Epidemiology for Infection Preventionists

Basics of Infection Prevention
2-Day Course
November 2018

Kelsey OYong, MPH, CIC
HAI Coordinator
Los Angeles County Department of Public Health
Objectives

• Discuss basic principles of epidemiology and how they apply to infection prevention
• Review basic surveillance analysis, interpretation, and communication of findings
• Describe epidemiology terms, process, and outcome measures for infection prevention
Epidemiology

• Study of distribution, frequency, and factors affecting health of populations

Clinical care: focus on the individual

— vs —

Epidemiology: focus on the group

• In healthcare, answers questions such as:
  • Which units in my hospital have the highest HAI rates?
  • What patient populations are at higher risk for developing HAIs?
  • Has the intervention reduced HAI incidence?
Applying Epidemiology in Healthcare

- Surveillance
- Assessment of intervention, new product
- Characterization of disease burden
- Outbreak identification
Infection Prevention and Hospital Epidemiology

• Goal is prevention of healthcare-associated infections (HAIs)
• Professional societies include:
  • Association for Professionals in Infection Control and Epidemiology (APIC)
  • Society for Healthcare Epidemiology of America (SHEA)
  • Infectious Diseases Society of America (IDSA)
• Epidemiologic research and surveillance underlies HAI prevention
  • Data for action
Terminology
**Mean**

- Measure of central tendency used to describe a data set
- The average value of a set of numbers
- Most affected by outliers
- To calculate:
  - Add the values in the data set
  - Divide by total number of variables

**Calculation**

\[
\frac{0+0+2+0+0+3+7+2+12+0+0+1}{12} = \frac{2.25}{12} = 2.25
\]
Median

- Another measure of central tendency used to describe a data set
- The midpoint of a distribution of values
- To calculate:
  - Order the values in the data set (low to high, or vice versa)
  - Identify middle value

Calculation:
0, 0, 2, 0, 0, 3, 7, 2, 12, 0, 0, 1
Order: 0, 0, 0, 0, 0, 1, 2, 2, 3, 7, 12
Median = 0.5
Types of numerical measurements

• Incidence
• Prevalence
• Standardized infection ratio (SIR)
• Incidence density rate
Prevalence

• Proportion of persons in a population who have a particular disease or attribute at a specified point in time
  • Includes both new and pre-existing cases

All new and pre-existing cases during a given time period
Population during the same time period

• Can be point or period

• Healthcare epidemiology example:

MRSA admission prevalence rate = \( \frac{2 \text{ patients colonized with MRSA}}{10 \text{ patients admitted on Mar 31, 2012}} \) = 0.2
**Incidence**

- Proportion of an initially disease-free population that develops disease during a specified period of time
  
  \[
  \text{Colon SSI rate} = \frac{8 \text{ SSI in 2015}}{240 \text{ colon surgeries in 2015}} \times 100 = 3.33
  \]

- Also referred to as attack rate or risk
- Healthcare epidemiology example:
Incidence density rate

• Measure of incidence that incorporates time directly into the denominator
  • Central line-days, patient-days, person-time
• Healthcare epidemiology example:

\[
\text{CLABSI rate} = \frac{5 \text{ CLABSI in 2015}}{11,400 \text{ line-days in 2015}} \times 10,000 = 4.38 \text{ CLABSI per 10,000 central-line days}
\]
Prevalence

Proportion of persons in a population who have a disease or condition at a given point in time

Measure of infections that are present

Incidence

Proportion of persons in a population who develop a disease or condition within a specified period of time

Measure of new infections

Incidence density rate

Rate of persons in a population who develop a disease or condition within a specified period of person-time

Measure of new infections
Confidence interval, p-value

- **Confidence interval**: range of values to describe uncertainty around a point estimate
  - Measure of variability in data
- **p-value**: measure of statistical significance which tells us the probability of an event occurring due to chance alone
  - Range: 0-1.0
  - Common cut-offs: 0.05, 0.01
  - E.g. An investigator found that men with hypertension were twice more likely to develop complications due to a smallpox vaccination than those with normal blood pressure (p=0.09). There is a 9% chance of finding such an association due to random error in the sample (chance).
Standardized infection ratio (SIR)

- Unique to NHSN
- Applies risk adjustment to standardize infection rates based on numerous variables
  - E.g. CLABSI SIR
    - Risk-adjusted for
      - Type of patient care location
      - Hospital affiliation with a medical school
      - Bed size of the facility
      - Facility type
  - \( SIR = \frac{\text{Observed}}{\text{Predicted}} \)
# 2x2 or Contingency Tables

- Tool to display frequency distribution
- Most commonly used in HAI epidemiology to show breakdown of ill and exposed persons
- Can use to calculate odds ratio
- **Odds ratio** = \( a \times d \div b \times c \)

<table>
<thead>
<tr>
<th></th>
<th>Outcome</th>
<th>No outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposed</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>Unexposed</td>
<td>c</td>
<td>d</td>
</tr>
<tr>
<td></td>
<td>a+c</td>
<td>b+d</td>
</tr>
</tbody>
</table>
• E.g. Case-control study

33 cases (CRE infection) and 33 controls (no CRE infection)
10 people underwent ERCP procedure, 9 of whom became ill and 1 who did not

\[
\begin{array}{ccc}
\text{CRE} & \text{No CRE} \\
\hline
\text{ERCP} & 9 & 1 & 10 \\
\text{No ERCP} & 24 & 32 & 56 \\
\hline
& 33 & 33 & 66 \\
\end{array}
\]

• Odds ratio $= 9 \times 32 \div 1 \times 24 = 12$

Persons exposed to ERCP have 12 times the odds of developing a CRE infection compared to those not exposed to ERCP
Data sources
Data sources for infection prevention

• Unit-specific data
  – Respiratory care, ED, OR
• Billing data
  – HAIs
• Laboratory data
  – HAIs, MDROs
• Medical records (EHR) & data-mining software
• Employee health records
• IP rounds
Databases for infection prevention

• National Healthcare Safety Network
  – HAIs
  – Antibiotic use, resistance
  – Healthcare worker influenza vaccination
  – Process measures (CLIP)

• Homegrown
  – Access, Excel, Oracle
Surveillance
Surveillance

• The ongoing, **systematic** collection, **recording**, analysis, **interpretation** and **dissemination** of data

• HAI surveillance data used to track infections and measure success of infection prevention program

• Used for public health **action** to identify risk factors for disease, reduce morbidity and mortality, and to improve health

• Common data source for epidemiologic analyses by infection preventionist
Surveillance

- A surveillance system is an **information** loop or cycle
- Starts and ends with communication and action
Endpoint of HAI Surveillance?

Data that demonstrates progress in HAI prevention!

Number of CLABSI by month, Hospital LAC, 2013-15
Surveillance Terms

• **Case definition (also called surveillance definition)**
  – the clinical and laboratory characteristics that a patient must have to be counted as a case for surveillance purposes: Time, place, & person (e.g., age, sex, other characteristics etc.)

• **Universal case reporting**
  – a surveillance system in which all cases of a disease are supposed to be reported

• **Laboratory-based reporting**
  – a surveillance method in which the reports of cases come from clinical laboratory data (forgoing case review/symptomatology)
Quality HAI Surveillance

Key tenets:

• A **written plan** should serve as the foundation
  • What HAI is am I tracking? Why?
  • How will data be used?
  • If only to meet mandates, how **can** data be used?
  • Where are opportunities to prevent HAI in **MY** facility?

• The **intensity** of surveillance needs to be maintained over time

• Stay **consistent** over time; apply same surveillance definitions
Reporting and using epidemiologic information
Reporting and Using Epidemiology Data

“The demonstrable power of surveillance is in sharing findings with those who need to know and who can act on the findings to improve patient safety.”

AJIC Am J Infect Control 2007; 35:427-40

- Plan for distribution of findings
- Report to health care providers most able to impact patient care
- Report in a manner to stimulate process improvement
- Use visual displays of data
  - Charts, graphs, tables, or other graphics data
# Tables and Line Lists

National Healthcare Safety Network

Line Listing for All Central Line-Associated BSI Events

As of: November 3, 2009 at 9:04 AM
Date Range: All CLAB(EVENTS)

<table>
<thead>
<tr>
<th>orgID</th>
<th>patID</th>
<th>dob</th>
<th>gender</th>
<th>admitDate</th>
<th>eventID</th>
<th>eventDate</th>
<th>eventType</th>
<th>spcEvent</th>
<th>location</th>
</tr>
</thead>
<tbody>
<tr>
<td>10018</td>
<td>7425</td>
<td>09/22/1961</td>
<td>M</td>
<td>06/06/2005</td>
<td>1676</td>
<td>06/11/2005</td>
<td>BSI</td>
<td>LCBI</td>
<td>BMT</td>
</tr>
<tr>
<td>10018</td>
<td>MD-4937</td>
<td>09/19/1922</td>
<td>F</td>
<td>05/30/2005</td>
<td>1678</td>
<td>06/21/2005</td>
<td>BSI</td>
<td>LCBI</td>
<td>BMT</td>
</tr>
<tr>
<td>10018</td>
<td>85613</td>
<td>04/18/1951</td>
<td>M</td>
<td>07/08/2005</td>
<td>1685</td>
<td>07/13/2005</td>
<td>BSI</td>
<td>LCBI</td>
<td>S-ICU</td>
</tr>
<tr>
<td>10018</td>
<td>10222</td>
<td>01/04/1978</td>
<td>F</td>
<td>08/01/2005</td>
<td>1927</td>
<td>08/08/2005</td>
<td>BSI</td>
<td>LCBI</td>
<td>MICU</td>
</tr>
<tr>
<td>10018</td>
<td>01-88-145</td>
<td>10/07/1939</td>
<td>M</td>
<td>03/17/2006</td>
<td>3321</td>
<td>03/21/2006</td>
<td>BSI</td>
<td>LCBI</td>
<td>S-ICU</td>
</tr>
<tr>
<td>10018</td>
<td>34-22-100</td>
<td>03/22/1940</td>
<td>M</td>
<td>03/12/2006</td>
<td>4789</td>
<td>03/20/2006</td>
<td>BSI</td>
<td>LCBI</td>
<td>MICU</td>
</tr>
<tr>
<td>10018</td>
<td>86-990-01</td>
<td>12/12/1926</td>
<td>M</td>
<td>03/10/2006</td>
<td>4798</td>
<td>03/14/2006</td>
<td>BSI</td>
<td>LCBI</td>
<td>S-ICU</td>
</tr>
<tr>
<td>10018</td>
<td>26-22-678</td>
<td>03/28/2006</td>
<td>M</td>
<td>03/28/2006</td>
<td>4800</td>
<td>03/31/2006</td>
<td>BSI</td>
<td>LCBI</td>
<td>NICU</td>
</tr>
<tr>
<td>10018</td>
<td>32-54-731</td>
<td>02/21/1959</td>
<td>M</td>
<td>03/06/2006</td>
<td>4820</td>
<td>03/09/2006</td>
<td>BSI</td>
<td>LCBI</td>
<td>S-ICU</td>
</tr>
<tr>
<td>10018</td>
<td>13-19</td>
<td>04/18/1934</td>
<td>F</td>
<td>03/07/2006</td>
<td>4821</td>
<td>03/16/2006</td>
<td>BSI</td>
<td>LCBI</td>
<td>MICU</td>
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<tr>
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<td>08/16/1944</td>
<td>F</td>
<td>02/11/2006</td>
<td>4824</td>
<td>02/21/2006</td>
<td>BSI</td>
<td>LCBI</td>
<td>MICU</td>
</tr>
</tbody>
</table>
Number of CLABSI by quarter and unit, Hospital LAC, 2015

- **Quarter 1**: ICU 5, NICU 2, CCU 4
- **Quarter 2**: ICU 4, NICU 3, CCU 5
- **Quarter 3**: ICU 1, NICU 1, CCU 3
- **Quarter 4**: ICU 4, NICU 3, CCU 2
Pie Charts

Number of CLABSI by birth-weigh category, Hospital LAC, 2015

- <= 750 grams
- 751-1000 grams
- 1001-1500 grams
- 1501-2500 grams
- >2500 grams
Line Graphs or Run Chart

CLIP observations with 100% bundle adherence, by unit, Hospital LAC, 2015

Percentage of CLIP observations with 100% bundle adherence

- ICU
- NICU
- CCU

Present data to demonstrate “surveillance for prevention”
Epi curve

- Visual display of onset of illness among outbreak cases
- Can indicate type of spread (point source, propagated)
- Understand magnitude of outbreak
Cost calculator

Cost of HAI Calculator

::: Determine Hospital Size Category :::

<table>
<thead>
<tr>
<th>REGION</th>
<th>TEACHING</th>
<th>HOSPITAL BEDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northeast</td>
<td>Non-teaching</td>
<td>1-124, 125-199</td>
</tr>
<tr>
<td></td>
<td>Teaching</td>
<td>1-249, 250-424</td>
</tr>
<tr>
<td>Midwest</td>
<td>Non-teaching</td>
<td>1-74, 75-174</td>
</tr>
<tr>
<td></td>
<td>Teaching</td>
<td>1-249, 250-374</td>
</tr>
<tr>
<td>South</td>
<td>Non-teaching</td>
<td>1-99, 100-199</td>
</tr>
<tr>
<td></td>
<td>Teaching</td>
<td>1-249, 250-449</td>
</tr>
<tr>
<td>West</td>
<td>Non-teaching</td>
<td>1-99, 100-174</td>
</tr>
<tr>
<td></td>
<td>Teaching</td>
<td>1-199, 200-324</td>
</tr>
</tbody>
</table>

::: View Expected and Actual Results - Annual :::

<table>
<thead>
<tr>
<th>TYPE</th>
<th>EXPECTED NUMBER OF INFECTIONS</th>
<th>EXPECTED INFECTION RATE</th>
<th>EXPECTED EXCESS COST</th>
<th>EXPECTED EXCESS LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSI</td>
<td>13</td>
<td>0.22%</td>
<td>$29,276</td>
<td>8.1</td>
</tr>
<tr>
<td>VAP</td>
<td>23</td>
<td>5.61%</td>
<td>$27,393</td>
<td>14.9</td>
</tr>
<tr>
<td>CLABSI</td>
<td>1</td>
<td>0.10%</td>
<td>$32,199</td>
<td>16.6</td>
</tr>
<tr>
<td>MRSA</td>
<td>253</td>
<td>1.58%</td>
<td>$6,248</td>
<td>4.5</td>
</tr>
<tr>
<td>C. Difficile</td>
<td>219</td>
<td>1.37%</td>
<td>$10,577</td>
<td>6.7</td>
</tr>
<tr>
<td>UTI</td>
<td>536</td>
<td>6.68%</td>
<td>$5,904</td>
<td>4.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1044</strong></td>
<td></td>
<td><strong>62,554</strong></td>
<td><strong>13.8</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TYPE</th>
<th>EXPECTED TOTAL COSTS</th>
<th>ACTUAL TOTAL COSTS</th>
<th>EXPECTED TOTAL LOS</th>
<th>ACTUAL TOTAL LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSI</td>
<td>$380,593</td>
<td>$0</td>
<td>106</td>
<td>0</td>
</tr>
<tr>
<td>VAP</td>
<td>$630,029</td>
<td>$0</td>
<td>344</td>
<td>0</td>
</tr>
<tr>
<td>CLABSI</td>
<td>$32,199</td>
<td>$0</td>
<td>17</td>
<td>0</td>
</tr>
<tr>
<td>MRSA</td>
<td>$1,580,645</td>
<td>$0</td>
<td>1150</td>
<td>0</td>
</tr>
<tr>
<td>C. Difficile</td>
<td>$2,316,408</td>
<td>$0</td>
<td>1471</td>
<td>0</td>
</tr>
<tr>
<td>UTI</td>
<td>$3,168,478</td>
<td>$0</td>
<td>2207</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$8,090,354</strong></td>
<td><strong>$0</strong></td>
<td><strong>5295</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>
**TAP Reports**

- **Targeted Assessment for Prevention**
- Can run TAP report for a single facility or group
- Customizable by HAI type, time period of interest, SIR
- Uses cumulative attributable difference (CAD) metric
  - Number of infections that a facility would have needed to prevent to achieve an HAI reduction goal during a specified time period
  - Prioritization metric to identify units with highest burden of excess infections
## Interpreting a TAP report

<table>
<thead>
<tr>
<th>Facility Org ID</th>
<th>Facility Name</th>
<th>Facility CAD</th>
<th>Location Rank</th>
<th>Location</th>
<th>CDC Location</th>
<th>Events</th>
<th>Urinary Catheter Days</th>
<th>DUR %</th>
<th>CAD</th>
<th>SIR</th>
<th>Sir Test</th>
<th>No. Pathogens (EC, YS, PA, KS, PM, ES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>DHQP Memorial</td>
<td>5.73</td>
<td>1</td>
<td>SICU</td>
<td>IN:ACUTE:CC:S</td>
<td>5</td>
<td>502</td>
<td>81</td>
<td>3.38</td>
<td>2.31</td>
<td>SIG</td>
<td>5 (0, 3, 1, 1, 0, 0)</td>
</tr>
<tr>
<td>2</td>
<td>NEURO</td>
<td></td>
<td>3</td>
<td>NEURO</td>
<td>IN:ACUTE:CC:N</td>
<td>3</td>
<td>257</td>
<td>77</td>
<td>1.58</td>
<td>1.58</td>
<td></td>
<td>3 (0, 0, 1, 0, 2, 0)</td>
</tr>
<tr>
<td>3</td>
<td>BURN</td>
<td></td>
<td>2</td>
<td>BURN</td>
<td>IN:ACUTE:CC:B</td>
<td>2</td>
<td>162</td>
<td>61</td>
<td>1.10</td>
<td>1.67</td>
<td></td>
<td>2 (1, 0, 0, 0, 0, 0)</td>
</tr>
<tr>
<td>4</td>
<td>REHAB</td>
<td></td>
<td>1</td>
<td>REHAB</td>
<td>IN:ACUTE:WARD:REHAB</td>
<td>1</td>
<td>76</td>
<td>11</td>
<td>0.18</td>
<td>0.91</td>
<td></td>
<td>1 (0, 0, 0, 0, 1, 0)</td>
</tr>
<tr>
<td>5</td>
<td>2N</td>
<td></td>
<td>1</td>
<td>2N</td>
<td>IN:ACUTE:WARD:M</td>
<td>1</td>
<td>239</td>
<td>20</td>
<td>-0.20</td>
<td>0.63</td>
<td></td>
<td>1 (0, 0, 0, 0, 0, 0)</td>
</tr>
<tr>
<td>6</td>
<td>6S</td>
<td></td>
<td>1</td>
<td>6S</td>
<td>IN:ACUTE:WARD:M</td>
<td>1</td>
<td>261</td>
<td>20</td>
<td>-0.31</td>
<td>0.57</td>
<td></td>
<td>1 (0, 0, 0, 0, 0, 0)</td>
</tr>
</tbody>
</table>

If location-level CADs are the same in a given facility, their ranks are tie.

(EC, YS, PA, KS, PM, ES) = No. of E. coli, yeast (both candida and non-candida species), P. aeruginosa, K. pneumoniae/k. oxytoca, Proteus Mirabilis, Enterococcus species
SIR is set to ‘‘1’’ when expected number of events is < 1.0
LOCATION CAD = (OBSERVED_LOCATION - EXPECTED_LOCATION*0.75)
LACDPH TAP Visits

• DPH is using county-wide NHSN data to identify hospitals with positive CADs and significantly high SIR for intervention
• Hospital staff completes an anonymous CDC survey that assesses their knowledge and awareness of infection prevention practices in the facility
• DPH staff analyzes all responses and sends facility a detailed report and spreadsheet
• Onsite meeting between DPH and hospital staff members to discuss prevention strategies based on findings
LACDPH Annual Report

- Summarizes county-level HAI data, including longitudinal trends
- Uses NHSN as data source
  - Includes CRE
- Can use to benchmark your facility to regional rates
CDPH Annual Report

- Summarizes state-level HAI data, including longitudinal trends
- Individual hospital-level reports (public)
- Uses NHSN as data source
- Can use to compare your facility to state-level rates
Designing studies
Infection prevention study types

• Observational
  – Prevalence studies
  – Case-control
    • Comparison of cases and non-cases to determine association between risk factors and infection
  – Individual case report
Infection prevention study types

• Intervention
  – Implementation study
    • Implement evidence-based practice
    • Study implementation in your own site
      – What led to successful/unsuccessful uptake?
  – Effectiveness studies
    • Pre-/post- design
    • Interrupted time series
    • Cost-effectiveness
    • Randomized control trial
Infection prevention study types

• Cohort
  – Sample of patients without infection is followed through time to determine who becomes infected
    • Can associate risk of becoming infection with various risk factors
    • E.g. Framingham Heart Study
References

Ebbing Lautenbach, Keith F. Woeltje, and Preeti N. Malani., Practical Healthcare Epidemiology, 3rd Edition

https://apic.org/Resources/Cost-calculators

Questions?