Cost-Effectiveness Analysis: 
Academic curiosity or practical means to get more “bang” for our “buck”?

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Why Cost-Effectiveness Analysis?

• US does not get good value from health
  – Spends 50% more but leaves 17% uninsured with life expectancies 5-6 years too low

• CEA is best way to measure value in health
  – Compares *incremental benefit* with *incremental cost*
    • *Incremental benefit* = \( \uparrow \) benefit beyond next best alternative
    • *Incremental cost* = \( \uparrow \) cost beyond next best alternative

• Increasing value important for
  – Programmatic decisions
  – Health reform
Why Cost-Effectiveness Analysis?

• Value impacts generalizability and scalability
  – Resources used for study intervention may be resources not available for alternative interventions
  – Does study intervention deliver more health benefit than alternative uses?

• Explicit, systematic, “level playing field”
Why Not Cost-Effectiveness Analysis?

• Difficult to synthesize evidence from different cost-effectiveness studies

• Assumptions in cost-effectiveness not transparent
  – An analysis based on a high-quality study may appear to have same certitude as analysis based on expert opinion

• A policy tool in search of U.S. policy “levers”
  – Other countries use it (e.g. Canada, U.K., Australia, Netherlands) but U.S. stakeholders usually don’t
Research to address limitations of cost-effectiveness analysis

• Synthesizing cost-effectiveness evidence
• Making assumptions underlying cost-effectiveness studies more transparent
• Making cost-effectiveness results more actionable for stakeholders
  – Program planning
  – Incentive design
Cost-effectiveness analysis IS:* The use of formal analysis to assist decision makers in choosing from among competing alternatives, in situations of limited resources.
Cost-effectiveness analysis is NOT:

- Indiscriminate cost-cutting
- Downsizing
- Bean counting
- The one and only answer
## Cost-Consequence Space

<table>
<thead>
<tr>
<th>Incremental Health Effect</th>
<th>Incremental Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Evaluate C/E Ratio</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Evaluate C/E Ratio</td>
</tr>
<tr>
<td></td>
<td>No</td>
</tr>
</tbody>
</table>
The C/E Ratio

Net Increase in Cost

\[ \frac{\text{Net Increase in Cost}}{\text{Net Increase in Health Effect}} \]

• A measure of “value for money”
• Comparison of competing alternatives
• Comparison across interventions
Cost-effectiveness Primer

• C/E ratios expressed in
  – Cost per life-year
  – Cost per QALY (quality-adjusted life-year)

• Higher numbers are less favorable
  – $1,000,000/QALY means society would pay one million dollars for an additional year of life

• Lower numbers are more favorable
  – $100/QALY means society would pay only one hundred dollars for an additional year of life
Cost-effectiveness Analysis Primer

• Analyses require evidence about benefit and cost

• Evidence may come from one study but often from mix of different studies and opinion

• **Sensitivity Analyses** evaluate impact of uncertainty about evidence
  – Smaller study = larger 95% CI = more uncertainty
Research to address limitations of cost-effectiveness analysis

• Synthesizing cost-effectiveness evidence
• Making assumptions underlying cost-effectiveness studies more transparent
• Making cost-effectiveness results more actionable for stakeholders
  – Program planning
  – Incentive design
Objective

• Research objective
  – Synthesize cost-effectiveness evidence to identify high-value cardiovascular health services

• Decision-centered goal:
  – Inform consumers to
    • Engage in more informed health discussions
    • Seek health plans offering high-value services without financial or administrative barriers
Methods – evidence synthesis

• Guiding principles
  – Define “services” broadly
    • Prevention
    • Diagnosis
    • Treatment
    • Management.
  – Limit group using standards of
    • Quality of CEA study
    • Non-obsolescence
    • Consistency of evidence
    • Relevance to consumers
Identifying CV services

• Query National Registry of Cost-Effectiveness Analysis (CEA) Results
  – Summarizes and reviews published, original, English-language cost-utility analysis articles
  – Search for “cardiovascular services” in “U.S.”

• Supplementary searches
  – Published literature
  – Guidelines of national medical and scientific societies
    • Published in peer-reviewed scientific journals
    • Used explicit standardized evidence syntheses.
Definition of “value”

• Value = additional benefit per additional cost
  – “Bang for buck”
  – Inverse of incremental cost-effectiveness ratio
  – Not the same as cost-saving

• High-value = Value better than what we know US willing to pay for
  – ≥ $100,000 per year of good-quality life (QALY)

• Low-value = Value worse than what we know US not willing to pay for
  – ≤ $300,000 per QALY

Braithwaite RS et al, Medical Care, 2008
Quality of CEA Study

• Obtain original publications

• Apply the *Quality of Health Economic Studies*
  – Validated instrument for measuring the quality of cost-effectiveness analyses.
    • 75 is a commonly-used cutoff for high quality
  – Each study was reviewed by at least one reviewer
    • Reviewers had inter-rater kappa of 0.68
Non-obsolescence

• Recommendation by up-do-date guideline(s) of clinical or scientific society.
  – Search National Guideline Clearinghouse

• Only considered guideline if
  – Published in peer-reviewed journals
  – Used explicit evidence rating scales

• High-value service must receive
  – Highest grade of supporting evidence
    • e.g. AHA “Level A”
  – Strongest recommendation in favor
    • e.g. AHA “Level 1”
Consistency of Results

- Results should be consistent if >1 published study addresses the same question.
- Results should be robust to alternative but plausible assumptions.
- Consistency assessed by implication for decision making:
  - Studies with ICERs of $40k and $70k would be consistent because results are on the same side of decision threshold (<$100k).
  - Therefore both would yield the favorable inference for decision making.
Assure consumer relevance

• Problem is not rare
• Service could be standardized across different settings
• Topic would be considered within “cardiovascular” domain by lay audiences.
• Consumer preferences may be reasonably expected to influence decision making
  – Excluded if decision
    • Would need to be made immediately
    • Was too technical to for shared decision making
Sensitivity analyses

- Some payers and consumer groups do not regard quality assessment as sufficiently sensitive for excluding conflict-of-interest bias
  - Base case excludes industry-funded studies
- Sensitivity analysis included industry-funded studies if endorsed by high-grade evidence/guideline
  - United States Preventive Services Task Force
Studies of value of cardiovascular health services in U.S. (N = 174)

Meets freedom from commercial bias standards?
Freedom from commercial bias [100 studies excluded]
  • Study not funded by entity with commercial interest or support not stated

Studies meeting freedom from commercial bias standards (N = 74)

Meets quality of evidence standards?
Meets validated quality criteria for cost-effectiveness studies (QHES > 75) [10 studies excluded]
  Analyzes interventions with high probability of effectiveness and are nonobsolete [11 studies excluded]
  Endorsed by guidelines published in peer-reviewed journals synthesize evidence using explicit criteria

Meets consistency of evidence standards?
Results robust to sensitivity analyses 4 [study excluded]

Applies to consumers?
Likely to have substantial health impact [0 studies excluded]
  Service is standard across health care settings [2 study excluded]
  Consumer preferences may be reasonably expected to influence decision making [27 studies excluded]
  • Decision does not need to be made immediately
  • Decision is not highly technical
  Applicable to adults [1 study excluded]
  Considered a “cardiovascular” problem [2 studies excluded]

Studies meeting all criteria (N = 17)

High-value cardiovascular health services (N = 10)
Results: High-value CV services

<table>
<thead>
<tr>
<th>High-value health service</th>
<th>Goal of service</th>
<th>People for whom value is likely high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cholesterol-lowering medication (statin)</td>
<td>Prevent heart attacks</td>
<td>Known coronary heart disease</td>
</tr>
<tr>
<td>Cholesterol-lowering medication (statin)</td>
<td>Prevent heart attacks</td>
<td>LDL &gt; 130 and 10-year CHD risk &gt; 5%</td>
</tr>
<tr>
<td>Screening for high blood pressure and tx with diuretic, b-bl or ACE</td>
<td>Prevent heart attacks and strokes</td>
<td>Known hypertension</td>
</tr>
<tr>
<td>Oral blood-thinning medication (warfarin)</td>
<td>Prevent blood clot to lung</td>
<td>First blood clot without known reason</td>
</tr>
<tr>
<td>Injectable blood-thinning medication (low molecular weight heparin)</td>
<td>Prevent blood clot to lung</td>
<td>Just diagnosed with blood clot</td>
</tr>
</tbody>
</table>

*Mentor SM and Braithwaite RS, Am J Managed Care, 2011*
# Results: High-value CV services

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</thead>
<tbody>
<tr>
<td>Implantable cardiac defibrillator</td>
<td>Prevent “sudden death”</td>
<td>Congestive heart failure because of a heart attack (EF &lt; 30%)</td>
</tr>
<tr>
<td>Blood-thinning medication (aspirin)</td>
<td>Prevent future heart attacks</td>
<td>Coronary heart disease</td>
</tr>
<tr>
<td>Anti-platelet medication (clopidogrel) for 12 months</td>
<td>Prevent future heart attacks</td>
<td>After heart attack or other acute coronary events</td>
</tr>
<tr>
<td>Medication that reduces strain on heart (beta-blocker)</td>
<td>Prevent future heart attacks</td>
<td>Coronary heart disease</td>
</tr>
<tr>
<td>Oral blood-thinning medication (warfarin) and necessary labs</td>
<td>Prevent future strokes</td>
<td>Non-valvular atrial fibrillation and &gt;=1 stroke risk factors</td>
</tr>
</tbody>
</table>

*Mentor SM and Braithwaite RS, Am J Managed Care, 2011*
Sensitivity Analyses

Industry funded studies with strong support of guidelines (N = 10)

Meets quality of evidence standards?
Meets validated quality criteria for cost-effectiveness studies (QHES > 75) [1 studies excluded]
Analyzes interventions with high probability of effectiveness and are nonobsolete [0 studies excluded]
   Endorsed by guidelines published in peer-reviewed journals synthesize evidence using explicit criteria

Meets consistency of evidence standards?
Results robust to sensitivity analyses and consistently suggest ICER < $100,000 per LY or per QALY [3 studies excluded]

Applies to consumers?
Likely to have substantial health impact [0 studies excluded]
Service is standard across health care settings [0 study excluded]
Consumer preferences may be reasonably expected to influence decision making [0 studies excluded]
   • Decision does not need to be made immediately
   • Decision is not highly technical
Applicable to adults [0 studies excluded]
Considered a “cardiovascular” problem [0 studies excluded]

Studies meeting all criteria
(N = 7)

High-value cardiovascular health services (N = 3)
### Sensitivity Analyses: High-value CV services

<table>
<thead>
<tr>
<th>High-value cardiovascular health service</th>
<th>Goal of service</th>
<th>People for whom value is likely high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoking cessation counseling, NRT, and pharmacotherapy</td>
<td>Stop smoking</td>
<td>All smokers</td>
</tr>
<tr>
<td>Stroke prevention with anti-platelet drugs (aspiring or clopidogrel)</td>
<td>Prevent stroke</td>
<td>People who have had a stroke or TIA (“mini-stroke”)</td>
</tr>
<tr>
<td>Aspirin for primary prevention of cardiovascular in men</td>
<td>Prevent heart attacks</td>
<td>Middle-age men with 10 year CHD risk &gt;5% without increased bleeding risk</td>
</tr>
</tbody>
</table>
Limitations

• Does not evaluate an exhaustive list of cardiovascular services
• Very few services have been studied in all relevant patient groups.
• Relatively sparse results highlight the importance of expanding comparative effectiveness research
Conclusions

• Many common cardiovascular services are identifiable as high-value
  – Expensive as well as cheap
• Identifying high-value services may help
  – Engage in more informed health discussions
  – Seek health plans that offer services without financial or administrative barriers
• Approach can be applied to other services
Research to address limitations of cost-effectiveness analysis

- Synthesizing cost-effectiveness evidence
- Making assumptions underlying cost-effectiveness studies more transparent
- Making cost-effectiveness results more actionable for stakeholders
  - Program planning
  - Incentive design
Objective

• Research Objective
  – Can we augment standard cost-effectiveness analysis methods to develop a sensitivity analysis based on quality of evidence?

• Decision centered goal
  – Clinicians and policy-makers often wonder “what goes into the model”
  – Make the uncertainty from low-quality evidence transparent to model users so they know whether to “trust the model” for their particular question
Methods

• Basic concept of our approach
  – When potential information sources have insufficient quality of evidence, don’t use them
  – Instead, assume that little is known by using uninformative distributions over wide range
  – Don’t obscure questionable data under a “false veneer of mathematical certitude”

• Warning! If you set evidence standards very high, not much of the available evidence may qualify.
Methods

– Assess quality of evidence using USPSTF guidelines
  • Study design
    – Design differs from controlled experiment
  • Internal validity
    – Results represent truth in study population
  • External validity
    – Results represent truth in target population
– Our approach can be used with any evidence-evaluation hierarchy
  • We chose USPSTF guidelines because of ubiquity not because of rigor
Methods

• Set minimum standard in each evidence domain
  – These can be “dialed” up or down at will
• Evaluate each possible source of evidence
• If source meets evidence criterion, use its 95% confidence interval in the analysis
• If evidence does not meet criterion, do not use it in the analysis
  – Instead use uninformative (“wide”) distribution
Test Case: Directly observed therapy for HIV antiretrovirals

• Base Case: No evidence criteria
  – All 17 data sources eligible for parameter estimation

• **Study Design** set to highest standard (“1”)
  – **13** out of 17 sources were eligible

• **Internal Validity** set to highest standard (“good”)
  – **9** out of 17 sources were eligible

• **External Validity** set to highest standard (“high”)
  – **5** out of 17 sources were eligible

• **All three criteria** set to highest standards
  – **3** out of 17 sources were eligible
Cost-Effectiveness Plane Primer

Incremental Cost

Each dot shows distinct run of model

Confidence Ellipse analogous to 95% Confidence Interval (wider = less precise) (narrow = more precise)

Separates unfavorable (above) from favorable (below)
Results: All Evidence

ICE Scatterplot
All Evidence Allowed

Braithwaite RS et al, Ann Intern Med 2007; 146:133-141
Results: Internal Validity “Good”

ICE Scatterplot
Evidence Criterion: IV = Good
Results: Study Design “1”

Braithwaite RS et al, Ann Intern Med 2007; 146:133-141
Results: External Validity “High”

ICE Scatterplot
Evidence Criterion: EV = High

Braithwaite RS et al, Ann Intern Med 2007; 146:133-141
Results: All 3 Criteria

ICE Scatterplot
All Three Evidence Criteria

Braithwaite RS et al, Ann Intern Med 2007; 146:133-141
Conclusions

• Quality of evidence may have profound impact on the precision and estimates of CEAs
• Stricter evidence criteria may produce more uncertain results because there are fewer studies to base assumptions on
• Approach shows when evidence is not good enough for decision making
  – Need higher-quality information on HIV DOT
Research to address limitations of cost-effectiveness analysis

• Synthesizing cost-effectiveness evidence
• Making assumptions underlying cost-effectiveness studies more transparent
• Making cost-effectiveness results more actionable for stakeholders
  – Program planning
  – Incentive design
Background

• Cost-sharing becoming a standard “volume knob” to control utilization in U.S.

• Cost-sharing has
  – Great potential to control costs
  – Great potential to cause harm

• Increasing calls to link cost-sharing to value (e.g. value-based insurance design)
  – No cost-sharing for high-value services
  – Same or increased cost-sharing for low-value services
Purpose

• Research Objective
  – To estimate the impact of value-linked cost-sharing if it were applied systematically across US health system

• Decision-centered Goal
  – To determine whether value-based insurance design should be scaled up or rolled back
Methods

- From RAND, we can estimate the impact of cost-sharing amount on health service demand

<table>
<thead>
<tr>
<th>Cost-sharing</th>
<th>0%</th>
<th>18% (Current)</th>
<th>30%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative utilization</td>
<td>1.06</td>
<td>1.00</td>
<td>0.85</td>
<td>0.65</td>
</tr>
</tbody>
</table>

- Results confirmed by >100 observational studies
New year = new “pull” from cost-effectiveness distribution

Age N

Health expenditure

Uninsured
- High cost-sharing lowers health expenditures

Insured
- Prevailing cost-sharing maintains health expenditures

Insured, value-based cost-sharing
- Value increases, lowers, or maintains health expenditures

Mortality

Age N+1
Methods

- Possible way to link cost-effectiveness results to cost-sharing
  - > $300K/QALY: *Increase* cost-sharing
  - $100K-300K/QALY: *No Δ* cost-sharing
  - < $100K/QALY: *Waive* cost-sharing
  - Cost-saving: *Reverse* cost-sharing?

*Braithwaite RS et al, Ann Intern Med. 2007*
Life Expectancy Gain (Years)

- No cost-shar, Expand insurance
- Value-based cost-shar Expand insurance
- Value-based cost-shar Current insurance
- Current cost-shar Expand insurance
- Current cost-shar Current insurance

20% 30% 40% 50% Copayment if low-value

Braithwaite RS et al, PLoS Medicine, 2010
Annual per-capita cost (2003 $)

- No cost-shar, Expand insurance
- Current cost-shar, Expand insurance
- Current insurance
- Value-based cost-shar, Expand insurance
- Value-based cost-shar, Current insurance

20%  30%  40%  50% Copayment if low-value

Braithwaite RS et al, PLoS Medicine, 2010
Conclusions

• Value-linked cost-sharing may increase life expectancy from health care while reducing costs
• Costs may be lowered sufficiently to offset incremental expenditures from expanding health insurance coverage
Research to address limitations of cost-effectiveness analysis

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Modeling HIV Prevention Priorities in New York City

• Research Objective
• Construct an operations research model to assist HIV prevention planners determine the optimal combination of prevention strategies that will maximize the number of new infections averted, within funding limits.

• Decision-centered goal:
• How much additional money to ask for, and what to spend it on?
Modeling HIV Prevention Priorities in New York City

• **Model Features:**
  – Includes 11 required and 8 recommended, or 19/24 interventions/strategies outlined by CDC in ECHPP
  – Allows decision maker to prioritize HIV prevention strategies based upon strength of evidence, budget, and feasibility constraints.
  – Explores the interplay between various HIV prevention strategies.
  – Accounts for complex behavioral heterogeneity (social network characteristics, partner mixing, etc.)
  – Includes behavioral feedback loops that may influence transmission risk.
Limitations

• Preliminary results
  – Additional sensitivity analyses needed
  – Some inputs need further verification
  – Formal optimization of portfolio in progress

• Evidence limitations

• Only considers the ECHPP interventions
  – Future work to consider broader range of interventions and targets
Conclusions

• Potential to reduce HIV incidence by 60%
  – Focus on HIV-infected
  – What is effective may not be low cost/infection averted

• Future work
  – Develop and evaluate new targeting for high-value interventions
  – Virtuous cycle for public health/academic partnership
    • Use inferences from models to inform decisions
    • Evaluate impact of decisions
    • Update model with new data
    • Repeat
Research to address limitations of cost-effectiveness analysis

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Community-based interventions aimed at HTN and colorectal cancer disparities

- **Intervention #1 (hypertension):** Therapeutic lifestyle change via **Motivational Interview (MINT or MI),** a counseling approach to motivate behavioral change and help people commit to it
- **Intervention #2 (CRC):** **Patient Navigation (PN)** based on the community health worker (CHW) model: “...to help patients access and chart a course through the healthcare system”
- **Intervention #3 (Hypertension and CRC):** MI and PN

**Where in community?**
- Mobile vans in front of churches and black-owned barbershops in Central Harlem, NYC (part of ongoing program)
CEA and Community-based research

• Research Objectives
  • What is cost-effectiveness of these community-based interventions?
  • Is value sufficient for scaling?
  • Will it deliver more “health” for the money compared to alternative uses?

• Decision Goal:
  • Should one or both interventions be rolled out, and given funding priority relative to other interventions addressing important health disparities in urban black men?
Methods

• Computer simulation for African-American men who reside in NYC incorporating two distinct outcomes:
  – Blood pressure control and the consequences of high BP over a period of time
  – Colorectal cancer screening and the long-term consequences of screening and the disease if left untreated.
Hypertension Model-Part I
Colorectal Cancer Model
Results

• Models were created while data is collected
  – Like “cartridges" into which data can be inserted, once it is collected and analyzed

• After data is inserted:
  – What is long-term effect of these 2 community-based intervention on life expectancy and high-quality life expectancy?
  – What is their value?
    • How much “health” would be bought if they were rolled-out, and how would this compare to the health that could be “bought” by spending the same money on alternative programs?
Research to address limitations of cost-effectiveness analysis

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Conclusions

• Methods exist to
  – Assess whether sufficient cost-effectiveness evidence could possibly impact a decision
  – Make evidence uncertainty transparent to inform whether cost-effectiveness should impact a decision

• Decision suitable for impact involve
  – Getting the most “health” from a portfolio of interventions by scaling up or down funding
  – Impacting incentives as well as coverage
Questions ??????