
# Basic Statistics for Surveillance

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1

# What are Statistics?

The margin of error…

17 in every 100 people…

Men are at 3 times higher risk…

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

1 in 9 children…

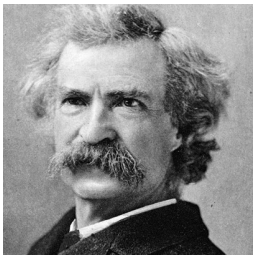
39% OF THE POPULATION…

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

There is a statistically significant difference…

Risk of dying is 8 times higher among…

2



**"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.

3

# Learning Objectives

**Describe Surveillance Data**

Define these terms: rates, prevalence, incidence, mean, median, mode, standard deviation

**Display and Interpret Surveillance Data**

Compare bar graphs, line graphs, pie charts and tables

**Determine the Significance of Changes to Surveillance Data**

Describe benchmarks (internal vs. external), create control charts, define p-values and 95% CI

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**

- *Dispersion: How widely your data is spread from the average.*

5

# Absolute Measures

Simplest type of measurement

Also known as counts or frequencies

Example:

- LTC A: 25 residents with novel coronavirus
- LTC B: 10 residents with novel coronavirus

*Is COVID19 worse at LTC A?*

6

# Relative Measures

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

7

# Absolute versus Relative

Example:

Novel coronavirus among LTC facility residents

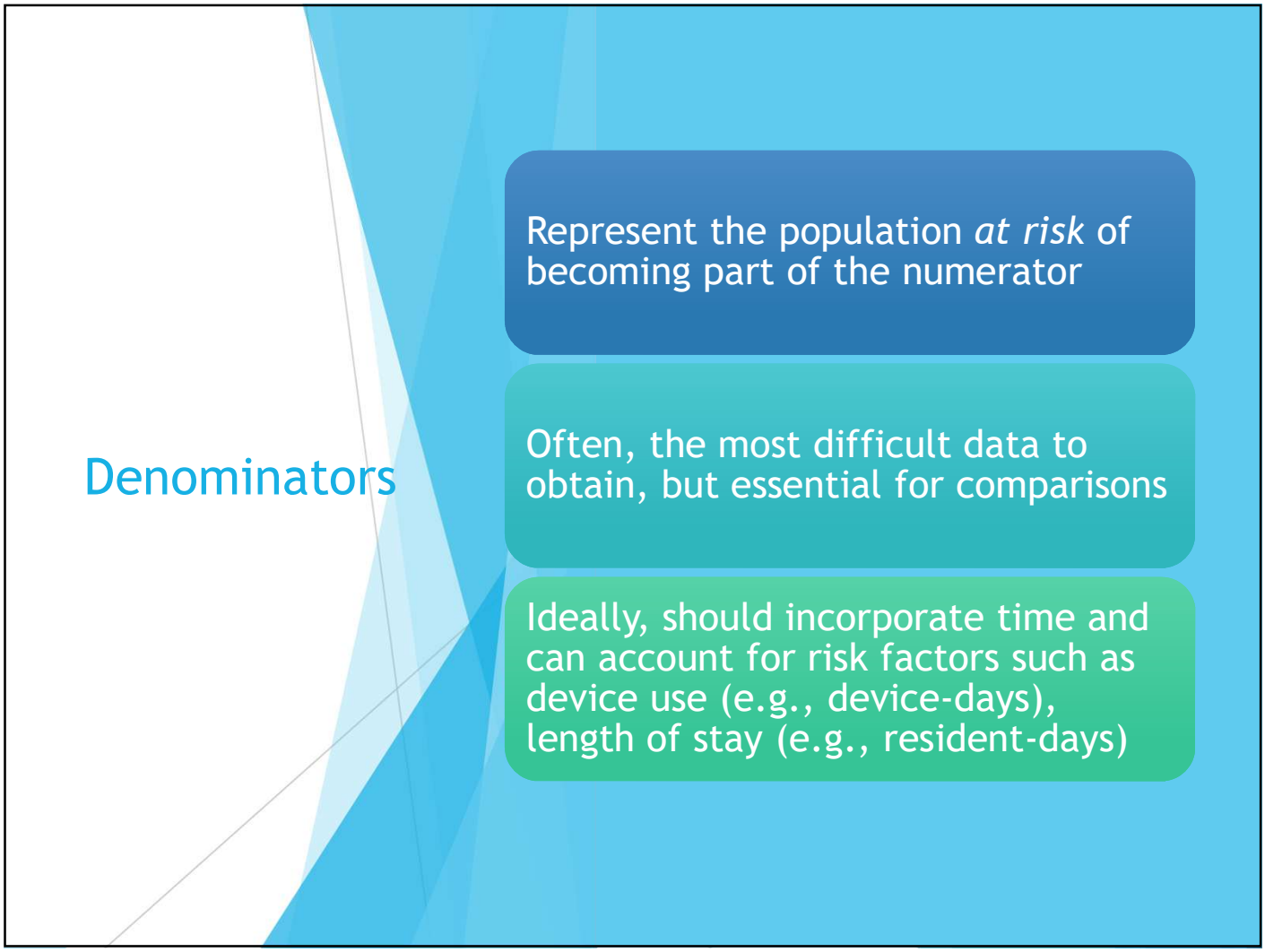
- Absolute measures
  - LTC A: 25 residents ill
  - LTC B: 10 residents ill
- Relative measures
  - LTC A: 25 ill per 100 residents = 0.25 or 25%
  - LTC B: 10 ill per 25 residents = 0.40 or 40%

8

# What Makes a Rate?

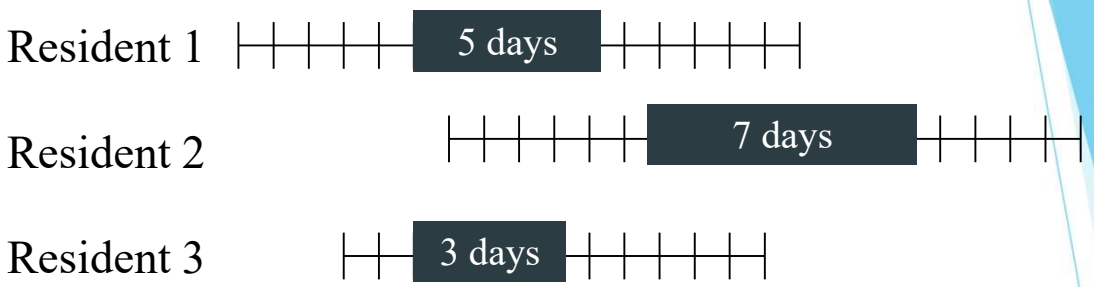

| | |
|---|---|
| Numerator (top number) | *e.g., number of infections* |
| Denominator (bottom number) | *e.g., number of residents [proportion]*<br>*e.g., number of resident-days, number of device-days [incidence density/rate]* |
| Time Frame | *e.g., day, week, month* |

9


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., resident-days)

10

# What is a Resident/Device-Day?



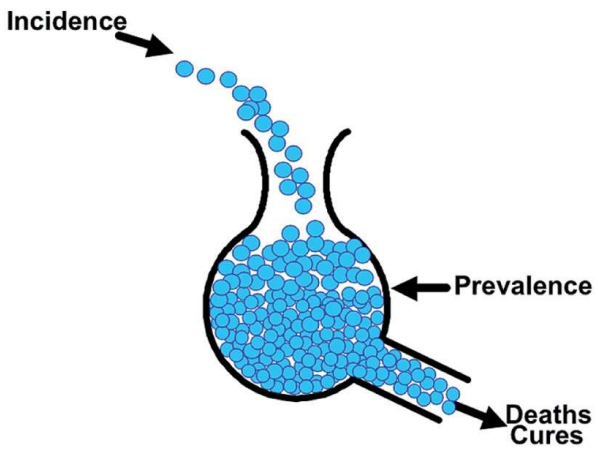

=15 resident-days, device-days, etc.

- More informative than simply saying "3 residents" since accounts for each resident's time of risk

11

# Rate Measures

- Prevalence
- Incidence
- Attack Rate




12

# Prevalence

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

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

13

# Incidence

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

Count of **new** cases / Number of people at risk x constant (e.g., 100 or 1000) =

# Attack Rate

- Attack Rate: the number of new 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 percent.
  - Often used for outbreaks or clusters that occur over a short period of time
  - *e.g., % of residents with MRSA during outbreak in LTC A in March*

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

15

# Example 1:

- You perform surveillance for urinary tract infections (UTIs) in your 200 resident facility.
- During the 1st quarter of the year, you identify 3 new UTIs.
- During the 1st quarter, there were 180 residents in the facility with 12,000 resident-days.

16

# Example 1:

- In the first quarter, what was the UTI rate?
  - Incidence or prevalence?
  - Numerator?
  - Denominator?
  - Units?

17

# Example 1: Answers

- In the first quarter, what was the UTI rate?
  - Incidence or prevalence?
    - Incidence
  - Numerator?
    - 3
  - Denominator?
    - 180 residents or 12,000 resident days
  - Units?
    - "infections per 100 residents or infections per 1000 resident days"
  - ANSWER: 1.7 infections per 100 residents or 0.25 infections per 1000 resident days

18

# Example 1:

- You are concerned about the UTI rate so on April 7, you conduct a “spot check” on all of the residents of one area of the facility for a UTI.
- At that time with a census of 25, you review 20 charts and find 1 healthcare associated UTI.

19

# Example 1:

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

20

# Example 1: Answers

- In April, what was the UTI infection rate at the time of your spot check?
  - Incidence or prevalence?
    - Prevalence
  - Numerator?
    - 1
  - Denominator?
    - 20
  - Units?
    - "prevalent infections per 100 residents on April 7th"
  - ANSWER: 5 prevalent infections per 100 residents on April 7th.

21

# Example 1:

- You also routinely track counts of influenza-like illness in your 200 resident facility.
- During March, there is a cluster of influenza-like illness. In a short time period, 25 residents become ill and meet your case definition.
- During March, there were 180 residents in the facility with 5,000 resident-days.

22

# Example 1:

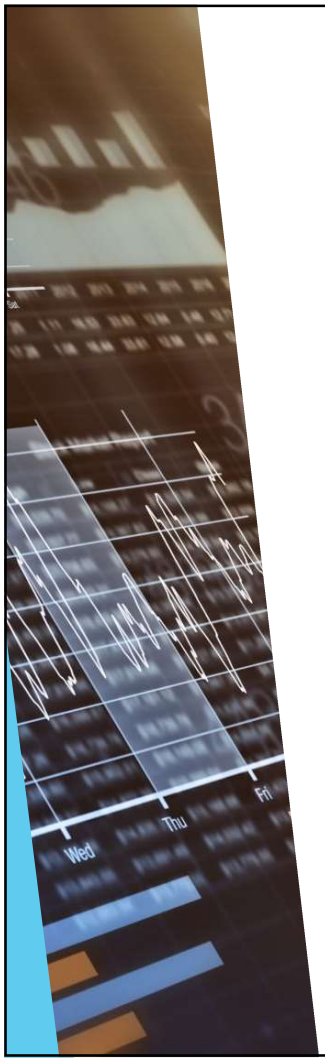
- What is the attack rate of influenza-like illness at your facility during March?
  - Numerator?
  - Denominator?
  - Units?

23

# Example 1: Answers

- What is the attack rate of influenza-like illness at your facility during March?
  - Numerator?
    - 25
  - Denominator?
    - 180
  - Units?
    - "percentage of residents who had influenza-like illness"
  - ANSWER: ***14%*** *of residents with influenza-like illness during outbreak in March*

24



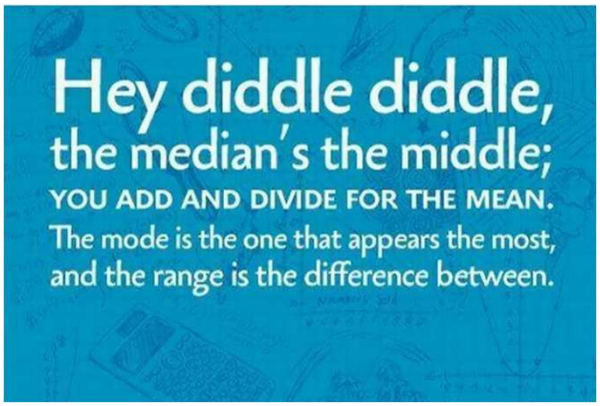

# Descriptive Statistics

- 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
  - *Dispersion: How widely your data is spread from the average*

25

# 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




26

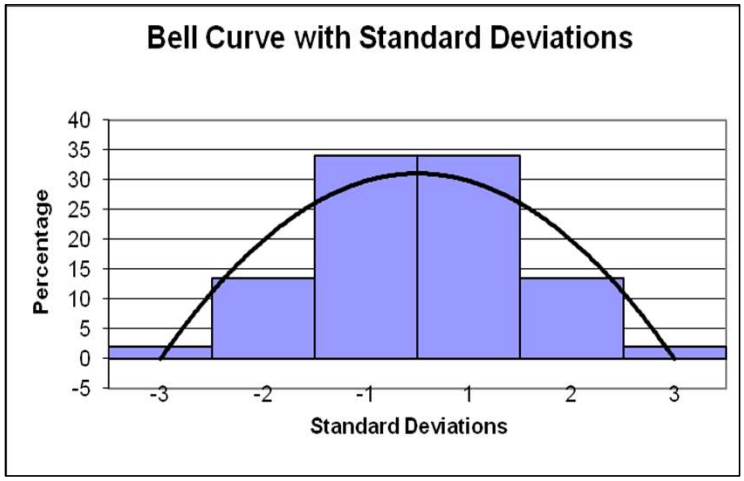
# Measures of Dispersion

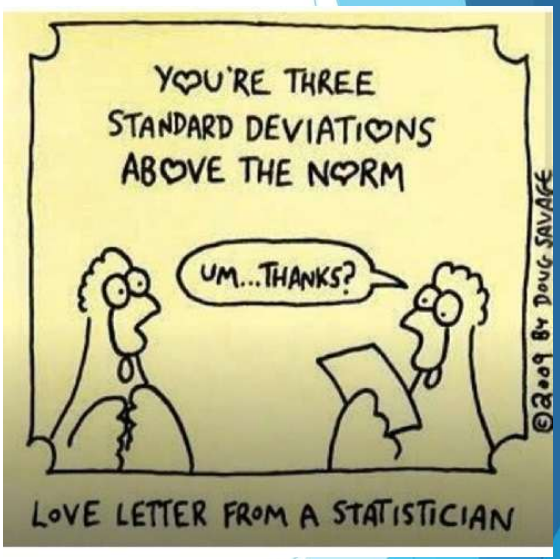
- Range: the largest value minus the smallest value
- Standard deviation: describes the variability or dispersion in the data set – tells you how spread out your data is

27

# Standard Deviation

- 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 that compliance with hand hygiene is not as high as it needs to be

She has asked you to provide her with some data to confirm or disprove her suspicions

29

# Example 2:

For the past year, once a month, you have been conducting hand hygiene audits in your facility – these are your monthly compliance results:

55%, 92%, 86%, 94%, 91%, 89%, 79%, 93%, 92%, 88%, 87%, 90%

You decide as a first step to calculate the mean, median, mode and range of the monthly data to help describe hand hygiene compliance at your facility

30

# Example 2:

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

*HINT: 55%, 79%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 92%, 93%, 94%*

31

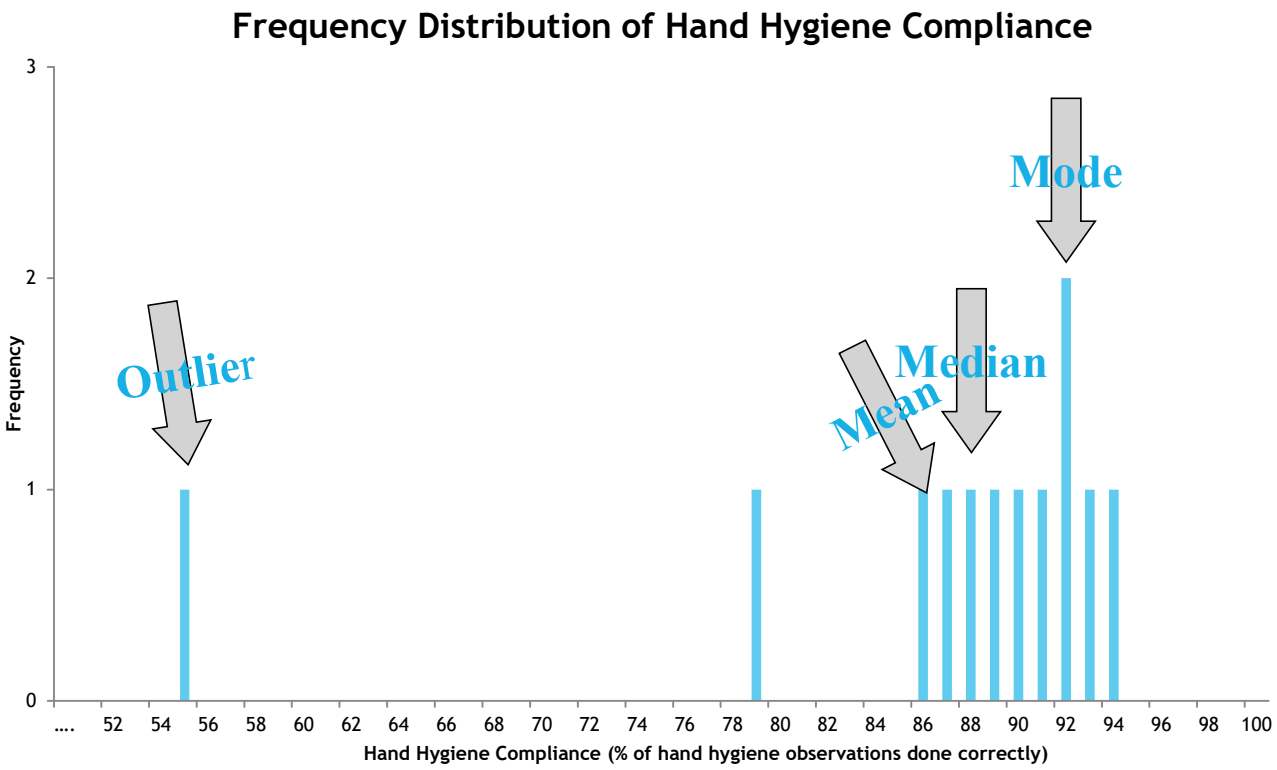
# Example 2: Answers

- What is the:
  - Mean?
    - 86.3%
  - Median?
    - 89.5%
  - Mode?
    - 92%
  - Range?
    - 39% *(94%[max]-55%[min])*
  - Standard Deviation?

    *can use programs like Excel to calculate*
    - 10.2%

32

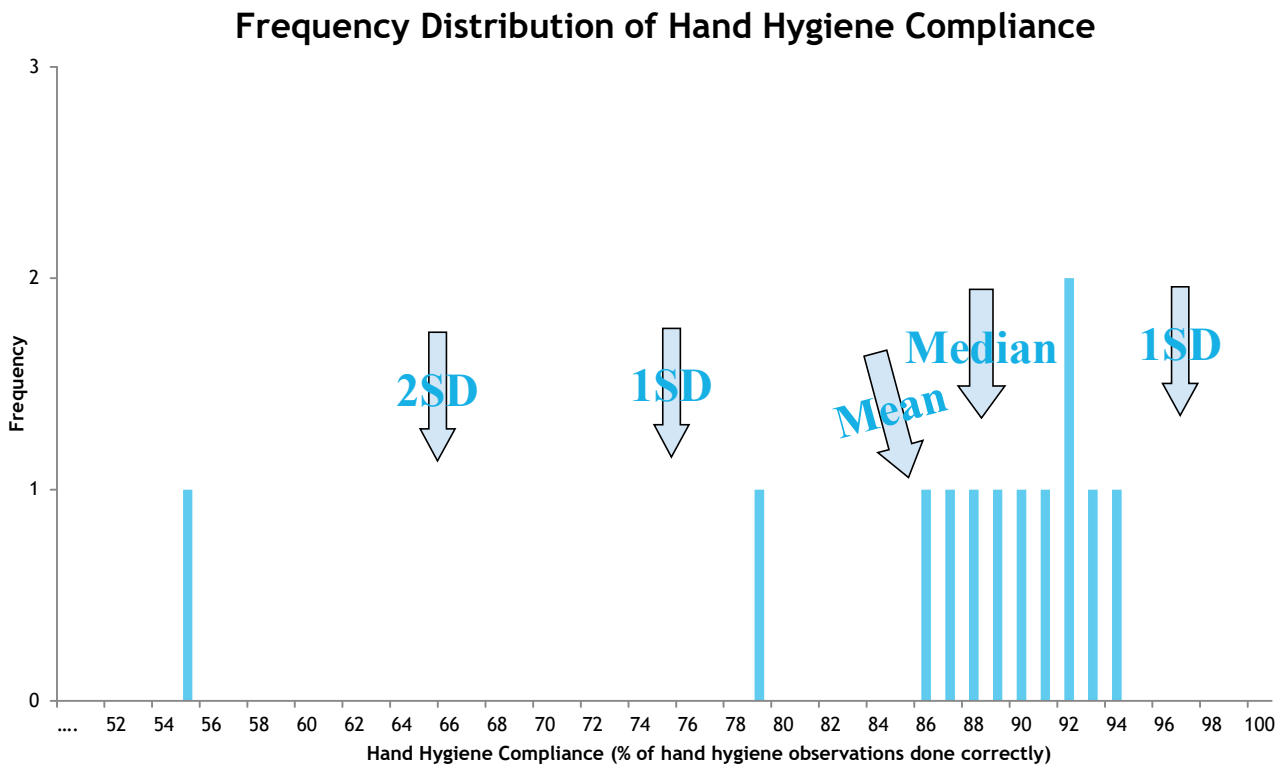
# Example 2: Central Tendency




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

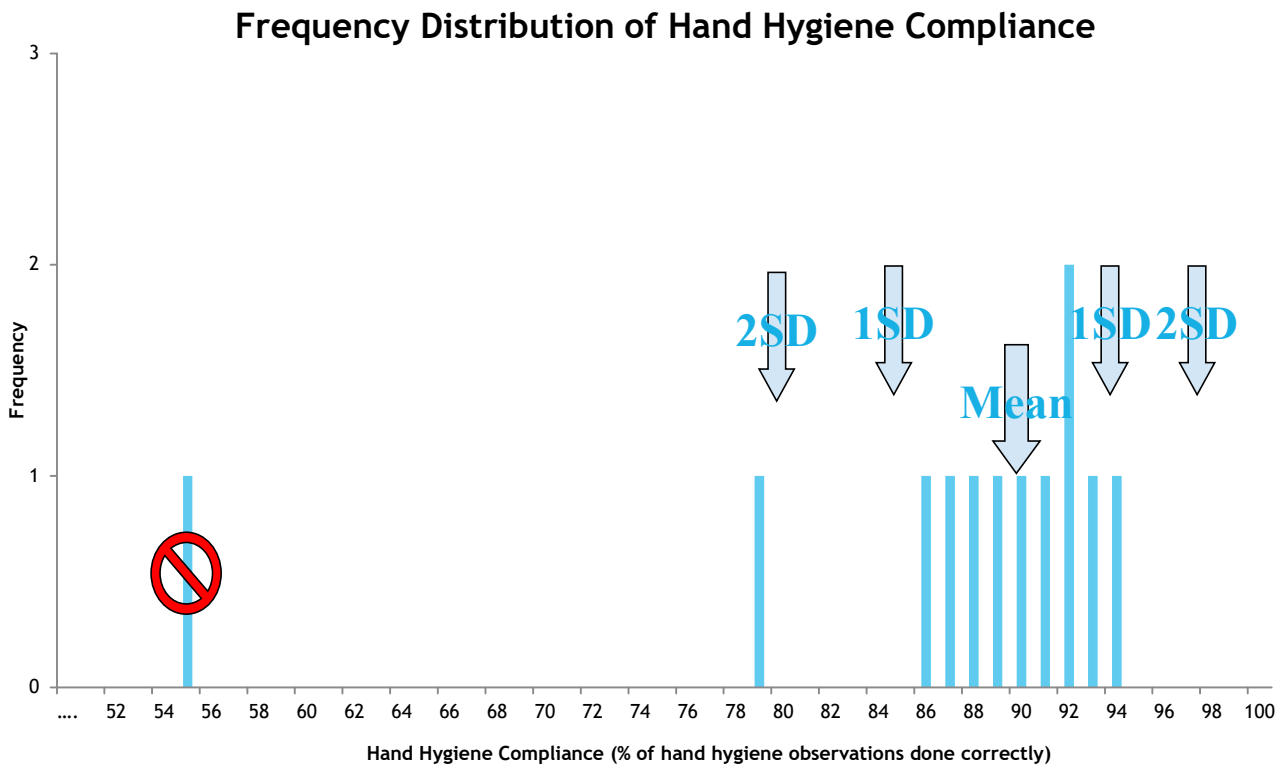
33

# Example 2: Dispersion




34

# Example 2: Dispersion




35


# Displaying Surveillance Data

36

# Data Types

- Quantitative variables: numerical values
  - *(e.g., number of infections, number of residents)*
- Categorical variables: descriptive groups or categories
  - *(e.g., areas of the facility, gender, occupational groups)*
- *Data visualization is typically a graphical representation of these two types of data that allows you to see and understand trends, outliers and patterns in data*

37

# Displaying and Interpreting Surveillance Data

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

38

# Line Lists

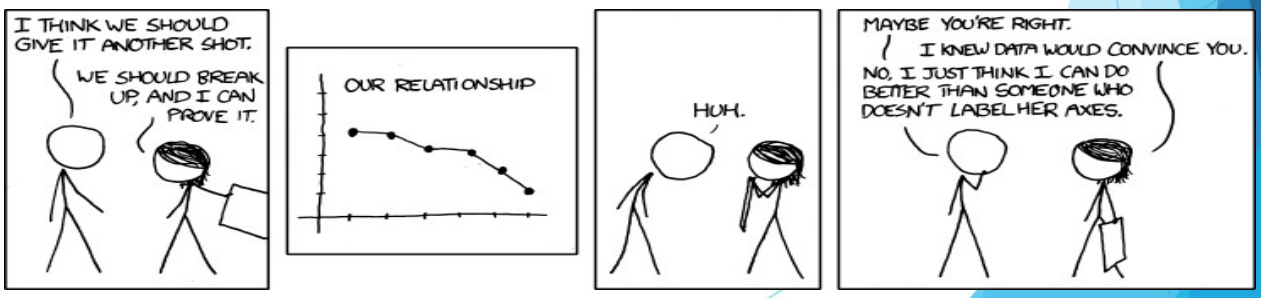
- Allow for record-level review of data
- Helpful way to standardize the data you want to routinely collect
- Helpful in pinpointing issues in data quality
- Can help inform rates or other summarized measures
- Can help identify trends

| Pt # | Name | Room # | Source | Organism | Culture date | Antibiotic | Date |
|---|---|---|---|---|---|---|---|
| 3685632 | | EW | Ucc **U-Mnd** | Prot mir | 3-14 | | |
| | | EW 322 | Ucc U+M+ | Prot mir | | | |
| 0532210 | | EW 316 | cellulitis | | | cephalexin | 3-9 |
| | | EW 356 | Ucc – outside doc | | | cephalexin | 3-2 |
| | | EW 324 | ucc | | | cephalexin | 3-30 |
| | | EW 346 | pneum | | | amox | 3-10 |
| | | EW 308 | ucc | ecoli | | | |
| | | | | | | | |
| 7802490 | | JW 234 | Ucc **U-Mnd** | Kleb pn, psea | 3-6 | | |
| | | JW 202 | wound | stau | | | |
| | | | | | | | |
| | | PW | eyes | | | tobra | 3-2 |
| 3887077 | | PW | Ucc **U-M+** | ecoli | 3-2 | | |
| | | PW 122 | Cellulitis foot | | | clinda | 3-12 |
| 2475260 | | PW | Ucc **U+Mnd** | Ecoli, ent | 3-12 | | |
| 4417105 | | PW | Ucc **U-Mnd** | steno | 3-22 | | |
| 2259700 | | PW | wound | Prot mir | 3-5 | Ssi reported to FX | |
| 7809247 | | PW | Ucc **U+M+** | ecoli | 3-30 | | |

# 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



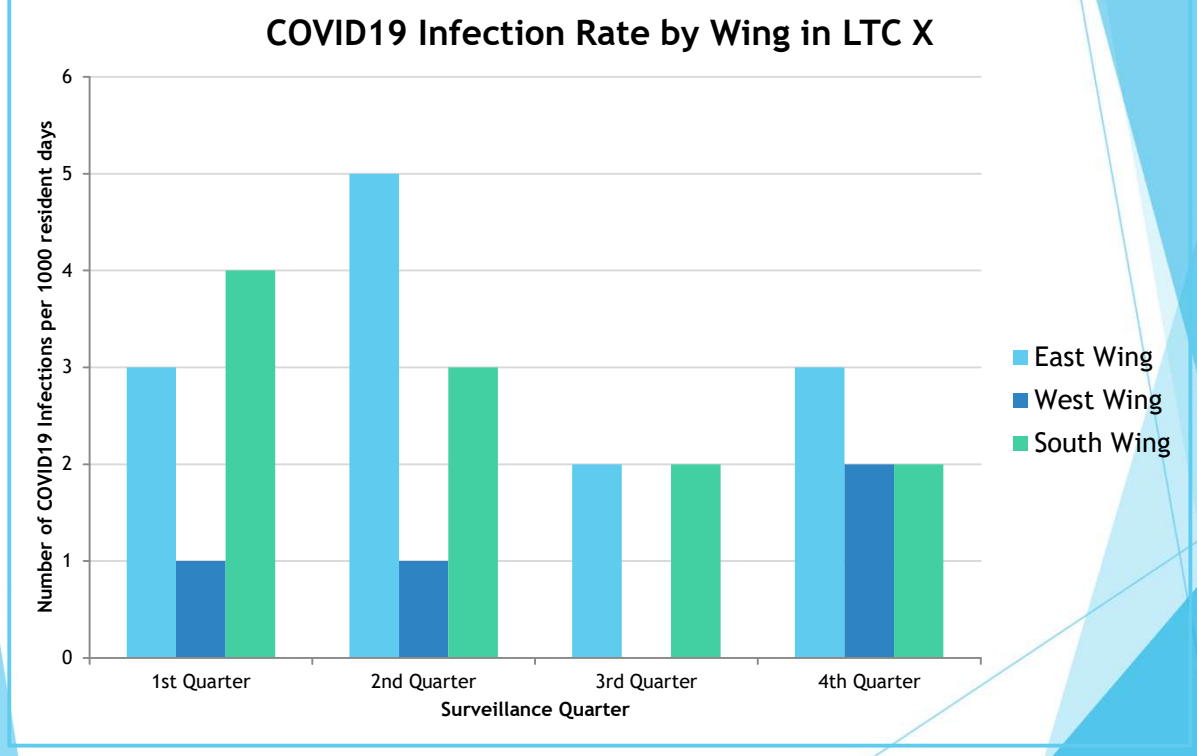

40

# 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*

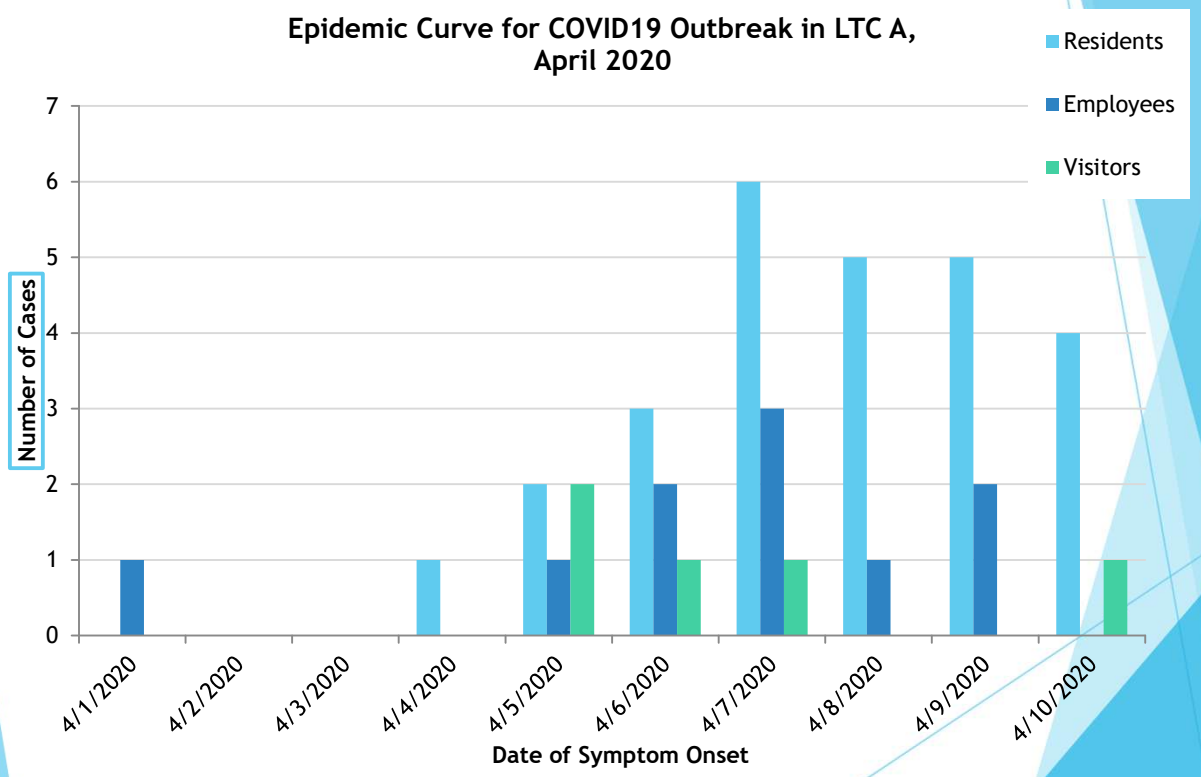
41

# Bar Graph


COVID19 Infection Rate by Wing in LTC X
Number of COVID19 Infections per 1000 resident days
0
1
2
3
4
5
6
1st Quarter
2nd Quarter
3rd Quarter
4th Quarter
Surveillance Quarter
East Wing
West Wing
South Wing

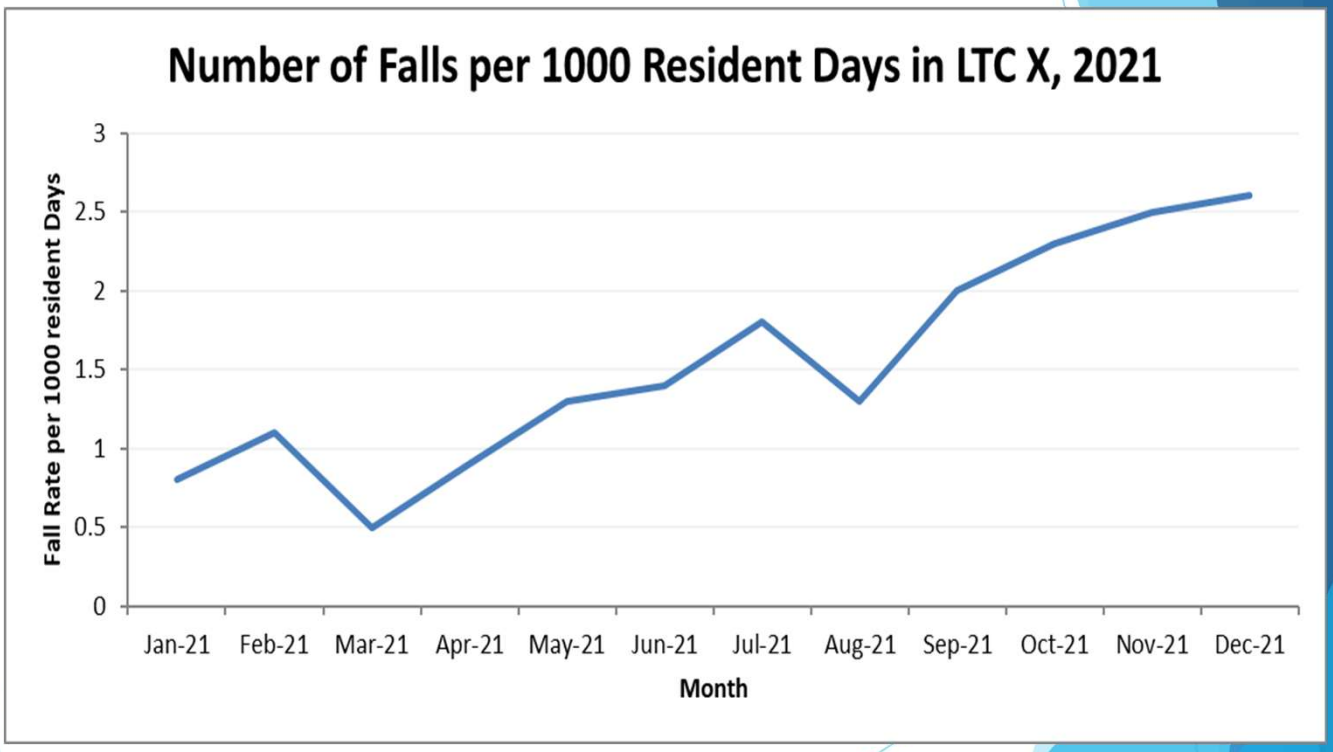
42

# Epi Curve


Epidemic Curve for COVID19 Outbreak in LTC A, April 2020
Residents
Employees
Visitors
Number of Cases
0
1
2
3
4
5
6
7
4/1/2020
4/2/2020
4/3/2020
4/4/2020
4/5/2020
4/6/2020
4/7/2020
4/8/2020
4/9/2020
4/10/2020
Date of Symptom Onset

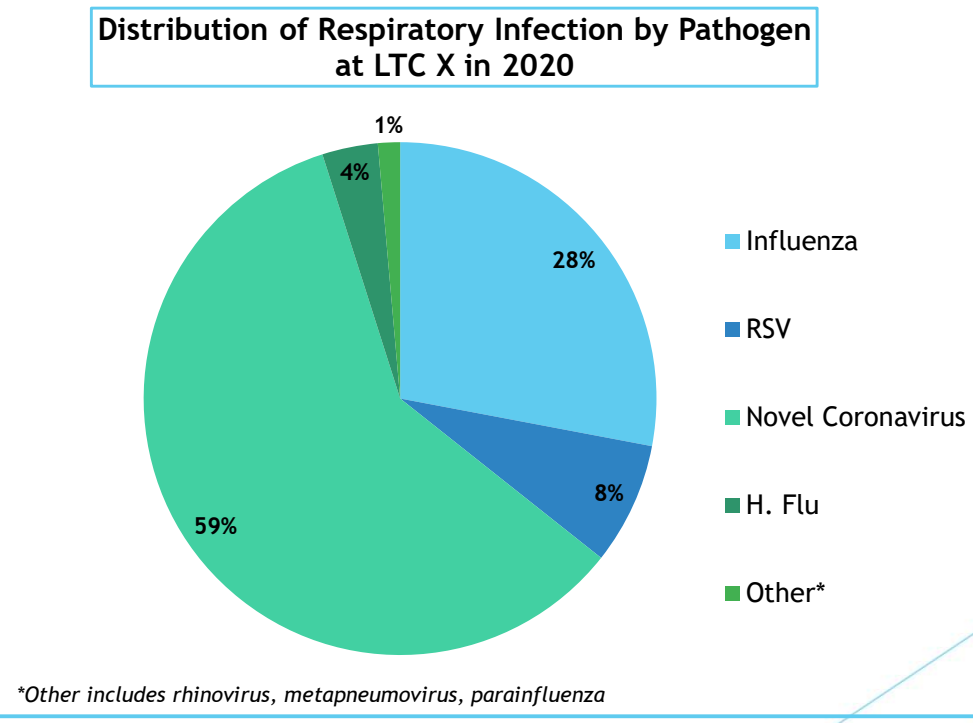
43

# Line Graph




44

# Pie Chart




*Other includes rhinovirus, metapneumovirus, parainfluenza

45

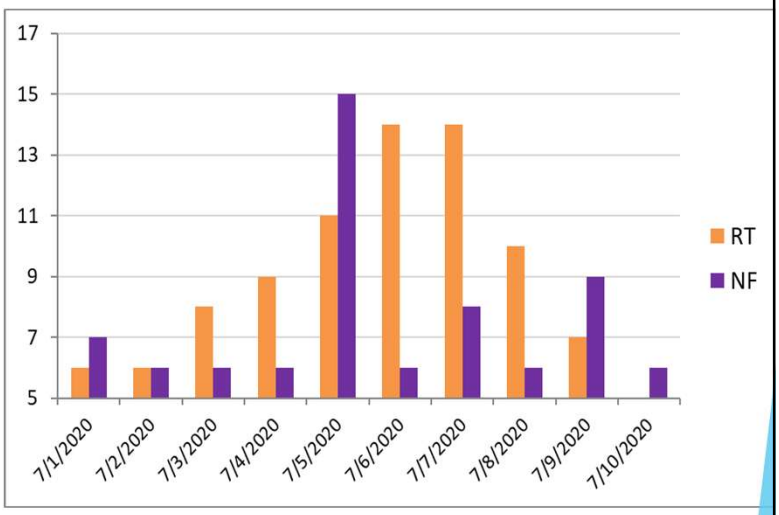
# Tables

| Number of UTIs by Age Group, LTC X, 2021 | |
|---|---|
| **Age Group (Years)** | **Number of Cases** |
| <50 | 0 |
| 51-60 | 2 |
| 61-70 | 7 |
| 71-80 | 6 |
| 81-90 | 3 |
| >90 | 1 |
| **Total** | **19** |

46

# *What's wrong with this graph?*

- *Missing a chart title*
- *Missing axis labels on the x and y axis*
- *The y axis starts at 5 (should start at 0)*
- *No explanation of abbreviations used in the legend*




47


# Interpreting Surveillance Data

48

# Why Analyze your Data?

- Provide feedback to internal stakeholders
- Analyzing data can help you identify areas that need improvement
- Reports can help inform prioritization and success of prevention activities
- Ultimately, these are YOUR data – you should know your data better than anyone else

49

# Checklist

- Before you begin analyzing your data, ask yourself these questions:
  - What data are you analyzing?
  - What is the time period of interest?
  - Why are you analyzing these data?
  - Who is the audience/stakeholders (and what do **they** want to see)?
    - Other IPs
    - Managers
    - Physicians
    - Administrative



50

# Data Analysis: Interpreting the Results

Examine trends over time

- Assess patterns to determine temporality
- Identify acute or unusual events which require immediate follow-up

Assess which risk groups are being most affected – allows you to target your prevention efforts

51

# Determine the Significance of your data - How?

**Practical/Clinical Significance vs. Statistical Significance**

**Make comparisons**

*For example: over time, to other areas of facility, to other facilities (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) - **is there special cause variation?***

**Other statistical tests and measures**

P-values

95% confidence intervals

52

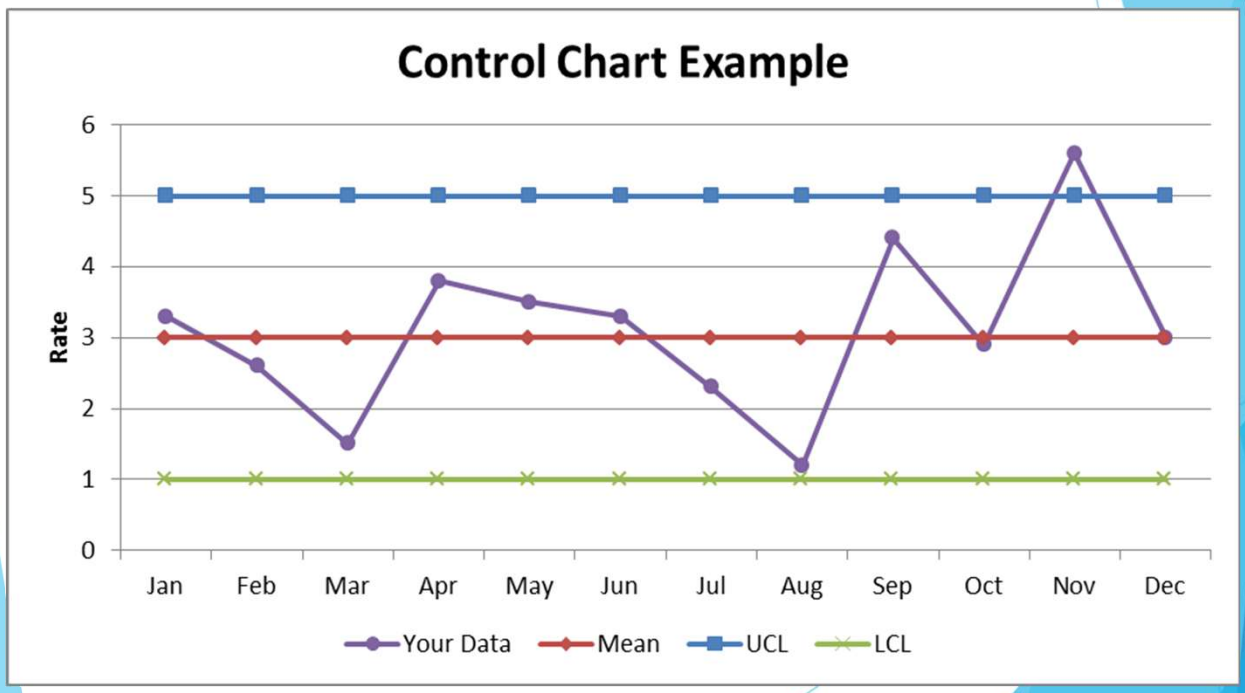
# Internal Benchmarks

- Compare current results to your own prior results
- Best way to chart your own progress over time
  - Select feasible and stretch goals
- Note when interventions took place
- Use when there is no external benchmark

53

# Control Charts

- Tool to help determine when infection rates are out of range –user sets control limits. *How high is TOO high?*




54

# Control Chart Example 3:

| MONTH | 2020 UTI Rate | Moving Range |
|---|---|---|
| JAN | 4.5 | --- |
| FEB | 3.2 | 1.3 |
| MAR | 3.6 | 0.4 |
| APR | 3.5 | |
| MAY | 3.0 | |
| JUNE | 4.0 | |
| JULY | 4.1 | |
| AUG | 4.6 | |
| SEPT | 4.8 | |
| OCT | 5.2 | |
| NOV | 5.7 | |
| DEC | 6.5 | |

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

55

# Control Chart Example 3 Answers:

| MONTH | 2020 UTI Rate | Moving Range |
|---|---|---|
| JAN | 4.5 | --- |
| FEB | 3.2 | 1.3 |
| MAR | 3.6 | 0.4 |
| APR | 3.5 | 0.1 |
| MAY | 3.0 | 0.5 |
| JUNE | 4.0 | 1.0 |
| JULY | 4.1 | 0.1 |
| AUG | 4.6 | 0.5 |
| SEPT | 4.8 | 0.2 |
| OCT | 5.2 | 0.4 |
| NOV | 5.7 | 0.5 |
| DEC | 6.5 | 0.8 |

- Find the mean of the UTI rates.

  =4.4

- Calculate the moving ranges

  See table

- Calculate the mean of the moving ranges.

  =0.5

56

# Control Chart Example 3:

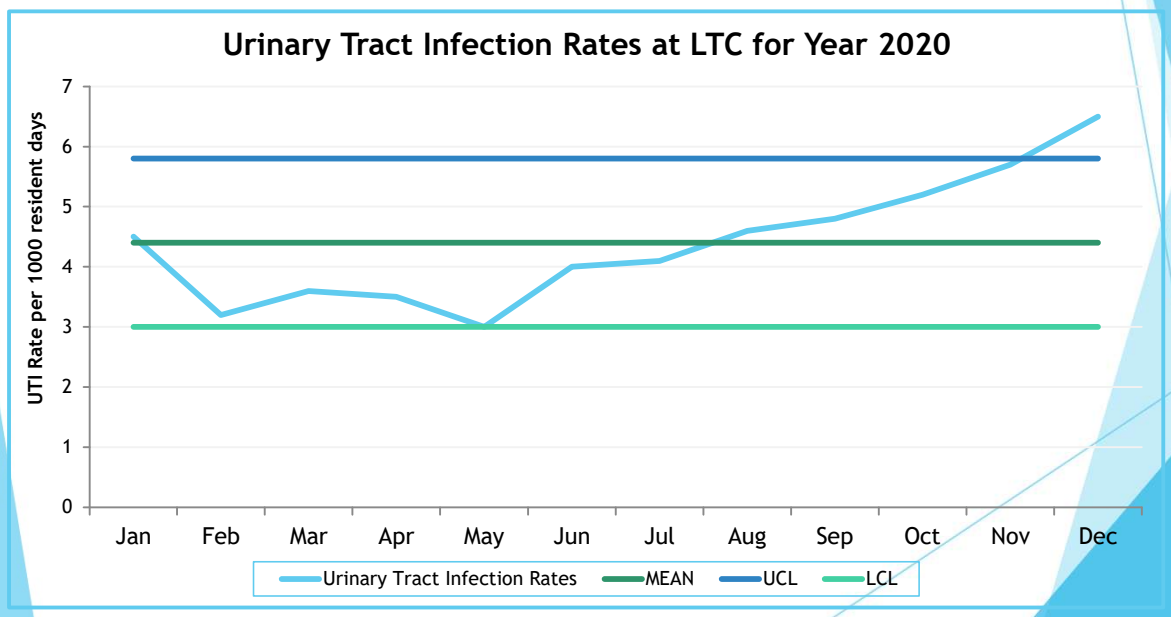
- Calculate Upper Control limit= Mean + (**2.66** x Mean of Moving Range)
- Calculate Lower Control limit= Mean - (**2.66** x Mean of Moving Range)

- In this example:
- UCL = 4.4 + (2.66 x 0.5) = 5.8
- LCL = 4.4 – (2.66 x 0.5) = 3.0

57

# Control Chart Example 3:

- 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.




58

# Interpretation of Other Statistical Tests *(more advanced topic)*

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

59

# Hypotheses

- Null hypothesis: values are equal
- Alternative hypothesis: values differ

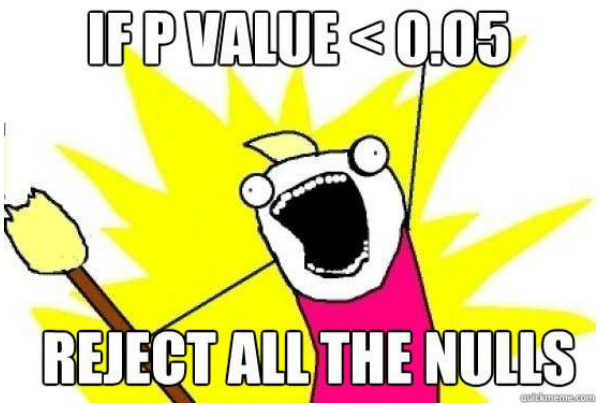
- These statements are mutually exclusive
  - They cover all possible outcomes
  - In the end, only one can be selected

**p=value:** the probability that the observed difference (or a more extreme one) was caused by random chance if the null hypothesis was true.

60

# Other Statistical Tests: P Value

- 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 is truly significant (and not due to chance)
- Generally. a level of P<0.05 is considered “statistically significant”




61

# P-Value Example:

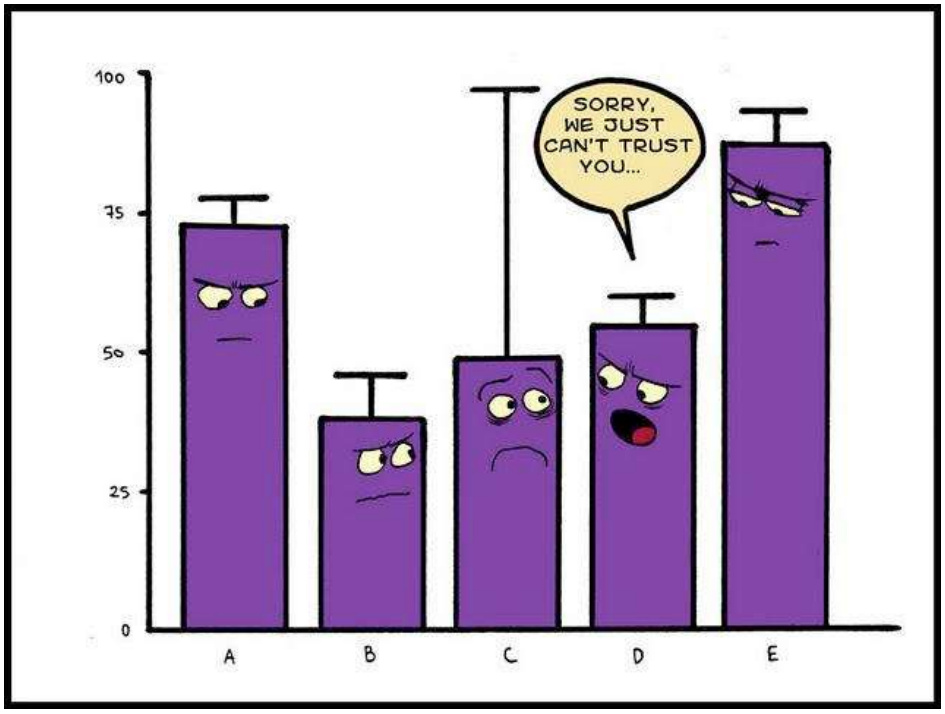
- "Our study showed that people who washed their hands were less likely to get sick (P=0.06) and more likely to be nurses (P=0.01)."


62

## Other Statistical Tests: 95% Confidence Interval

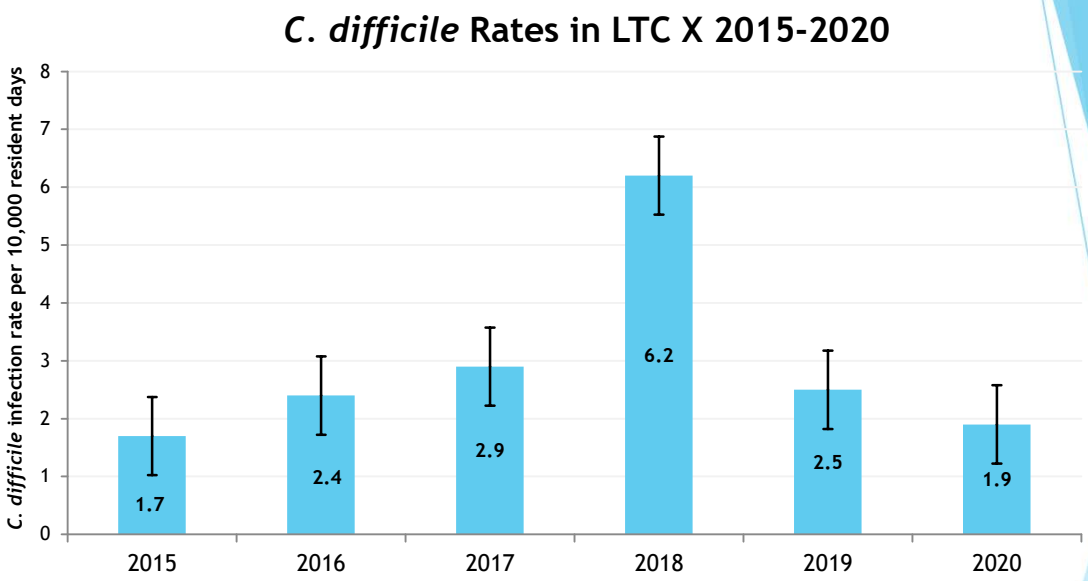
- Means that you are 95% confident that the *true* average value lies within this interval
- Confidence interval size:
  - Wide: less confident with that estimate
  - Narrow: more confident with that estimate
- For comparisons:
  - Overlapping intervals suggest no significant difference
  - Non-overlapping intervals suggest significant differences

63




64

# 95% Confidence Interval Example:




*Is the C. difficile infection rate at this LTC in 2018 statistically significantly different than the C. difficile infection rate in other years?*

*YES – the 95% CI do not overlap*

*Is the C. difficile infection rate at this LTC in 2020 statistically significantly different than the rate in 2019?*

*NO- the 95% CI overlap*

65

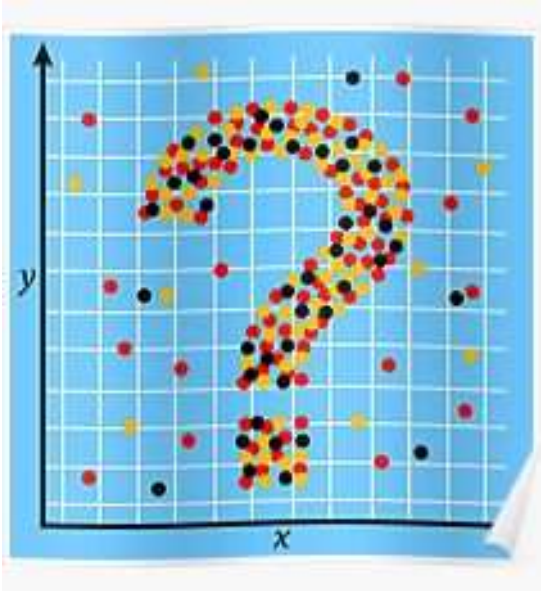
# Learning Objectives

| | |
|---|---|
| Describe Surveillance Data | Define these terms: rates, prevalence, incidence, mean, median, mode, standard deviation |
| Display and Interpret Surveillance Data | Compare bar graphs, line graphs, pie charts and tables |
| Determine the Significance of Changes to Surveillance Data | Describe benchmarks (internal vs. external), create control charts, define p-values and 95% CI |

66

*"The world cannot be understood without numbers. But the world cannot be understood with numbers alone."*

*-Hans Rosling*




# *Thank you!*

67

# *Online Excel Resources*

www.excel-easy.com

https://excelexposure.com/

https://www.thoughtco.com/excel-formulas-step-by-step-tutorial-3123636

https://www.gcflearnfree.org/excel2016/sorting-data/1/