Preventing Healthcare Associated Infections: Defining the Return on Investment

John Jernigan, MD, MS

Office of Prevention Research and Evaluation
Division of Healthcare Quality Promotion
Centers for Disease Control and Prevention
November 2017

The findings and conclusions in this presentation are those of the author and do not necessarily represent the official position of the Centers for Disease Control and Prevention.
Acknowledgments

**DHQP**
- James Baggs
- John Jernigan
- Kelly McCormick
- Doug Scott
- Rachel Slayton
- Sarah Yi
- Prabasaj Paul
- Justin O’Hagan
- Brajendra Singh

**Emory University**
- Steve Culler
- Kim Rask

**University of Utah**
- Rich Nelson
- Damon Toth
- Matt Samore
Presentation Outline

- Review past and current DHQP portfolio of return-on-investment projects and supporting work
- Review challenges
- Future directions
Goals for DHQP ROI Analyses

- Provide information on economic benefit of preventing healthcare associated infections that can be used by decision makers to guide policy and investment decisions
  - State Government
  - Federal Government
  - Healthcare payers
  - Healthcare providers
  - Healthcare purchasers
How much does it cost? It depends on who’s asking

• What is the point of view which the analysis of costs is based?
  – Determines which benefits and costs should be included

• Healthcare Facility Perspective
  – Cost attributable to HAI = (Excess expenditure for care - Extra reimbursement from Payer)
  – Cost of intervention = implementing preventive practice (e.g. CDC recommendations)

• Payer Perspective
  – Cost attributable to HAI = excess reimbursement attributable to HAI
  – Cost of intervention =
    • Private payer = incentive payments or discounts
    • Federal payer = cost of investment in policy and public health prevention activities (e.g. CDC)

• Societal perspective
  – Considers not only direct healthcare costs, but other costs to society
    • For example: changes in insurance premiums, personal income lost from morbidity/mortality, larger cost to economy from loss of productivity, quality of life cost, etc.
Quantifying Attributable CMS Reimbursement for Healthcare Associated Infections

- Retrospective cohort studies using Combined CDC Surveillance Data with CMS Databases
- Central Line associated Bloodstream Infections
  - $25,135 (95% CI: $22031, $28235)¹
- Surgical site infections
  - post-total hip replacement- $67,077²
  - Post total knee replacement- $56,771²
  - Colorectal surgery (planned)
  - Hysterectomy (planned)
- Catheter-associated Urinary Tract Infection
  - ICU- $8,548 ($6,062-$11,035)³
  - Non-ICU- $1,479 ($909-$2,050)³

THE COST OF ANTIMICROBIAL RESISTANT HAIs IN THE UNITED STATES (Nelson et al.)

- Simulation model to determine attributable cost of an HAI (pre-discharge costs, post-discharge readmission costs)
  - input parameters from literature review and CDC data
    - Cohort comparison of ARHAI/ no HAI, controlling for time dependent bias, and co-morbid conditions, severity of illness
    - excess LOS and readmission days multiplied by the cost per inpatient day from the payer perspective.
    - model used 1,000 1st order and 10,000 2nd order Monte Carlo simulations

- Calculated the number of AR-HAIs for each organism in the US using;
  - organism-specific incidence estimates
  - number of hospitalizations in the United States per year between 2005-2009.
Nelson RE et al. THE COST AND MORTALITY BURDEN OF HOSPITAL-ONSET ANTIMICROBIAL RESISTANT HEALTHCARE-ASSOCIATED INFECTIONS IN THE UNITED STATES. Abstract #466, IDWeek 2017, San Diego, CA

**Attributable Cost Per HAIs by Pathogen**

- **MDR Acinetobacter**: $39,787
- **MRSA**: $35,069
- **MDR Pseudomonas**: $33,835
- **MDR Enterbacteriaceae**: $31,072
- **Clostridium difficile**: $15,365
- **VRE**: $3,384

Nelson RE et al. THE COST AND MORTALITY BURDEN OF HOSPITAL-ONSET ANTIMICROBIAL RESISTANT HEALTHCARE-ASSOCIATED INFECTIONS IN THE UNITED STATES. Abstract #466, IDWeek 2017, San Diego, CA
Aggregate Attributable Cost Per Year, US, By Pathogen

Total cost = $4,141,146,837

- $1,886,741,703
- $1,244,375,491
- $499,592,778
- $253,287,070
- $168,346,942
- $88,802,853

- Clostridium difficile
- MRSA
- MDR Enterbacteriaceae
- MDR Pseudomonas
- MDR Acinetobacter
- VRE

Nelson R et al. THE COST AND MORTALITY BURDEN OF HOSPITAL-ONSET ANTIMICROBIAL RESISTANT HEALTHCARE-ASSOCIATED INFECTIONS IN THE UNITED STATES. Abstract #466, IDWeek 2017, San Diego, CA
Challenges

- Capturing all the costs
  - HAIs can trigger a cascade of events that might result in costs that accrue over time (i.e., following discharge from the index hospitalization)
Medicare Reimbursement Among Patients With and Without Prosthetic Joint Infection Following Hip or Knee Replacement

Challenges (cont.)

- Capturing all the costs
  - HAIs can result in transmission events that, in turn, lead to subsequent generations of HAIs in other patients, and in other facilities
Challenges (continued)

- **Facility/Provider Perspective**
  - Payer/provider cost relationships unclear
    - What proportion of costs are shifted to the payer?
      - Are facilities actually benefitting from HAIs? (excess reimbursement for complications, additional hospitalizations, etc.)
Challenges (continued)

- What about predicting return on investment?
Using Mathematical Modeling to Predict the Future Economic Benefit of Investment in Prevention

Method

- Quantify the economic value from the federal perspective of CDC investment in CDI prevention
- Markov Chain Monte Carlo Modeling
- Modeled parameters are estimated from existing data sources
- Compared outcomes of a cohort with an intervention attenuating the probability of disease to a cohort without an intervention

The Cost–Benefit of Federal Investment in Preventing *Clostridium difficile* Infections through the Use of a Multifaceted Infection Control and Antimicrobial Stewardship Program

Rachel B. Slayton, PhD, MPH; R. Douglas Scott II, PhD; James Baggs, PhD; Fernanda C. Lessa, MD; L. Clifford McDonald, MD; John A. Jernigan, MD

Sensitivity Analysis of Intervention Effectiveness
Assumptions: cohort of 70 year olds, 10 year time horizon

Effectiveness = 35%
Cost-savings by intervention effectiveness over a five year time horizon

Trends in Rates of *Clostridium difficile* Infection, United Kingdom, 2008-2013

>50% decrease

http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1278944283388
Number of Infections and Deaths Averted: Cohort of >65 year olds

<table>
<thead>
<tr>
<th>Intervention Effectiveness</th>
<th>10%</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohort of 1,000 hospitalized Medicare beneficiaries ≥65 years old</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total CDI infections averted over 5 years</td>
<td>7.36</td>
<td>18.59</td>
<td>36.94</td>
<td>56.06</td>
</tr>
<tr>
<td>Total CDI-attributed deaths averted over 5 years</td>
<td>1.20</td>
<td>2.93</td>
<td>5.91</td>
<td>8.97</td>
</tr>
<tr>
<td>Among all hospitalized Medicare beneficiaries ≥65 years old</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total CDI infections averted over 5 years</td>
<td>101,000</td>
<td>257,000</td>
<td>509,000</td>
<td>773,000</td>
</tr>
<tr>
<td>Total CDI-attributed deaths averted over 5 years</td>
<td>16,000</td>
<td>41,000</td>
<td>82,000</td>
<td>124,000</td>
</tr>
</tbody>
</table>

The national burden of SSI following hip and knee arthroplasty will likely increase as the US population ages, even if SSI rates remain unchanged.

Wolford et al. Projected Burden of Complex Surgical Site Infections following Total Hip and Knee Arthroplasty among Adults in the United States, 2020 through 2030. Abstract # 2217, IDWeek 2017, San Diego, CA
23,297 fewer infections
$2.4$ billion in Medicare savings
Challenges (continued)

- What about the societal perspective?
Use of Societal Perspective in Federal Regulatory Impact Analysis

- Federal regulatory agencies conducting economic analyses of regulations impacting human health often take the societal perspective, which includes measuring the economic benefit of mortality risk reductions
  - Often use the value of statistical life (VSL) which is a monetized measure of the additional cost that individuals would be willing to pay for a small reduction in the risk of mortality
  - Until recently, only the Environmental Protection Agency (EPA) and the Department of Transportation (DOT) had issued their own guidelines to ensure that their use of VSL in internal analyses
- HHShas now published draft guidelines (2017) to inform and advise department agencies on the methods used in conducting regulatory impact analysis
  - discusses use of VSL
Incorporating the Social Value of Reducing the Risk of Mortality

- **Value of Statistical Life - Definition**
  
  An estimate of how much people are willing to pay for small reductions in their risks of dying from adverse health conditions.

- **VSL is not the value of an individual life but a value for small reductions to the risk of mortality.**
  
  For example: if an individual is willing to pay $800 for a 1 in 10,000 reduction in his or her risk of dying in the current year, his or her VSL is calculated as: 
  
  \[ \frac{800 \text{ willingness to pay}}{1/10,000 \text{ risk change}} = 8.0 \text{ million VSL} \]

- **VSL values used by other federal agencies**
  
  - 2006 Environmental Protection Agency VSL estimate: $7,400,000
  - 2005 Food and Drug Administration VSL: $5,000,000
FEDERAL REGISTER

Vol. 81 Thursday,
No. 116 June 16, 2016

Part IV

Department of Health and Human Services

Centers for Medicare & Medicaid Services

42 CFR Parts 482 and 485

Medicare and Medicaid Programs; Hospital and Critical Access Hospital (CAH) Changes To Promote Innovation, Flexibility, and Improvement in Patient Care; Proposed Rule
Regulatory impact analysis concluded that requiring acute care hospitals to staff antibiotic stewardship programs would result in net annual savings to Medicare, but......
Regulatory impact analysis concluded that requiring acute care hospitals to staff antibiotic stewardship programs would result in net annual savings to Medicare, but...
Regulatory impact analysis concluded that requiring acute care hospitals to staff antibiotic stewardship programs would result in net annual savings to Medicare, but......
Dynamic transmission models for economic analysis applied to healthcare-associated infections

- The most common model types are decision trees or Markov models, both assume:
  - no interaction between patients
  - probability of patient exposure is constant over time.
- Neither assumption is likely to be true regarding spread of infectious diseases
  - Risk is affected by the amount of contact individuals have.
  - Interventions for infectious diseases are designed to reduce transmission, progression from exposure to infection, or reduce duration of symptoms
    - Such interventions will therefore influence not only whether treated individuals become sick (direct effect) but also whether other individuals will be exposed to the disease (indirect effect).
- Models that take into account these transmission effects are called dynamic models because the risk, or force, of infection changes over time
- Dynamic models are necessary for CEAs that evaluate interventions that affect a pathogen’s ecology or transmission

Nelson at al. AJIC, published online, http://dx.doi.org/10.1016/j.ajic.2017.02.035
Impact of Delays between Clinical and Laboratory Standards Institute and Food and Drug Administration Revisions of Interpretive Criteria for Carbapenem-Resistant Enterobacteriaceae

Sarah M. Bartsch,¹ Susan S. Huang,¹ Kim F. Wong,³ Rachel B. Slayton,⁴ James A. McKinnell,⁵ Daniel F. Sahm,⁹ Krystyna Kazmierczak,¹ Leslie E. Mueller,⁴ John A. Jernigan,⁹ Bruce Y. Lee⁹

Public Health Computational and Operations Research (PHCOR), Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA; Division of Infectious Diseases and Health Policy Research Institute, University of California—Irvine School of Medicine, Orange, California, USA; Center for Simulation and Modeling, University of Pittsburgh, Pittsburgh, Pennsylvania, USA; Division of Healthcare Quality Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia, USA; Infectious Disease Clinical Outcomes Research Unit (ID-CORE), Los Angeles Biomedical Research Institute, Harbor-UCLA Medical Center, Torrance, California, USA; Torrance Memorial Medical Center, Torrance, California, USA; International Health Management Associates, Inc., Schaumburg, Illinois, USA

Delays often occur between CLSI and FDA revisions of antimicrobial interpretive criteria. Using our Regional Healthcare Ecosystem Analyst (RHEA) simulation model, we found that the 32-month delay in changing carbapenem-resistant Enterobacteriaceae (CRE) breakpoints might have resulted in 1,821 additional carriers in Orange County, CA, an outcome that could have been avoided by identifying CRE and initiating contact precautions. Policy makers should aim to minimize the delay in the adoption of new breakpoints for antimicrobials against emerging pathogens when containment of spread is paramount; delays of < 1.5 years are ideal.
Successful reduction of transmission among LTACH patients (<10% of regional facility population) reduced regional CRE transmissions substantially.
Summary Observations and Conclusions

- Return on investment analyses can be useful for guiding policy and investment decisions.
- Requires making parameter estimates in the absence of perfect data:
  - Important to acknowledge limitations, but should not be paralyzed by them.
- Analytic Perspective is important:
  - Facility/Program
  - Payer
  - Society
- Should we be considering societal Perspective?
  - May provide an “apples to apples” comparison of the economic benefit of HAI prevention against a diverse array of other government programs.
- Dynamic mathematical models should be used more often for economic analysis of HAI prevention.
Thank You!

Office of Prevention Research and Evaluation
Division of Healthcare Quality Promotion
Centers for Disease Control and Prevention