# *Making the Most of Your Surveillance Data:*

## *Biostatistics for Infection Control*

Emily Sickbert-Bennett, PhD, CIC

Director of Hospital Epidemiology, UNC Health Care

Research Associate Professor of Medicine-Infectious Diseases,
UNC School of Medicine

Adjunct Associate Professor of Epidemiology,
Gillings School of Global Public Health

# *Statistics*

**The margin of error…**

Men are at 3 times higher risk…

**17 in every 100 people…**

**Numbers** that describe the health of the population

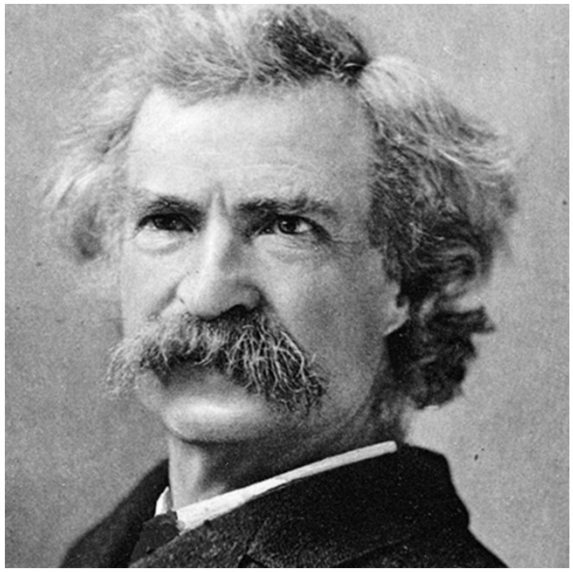
1 in 9 children…

**39% OF THE POPULATION…**

The **science** used to interpret these numbers.

There is a statistically significant difference…

**Risk of dying is 8 times higher among…**



**"There are 3 kinds of lies. Lies, damned lies, and statistics."**

~Popularized by Mark Twain

- Describes the persuasive power of numbers, particularly the use of statistics, to bolster weak arguments, and the tendency of people to disparage statistics that do not support their positions.

# *Outline*

- Describe Surveillance Data
- Display and Interpret Surveillance Data
- Determine the Significance of Changes to Surveillance Data

# *Describing Surveillance Data Using Descriptive Statistics*

# *Absolute Measures*

- Simplest type of measurement
- Also known as counts
- Example:
  - Hospital A: 25 patients with norovirus
  - Hospital B:  10 patients with norovirus
- Is norovirus worse at Hospital A?

# *Relative Measures*

- Includes a denominator
- Useful for comparisons
- Examples:
  - 16 cases of *C. difficile* out of 1000 patients
  - 1 positive *C. difficile* test out of 7 samples tested

# *Absolute versus Relative*

Example: Norovirus activity at different hospitals

- Absolute measures
  - Hospital A: 25 patients ill
  - Hospital B: 10 patients ill
- Relative measures
  - Hospital A: 25 ill per 1000 patients = 0.025 or 2.5%
  - Hospital B: 10 ill per 250 patients = 0.040 or 4%

# *Descriptive Statistics*

- Measures of Rates and Ratios
  - *Rate: How fast disease occurs in a population.*
  - *Ratio: How much disease compared to standard.*
- Measures of Central Tendency
  - *Central Tendency: How well the data clusters around an average value.*
- Measures of Dispersion (Variability)
  - *Dispersion: How widely your data is spread from the average.*

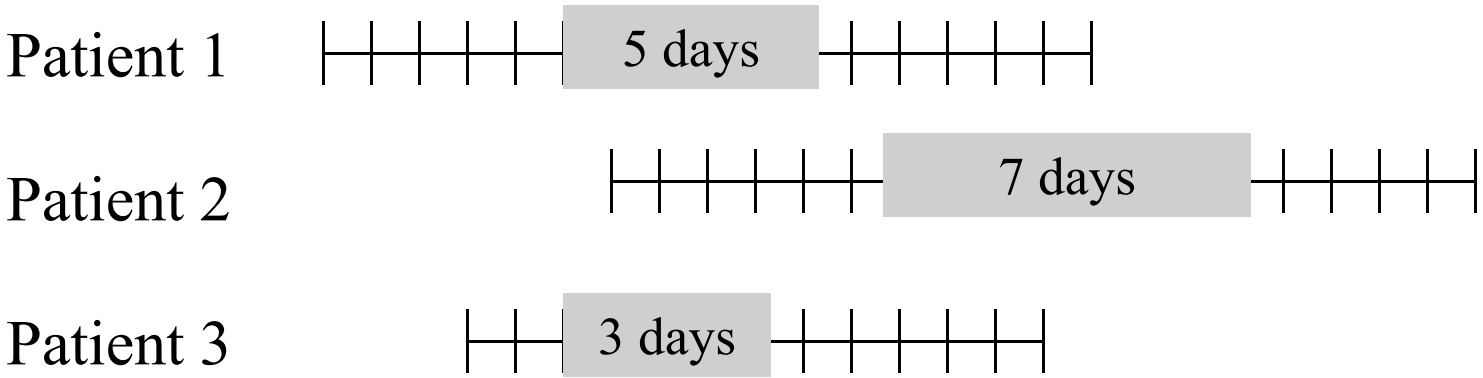
# *What Makes a Rate?*

1. Numerator (top number)
   - *e.g., number of infections*
2. Denominator (bottom number)
   - *e.g., number of patients [proportion]*
   - *e.g., number of patient-days, number of device-days [incidence density/rate]*
3. Time Frame
   - *e.g., day, week, month*

# *Denominators*

- Represent the population at risk of becoming part of the numerator
- Often, the most difficult data to obtain, but essential for comparisons
- Ideally, should incorporate time and can account for risk factors such as device use (e.g., device-days), length of stay (e.g., patient-days)

# *What is a Patient/Device-Day?*




=15 patient-days, device-days, etc.

- Gives more information than simply—3 patients
- Strategies: e.g., count how many at 9 am

# *Rate Measures*

- Prevalence
- Incidence
- Attack Rate

# *Prevalence*

- Prevalence: the <u>total</u> number of cases of disease existing in a population <u>at a point in time</u>.
  - *e.g., # of MRSA cases per population **<u>on</u>** March 8*

<u>Count of existing cases</u> x constant (e.g., 100 or 1000) =
Number of people at risk

# *Incidence*

- Incidence: the number of <u>new</u> cases of disease in a population <u>over a period of time</u>.
  - *e.g., # of **<u>new</u>** MRSA cases per population **<u>during</u>** March*

$$\frac{\text{Count of new cases}}{\text{Number of people at risk}} \times \text{constant (e.g., 100 or 1000)} =$$

# *Attack Rate*

- Attack Rate: the number of <u>new</u> cases of disease out of the population at risk.
  - Related to incidence but always uses 100 as the constant, so it is expressed as a <u>percent</u>.
  - Often used for outbreaks or clusters that occur over a short period of time
  - *e.g., <u>**%**</u> of patients with MRSA during outbreak in Med ICU in March*

$$\frac{\text{Count of new cases}}{\text{Number of people at risk}} \times 100 =$$

# *Example 1:*

- You perform HAI surveillance for ventilator associated pneumonias (VAP) and central line associated bloodstream infections (CLABSI) in your 12 bed intensive care unit.

- In March, you identify 2 new VAPs, 4 new CLABSIs and 3 new respiratory infections (not ventilator associated).

# *Example 1:*

- The admitting department tells you that in March there were 89 patients in the unit with 311 patient-days.

- Respiratory care tells you that they provided 162 ventilator-days of care to 47 patients in March.

- You count the central line-days and find 284 line-days in 84 patients in March.

# *Example 1:*

- In March, what was the VAP rate?
  - Incidence or prevalence?
  - Numerator?
  - Denominator?
  - Units?

# *Example 1: Answers*

- In March, what was the VAP rate?
  - Incidence or prevalence?
    - Incidence
  - Numerator?
    - 2
  - Denominator?
    - 162 or 47
  - Units?
    - "infections per 1000 ventilator-days" or "infections per 100 ventilated patients during March"
  - ANSWER: 12.3 infections per 1000 ventilator-days; 4.3 infections per 100 ventilated patients during March.

# *Example 1:*

- In March, what was the CLA-BSI rate?
  - Incidence or prevalence?
  - Numerator?
  - Denominator?
  - Units?

# *Example 1: Answers*

- In March, what was the CLA-BSI rate?
  - Incidence or prevalence?
    - Incidence
  - Numerator?
    - 4
  - Denominator?
    - 284 or 84
  - Units?
    - "infections per 1000 central line-days" or "infections per 100 patients with central lines during March"
  - ANSWER: 14.1 infections per 1000 central line-days or 4.8 infections per 100 patients with central lines during March

# *Example 1:*

- In March, what was overall infection rate?
  - Incidence or prevalence?
  - Numerator?
  - Denominator?
  - Units?

# *Example 1: Answers*

- In March, what was overall infection rate?
  - Incidence or prevalence?
    - Incidence
  - Numerator?
    - 9
  - Denominator?
    - 311 or 89
  - Units?
    - "infections per 1000 patient-days" or "infections per 100 patients during March"
  - ANSWER: 28.9 infections per 1000 patient-days or 10.1 infections per 100 patients during March

# *Example 1:*

- On April 7, you were worried about the BSI rate so you return to the unit to do a “spot check” on all of the patients for a BSI.

- At that time with a census of 12, you reviewed 11 charts and found 1 healthcare associated BSI.

# *Example 1:*

- On April 7th, what was the BSI infection rate at the time of your spot check?
  - Incidence or prevalence?
  - Numerator?
  - Denominator?
  - Units?

# *Example 1: Answers*

- In April, what was the BSI infection rate at the time of your spot check?
  - Incidence or prevalence?
    - Prevalence
  - Numerator?
    - 1
  - Denominator?
    - 11
  - Units?
    - "prevalent infections per 100 patients on April 7th"
  - ANSWER: 9 prevalent infections per 100 patients on April 7th.

# *What Makes a Standardized Infection Ratio (SIR)?*

1. Numerator (top number)
   =*number of observed infections*
2. Denominator (bottom number)
   =*number of expected or predicted infections*

   - Number of predicted infections =
     calculated based on your hospital's number of procedures, device days, risk factors, nursing units *compared to a standard infection rate* (e.g., historical data, state data, national data)

# *Predicted Number of Infections*

- 2015 as baseline year
- Logistic regression/negative binomial regression
- Limited patient level risk adjustment
  - facility type, bed size, med school affiliation, types of units.

SIR Example: CLABSI

Predicted CLABSI (#) = $\frac{\text{NHSN CLABSI rate x central line days}}{1000}$

| Location type | CLABSI (#) | Central line days (#) | NHSN CLABSI rate | Predicted CLABSIs (#) |
|---|---|---|---|---|
| Medical cardiac | 2 | 380 | 2.0 | 0.76 |
| Medical | 1 | 257 | 2.6 | 0.67 |
| Med/Surg | 3 | 627 | 1.5 | 0.94 |
| Neurosurg | 2 | 712 | 2.5 | 1.78 |
| Total | 8 | | ------ | 4.15 |

Overall CLABSI SIR = $\frac{\text{observed}}{\text{predicted}} = \frac{8}{4.15} = 1.93$

Details:
*https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/nhsn-sir-guide.pdf*

# *Standardized Infection Ratio*

- SIR = $\frac{\text{\# observed infections}}{\text{\# predicted infections}}$

- SIR >1.0 → *more infections than predicted*
- SIR <1.0 → *fewer infections than predicted*

- *~LOWER SIRs are BETTER~*

# *SIR Interpretations*

- **SIR=1**
- The number of infections is the same as the number of  expected infections
- No progress has been made in reducing infections since the baseline period or compared to another standard population (e.g., all NC, all US).

# *SIR Interpretations*

- If the **SIR is less than 1**
  - Fewer infections than predicted based on standard or baseline data
  - Infection reduction/prevention compared to standard or baseline data
  - 1 minus the SIR = percent reduction:
    For example, a SIR of 0.80 means that there was a 20 percent reduction from the standard population or baseline time period

# *SIR Interpretations*

- If the **SIR is greater than 1**
  - More infections than predicted based on standard or baseline data
  - Infections are increased compared to standard or baseline data
  - SIR minus 1 = percent increase:
    For example, a SIR of 1.25 means that there was a 25 percent increase from the standard population or baseline time period

# *Example 1: SIR*

- CLABSI rate = 4 CLABSI/284 line days
- Predicted Infections = 0.57

- What is the SIR?
- How would you explain the SIR to your administrator?

# *Example 1 SIR: Answers*

- CLABSI rate = 4 CLABSI/284 line days
- Predicted Infections = 0.57

- What is the SIR?
  - **SIR = 4 CLABSIs observed/0.57 CLABSIs predicted**
  - **SIR=7.02**
- How would you explain this SIR to your administrator?
  - **We observed more (7 times) CLABSIs than predicted based on comparison to a standard rate***

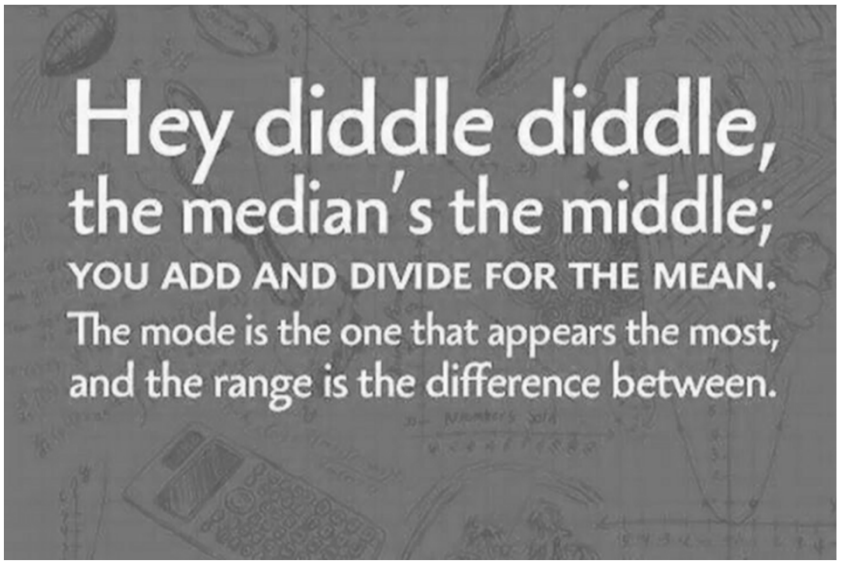
    ***state the source of standard rate, NHSN? which years?**

# *Descriptive Statistics*

- Measures of Rates
  - *Rate: How fast disease occurs in a population.*
  - *Ratio: How much disease compared to standard.*
- Measures of Central Tendency
  - *Central Tendency: How well the data clusters around an average value.*
- Measures of Dispersion (Variability)
  - *Dispersion: How widely your data is spread from the average.*

# *Measures of Central Tendency*

- **Mean:** average of a group of numbers
- **Median:** middle number in an ordered group of numbers
- **Mode:** most common value in a group of numbers



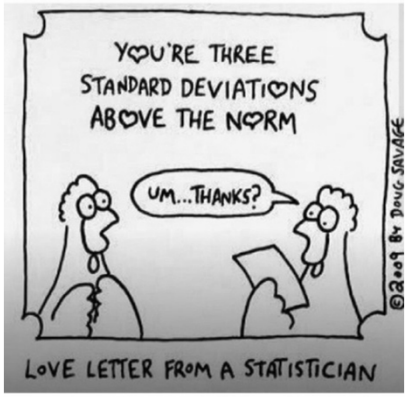
# *Descriptive Statistics*

- Measures of Rates
  - *Rate: How fast disease occurs in a population.*
  - *Ratio: How much disease compared to standard.*
- Measures of Central Tendency
  - *Central Tendency: How well the data clusters around an average value.*
- Measures of Dispersion (Variability)
  - *Dispersion: How widely your data is spread from the average.*

# *Measures of Dispersion*

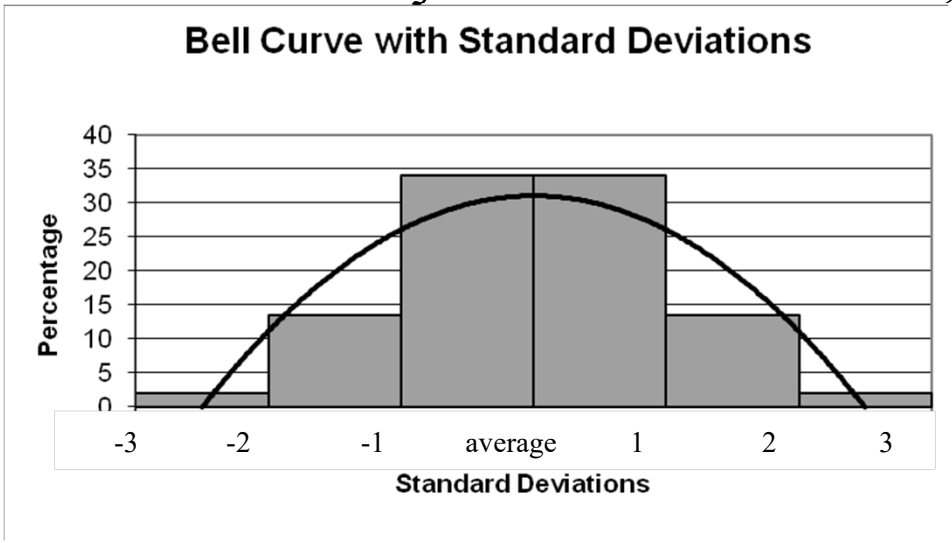
- Range: the largest value minus the smallest value

- Standard deviation: describes the variability or dispersion in the data set




# *Standard Deviation*

- **A** measure of degree of variability (spread) in individuals in the sample
  - Standard ("average") deviation ("difference") between an individual's mean and the sample mean
- In a normally distributed data set,




68% of values $\pm$ 1 SD

95% of values $\pm$ 2 SD

99% of values $\pm$ 3 SD

# *Example 2:*

- Your administrator is becoming concerned about the impact of healthcare associated infections on the length of stay in your ICU.

- She has asked you to provide her with some data to confirm her suspicions.

# *Example 2:*

- Over the last 3 months you have identified a series of 31 ventilator-associated pneumonias with the total length of stay for each ICU patient as follows:

  9, 7, 14, 11, 12, 22, 15, 10, 29, 16, 11, 7, 5, 12, 17, 25, 14, 14, 15, 23, 20, 11, 12, 18, 19, 11, 8, 6, 84, 12, 11

# *Example 2:*

- What is the:
  - Mean?
  - Median?
  - Mode?
  - Range?

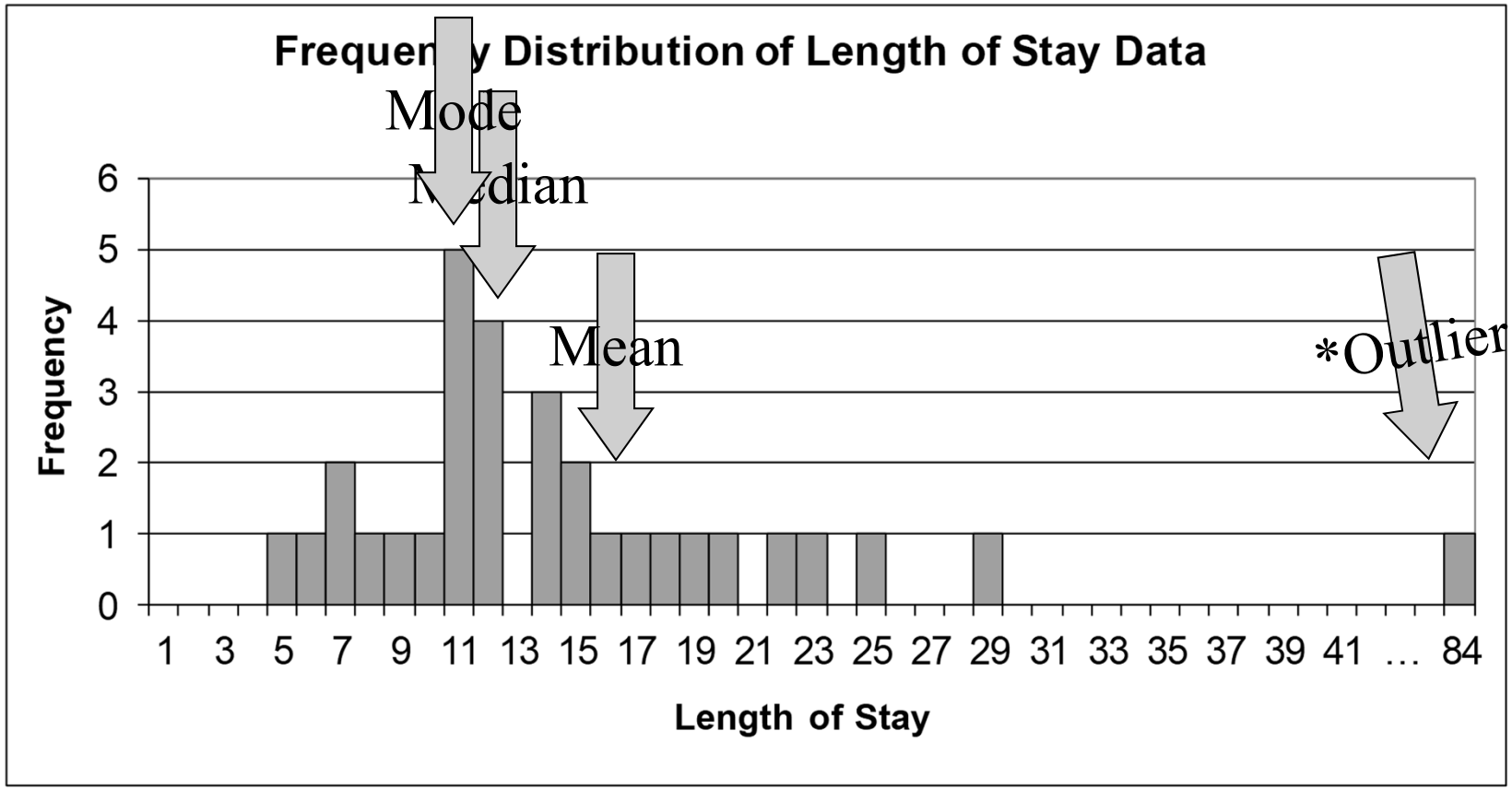
*HINT: 5, 6, 7, 7, 8, 9, 10, 11, 11, 11, 11, 11, 12, 12, 12, 12, 14, 14, 14, 15, 15, 16, 17, 18, 19, 20, 22, 23, 25, 29, 84*

# *Example 2: Answers*

- What is the:
  - Mean?
    - 16.1
  - Median?
    - 12
  - Mode?
    - 11
  - Range?
    - 79 *(84[max]-5[min])*
  - Standard Deviation?

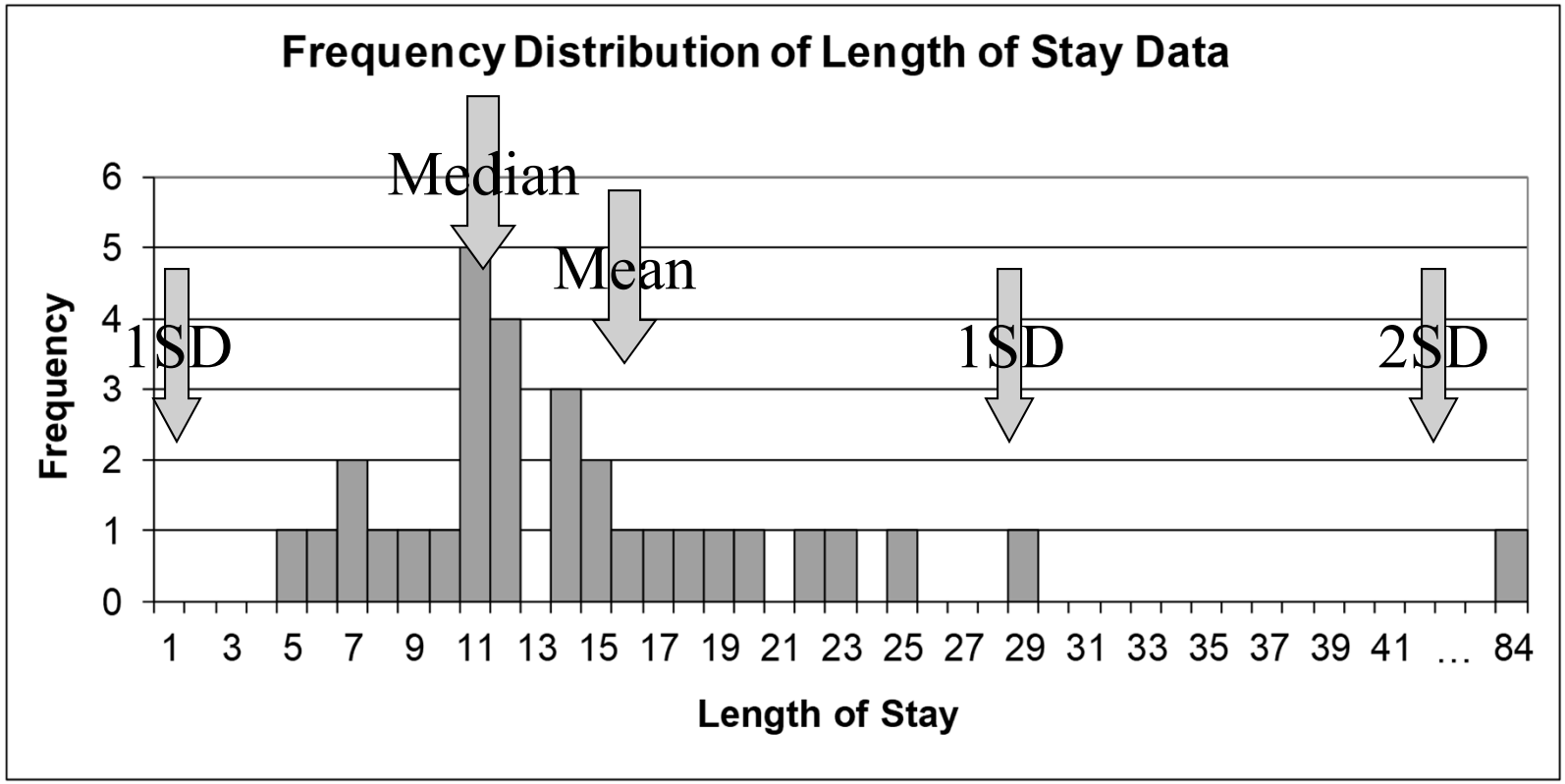
    *can use programs like Excel to calculate*
    - 13.8

# *Example 2: Central Tendency*

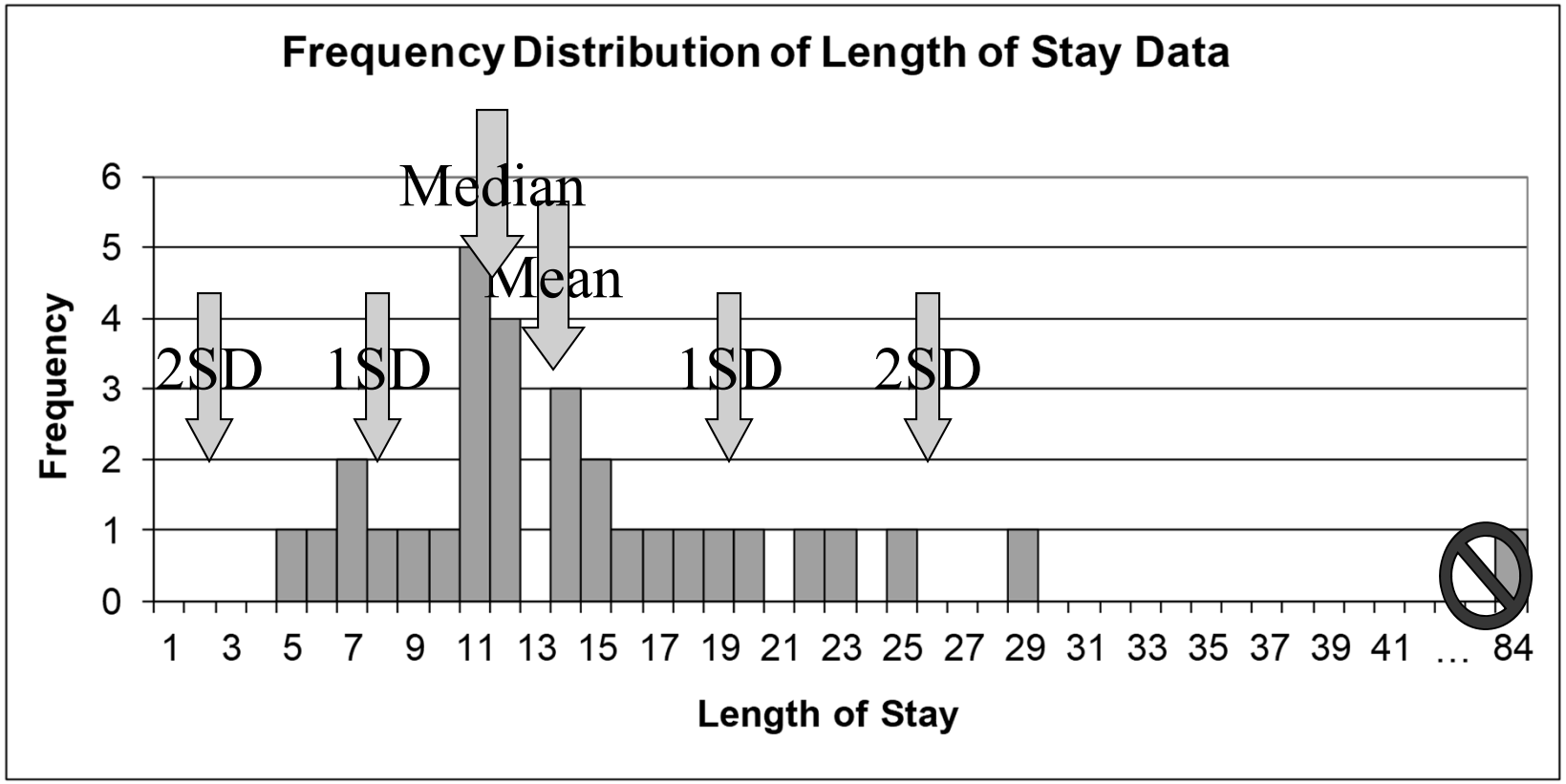



*outlier: a value that falls outside the overall pattern.

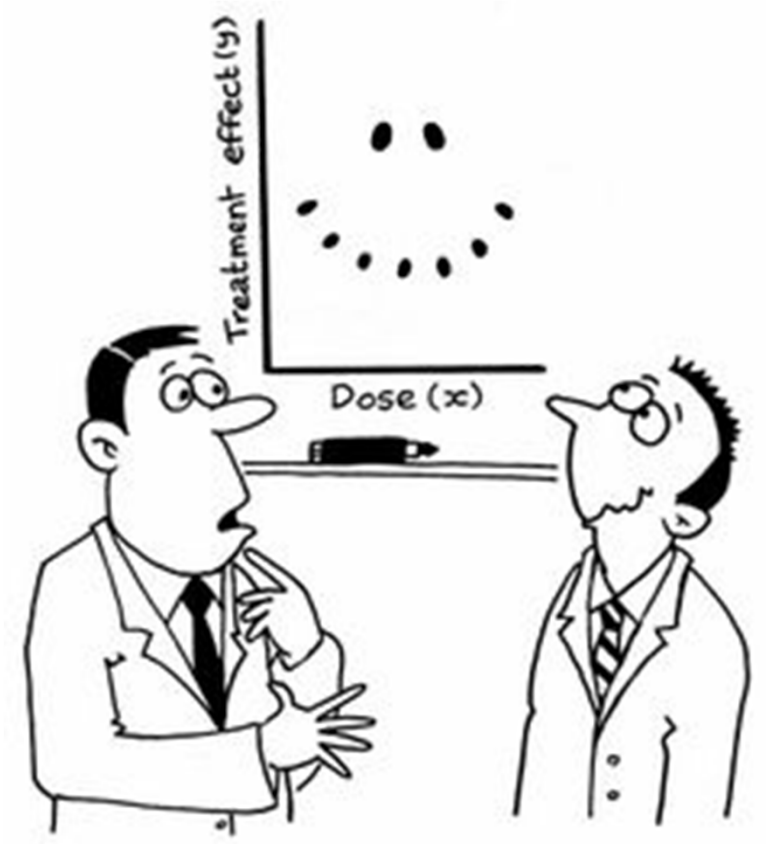
# *Example 2: Dispersion*



# *Example 2: Dispersion*



# *Displaying Surveillance Data*



# *Displaying and Interpreting Surveillance Data*

- Graphs: a visual representation of data on a coordinate system (e.g., two axes)
- Tables: a set of data arranged in rows and columns

# *Data Types*

- Quantitative variables: numerical values
  - *(e.g., number of infections, number of patients)*

- Categorical variables: descriptive groups or categories
  - *(e.g., units in the hospitals, occupational groups)*

# *Features of Graphs and Tables*

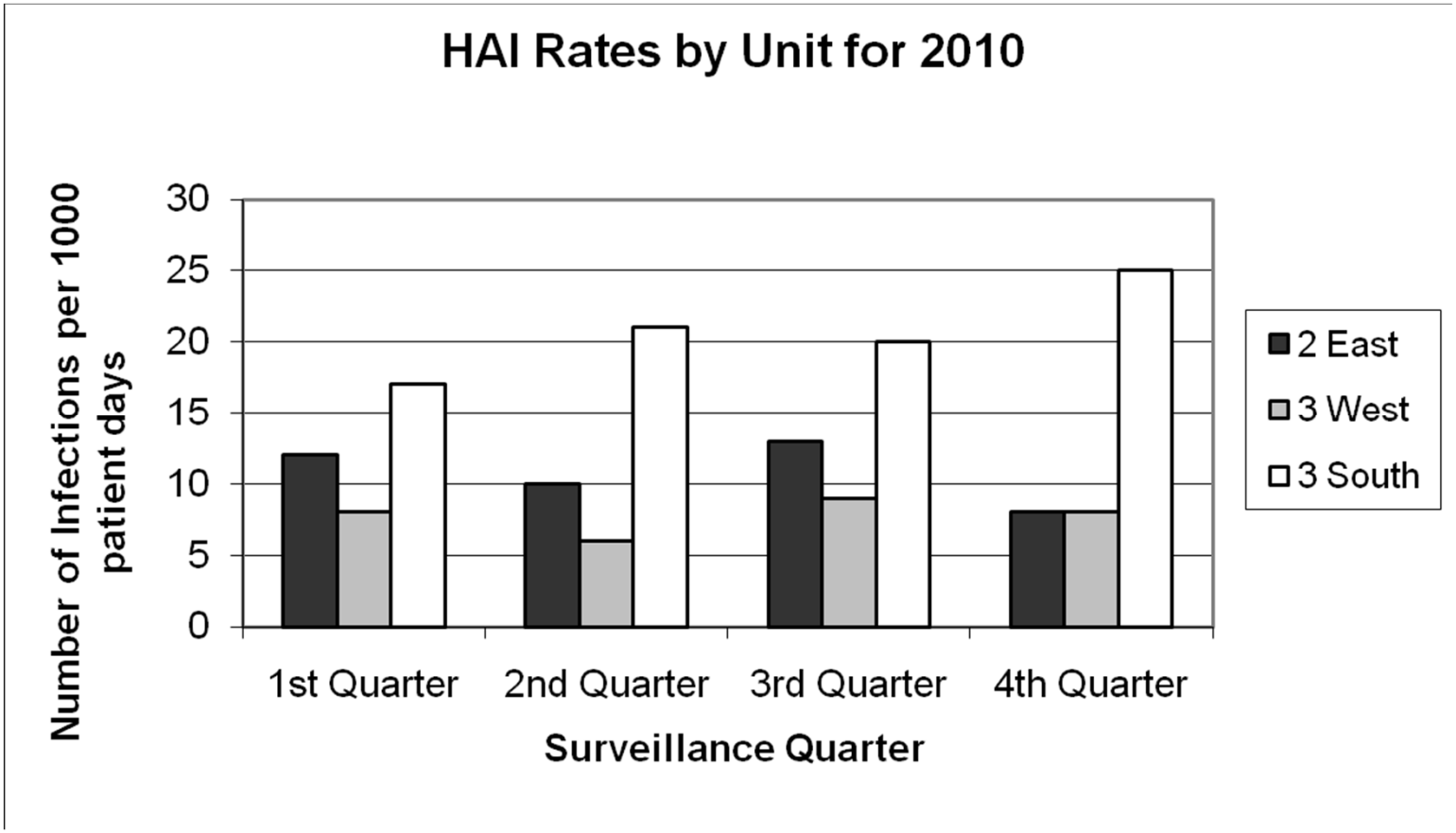
*Graphs and tables should be self-explanatory!*

- Clear, concise title: describes person, place, time
- Informative labels: axes, rows, columns
- Appropriate intervals for axes
- Coded and labeled legends or keys
- Use footnotes to:
  - Explain codes, abbreviations, and symbols
  - Note exclusions
  - Note data source

# *Graph Types*

- Bar Graphs
  - *E.g, Histograms (shown in previous example)*
  - *E.g., Comparison between categories*
  - *E.g., Epidemic Curves*
- Line Graphs
  - *E.g., To show trends over time*
- Pie Charts
  - *E.g., As a percentage of a whole*

# *Bar Graph*


HAI Rates by Unit for 2010
Number of Infections per 1000 patient days
30
25
20
15
10
5
0
1st Quarter
2nd Quarter
3rd Quarter
4th Quarter
Surveillance Quarter
2 East
3 West
3 South

NHSN Output - Bar Chart for All Central Line-Associated BSI Events - Windows Internet Explorer

https://sdn7.cdc.gov/nhsn/analysisrequest.do?method=runFromList&NHSNSessionID=5443

File Edit View Favorites Tools Help

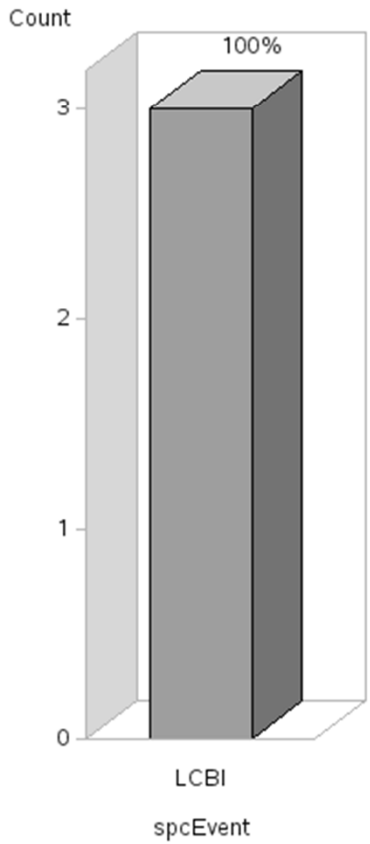
**National Healthcare Safety Network**

Bar Chart for All Central Line-Associated BSI Events

As of: March 29, 2013 at 5:06 PM

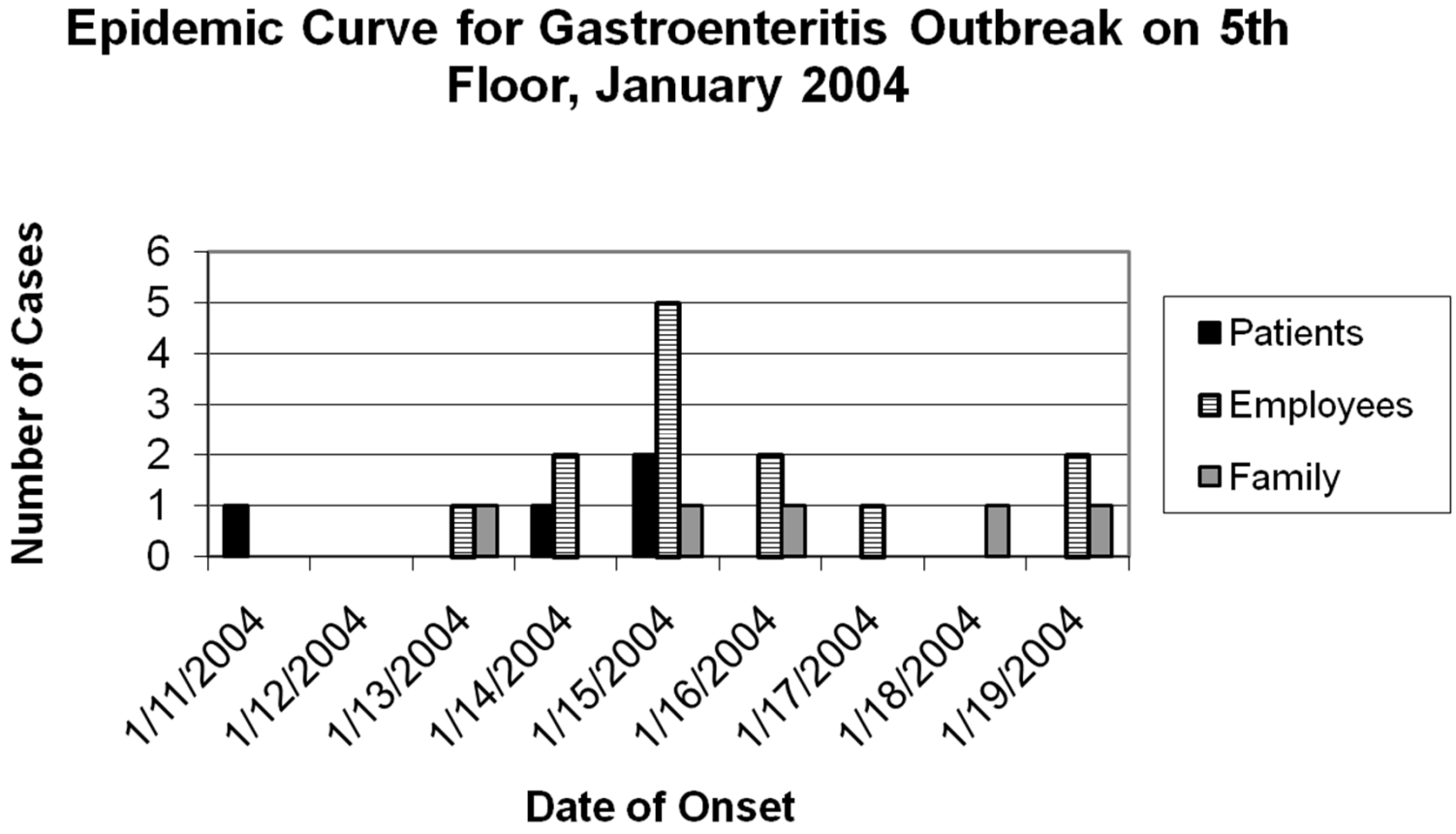
Date Range: All CLAB_EVENTS

location=SICU

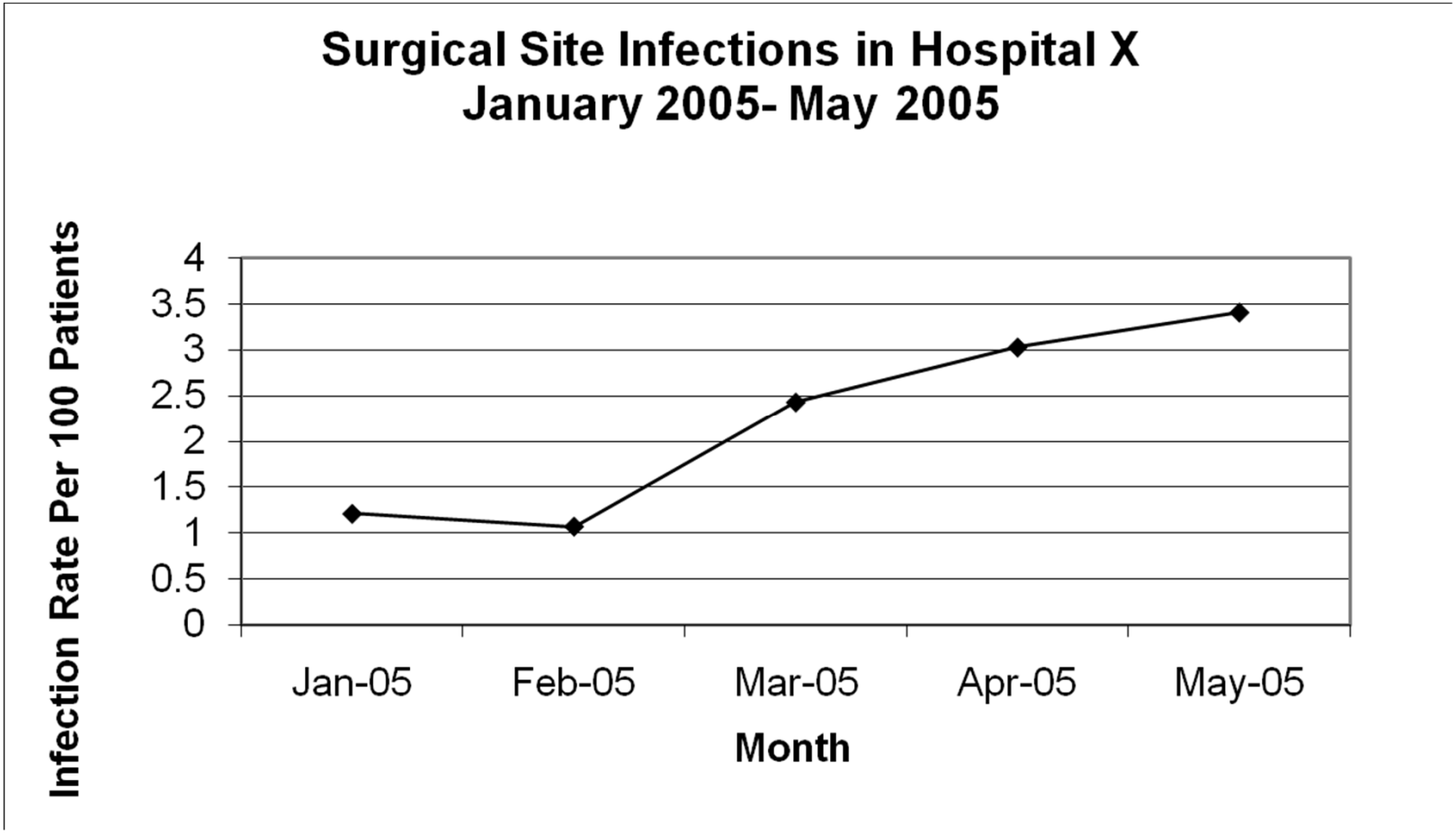



Data contained in this report were last generated on March 22, 2013 at 3:40 PM.

# *Epi Curve*


Epidemic Curve for Gastroenteritis Outbreak on 5th Floor, January 2004
Number of Cases
0
1
2
3
4
5
6
1/11/2004
1/12/2004
1/13/2004
1/14/2004
1/15/2004
1/16/2004
1/17/2004
1/18/2004
1/19/2004
Date of Onset
Patients
Employees
Family

# *Line Graph*


Surgical Site Infections in Hospital X
January 2005- May 2005
Infection Rate Per 100 Patients
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-05
Feb-05
Mar-05
Apr-05
May-05
Month

https://sdn7.cdc.gov/nhsn/analysisrequest.do?method=runFromList&NHSNSessionID=5178

File Edit View Favorites Tools Help

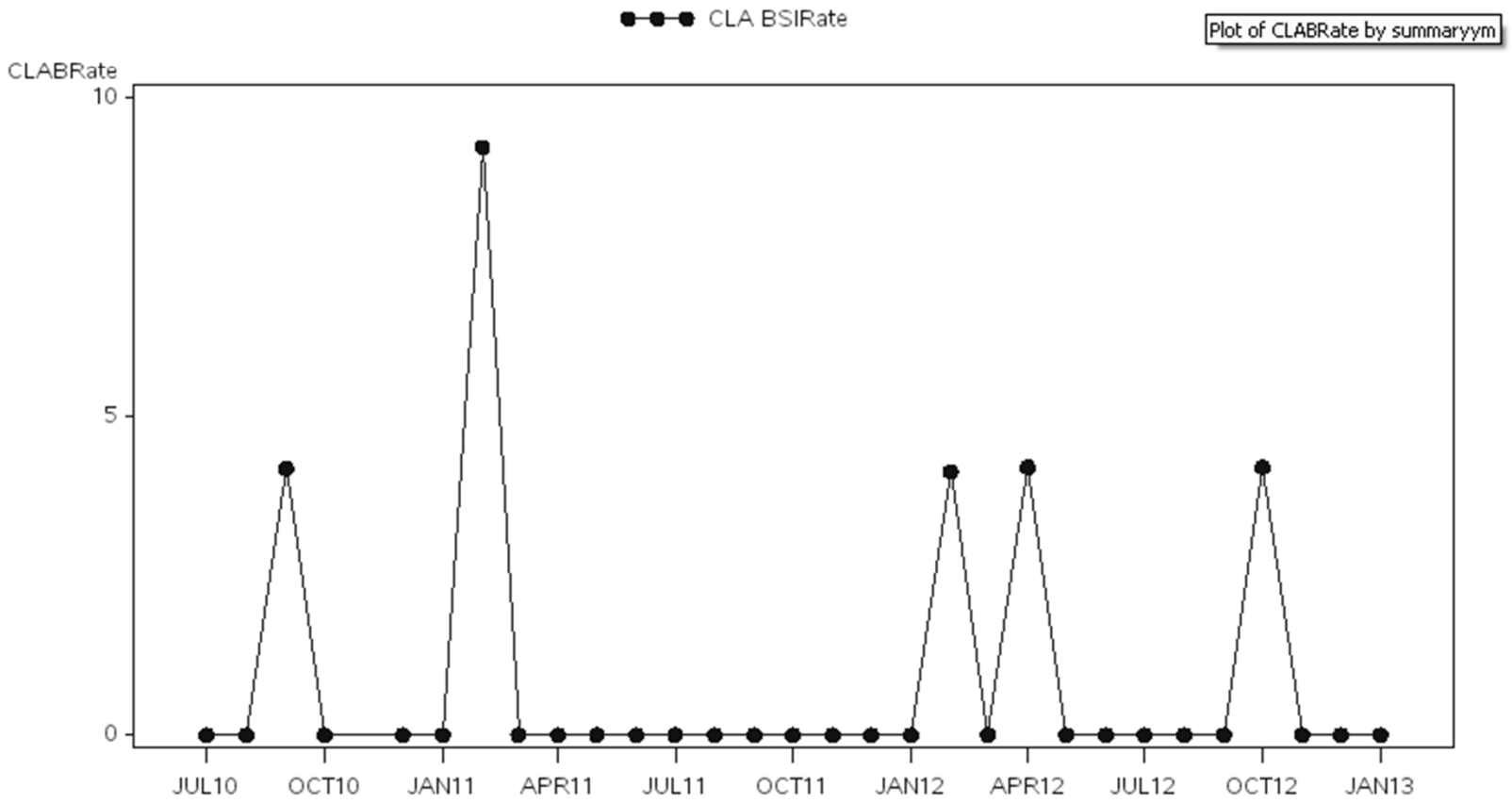
Data contained in this report were last generated on March 22, 2013 at 3:40 PM.

**National Healthcare Safety Network**

Run Chart for Central Line-Associated BSI Data for ICU-Other

As of: March 22, 2013 at 4:15 PM Date Range: All CLAB_RATESICU

orgID=16195 location=CTICU

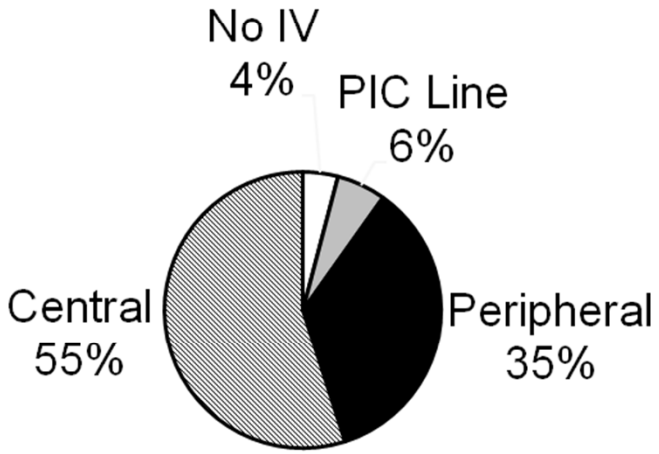


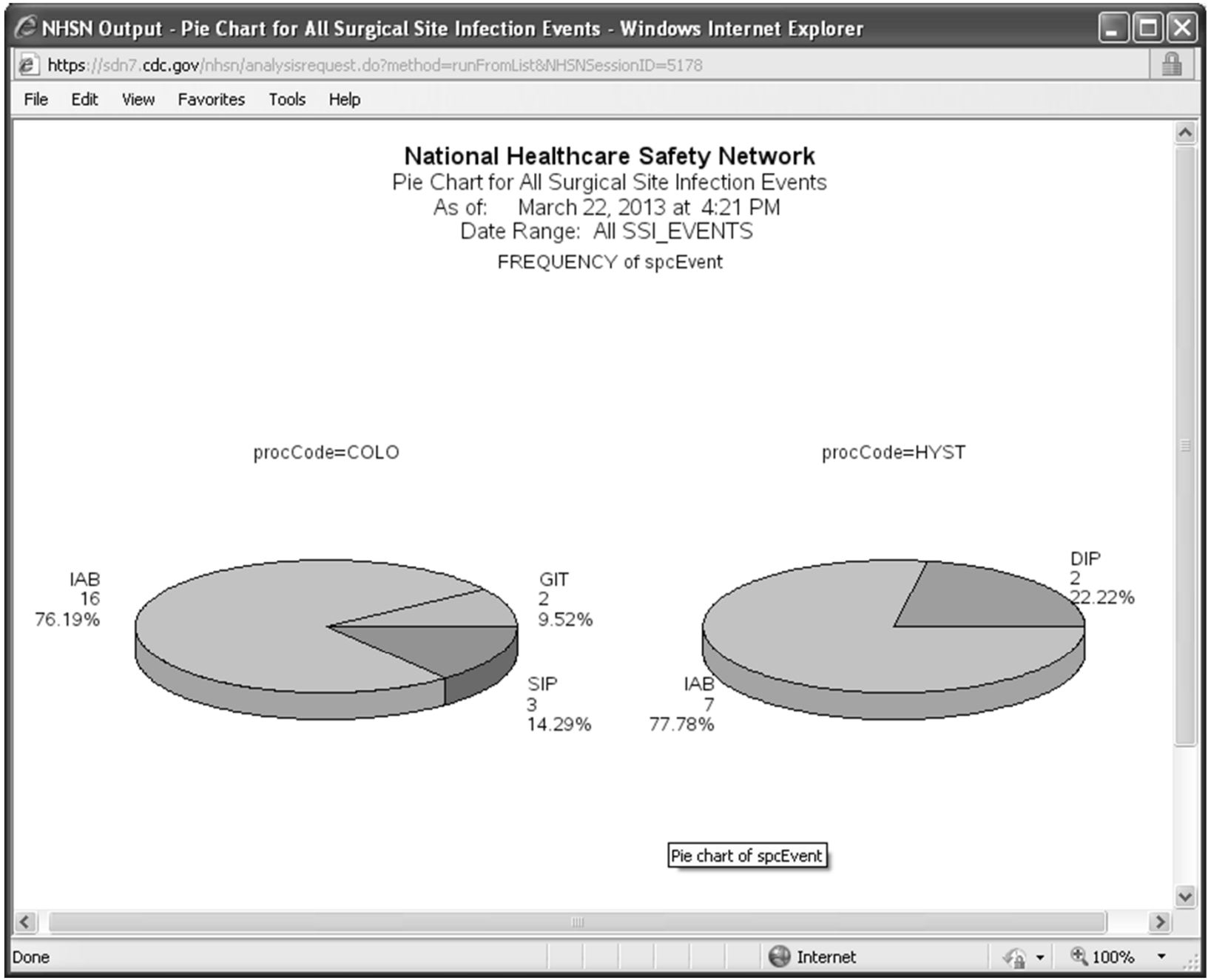

NOTE: Strata with fewer than 2 data points have been omitted.

Done Internet 100%

# *Pie Chart*

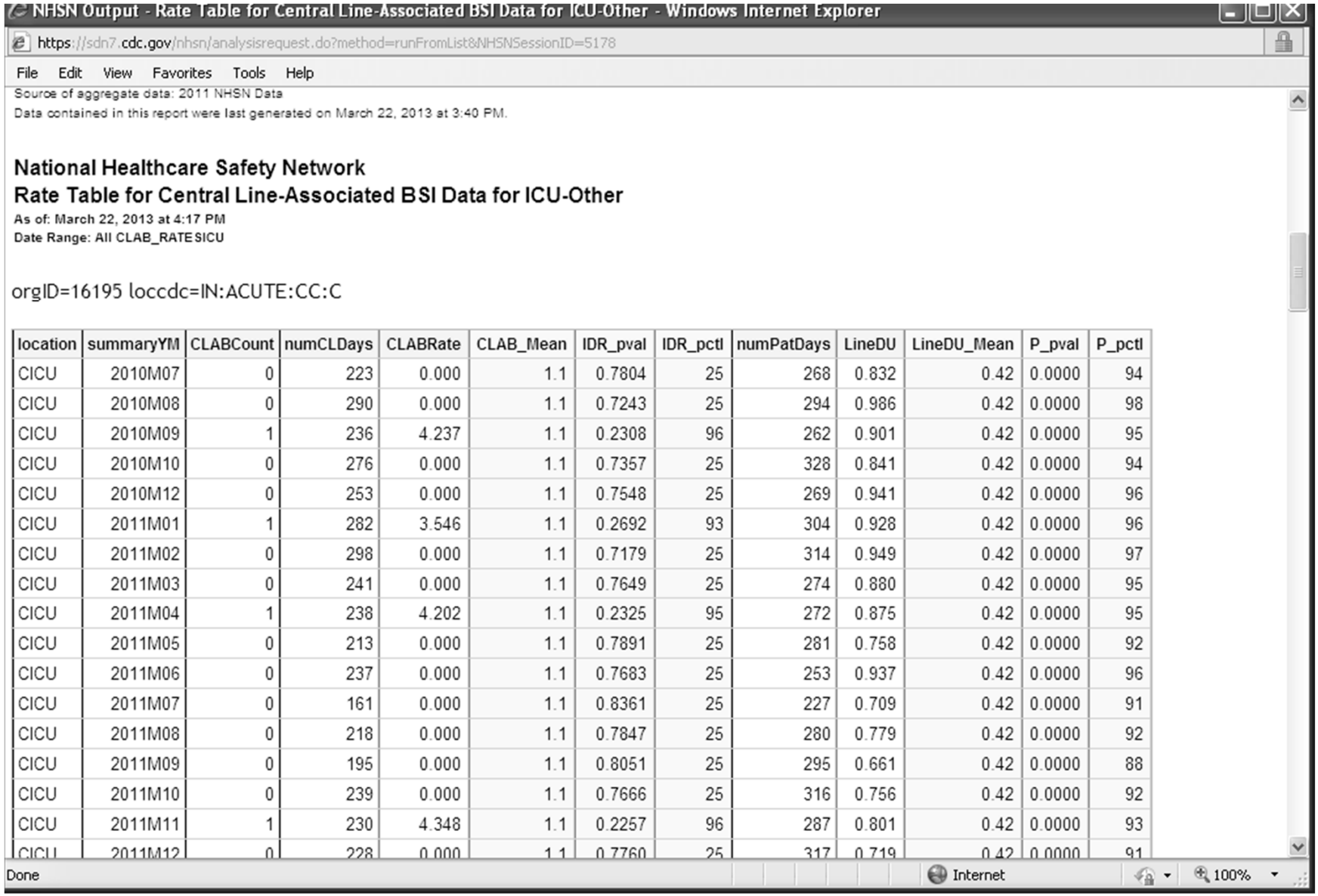
**Distribution of Primary Bloodstream Infections by Device Type at Hospital X for 2009**




NHSN Output - Pie Chart for All Surgical Site Infection Events - Windows Internet Explorer
https://sdn7.cdc.gov/nhsn/analysisrequest.do?method=runFromList&NHSNSessionID=5178
File Edit View Favorites Tools Help
National Healthcare Safety Network
Pie Chart for All Surgical Site Infection Events
As of: March 22, 2013 at 4:21 PM
Date Range: All SSI_EVENTS
FREQUENCY of spcEvent
procCode=COLO
IAB
16
76.19%
GIT
2
9.52%
SIP
3
14.29%
procCode=HYST
DIP
2
22.22%
IAB
7
77.78%
Pie chart of spcEvent
Done
Internet
100%

# *Tables*

| Number of Newly Diagnosed Cases by Age, United States, 2010 | |
|---|---|
| **Age Group (Years)** | **Number of Cases** |
| 0-4 | 1242 |
| 5-14 | 1081 |
| 15-24 | 2482 |
| 25-44 | 8153 |
| 45-64 | 10916 |
| 65+ | 7124 |
| **Total** | **30998** |




| location | summaryYM | CLABCount | numCLDays | CLABRate | CLAB_Mean | IDR_pval | IDR_pctl | numPatDays | LineDU | LineDU_Mean | P_pval | P_pctl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CICU | 2010M07 | 0 | 223 | 0.000 | 1.1 | 0.7804 | 25 | 268 | 0.832 | 0.42 | 0.0000 | 94 |
| CICU | 2010M08 | 0 | 290 | 0.000 | 1.1 | 0.7243 | 25 | 294 | 0.986 | 0.42 | 0.0000 | 98 |
| CICU | 2010M09 | 1 | 236 | 4.237 | 1.1 | 0.2308 | 96 | 262 | 0.901 | 0.42 | 0.0000 | 95 |
| CICU | 2010M10 | 0 | 276 | 0.000 | 1.1 | 0.7357 | 25 | 328 | 0.841 | 0.42 | 0.0000 | 94 |
| CICU | 2010M12 | 0 | 253 | 0.000 | 1.1 | 0.7548 | 25 | 269 | 0.941 | 0.42 | 0.0000 | 96 |
| CICU | 2011M01 | 1 | 282 | 3.546 | 1.1 | 0.2692 | 93 | 304 | 0.928 | 0.42 | 0.0000 | 96 |
| CICU | 2011M02 | 0 | 298 | 0.000 | 1.1 | 0.7179 | 25 | 314 | 0.949 | 0.42 | 0.0000 | 97 |
| CICU | 2011M03 | 0 | 241 | 0.000 | 1.1 | 0.7649 | 25 | 274 | 0.880 | 0.42 | 0.0000 | 95 |
| CICU | 2011M04 | 1 | 238 | 4.202 | 1.1 | 0.2325 | 95 | 272 | 0.875 | 0.42 | 0.0000 | 95 |
| CICU | 2011M05 | 0 | 213 | 0.000 | 1.1 | 0.7891 | 25 | 281 | 0.758 | 0.42 | 0.0000 | 92 |
| CICU | 2011M06 | 0 | 237 | 0.000 | 1.1 | 0.7683 | 25 | 253 | 0.937 | 0.42 | 0.0000 | 96 |
| CICU | 2011M07 | 0 | 161 | 0.000 | 1.1 | 0.8361 | 25 | 227 | 0.709 | 0.42 | 0.0000 | 91 |
| CICU | 2011M08 | 0 | 218 | 0.000 | 1.1 | 0.7847 | 25 | 280 | 0.779 | 0.42 | 0.0000 | 92 |
| CICU | 2011M09 | 0 | 195 | 0.000 | 1.1 | 0.8051 | 25 | 295 | 0.661 | 0.42 | 0.0000 | 88 |
| CICU | 2011M10 | 0 | 239 | 0.000 | 1.1 | 0.7666 | 25 | 316 | 0.756 | 0.42 | 0.0000 | 92 |
| CICU | 2011M11 | 1 | 230 | 4.348 | 1.1 | 0.2257 | 96 | 287 | 0.801 | 0.42 | 0.0000 | 93 |
| CICU | 2011M12 | 0 | 228 | 0.000 | 1.1 | 0.7760 | 25 | 317 | 0.719 | 0.42 | 0.0000 | 91 |

# *Interpreting Surveillance Data*


THINGS GOT REALLY INTERESTING WHEN THE STATISTICIAN STARTED DOING WARD ROUNDS

# *NHSN data summary, 2013*

| Urinary catheter associated UTI Rate* | | | | | Percentile | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Types of Location: Critical care units | No. Loca-tions | No. of CAUTI | Urinary catheter days | Pooled Mean | 10% | 25% | 50% (median) | 75% | 90% |
| Medical cardiac | 384 | 1494 | 658,345 | 2.3 | 0.0 | 0.7 | 1.9 | 3.4 | 4.9 |
| Medical/surgical ≤15 beds | 1645 | 2429 | 1,910,118 | 1.3 | 0.0 | 0.0 | 0.4 | 1.7 | 3.1 |
| Surgical cardiothoracic | 453 | 1715 | 942,852 | 1.8 | 0.0 | 0.7 | 1.5 | 2.4 | 3.4 |

$$* \frac{\text{Number of CA UTIs}}{\text{Number of urinary catheter days}} \times 1000$$

# *What does this NHSN data summary tell you?*

- What is the mean UTI rate in the medical cardiac critical care unit?
  - 2.3 UTIs per 1000 urinary catheter days
- If your medical/surgical ( $\leq$15 beds) critical care unit has a rate of 1.6 UTIs per 1000 urinary catheter days—between what percentiles is it compared to the NHSN data?
  - Between the $50^{th}$-$75^{th}$ percentiles
- If your surgical cardiothoracic critical care unit has a rate of 4.2 UTIs per 1000 urinary catheter days—between what percentiles is it compared to the NHSN data?
  - Greater than the $90^{th}$ percentile


Which infection type is NC performing the best/worst in compared to the 2017 national experience?

Which infection type has NC achieved the most prevention from 2016 to 2017?

## North Carolina Data for Acute Care Hospitals, Year 2017

Card View | Table

### North Carolina Data by HAI Type

| HAI Type | # OF FACILITIES THAT REPORTED DATA TO CDC'S NHSN, 2017* | 2017 STATE SIR VS. 2016 STATE SIR | 2017 STATE SIR VS. 2017 NATIONAL SIR | 2017 STATE SIR VS. NATIONAL BASELINE* | 2017 STATE SIR | 2017 NATIONAL SIR |
|---|---|---|---|---|---|---|
| CLABSI | 98 | = 6% | ↑ 40% | = 2% | 0.98 | 0.81 |
| CAUTI | 98 | = 2% | = 2% | ↓ -11% | 0.89 | 0.88 |
| VAE | 42 | = 7% | ↑ 46% | ↑ 38% | 1.38 | 0.95 |
| SSI: Abdominal Hysterectomy | 86 | = 23% | ↓ -38% | ↓ -44% | 0.56 | 0.89 |
| SSI: Colon Surgery | 87 | = 4% | = 8% | ↓ -17% | 0.83 | 0.91 |
| MRSA Bacteremia | 99 | ↓ -17% | = 10% | ↓ -22% | 0.78 | 0.86 |
| C. *difficile* Events | 100 | ↓ -14% | ↓ -4% | ↓ -23% | 0.77 | 0.80 |

Healthcare-associated infections (HAIs) are infections patients can get while receiving medical treatment in a healthcare facility. Working toward the elimination of HAIs is a CDC priority. The standardized infection ratio (SIR) is a summary statistic that can be used to track HAI prevention progress over time; lower SIRs are better. The infection data are reported to CDC's National Healthcare Safety Network (NHSN). HAI data for nearly all U.S. hospitals are published on the Hospital Compare website. **This report is based on 2017 data, published in 2019 and uses the 2015 Baseline and risk-adjusted models.**

https://gis.cdc.gov/grasp/PSA/HAIreport.html

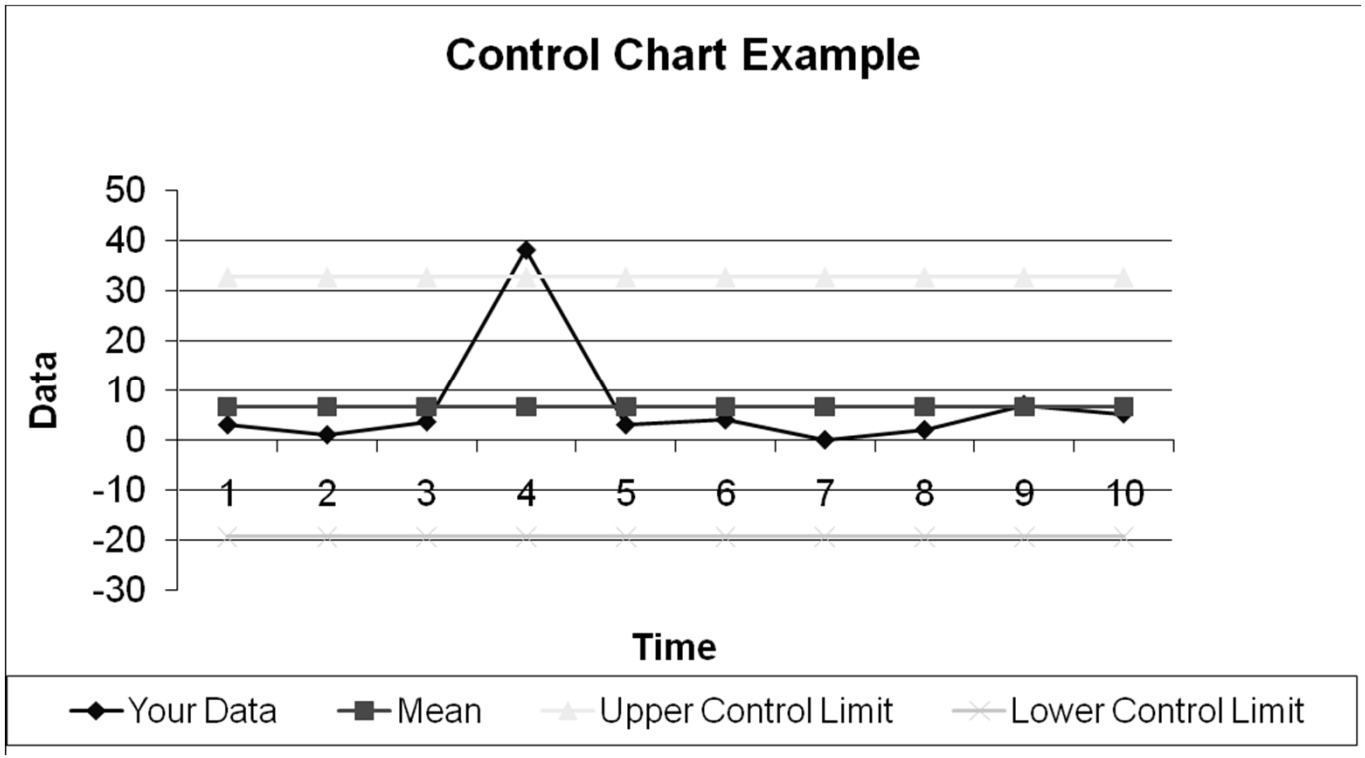
# *Determine the Significance of Changes to Surveillance Data*

# *Determine the Significance- How?*

- Practical Significance vs. Statistical Significance
- Make comparisons
  - *For example: over time, to other units, to other hospitals (NHSN data)*
  - Remember to choose appropriate data for comparison (*i.e., same denominator units)*
- Apply a type of statistical test
  - *e.g., control charts (for time trends)*
- Other statistical tests and measures
  - P-values
  - 95% confidence intervals

# *Control Charts*

- Tool to determine when infection rates are out of range. *How high is TOO high?*



# *Control Chart Example 3:*

| Month | 2015 BSI Rate | Moving Range |
|---|---|---|
| 1 | 4.5 | -- |
| 2 | 3.2 | 1.3 |
| 3 | 3.6 | 0.4 |
| 4 | 3.5 | |
| 5 | 3.0 | |
| 6 | 4.0 | |
| 7 | 4.1 | |
| 8 | 4.6 | |
| 9 | 4.8 | |
| 10 | 5.2 | |
| 11 | 5.7 | |
| 12 | 6.5 | |

- Find the mean of the BSI rates for the last year.
- Calculate the moving ranges (subtract month 1 from 2, month 2 from 3…) and take absolute values (no negative values).
- Calculate the mean of the moving ranges.

# *Control Chart Example 3: Answers*

| Month | 2015 BSI Rate | Moving Range |
|---|---|---|
| 1 | 4.5 | |
| 2 | 3.2 | 1.3 |
| 3 | 3.6 | 0.4 |
| 4 | 3.5 | 0.1 |
| 5 | 3.0 | 0.5 |
| 6 | 4.0 | 1.0 |
| 7 | 4.1 | 0.1 |
| 8 | 4.6 | 0.5 |
| 9 | 4.8 | 0.2 |
| 10 | 5.2 | 0.4 |
| 11 | 5.7 | 0.5 |
| 12 | 6.5 | 0.8 |

- Find the mean of the BSI rates.

  =4.4

- Calculate the moving ranges

  See table

- Calculate the mean of the moving ranges.

  =0.5

# *Control Chart Example 3:*

- Calculate Upper Control limit= Mean + (2.66 x Mean of Moving Range)
- Calculate Lower Control limit= Mean - (2.66 x Mean of Moving Range)

- Draw horizontal lines at the mean, UCL and LCL based on your historical data
- Then graph your current data and use the limits to identify potential problems.

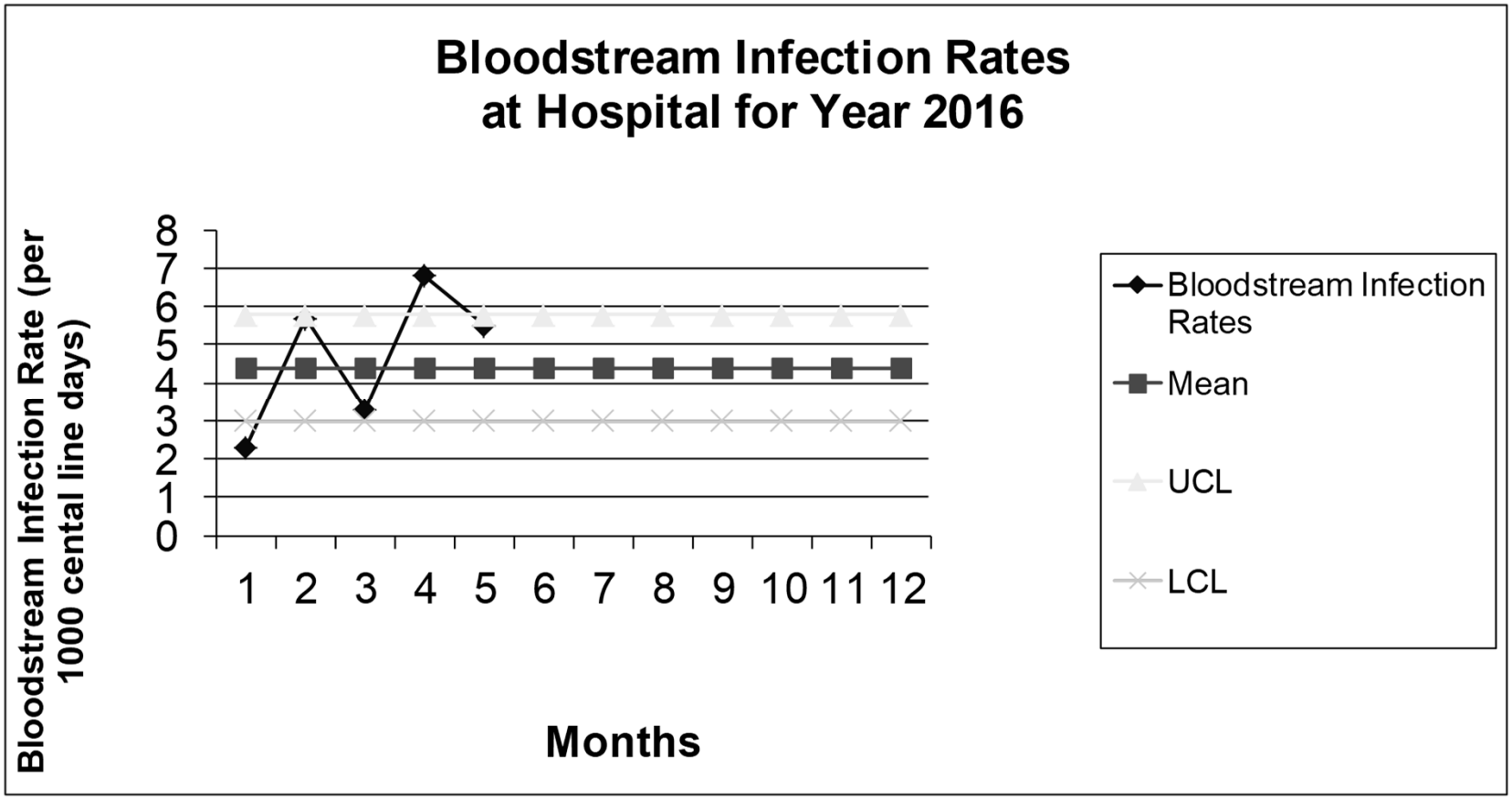
# *Control Chart Example 3: Answers*

- Calculate Upper Control limit= 5.8
- Calculate Lower Control limit= 3.0

- Draw horizontal lines at the mean, UCL and LCL based on your historical data

- Then graph your current data and use the limits to identify potential problems.

# *Control Chart Example 3:*



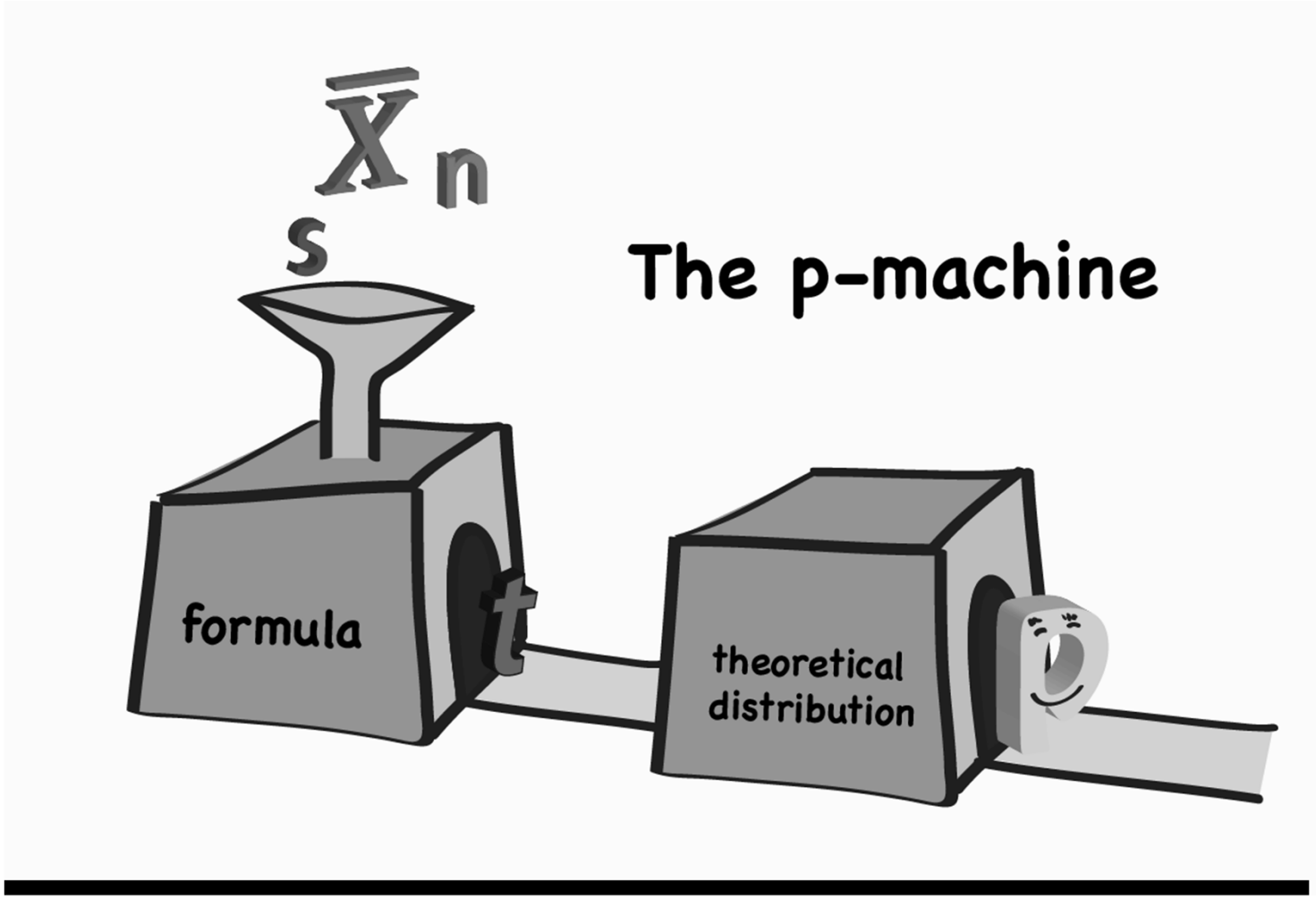
# *Statistical Tests – Why do we need them?*

- **Is this real?** Use in clinical research designed to tell if the difference seen is due to chance, or due to some other cause (i.e. a real difference)

- We use these measures to make an **inference**
  - Process of drawing a conclusion about a larger group based on a sample or subset of the group

# *P value*

- **P value**: probability of finding a difference as extreme or more extreme than what was found, assuming that the null hypothesis is true
  - Can be used as a measure of the degree of compatibility between observed data and null hypothesis
  - The conventional (yet arbitrary) threshold is 0.05, below which the null hypothesis is rejected
  - 0.05 accepts a 5% risk of a Type 1 error




$\bar{x}$ average value

s standard deviation

n sample size (number of measurements)

t test statistic $= \frac{\bar{x}}{s/\sqrt{n}}$

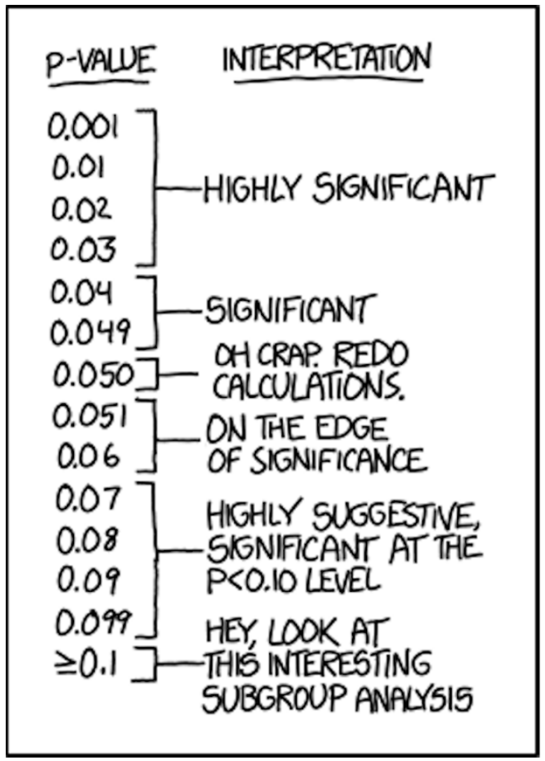
p p-value (probability)

# *P-Value Example:*

- "Our study showed that people who washed their hands were less likely to get sick (P=0.06) and more likely to be nurses (P=0.01)."

# *P-Value Interpretation*

- Probability that the difference does not reflect a true difference and is only due to chance.
- e.g., P=0.05 means that 95 out of 100 times your estimate was truly significant
- Generally a level of P<0.05 is considered “statistically significant.”



# *Estimation: 95% Confidence Interval*

- **95% Confidence Interval (CI): calculated range of values surrounding the point estimate that are consistent with true effect**
  - Formula: point estimate of the mean +/- $(2^* {}^{s}/_{\sqrt{n}})$
- **Means that you are 95% confident that the true average value lies within this interval.**

# *Statistical Variation of Estimates*

- Consider your calculated infection rate to be an estimation of the true rate.

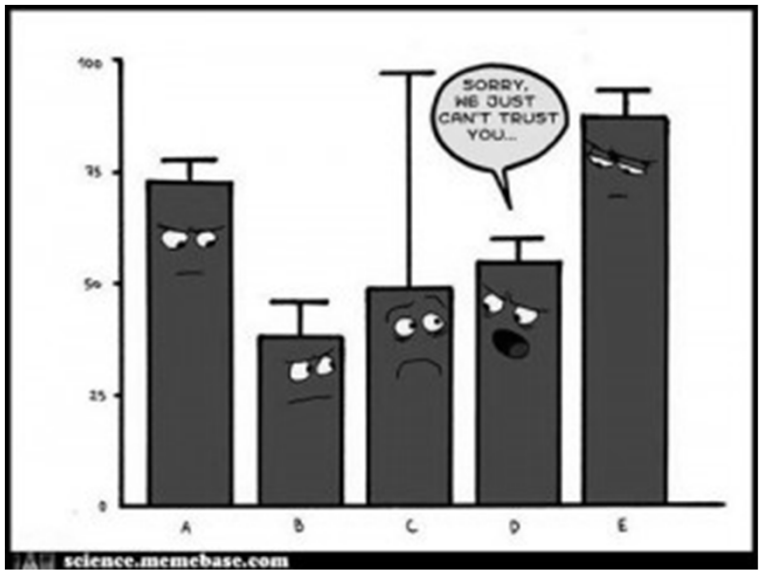
  Why an estimation?

  – You may only do surveillance on a sample of patients in your hospital.

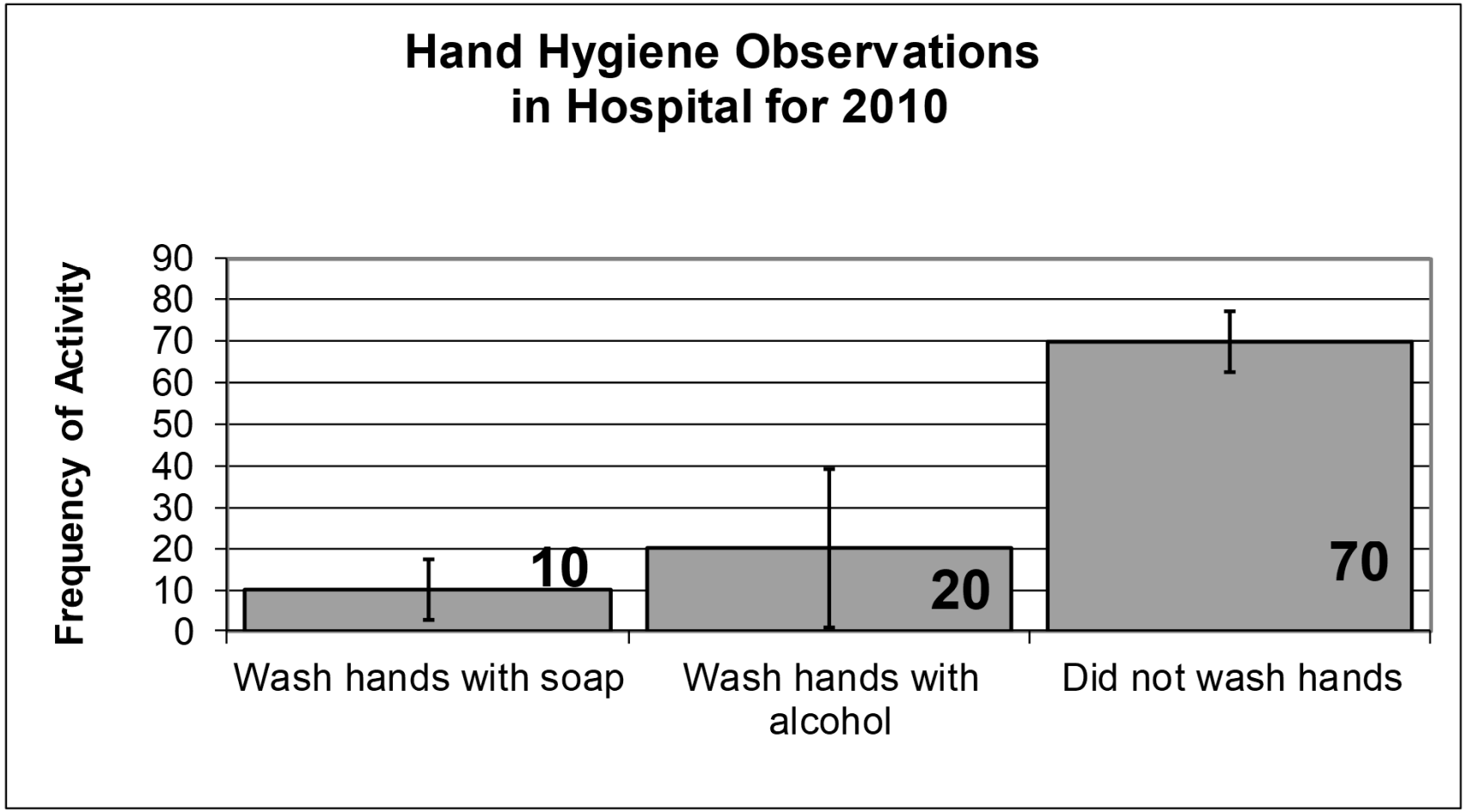
  – If surveillance activities were repeated by other IPs, your numerators may vary slightly based on interpretation of case definitions, available clinical information in the chart, etc.

# *95% Confidence Interval Interpretation*

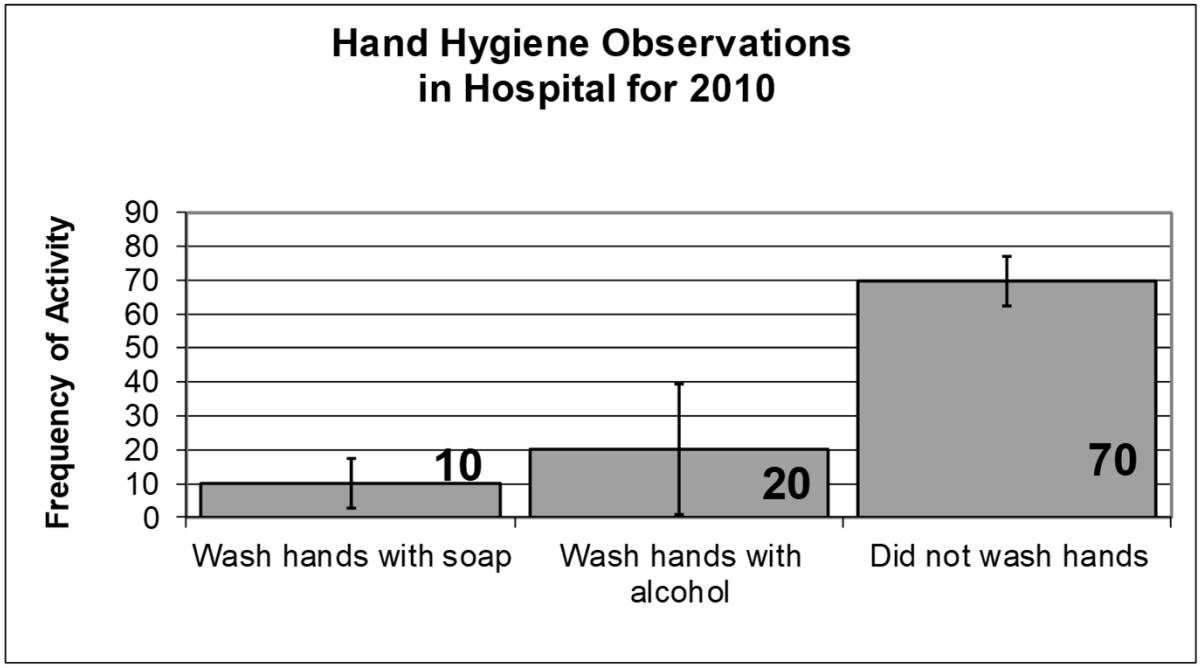
- Confidence interval size:
  - Wide: less confident with that estimate
  - Narrow: more confident with that estimate
- For comparisons,
  - Overlapping intervals suggest no significant difference
  - Non-overlapping intervals suggest significant differences



# *95% Confidence Interval Example:*

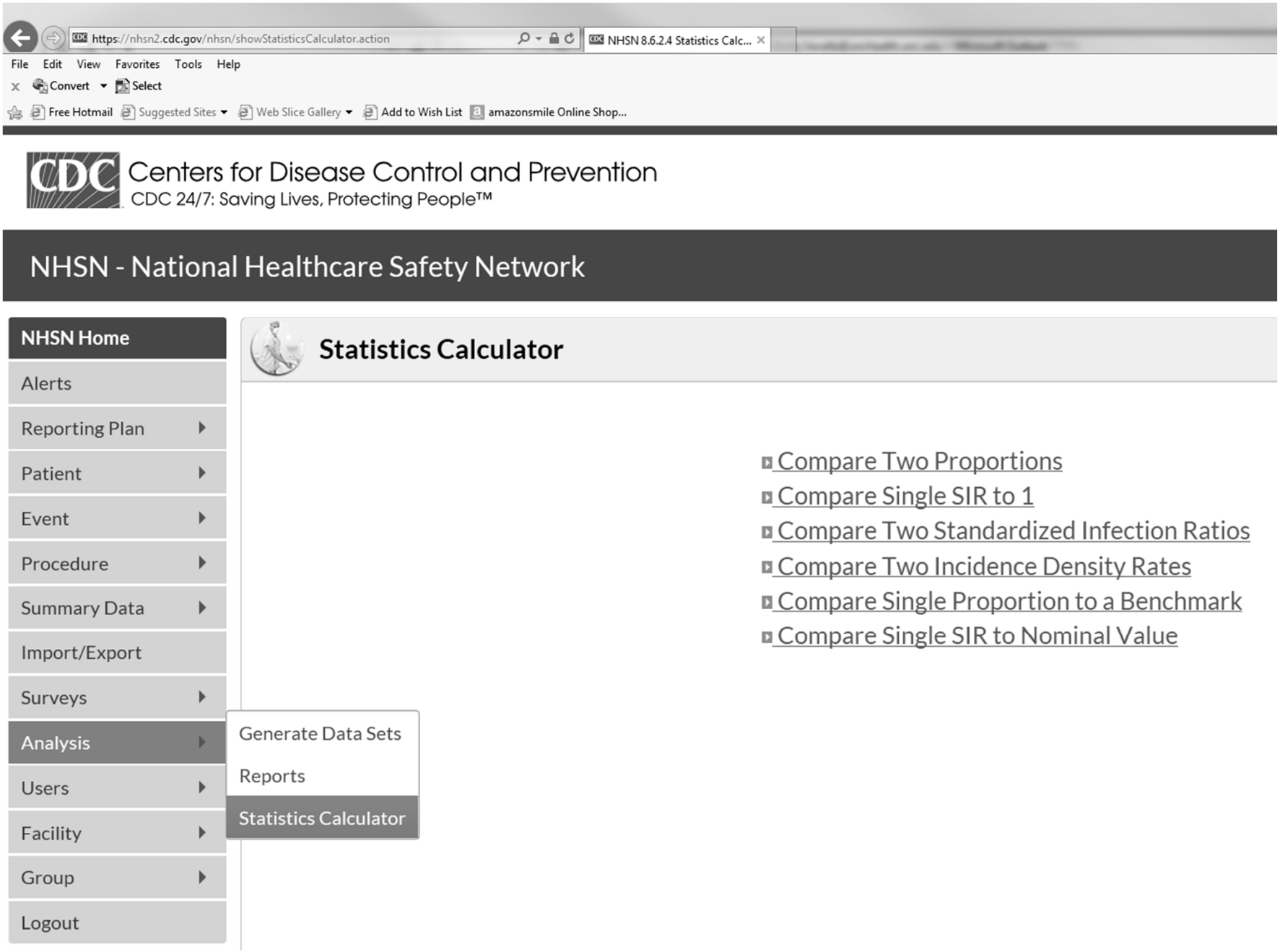


# *95% Confidence Interval Example:*




*Is the frequency of not washing hands at this hospital statistically significantly different than the frequency of washing hands with soap?* *YES – the 95% CI do not overlap*

*Is the frequency of washing hands with soap at this hospital statistically significantly different than the frequency of washing hands with alcohol?* *NO– the 95% CI overlap*


https://nhsn2.cdc.gov/nhsn/showStatisticsCalculator.action
NHSN 8.6.2.4 Statistics Calc...
File Edit View Favorites Tools Help
Convert Select
Free Hotmail Suggested Sites Web Slice Gallery Add to Wish List amazonsmile Online Shop...
Centers for Disease Control and Prevention
CDC 24/7: Saving Lives, Protecting People™
NHSN - National Healthcare Safety Network
NHSN Home
Alerts
Reporting Plan
Patient
Event
Procedure
Summary Data
Import/Export
Surveys
Analysis
Users
Facility
Group
Logout
Generate Data Sets
Reports
Statistics Calculator
Statistics Calculator
Compare Two Proportions
Compare Single SIR to 1
Compare Two Standardized Infection Ratios
Compare Two Incidence Density Rates
Compare Single Proportion to a Benchmark
Compare Single SIR to Nominal Value

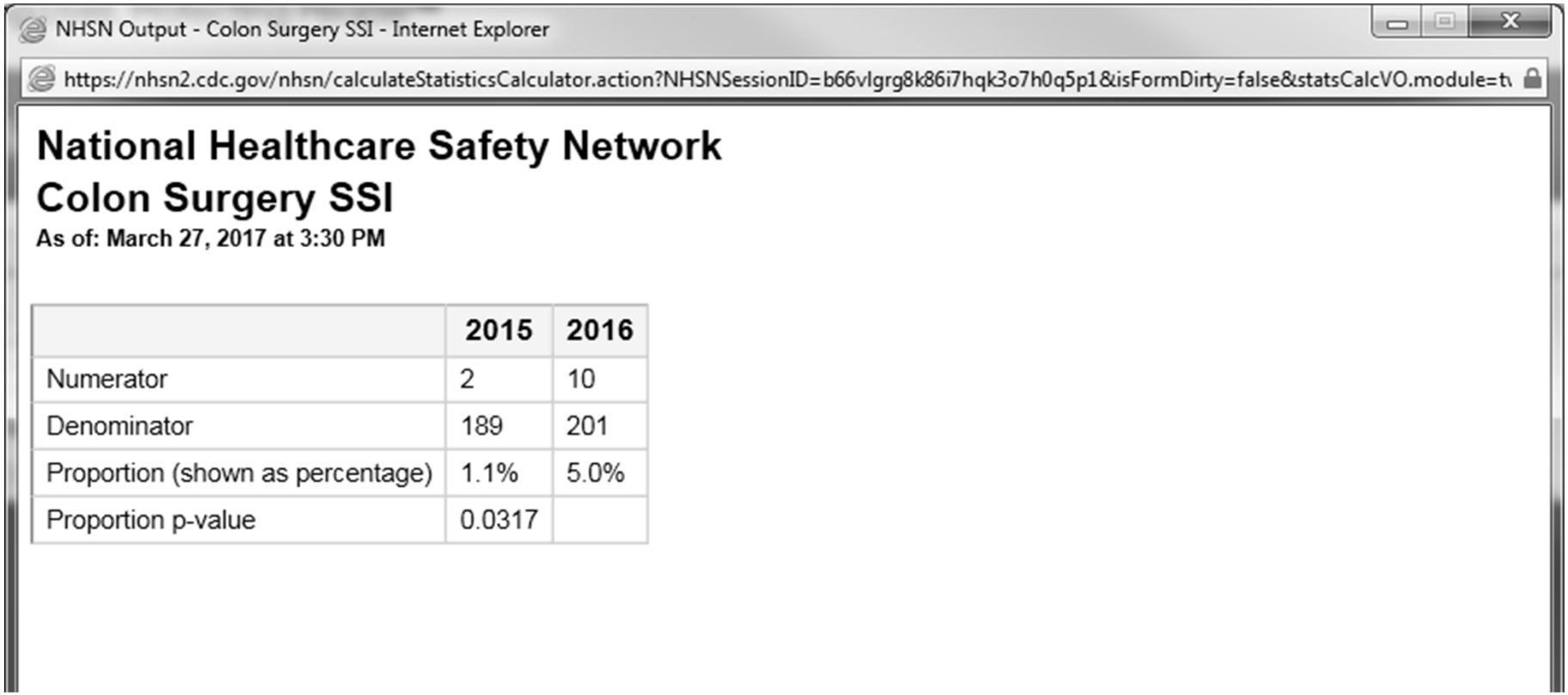
## Compare Two Proportions

When comparing two proportions (e.g. SSI Rates, Device Utilization ratios etc.), the hypothesis is that the rates are not different from each other. To perform a statistical test and calculate a p-value, enter the number of events as the numerator and the number of trials as the denominator (e.g. procedures, patient days) for two data sources. Press calculate.

| | Data Source #1 | Data Source #2 |
|---|---|---|
| **Group Labels:** | 2015 | 2016 |
| **Numerator (Number of Events):** | 2 | 10 |
| **Denominator (Number of Trials):** | 189 | 201 |

**Title:** Colon Surgery SSI ×

Calculate Back


NHSN Output - Colon Surgery SSI - Internet Explorer
https://nhsn2.cdc.gov/nhsn/calculateStatisticsCalculator.action?NHSNSessionID=b66vlgrg8k86i7hqk3o7h0q5p1&isFormDirty=false&statsCalcVO.module=t
National Healthcare Safety Network
Colon Surgery SSI
As of: March 27, 2017 at 3:30 PM
2015
2016
Numerator
2
10
Denominator
189
201
Proportion (shown as percentage)
1.1%
5.0%
Proportion p-value
0.0317

# Compare Two Incidence Density Rate

When comparing two incidence density rates (i.e. person-time), the hypothesis is that the rates are not different from each other. To perform a statistical test and calculate a p-value, enter the number of events as the numerator, the number of person-time units (i.e. exposure) as the denominator, and choose the multiplier you wish for the rate calculation. Press calculate. (See examples below)

| | Data Source #1 | Data Source #2 |
|---|---|---|
| **Group Labels:** | Jan | Feb |
| **Numerator(Number of events):** | 2 | 5 |
| **Denominator(Number of person-time units):** | 267 | 301 |
| **Multiplier:** | 1000 | |

**Title:** Medicine ICU CLABSI Rate

Calculate Back

**Example 1**

**To compare 2 C.difficile LabID incidence rates:**

- Enter the # of CDI HO Incident LabID events
- Enter the # of patient days
- Choose the desired multiplier(i.e., 10,000)
- Press calculate
- Output will provide the CDI HO Incident LabID Event rates per 10,000 patient days and the p-value to indicate the level of statistical significance

**Example 2**

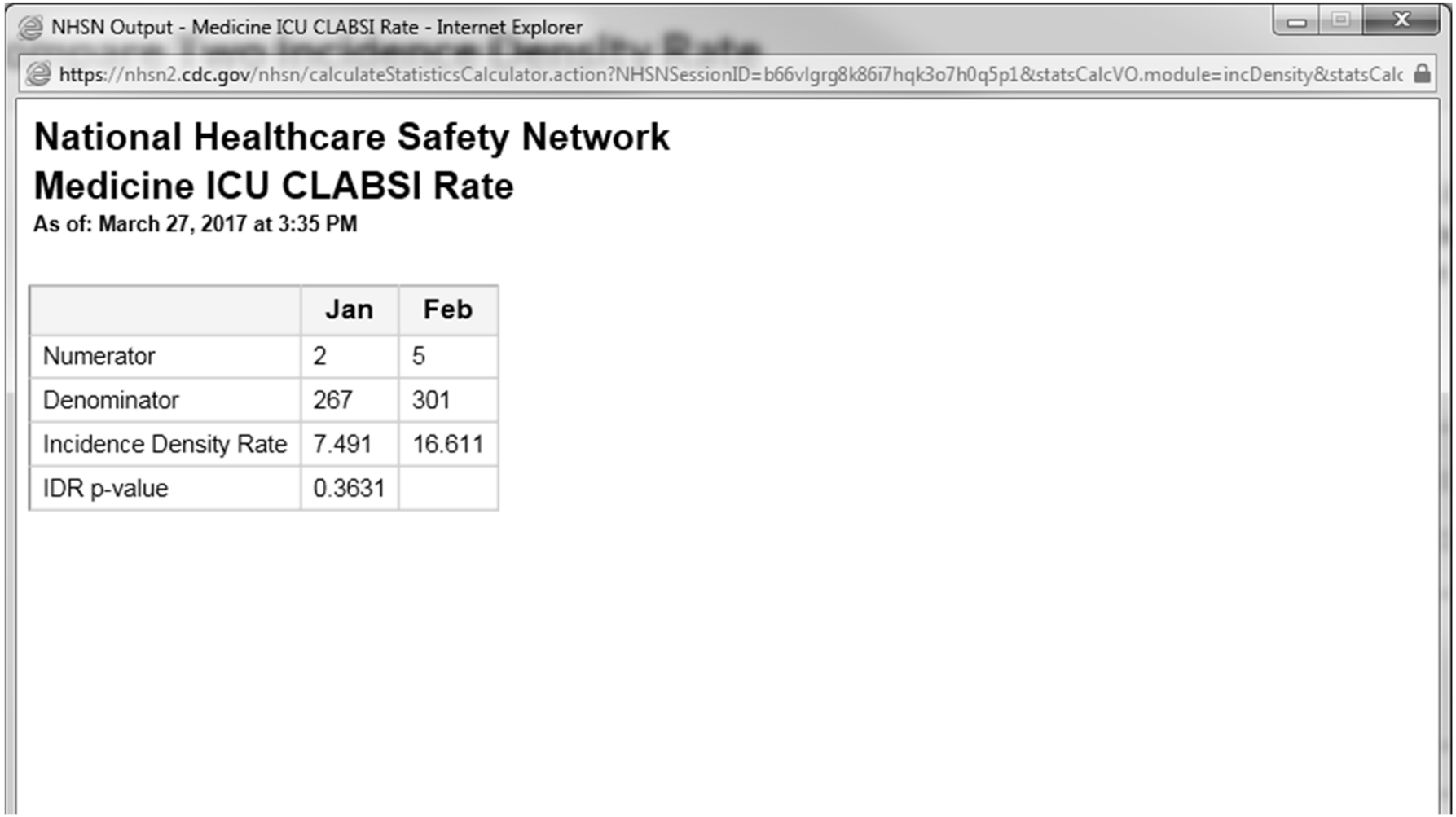
**To compare 2 Dialysis Event bloodstream infection rates:**

- Enter the # of Dialysis Event positive blood cultures
- Enter the # of patient months
- Choose the desired multiplier(i.e., 100)
- Press calculate
- Output will provide the DE positive blood culture rates per 100 patient months and the p-value to indicate the level of statistical significance

**Example 3**

**To compare 2 central-line associated bloodstream infection rates:**

- Enter the number of CLABSIs
- Enter the # of central line days
- Choose the desired multiplier(i.e., 1000)
- Press calculate
- Output will provide the CLABSI rates per central line and the p-value to indicate level of statistical significance


NHSN Output - Medicine ICU CLABSI Rate - Internet Explorer
https://nhsn2.cdc.gov/nhsn/calculateStatisticsCalculator.action?NHSNSessionID=b66vlgrg8k86i7hqk3o7h0q5p1&statsCalcVO.module=incDensity&statsCalc
National Healthcare Safety Network
Medicine ICU CLABSI Rate
As of: March 27, 2017 at 3:35 PM
Jan
Feb
Numerator
2
5
Denominator
267
301
Incidence Density Rate
7.491
16.611
IDR p-value
0.3631

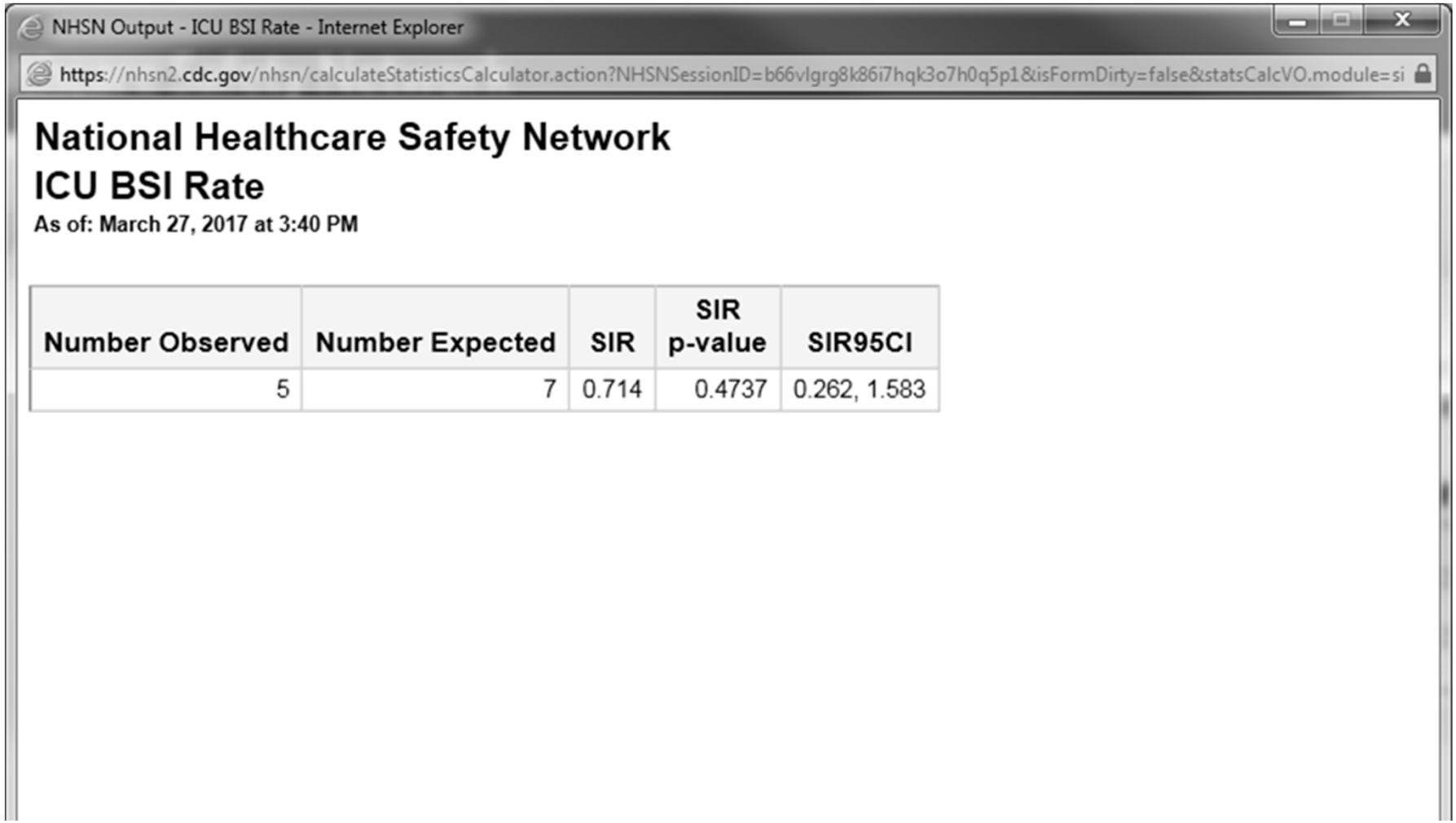
# Compare Single SIR to 1

When comparing a standardized infection ratio, the hypothesis is that the SIR is not different from one. To perform a hypothesis test and calculate a p-value, enter the number of observed events and the number of expected events. The SIR will be displayed automatically. Press calculate.

| | Data Source #1 |
|---|---|
| **Group Labels:** | |
| **Number observed:** | 5 |
| **Number expected:** | 7 |
| **Standardized Infection Ratio:** | 0.714 |

**Title:** ICU BSI Rate

Calculate Back


NHSN Output - ICU BSI Rate - Internet Explorer
https://nhsn2.cdc.gov/nhsn/calculateStatisticsCalculator.action?NHSNSessionID=b66vlgrg8k86i7hqk3o7h0q5p1&isFormDirty=false&statsCalcVO.module=si
National Healthcare Safety Network
ICU BSI Rate
As of: March 27, 2017 at 3:40 PM
Number Observed
Number Expected
SIR
SIR p-value
SIR95CI
5
7
0.714
0.4737
0.262, 1.583

# *Conclusions*

- Describe Surveillance Data
- Display and Interpret Surveillance Data
- Determine the Significance of Changes to Surveillance Data

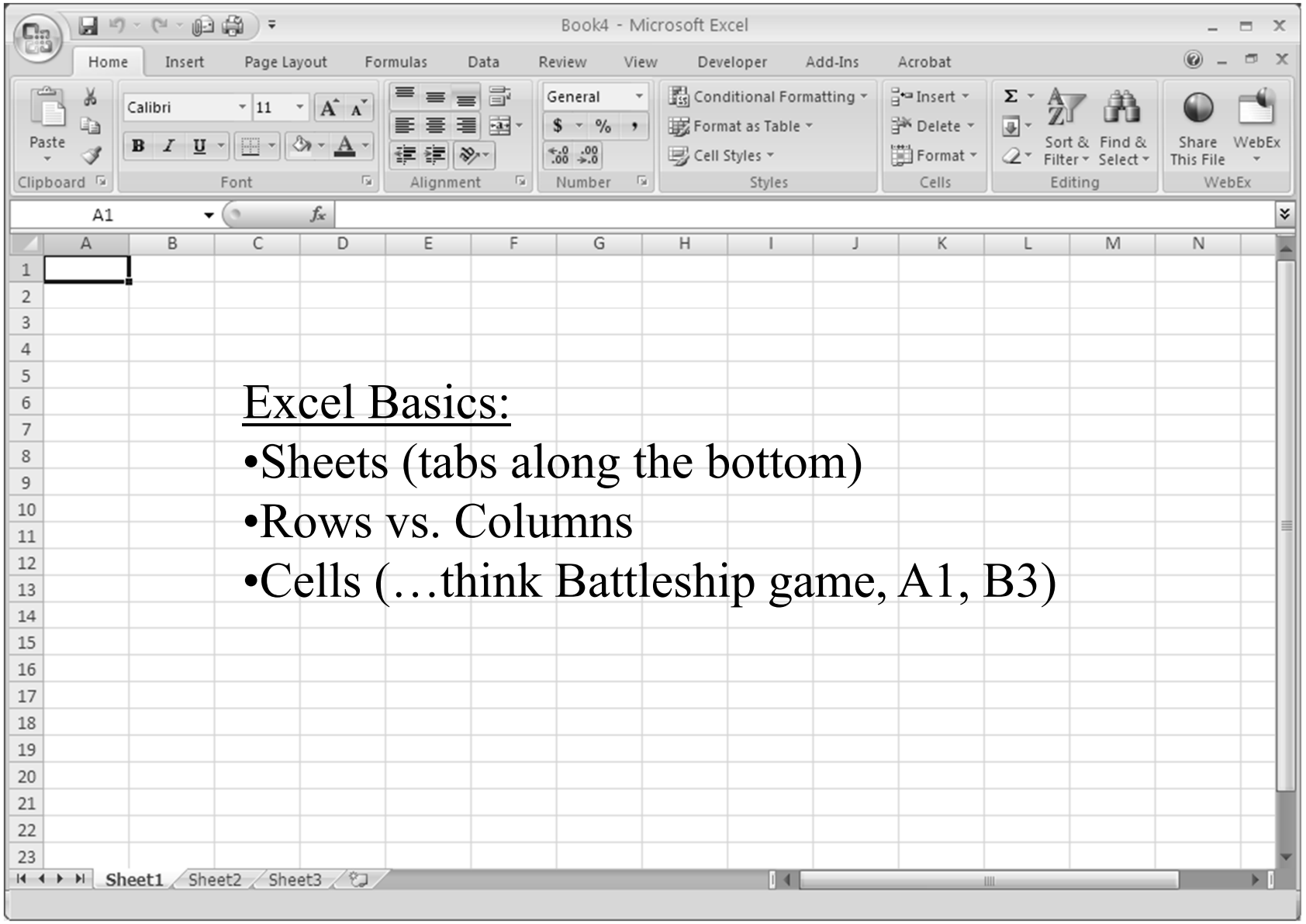
*Questions?*

# *Group Exercises Using Excel*

- Infection Rates
  - Create a table
  - Practice formulas
  - Optional activities
    - Graph rates
    - Add 2nd series on graph for NHSN benchmark
    - SIR calculation

# *Group Exercises Using Excel*

- Outbreak Investigation
  - Create line-listing of outbreak cases
  - Practice formatting cells, copy/paste, sorting
  - Optional activities:
    - Create a frequency table of cases
    - Graph outbreak epi-curve




## Excel Basics:

- Sheets (tabs along the bottom)
- Rows vs. Columns
- Cells (…think Battleship game, A1, B3)

# *Exercise Wrap-up*

- Use Excel as a tool for
  - Calculations of infection rates
  - Creating line-listing for outbreaks or cluster investigations
  - Displaying data graphically

- Use each cell in Excel to capture single piece of data
- Graphs and tables should be self-explanatory!
  - Clear, concise title, informative labels
- Practice, practice, practice!