Introduction to the Standardized Infection Ratio (SIR)

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I have no relevant financial relationships to disclose.

Learning Objectives

• Define a Standardized Infection Ratio (SIR)
• Describe SIR calculation
• Describe advantages/disadvantages of an SIR
• Extract SIR reports from the National Healthcare Safety Network (NHSN)
• Interpret SIR reports
• Interpret a 95% confidence interval
What is an SIR?

It is a standardized ratio that compares the ‘observed’ number of healthcare-associated infections (HAI) in a given healthcare setting to an ‘expected’ number of HAI.

\[
\text{SIR} = \frac{\text{Observed Infections (O)}}{\text{Expected Infections (E)}}
\]


What are Observed (O) Infections?

• Observed is the actual number of HAI in your healthcare setting

• For example:
  – Using NHSN guidelines, 5 central line-associated blood stream infections (CLABSIs) were observed in the Medical Intensive Care Unit (MICU) in June 2011

What are Expected (E) Infections?

• Predicted HAI in your healthcare facility using baseline data from the standard population during the period 2006-2008

• Varies for CLABSI and Surgical Site Infections (SSIs)
  – CLABSI based on the number of central line days
  – SSI based on multiple risk factors

• If Expected HAI (E) < 1, no SIR will be calculated
How Do You Interpret an SIR?

• An SIR > 1 indicates that more HAI were observed than expected

• An SIR < 1 indicates that fewer HAI were observed than expected

• An SIR = 1 indicates that same number of HAI were observed as were expected

How Do You Interpret an SIR?

• An SIR of 1.5 is 50% higher than expected

• An SIR of 0.6 is 40% lower than expected

• An SIR of 2.5 is 150% higher than expected

• An SIR of 0.97 is 3% lower than expected

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• Interpret SIR reports
• Interpret a 95% confidence interval
How is an SIR Calculated for CLABSI?

• SIR = \( \frac{\text{Observed CLABSI (O)}}{\text{Expected CLABSI (E)}} \)

• Observed CLABSI is the actual number of HAI for your location of interest

<table>
<thead>
<tr>
<th>Type of Location</th>
<th># of CLABSI</th>
<th># of Central Line (CL) Days</th>
<th>NHSN Baseline Rate</th>
<th>Expected # of CLABSI</th>
<th>SIR (O/E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical Intensive Care Unit (MICU)</td>
<td>5</td>
<td>500</td>
<td>2.0</td>
<td>1</td>
<td>( \frac{5}{1} = 5 )</td>
</tr>
<tr>
<td>Surgical Intensive Care Unit (SICU)</td>
<td>0</td>
<td>250</td>
<td>4.0</td>
<td>0</td>
<td>( \frac{0}{1} = 0 )</td>
</tr>
<tr>
<td>Pediatric Intensive Care Unit (PICU)</td>
<td>1</td>
<td>250</td>
<td>2.0</td>
<td>( \frac{1}{0.5} = 2.0 )</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>6</strong></td>
<td><strong>1000</strong></td>
<td><strong>2.0</strong></td>
<td><strong>3.5</strong></td>
<td>( \frac{6}{2.5} = 2.4 )</td>
</tr>
</tbody>
</table>

**Key Points**
- The SIR allows you to make comparisons across multiple units

Key Point
- During this time period, 5 CLABSIs were identified in the MICU
- Based on the 2006-2008 baseline data, 1 CLABSI was expected
- The results in an SIR for this unit of 5.0. This can be interpreted as saying 'this unit had 400% more infections than expected'
How is an SIR Calculated for CLABSI?

Time Period: January – June 2011

<table>
<thead>
<tr>
<th>Type of Location</th>
<th># of CLABSI</th>
<th># of Central Line (CL) Days</th>
<th>NHSN Baseline Rate</th>
<th>Expected # of CLABSI</th>
<th>SIR (O/E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PICU</td>
<td>1</td>
<td>250</td>
<td>2.0</td>
<td>3</td>
<td>---</td>
</tr>
<tr>
<td>SICU</td>
<td>0</td>
<td>250</td>
<td>4.0</td>
<td>1</td>
<td>0/1=0.0</td>
</tr>
<tr>
<td>MICU</td>
<td>5</td>
<td>500</td>
<td>2.0</td>
<td>1</td>
<td>5/1=5.0</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>1000</td>
<td>---</td>
<td>2.5</td>
<td>6/2.5=2.4</td>
</tr>
</tbody>
</table>

Key Points:
- During this time period, 1 CLABSI was identified in the PICU.
- Based on the 2006-2008 baseline data, 0.5 were expected.
- Since the number of HAI is < 1, no SIR is calculated.

How is an SIR Calculated for CLABSI?

Time Period: January – June 2011

<table>
<thead>
<tr>
<th>Type of Location</th>
<th># of CLABSI</th>
<th># of CL days</th>
<th>NHSN baseline rate</th>
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<th>SIR (O/E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MICU</td>
<td>5</td>
<td>500</td>
<td>2.0</td>
<td>1</td>
<td>5/1=5.0</td>
</tr>
<tr>
<td>SICU</td>
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<td>4.0</td>
<td>1</td>
<td>0/1=0.0</td>
</tr>
<tr>
<td>PICU</td>
<td>1</td>
<td>250</td>
<td>2.0</td>
<td>0.5</td>
<td>---</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>1000</td>
<td>---</td>
<td>2.5</td>
<td>6/2.5=2.4</td>
</tr>
</tbody>
</table>

Key Points:
- You can compare different units (ex. MICU and PICU).
- You can aggregate all units to get an overall facility SIR.
- The facility SIR is 2.4. This can be interpreted as saying this facility had 140% more infections than expected.

How is an SIR Calculated for SSI?

- SIR = \( \frac{\text{Observed SSI (O)}}{\text{Expected SSI (E)}} \)

- Observed SSI is the number of HAI for your procedure of interest (eg. abdominal hysterectomy, colon).
How are Expected SSI Calculated?

- Uses a logistic regression model from the standard population during the period 2006-2008
- Assigns a probability of infection to each procedure
- NHSN performs these calculations

Logistic Regression Model

- Flexible model that allows for a more precise way of risk adjusting

Example:
- For abdominal hysterectomies, HAI risk factors include:
  - Patient age
  - American Society of Anesthesiologists (ASA) score
  - Procedure duration
  - Endoscope
  - Number of beds

Sample SSI SIR Calculation

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Duration</th>
<th>ASA</th>
<th>Medical</th>
<th>SSI</th>
<th>Probability of SSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
<td>117</td>
<td>4</td>
<td>Y</td>
<td>0</td>
<td>0.050</td>
</tr>
<tr>
<td>2</td>
<td>53</td>
<td>95</td>
<td>2</td>
<td>N</td>
<td>0</td>
<td>0.004</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>107</td>
<td>2</td>
<td>Y</td>
<td>1</td>
<td>0.033</td>
</tr>
</tbody>
</table>

TOTAL Observed (O) = 3
Expected (E) = 2.91

SIR = O/E = 3/2.91 = 1.03

Key Points
- Expected number of HAI are based on probabilities of infection
- During this time period, 3 SSI were observed for this facility
- Based on the NHSN 2006-2008 baseline data, 2.91 infections were expected
- This results in an SIR for the facility of 1.03. This facility had 3% more infections than expected

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Using SIR
Advantages and Disadvantages

• Advantages
  – Better method of risk adjusting
  – Easily compare healthcare setting locations on measures such as CLABSI and SSI
  – Easy measure to interpret

• Disadvantages
  – CDC recommends at least 6 months of data to allow for a precise measurement
Sample CLABSI Output

<table>
<thead>
<tr>
<th>summaryYr</th>
<th>infCount</th>
<th>numExp</th>
<th>numCLDays</th>
<th>SIR</th>
<th>SIR_pval</th>
<th>SIR95CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>15</td>
<td>22.17</td>
<td>8343</td>
<td>0.68</td>
<td>0.02</td>
<td>0.35, 0.94</td>
</tr>
</tbody>
</table>

Key Points
- Output using the SummaryYr option
- An SIR of 0.68 signifies this hospital had 32% fewer HAIs than expected

Sample CLABSI Output

<table>
<thead>
<tr>
<th>summaryYH</th>
<th>infCount</th>
<th>numExp</th>
<th>numCLDays</th>
<th>SIR</th>
<th>SIR_pval</th>
<th>SIR95CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011H1</td>
<td>5</td>
<td>10.52</td>
<td>4123</td>
<td>0.48</td>
<td>0.03</td>
<td>0.27, 0.76</td>
</tr>
<tr>
<td>2011H2</td>
<td>10</td>
<td>11.65</td>
<td>4220</td>
<td>0.86</td>
<td>0.41</td>
<td>0.56, 1.42</td>
</tr>
</tbody>
</table>

Key Points
- Output using the SummaryYH option.
- 2011H1 represents January – June 2011
- 2011H2 represents July – Dec 2011
- For 2011H1 this hospital had an SIR of 0.48 which signifies it had 52% fewer HAIs than expected

Extracting SSI SIR Data from NHSN
## Sample SSI SIR Output

<table>
<thead>
<tr>
<th>Summary</th>
<th>procCount</th>
<th>infCountAll</th>
<th>numExpAll</th>
<th>SIRAll</th>
<th>SIRAll_pval</th>
<th>SIRAll95CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011H1</td>
<td>1731</td>
<td>12</td>
<td>24.15</td>
<td>0.50</td>
<td>0.004</td>
<td>0.36, 0.89</td>
</tr>
<tr>
<td>2011H2</td>
<td>1640</td>
<td>15</td>
<td>21.43</td>
<td>0.70</td>
<td>0.23</td>
<td>0.588, 1.229</td>
</tr>
</tbody>
</table>

**Key Points**
- Output using the SummaryYH option
- 2011H1 SIR of 0.50 signifies this hospital had 50% fewer infections than expected
- 2011H2 SIR of 0.70 signifies this hospital had 30% fewer infections than expected

## Learning Objectives

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- Interpret a 95% confidence interval

## P Value

- P value is a probability that your results are statistically significant

- P value $\leq 0.05$ shows statistical significance
  - P value of 0.02 is statistically significant
  - P value of 0.14 is not statistically significant
What is a Confidence Interval?

• Estimated range of values which is likely to include an unknown parameter estimate (e.g. SIR)

• There is always variability in data so the confidence interval tries to capture this variability

What is a Confidence Interval?

• You can think of a confidence interval as a margin of error (e.g. political polls)

• The range of the interval is dependent on the number of observations
  – More observations = narrower interval
  – Fewer observations = wider interval

Interpreting a 95% Confidence Interval

• In relation to SIRs, a confidence interval that spans 1 (e.g. 0.5, 1.5) is not statistically significant

• A confidence interval that does not span 1 (e.g. 0.2, 0.8) is statistically significant
Sample SIR and Confidence Interval Table

<table>
<thead>
<tr>
<th>Procedure</th>
<th>SIR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart Transplant</td>
<td>1</td>
<td>0.3, 2.5</td>
</tr>
<tr>
<td>Fusion</td>
<td>1.2</td>
<td>0.4, 1.7</td>
</tr>
<tr>
<td>Colon</td>
<td>1.5</td>
<td>1.2, 1.8</td>
</tr>
<tr>
<td>Cardiac</td>
<td>0.5</td>
<td>0.2, 0.7</td>
</tr>
</tbody>
</table>

Key Points
- SIR for Heart Transplant and Fusion procedures is not statistically significant
- SIR for Colon and Cardiac procedures is statistically significant

Examples of 95% Confidence Intervals

Interpreting a 95% Confidence Interval

<table>
<thead>
<tr>
<th>summaryYr</th>
<th>procCount</th>
<th>intCountAll</th>
<th>numExpAll</th>
<th>SIRAll</th>
<th>SIRAll_pval</th>
<th>SIRAll95CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>4205</td>
<td>40</td>
<td>29.42</td>
<td>1.36</td>
<td>0.008</td>
<td>1.102, 1.496</td>
</tr>
</tbody>
</table>

Interpretation:

- We are 95% confident that the true SIR lies in the range 1.102 to 1.496

Key Point
- We are 95% confident that the true SIR lies in the range 1.102 to 1.496
Interpreting Statistical Significance

### CLABSI

<table>
<thead>
<tr>
<th>ICU Type</th>
<th>Observed Infections</th>
<th>Expected Infections</th>
<th>CL Days</th>
<th>SIR</th>
<th>SIR p-Value</th>
<th>95% Confidence Interval</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>MICU</td>
<td>5</td>
<td>8.53</td>
<td>853</td>
<td>0.59</td>
<td>0.085</td>
<td>0.35, 1.20</td>
<td>Not statistically significant</td>
</tr>
<tr>
<td>PICU</td>
<td>1</td>
<td>0.852</td>
<td>125</td>
<td>--</td>
<td>--</td>
<td></td>
<td>Expected Infections = 1</td>
</tr>
</tbody>
</table>

**Key Point**
- For the MICU, we are 95% confident that the true SIR lies in the range 0.35 to 1.20

### SSI

<table>
<thead>
<tr>
<th>Procedure Type</th>
<th>Observed Infections</th>
<th>Expected Infections</th>
<th>Number of Procedures</th>
<th>SIR</th>
<th>SIR p-Value</th>
<th>95% Confidence Interval</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cecal</td>
<td>6</td>
<td>12.14</td>
<td>5025</td>
<td>0.49</td>
<td>0.002</td>
<td>0.35 - 0.76</td>
<td>Statistically significant</td>
</tr>
<tr>
<td>Abdominal</td>
<td>5</td>
<td>0.852</td>
<td>801</td>
<td>--</td>
<td>--</td>
<td></td>
<td>Expected Infections = 1</td>
</tr>
</tbody>
</table>

**Key Point**
- For cecals, we are 95% confident that the true SIR lies in the range 0.35 to 0.76

### Summary

- CDC recommends using SIR to report HAI
- At least 6 months of data is recommended to calculate an SIR
- SIR is a better method of risk adjusting
- Need at least 1 ‘expected’ HAI in order to generate an SIR
- 95% confidence interval shows the statistical significance of your SIR with a range of values
Helpful Links

Where can I find more information?
• For a guide to the Standardized Infection Ratio (SIR) please visit:
• For in-depth Analysis Training, please visit:
  http://www.cdc.gov/nhsn/training.html
• For a Basic Analysis Quick Tips guide, please visit:
  http://www.cdc.gov/nhsn/PDFs/AnalysisBasics.pdf