THE ECONOMIC BURDEN OF ANTIBIOTIC RESISTANCE – EVIDENCE FROM THREE RECENT STUDIES

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Roadmap of presentation

- Cost concepts
- Data on cost of AMR
  - Massachusetts hospital discharge study
  - Chicago Cook County (Stroger) Hospital (CARP extension) study
  - Study of experience of patients with MRSA
- Overall estimate of cost of AMR for the United States
The direct costs of drug resistance

- longer medical treatment
- costly second- and third-line therapies
- development of replacement drugs for those that no longer work, and
- screening and diagnostics to detect and prevent the spread of resistant strains
The indirect economic costs

- poor patient health
- longer term disability
- excess mortality
- economic burden on patients and families
- loss of drug effectiveness
- expensive risk-reduction efforts to limit the spread of the resistant pathogens

adapted from Center for Global Development
The Massachusetts Hospital Discharge Study

- Uses Massachusetts hospital discharge data from 2000-2007
- Based on presence of ICD-9 V09 codes in discharge dataset
- Data on number of cases with reported resistance, including demographics
  - Age, sex, payer
- Allows us to see trends over time
- Permits a lower-bound estimate of the cost to Massachusetts to be made
Trends in hospital discharges reporting antibiotic resistance and total hospital charges in Massachusetts, 2000-2007
Average hospital LOS and hospital charge per discharge (inflation adjusted) for drug-resistant infections and drug-susceptible infections in Massachusetts, 2000-2007

Average hospital LOS, day

Year

2000 2001 2002 2003 2004 2005 2006 2007

LOS_resistant

$12,449 $12,933 $13,096 $13,360 $14,201 $14,685 $14,308 $15,104

LOS_susceptible

$4.9 $4.9 $4.9 $4.8 $4.8 $4.8 $4.8 $4.7

Average hospital charge per discharge, inflation adjusted

Charges_resistant

$34,975 $37,060 $31,196 $28,482 $29,516 $27,084 $29,516 $25,380

Charges_susceptible

$12,449 $12,933 $13,096 $13,360 $14,201 $14,685 $14,308 $15,104

Age Distribution of Hospital Discharges with Drug-Resistant Infections in Massachusetts, 2000 and 2007

- In 2000:
  - <=18: 2.1%
  - 19-64: 30.2%
  - 65-80: 38.0%
  - >80: 25.1%

- In 2007:
  - <=18: 5.3%
  - 19-64: 45.5%
  - 65-80: 24.1%
  - >80: 25.1%
Age distribution of cases in Massachusetts, 2000, 2006 and 2007
Payer Distribution of Hospital Discharges with Drug-Resistant Infections in Massachusetts

- Medicare: 73.0% in 2000, 57.6% in 2007
- Medicaid: 20.5% in 2000, 27.7% in 2007
- Other including insurance: 6.4% in 2000, 14.7% in 2007
Drug resistant cases by payer, Massachusetts, 2000-2007

<table>
<thead>
<tr>
<th>Year</th>
<th>Medicare</th>
<th>Medicaid</th>
<th>Other (including private insurers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>2,822</td>
<td>792</td>
<td>247</td>
</tr>
<tr>
<td>2006</td>
<td>6,449</td>
<td>1,328</td>
<td>1,648</td>
</tr>
<tr>
<td>2007</td>
<td>6,461</td>
<td>3,109</td>
<td>792</td>
</tr>
</tbody>
</table>
Destination of discharges, 2000 and 2006

- 2000: 32.9% Home, 31.9% Nursing home, 11.4% Died, 23.8% Other
- 2006: 47.6% Home, 28.3% Nursing home, 5.2% Died, 18.9% Other

Legend:
- Purple: Home
- Orange: Nursing home
- Green: Died
- Cyan: Other
The Chicago Cook County (Stroger) Hospital Study

- Based on Chicago Antimicrobial Resistance Project (CARP) dataset, expanded to include all resistant infections to measure costs attributable to ARI
  - Random sample, age > 17 years, and > 5 ICD9 codes at discharge
  - Exclusion for trauma, burn, or obstetrical care
- Detailed chart review and costing of 1391 patients, of whom 188 (13.5%) had an ARI
- Excess LOS was 6.4-12.7 days
- Attributable mortality was 6.5%
- Societal costs estimated at $10.7-15 million in this hospital for this year (2000)
- Total cost estimated at $13.35 million in 2008
### Characteristics of the patient sample

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>ARI patients</th>
<th>Non-ARI patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients (n=1391)</td>
<td>188 (13.5%)</td>
<td>1203 (86.5%)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>53.0</td>
<td>54.5</td>
</tr>
<tr>
<td>Male sex (%)</td>
<td>64.9</td>
<td>57.1</td>
</tr>
<tr>
<td>APACHE III Score *</td>
<td>54.8</td>
<td>40.1</td>
</tr>
<tr>
<td>Duration of stay (d) *</td>
<td>24.2</td>
<td>8.0</td>
</tr>
<tr>
<td>HAI *</td>
<td>135 (71.8%)</td>
<td>125 (10.4%)</td>
</tr>
<tr>
<td>Cost per day, US$ *</td>
<td>2,098</td>
<td>1,581</td>
</tr>
<tr>
<td>Total cost, US$ *</td>
<td>58,029</td>
<td>13,210</td>
</tr>
<tr>
<td>Death *</td>
<td>34 (18.1%)</td>
<td>36 (3.0%)</td>
</tr>
</tbody>
</table>

* P < .001

Costs of different infections: Chicago Cook County Stroger Memorial Hospital (hospital vs community acquired)

- Amikacin- or imipenem-resistant Enterobacter, Pseudomonas, or Acinetobacter (AIR)
- Resistant E. coli and Klebsiella species (AREK)
- Vancomycin-resistant enterococci (VRE)
- Methicillin-resistant S.aureus (MRSA) infections
- Multiple infections

Source: RR Roberts et al, CID 2009:49, 1175-1184 (15 October 2009)
Overall resistant infections by type, Chicago Cook County Hospital (2000)

- MRSA: 31%
- VRE: 16%
- AREK: 6%
- AIR: 4%
- Multiple: 43%

Contribution to total cost by infection, Chicago Cook County Hospital (2000)

Impact of infection on surgery charges

Engemann et al (CID 2003) found that

- Charges for surgeries: $29,455
- Non-AB resistant SSIs: $52,791
- AB resistant SSIs: $92,363
- Surgeries with AB resistant infections resulted in charges 3.1 times those of surgeries with no infection
- Charges for surgeries with resistant infections were 1.75 times those of AB susceptible infections

## What does resistance add to costs?

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Susceptible</th>
<th>Resistant</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ESBL</strong> (Schwaber MJ, Antimicrob Agents Chemother 2006)</td>
<td>$16,877 LOS 5 days Mortality 35%</td>
<td>$46,970 LOS 11 days Mortality 18%</td>
<td>Cost: 2.8 x LOS: 2.2 x Mortality: 1.94 x</td>
</tr>
<tr>
<td><strong>P. aeruginosa</strong> (Harris A et al, CID 1999)</td>
<td>$22,116</td>
<td>$54,081</td>
<td>Cost: 2.44 x</td>
</tr>
<tr>
<td><strong>Various pathogens, Massachusetts, 2007</strong></td>
<td>$15,104 LOS 4.7 days</td>
<td>$25,380 LOS 9 days</td>
<td>Cost: 1.9 x LOS: 1.7 x</td>
</tr>
</tbody>
</table>

Source: cited in Slama TG, Critical Care 2008, 12(suppl 4):S4 and author’s data from Massachusetts Hospital Discharge Database.
Extrapolating to the US on the basis of Chicago data:

- In 2000, there were 900,000 admissions with same criteria as used in study
- Applying costs found at Cook County Stroger gives $16.6 - 26 billion additional healthcare costs (year 2000 costs)
- Updating the figure to 2009 costs gives approximately $21 - $34 billion using the CPI
- Using medical inflation rates the cost might be as high as $24 - 38 billion
Study of impact of MRSA on patients and households

- Internet-based study of 300+ respondents
- Recruited through MRSA chatrooms and listservs, Google adwords
- Filters to screen out carriers and proxies
- Limitations of internet-based surveys
  - Computer access needed to learn about study and to complete it
  - Draws those most concerned -- linking through keywords, Google ads, chat groups
  - Biased towards those who are well enough to complete survey, and probably towards younger respondents
Impact of MRSA on individuals

- “I have been isolated/alienated from near everyone and everything; including being with my 2 small grandchildren. I had infected my father and two co-workers at my last job. I cannot be in the heat or any sunlight due to the antibiotics. I have no social life anymore, whatsoever. I am 52, single, no income, no insurance and scared to death…”
- 52 year old woman respondent
Impact on individuals: another example

- “It has destroyed my life. I cannot use my pool, maintain my house, earn a living, go anywhere for more than a few hours, and I’ve had to rehome 4 of my beloved birds. It is DEVASTATING! I can only stand for a few minutes at a time (I had a hip replacement that got infected and I currently have NO left hip.) I no longer go anywhere and have become a burden on my family. I hate my life.” – 59 year old woman
Reported out of pocket expenditures by MRSA patients (preliminary data)

Patients report a mean out of pocket expenditure of $2251:

<table>
<thead>
<tr>
<th>Cost Item</th>
<th>Mean ($)</th>
<th>Median ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outpatient visits (incl. co-pays)</td>
<td>588</td>
<td>222</td>
</tr>
<tr>
<td>Prescription drugs</td>
<td>222</td>
<td>100</td>
</tr>
<tr>
<td>Hospital stay</td>
<td>536</td>
<td>0</td>
</tr>
<tr>
<td>Wound care supplies</td>
<td>212</td>
<td>50</td>
</tr>
<tr>
<td>Non-prescription drugs</td>
<td>53</td>
<td>12</td>
</tr>
<tr>
<td>Home medical care</td>
<td>603</td>
<td>0</td>
</tr>
<tr>
<td>Mental health care</td>
<td>37</td>
<td>0</td>
</tr>
</tbody>
</table>
## Insurance status of respondents

<table>
<thead>
<tr>
<th>Type</th>
<th>Percentage</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medicare</td>
<td>9%</td>
<td>28</td>
</tr>
<tr>
<td>Medicaid</td>
<td>6.1%</td>
<td>19</td>
</tr>
<tr>
<td>Private insurance, HMO, or PPO</td>
<td>68.6%</td>
<td>214</td>
</tr>
<tr>
<td>Uninsured</td>
<td>13.8%</td>
<td>43</td>
</tr>
<tr>
<td>Not sure</td>
<td>1.6%</td>
<td>5</td>
</tr>
<tr>
<td>Prefer not to say</td>
<td>1.6%</td>
<td>5</td>
</tr>
<tr>
<td>Other</td>
<td>9.6%</td>
<td>30</td>
</tr>
</tbody>
</table>
Conclusion

- Burden of antibiotic resistance is rising steadily, although costs per patient may be declining
  - MRSA effect? Younger, healthier patients?
- Affecting younger age groups and consequently more with private insurance and uninsured
- Overall cost burden of hospital care may be as high as $38 billion
  - No good estimates seem to exist of cost in outpatient settings
- Individuals and households affected by drug resistance bear a large uncompensated burden in terms of out of pocket expenses and lost wages
Acknowledgments

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- Stephanie Boyd, MA for work on the MRSA study
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<table>
<thead>
<tr>
<th>ICD9 Code</th>
<th>Full_Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V090</td>
<td>Infection with microorganisms resistant to penicillins</td>
</tr>
<tr>
<td>V091</td>
<td>Infection with microorganisms resistant to cephalosporins and other B-lactam antibiotics</td>
</tr>
<tr>
<td>V092</td>
<td>Infection with microorganisms resistant to macrolides</td>
</tr>
<tr>
<td>V093</td>
<td>Infection with microorganisms resistant to tetracyclines</td>
</tr>
<tr>
<td>V094</td>
<td>Infection with microorganisms resistant to aminoglycosides</td>
</tr>
<tr>
<td>V0950</td>
<td>Infection with microorganisms resistant to quinolones and fluoroquinolones without mention of resistance to multiple quinolones and fluoroquinolones</td>
</tr>
<tr>
<td>V0951</td>
<td>Infection with microorganisms resistant to quinolones and fluoroquinolones with resistance to multiple quinolones and fluoroquinolones</td>
</tr>
<tr>
<td>V096</td>
<td>Infection with microorganisms resistant to sulfonamides</td>
</tr>
<tr>
<td>V0970</td>
<td>Infection with microorganisms resistant to other specified antimycobacterial agents without mention of resistance to multiple antimycobacterial agents</td>
</tr>
<tr>
<td>V0971</td>
<td>Infection with microorganisms resistant to other specified antimycobacterial agents with resistance to multiple antimycobacterial agents</td>
</tr>
<tr>
<td>V0980</td>
<td>Infection with microorganisms resistant to other specified drugs without mention of resistance to multiple drugs</td>
</tr>
<tr>
<td>V0981</td>
<td>Infection with microorganisms resistant to other specified drugs with resistance to multiple drugs</td>
</tr>
<tr>
<td>V0990</td>
<td>Infection with unspecified drug-resistant microorganisms, without mention of multiple drug resistance</td>
</tr>
<tr>
<td>V0991</td>
<td>Infection with unspecified drug-resistant microorganisms, with multiple drug resistance</td>
</tr>
</tbody>
</table>