Outline

- Overview of HAIs
- Common HAIs
- Common Organisms
- Prevention and Control Strategies
- Economic Impact of HAIs
- Looking ahead
More than a year of antibiotics, repeated hospitalizations lead to...

- 30F initially admitted one year ago for exploratory abdominal surgery for tubo-ovarian abscess
- Prior to surgery and afterwards, she had been treated with several courses of antibiotics empirically.
- Post-op course complicated by months of wound breakdown.
- Admitted recently with wound drainage
- Organism growing: **ESBL E. Coli**
Definition

- Infections patients acquire while in the hospital receiving treatment for another illness.
- One of the top 10 leading causes of death in the U.S.
HAIs: Scope of the Problem

- Affect about 1.7 million hospitalizations a year.
- 4.5 HAIs for every 100 admissions.
- Associated with increases in patient morbidity and mortality, costs and length of stay.
- Direct medical costs estimated to be $25 billion- $45 billion each year.

Common HAIs

- Surgical site infections (SSI)
- Catheter-associated urinary tract infections (CAUTI)
- Central line-associated blood stream infections (CLABSI)
- Ventilator-Associated Pneumonia (VAP)
Surgical Site Infections (SSI)

- 30 million surgeries in the US each year
- Approximately 2.6% result in SSIs
- Rate varies by operation—some rates as high as 11%.
- Associated with increased length of stay (LOS) and increased costs.
- Prevention strategies: appropriate peri-operative antibiotics in the right time frame, appropriate hair removal, glucose control, normothermia.

Catheter-Associated Urinary Tract Infections (CAUTIs)

- Foley catheters are commonly used in hospitalized patients.
- Defined as UTI with catheter in place or within 48 hours of removal.
- Accounts for 40% of all HAIs.
- Costly: between $500-$3000/CAUTI → $450 million each year.
- Prevention strategies: reminders, RN-driven protocols, reduction in “foley days”, aseptic technique for placement.

Central Line Associated Blood-Stream Infections (CLABSI)

- Bloodstream infections account for 14% of all HAIs.
- CVCs are commonly used in ICUs but more recently becoming common outside of ICUs in the form of PICCs or other central access used in outpatients.
- Increased LOS: + approximately 7 days
- Increased costs: + $3700-$29,000/CLABSI
- Attributable mortality ranges from 4%-20%.
- Prevention strategies: insertion bundles

Example of Checklist

<table>
<thead>
<tr>
<th>Critical Steps</th>
<th>Yes</th>
<th>Yes With Reminder</th>
<th>Report Completed for Procedure Deviation?</th>
<th>Comments:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obtain informed consent?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obtain supervision if needed (see roles above)?</td>
<td></td>
<td></td>
<td></td>
<td>N/A [ ]</td>
</tr>
<tr>
<td>Perform a time-out/briefing?</td>
<td></td>
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<tr>
<td>Confirm hand washing/sanitizing immediately prior?</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Operator(s): cap, mask, sterile gown/gloves, eye protection?</td>
<td></td>
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</tbody>
</table>

Ventilator-Associated Pneumonia (VAP)

- Pneumonia acquired in the hospital is the leading cause of death from HAIs→ perhaps as much as 60% of all HAI deaths.
- Defined as pneumonia developing after a patient has been on a ventilator for > 48 hours
- Occurs in 15% of ventilated patients.
- Prolongs length of stay.
- Increase in costs of $40,000 per case.
- Prevention strategies: elevation of head, daily sedation vacations, daily assessment of weaning, DVT prophylaxis, stress bleeding prophylaxis→ as part of VAP Prevention Bundle.

Common Organisms
MRSA
Methicillin-Resistant *Staphylococcus aureus*

- Found on the skin; causes skin and soft tissue infections and often associated with more serious blood-stream infections and pneumonia.
- Transmitted from patient to patient via HCW, also through contaminated surfaces.
- Hospital vs. Community Acquired
- Resistance to oxacillin/methicillin mediated by *meca* gene
- Treatment of choice is vancomycin
- Patients are isolated using “contact precautions”
Methicillin (oxacillin)-resistant 
*Staphylococcus aureus* (MRSA) Among ICU 
Patients, 1995-2004
Brief History of Resistance

- **1880s**: S. Aureus discovered
- **1940s**: Successful treatment with penicillins
- **Late 1940s-1950s**: Resistance to penicillins; methicillin introduced
- **1961**: MRSA; 1968 MRSA in US
- **Late 1990s**: Reduced susceptibility to vancomycin
- **2002**: VISA, VRSA
VISA and VRSA
Vancomycin-Intermediate and Vancomycin-Resistant *Staphylococcus aureus*

- Resistance to Vancomycin
  
  MIC (Minimum Inhibitory Concentration)
  
  VISA  4-8µg/ml
  VRSA  ≥ 16µg/ml

- Resistance in VRSA mediated by *vanA* gene

- Associated with underlying health conditions
  
  - History of MRSA
  - Diabetes
  - Kidney disease
  - Indwelling catheters
  - Hospitalizations

- Treatment options are limited, but include daptomycin and linezolid, among others.
VRE
Vancomycin-Resistant Enterococci

- Enterococci are found in the GI & female GU tract.
- Can cause infections urinary tract, bloodstream, wounds, etc.
- Has resulted from widespread use of vancomycin.
- RF for acquisition include: prior abx use (esp vancomycin), history of hospitalization, admission to ICU, catheters, history of colonization with VRE).
- Patients are isolated using “contact precautions”, which requires HCWs to wear gowns and gloves.

CDC, 2010.
Vancomycin-resistant *Enterococi* Among ICU Patients, 1995-2004

Source: National Nosocomial Infections Surveillance (NNIS) System

**Safer • Healthier • People™**
Clostridium difficile

- Spore-forming organism.
- Causes diarrhea, life-threatening colitis.
- Associated with overuse of antibiotics.
- Antibiotics prescribed for other illnesses (i.e. pneumonia, bronchitis) result in decreasing normal gut flora, allowing *C. difficile* to become predominant.
- Patients are isolated with “Contact Precautions-PLUS” which requires HCWs to wear gowns and gloves, and to both wash hands and use alcohol-based disinfectant.
Multi-drug-Resistant Gram-Negative Organisms
*Klebsiella, Acinetobacter, E. coli, Pseudomonas aeruginosa…*

- **ESBL: Extended Spectrum Beta-Lactamases**
  - Produce beta lactamase that hydrolyzes pencillins and cephalosporins
  - Carbapenems remain effective

- **CRE (Carbapenem-Resistant Enterobacteriaceae), also referred to as KPC (Klebsiella pneumoniae Carbapenemase)**
  - Enterobacteriaceae that produce carbapenemases, initially identified mostly as plasma encoded enzymes from *K. pneumoniae*
  - Associated with genes encoding resistance for other antimicrobials
  - NDM-1 (New Delhi metallo-beta-lactamase 1) is one particular gene that provides resistance to the carbapenems and was recently identified in India, and in patients treated in the U.S. who had recently been in hospitals in India
  - They hydrolize PCN, cephalosporins, and carbapenems
  - Well-known from widely reported outbreaks in NYC in early 2000s.
  - Treatments: tigecycline, polymyxins (incl colistin)

- Associated with high mortality
- Spread in healthcare environments, likely by HCWs
- Patients usually isolated in single room, with contact precautions.
3rd generation cephalosporin-resistant \textit{Klebsiella pneumoniae} Among ICU Patients, 1995-2004

Source: National Nosocomial Infections Surveillance (NNIS) System

SAFER • HEALTHIER • PEOPLE™
Prevention and Control Strategies
Prevention & Control Strategies

- Hand Hygiene
- Isolation of patients
- Device-related best practices
- Environment
- Antimicrobial stewardship
Hand Hygiene...Works!

Figure 1: Hand-hygiene compliance trend during seven consecutive hospital-wide surveys, University of Geneva Hospitals, 1994-97

Figure 3: Trends in prevalence of nosocomial infections and annual attack rate of MRSA, 1993-98, University of Geneva Hospitals

Effectiveness of a hospital-wide programme to improve compliance with hand hygiene.
Pittet, Didier; Hugonnet, Stephane; Harbarth, Stephan; Mourouga, Philippe; Sauvan, Valerie; Touveneau, Sylvie; Perneger, Thomas

Contact Precautions

- HCW use gowns and gloves with every patient contact.
- Special environmental de-contamination
- Private room if possible; cohorting common.

A downside:
- Patients on contact precautions have been shown to receive less care and report greater dissatisfaction with care.

Device-Related Best Practices

- Checklists for sterile insertion of central venous catheters
- Reduction in urinary cathether use ("foley days")
- Guidelines for disinfection of devices (i.e. endoscopes)
Environment

- National guidelines for disinfection and sterilization in healthcare facilities as well as environmental infection control published by CDC
- Equipment/devices
- Mode of transmission
  - Airborne (i.e. TB, fungi, etc)
  - Waterborne (i.e. Legionella and Pseudomonas, NTM, among others)
  - Environmental (i.e. minimal hand-contact, high-contact surfaces), also minimize contamination of cleaning supplies themselves
  - Flowers and plants (i.e. Aspergillus spp)
  - Pests
  - HCW lab coats
- Organisms
  - MRSA, VRE: prevent hand transmission (disinfectant - proper dilution, sufficient contact time)
  - C diff: meticulous cleaning + disinfection
Antimicrobial Stewardship

- Programs in place to encourage responsible use of antibiotics in an effort to decrease/slow development of antibiotic resistance.
Figure 1. Time-series analysis of the effect of infection control and antimicrobial stewardship interventions on *Clostridium difficile* infection rates. CDAD = *C*. difficile–associated disease. (Adapted with permission from reference 79.)
Economic Impact
Economic Impact of HAIs

- Direct medical costs
- Indirect medical costs related to productivity
- Costs related to decreased quality of life
### Table 1: The Social Costs of Hospital-Associated Infections

<table>
<thead>
<tr>
<th>Categories of Cost*</th>
<th>Direct Hospital Costs</th>
<th>Fixed Costs</th>
<th>Variable Cost:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Buildings</td>
<td>Medications</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Utilities</td>
<td>Food</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Equipment/Technology</td>
<td>Consultations</td>
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<tr>
<td></td>
<td></td>
<td>Labor (laundry, environmental control, administration)</td>
<td>Treatments</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Procedures</td>
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<td></td>
<td></td>
<td></td>
<td>Devices</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Testing (laboratory and radiographic)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Supplies</td>
</tr>
<tr>
<td>Indirect Costs</td>
<td>Lost/Wages</td>
<td>Diminished worker productivity on the job</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Short term and long term morbidity</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mortality</td>
<td>Income lost by family members</td>
<td></td>
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<tr>
<td></td>
<td>Forgone leisure time</td>
<td>Forgone leisure time</td>
<td></td>
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<tr>
<td></td>
<td>Time spent by family/friends for hospital visits, travel costs, home care</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intangible Cost</td>
<td>Psychological Costs (i.e., anxiety, grief, disability, job loss)</td>
<td></td>
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<tr>
<td></td>
<td>Pain and suffering</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Change in social functioning/daily activities</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


# Direct Medical Costs of 5 HAIs

Table 5: Aggregate attributable patient hospital costs by site of infection

<table>
<thead>
<tr>
<th></th>
<th># of infections</th>
<th>Range of $ estimates based on 2007 CPI for all urban consumers</th>
<th>Range of $ estimates based on 2007 CPI for Inpatient hospital services</th>
<th>Range of estimate using CPI for all urban consumers (billions)</th>
<th>Range of estimate using CPI for Inpatient hospital services (billions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSI</td>
<td>290,485</td>
<td>$11,087 - $29,443</td>
<td>$11,874 - $34,670</td>
<td>$3.22 - $8.55</td>
<td>$3.45 - $10.07</td>
</tr>
<tr>
<td>CLABSI</td>
<td>92,011</td>
<td>$6,461 - $25,849</td>
<td>$7,288 - $29,156</td>
<td>$0.59 - $2.38</td>
<td>$0.67 - $2.68</td>
</tr>
<tr>
<td>VAP</td>
<td>52,543</td>
<td>$14,806 - $27,520</td>
<td>$19,633 - $28,508</td>
<td>$0.78 - $1.45</td>
<td>$1.03 - $1.50</td>
</tr>
<tr>
<td>CAUTI</td>
<td>449,334</td>
<td>$749 - $832</td>
<td>$862 - $1,007</td>
<td>$0.34 - $0.37</td>
<td>$0.39 - $0.45</td>
</tr>
<tr>
<td>CDI</td>
<td>178,000</td>
<td>$5,682 - $8,090</td>
<td>$6,408 - $9,124</td>
<td>$1.01 - $1.44</td>
<td>$1.14 - $1.62</td>
</tr>
</tbody>
</table>

*Example calculation for SSI: 2007 CPI for all urban consumers:
  Low: $290,485 x $11,087 = $3.22 billion
  High: $290,485 x $29,443 = $8.55 billion

  2007 CPI for hospital inpatient services:
  Low: $290,485 x $11,874 = $3.45 billion
  High: $290,485 x $34,670 = $10.07 billion
Potential savings from prevention

Table 8: Range of estimated annual direct medical cost of all HAIs adjusted by the preventable proportion of infections

<table>
<thead>
<tr>
<th></th>
<th>Range of Estimates (billions $)</th>
<th>20% of infections preventable (billions $)</th>
<th>50% of infections preventable (billions)</th>
<th>70% of infections preventable (billions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007 CPI-U</td>
<td>$28.4 - $33.8</td>
<td>$5.7 - $6.8</td>
<td>$14.2 - $16.9</td>
<td>$19.9 - $23.7</td>
</tr>
<tr>
<td>2007 CPI hospital inpatient services</td>
<td>$35.7 - $45.0</td>
<td>$7.1 - $9.0</td>
<td>$17.9 - $22.5</td>
<td>$25.0 - $31.5</td>
</tr>
</tbody>
</table>
# CMS Hospital Acquired Conditions Initiative ("No Pay Rule")

<table>
<thead>
<tr>
<th>TABLE 1. Hospital-Acquired Conditions Not Eligible for Payment from Centers for Medicare and Medicaid Services[^1-2]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Effective October 1, 2008</strong></td>
</tr>
<tr>
<td>Catheter-associated urinary tract infection*</td>
</tr>
<tr>
<td>Decubitus ulcer (pressure ulcer)</td>
</tr>
<tr>
<td>Vascular catheter-associated infection</td>
</tr>
<tr>
<td>Falls and trauma</td>
</tr>
<tr>
<td>Serious preventable &quot;never events&quot;:</td>
</tr>
<tr>
<td>Foreign object retained after surgery</td>
</tr>
<tr>
<td>Air embolism</td>
</tr>
<tr>
<td>Blood incompatibility</td>
</tr>
<tr>
<td>Deep vein thrombosis or pulmonary embolism after certain</td>
</tr>
<tr>
<td>orthopedic surgeries</td>
</tr>
<tr>
<td>Manifestations of poor glycemic control</td>
</tr>
<tr>
<td>Diabetic ketoacidosis</td>
</tr>
<tr>
<td>Nonketotic hyperosmolar coma</td>
</tr>
<tr>
<td>Hypoglycemic coma</td>
</tr>
<tr>
<td>Secondary diabetes with ketoacidosis</td>
</tr>
<tr>
<td>Hyperosmolarity</td>
</tr>
<tr>
<td>Surgical-site infections after certain surgeries</td>
</tr>
<tr>
<td>Mediastinitis after coronary artery bypass</td>
</tr>
<tr>
<td>Certain orthopedic surgical-site infections</td>
</tr>
<tr>
<td>Certain bariatric surgical-site infections</td>
</tr>
<tr>
<td>Considered for future implementation</td>
</tr>
<tr>
<td>Ventilator-associated pneumonia</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em> septicaemia</td>
</tr>
<tr>
<td><em>Clostridium difficile</em> infection</td>
</tr>
<tr>
<td>Iatrogenic pneumothorax</td>
</tr>
<tr>
<td>Legionnaires disease</td>
</tr>
<tr>
<td>Delirium</td>
</tr>
</tbody>
</table>


* Focus of our study.
Looking Ahead

- International aspects
- Ensuring a stable supply of new antimicrobials
Questions
Useful Websites

- General information on HAIs
  - CDC HAI website: www.cdc.gov/ncidod/dhq/hq/healthDis.html

- Antimicrobial Stewardship
  - CDC “Get Smart” Program: www.cdc.gov/getsmart/

- National MRSA Education Initiative
  - www.cdc.gov/mrsa/mrsa_initiative/skin_infection

- Insititute for Healthcare Improvement
  - www.ihi.org

- NASL Searchable Database for State Laws related to reporting of HAIs
  - www.ncsl.org/?tabid=13858
References

Contact Information

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