

COLLEGE OF POPULATION HEALTH

Spread the Science, *NOT* the Virus



A lecture series hosted by
the MPH Program at JCPH



Spread the Science, *NOT* the Virus Series Hosts



Rosie Frasso
PhD, CPH
rosie.frasso@jefferson.edu



Ami S. Patel
PhD, MPH
ami.patel@jefferson.edu



Robert Wilson
MD-MPH Student
robert.wilson@jefferson.edu



Spread the Science, *NOT* the Virus Series



Today: COVID-19 Epidemiologic Basics **Dr. Ami Patel, PhD, MPH**

Dr. Ami Patel is an adjunct instructor at Jefferson's College of Population Health. She has spent 10 years teaching epidemiology to Jefferson students and recently developed the Infectious Disease Epidemiology course within the College. Outside of the college she has extensive applied epidemiological experience in both government and industry settings.

Currently, Dr. Patel is an Associate Director of Epidemiology at CSL Behring where she is responsible for the planning, coordination, and execution of epidemiology research programs to support product development and lifecycle management activities in immunology, cardiovascular, and transplant therapeutic areas.

Prior to transitioning into her present role, Dr. Patel directed the Philadelphia Department of Public Health Acute Communicable Disease Program as a Centers for Disease Control (CDC) and Prevention Career Epidemiology Field Officer. At the health department, she and her team performed surveillance and investigation of enteric, vaccine-preventable, vectorborne, waterborne, health-care associated, and emerging infections and conditions.

Dr. Patel began her 15 year career at the Centers for Disease Control Prevention while in graduate school at the University of Pittsburgh. Upon receiving her doctoral degree she completed CDC's Epidemic Intelligence Service (EIS) Fellowship.

COVID-19: What can epidemiology tell us?

Ami S. Patel, PhD MPH

Jefferson College of Population Health

Disclosures and Acknowledgement

- Dr. Patel is an employee of CSL Behring and a former employee of the Centers for Disease Control and Prevention
- Sincere thanks to all frontline public health professionals who were involved in the collection, analysis, and interpretation of the data presented in this webinar

Objectives

- Introduce the emergence of COVID-19
- Detail the overall epidemiology of COVID-19 with a focus on US and local data
- Describe public health surveillance systems for COVID-19
- Identify strengths and limitations of surveillance data
- Illustrate the importance of epidemiological studies in generating evidence for disease control

Coronaviruses: Mild Nuances with Pandemic Potential

- Coronaviruses routinely circulate globally
- The first human coronavirus (HCoV) was isolated during 1965 from the nasal discharge of patients with the common cold and termed B814
- Typically, coronaviruses cause mild, self-limiting, upper respiratory tract infections
 - 10-30% of colds have been estimated to be caused by these viruses
- Currently, seven different CoV strains are known to infect humans
 - HCoV- 229E (229E), HCoV-OC43 (OC43), severe acute respiratory syndrome coronavirus (SARS-CoV), HCoV-NL63 (NL63), HCoV-HKU1 (HKU1), Middle East respiratory syndrome coronavirus (MERS-CoV), and SARS-CoV-2

[Su, Shuo et al. \(2016\) Epidemiology, Genetic Recombination, and Pathogenesis of Coronaviruses. Trends in Microbiology, Volume 24, Issue 6, 490 - 502.](#)

Emergence of Novel Coronaviruses: From Reservoir to Animal to Human

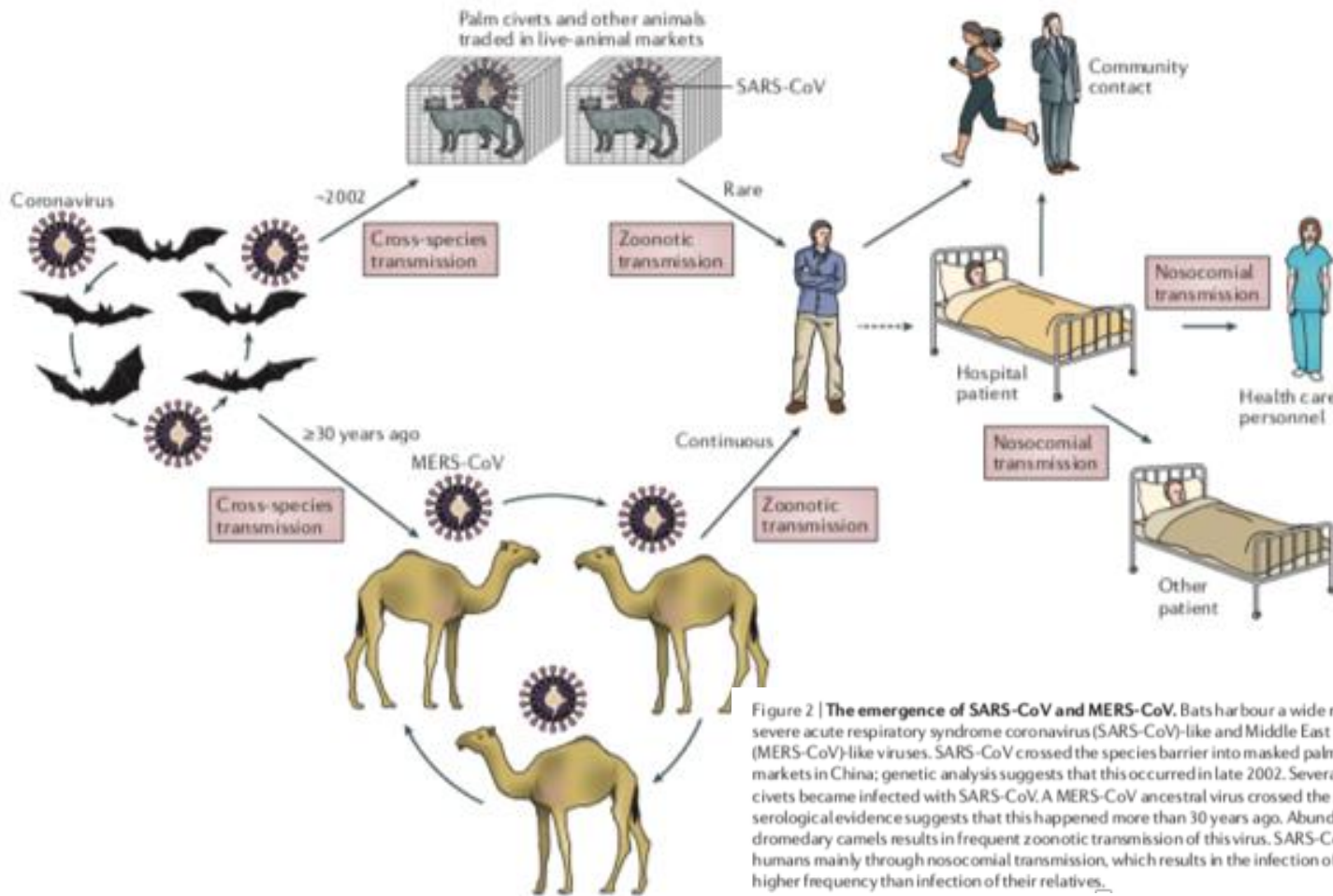


Figure 2 | **The emergence of SARS-CoV and MERS-CoV.** Bats harbour a wide range of coronaviruses, including severe acute respiratory syndrome coronavirus (SARS-CoV)-like and Middle East respiratory syndrome coronavirus (MERS-CoV)-like viruses. SARS-CoV crossed the species barrier into masked palm civets and other animals in live-animal markets in China; genetic analysis suggests that this occurred in late 2002. Several people in close proximity to palm civets became infected with SARS-CoV. A MERS-CoV ancestral virus crossed the species barrier into dromedary camels; serological evidence suggests that this happened more than 30 years ago. Abundant circulation of MERS-CoV in dromedary camels results in frequent zoonotic transmission of this virus. SARS-CoV and MERS-CoV spread between humans mainly through nosocomial transmission, which results in the infection of health care workers and patients at a higher frequency than infection of their relatives.

de Wit, E., van Doremalen, N., Falzarano, D., & Munster, V. J. (2016). SARS and MERS: recent insights into emerging coronaviruses. *Nature reviews. Microbiology*, 14(8), 523-534. <https://doi.org/10.1038/nrmicro.2016.81>

Emergence of COVID-19

- On December 27, 2019, 3 adult patients presented with severe pneumonia to a hospital in Wuhan, China; a 49-year-old woman, a 61-year-old man, and a 32-year-old man. The woman was a known retailer in a seafood and wet animal wholesale market, while the older man was a frequent visitor. Similar circumstances and patients had been involved with the SARS-CoV outbreak, leading to suspicions of an n-CoV, and further testing revealed an n-CoV as the likely etiologic agent in all 3 cases.

[Zhu, N., et al \(2020\). A Novel Coronavirus from Patients with Pneumonia in China, 2019. *The New England journal of medicine*, 382\(8\), 727-733. <https://doi.org/10.1056/NEJMoa2001017>](https://doi.org/10.1056/NEJMoa2001017)

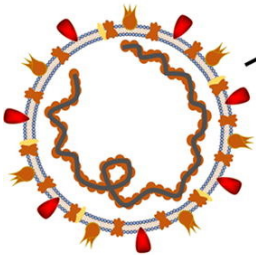


Lam Yik Fei for the New York Times
Retrieved from: <https://www.nytimes.com/2020/01/25/world/asia/china-markets-coronavirus-sars.html> on April 10 2020

Emergence of Novel Coronaviruses: From Reservoir to Animal to Human

Phylogenetically and

SARS-CoV-2



CDC/ Brian Judd 2009

Shereen MA, et al. (2020) COVID-19 infection: Origin, transmission, and characteristics of human coronaviruses. Journal of Advanced Research, Volume 24: 91-98.

Transmission Aspects

- Virus can be secreted within respiratory droplets, sputum, serum, blood, stool (?)
- Average incubation period = 4 - 5 days
 - Range = 2 - 14 days

Clinical Picture of COVID-19

Asymptomatic

Mild Disease

- Fever
- Fatigue
- Dry Cough
- Shortness of Breath

Moderate Disease

- Acute Respiratory Distress Syndrome
- Dyspnea
- Cardiac injury
- Renal dysfunction

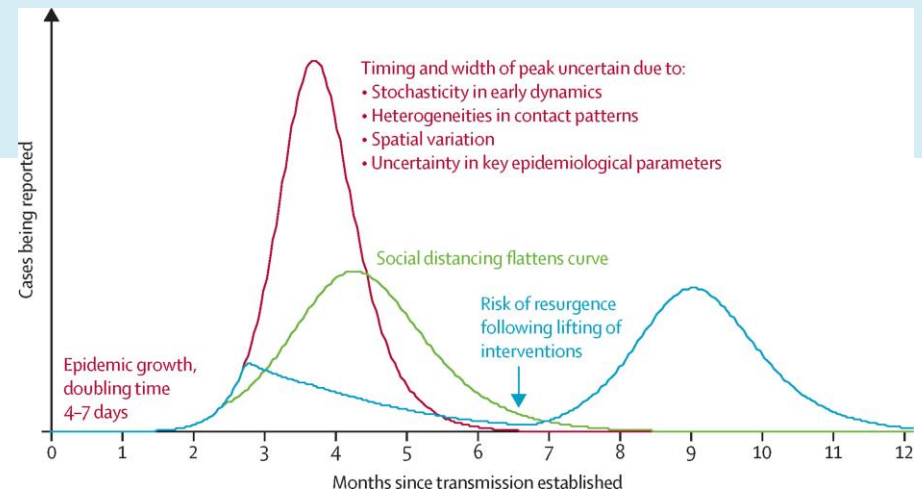
Critical Disease

- Septic shock
- Multi-organ system dysfunction
- Respiratory failure

Death

- Case Fatality rates vary based on age, underlying medical conditions, and timing of outbreak

Data for “The Curve”

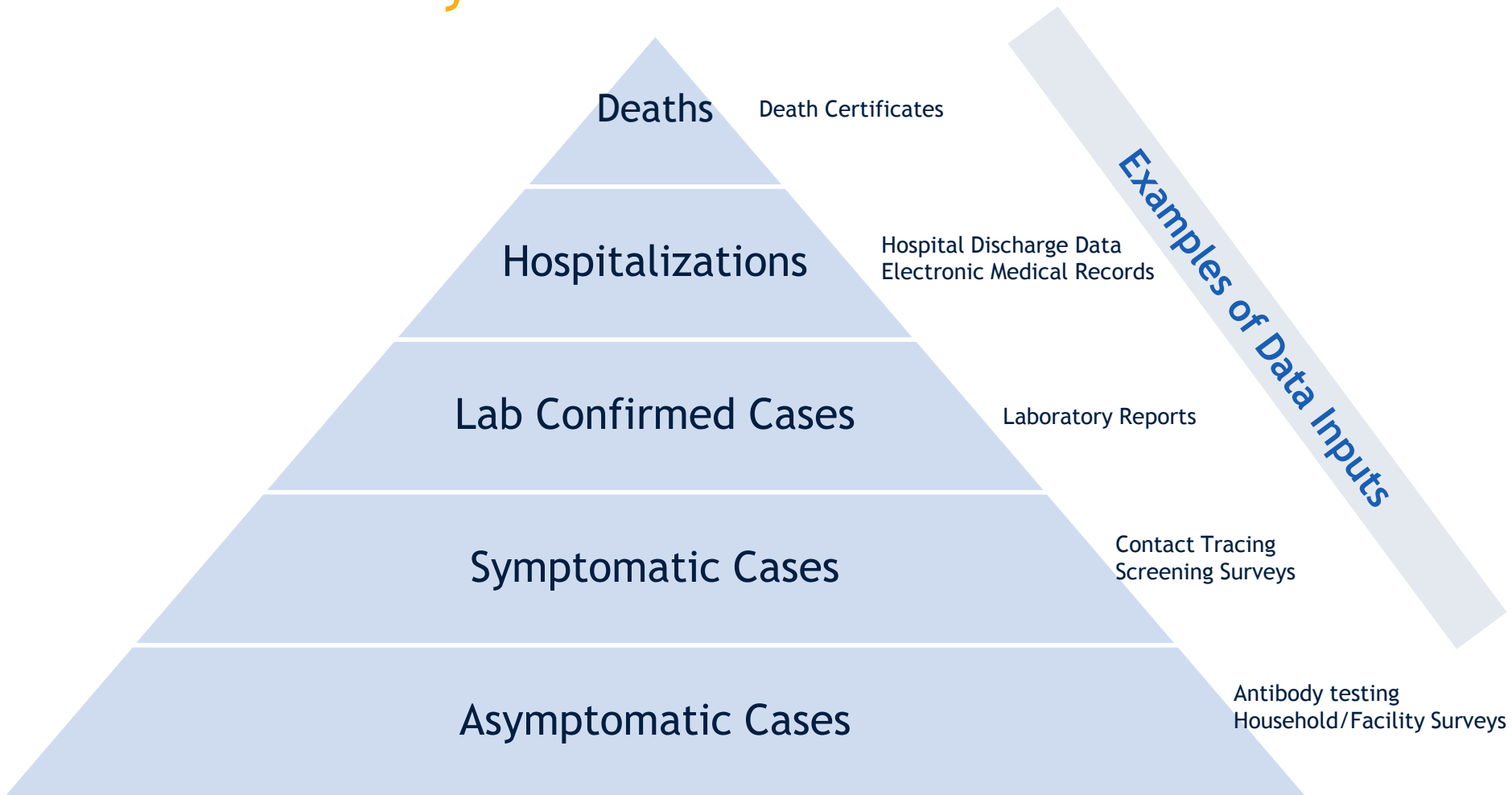


The Lancet 2020 395:931-934 DOI: (10.1016/S0140-6736(20)30567-5)

Public Health Surveillance: Definition and Purpose

- The ongoing systematic collection, analysis, and interpretation of outcome-specific data for use in the planning, implementation, and evaluation of public health practice.
- To assess public health status, to define public health priorities, to evaluate programs, and to stimulate research
- Tells us where the problems are, who is affected, and where the programmatic and prevention activities should be directed

Surveillance Pyramid



Surveillance Systems: Information Outputs

Case-Based Surveillance

- Magnitude of Disease
- Clinical Picture
- Contacts for Tracing

Outpatient and Emergency Department Illness Surveillance

- Magnitude of Disease
- Clinical Picture

Hospitalization Surveillance

- Clinical Burden
- Risk Factors for Severe Disease

Mortality Surveillance

- Risk Factors for Severe Disease

Virologic Surveillance

- Additional measure of disease magnitude
- Strains for vaccine development, antiviral recommendations
- Mutation detections

Epidemiological Studies Provide Needed Evidence for Disease Control

Types of Evidence Needed for Controlling an Epidemic.	
Evidence Needed	Study Type
No. of cases, including milder ones	Syndromic surveillance plus targeted viral testing
Risk factors and timing of transmission	Household studies
Severity and attack rate	Community studies
Severity “pyramid”	Integration of multiple sources and data types
Risk factors for infection and severe outcomes, including death	Case–control studies
Infectiousness timing and intensity	Viral shedding studies

Lipsitch M, Swerdlow D, Finelli L. 2020. Defining the Epidemiology of Covid-19 – Studies Needed. N Engl J Med 2020; 382:1194-1196.

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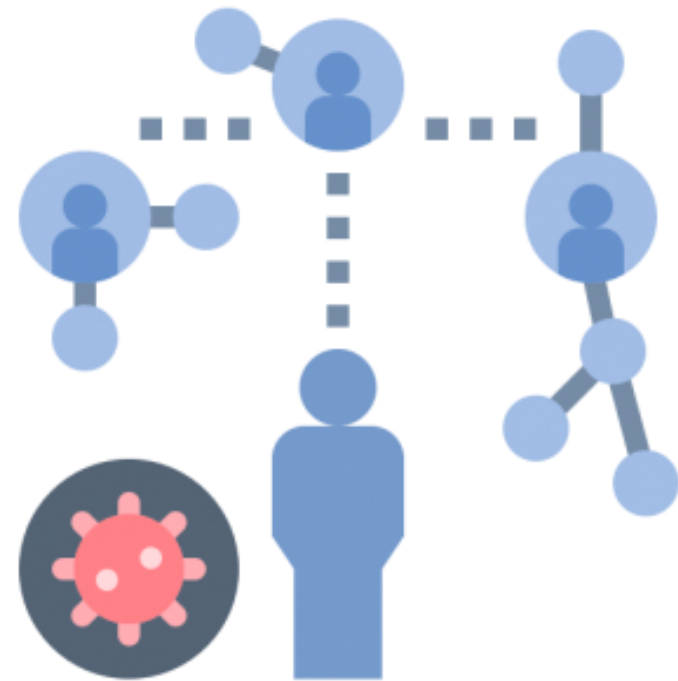
- Risk Factors for Severe Disease

Virologic Surveillance

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- Mutation detections

Case-Based Surveillance

- Case identification
 - Laboratory testing
 - Contact tracing
- Data provided
 - Demographics
 - Clinical picture
 - Risk Factors
 - Epidemiological linkages
- Prevention and control
 - Disease prevention education
 - Case-finding



Data Collection

- Demographics
- Symptoms
- Clinical Course
- Travel History
- Healthcare exposure
- Diagnostic Testing

Patient first name _____ Patient last name _____ Date of birth (MM/DD/YYYY): ____/____/____

.....PATIENT IDENTIFIER INFORMATION IS NOT TRANSMITTED TO CDC.....

**Human Infection with 2019 Novel Coronavirus
Person Under Investigation (PUI) and Case Report Form**

Reporting jurisdiction: _____ Case state/local ID: _____
 Reporting health department: _____ CDC 2019-nCoV ID: _____
 Contact ID #: _____ NNDSS loc. rec. ID/Case ID #: _____

a. Only complete if case-patient is a known contact of prior source case-patient. Assign Contact ID using CDC 2019-nCoV ID and request ID contact ID, e.g., Confirmed case CA 80030467 has contacts CA10030467-01 and CA10030467-02. *For NNDSS reporters, use GENV 2 or NNDSS patient identifier.

Interviewer information
 Name of interviewer: Last _____ first _____
 Affiliation/Organization: _____ Telephone _____ Email _____

Basic information

What is the current status of this person? <input type="checkbox"/> Patient under investigation (PUI) <input type="checkbox"/> Laboratory-confirmed case Report date of PUI to CDC (MM/DD/YYYY): ____/____/____ Report date of case to CDC (MM/DD/YYYY): ____/____/____ County of residence: _____ State of residence: _____	Ethnicity: <input type="checkbox"/> Hispanic/Latino <input type="checkbox"/> Non-Hispanic/Latino <input type="checkbox"/> Not specified Sex: <input type="checkbox"/> Male <input type="checkbox"/> Female <input type="checkbox"/> Unknown <input type="checkbox"/> Other	Date of first positive specimen collection (MM/DD/YYYY): ____/____/____ <input type="checkbox"/> Unknown <input type="checkbox"/> N/A Did the patient develop pneumonia? <input type="checkbox"/> Yes <input type="checkbox"/> Unknown <input type="checkbox"/> No Did the patient have acute respiratory distress syndrome? <input type="checkbox"/> Yes <input type="checkbox"/> Unknown <input type="checkbox"/> No Did the patient have another diagnosis/etiology for their illness? <input type="checkbox"/> Yes <input type="checkbox"/> Unknown <input type="checkbox"/> No Did the patient have an abnormal chest X-ray? <input type="checkbox"/> Yes <input type="checkbox"/> Unknown <input type="checkbox"/> No	Was the patient hospitalized? <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown If yes, admission date 1 ____/____/____ (MM/DD/YYYY) If yes, discharge date 1 ____/____/____ (MM/DD/YYYY) Was the patient admitted to an intensive care unit (ICU)? <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown Did the patient receive mechanical ventilation (MV)/intubation? <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown If yes, total days with MV (days) _____ Did the patient receive ECMO? <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown Did the patient die as a result of this illness? <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown Date of death (MM/DD/YYYY): ____/____/____ <input type="checkbox"/> Unknown date of death
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Race (check all that apply):
☐ Asian ☐ American Indian/Alaska Native
☐ Black ☐ Native Hawaiian/Other Pacific Islander
☐ White ☐ Unknown
☐ Other, specify: _____
 Date of birth (MM/DD/YYYY): ____/____/____
 Age: _____
 Age units (y/mo/day): _____

Symptoms present during course of illness:
☐ Symptomatic
☐ Asymptomatic
☐ Unknown

 If symptomatic, onset date (MM/DD/YYYY): ____/____/____
☐ Unknown

 If symptomatic, date of symptom resolution (MM/DD/YYYY): ____/____/____
☐ Still symptomatic ☐ Unknown symptom status
☐ Symptoms resolved, unknown date

Is the patient a health-care worker in the United States? ☐ Yes ☐ No ☐ Unknown
 Does the patient have a history of being in a health-care facility (as a patient, worker or visitor) in China? ☐ Yes ☐ No ☐ Unknown
 In the 14 days prior to illness onset, did the patient have any of the following exposures (check all that apply):
☐ Travel to Wuhan ☐ Community contact with another lab-confirmed COVID-19 case-patient ☐ Exposure to a cluster of patients with severe acute lower respiratory distress of unknown etiology
☐ Travel to Hubei ☐ Any healthcare contact with another lab-confirmed COVID-19 case-patient ☐ Other, specify: _____
☐ Travel to mainland China ☐ Patient ☐ Visitor ☐ HCW ☐ Unknown
☐ Travel to other non-US country ☐ Household contact with another lab-confirmed COVID-19 case-patient ☐ Animal exposure

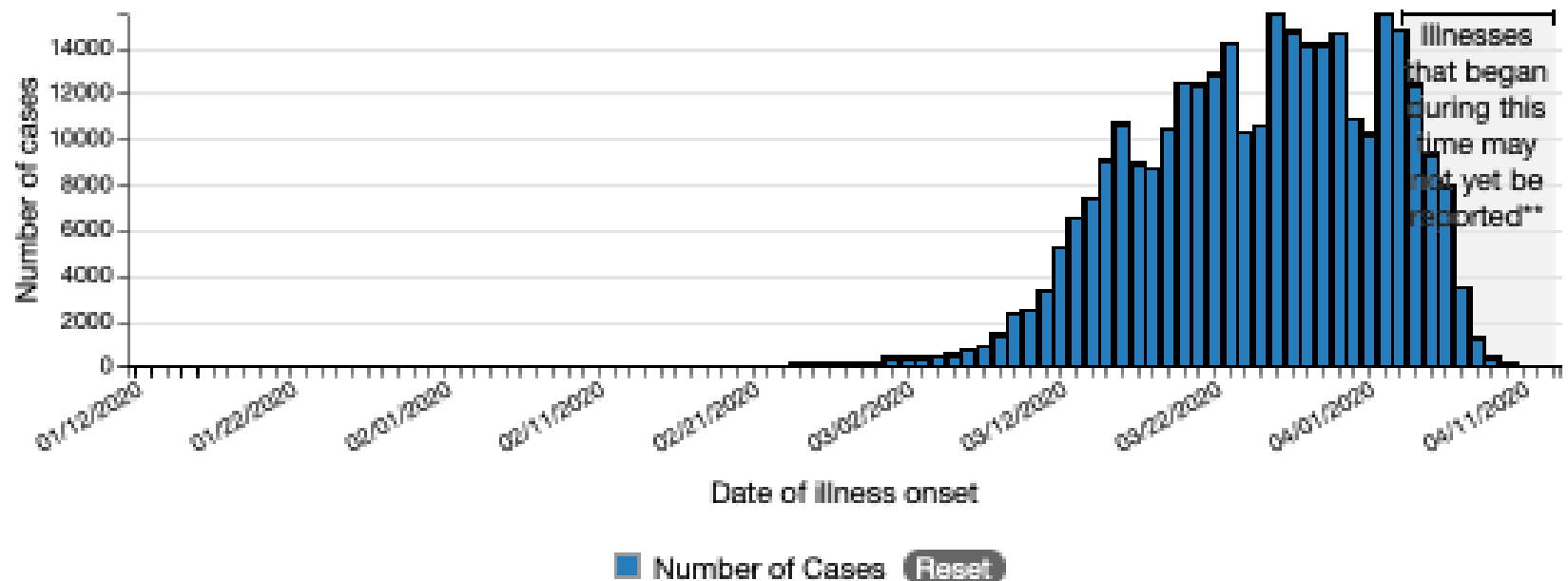
If the patient had contact with another COVID-19 case, was this person a U.S. case? ☐ Yes, nCoV ID of source case: _____ ☐ No ☐ Unknown ☐ N/A
 Under what process was the PUI or case first identified? (check all that apply): ☐ Clinical evaluation leading to PUI determination
☐ Contact tracing of case-patient ☐ Routine surveillance ☐ SpX notification of travelers; if checked, DGMQID: _____
☐ Unknown ☐ Other, specify: _____

Symptoms, clinical course, past medical history and social history

Collected from (check all that apply): ☐ Patient interview ☐ Medical record review

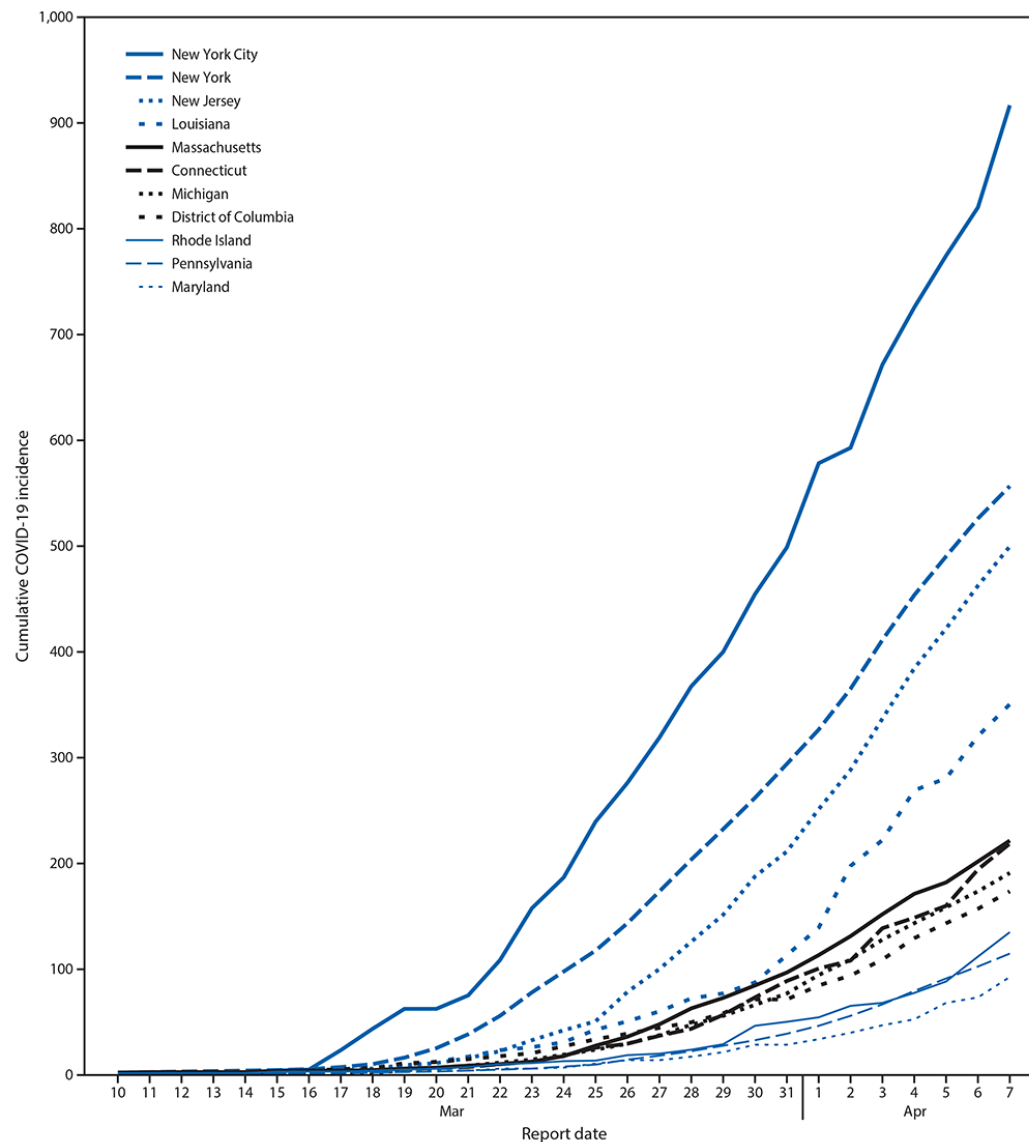
Public reporting burden of this collection of information is estimated to average 30 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. An agency may not conduct or sponsor, and a person is not required to respond to a collection of information unless it displays a currently valid OMB control number. Send comments regarding this burden estimate or any other aspect of this collection of information including suggestions for reducing this burden to CDC/RTIIR Reports Clearance Office, 1601 Clifton Road NE, MS D-14 Atlanta, Georgia 30333, ATTN: PRA (0150-3033).

COVID-19 cases in the United States by date of illness onset, January 12, 2020, to April 13, 2020, at 4pm ET (n=313,279)*



Content source: www.cdc.gov/coronavirus/2019-ncov/cases-updates/cases-in-us.html (last accessed: April 15 2020)

FIGURE 2. Cumulative incidence* of COVID-19, by report date — selected U.S. jurisdictions,^{†, §} March 10–April 7, 2020



Abbreviation: COVID-19 = coronavirus disease 2019.

* Cases per 100,000 population.

[†] Restricted to the 11 jurisdictions reporting the largest absolute increase in COVID-19 cumulative incidence during the most recent 7-day reporting period, March 31–April 7, 2020.

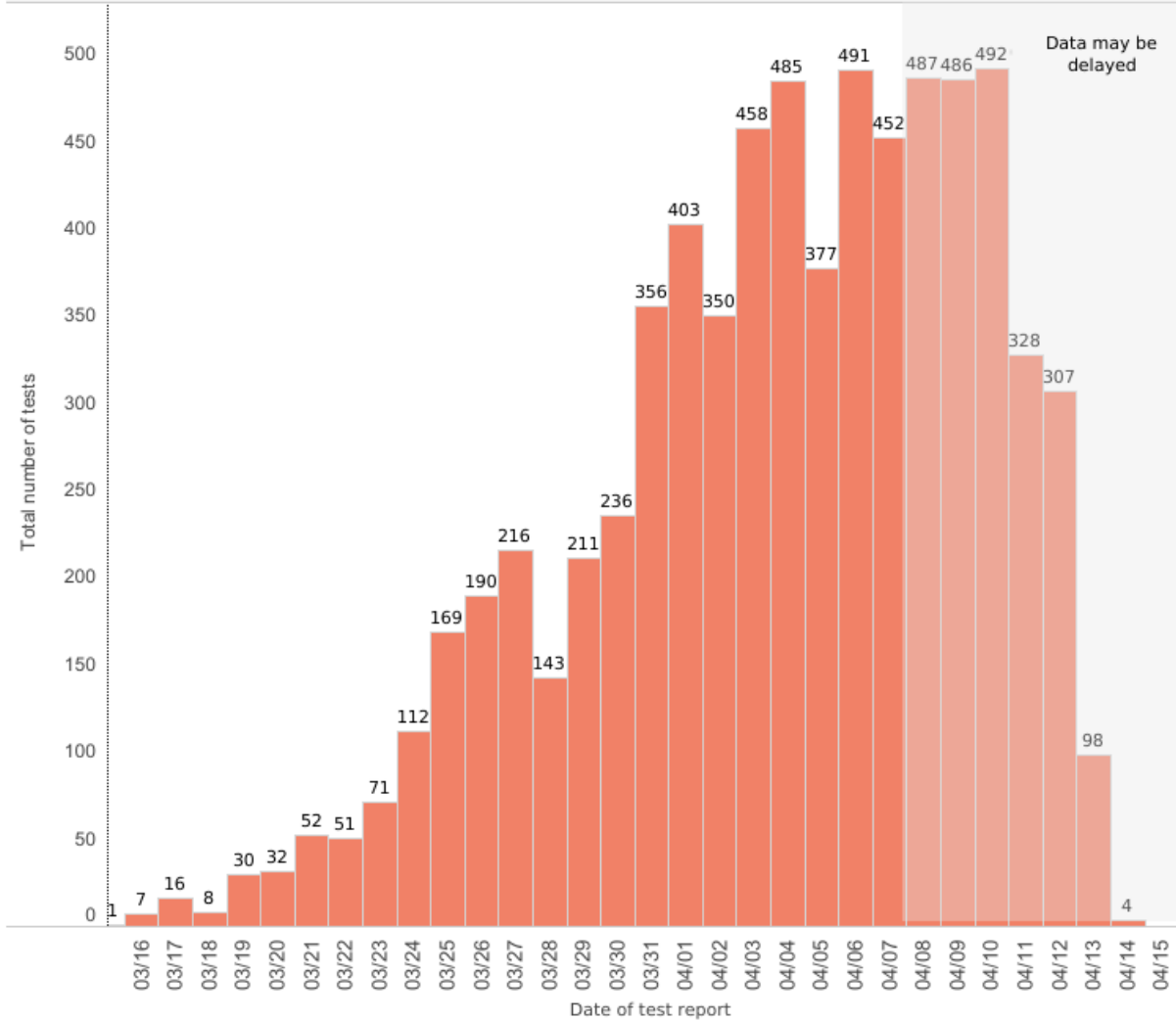
[§] Data from New York are exclusive of New York City.

Geographic Differences in COVID-19 Cases, Deaths, and Incidence — United States, February 12–April 7, 2020. MMWR Morb Mortal Wkly Rep. ePub: 10 April 2020.

DOI: <http://dx.doi.org/10.15585/mmwr.mm6915e4external icon>

City of Philadelphia COVID-19 Cases among Philadelphia Residents

Total COVID-19 Cases: 7,130
4/14/2020 1:00 PM



Data may be delayed several days due to reporting timeframe varying between laboratories. Past days will sometimes increase in volumes due to this delay.

Content source: <https://www.phila.gov/programs/coronavirus-disease-2019-covid-19/testing-and-data/> (last accessed: April 15 2020)

City of Philadelphia

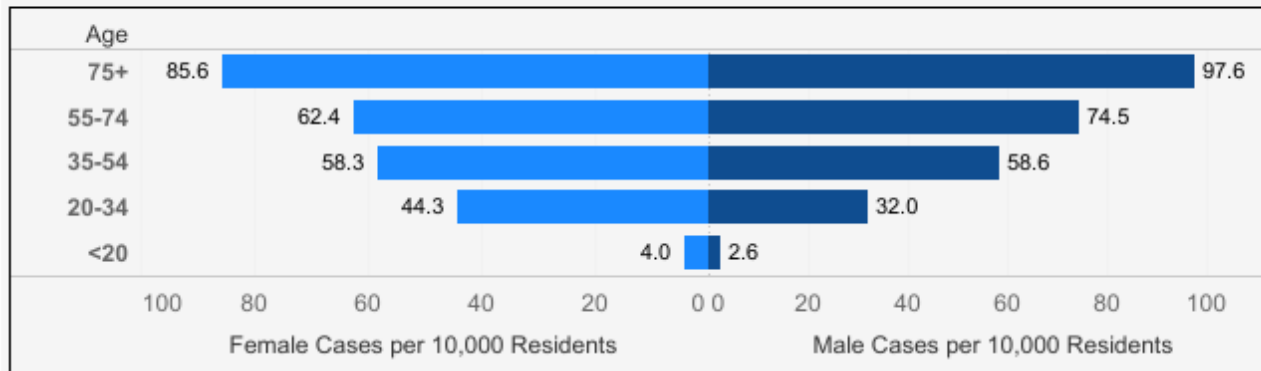
Characteristics of Philadelphia Residents with COVID-19

Total COVID-19 Cases: 7,130

55% Female 45% Male

4/14/2020 1:00 PM

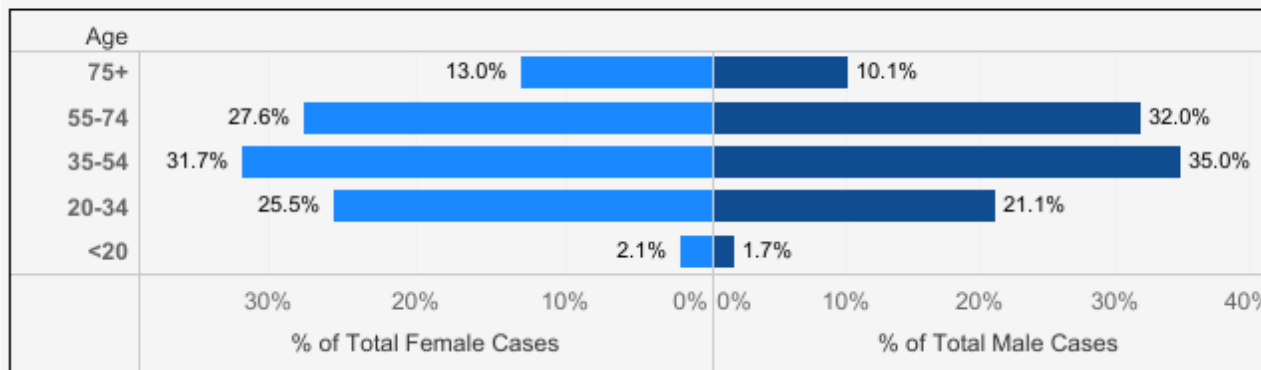
Rate of COVID-19 Cases by Age and Sex (Per 10,000 Residents)



Rates by Age

Age	
75+	90.5
55-74	68.5
35-54	59.0
20-34	38.5
<20	3.3

% of COVID-19 Cases By Age and Sex

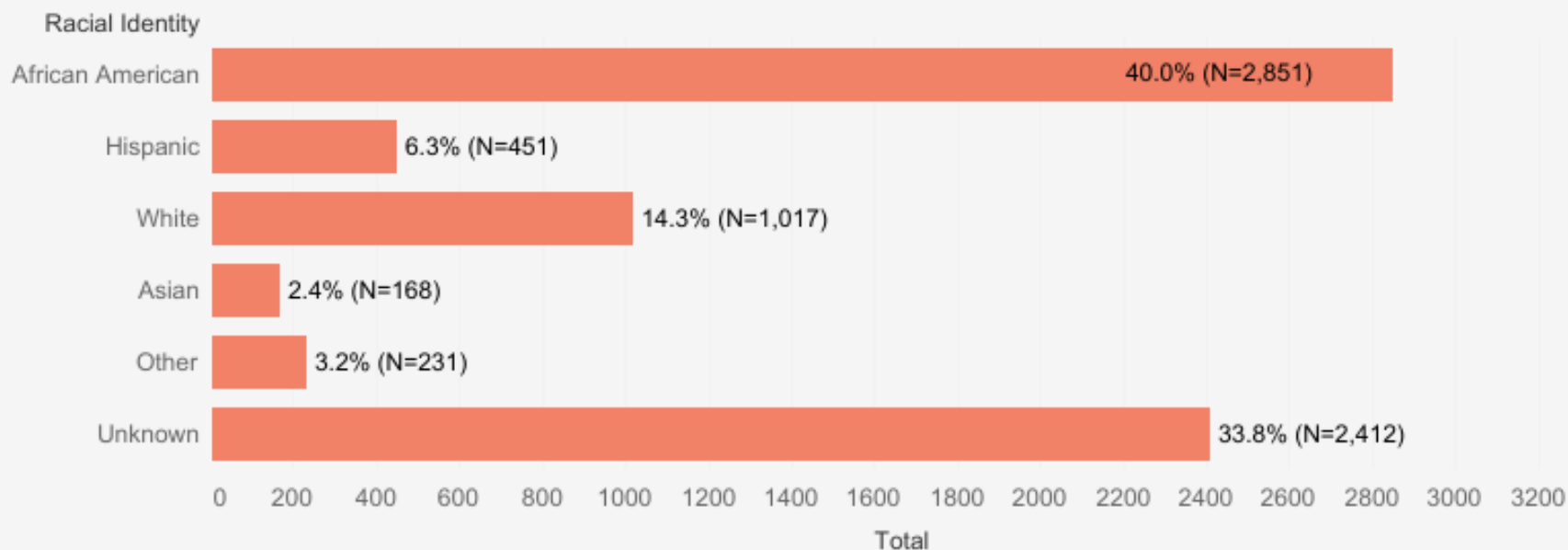


Counts by Age

Age	
75+	831
55-74	2,114
35-54	2,371
20-34	1,672
<20	137

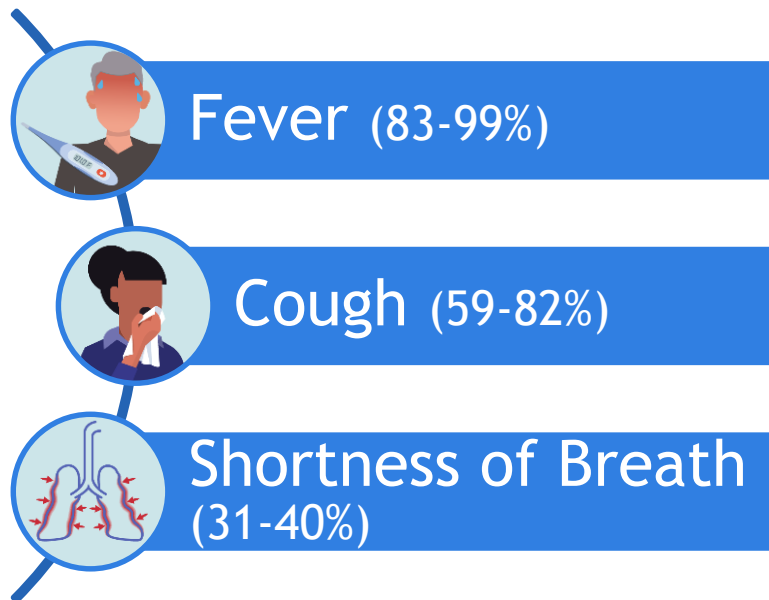
City of Philadelphia
Characteristics of Philadelphia Cases with COVID-19
Total COVID-19 Cases=7,130
4/14/2020 1:00 PM

% of COVID-19 Cases by Racial Identity



*Efforts to identify racial identity of cases and deaths with unknown race is ongoing

Clinical Picture: Insight from Surveillance in China

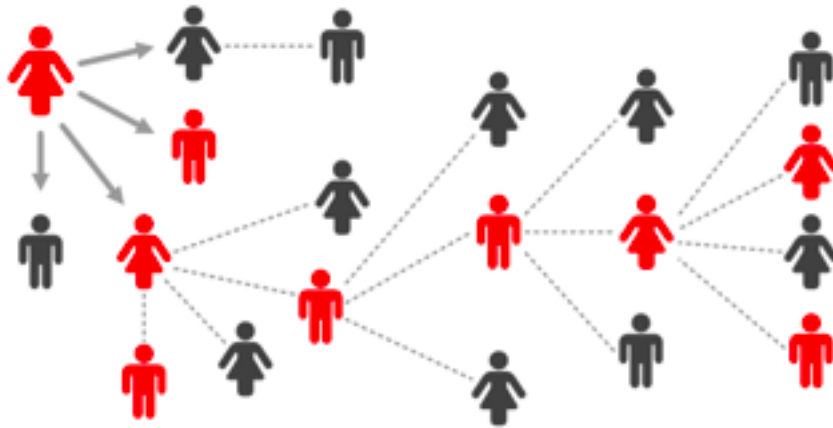


Symptom	Reported Frequency
Fatigue	44-70%
Anorexia	40-84%
Sputum production	28-33%
Myalgias	11-35%
Headache, confusion, rhinorrhea, sore throat, hemoptysis, vomiting, diarrhea	<10%

- Guan WJ, Ni ZY, Hu Y, et al. Clinical Characteristics of Coronavirus Disease 2019 in China. *The New England journal of medicine*. 2020.
- Chen N, Zhou M, Dong X, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *Lancet (London, England)*. 2020;395(10223):507-513.
- Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet (London, England)*. 2020;395(10223):497-506.
- Wang D, Hu B, Hu C, et al. Clinical Characteristics of 138 Hospitalized Patients With 2019 Novel Coronavirus-Infected Pneumonia in Wuhan, China. *Jama*. 2020.

Contact Tracing

1. Develop rapport with case-patient
2. Identify contacts of case-patient
3. Develop rapport with contacts and follow-up



Apple and Google Team Up to 'Contact Trace' the Coronavirus

The technology giants said they would embed a feature in iPhones and Android devices to enable users to track infected people they'd come close to.



Apple and Google said they would be able to release the smartphone tool in several months. Ben Sklar for The New York Times

Surveillance Systems: Information Output

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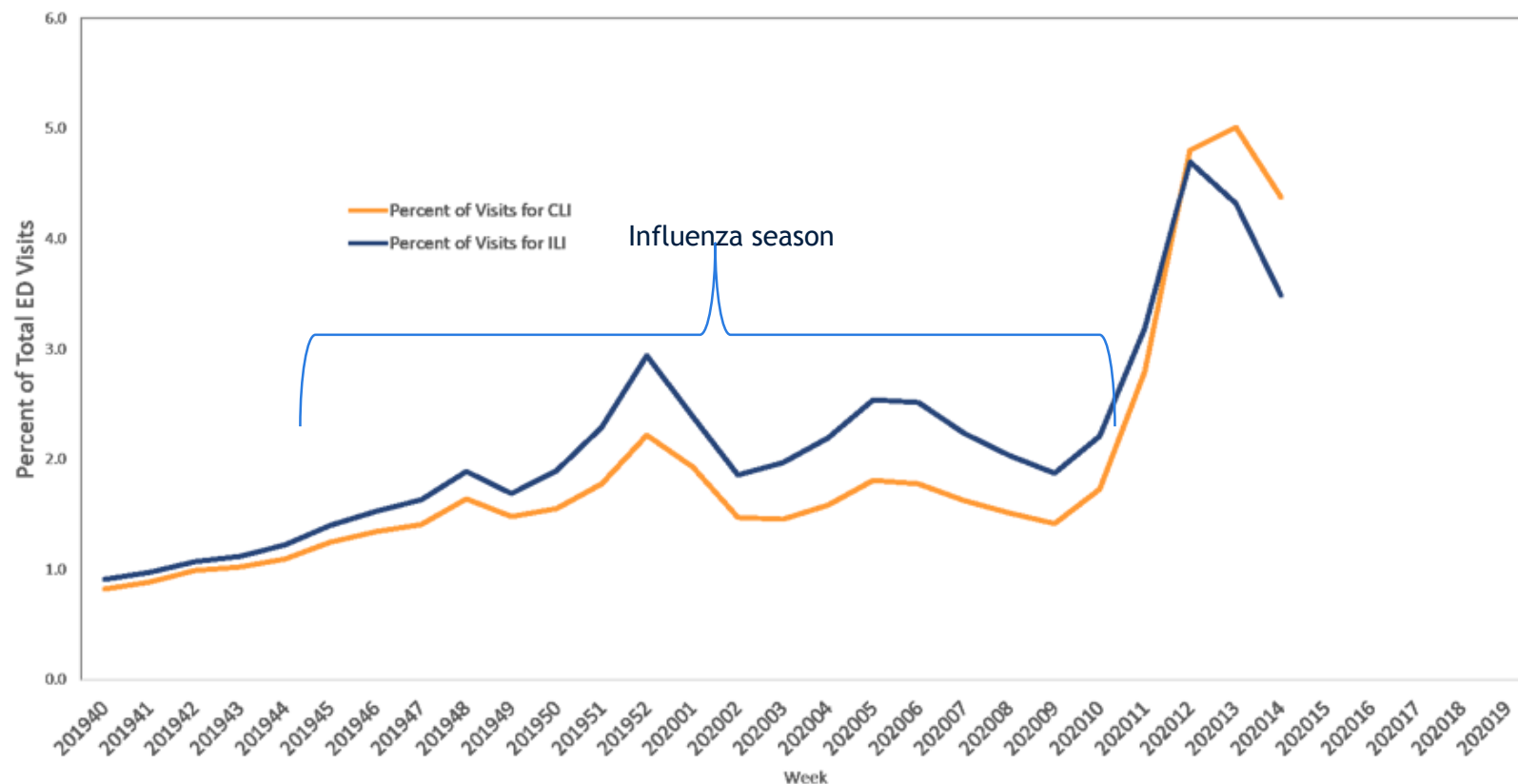
- Risk Factors for Severe Disease

Virologic Surveillance

- Additional measure of disease magnitude
- Strains for vaccine development, antiviral recommendations
- Mutation detections

Outpatient/Emergency Department Surveillance

NSSP: Percentage of Visits for Influenza-Like Illness (ILI) and COVID-19-Like Illness to Emergency Departments
Weekly National Summary, September 29, 2020 - April 4, 2020



- Outpatient Surveillance leveraging Influenza Like Illness Network (ILINet)
 - % of patients seen with fever and sore throat each week
- Emergency Department Syndromic Surveillance
 - COVID-19 Syndrome: fever and cough or shortness of breath or difficulty breathing

CDC. 2020. COVID View Report: Week 14, ending April 4 2020. Accessed from: <https://www.cdc.gov/coronavirus/2019-ncov/covid-data/covidview/index.html> on April 14 2020

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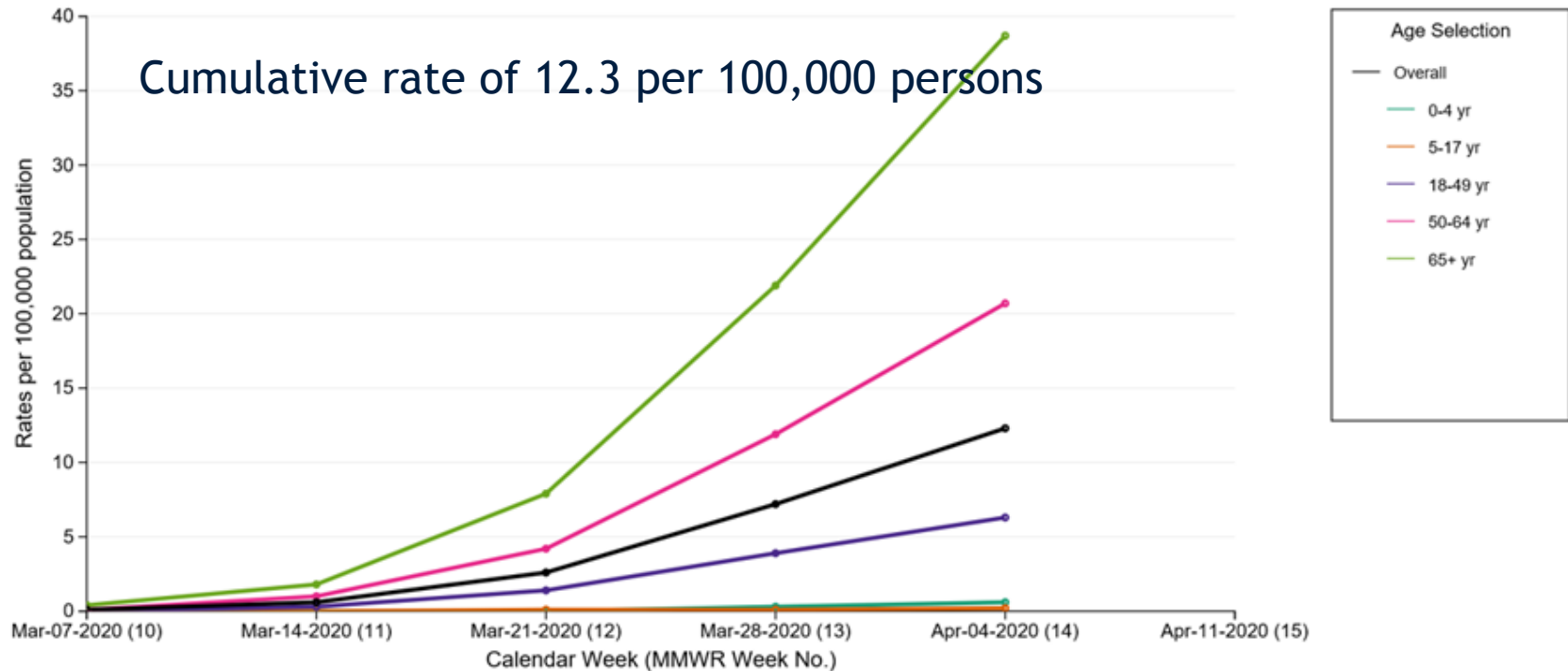
Virologic Surveillance

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Hospitalization Data

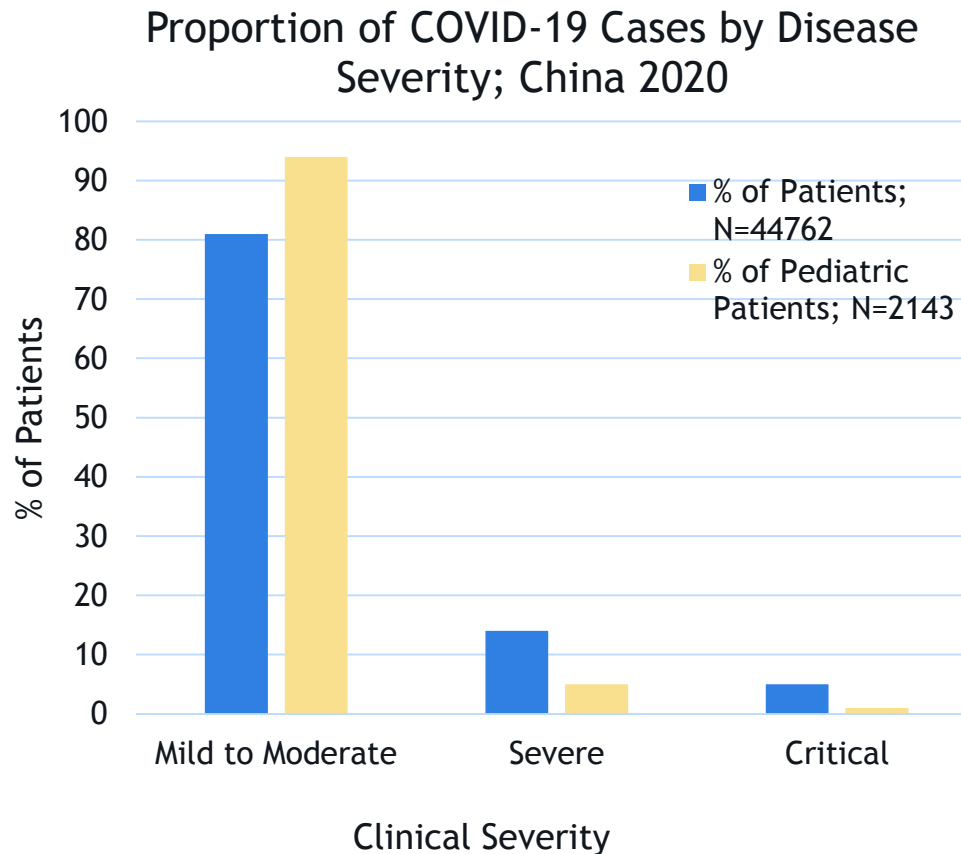
Laboratory-Confirmed COVID-19-Associated Hospitalizations

Preliminary cumulative rates as of Apr 04, 2020



CDC. 2020. COVID View Report: Week 14, ending April 4 2020. Accessed from: <https://www.cdc.gov/coronavirus/2019-ncov/covid-data/covidview/index.html> on April 14 2020

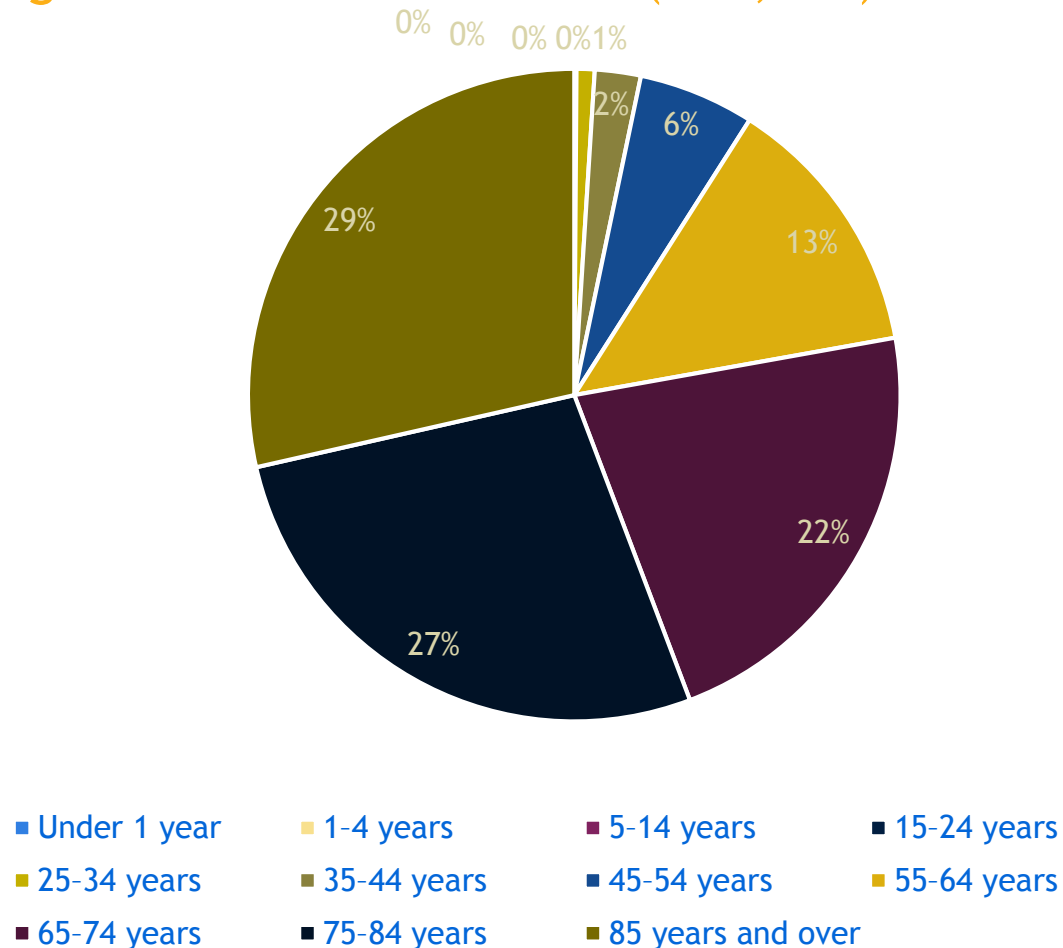
Characterization of Clinical Severity



Wu Z, McGoogan JM. Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72314 Cases From the Chinese Center for Disease Control and Prevention. *Jama*. 2020.

Dong Y, Mo X, Hu Y, et al. Epidemiological Characteristics of 2143 Pediatric Patients With 2019 Coronavirus Disease in China. *Pediatrics*. 2020.

Deaths involving coronavirus disease 2019 (COVID-19) reported to the National Center for Health Statistics by age group, United States Week ending 2/1/2020 to 4/11/2020 (N=8,259)



It's More Than the Curve

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Risk Factors

- >65 years of age
- Resident of a nursing home or long-term care facility
- Persons with underlying medical conditions, particularly if not well controlled, including:
 - Chronic lung disease or moderate to severe asthma
 - Serious heart conditions
 - Immunocompromised
 - BMI ≥ 40
 - Diabetes
 - Chronic kidney disease undergoing dialysis
 - Liver disease

CDC. 2020. Information for Healthcare Professionals: COVID-19 and Underlying Conditions. Accessed on April 14 2020 from: <https://www.cdc.gov/coronavirus/2019-ncov/hcp/underlying-conditions.html>

Risk factors associated with in-hospital death among 191 cases with confirmed COVID-19; Wuhan, China

	Univariable OR (95% CI)	p value	Multivariable OR (95% CI)	p value
Demographics and clinical characteristics				
Age, years*	1.14 (1.09-1.18)	<0.0001	1.10 (1.03-1.17)	0.0043
Female sex (vs male)	0.61 (0.31-1.20)	0.15	..	..
Current smoker (vs non-smoker)	2.23 (0.65-7.63)	0.20	..	..
Comorbidity present (vs not present)				
Chronic obstructive lung disease	5.40 (0.96-30.40)	0.056	..	..
Coronary heart disease	21.40 (4.64-98.76)	<0.0001	2.14 (0.26-17.79)	0.48
Diabetes	2.85 (1.35-6.05)	0.0062	..	..
Hypertension	3.05 (1.57-5.92)	0.0010	..	..
Respiratory rate, breaths per min				
≤24	1 (ref)	..	..	..
>24	8.89 (4.34-18.19)	<0.0001	..	..
SOFA score	6.14 (3.48-10.85)	<0.0001	5.65 (2.61-12.23)	<0.0001
qSOFA score	12.00 (5.06-28.43)	<0.0001	..	..

Zhou F et al. 2020. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *The Lancet* Volume 395 Issue 10229 Pages 1054-1062

Learning from Clusters

Long Term Care Facility Clusters

- Insight into asymptomatic presentation, attack rates, PPV, timing of transmission

Facility A; King County, WA

101/118 (86%) residents tested positive with the majority reporting symptoms

Hospitalization Rate for Residents: 54.5%

Case Fatality Rate for Residents: 33.7%

McMicheal et al. 2020. Epidemiology of Covid-19 in a Long-Term Care Facility in King County, Washington. NEJM.

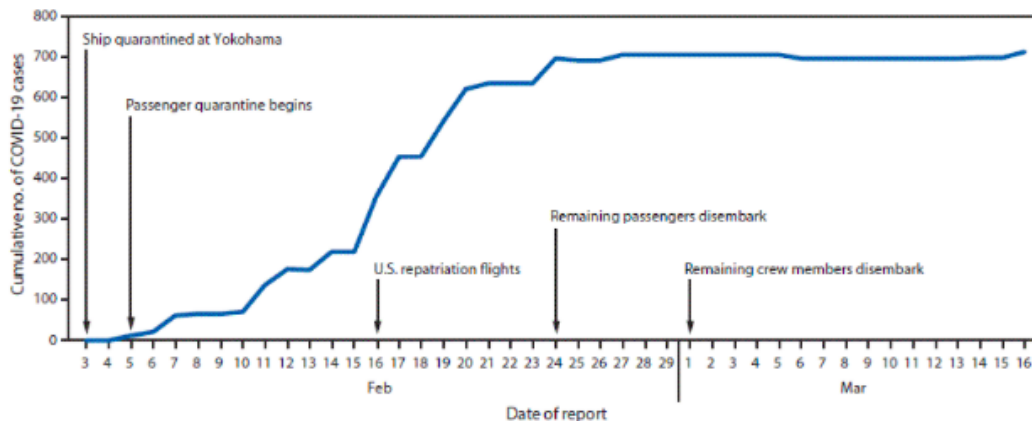
Facility B; King County, WA

- 30% prevalence of SARS-CoV-2 within 16 days of introduction into Facility
- “Among 23 (30%) residents with positive test results, 10 (43%) had symptoms on the date of testing, and 13 (57%) were asymptomatic. Seven days after testing, 10 of these 13 previously asymptomatic residents had developed symptoms” Kimball et al 2020

Kimball A, Hatfield KM, Arons M, et al. Asymptomatic and Presymptomatic SARS-CoV-2 Infections in Residents of a Long-Term Care Skilled Nursing Facility — King County, Washington, March 2020. MMWR Morb Mortal Wkly Rep 2020;69:377–381. DOI: <http://dx.doi.org/10.15585/mmwr.mm6913e1external icon>

Lessons Learned from Cruise Ship Investigation

FIGURE 1. Cumulative number of confirmed coronavirus disease 2019 (COVID-19) cases* by date of detection — Diamond Princess cruise ship, Yokohama, Japan, February 3–March 16, 2020



Source: World Health Organization (WHO) coronavirus disease (COVID-2019) situation reports. <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports/> [7].

* Decline in cumulative number of cases on February 13 and February 25 due to correction by WHO for cases that had been counted twice.

Cruise Ship N=3,711
19.2% positive for SARS-CoV-2

Clinical Status	Number of Patients (%) N=712
Asymptomatic	331 (46.5%)
Symptomatic	381 (53.5%)
Intensive Care	37 (9.7%)
Fatal	8 (2.1%)

Moriarty LF, Plucinski MM, Marston BJ, et al. Public Health Responses to COVID-19 Outbreaks on Cruise Ships — Worldwide, February–March 2020. MMWR Morb Mortal Wkly Rep 2020;69:347–352.

DOI: <http://dx.doi.org/10.15585/mmwr.mm6912e3external icon>

Epidemiological Studies Provide Needed Evidence for Disease Control

Types of Evidence Needed for Controlling an Epidemic.

Evidence Needed	Study Type
No. of cases, including milder ones	Syndromic surveillance plus targeted viral testing
Risk factors and timing of transmission	Household studies
Severity and attack rate	Community studies
Severity “pyramid”	Integration of multiple sources and data types
Risk factors for infection and severe outcomes, including death	Case–control studies
Infectiousness timing and intensity	Viral shedding studies

Natural History of Disease → Registries

Treatment/Vaccine Effectiveness and Safety → Real World Evidence

Lipsitch M, Swerdlow D, Finelli L. 2020. Defining the Epidemiology of Covid-19 – Studies Needed. N Engl J Med 2020; 382:1194-1196.

It's More Than the Curve: Concluding Remarks

- ami.patel@jefferson.edu



Spread the Science, *NOT* the Virus Series

Next Week: Impact on our Healthcare System

Drew Harris, DPM, MPH

4/22/20 4-5pm

Register [here](#) or at:

<https://www.jefferson.edu/university/population-health/degrees-programs/public-health/seminar-series-covid19-spread-the-science.html>

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