Introduction to Cost-Effectiveness Analysis

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RSNA Clinical Trials Methodology Workshop

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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.
Diagnostic Imaging

• **Traditional goal**
  - Provide images of the highest technical quality that permit the most accurate diagnoses possible

• **Broader view**
  - Provide effective and efficient diagnosis and treatment of patients

• **Contribution of radiology research**
  - Assess technology along the entire spectrum of clinical efficacy
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?”

How to define the benefit of a diagnostic test?

Levels of Clinical Efficacy

1. Technical  “How good is the image?”
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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?”

Is this diagnostic test worth doing?

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

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

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

--Hippocrates
Clinical Decision Making

- Judgment traditionally based on
  - Experience
  - Accumulated knowledge

- Complicated by
  - Complexity
  - Uncertainty
  - Competing values and objectives
Theoretically…

More Knowledge.

Better Practice.
Better Outcomes.
Not only is judgment difficult, there is evidence we are not doing it well!

How can we make better decisions?

• New knowledge and new technologies present us with 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.
Decision Analysis

- Application of explicit, quantitative methods to analyze decisions under conditions of uncertainty
- Usually using a computer simulation model
A Decision Must Be Made!

Decision Analysis

- Guides management based on the best available data
- **Explicit**
  - Describes decision
    - Assumptions made Explicit
    - Importance of 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
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

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
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)
Cost-effectiveness

Spend $  Save $

Gain QALYs  Lose QALYs

Current Standard

Yes  No

Probably not  Maybe $/QALY
Screening ultrasound CEA

Objective: To evaluate the comparative clinical effectiveness and cost-effectiveness of supplemental ultrasound screening for U.S. women with dense breasts.

Spectrum of breast density

Predominantly Fatty
Scattered Areas
Heterogeneously Dense
Extremely Dense

Breast Imaging Reporting and Data System (BI-RADS), American College of Radiology
Background

- Increasing demand for supplemental screening
- Based on advances in both
  - Knowledge of cancer biology
  - Breast imaging techniques
- Breast Density
  - Known risk factor for developing breast cancer
  - Mediates mammographic accuracy
Breast density and cancer risk

- Known risk factor for developing breast cancer
- Mediates mammographic accuracy

<table>
<thead>
<tr>
<th>Density</th>
<th>Relative Risk</th>
<th>Prevalence</th>
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</thead>
<tbody>
<tr>
<td>Almost entirely fatty</td>
<td>0.5</td>
<td>10%</td>
</tr>
<tr>
<td>Scattered densities</td>
<td>1 (reference group)</td>
<td>42%</td>
</tr>
<tr>
<td>Heterogeneously dense</td>
<td>1.5 - 1.6</td>
<td>40%</td>
</tr>
<tr>
<td>Extremely dense</td>
<td>1.8 - 2.0</td>
<td>7%</td>
</tr>
</tbody>
</table>

Sprague BL, et al. 2014; manuscript under review
Additional BCSC unpublished data
Digital mammography performance
women 40-74 years, 2003-2011

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity %</th>
<th>Specificity %</th>
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<tr>
<td>Almost entirely fat (10%)</td>
<td>90</td>
<td>94</td>
</tr>
<tr>
<td>Scattered (42%)</td>
<td>89</td>
<td>90</td>
</tr>
<tr>
<td>Heterogeneously dense (40%)</td>
<td>82</td>
<td>87</td>
</tr>
<tr>
<td>Extremely dense (7%)</td>
<td>75</td>
<td>90</td>
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Unpublished data from BCSC
Study Overview

• Three established, validated breast cancer microsimulation models from CISNET
  • Wisconsin/Harvard, Erasmus/Netherlands, Georgetown/Einstein

• Projected outcomes for two screening strategies among U.S. women aged 50-74 years with dense breasts:
  • Biennial supplemental ultrasound screening after negative mammogram
  • Biennial mammography screening alone

• Federal payer perspective and lifetime horizon

• Health care costs and benefits (QALYs) discounted 3% annually

• Multi-way sensitivity analyses to explore implications of varying key parameters

• Secondary analyses: earlier start, annual screening
Parameter inputs

- Population and test performance characteristics from NCI’s Breast Cancer Surveillance Consortium (BCSC) and medical literature
  - Dense breasts prevalence and relative risk from BCSC and literature
  - Screening ultrasound after negative mammogram:
    - Sensitivity 55% (45%-85%)
    - Specificity 94% (90%-98%)

- Costs from Medicare reimbursement rates, data from BCSC, medical literature
  - Screening US additional $100
  - 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
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^Model W results, Appendix Table 3  *US after negative mammography
Effects of Biennial Screening Outcomes per 1000 women for Screening Between Ages 50 and 74 years^  

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<th>ICER (Δ$ / ΔQALYs)</th>
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**ICER Range across three models:** $121,000 - $562,000/QALY gained
Cost-effectiveness

Gain QALYs

Yes

Spend $  Save $

Lose QALYs

Current Standard

probably not

maybe

$/QALY

no
“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.

Indication creep can also lead to “flat of the curve” medicine
Intermediate Outcomes: Effects of Biennial Screening Strategies per 1000 women Between Ages 50 and 74 years

<table>
<thead>
<tr>
<th>Screening Strategy</th>
<th>No. of Screening Ultrasound Exams</th>
<th>No. of Benign Bx After False Positive Ultrasound</th>
<th>No. of Breast Cancer Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM alone</td>
<td>0</td>
<td>0</td>
<td>19.70</td>
</tr>
<tr>
<td>DM + US (if DM negative)</td>
<td>3827</td>
<td>354</td>
<td>19.34</td>
</tr>
<tr>
<td>Incremental difference</td>
<td>+3827</td>
<td>+354</td>
<td>-0.36</td>
</tr>
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Sensitivity analyses
Conclusions

• Supplemental ultrasound screening after negative mammogram for U.S. women with dense breasts would:
  • Avert 1 cancer death per 2778 women screened.
  • Add 3,827 additional screening ultrasound exams and 354 false-positive biopsies per 1000 women screened.

• Supplemental ultrasound screening for women with dense breasts would substantially increase costs while producing relatively small benefits.
  • Only approaches cost-effective threshold with marked improvement in screening ultrasound sensitivity and specificity (at values higher than mammography screening itself)
CEAs and Budgets

• 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

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?*
Published September 2016

Follows up original panel report and book from 1996, which became the standard reference for CEA
What’s new?

- **Two reference cases**: Societal and *new* Health Sector perspective
  - To increase comparability across interventions for decision makers

- **Impact Inventory** to include health and non-health consequences of an intervention
  - To provide a framework for considering all types of consequences

- Specific discussion of additional areas:
  - Importance of modeling as framework, methodological challenges of valuing costs and outcomes, evidence synthesis, ethical considerations
Additional references
Additional references

Methods for the Economic Evaluation of Health Care Programmes

Michael F. Drummond
Mark J. Sculpher
George W. Torrance
Bernie J. O'Brien
Greg L. Stoddart

THE UNDOING PROJECT
A Friendship That Changed Our Minds
Thank you!

Eric Stern, MD
Organisation for Economic Co-operation and Development (OECD)

- Purpose: to promote policies that will improve the economic and social well-being of people around the world
- Provides a forum for governments to work together and seek solutions to common problems.
- Established 1961
- 35 member countries
  - Europe: UK, France, Germany, Italy, Norway, Switzerland
  - Also: Japan, Korea, Canada, Mexico, Australia, Israel