Are HAIs Costly? It Depends - Who’s Asking?

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Disclaimer: The findings and conclusions in this presentation are those of the author and do not necessarily represent the views of the Centers for Disease Control and Prevention.

Consider This:
“Monetary valuations of the economic cost of health care–associated infections (HAIs) are important for decision making and should be estimated accurately. Erroreously high estimates of costs, designed to jolt decision makers into action, may do more harm than good in the struggle to attract funding for infection control.

Expectations among policy makers might be raised, and then they are disappointed when the reduction in the number of HAIs does not yield the anticipated cost saving.

The “HAI costs a lot” approach to influencing decision making has served the infection control community well. The time has arrived, however, for the methodological advances that have been achieved in this area to be implemented by researchers.”


Objectives
- Describe economic theory underlying divergent cost perspectives.
- Present cost (cost saving or benefit) estimates of HAIs (mostly hospital-onset) from varying cost perspectives.
  - Economic burden to the healthcare system
  - Excess reimbursements made to Medicare
  - Introduce the societal cost perspective
- Illustrate the use of the “statistical value of life” (VSL) as used by the federal government for regulatory impact analysis.
- Back to the past - current musings on measuring the cost of infection control and the “limits” of traditional accounting practices.

Cost Perspectives of Economic Evaluations of Healthcare Investments
Perspective: What is the point of view which the analysis is based? Determines which benefits and costs to included:
- The cost perspective of healthcare providers includes those costs of the resources used to prevent and/or treat patients while in their care
- The cost perspective from patients include lost work days, out-of-pocket costs for care, pain and suffering, impact on family and / or other caregivers, long term morbidity and mortality.
- The cost perspective of third party payers (like Medicare) assesses the excess reimbursements that would be saved due to infections averted by investing in HAI prevention.
- Societal perspective must consider all cost and benefits to all members of society

Characteristics of a Perfectly Competitive Market
- Large number of buyers and sellers willing to buy or sell the product at a certain price.
- Perfect information – All consumers and producers know all prices of products and what their value is to the consumer.
- Homogeneous products – The products made by producers are perfect substitutes for each other.
- Well-defined Property rights with no externalities (Costs or benefits of an activity do not affect third parties.)
- No barriers to entry or exit.

Source: https://en.wikipedia.org/wiki/Perfect_competition

Characteristics of a Perfectly Competitive Market
- Every participant is a price taker – No participant with market power to set prices.
- Perfect factor mobility – In the long run factors of production are perfectly mobile.
- Profit maximization of sellers – Firms sell where the most profit is generated
- Rational buyers: Buyers act according to their own self-interest.
- Zero transaction costs – No cost incurred in exchange of goods.

Source: https://en.wikipedia.org/wiki/Perfect_competition
Underlying Theory

- Neoclassical economics — theory of how individual decision makers behave in various market structures focusing on the determination of distribution of goods, outputs, and income.
- Key assumption on human behavior — rational choice: Individuals will act to promote their self-interest (maximize their own welfare or utility).

But Why?

- Multiple cost perspectives are the result of “market failure” in markets for healthcare services - one or more characteristics needed for a market to function efficiently is lacking.
- Problem is one of asymmetric information or the principal-agent problem (Kenneth Arrow).
- Problem occurs when one individual, acting as an agent but processing more information, is able to make decisions on behalf of another individual, or principal, who cannot be sure that the agent is always acting in the principal’s best interest (i.e., doctor-patient relationship, doctor-third party payer relationship).

Healthcare Provider Perspective: Business Case for HAI prevention

- Majority of economic evaluations of HAI Investments by hospitals have been done from the cost perspective of the hospital or healthcare system (direct medical costs only).
- HAI prevention efforts will reduce hospital costs by reducing cases (and length of stay).
- Difficult to estimate using traditional economic models of production (at the hospital level) – non-standardized production processes.
- Non-standardized accounting practices for cost accounting (unlike financial statements).
- Attributable HAI patients cost are typically measured using epidemiologic methods (cohort studies).

Results In This:

Desirable Outcome: Resources are valued at their opportunity costs

The Categories of Costs Related to Hospital-Associated Infections

<table>
<thead>
<tr>
<th>Category of Cost</th>
<th>Direct Medical Costs</th>
<th>Indirect Costs</th>
<th>Intangible Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Costs</td>
<td>Buildings</td>
<td>Unbilled</td>
<td>Psychological Costs (i.e., anxiety, grief, disability, job loss)</td>
</tr>
<tr>
<td></td>
<td>Utilities</td>
<td></td>
<td>Pain and suffering</td>
</tr>
<tr>
<td></td>
<td>Equipment/Technology</td>
<td></td>
<td>Change in social functioning/daily activities</td>
</tr>
<tr>
<td></td>
<td>Labor (including environmental control, administration)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable Costs</td>
<td>Medications</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Per Consultation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Procedures</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Devices</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Testing (lab and radiographic)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supplies</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Downstream or Upstream Encounters (Readmissions + Outpatient visits + Physician visits, etc.)</td>
<td></td>
</tr>
</tbody>
</table>


Assessing the Economic Impact of HAI to Hospitals: Previous Approaches

As production of hospital patient health is unique to each patient (non-standardized production process), detailed accounting data for each patient is lacking.

Instead, epidemiologic (cohort) models have been used that included non-HAI infected patients and patients with HAI

1. Crude group comparisons on patient cost
2. Matched group comparison on patient cost
3. Statistical Model with measures on confounders
4. Combination of 2 and 3

5. AEP (Appropriateness Evaluation Protocol)
Searching for the Attributable Cost of HAIs

- Early attempts at understanding the economic impacts to hospital finances were mostly limited to measuring the excess or “attributable cost” of HAI as opposed to doing a cost-effectiveness analysis.
  
  Conclusion: Published economic evidence on HAIs and infection control and prevention lacked rigor due to the variety of study designs, statistical methods, study settings, and cost outcomes used.

Roberts Results

<table>
<thead>
<tr>
<th>Method of Analysis (Total cost: not adjusted for ARI)</th>
<th>Estimated Cost per Infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generalized linear model</td>
<td>$20,888</td>
</tr>
<tr>
<td>OLS linear regression</td>
<td>$19,917</td>
</tr>
<tr>
<td>OLS linear regression: total cost minus MD and procedures</td>
<td>$18,615</td>
</tr>
<tr>
<td>Propensity score matched comparison</td>
<td>$19,251</td>
</tr>
<tr>
<td>LOS multiplied by mean HAI cost/d</td>
<td>$19,344</td>
</tr>
<tr>
<td>OLS linear regression: 98% Winsorized</td>
<td>$15,203</td>
</tr>
<tr>
<td>LOS multiplied by mean non-HAI cost/d</td>
<td>$15,149</td>
</tr>
<tr>
<td>3S-PHM LOS multiplied by mean HAI cost/d</td>
<td>$11,889</td>
</tr>
<tr>
<td>Quantile linear regression</td>
<td>$11,662</td>
</tr>
<tr>
<td>OLS linear regression: 95% Winsorized</td>
<td>$11,299</td>
</tr>
<tr>
<td>3S-PHM LOS multiplied by mean non-HAI cost/d</td>
<td>$9,310</td>
</tr>
</tbody>
</table>

Biased Estimation in Cohort Studies of Attributable Cost

- Models of excess length of stay (LOS) that do not account for time to infection overstate the excess LOS due to HAI
- VA study comparing three strategies to estimate HCO-MRSA*

<table>
<thead>
<tr>
<th>Measurement Strategies</th>
<th>Incremental LOS</th>
<th>Incremental Variable Costs</th>
<th>Incremental Total Costs</th>
<th>% Change in Total Costs from Post-HAI Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-HAI costs only</td>
<td>$11,436</td>
<td>$12,559</td>
<td>$24,015</td>
<td>-</td>
</tr>
<tr>
<td>Convention Cohort Method</td>
<td>$17,676</td>
<td>$31,570</td>
<td>$49,246</td>
<td>31.5%</td>
</tr>
<tr>
<td>Matched on Time to Infection</td>
<td>$13,976</td>
<td>$26,855</td>
<td>$40,831</td>
<td>11.8%</td>
</tr>
</tbody>
</table>


Measuring the Economic Burden of HAIs*: Systematic Literature Reviews

For economic burden (to hospitals) of those HAIs that are the primary focus of prevention efforts, the average cost per case is:
- Central-line bloodstream infections - $45,814
- Ventilator-associated pneumonia - $40,144
- Surgical site infections - $20,786
- Clostridium difficile infection - $11,285
- Catheter-associated urinary tract infections - $896

The total annual costs for the 5 major infections - $9.8 billion (95% CI, $8.3-$11.5 billion), with:
- Surgical site infections represents 33.7% of total costs
- Ventilator-associated pneumonia (31.6%)
- Central line-associated bloodstream infections (18.9%)
- C difficile infections (15.4%)
- Catheter-associated urinary tract infections (<1%)

*The16 studies assessed 21 HAIs, including the primary focus of prevention efforts. A meta-analysis of costs and financial impact on the US health care system. Health Affairs. 2017;37(2):233-244.
**Cost Estimates: PfP Program**

<table>
<thead>
<tr>
<th>PfP Hospital Acquired Condition</th>
<th>Estimated Additional Cost* per HAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catheter-Associated Urinary Tract Infections</td>
<td>$1,000</td>
</tr>
<tr>
<td>Central Line-Associated Bloodstream Infections</td>
<td>$17,000</td>
</tr>
<tr>
<td>Surgical Site Infections (17 procedures in 2010 NHSN)</td>
<td>$21,000</td>
</tr>
<tr>
<td>Ventilator-Associated Pneumonia</td>
<td>$21,000</td>
</tr>
<tr>
<td>Hospital-Acquired MRSA</td>
<td>$17,000</td>
</tr>
<tr>
<td>Hospital-Acquired VRE</td>
<td>$17,000</td>
</tr>
<tr>
<td>Hospital-Acquired Antibiotic-Associated C. difficile</td>
<td>$17,000</td>
</tr>
</tbody>
</table>

Sources: Literature review and expert opinion

**However!!!**

DHQP is experimenting with an analogy costing methodology used by the Defense Department to develop economic burden estimates using administrative data.

**Third Party Payer Perspective**

- Do HAIs result in excess reimbursements paid by Medicare?*
  - CLABSI patients in intensive care unit: $25,000
  - CAUTI - intensive care unit (ICU): $8,500; non-ICU: $1500
  - Multifaceted Infection Control and Antimicrobial Stewardship Program to prevent CDI: $2.5 billion in saved reimbursements over 5 year period.
    - See Slayton et al. The Cost–Benefit of Federal Investment in Preventing Clostridium difficile Infections through the Use of a Multifaceted Infection Control and Antimicrobial Stewardship Program. Infect Control Hosp Epidemiol 2015;00(0):1-7

**What is the Societal Cost Perspective?**

Societal Cost = Direct Medical Costs + Indirect Costs + Intangible Costs

Note: Third party reimbursements are not included – only the costs associated with the resources used for patient treatment are considered in cost-benefits analysis.

**What About Calculating Societal Cost Perspective**

- Can estimate direct medical cost and lost productivity due to hospital stays with available data.
- Additional data needed including:
  - Long-term sequelae (amputations, discharge to long-term care, etc.).
  - Lost productivity long-term
  - Value of premature death
  - Lost productivity of care giver if employment is forgone
  - Intangible cost (lost leisure time, disability)
  - Patient out-of-pocket costs
- Very little data for HAI patients on most these items – difficult to estimate societal perspective – except mortality (somewhat).

**Societal cost of hospital-acquired infections.***

<table>
<thead>
<tr>
<th>Category</th>
<th>Societal Low</th>
<th>Societal High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct costs (Billions – 2010$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Index hospitalization</td>
<td>$24.8</td>
<td>$53.9</td>
</tr>
<tr>
<td>Professional fees index hospitalization</td>
<td>$4.9</td>
<td>$13.2</td>
</tr>
<tr>
<td>Post-discharge outpatient</td>
<td>$0.2</td>
<td>$0.2</td>
</tr>
<tr>
<td>Readmission post-index hospitalization</td>
<td>$3.4</td>
<td>$4.0</td>
</tr>
<tr>
<td>Professional fees readmission</td>
<td>$0.7</td>
<td>$1.0</td>
</tr>
<tr>
<td>Post-discharge diagnosed infection</td>
<td>$0.3</td>
<td>$1.7</td>
</tr>
<tr>
<td>Sub-totals</td>
<td>$34.3</td>
<td>$74.0</td>
</tr>
<tr>
<td>Indirect costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lost wages, incapacitation ($149 a day)</td>
<td>$2.5</td>
<td>$3.9</td>
</tr>
<tr>
<td>Lost future wages, premature death ($685,225)</td>
<td>$99.1</td>
<td>$66.7</td>
</tr>
<tr>
<td>Sub-totals</td>
<td>$101.6</td>
<td>$72.6</td>
</tr>
<tr>
<td>Total societal costs</td>
<td>Societal cost of illness</td>
<td>$96*</td>
</tr>
</tbody>
</table>

Valuing Reductions to the Risk of Death

- Marchetti study used an accounting value to represent the value of a lost life (lost productivity).
- An alternative value used by federal regulatory agencies for regulatory impact analysis (RIA) is the value of statistical life (VSL) or value of mortality risk reduction.
- VSL - the value that an individual places on a marginal change in their likelihood of death.

Valuing Reductions to the Risk of Death - Measurement Issues

- VSL measured in 2 ways
  - Wages studies that examine wages differentials for with varying job-related risks.
  - Survey methods where respondents are asked what they would be willingness to pay for changes in risk of death.
- VSL estimate is age invariant
- An alternative to VSL that accounts for age differences in remaining life expectancy is the value of a statistical life year (VSLY) but this measure is not consistent with economic theory and not used.
- Current VSL used by the U.S. Environmental Protection Agency is $7.6 million (2006$)

Value of Statistical Life

- Example – take a population of 100,000
  - Suppose each person would be willing to pay (WTP) an average of $50 to reduce their risk of dying by 1 / 100,000.
  - VSL is equal to $50 ÷ (1 / 100,000) or $5 million.
  - Works for small changes in risk – WTP will change in proportion with the risk change as long as WTP is small fraction of income.

Table 5: Marchetti Direct Cost of Associated Hospital-Onset HAI and EPA VSL

<table>
<thead>
<tr>
<th>Measure</th>
<th>Number of Attributable cases</th>
<th>Per Patient Cost Estimates</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using EPA values for Mortality</td>
<td>39,595 (40% of 98,987)</td>
<td>$4 million (low) $8 million (high)</td>
<td>$158 billion - $317 billion</td>
</tr>
<tr>
<td>Marchetti Direct Medical Costs</td>
<td>1,463,077 (low) 1,676,628 (high)</td>
<td>$17,070 (low) $32,176 (high)</td>
<td>$34 billion - $74 billion</td>
</tr>
<tr>
<td>Total Societal Costs</td>
<td></td>
<td></td>
<td>$192 billion - $391 billion</td>
</tr>
</tbody>
</table>

Implication

- The benefits from reductions to the risk of mortality significantly outweigh the benefits of reduced direct medical costs.

HHS Guidelines

- DEPARTMENT OF HEALTH AND HUMAN SERVICES (HHS) HAS DEVELOP GUIDELINES FOR CONDUCTING REGULATORY IMPACT ANALYSIS (RIA) THAT COMPLY WITH OFFICE OF MANAGEMENT AND BUDGET (OMB) GUIDELINES.
- HTTPS://ASPE.HHS.GOV/PDF-REPORT/GUIDELINES-REGULATORY-IMPACT-ANALYSIS.
Another Example: Antimicrobial Stewardship

Proposed Federal Regulation: 42 CFR Parts 482 and 485

- Requires hospitals (including critical access) to have policies and procedures for, and to demonstrate evidence of, an active and hospital-wide antibiotic stewardship program along with updating requirements for infection control programs.
- Estimated costs - $773 million to $1.1 billion
- Estimated net savings to society - $284 million
- No estimate for the value of mortality risk reductions


<table>
<thead>
<tr>
<th>AIS</th>
<th>Description of Injury</th>
<th>Fraction of VSL</th>
<th>Dollar Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIS 1</td>
<td>Minor</td>
<td>0.003</td>
<td>$28,800</td>
</tr>
<tr>
<td>AIS 2</td>
<td>Moderate</td>
<td>0.047</td>
<td>$451,200</td>
</tr>
<tr>
<td>AIS 3</td>
<td>Serious</td>
<td>0.105</td>
<td>$1,008,000</td>
</tr>
<tr>
<td>AIS 4</td>
<td>Severe</td>
<td>0.286</td>
<td>$2,553,600</td>
</tr>
<tr>
<td>AIS 5</td>
<td>Critical</td>
<td>0.593</td>
<td>$5,692,800</td>
</tr>
<tr>
<td>AIS 6</td>
<td>Unsurvivable/Fatal</td>
<td>1.000</td>
<td>$9,600,000</td>
</tr>
</tbody>
</table>

Selected Sample of Injuries by the Abbreviated Injury Scale (AIS)

<table>
<thead>
<tr>
<th>AIS</th>
<th>Injury Severity</th>
<th>Selected Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Minor</td>
<td>Superficial abrasion or laceration of skin, dig sprain, first-degree burn, head trauma with headache or dizziness (no other neurological signs).</td>
</tr>
<tr>
<td>2</td>
<td>Moderate</td>
<td>Major abrasion or laceration of skin; cerebral concussion (unconsciousness less than 15 minutes); finger or toe crush/avulsion; closed pelvic fracture with or without dislocation.</td>
</tr>
<tr>
<td>3</td>
<td>Serious</td>
<td>Major nerve laceration; multiple rib fracture (but without flat chest); abdominal organ contusion; hand, foot, or arm crush/amputation.</td>
</tr>
<tr>
<td>4</td>
<td>Severe</td>
<td>Spinal fracture; leg crush; chest wall perforation; cerebral concussion with other neurological signs (unconsciousness less than 24 hours).</td>
</tr>
<tr>
<td>5</td>
<td>Critical</td>
<td>Spinal cord injury (with cord transection); extensive second- or third-degree burns; cerebral concussion with severe neurological signs (unconsciousness more than 24 hours).</td>
</tr>
<tr>
<td>6</td>
<td>Unsurvivable</td>
<td>Injuries, which although not fatal within the first 30 days after an accident, ultimately result in death.</td>
</tr>
</tbody>
</table>

What About Morbidity Impacts?

- HHS Guidelines:
  Use suitable WTP estimates of reasonable quality if available. If not, use monetized QALYs as a proxy.

- Federal Aviation Administration Guidelines:
  Abbreviated Injury Scale -- for each level, the value of injury is related to the loss of quality and quantity of life resulting from an injury typical of that level.

EPA 1990 Clean Air Act Amendments prevent:*
In Summary:

- Approach to measure economic burden to healthcare system is in development
- NSHN data has been successfully linked to Medicare claims data – this should be become easier in time.
- New HHS guidelines should help with developing regulatory impact-type analysis that incorporates values for mortality and morbidity risk reductions.

Economic Evaluation of HAIs: Further Musings

- Partial Equilibrium Analysis vs. System Analysis
  Cost-Effectiveness / Cost Benefit frameworks assume all other factors are kept constant while investigating a particular policy.
- Alternative evaluation model – Cost of Quality (CoQ)

Figure 2: Classical P-A-F Model

How Does CoQ Work?

- It starts with accounting system
- The point of a cost accounting system (or managerial accounting system) understand the expenditures or costs generated within an organization to improve decision making
- Many hospital accounting systems are based on the Medicare cost report method – ICR method
  - Identify nonrevenue or cost support centers vs revenue center.
  - Determine cost for each cost center, allocate from cost to revenue centers, allocate costs to the units of service.

Consider Daily Costs

Typical Cost Equation

\[ TC_i = \sum_{k=1}^{5} (Fixed_{ik} + Hotel_{ik} + Treatment_{ik}) \]

Cost of Quality

\[ TC_i = \sum_{k=1}^{5} (Fixed_{ik} + Hotel_{ik} + Treatment_{ik} + IC_{ik}) \]

Or

\[ TC_i = \sum_{k=1}^{5} (Fixed_{ik} + Hotel_{ik} + Treatment_{ik} + Prevention_{ik} + Failure_{ik}) \]
Consider This:

“Monetary valuations of the economic cost of health care–associated infections (HAIs) are important for decision making and should be estimated accurately. Erroneously high estimates of costs, designed to jolt decision makers into action, may do more harm than good in the struggle to attract funding for infection control.

Expectations among policy makers might be raised, and then they are disappointed when the reduction in the number of HAIs does not yield the anticipated cost saving.

The “HAI costs a lot” approach to influencing decision making has served the infection control community well. The time has arrived, however, for the methodological advances that have been achieved in this area to be implemented by researchers.”

Questions?

Implications

➢ Restructuring of Medicare cost reports?
  Infection Control as Revenue Center or Service Center?

➢ Question becomes what price to charge to fund infection control programs at levels wanted / needed.

➢ Move from disease management to risk management (like FAA)