Healthcare Associated Infections - Overview, Surveillance and Prevention

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Objectives

• Review the burden of HAIs/MDROs Worldwide
• Describe surveillance strategies and challenges
• Review general models for interventions
• Provide a framework for diffusion of ideas
Total Expenditure on Health as a Percent of Gross Domestic Product 2017

http://www.who.int/gho/health_financing/total_expenditure/en
Countries that Procure Medical Devices

Lists of medical devices for different types of healthcare facilities or procedures*

* status as of 2014

Data Source: Baseline country survey on medical devices, 2014 update
Map Production: Information Evidence and Research (IER)
World Health Organization

Data: http://gamapserver.who.int/mapLibrary/Files/Maps/Global_MedicalDeviceLists_availability.png
What Are Healthcare Associated Infections?

- HAIs are infections in patients receiving treatment for medical or surgical care. Infections can be associated with procedures, the processes and the devices used in medical procedures.
- HAIs occur in all types of care settings, including:
  - Acute care hospitals
  - Ambulatory surgical centers
  - Dialysis facilities
  - Outpatient care (e.g., physicians' offices and health care clinics)
  - Long-term care facilities (e.g., nursing homes and rehabilitation facilities)
Healthcare Associated Infections (HAI)

- Three targets
  - HAIs (acute care, long-term care, surgical centers, rehabilitation facilities, home care, etc…)
  - Antimicrobial resistant and epidemiologically important organisms
  - Emerging infections transmitted in healthcare settings
- US: 1.7 million pts/yr with a HAI
  - 2 - 10% of hospitalized patients develop healthcare associated infections; the rate varies by size of the hospital
  - Represent a significant portion of adverse events/medical errors
- HAIs = 4th leading cause of death in U.S. behind heart disease, cancer, CVA
The Burden of HAIs

• Systematic review and meta-analysis
• 220 articles included in final analysis
• Prevalence (Overall): 15.5/100 pts (95CI 12.6-18.9)
• Infection density in adult ICU: 47.9/1000 pt days (95CI 36.7-59.1)
• SSI pooled cum incidence: 5.6/100 procedures
• GNR most common nosocomial isolate
• 54% of *S. aureus* isolates resistant to methicillin

Allegranzi et al. Lancet 2011;377:228-241
Studies Reporting HAIs in Developing Countries (WHO)

- Canada: 11.6%
- USA**: 4.5%
- Scotland: 9.5%
- Finland: 9.1%
- UK & Ireland: 7.6%
- Switzerland: 10.1%
- Greece: 9.3%
- Italy: 8.3%
- Cyprus: 7.9%
- Korea**: 3.7%

http://www.who.int/gpsc/country_work/summary_20100430_en.pdf
Figure 3.4
Incidence of overall health care-associated infection and device-associated infection in high-risk adult patients in high-income countries, 1995-2010

HCAI = health care-associated infection
CR-BSI = catheter-related bloodstream infection
CR-UTI = catheter-related urinary tract infection
VAP = ventilator-associated pneumonia

http://apps.who.int/iris/bitstream/10665/80135/1/9789241501507_eng.pdf?ua=1
Prevalence of HAI’s Low to Middle Income Countries 1995-2010

Prevalence of health care-associated infection in low- and middle-income countries, 1995-2010

- Cuba: 7.3%
- Morocco: 17.8%
- Ghana: 6.7%
- Brazil: 14%
- Senegal: 10.9%
- Mali: 18.7%
- Tunisia: 17.9%
- United Republic of Tanzania: 14.8%
- Latvia: 5.7%
- Lithuania: 9.2%
- Mongolia: 5.4%
- Serbia: 17.4%
- Turkey: 12.5%
- Lebanon: 6.8%
- Thailand: 6.5%
- Indonesia: 7.1%
- Islamic Republic of Iran: 8.8%
### Comparison of HAI Rates

<table>
<thead>
<tr>
<th>Developed countries</th>
<th>Number of ICUs</th>
<th>CR-BSI (95% CI)</th>
<th>Catheter-days</th>
<th>CR-UTI (95% CI)</th>
<th>Urinary catheter-day</th>
<th>VAP (95% CI)</th>
<th>Ventilator-days</th>
</tr>
</thead>
<tbody>
<tr>
<td>NNIS (1995-2003), USA</td>
<td>85-133†</td>
<td>5.0‡</td>
<td>1356490</td>
<td>5.3‡</td>
<td>1356490</td>
<td>5.8‡</td>
<td>115900</td>
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<tr>
<td>NHSN (2006-2008), USA</td>
<td>89-182†</td>
<td>2.1‡</td>
<td>699300</td>
<td>3.4‡</td>
<td>546824</td>
<td>2.9‡</td>
<td>383068</td>
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<tr>
<td>KISS (1997-2003), Germany</td>
<td>309</td>
<td>1.8‡</td>
<td>193541</td>
<td>-</td>
<td>-</td>
<td>8.0‡</td>
<td>1177137</td>
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<tr>
<td>KISS (2004-2009), Germany</td>
<td>514-583†</td>
<td>1.3‡</td>
<td>4002108</td>
<td>2.0‡</td>
<td>4757133</td>
<td>5.1‡</td>
<td>2391381</td>
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<th>Ventilator-days</th>
</tr>
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<tbody>
<tr>
<td>INICC (2002-2007), 18 developing countries</td>
<td>60</td>
<td>8.9‡</td>
<td>132061</td>
<td>6.6‡</td>
<td>1030</td>
<td>19.8‡</td>
<td>1802</td>
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<tr>
<td>Argentina (1998-2004; current systematic review)</td>
<td>15</td>
<td>247 (7.4-42.0)</td>
<td>9458</td>
<td>17.2 (13.4-21.1)</td>
<td>19013</td>
<td>48.0 (42.0-54.0)</td>
<td>5777</td>
</tr>
<tr>
<td>Turkey (1999-2005; current systematic review)</td>
<td>16</td>
<td>11.0 (2.2-24.3)</td>
<td>23503</td>
<td>10.8 (4.2-17.4)</td>
<td>36343</td>
<td>26.0 (20.0-32.0)</td>
<td>39504</td>
</tr>
<tr>
<td>Current systematic review (1995-2008)</td>
<td>226</td>
<td>11.3 (9.0-13.6)</td>
<td>373848</td>
<td>9.8 (7.7-11.8)</td>
<td>427831</td>
<td>22.9 (19.1-26.6)</td>
<td>263027</td>
</tr>
</tbody>
</table>

Data are overall (pooled mean) infection episodes per 1000 device-days. ICUs—intensive care units. CR-BSI—catheter-related bloodstream infection. CR-UTI—catheter-related urinary tract infection. VAP—ventilator-associated pneumonia. NNIS—National Nosocomial Infection Surveillance. NHSN—National Healthcare Safety Network. KISS—Krankenhaus Infektions Surveillance System. INICC—International Nosocomial Infection Control Consortium. *Medical or surgical ICUs in major teaching hospitals. †Range reported because number of ICUs included in data pooling varied according to the type of device-associated infection. ‡95% CI not reported. §Argentina, Brazil, Colombia, Costa Rica, Cuba, El Salvador, India, Kosovo, Lebanon, Macedonia, Mexico, Morocco, Nigeria, Peru, Philippines, Turkey, Uruguay.
To Recapitulate

- 23 developing countries (23/147 [15.6%]) reported a functioning HAI surveillance system in 2010.
- No published data on HAI endemic burden from 66% (97/147) of developing countries.
- HCAI pooled prevalence in mixed patient populations in low- and middle-income countries: 10.1%. In high-quality papers, prevalence: 15.5%.
- SSI is the most frequent HAI hospital-wide in low- and middle-income countries with a pooled incidence of 11.8/100 pts.
Healthcare Associated Infections: HK

- 20,355 patients surveyed, 637 had HAIs and 13 patients had >1 HAI.
- Overall prevalence of HAIs was 3.1% (95% CI: 2.9%-3.4%).
  - pneumonia 0.93% (95% C.I.: 0.80%-1.07%),
  - urinary tract infection 0.57% (95% C.I.: 0.48%-0.69%),
  - SSI: 0.52% (95% C.I.: 0.42%-0.62%), skin & soft tissue infection: 0.36% (95% C.I.: 0.28%-0.45%)
  - BSI: 0.33% (95% C.I.: 0.26%-0.42%).
The World of Antimicrobial Resistance

Figure 1.2
Documented examples of drug resistance by disease

HIV
United States and United Kingdom
In New York, New York, primary resistance increased from 13.3% in 1995-1998 to 26.1% in 2003-2004 (Sacket et al. 2006). In the UK, primary resistance for any ARV was reported to be 7.0% in 2003 (Hirsch et al. 2008).

MRSA
Estimated worldwide prevalence of MRSA by country (Guanadelli et al. 2010).

*Mortality of S. aureus-infected individuals carrying resistant strains.
Symbols are only displayed for countries with data available.
• Data based on one hospital.

SHIGELLA
United States
Amoxicillin-resistant Shigella • strains increased from 22% in 1986 to 67% in 1993 to 78% of all isolates over the 1999-2002 period. Trimethoprim/ sulfamethoxazole (TMP/SMX)-resistant Shigella • strains increased from 7% in 1990 to 35% in 1993 to 49% over the 1999-2002 period (Skupski and Nagai 2010).

Uganda
One study found that 100% of Shigella isolates were resistant to TMP/SMX, while 66% were resistant to amoxicillin (Lepos et al. 1998).

Bangladesh
A 1997 study found that 100% of Shigella dysenteriae isolates were resistant to amoxicillin, trimethoprim, and clindamycin. 53% were resistant to ampicillin, tetracycline, and chloramphenicol. 10% of isolates had resistance to amoxicillin, trimethoprim, and nitrofuric acid (Islam and Hossain 1997).
Worldwide Prevalence of MRSA

- Two targets:
  - HAIs (acute care, long-term care, surgical centers, rehabilitation facilities, home care, etc.)
  - Antimicrobial resistance and epidemiologically important organisms

- 1996: 34 million pts in US acute care hospitals
- 1.7 million pts/yr with a HAI

- 2 - 10% of hospitalized patients develop nosocomial infections; the rate varies by size of the hospital
- Represent a significant portion of adverse events/medical errors

- Nosocomial infections = 4th leading cause of death in U.S. behind heart disease, cancer, CVA

Grundmann et al. Lancet 2006; 368: 874-85
MDR TB

CTX β-lactamase Pandemic

Canton et al. Current Opinion Micro 2006;9:466-75
Spread of KPC-containing *Klebsiella pneumoniae*: Global Travel

The New Kid on the Block

Countries reporting plasmid-mediated colistin resistance encoded by mcr-1

Isolate source(s):

- Animals
- Humans
- Animals and humans
- Animals and environment
- Animals, humans and environment

Mortality Carbapenem Sensitive vs Resistant *Klebsiella pneumoniae*

\[
p < 0.001
\]

**Overall Mortality**
- CRKP: 48
- CSKP: 20
- OR 3.71 (1.97-7.01)

**Attributable Mortality**
- CRKP: 38
- CSKP: 12
- OR 4.5 (2.16-9.35)
Hospital costs from *E. coli* BSIs increased by ESBL Production

- Economic impact of
  - ESBL production
  - Inadequate initial antimicrobial treatment
- ESBL: longer (7d) and more costly (56.5% to 59.4%↑) post-BSI-onset hospital stays
- IIAT: longer (6d) and more costly (45.7% to 48.4%↑) post-BSI-onset hospital stays

## The SENIC Study: Is HAI Surveillance Efficacious?

<table>
<thead>
<tr>
<th>Infection</th>
<th>% prevented</th>
</tr>
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<tbody>
<tr>
<td>SSI</td>
<td>20 - 35</td>
</tr>
<tr>
<td>UTI</td>
<td>38</td>
</tr>
<tr>
<td>BSI</td>
<td>15 - 35</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>15</td>
</tr>
<tr>
<td>Medical</td>
<td>27</td>
</tr>
<tr>
<td>Surgical</td>
<td>13</td>
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</table>
Surveillance is Difficult: Case Finding

- Follow cases as identified systematically—ICD-9 or ICD-10 codes
- Reporting mechanisms
  - Surgeons and OR Staff; ICU personnel
  - ID consults
- Microbiology reports
- Readmissions/Re-operations
- Pharmacy records for ABX use
- Post-discharge surveillance
- Machine learning algorithms
Surveillance Methods

- 100% Chart Review
- Targeted SSI Surveillance: 100% Chart Review for Selected Procedures
- Targeted SSI Surveillance: 100% Chart Review of Patients at High Risk
- Selective Chart Review
- Sampling of patient records and chart review
- Postdischarge Surveillance
- Use of electronic Data Surveillance alone or with “human” surveillance
Challenges

- 100% Chart Review
  - Not practical & feasible in large hospitals
  - Take IP away from educational activities
  - The ICP identified 84% of SSIs noted by the hospital epidemiologist
  - Quality depends on completeness of medical records & on the reviewer’s experience
How Do You Define a CLABSI: Traditional vs Computer Surveillance

- 241,518 pt days and 165,963 CLdays. Median IP CLABSI 3.0 (2-4.5) vs Computer CLABSI 9 (6.3-11.3)
- Correlation between IP and computer algorithm 0.34

Lin et al JAMA 2010:304; 2035
How Do We Find Cases--Can Administrative Data Identify HAI Accurately?

- Cross sectional prospective study--over 9 months 2004-CHOP
- Cases ("true") met NNIS definitions of HAI
- Determined sensitivity/specificity of identifying HAI by use of administrative data or targeted surveillance

<table>
<thead>
<tr>
<th></th>
<th>Sens</th>
<th>PPV</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cases identified by</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>administrative data</td>
<td>61</td>
<td>20</td>
<td>99</td>
</tr>
<tr>
<td>Cased identified by</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>targeted surveillance</td>
<td>76</td>
<td>100</td>
<td>99</td>
</tr>
</tbody>
</table>

Sherman et al. 2006 ICHE:17 (4); 332
Comparison of Traditional and Computer Surveillance

Figure 4. Relative Ranking of 4 Medical Centers

Lin et al JAMA 2010:304; 2035
Insights From CAUTI

- Retrospective chart review of 80 records comparing coders to MD abstractors
- Coders identified 20 HA UTI (25%) and no CA UTI versus 37 (45%) & 36 CAUTI among MD abstractors; 8 were present on admission

Meddings et al ICHE 2010: 31(6):627-33
501 randomly selected surgeries
38% contacted by telephone
89% reported no complications
1% reported no complications and had documented SSI while in hospital
9.5% had symptoms: pus, pain, fever
89% of patients with symptoms had seen an MD and no MDs reported an SSI
Required 15 minutes per patient
SSI Rates
Routine vs Enhanced Surveillance

SSI Detection: Claims Data

Does it Matter if We Clean Our Hands?

Start of Intervention

New MRSA per 100 admissions

MRSA incidence

Nosocomial Infections

Since hepatitis B vaccine became available in 1982, the annual incidence of occupational Hep B infections has decreased 95%. 

Mahoney FJ et al. Arch Internal Med 1997;157:2601+
IP PLANNING

INFECTION PREVENTION (DURING OPERATIONS)

Operations

Begin

rate or cost of HAIs

TIME

LESSONS LEARNED

Outbreak

Original Infection Rate

New Infection Rate

Endemic Rate (opportunity for improvement)

INTERVENTION

Begin
Anatomy of an Intervention

Predisposing factors
- Knowledge
- Attitudes
- Beliefs

Enabling factors
- Skills
- Equipment
- Facilities

Reinforcing factors
- Feedback
- Peer/supervisor support
- Patient participation
- Link to changes in infection rates

Positive Deviance
CUSTP
Other methods or frame works of organizational implementation
How Does Innovation Disseminate?

• Most innovations diffuse at a disappointingly slow rate

• 1497 - Vasco de Gama’s voyage around the Cape of Good Hope: 100/160 crew members died of scurvy

• 1601 – James Lancaster (English captain): quasi-experimental study of 4 ships to India.
  – Sailors on 1 ship received lemon juice (3 tsp/d); sailors in other 3 ships got nothing
  – “Lemon” ship = all healthy; control ships = 110/278 died
And Then!

- British Navy should adopt citrus juice for scurvy prevention given these findings, correct?

- 1747 - James Lind (British Navy physician): confirmed Lancaster’s findings from 150 years earlier

- 1795 – British Navy adopted this innovation and scurvy eradicated (48 years after Lind’s study)

- 1865 (70 years later) – this innovation adopted in the British merchant marine

- Does this type of delay (non-diffusion) happen today?
• QWERTY keyboard invented in 1873; intentionally inefficient

Is there a better keyboard?
• Dvorak (1932): a new keyboard based on time-motion studies
• Each finger’s work is proportionate to its skill & strength
• National organizations: approved this keyboard as an alternative
• Despite obvious advantages: >90 years w/out much use
The ‘Take Off’ Point
The Majority Engages, Adoption Becomes Irresistible
Building Confidence, Implementing Change

Degree of belief that the change will result in improvement:
- High
- Moderate
- Low

Prototype: A successful change
- Change still needs further testing. There is a risk of implementing at this stage.

Pilot: Unsuccessful proposed change

Adapt & Spread
Conclusion

- HAI’s and antimicrobial resistance remain significant causes of morbidity and mortality.
- Surveillance is a tool which has helped define the impact of HAIs but now must innovate to help channel resources elsewhere.
- Implementation of simple prevention strategies will generate improved patient safety and visibility at the institution.
- Ultimate patient and healthcare worker safety will require healthcare innovation.
- The components and paradigm in healthcare requires evidence based practices & implementation of social theory change.