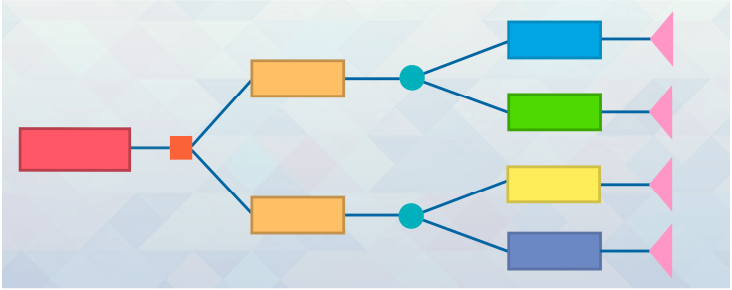
Decision Analysis

- Application of explicit, quantitative methods to analyze decisions under conditions of uncertainty
- Guides management based on the best available data
- Usually using a computer simulation model



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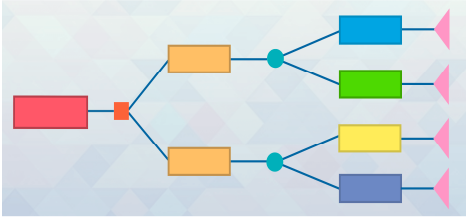
A Decision Must Be Made!

Decision Analysis

- **Explicit**
  - Describes decision
    - Assumptions made Explicit
    - Key Parameters Identified
  - Options available
  - Inherent trade-offs
- **Quantitative**
  - Known risks and benefits
  - Identifies areas of uncertainty – May guide future data collection
  - Can be updated and repeated



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Role for decision models

Useful tools for

- Synthesizing evidence
  - Estimating long term outcomes and magnitude of potential harms
  - Based on currently available data
- What-if analyses
  - When a definitive RCT is not feasible
  - i.e. Comparing 20 different screening strategies head to head


Table 1. **Breast Cancer Screening Strategies***

No screening

Screen from age 40 to 69 y
Screen from age 40 to 79 y
Screen from age 40 to 84 y
Screen from age 45 to 69 y

Screen from age 50 to 69 y
Screen from age 50 to 74 y
Screen from age 50 to 79 y
Screen from age 50 to 84 y

Screen from age 55 to 69 y
Screen from age 60 to 69 y

Mandelblatt, et al. Ann Int Med 2009; 151: 738-747

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Cost-Effectiveness Analysis

- Specific type of decision analysis
- Focused on guiding decisions where resources are limited
  - Begins with the purpose of maximizing health within budget constraints
- *Comparative* analysis of *alternative courses of action* accounting for *both* health consequences and costs

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Cost-effectiveness Analysis

- Takes into account
  - Outcomes of alternative interventions
    - Usually measured in QALYs (Quality adjusted life years)
  - Cost of resources
    - Measured in USD ($)
- Quantifies additional resources required to gain an additional unit of benefit
  - Relative measure of choosing one option over another (usually the current clinical standard)
  - Usually from a societal, often from health care sector perspective
  - Measured in $/QALY gained, aka incremental cost-effectiveness ratio (ICER)

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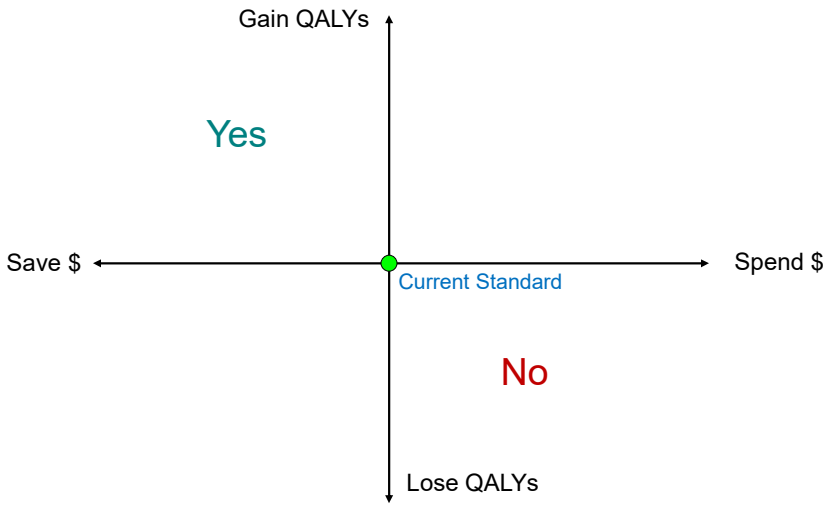
Cost-effectiveness



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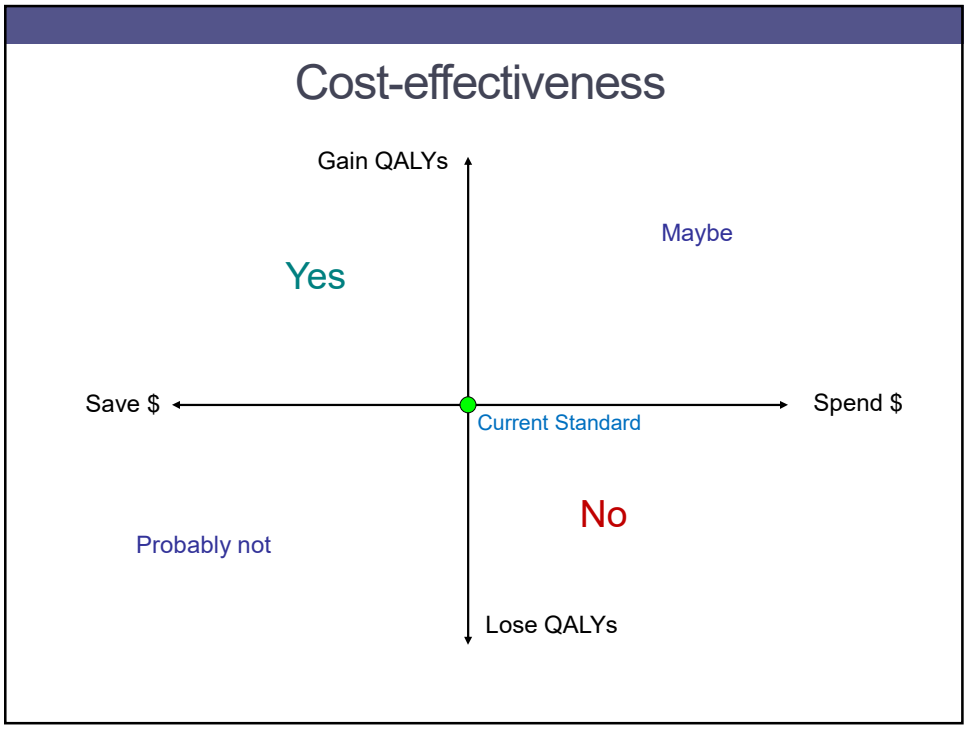
Cost-effectiveness
Gain QALYs
Maybe
Yes
Save $
Spend $
Current Standard
No
Probably not
Lose QALYs

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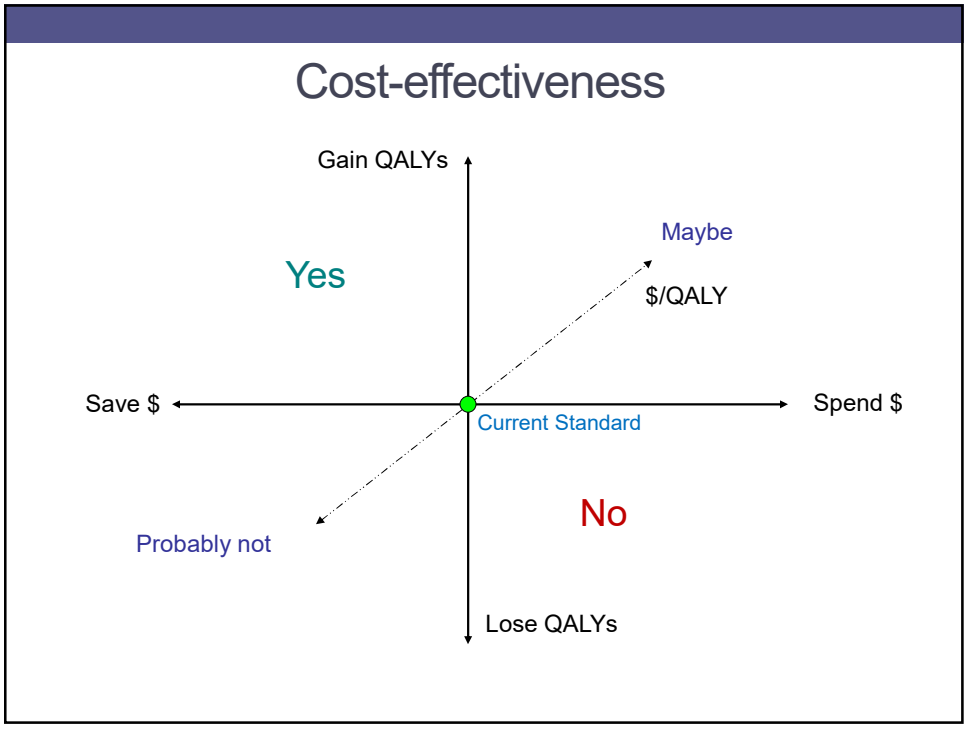
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OXFORD

JNCI J Natl Cancer Inst (2020) 112(6): djz184

doi: 10.1093/jnci/djz184
First published online September 10, 2019
Article

Long-Term Outcomes and Cost-Effectiveness of Breast Cancer Screening With Digital Breast Tomosynthesis in the United States

Kathryn P. Lowry *, Amy Trentham-Dietz, Clyde B. Schechter, Oguzhan Alagoz, William E. Barlow, Elizabeth S. Burnside, Emily F. Conant, John M. Hampton, Hui Huang, Karla Kerlikowske, Sandra J. Lee, Diana L. Miglioretti, Brian L. Sprague, Anna N. A. Tosteson, Martin J. Yaffe, Natasha K. Stout

Objective: Estimate screening outcomes and cost-effectiveness of DBT versus DM for routine breast cancer screening in the U.S.

CISNET BCSC PROSPR

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Background

- Digital breast tomosynthesis (DBT) for breast cancer screening
  - FDA approval in 2011
  - CMS reimbursement codes in 2015
  - DBT units in >84% of MQSA-certified facilities in 2022
- Early performance studies show improved recall rates and cancer detection rates compared to digital mammography (DM)*

Friedewald et al. JAMA 2014

https://www.fda.gov/radiation-emitting-products/mqsa-insights/mqsa-national-statistics

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Background

- Randomized trial of use of DBT compared to DM for routine screening in progress (TMIST)
  - Long-term results will not be available for many years
- Opportunity to use modeling to predict long-term impact of transition from DM to DBT for routine screening

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Study Overview

- Three established, validated breast cancer microsimulation models from CISNET
  - Wisconsin/Harvard, Dana Farber Cancer Institute, Georgetown/Einstein
- Patient population
  - US screening eligible women, 40-74 years
- Strategies compared
  - Replacement of DM with DBT for all screening exams starting in 2011

  vs
  - Continuation of DM screening alone
- Projected outcomes
  - QALYs
  - Costs

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Study Overview – Approach

- Federal payer perspective and lifetime horizon
- Health care costs and benefits (QALYs) discounted 3% annually
- Secondary analyses: Higher sensitivity of DBT (4% higher than DM)
- Multi-way sensitivity analyses to explore implications of varying key parameters

Skaane et al. Breast Cancer Res Treat 2018

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Parameter inputs

- Population and test performance characteristics from Population-Based Research Optimizing Screening through Personalized Regimens (PROSPR)*
  - Data for ~200,000 DBT and DM screening exams across community and academic facilities from 2011-2014
  - Sensitivity/specificity for DM and DBT by age, density, baseline versus subsequent screen
- Screening utilization by age and birth year
  - Dissemination model using National Health Information Survey (NHIS) and BCSC data
  - Distribution of annual, bi-ennial, irregular and never patterns

**Conant et al., JAMA Oncology 2019*

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Parameter inputs

- Costs from 2018 Medicare reimbursement rates, data from BCSC, medical literature
  - DBT screening costs: additional $56 (vs DM)
  - Diagnostic work-up (+/-) (BCSC), treatment costs by stage (literature)
- Health state utilities from the medical literature*
  - Age-specific utilities by stage of cancer
  - Disutilities for screening, diagnostic work-up

*Stout et al. JNCI 2006, de Haes et al Int J Cancer 1991

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Results: Base Case across 3 models*

	DM	DBT
QALYs	14,912-15,756	14,914-15,757

*Results are per 1,000 simulated U.S. women ages 40-80 in the year 2011, followed for their lifetimes. Costs and QALYs are discounted at a rate of 3% annually beginning in 2018.

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Results: Base Case across 3 models *

	DM	DBT
QALYs	14,912-15,756	14,914-15,757
Costs ($1 million USD)	$4.18-$4.60	$4.57-$5.03

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Δ QALYs	----	1.65-2.18
Δ Costs	----	$400,000-$430,000

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Δ Costs	----	$400,000-$430,000
ICER ($/QALY)	----	**$195,026-$270,135**

*Results are per 1,000 simulated U.S. women ages 40-80 in the year 2011, followed for their lifetimes. Costs and QALYs are discounted at a rate of 3% annually beginning in 2018.

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What if: DBT Sensitivity was higher?*

	DM	DBT (↑4% Sensitivity)
QALYs	14,912-15,756	14,914-15,759

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What if: DBT Sensitivity was higher?*

	DM	DBT (↑4% Sensitivity)
QALYs	14,912-15,756	14,914-15,759
Costs ($1 million USD)	$4.18-$4.60	$4.56-$5.03

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QALYs	14,912-15,756	14,914-15,759
Costs ($1 million USD)	$4.18-$4.60	$4.56-$5.03
Δ QALYs	----	2.46-3.23

*Results are per 1,000 simulated U.S. women ages 40-80 in the year 2011, followed for their lifetimes. Costs and QALYs are discounted at a rate of 3% annually beginning in 2018.

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Costs ($1 million USD)	$4.18-$4.60	$4.56-$5.03
Δ QALYs	----	2.46-3.23
Δ Costs	----	$390,000-$420,000

*Results are per 1,000 simulated U.S. women ages 40-80 in the year 2011, followed for their lifetimes. Costs and QALYs are discounted at a rate of 3% annually beginning in 2018.

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What if: DBT Sensitivity was better? *

	DM	DBT (↑4% Sensitivity)
QALYs	14,912-15,756	14,914-15,759
Costs ($1 million USD)	$4.18-$4.60	$4.56-$5.03
Δ QALYs	----	2.46-3.23
Δ Costs	----	$390,000-$420,000
ICER ($/QALY)	----	**$130,533-$156,624**

*Results are per 1,000 simulated U.S. women ages 40-80 in the year 2011, followed for their lifetimes. Costs and QALYs are discounted at a rate of 3% annually beginning in 2018.

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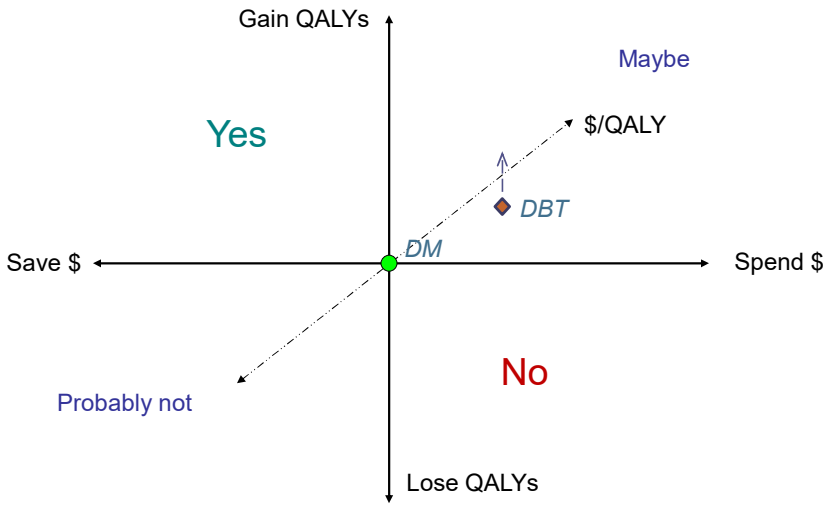
Cost-effectiveness



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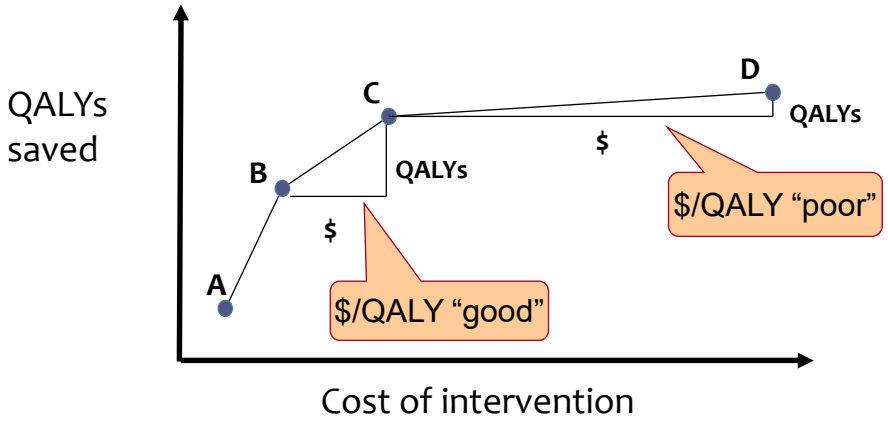
"Flat of the curve medicine"



It may be "cost-effective" to go from A to B or B to C, but change in practice from C to D is not.

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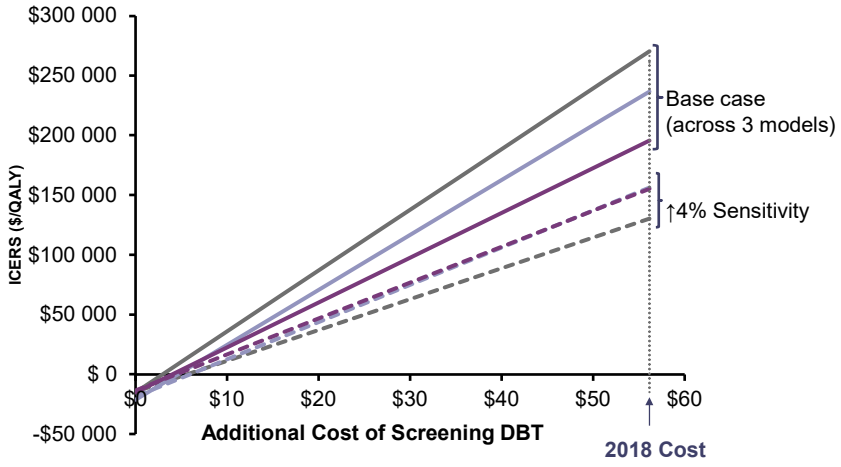
Two-Way Sensitivity Analysis: Performance x Costs of DBT



Cost-effectiveness improves with increasing sensitivity or decreased cost

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Other Outcomes*

	DM	DBT	Δ
Breast Cancer Deaths	12.42-17.08	12.41-16.87	0.00 to 0.21
Life Years	26,258-28,035	26,239-28,035	-0.16 to 1.58
False Positive Screens	911-1,034	657-767	-237 to -268

*Undiscounted outcomes per 1,000 simulated U.S. women ages 40-80 in the year 2011, followed for their lifetimes.

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*Undiscounted outcomes per 1,000 simulated U.S. women ages 40-80 in the year 2011, followed for their lifetimes.

Primary benefit of DBT is reduction of FP exams

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Implications

- Costs incurred are high relative to projected benefits
  - Primary benefit of DBT is reduction of FP exams
  - Impact on mortality is likely small
- DBT screening could be cost-effective at lower costs

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CEAs and Budgets: Additional notes

- CEAs do NOT set budgets.
- CEAs are NOT a tool for controlling costs
- By itself CEA will NOT reduce medical spending, or even reduce its growth rate
- Rather *CEA is a tool* for setting priorities among available alternatives and for guiding the use of available resources to maximize health

https://www.ahrq.gov/professionals/education/curriculum-tools/population-health/russell.html

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CEA is only part of the process

- And probably not even the most important part!
- Optimal choices also consider
  - Healthcare system infrastructure
  - Feasibility of intervention adoption
  - Values of decision makers, patients and families
    - Specifically, questions of:
      - Priority – *Should priority be given to the sickest, or most vulnerable?*
      - Aggregation – *When should large benefits to a small number of people outweigh small benefits to a large number of people?*
      - Equity – *Does CEA discriminate against people with disabilities, or elderly people?*

Second Panel on Cost-effectiveness in Health and Medicine 12/7/16 conference slides

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JAMA | Special Communication

Recommendations for Conduct, Methodological Practices, and Reporting of Cost-effectiveness Analyses

Second Panel on Cost-Effectiveness in Health and Medicine

Gillian D. Sanders, PhD; Peter J. Neumann, ScD; Anirban Basu, PhD; Dan W. Brock, PhD; David Feeny, PhD; Murray Krahn, MD, MSc; Karen M. Kuntz, ScD; David O. Meltzer, MD, PhD; Douglas K. Owens, MD, MS; Lisa A. Prosser, PhD; Joshua A. Salomon, PhD; Mark J. Sculpher, PhD; Thomas A. Trikalinos, MD; Louise B. Russell, PhD; Joanna E. Siegel, ScD; Theodore G. Ganiats, MD

- Published September 2016
- Follows up original panel report and book from 1996, which became the standard reference for CEA

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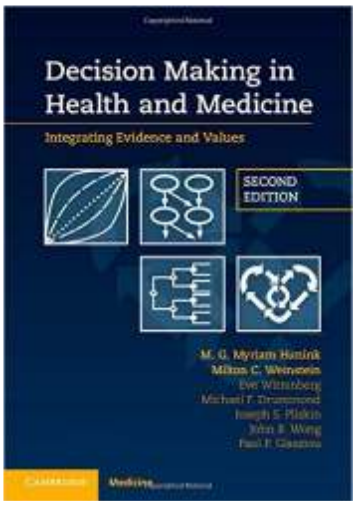
Additional references



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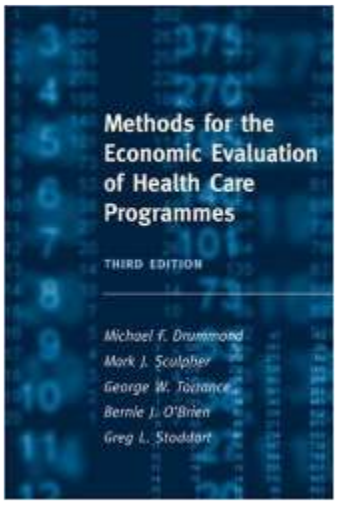
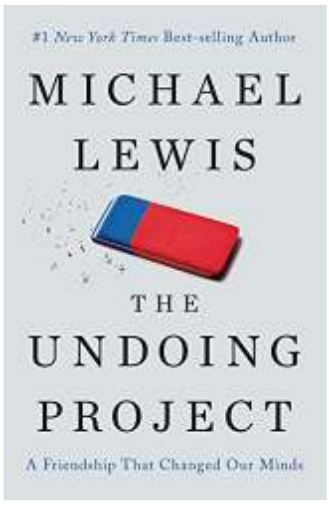
Additional references





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Additional references - online

- At RSNA Education Portal:
  - An Introduction to Decision Analytic Models in Radiology
    - Pari Pandharipande, MD, MPH
- Youtube: CDC Introduction to Economic Evaluation
  https://www.youtube.com/watch?v=x6qgiy6-c7s
  - Part 1: Introduction
  - Part 2: Economic Impact Analysis
  - Part 3: Programmatic Cost Analysis
  - Part 4: Benefit-Cost Analysis
  - Part 5: Cost-Effectiveness Analysis

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Thank you!

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