MEASURES OF DISEASE FREQUENCY

Infectious Disease Epidemiology Bootcamp

Session 3

July 21, 2020

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INFECTIOUS DISEASE EPIDEMIOLOGY BOOTCAMP OBJECTIVES

1. Explain the basics of infectious disease epidemiology, including transmission and conceptual model.
2. **Evaluate infectious disease measures (e.g., R-naught, case fatality, incidence)**
3. Explain the importance of controlling infectious disease spread through quarantine, vaccination, and other treatment measures
4. Describe the process of testing, case investigation, and contact tracing for infectious diseases
5. Compare sensitivity, specificity, and positive and negative predictive value of screening tests
6. Understand the concepts of database construction and data entry for quality data reporting
7. Interpret data tables and charts related to infectious disease measures

REMEMBER TO JOIN US FOR THE LAST BOOTCAMP!

- Tuesday, July 28 at 11:30 PDT – Getting the Most Out of Your Data
  - **Data interpretation**
  - **Data visualization**

IF YOU HAVE QUESTIONS

- Use the chat function
  - **We want to hear from you ☺**
- Questions will be answered at the end during a discussion period in the order they come in

OBJECTIVES

1. Review math terms associated with measures of disease frequency
2. Define and interpret prevalence, incidence, and incidence rate
3. Explain the relationship between prevalence and incidence
4. Explain and interpret
    1. **Mortality**
    2. **Case fatality**
    3. **Percent positivity**

WHAT WE WILL NOT COVER

- Risk
  - **“the probability of an event during a specified period of time”**

Cole SR, et al. Risk. Am J Epidemiol. 2015;181(4):246-50

  - **Who is at increased/decreased risk of COVID over time?**

EPIDEMIOLOGY

- Epi: on or upon
- Demos: people
- Logos: the study of

- Study of what befalls a population

*"Epidemiology is the **study** of the **distribution** and **determinants** of **health-related states or events** in **specified populations**, and the **application** of this study to the control of health problems."*[p.61] (Last JM. Dictionary of Epidemiology, 4th ed. New York: Oxford University Press; 2001.)

DESCRIPTIVE EPIDEMIOLOGY

Figure 1.11 Mortality Rates for Asbestosis, by State — United States, 1968–1981 and 1982–2000

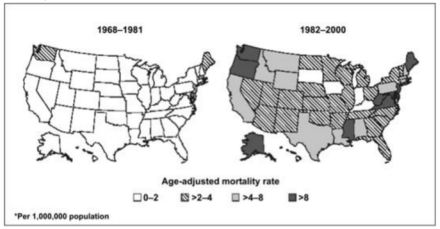


Image Description

Source: Centers for Disease Control and Prevention. Changing patterns of pneumoconiosis mortality–United States, 1968–2000. MMWR 2004;53:627–32.

Figure 1.15 Infant Mortality Rates for 2002, by Race and Ethnicity of Mother

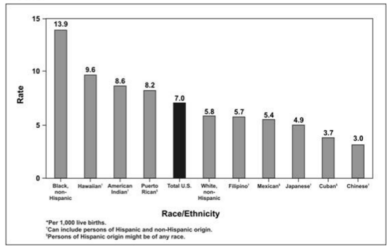


Image Description

Source: Centers for Disease Control and Prevention. QuickStats: Infant mortality rates†, by selected racial/ethnic populations — United States, 2002. MMWR 2005;54(05):126.*

Figure 1.4 Reported Cases of Salmonellosis per 100,000 Population, by Year — United States, 1972–2002

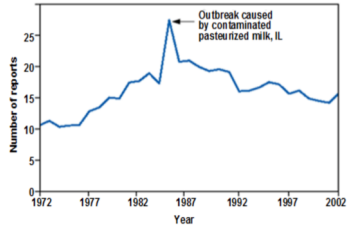
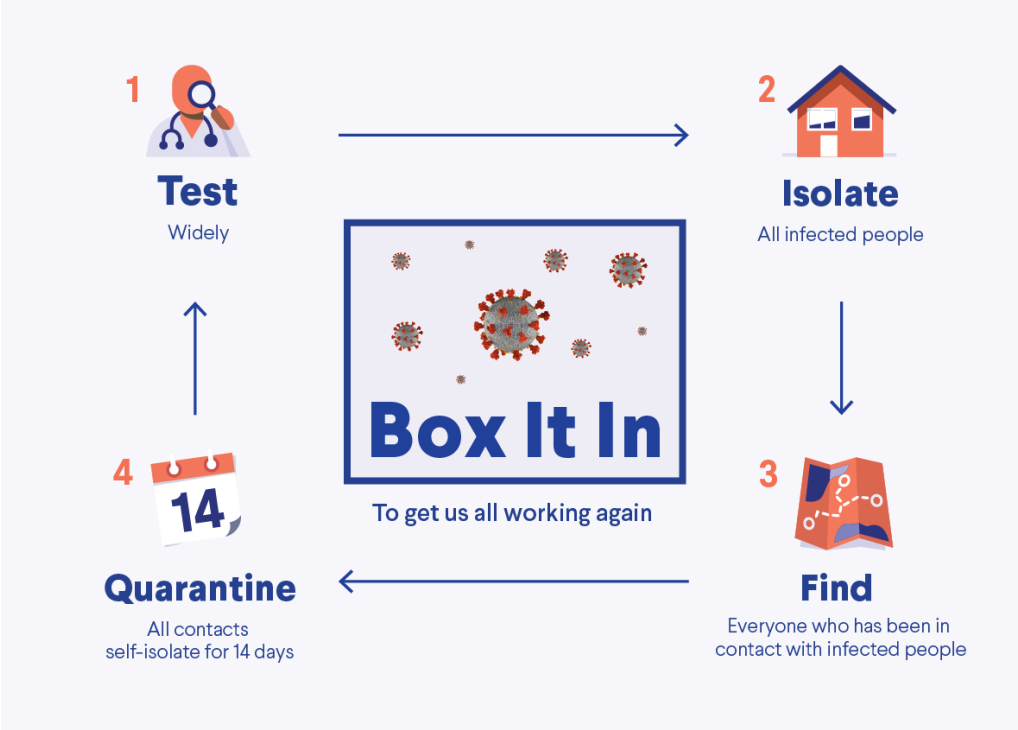


Image Description

Source: Centers for Disease Control and Prevention. Summary of notifiable diseases–United States, 2002. Published April 30, 2004, for MMWR 2002;51(No. 53): p. 59.

BOX IT IN! – DISEASE CONTROL

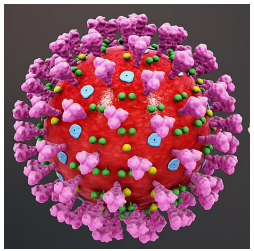


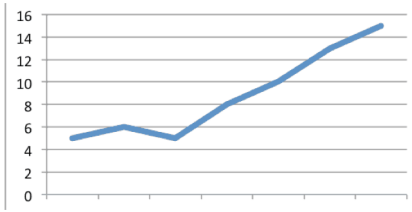
https://preventepidemics.org/wp-content/uploads/2020/04/COV035_BoxItInBriefingDoc_v9.pdf

OUTBREAK INVESTIGATION

- Who has it, why they have it, and what can be done about it

Identify the source of the outbreak → Monitor and track the disease → Study the disease → Develop interventions to slow disease spread & lessen impact

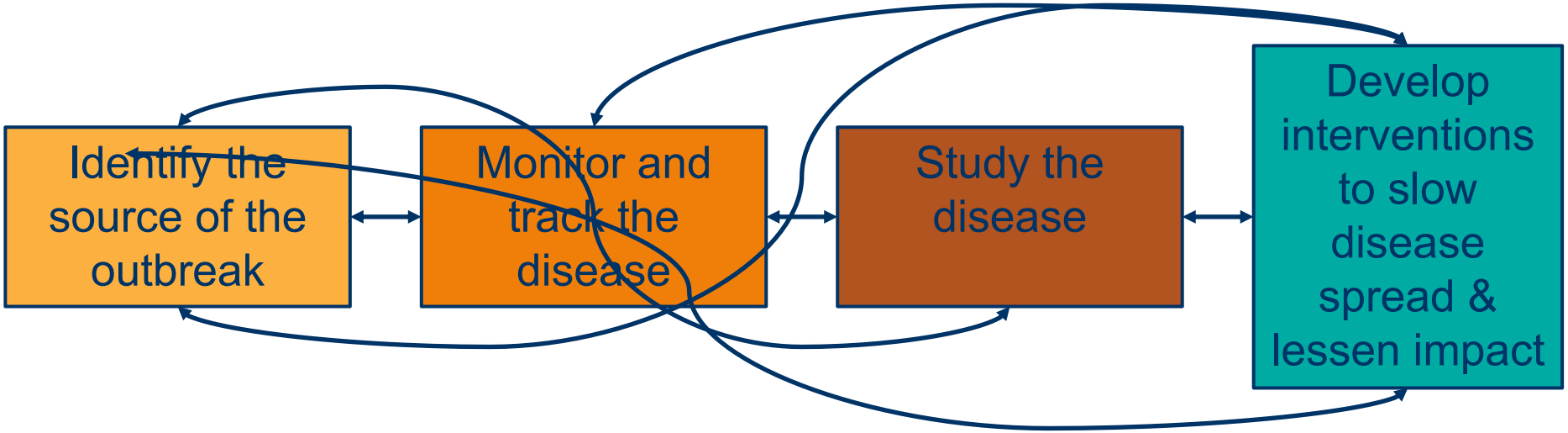




https://www.who.int/news-room/detail/29-06-2020-covidtimeline

OUTBREAK INVESTIGATION: REALITY

- Who has it, why they have it, and what can be done about it



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MEASURES OF DISEASE FREQUENCY

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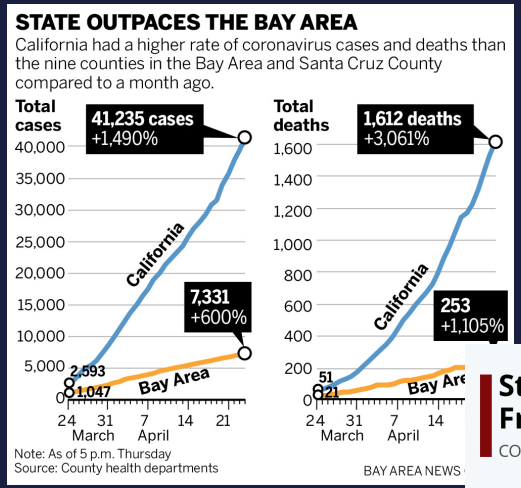

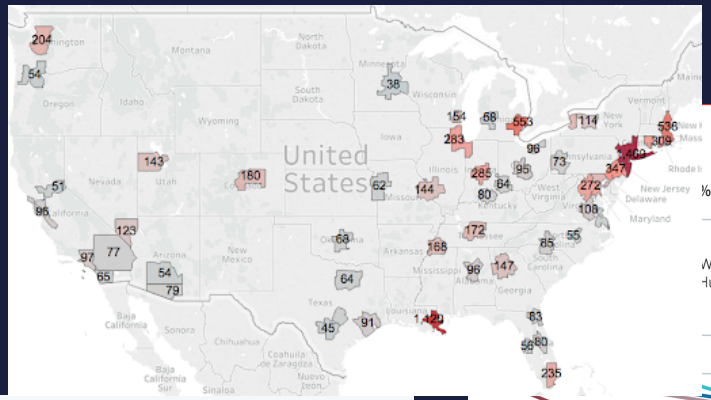

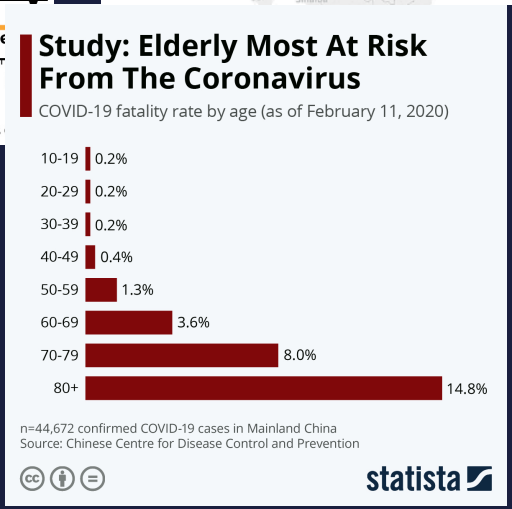

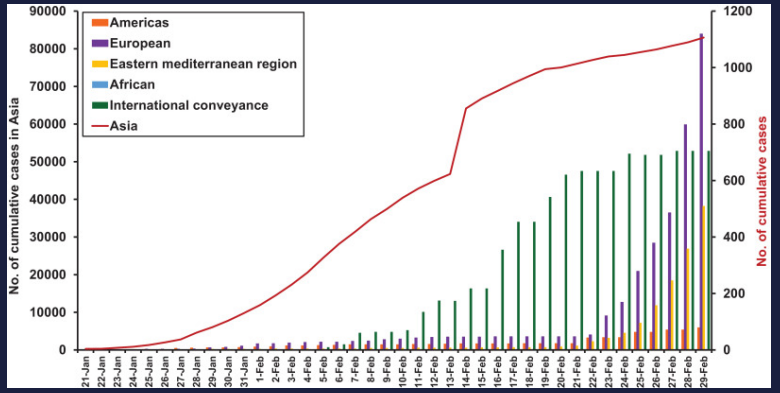

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REVIEW

- Numerator = top number
- Denominator = bottom number

RATIOS → PROPORTIONS & RATES

- Ratio: dividing one number by another
  - **Does not imply a relationship between the numerator and denominator**
  - **Example: body mass index (BMI) = weight/height**

- Proportion: relates to parts of a whole
  - **Often expressed as a percentage**
  - **Example: 20 cases of the flu in a nursing home of 130 residents**
    - 20 cases/130 people = the prevalence of flu in the nursing home is 15%

- Rate: denominator takes into account another dimension
  - **Often time**
  - **Example**
    1. Motor vehicle deaths per vehicle-miles
    2. Number of sports injuries per athlete exposures

COUNT

State	Number of cases of COVID (as of July 12) Since 1/21/20
California	320,804
Arizona	122,467
Utah	30,177
Nevada	27.894

https://www.cdc.gov/covid-data-tracker/#cases

COUNT

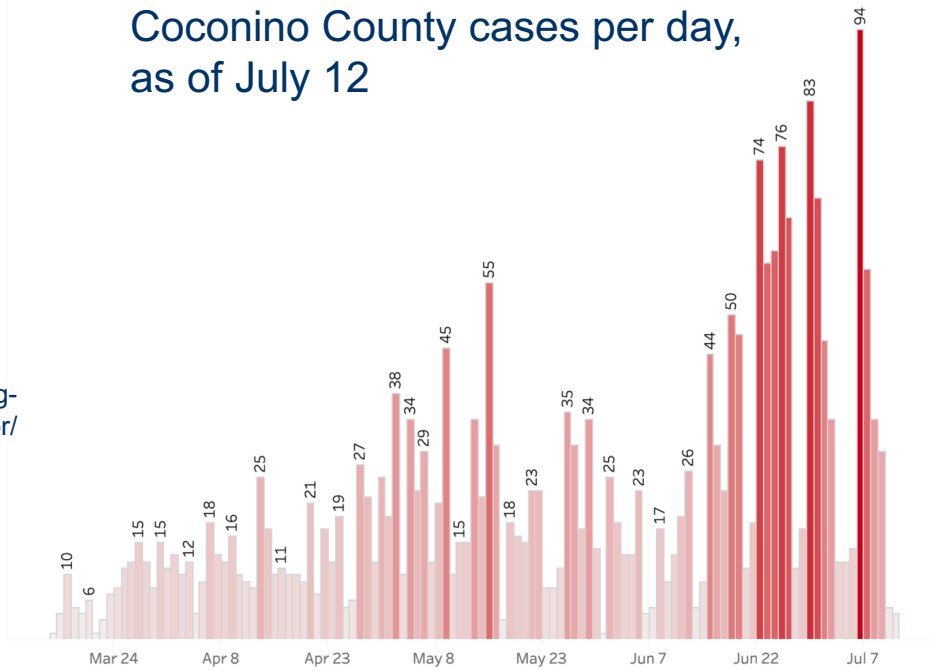
What is a count good for?

- Identify when there is excess disease
- Identifying distribution of disease
  - **Person, place, time**
- Resource allocation
  - **How many case investigators and contact tracers need to be hired?**

https://preventepidemics.org/covid19/resources/contact-tracing-staffing-calculator/

- When the population is stable
- When no comparison is required

Coconino County cases per day, as of July 12



*Illnesses in the last 4-7 days may not be reported yet

https://www.azdhs.gov/preparedness/epidemiology-disease-control/infectious-disease-epidemiology/covid-19/dashboards/index.php

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What is a count good for?

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What are limitations of a count?

- Comparing different populations

- When the population is stable
- When no comparison is required

https://www.azdhs.gov/preparedness/epidemiology-disease-control/infectious-disease-epidemiology/covid-19/dashboards/index.php

Prevalence

- Proportion of the population that has disease at a particular time
- Overall burden of disease in a population

Prevalence (a proportion)

$$= \frac{\text{People } \# \text{ People with disease at a point in time}}{\text{Total People } \# \text{ People in the study population}}$$

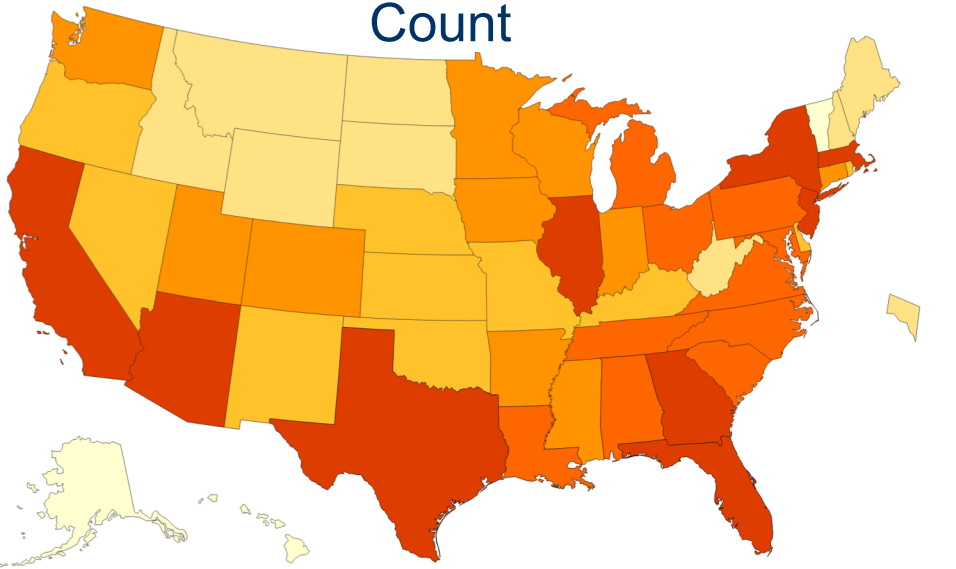
- Often expressed per 1,000 (or 10,000 or 100,000) people

State	Number of cases of COVID (as of July 12) Since 1/21/20	Population	Prevalence of COVID per 100,000 people
California	320,804	39,556,597	811.0
Arizona	122,467	7,171,459	1,707.7
Utah	30,177	3,161,219	954.6
Nevada	27,894	3,034,265	919.3

https://www.cdc.gov/covid-data-tracker/#cases

Total Number of COVID-19 Cases in the US Reported to the CDC, by State/Territory

Count



Territories

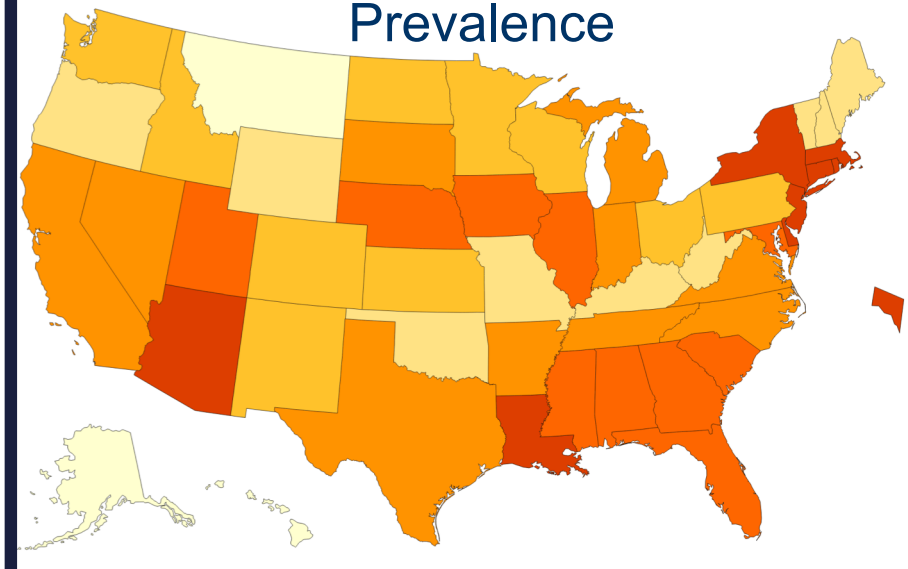
AS | FSM | GU | MP | PR | PW | RMI | VI

Total Cases

0 - 1,479 | 1,841 - 10,902 | 12,170 - 27,894 | 28,367 - 51,612 | 53,587 - 95,742 | 111,597 - 320,804

COVID-19 Case Rate in the US Reported to the CDC, by State/Territory (cases per 100,000)

Prevalence



Territories

AS | FSM | GU | MP | PR | PW | RMI | VI

Case Rate per 100,000

0 - 200.6 | 206.9 - 505.5 | 539.5 - 762.3 | 768.8 - 941.2 | 954.6 - 1,249.4 | 1,323.6 - 2,629.2

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https://www.cdc.gov/covid-data-tracker/#cases

INCIDENCE

- Occurrence of ***new*** cases during a period of time

1. Incidence proportion (cumulative incidence): probability of developing disease over a stated period of time
   - **Estimate of risk**
   - **Must specify a time period**

Cumulative Incidence (a proportion)

= People # new cases in a specified period

Total People # People (at risk) in the study population

INCIDENCE OF COVID

State	Number of cases of COVID (as of July 12) Since 1/21/20	Number of new cases in the past 7 days	Population	Prevalence of COVID per 100,000 people	Incidence of COVID per 100,000 people****
California	320,804	60,649	39,556,597	811.0	153.3
Arizona	122,467	24,378	7,171,459	1,707.7	339.9
Utah	30,177	4,677	3,161,219	954.6	147.9
Nevada	27,894	5,248	3,034,265	919.3	173.0

***** = caution

Cumulative Incidence (a proportion)

= People # new cases in a specified period

Total People # People (at risk) in the study population

https://www.cdc.gov/covid-data-tracker/#cases

Population at risk example

- Nursing home with 800 residents
- Blood tests for diabetes
  - **Fasting glucose**
  - **A1C**

- 50 residents had diabetes

- Prevalence = 50/800
  = 0.63
  = 63/100 people
  = 6.3%

- Incidence of diabetes in the residents over 12 months
  - **Going to assume no one moves away or dies in a year**

- 25 residents are diagnosed with diabetes in 12 months

- Incidence = 25/750
  = 0.33
  = 33/100 people
  = 3.3%

INCIDENCE

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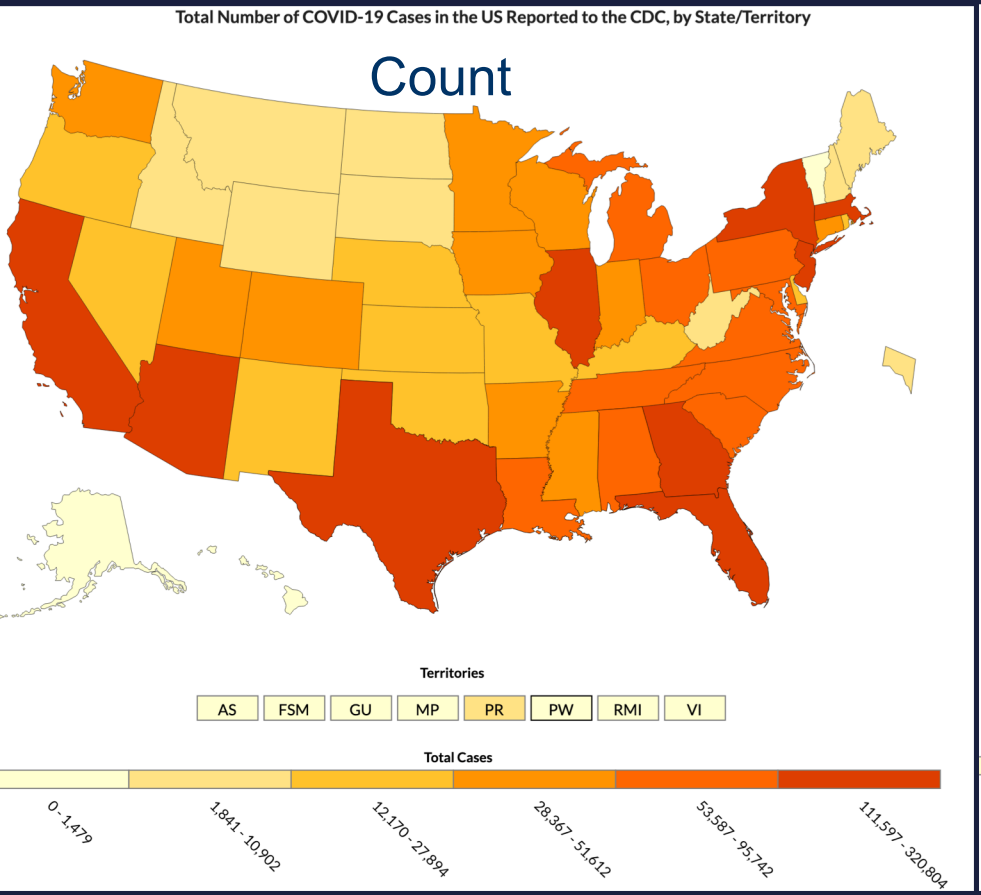
***** = need population at risk

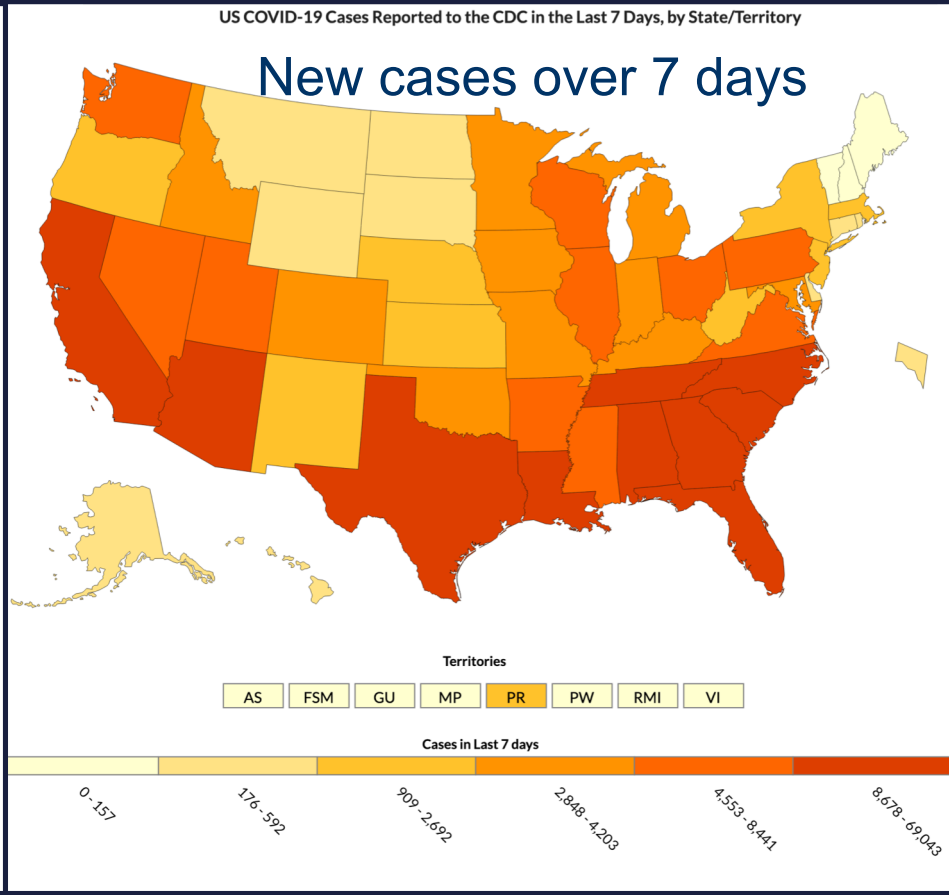
Cumulative Incidence (a proportion)

= People # new cases in a specified period

Total People # People (at risk) in the study population

https://www.cdc.gov/covid-data-tracker/#cases





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https://www.cdc.gov/covid-data-tracker/#cases

INCIDENCE

- Occurrence of ***new*** cases during a period of time

1. Incidence proportion (cumulative incidence): probability of developing disease over a stated period of time
   - **Estimate of risk**
   - **Must specify a time period**

2. Incidence rate: number of new cases per unit of time

Cumulative Incidence (a proportion)

= People # new cases in a specified period

Total People # People (at risk) in the study population

Incidence Rate (a rate)

$$\frac{\text{number of new cases of disease}}{\text{person-time at risk}}$$

INCIDENCE RATE (AND INCIDENCE DENSITY)

- In studies or communities, people are often followed for different lengths of time
  - **Move away**
  - **Move away and then come back**
  - **Drop out**
  - **Death**
  - **Births**

- Good when there are dynamic populations
  - **Or long follow-up times**

Incidence Rate (a rate)

$$\frac{\text{number of new cases of disease}}{\text{person-time at risk}}$$

HIV IN A BROTHEL: 15 WOMEN TESTED; 5 HAD HIV

	Follow-up						
Participant	1989	1990	1991	1992	1993	1994	
1	----------	+ ----------	----------	----------	----------	----------	
2	----------	?					
3	----------	----------	+ ----------	----------	----------	----------	
4	----------	?					
5	----------	----------	----------	?			
6	----------	----------	----------	----------	----------	?	
7	----------	----------	----------	----------	----------	----------	
8	----------	----------	----------	----------	----------	?	
9	----------	+ ----------	----------	----------	----------	----------	
10	----------	+ ----------	----------	----------	----------	?	

- Cumulative incidence over 6 years = 4/10 = 0.4 = 4 cases per 10 people = 40%

https://sphweb.bumc.bu.edu/otlt/MPH-Modules/EP/EP713_DiseaseFrequency/EP713_DiseaseFrequency4.html

HIV IN A BROTHEL: 15 WOMEN TESTED; 5 HAD HIV

	Follow-up						
Participant	1989	1990	1991	1992	1993	1994	Disease-free years
1	----------	+ ----------	----------	----------	----------	----------	1
2	----------	?					1
3	----------	----------	+ ----------	----------	----------	----------	2
4	----------	?					1
5	----------	----------	----------	?			3
6	----------	----------	----------	----------	----------	?	5
7	----------	----------	----------	----------	----------	----------	6
8	----------	----------	----------	----------	----------	?	5
9	----------	+ ----------	----------	----------	----------	----------	1
10	----------	+ ----------	----------	----------	----------	?	1

- Incidence rate = 4 cases of HIV/26 person-years = 0.15 = 15/100 person-years

Interrelationship between prevalence and incidence

- Prevalence depends on:
  - **New disease during a time period (incidence)**
  - **Duration of disease**
- Incidence is low, but those with it have it for a long time → prevalence high relative to incidence
  - **Type 2 diabetes**
- Incidence is high, but duration is short → prevalence will be low relative to incidence
  - **Chicken pox**

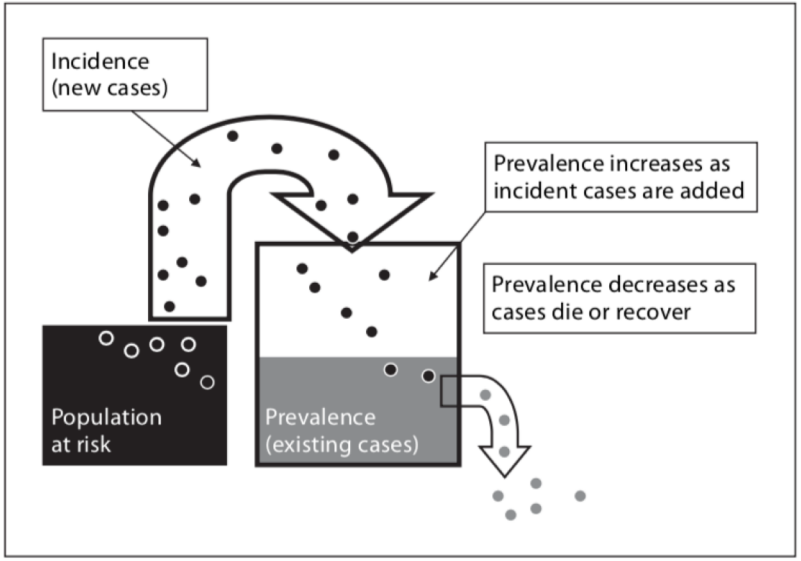


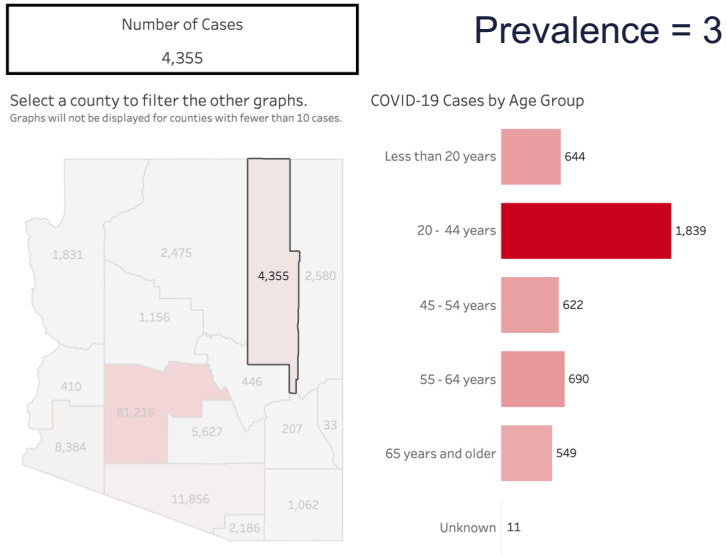
Fig. 2. Relationship between incidence and prevalence.

A full understanding of COVID is still evolving

CATEGORY-SPECIFIC MEASURES

- Categories can be anything (e.g., sex, geographic areas)

Age and Race/Ethnicity of COVID in Navajo county
Population = 110,924
Prevalence = 3,860.0/100,000 population



Age groups	Number of cases	Population estimates**	Prevalence per 100,000 population
< 20 y/o	644	29,173	2,207.5
20 – 64 y/o	3,151	60,897	5,174.3
> 64 y/o	549	20,854	2,632.6

https://www.azdhs.gov/preparedness/epidemiology-disease-control/infectious-disease-epidemiology/covid-19/dashboards/index.php

Population estimates from https://www.census.gov/quickfacts/navajocountyarizona

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MEASURES OF MORTALITY

MORTALITY ‘RATES’

1. Mortality
- Overall burden of death

$$\frac{\text{\# of deaths}}{\textbf{\textit{Population size}}}$$

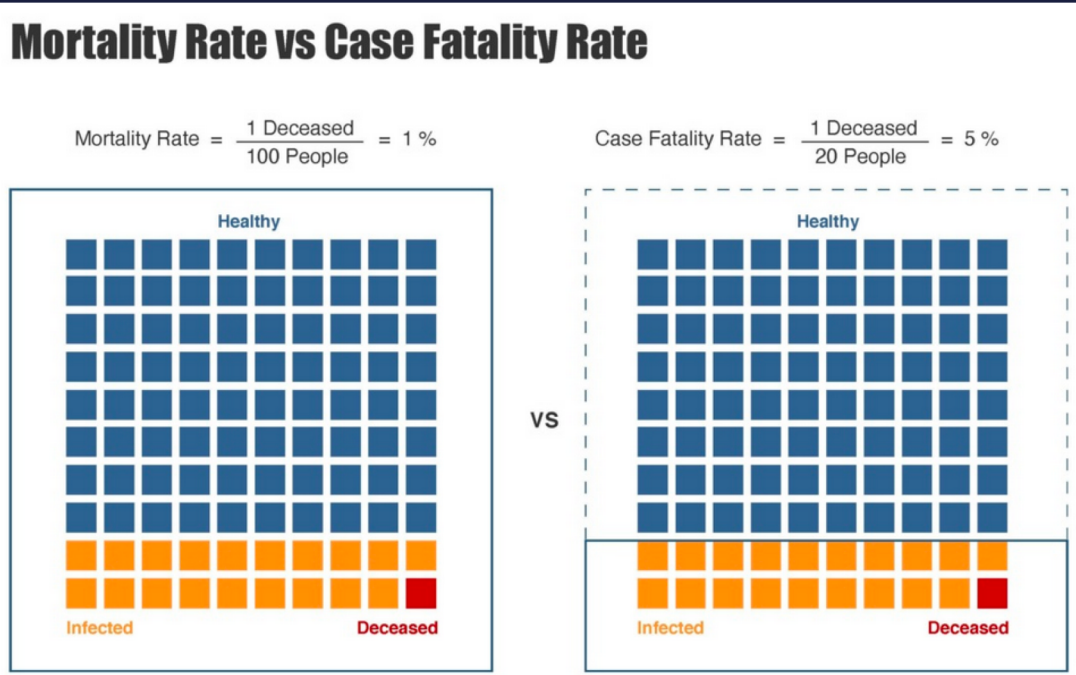
- Typically expressed per 1,000 or 100,000 people
  - **Or percent**

2. Case fatality
- Measure of disease severity

$$\frac{\text{\# of deaths from a specific disease}}{\textbf{\textit{\# of people with the disease}}}$$

- Typically expressed as a percent

MORTALITY VS. CASE FATALITY RATE



Graphic courtesy of SAS.

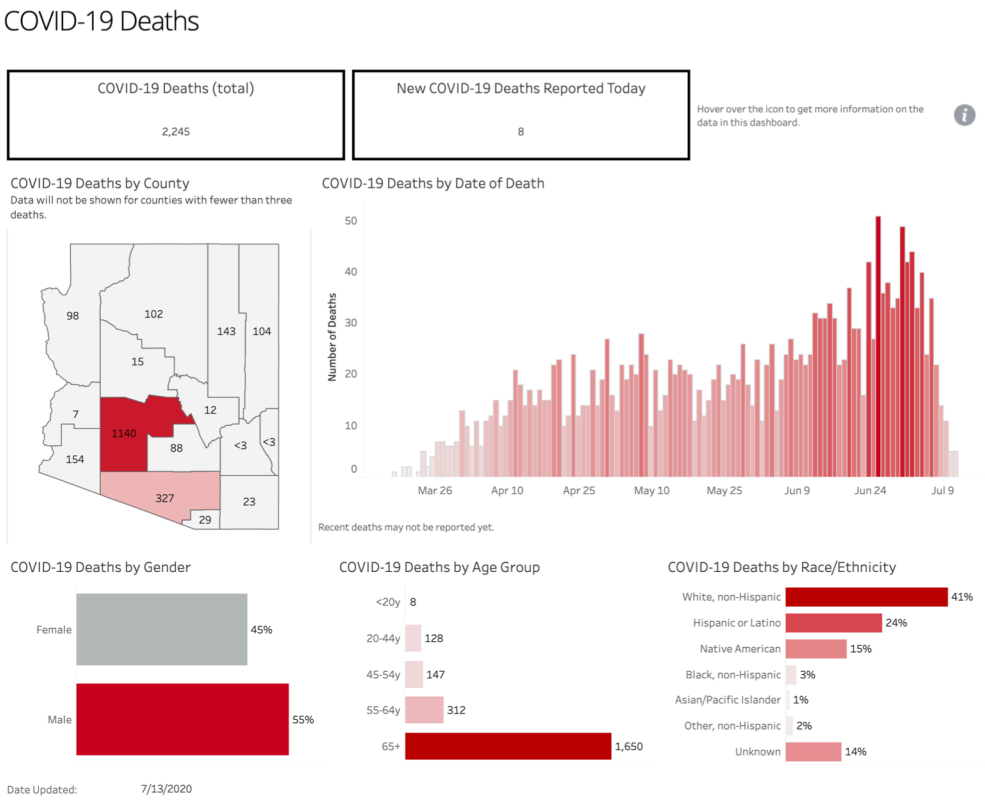
https://newslit.org/updates/case-fatality-rate-vs-mortality-rate/

AZ MORTALITY ‘RATES’

- Population of Arizona = 7,171,459
- Number of COVID cases = 123,824
- Number of COVID deaths = 2,245

- Mortality ‘rate’ = 2,245/7,171,459
  = 0.000313
  = 31.3/100,000

- Case fatality ‘rate’ = 2,245/123,854
  = 0.01812
  = 1.8%



As of July 12, 2020

A CHANGING PANDEMIC

- Since December 2019, case fatality
  - **15%, but in patients who were hospitalized**
  - **4.3 – 11.0%, but this was early (China)**
  - **0.4% in February (worldwide)**
  - **0.99% on Diamond Princess cruise ship**

Rajgor DD, et al. The many estimates of the COVID-19 case fatality rate. Lancet Infect Dis. 2020;20(7): 776-7.

- Case fatality estimated between 0.06% and 18.94%

Oke J, Heneghan C. Global COVID-19 Case Fatality Rates. Available at: https://www.cebm.net/covid-19/global-covid-19-case-fatality-rates/. Accessed July 13, 2020.

How does it compare?

- Compared to other viral disease
  - ↑ **severe seasonal influenza and 1957 and 1968 influenza (case fatality < 0.1%)**
  - ↓ **SARS (2002-3; 9% – 10%) and MERS (2012 – present; 36%)**

Fauci AS, Clifford HL, Redfield RR. Covid-19 — Navigating the Uncharted. New Engl J Med. 2020;382(13): 1268-9.

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PERCENT POSITIVE

Percent positivity

- Percentage of tests that were positive

$$\frac{\text{\# of positive tests}}{\text{\# of completed tests}}$$

- Sometimes referred to as positivity rate
  - **But it is not actually a rate**

- Indicator into whether a community is conducting enough testing to find cases
  - **High: may largely be testing the sickest patients and possibly missing milder or asymptomatic cases**
    - Not casting a wide enough net
  - **Low: including patients with milder or no symptoms**
    - Sufficient testing capacity for the size of the outbreak

WHAT IS HIGH PERCENT POSITIVITY?

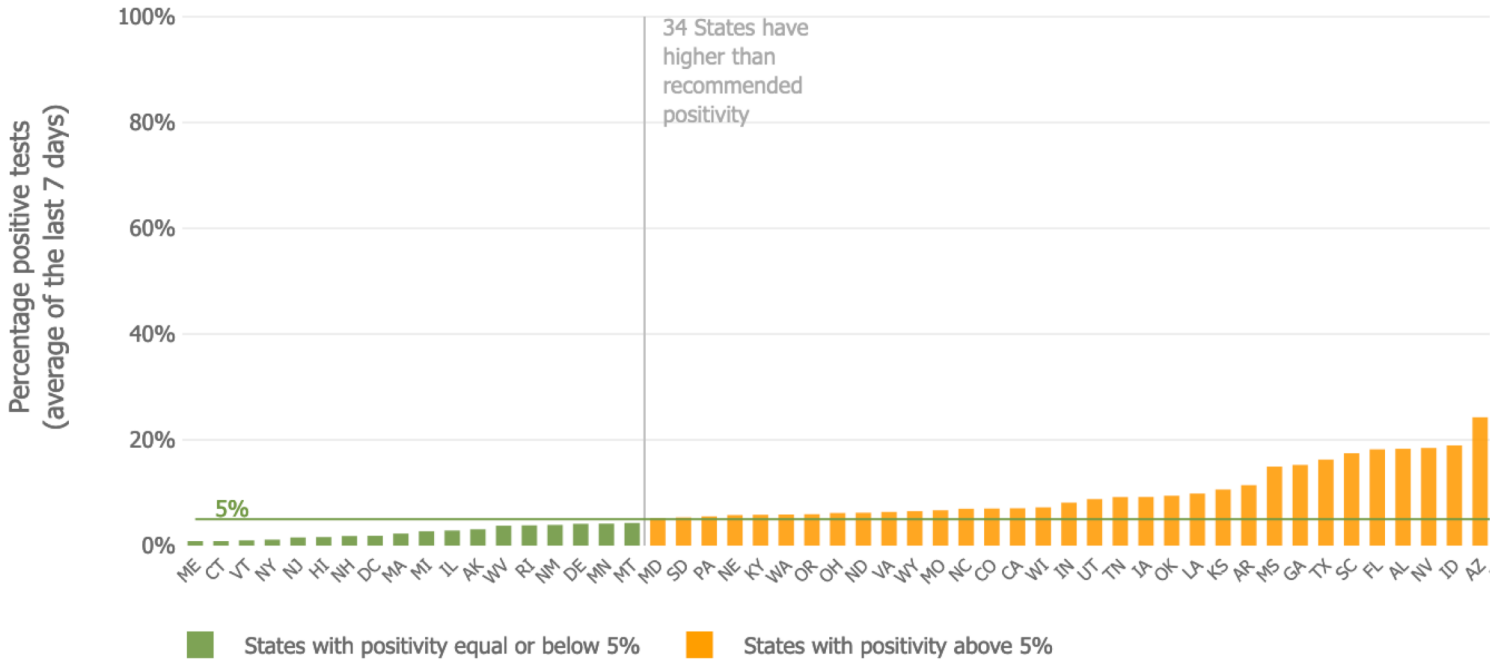
WHAT IS LOW PERCENT POSITIVITY?

PERCENT POSITIVITY FOR EPIDEMIC CONTROL

Epidemiological criteria
Decline of at least 50% of a 3-week period since the latest person and continuous decline in incidences of confirmed and probable cases
Less than 5% of samples positive for COVID-19, at least for the last 2 weeks (assuming that surveillance for suspected cases is comprehensive)
At least 80% of cases are from contact list and can be linked to known clusters
Decline in the number of deaths among confirmed and probable cases at least for the last 3 weeks
Continuous decline in the number of hospitalizations and ICU admissions of confirmed and probable cases at least for the last 2 weeks
Among others….

World Health Organization. Public Health Criteria to Adjust Public Health and Social Measures in the Context of COVID-19. Available at: https://www.who.int/publications/i/item/public-health-criteria-to-adjust-public-health-and-social-measures-in-the-context-of-covid-19. Accessed 7/13/20.

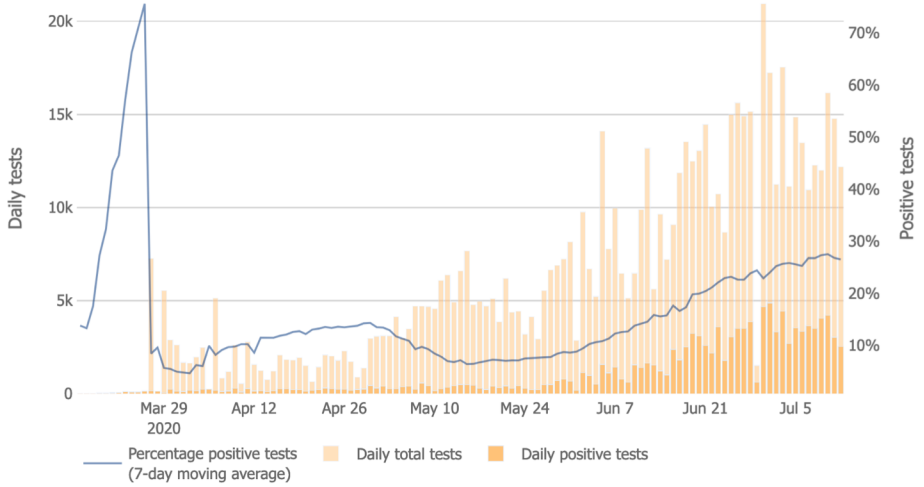
Percent positivity by state



This page was last updated on Sunday, July 19, 2020 at 3:00 AM EDT.

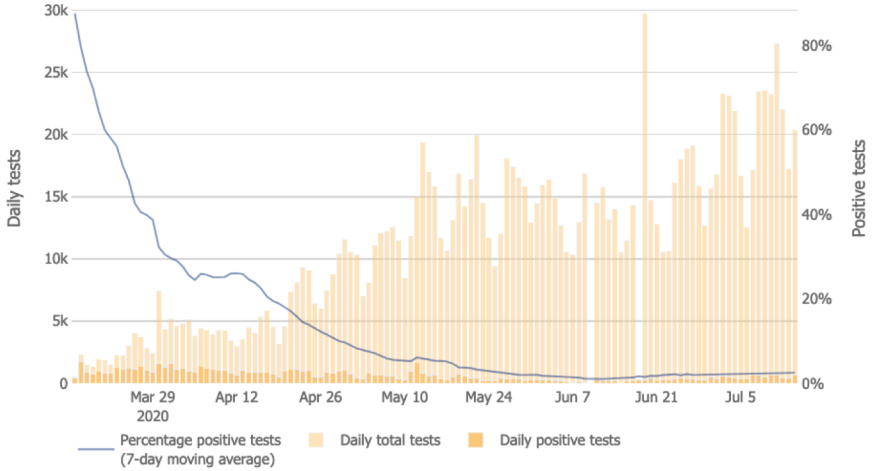
https://coronavirus.jhu.edu/testing/testing-positivity

CASE POSITIVITY COMPARISON



Arizona

Michigan



https://coronavirus.jhu.edu/testing

To review

Frequency measure	Numerator	Denominator
Prevalence	Number of people with COVID	Number of people in the population
Incidence	Number of new cases with COVID	Number of people at risk for COVID
Incidence rate (density)	Number of new cases with COVID	Follow-up (person-time) or other exposure
Mortality	Number of people who died from COVID	Number of people in the population
Case fatality	Number of people who died from COVID	Number of people with COVID
Percent positivity	Number of people with a positive COVID test	Number of people who were tested for COVID

Remember to look at the time period being reported

But all of these are estimates!

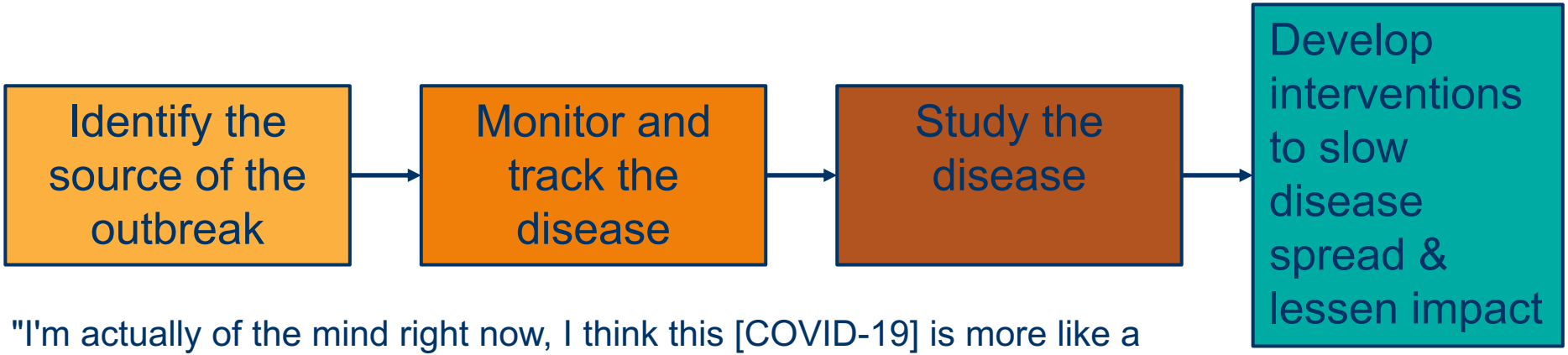
1. Number of people with COVID (Prevalence, incidence, incidence rate, case fatality, percent positivity)
   - **Probably an underestimate**
     - Testing capacity/availability
     - Testing policies
     - Asymptomatic people
   - **Accuracy of the tests**
   - **Case definition of 'with COVID'**
     - Confirmed case
     - Probable case
2. Number of people who died from COVID (Mortality and case fatality)
     - Competing conditions
     - Death certificate availability/accuracy
3. Number of people with a positive COVID test (Percent positivity)
   - **Accuracy of the tests**

But all of these are estimates!

- Number of people in the population (Prevalence and mortality)
  - **May be OK, except for dynamic population**
    - # of people in Flagstaff in Feb 2020 vs. July 2020
  - **Census population**
- Number of people at risk for COVID (Incidence)
  - **Who is 'at risk?'**
    - Current disease
    - Immunity after disease
    - Deaths and births
- Number of people tested for COVID
  - **Traveling**

FUTURE?

- Much has to be done to better understand the epidemiology and science of COVID-19
  - **But that does not mean that interventions should not be implemented and continued!!!**



"I'm actually of the mind right now, I think this [COVID-19] is more like a forest fire. I don't think that this is going to slow down. I'm not sure that the influenza analogy applies anymore. I think that wherever there is wood to burn, this fire is going to burn. And right now we have a lot of susceptible people." – M. Osterholm, 6/21/20

REFERENCES

- Many in slide citations

1. Friis RH, Sellers TA. Epidemiology for Public Health Practice. 4th ed. Sudbury, MA: Jones and Bartlett Publishers; 2009.
2. Gordis L. Epidemiology. 2nd ed. Philadelphia: WB Saunders Co; 2000.

OBJECTIVES

1. Review terms associated with measures of disease frequency
2. Define and interpret prevalence, incidence, and incidence rate
3. Explain the relationship between prevalence and incidence
4. Explain and interpret
    1. **Mortality**
    2. **Case fatality**
    3. **Percent positivity**

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Thank You!

Questions?

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CASE DEFINITION: CONFIRMED VS. PROBABLE CASES

Confirmed case

- Person who had a confirmatory viral test performed
  - **Positive for SARS-CoV-2, which is the virus that causes COVID-19**

- Probable case
- Meet clinical criteria **AND** epidemiological evidence
  - **NO confirmatory laboratory testing performed**
- Meet presumptive laboratory evidence, AND either clinical criteria **OR** epidemiological evidence
- Vital records criteria
  - **No confirmatory laboratory testing performed for COVID-1**

https://wwwn.cdc.gov/nndss/conditions/coronavirus-disease-2019-covid-19/case-definition/2020/