Economic Impact of Disease and the Case for Surveillance

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Overview

• The Value of Surveillance
• Cost of Disease
• Public Health Response Costs
• Direct Health Care Costs
• Productivity Losses
• Additional Economic Costs
• Conclusions
Value of Surveillance

- The Value of Surveillance
- Cost of Disease
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- Conclusions
Economic Value of an Intervention

Net Returns = Savings from Outcomes Averted - Cost of Intervention

Economic Value of Influenza Vaccine = Cost of Influenza Outcomes Prevented - Cost of Influenza Vaccine
Surveillance as “Insurance”

- Disease Costs
- Surveillance Costs


- 2009: Yellow bar
- 2010: Yellow bar
- 2011: Yellow bar
- 2012: Yellow bar
- 2013: Yellow bar
- 2014: Yellow bar
- 2015: Red bar
- 2016: Yellow bar
- 2017: Yellow bar
- 2018: Yellow bar
- 2019: Red bar

Questions marks (?) for 2015 and 2019.
Value of “Insurance”

Actuarially Fair Premium = Reduction of Loss Probability \times Value of Avoidable Loss
What can be done during this time to alter “history”?
Early Response can Be Cost-Savings

Kaufmann AF, Meltzer MI, Schmid GP. Emerg Infect Dis. 1997
Economic Value of BioWatch

- Cost-benefit model of biological surveillance
- Reduces time to treatment to 48 hours
- Economic benefit: $1.11 billion to $50.74 billion
- Depends on nature of release and value of statistical life assigned.
- Costs of BioWatch justified when probability of biological threat >1.26 percent.

Early Information Interrupts Chain

Outbreak → Infected → Disease

- Alter the course of disease
- Decrease transmission

Disease → Morbidity → Mortality

- Alter outcomes of disease
- Reallocate replacement resources

Morbidity

- Health Care Costs
- Productivity Loss

Mortality

- Productivity Loss
- Reallocate replacement resources
## Potential Interventions

<table>
<thead>
<tr>
<th>Decrease Transmission</th>
<th>Alter Course of Disease</th>
<th>Alter Outcomes of Disease</th>
<th>Reallocate Replacement Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment-Human</td>
<td>Environmental Containment</td>
<td>Antibiotics</td>
<td>Always Possible</td>
</tr>
<tr>
<td>Animal-Human</td>
<td>Vector Control</td>
<td>Supportive Care</td>
<td>Always Possible</td>
</tr>
<tr>
<td>Human-Human</td>
<td>Vaccine NPI</td>
<td>Supportive Care Antivirals</td>
<td>Always Possible</td>
</tr>
<tr>
<td>Combined</td>
<td>NPI</td>
<td>Supportive Care</td>
<td>Always Possible</td>
</tr>
</tbody>
</table>

**West Nile Virus**
- NPI

**Influenza**
- Always Possible

**SARS**
- Environmental Containment
- Antibiotics

**Anthrax**
- Animal-Human
- Environment-Human
- Combined
- Always Possible

**Antivirals**
- Always Possible
Cost of Disease

- The Value of Surveillance
- **Cost of Disease**
- Public Health Response Costs
- Direct Health Care Costs
- Productivity Losses
- Additional Economic Costs
- Conclusions
## Types of Economic Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Methods</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prospective</td>
<td>Active data collection during outbreak or epidemic</td>
<td>Validity</td>
<td>Requires surveillance system Generalizability</td>
</tr>
<tr>
<td>Retrospective</td>
<td>Review of records, interviews, and surveys</td>
<td>Validity</td>
<td>Data capture Generalizability</td>
</tr>
<tr>
<td>Modeling and Simulation</td>
<td>Mathematical/computer model</td>
<td>Generalizability Scenario analysis Sensitivity analyses</td>
<td>Needs to be grounded in data</td>
</tr>
</tbody>
</table>
Time Frame or Time Horizon

Cost

Study Time Frame

Time
Components of Economic Costs

- Retrospective analysis of Milwaukee Cryptosporidium outbreak
- Corso, et al. 2003
- Societal perspective
- 4 month horizon

Total: $96.2 million
About $240 per person
Public Health Response Costs

- The Value of Surveillance
- Cost of Disease
- Public Health Response Costs
- Direct Health Care Costs
- Productivity Losses
- Additional Economic Costs
- Conclusions
2002 Louisiana West Nile Virus Epidemic

$20.1 Million

- Medical $4.4 M
- Non-Medical $6.5 M
- Public Health Response $9.2 M

329 of 4,156 Cases

June 2002 to February 2003

Zohrhabian, EID, 2004
Cost of Public Health Response

• One case of measles in Iowa, 2004

• 2525 hours of personnel time for contact tracing and quarantine

• Estimated cost: $142,452

(Dayan, Pediatrics, 2005)
Direct Health Care Costs

- The Value of Surveillance
- Cost of Disease
- Public Health Response Costs
- **Direct Health Care Costs**
- Productivity Losses
- Additional Economic Costs
- Conclusions
## Hospitalization Costs

<table>
<thead>
<tr>
<th>Condition</th>
<th>Median</th>
<th>Mean</th>
<th>Deaths</th>
<th>Routine Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumonia</td>
<td>$5,329</td>
<td>$8,127 +/- $111</td>
<td>3.69 +/- 0.07%</td>
<td>62.11 +/- 0.42%</td>
</tr>
<tr>
<td>Influenza</td>
<td>$3,415</td>
<td>$5,341 +/- $186</td>
<td>0.99 +/- 0.13%</td>
<td>77.47 +/- 0.93%</td>
</tr>
<tr>
<td>Respiratory Failure</td>
<td>$12,260</td>
<td>$21,298 +/- $533</td>
<td>19.73 +/- 0.35%</td>
<td>33.13 +/- 0.67%</td>
</tr>
<tr>
<td>Bacteria Infection</td>
<td>$5,881</td>
<td>$12,419 +/- $748</td>
<td>2.74 +/- 0.37%</td>
<td>69.64 +/- 1.79%</td>
</tr>
</tbody>
</table>

Source: National Inpatient Sample (NIS) from Healthcare Utilization Project (HCUP)
Total Costs from Hospitalizations

- $0
- $2 Million
- $4 Million
- $6 Million
- $8 Million
- $10 Million
- $12 Million
- $14 Million

Histogram of Hospitalizations:
- 1 hospitalization
- 99 hospitalizations
- 197 hospitalizations
- 295 hospitalizations
- 393 hospitalizations
- 491 hospitalizations
- 589 hospitalizations
- 687 hospitalizations
- 785 hospitalizations
- 883 hospitalizations
- 981 hospitalizations

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## Underestimation of Hospitalization Costs

<table>
<thead>
<tr>
<th>Linear Curve</th>
<th>Complex Curve</th>
</tr>
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<tbody>
<tr>
<td>Common Diagnosis</td>
<td>Testing/Diagnostic Costs</td>
</tr>
<tr>
<td>Infinite Hospital Capacity</td>
<td>Transfer Costs</td>
</tr>
<tr>
<td>Infinite Resources</td>
<td>Decreased efficiency</td>
</tr>
<tr>
<td>No In-Hospital Transmission</td>
<td>Isolation, Quarantine, and Decontamination Costs</td>
</tr>
<tr>
<td>No Re-Admissions</td>
<td>Repeat Hospitalizations</td>
</tr>
<tr>
<td>Equivalent Acuity</td>
<td>Treatment Costs</td>
</tr>
<tr>
<td>No Additional Procedures</td>
<td>Procedural Costs</td>
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</table>
Secondary Hospitalizations

- Infected Patients
  - Stress-Induced Co-Morbidity Exacerbations
  - Misdiagnosed Patients
  - Worried Well
# Outpatient Costs

<table>
<thead>
<tr>
<th></th>
<th>CPT Code</th>
<th>Charge</th>
<th>Cost*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Clinic Visit</td>
<td>99214</td>
<td>$95.70</td>
<td>$44.31</td>
</tr>
<tr>
<td>Follow-Up Clinic Visit</td>
<td>99213</td>
<td>$63.69</td>
<td>$29.49</td>
</tr>
<tr>
<td>Chest X-Ray</td>
<td>71020</td>
<td>$36.64</td>
<td>$16.96</td>
</tr>
</tbody>
</table>

*Assuming Cost-to-Charge Ratio of 0.463

$90.76
### Underestimation of Outpatient Costs

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</tr>
<tr>
<td>No In-Clinic Transmission</td>
<td>Isolation, Quarantine, and Decontamination Costs</td>
</tr>
<tr>
<td>Minimal Follow-Up</td>
<td>Additional Visits</td>
</tr>
<tr>
<td>Equivalent Acuity</td>
<td>Treatment Costs</td>
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Productivity Losses

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Productivity Losses

- # Deaths × NPV Future Earnings
- # Hospitalizations × Average LOS × 8 Hours × Average Wage
- # Outpatients × # Visits/Patient × 4 Hours × Average Wage
Life Expectancy Distribution

Age vs. Life Expectancy

Life Expectancy Distribution
## Wage Increases Since 1990

<table>
<thead>
<tr>
<th>Year</th>
<th>Index</th>
<th>Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>21,027.98</td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td>21,811.60</td>
<td>3.7%</td>
</tr>
<tr>
<td>1992</td>
<td>22,935.42</td>
<td>5.2%</td>
</tr>
<tr>
<td>1993</td>
<td>23,132.67</td>
<td>0.9%</td>
</tr>
<tr>
<td>1994</td>
<td>23,753.53</td>
<td>2.7%</td>
</tr>
<tr>
<td>1995</td>
<td>24,705.66</td>
<td>4.0%</td>
</tr>
<tr>
<td>1996</td>
<td>25,913.90</td>
<td>4.9%</td>
</tr>
<tr>
<td>1997</td>
<td>27,426.00</td>
<td>5.8%</td>
</tr>
<tr>
<td>1998</td>
<td>28,861.44</td>
<td>5.2%</td>
</tr>
<tr>
<td>1999</td>
<td>30,469.84</td>
<td>5.6%</td>
</tr>
<tr>
<td>2000</td>
<td>32,154.82</td>
<td>5.5%</td>
</tr>
<tr>
<td>2001</td>
<td>32,921.92</td>
<td>2.4%</td>
</tr>
<tr>
<td>2002</td>
<td>33,252.09</td>
<td>1.0%</td>
</tr>
<tr>
<td>2003</td>
<td>34,064.95</td>
<td>2.4%</td>
</tr>
<tr>
<td>2004</td>
<td>35,648.55</td>
<td>4.6%</td>
</tr>
<tr>
<td>2005</td>
<td>36,952.94</td>
<td>3.7%</td>
</tr>
<tr>
<td>2006</td>
<td>38,651.41</td>
<td>4.6%</td>
</tr>
</tbody>
</table>

Average Increase: 3.9%
Median Increase: 4.3%
Net Present Value of Lifetime Earnings

NPV of 35 Year Old Working Until 65 Years Old

$\sum \frac{(Wage)^{Age-35}}{(1.03)^{Age-35}} = $1.67 million

NPV of 35 Year Old Working Until 75 Years Old

$\sum \frac{(Wage)^{Age-35}}{(1.03)^{Age-35}} = $2.4 million

NPV of 65 Year Old Working Until 75 Years Old

$\sum \frac{(Wage)^{Age-35}}{(1.03)^{Age-35}} = $0.5 million
Productivity Losses from Mortality

The graph illustrates the relationship between productivity loss and deaths. The productivity loss is measured in millions of dollars, while the deaths are counted in increments of 20.

- **General Population to 75**: A red line shows the productivity loss as deaths increase. The losses range from $0 to $600 million.
- **General Population to 65**: A blue line indicates productivity loss for this population. The losses range from $0 to $500 million.
- **Older Population**: A yellow line represents productivity loss for the older population. The losses range from $0 to $400 million.

The graph highlights the significant financial impact of mortality on productivity.
Productivity Losses from Hospitalizations
Underestimation of Productivity Loss

**Productivity Losses**
- Wages are a perfect proxy
- No operational concerns

**Hospital Time**
- Minimal length of stay.
- Maximum efficiency and no delays
- Discharge to home and no recovery time.
- Perfect insurance.

**Clinic Time**
- Maximum efficiency and no queues
- Immediate scheduling
- No test waiting times
- Minimal travel
- Perfect insurance
Additional Economic Costs

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Congressional Budget Office: Pandemic Influenza

- Lost production as a result of work absence.
- “Mild” scenario: would cost about 1% of GDP while a
- “Severe” scenario would cost 4.25% of GDP.
- Costs of $130-550 billion
- Did not consider threshold and compounding effects
- Did not include other important economic effects.
Blackouts Disrupted Operations

- On August 14, 2003, 50 million people, from Cleveland to Toronto to New York City lost electricity for almost a day. Significant disruptions.
- 1967 blackout in New York City resulted in looting, arson, and mayhem.
- Infectious disease outbreak could be worse.
Major Economic Disruptions

- Stock Market
- Tourism
- Consumer Confidence
Threshold at which Costs Explode

Costs vs. % of Population Infected
Economic Trends

- Increased Specialization
- Just in Time Inventory
- Maximal Operating Capacity

- Decreased Interchangeability and Adaptability
- Decreased Reserves
- Minimal Surge Capacity

Shift Failure Curve to the Left

10%

Lave, Casman, and Lee, 2008
Conclusions

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## Summary

<table>
<thead>
<tr>
<th>Cost Range</th>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$4,000 to $13,000 Per Hospitalization</td>
<td>Additional Treatment Costs</td>
<td>Follow-Up Care</td>
</tr>
<tr>
<td>$200 Per Clinic Visit</td>
<td>Additional Treatment Costs</td>
<td>Follow-Up Care</td>
</tr>
<tr>
<td>$1-2 Million Per Death</td>
<td>Operational Costs</td>
<td>Transaction Costs</td>
</tr>
<tr>
<td>$26,000 to $150,000 Per Case</td>
<td>Communications Costs</td>
<td>Legal Costs</td>
</tr>
<tr>
<td></td>
<td>Investor and Consumer Confidence</td>
<td>Follow-Up Care</td>
</tr>
</tbody>
</table>
Conclusions

- Economic studies and models are likely to produce optimistic underestimates of the cost-of-disease.
- Costs do not scale linearly
- Economic trends increasing the potential costs of outbreaks and epidemics
- Anything that affects more than 10% of a local population may cause an explosion in costs.
- **Positive Externalities**: Facilitate research and understanding in seasonal and endemic infectious diseases (e.g., influenza, mononucleosis, Lyme disease)