Health Technology Defined

- Narrowly defined, health technology includes the medical equipment, devices, drugs, and techniques used in the diagnosis and treatment of diseases or conditions.
- Broadly defined, it includes all types of health care interventions, such as:
  - Public health programs
  - Health promotion/disease prevention programs
  - Changes in the mix of providers (PAs versus MDs)
Why Is It Necessary to Assess Health Technology?

- Contrast the market for health care services with other product markets, such as the market for automobiles.
- When purchasing a car, we would like information on:
  - purchase price
  - cost of ownership (i.e., operating cost)
  - reliability
  - safety
- In most markets, technology tends to produce lower costs, so that consumers receive higher quality products for lower prices.
  - *Competition* drives producers to develop cost-saving, or cost-effective, innovations.
- In health care, technology tends to produce higher costs, and the improvement in health outcomes may be uncertain.
  - *Competition doesn’t (always) work in health care markets to produce better products for lower costs*
What’s Important When We Purchase Health Care?

- Price of the service
- Quality of the provider
- Effectiveness or appropriateness of the service
- Likely outcome

- If this information is valuable:
  - Do we have ready access to this information?
  - If not, why not?
- Who needs this information?
The Lack of Information in Health Care is a One Source of Market Failure

In economic theory, there are four sources of market failure, which prevent markets from functioning properly:

- Market power
- Incomplete information
- Externalities
- Public goods
Why Do Health Care Markets Fail?

- Information asymmetry (market power)
  - Physicians, like many professionals, possess substantially more information than their clients
    - Information on price, quality, effectiveness, and outcomes is difficult to obtain or understand

- Physician agency (market power)
  - Physicians may not function as perfect agents on behalf of their patients

- Extensive insurance => moral hazard (externality)
  - Price does not equal marginal benefit
Why Do Health Care Markets Fail?

- **Uncertainty (incomplete information)**
  - Many medical services are risky, and outcomes are uncertain or probabilistic
  - Medicine is both art and science
  - Practice pattern variations

- **Difficulty in assigning property rights (public goods)**
  - Some innovations, especially those in public health and health promotion, are difficulty to trademark
    - No profit motive for the private market => no incentive to supply these services
Goals of Health Care Technology Assessment

- To provide information about the effectiveness and value of health care technologies, usually after their introduction into the market.
  - In other words, technology assessment is an alternative method for achieving economic efficiency that occurs in most other markets as a result of competition.

- Audiences
  - Health care professionals
  - Consumers
  - Purchasers, including government
Identification

How do technologies get identified for evaluation?

- Usually after diffusion in the market
- High impact
  - Volume
  - Cost
  - Outcome
- Usually determined by independent researchers or by manufacturers of specific products
- Other than the FDA, there is no systematic public process in the U.S. to investigate new technologies
  - Congress eliminated the Office of Technology Assessment (OTA) in 1995
- Affordable Care Act has several provisions to increase technology assessment
  - Independent Payment Advisory Board (IPAB) (§ 3403)
  - Patient-Centered Outcomes Research Institute (PCORI) (§ 6301)
Tools of Technology Assessment

- Decision analysis
- Risk analysis
- Health impact assessment (HIA)
- Economic evaluation, including cost-effectiveness (CEA), cost-benefit (CBA), and cost-utility analysis (CUA)

In principle, these economic evaluation methods use the same tools employed by private companies when they are deciding how to maximize their return on investment (ROI)

- The major difference is that the economic evaluation of health care technology is usually done from a societal perspective, rather than the perspective of a specific organization
CBA, CEA, and CUA

- CBA assumes all costs and benefits can be measured in economic (i.e., dollar) terms

- CEA measures benefits in units of health outcome, for example, years of life saved

- CUA measures benefits in outcomes that account for quality of life, such as quality adjusted life years (QALYs)
Major Limitation of Applying CBA to the Health Sector: How Should We Value Human Life?

- Human capital approach
  - You are what you produce in a market oriented economy
  - Ignores non-market activities, and quality of life

- Willingness to pay
  - Obtained through revealed preferences or surveys
  - Maximizes social welfare, but ignores the distribution of benefits, and does not accounts for differences in income distribution or ability to pay
Cost-Effectiveness Analysis

- Outputs are usually measured in units of health outcome, usually years of life saved
  - Intermediate outputs, such as cases detected or confirmation of true negatives, may be studied
- Outcomes are valued equally across individuals
- Outcomes are valued equally across conditions
  - Years of life saved are counted the same regardless of quality of life
- Indirect costs, such as days of work lost, are often excluded or averaged across populations, to avoid problems associated with CBA
  - CUA assumes that these indirect costs are captured in the utility measure
Cost-Utility Analysis

- Intended to address the major limitation of CEA, by valuing outcomes differently based on quality of life.
- Assumes a year of healthy life has a value that is equal for everyone.
- Utilities are obtained by surveying individuals, or by assigning values from other studies, which may not be valid.
- CUA and CEA are used interchangeably, but conceptually are not the same.
  - Most CEAs are really CUAs.
BREAK

QUESTIONS?
Framework for CEA

- State objectives and perspective
- Identify alternatives
- Identify and measure costs and benefits
- Discount future costs and benefits
- Perform sensitivity analysis
- Discuss assumptions and results of analysis, including costs and benefits that are difficult to quantify, e.g., ethical issues

Objectives and Perspective

- Economic analysis can be conducted from the following perspectives:
  - providers
  - payers
  - society

- Cost-effectiveness analysis should always be performed from the broadest perspective, i.e., society’s
Identify Alternatives

- To conduct an economic analysis, we must identify all the possible alternatives to the treatment or intervention we are analyzing.

- In the simplest case, the alternative is doing nothing, i.e., no intervention.
Identify and Measure Costs

Costs include:

- **Direct** actual expenditures for labor, supplies, equipment, etc. of the intervention or treatment

- **Indirect** or *overhead* expenses of administering the intervention or treatment
  - Overhead expenses should be excluded from the analysis if they would be incurred regardless of the intervention or treatment
Discount Costs and Benefits

Both costs and benefits should be discounted to account for the effects of time, using the following formula:

\[
costs = \sum_{t} \frac{\text{costs}_t}{(1 + i)^t}
\]

\[
benefits = \sum_{t} \frac{\text{benefits}_t}{(1 + i)^t}
\]

where \( i \) = discount rate (net of inflation, usually 3%) and \( t \) = year
Incremental Cost Effectiveness Ratio

\[
\text{ICER} = \frac{\Delta \text{Costs}}{\Delta \text{Health Outcomes}}
\]
### CE Ratios: Decision Rules

<table>
<thead>
<tr>
<th>Outcomes (H)</th>
<th>Costs (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 CE &lt; 0 and ΔH&lt;0 =&gt; do not adopt</td>
<td>1 CE &gt; 0 and ΔH&gt;0 =&gt; adopt if &lt; CE(max) =&gt; “cost effective”</td>
</tr>
<tr>
<td>3 CE &gt; 0 and ΔH&lt;0 =&gt; adopt only if savings is worth health cost</td>
<td>4 CE &lt; 0 and ΔH&gt;0 =&gt; adopt =&gt; “cost saving”</td>
</tr>
</tbody>
</table>
Conduct Sensitivity Analyses

- The analysis of costs and benefits may be sensitive to the definition of costs, benefits, or discount rate.

- Therefore, analyses should be repeated by varying assumptions about costs, benefits, and discount rate.
Incorporate Non-Economic Factors

- Economic analysis is a valuable tool in decision making, but it is only one factor.

- Other social, ethical, political, and legal considerations should be combined with the economic analysis to reach a final decision about the “value” of an intervention or treatment.
CEA Example: Is Screening for Breast Cancer Cost-Effective?

- **Objective and Perspective**
  - To determine whether mass mammography screening is cost-effective for identifying breast cancer from society’s perspective
  - **Source:** Mushlin and Fintor, *Cancer*, 69(7):1957-62, April 1, 1992

- **Alternatives**
  - Self-examination
  - Mammography
  - Clinical breast exam
Is Screening for Breast Cancer Cost-Effective?

Factors Influencing Costs and Benefits

- incidence of disease
- length of preclinical period (i.e., time between detection and onset of disease)
- effectiveness of treatments
- cost of initial screening
- sensitivity (1 - false negative rate) and specificity (1 - false positive rate) of screening procedures
- periodicity of screening
- follow-up diagnostic procedures
- stage-specific treatment costs
- risk characteristics of eligible population
### Is Screening for Breast Cancer Cost-Effective?

<table>
<thead>
<tr>
<th>Screening Result</th>
<th>Positive</th>
<th>Negative</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>12</td>
<td>300</td>
<td>312</td>
</tr>
<tr>
<td>Negative</td>
<td>3</td>
<td>9685</td>
<td>9688</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>9985</td>
<td>10000</td>
</tr>
</tbody>
</table>

Incidence = 15/10000 = 0.15%
Sensitivity = 12/15 = 80%
Specificity = 9685/9985 = 97%
Is Screening for Breast Cancer Cost-Effective?

- **Costs**
  - $100 per mammography (N = 10,000)
  - $900 in diagnostic follow-up for those who screen positive (N = 312)
  - $25,000 in terminal costs avoided per life saved

- **Benefits**
  - 12 cancers detected x .65 mortality x .25 effectiveness = 1.95 lives saved
  - 1.95 lives saved x 23.8 years of life per life saved = 46 years of life saved
Is Screening for Breast Cancer Cost-Effective?

- **Total costs**
  - Mammography screening: $100 x 10,000 = $1,000,000
  - Follow-up biopsy: $900 x 312 = $280,800
  - Terminal costs saved: $25,000 x 1.95 = ($48,750)
  - Total = $1,232,050

Incremental cost-effectiveness ratio (ICER) = $1,232,050 / 46 years of life saved = $26,800 per year of life saved
Is Screening for Breast Cancer Cost-Effective?

- In this example, costs and benefits were not discounted according to the authors because the time frame of the analysis is one year.

- If the analysis were done “correctly,” years of life saved would be discounted => CE ratio would be higher, but not substantially.

- What about false negatives?
Is Screening for Breast Cancer Cost-Effective?

- **Sensitivity analysis**
  - incidence: 0.15% (0.10-0.20%)
  - sensitivity: 80% (75-85%)
  - 1 - specificity: 3% (2-4%)
  - mortality: 65% (60-70%)
  - effectiveness: 25% (20-30%)
  - costs if not detected: $25,000 ($20,000-$30,000)
  - mammography costs: $100 ($75-$125)
  - biopsy costs: $900 ($800-$1000)
QUESTIONS?

BREAK 2
Cost-Effectiveness Analysis: Basic Models and Measuring Costs
CE Ratios

- **Average CER**
  - measures the total cost divided by the total benefit of a program or intervention, relative to *no intervention*

- **Incremental CER**
  - compares the *relative* effect of multiple programs or interventions
  - assumes *sequential* implementation of multiple programs

- **Marginal CER**
  - measures the effect of expanding an *existing* program or intervention
    - this type of CEA is rarely performed
CE of Preventive Treatment

\[ \Delta C = p_1 C(1) + p_2 C(2) + p_3 C(3) + p_4 C(4) - p_5 C(5) - p_6 C(6) \]

\[ \Delta H = p_1 H(1) + p_2 H(2) + p_3 H(3) + p_4 H(4) - p_5 H(5) - p_6 H(6) \]

ICER = \[ \frac{\Delta C}{\Delta H} \]
CE of Preventive Treatment

\[
\text{ICER} = \frac{\sum_{i=1}^{\text{post outcomes}} p_i \bar{C}(\text{post})_i - \sum_{j=1}^{\text{pre outcomes}} p_j \bar{C}(\text{pre})_j}{\sum_{i=1}^{\text{post outcomes}} p_i \bar{H}(\text{post})_i - \sum_{j=1}^{\text{pre outcomes}} p_j \bar{H}(\text{pre})_j}
\]

where \(i\) and \(j\) represent the full range of outcomes in a decision tree.
CE of a New Diagnostic Test

- **receives Dx test**
  - **new**
    - **positive result**
      - true positive: \((C[1]) / (H[1])\)
      - false positive: \((C[2]) / (H[2])\)
      - false positive: \((C[3]) / (H[3])\)
    - **negative result**
      - true negative: \((C[4]) / (H[4])\)
      - false negative: \((C[7]) / (H[7])\)
  - **old**
    - **positive result**
      - true positive: \((C[5]) / (H[5])\)
      - false positive: \((C[6]) / (H[6])\)
    - **negative result**
      - true negative: \((C[7]) / (H[7])\)
      - false negative: \((C[8]) / (H[8])\)

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CE of a New Diagnostic Test

\[
\text{ICER} = \frac{\sum_{i=1}^{\text{new outcomes}} p_i \overline{C}(newDx)_i - \sum_{j=1}^{\text{old outcomes}} p_j \overline{C}(oldDx)_j}{\sum_{i=1}^{\text{new outcomes}} p_i \overline{H}(newDx)_i - \sum_{j=1}^{\text{old outcome}} p_j \overline{H}(oldDx)_j}
\]

where \( i \) and \( j \) represent the full range of outcomes in a decision tree.
CE of a New Treatment

Diagram:

- **new Rx**: Receives new treatment
  - **recovers**
    - **full recovery** with probability $p_1$ and complications with probability $p_2$
    - **recovery with complications** with probability $p_2$
    - **survives** with probability $p_3$
    - **dies** with probability $p_4$

- **old Rx**: Receives old treatment
  - **recovers**
    - **full recovery** with probability $p_5$
    - **recovery with complications** with probability $p_6$
    - **survives** with probability $p_7$
    - **dies** with probability $p_8$
      - $C[8] / H[8]$

Note: $p_1, p_2, p_3, p_4, p_5, p_6, p_7, p_8$ represent probabilities.
CE of New Treatment

ICER =

\[
\frac{\sum_{i=1}^{\text{new outcomes}} p_i \bar{C}(newRx)_i - \sum_{j=1}^{\text{old outcomes}} p_j \bar{C}(oldRx)_j}{\sum_{i=1}^{\text{new outcomes}} p_i \bar{H}(newRx)_i - \sum_{j=1}^{\text{old outcomes}} p_j \bar{H}(oldRx)_j}
\]

where i and j represent the full range of outcomes in a decision tree.
QUESTIONS ?
Measuring Costs

Cost Categories

- Medical costs
  - Hospital costs
  - Other institutional costs, including nursing home, rehabilitation, etc.
  - Ambulatory costs, including physicians, home health services, etc.
  - Pharmaceuticals

- Social costs
  - Costs borne by patients and their families, including lost income, travel costs, etc.
  - Costs borne by society, such as criminal justice system costs
Measuring Costs

Types of Costs

- Fixed vs. variable costs
  - Fixed costs are considered “sunk,” and thus can be excluded
  - In practice, it is often difficult/impossible to measure only variable costs
    - Thus average costs are most often used
- Joint products
  - May be difficult to separate joint production costs
- Time horizon
  - Should be long enough to capture relevant health benefits
1. Specify, in detail, all relevant resources to be used in the intervention or treatment being assessed

2. Measure actual resources used
   - Requires data collection or abstraction tools, developed to collect the information identified in the previous step
   - In many cases, may be available from administrative data

3. Place a monetary value on resources used
   - In many cases, will have to be imputed
Micro versus Gross Costing

- Gross costing
  - Uses readily available sources of data about either the cost of production, or more commonly, the price paid for services
  - Requires collection of aggregate utilization data, which is then priced using standard reimbursement or payment rates
    - Data are easier to collect, but refined analyses of changes in resource use aren’t possible

- Micro costing
  - Requires collection of detailed utilization data, usually with instruments developed specifically for an individual study
  - Usually requires collection of detailed cost or pricing data
    - Costs may lack external validity
Measuring Costs

- Pharmaceuticals
  - Acquisition costs
  - Costs of administering, monitoring, compliance

- Hospitals
  - Time and motion studies may be necessary to obtain accurate measure of resources used in treatment
  - Costs are often estimated from charges using the ratio of costs-to-charges (RCC)
  - Public payment rates, such as Medicare DRG rates, can be used if we assume that marginal revenue for public payers (roughly) equals marginal costs
Measuring Costs

- Physicians
  - Cost data are usually difficult to obtain
  - Payment data, such as Medicare payment rates based on the Resource-Based Relative Value Scale, again may be used assuming that marginal revenue roughly equals marginal cost
Measuring Costs

- Personal/Family Costs
  - Often ignored, because in CUA, costs of lost productivity or functional status are already included in outcome measure (i.e., QALY)
  - Depending on the intervention, may be important
    - Caregiver costs
    - Travel costs
    - Time in treatment

- Social Costs
  - Missed school
  - Criminal justice system
  - Environmental effects
  - May be particularly important when evaluating MH/SA interventions
Measuring Costs

- Induced costs, i.e., costs of added years of life
  - may have a large impact on programs with low CE ratios
- Panel on Cost-Effectiveness in Health and Medicine suggests ignoring these costs, unless they are likely to have a large impact
QUESTIONS?

THANK YOU!

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