

Wastewater Epidemiology and Disinfection of SARS-CoV-2

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SARS- CoV-2 Studies Underway

- Sewage surveillance of
 - Communities
 - Dormitories
- Determination of infectivity of SARS-CoV-2 in wastewater
- Survival of SARS-CoV-2 in wastewater
- Disinfectant assessment
 - UV light
 - Chloramines
- Persistent anti-viral coatings and fabrics
 - Anti-viral clothing (Masks and protective equipment)



Sewage Surveillance

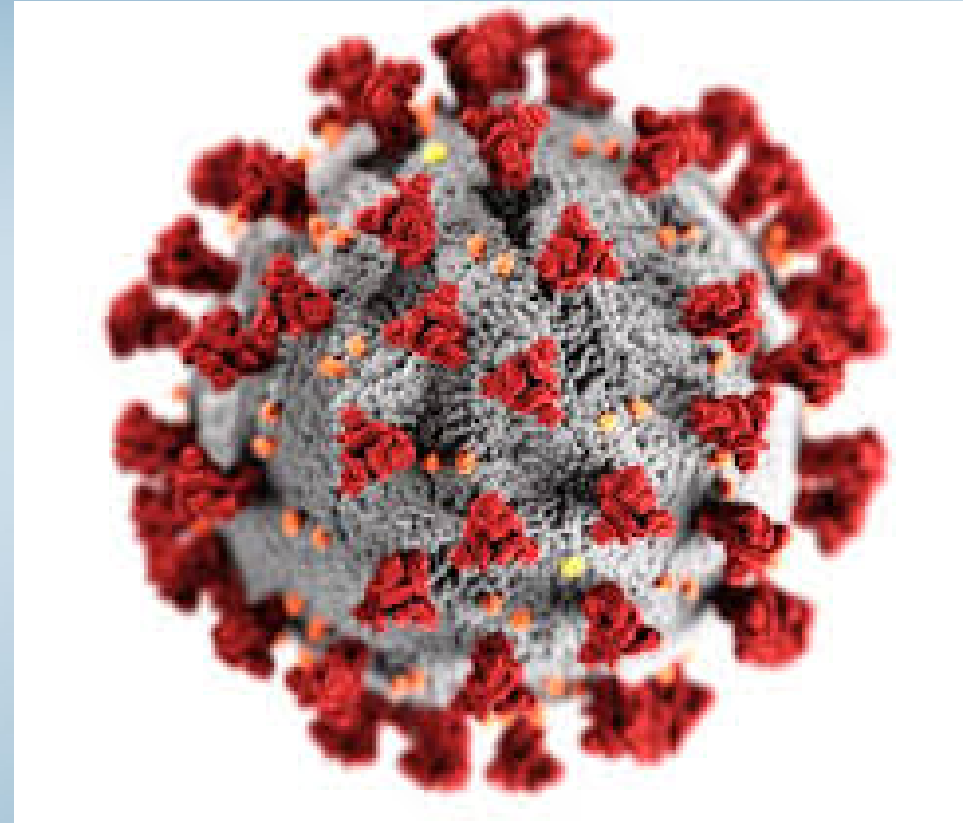
- The virus concentration in sewage is related to the number of cases in a community
- Goes back more than 40 years for detecting poliovirus cases in communities – in use by poliovirus eradication program
- Advantages:
 - Can detect one case of infection in 100,000 persons
 - Can determine success or failures of interventions
 - Can predict the number of cases 7 to 10 days before clinical cases are recognized
 - Can be use to identify facilities with infected individuals
 - Less costly than large numbers of clinical tests

LIMITATIONS WITH CLINICAL DATA

- Limited test availability
- Test negative on Monday – What about Tuesday?
- Asymptomatic carriers often not tested
- Lag in reporting cases
- Test efficacy: False –ve and False +ve results

CORONAVIRUS

- Group of viruses that cause disease in mammals and birds
- Humans: respiratory infections
 - Usually mild
 - Severe diseases: SARS and MERS
- Named for the 'corona' (crown) shaped spikes

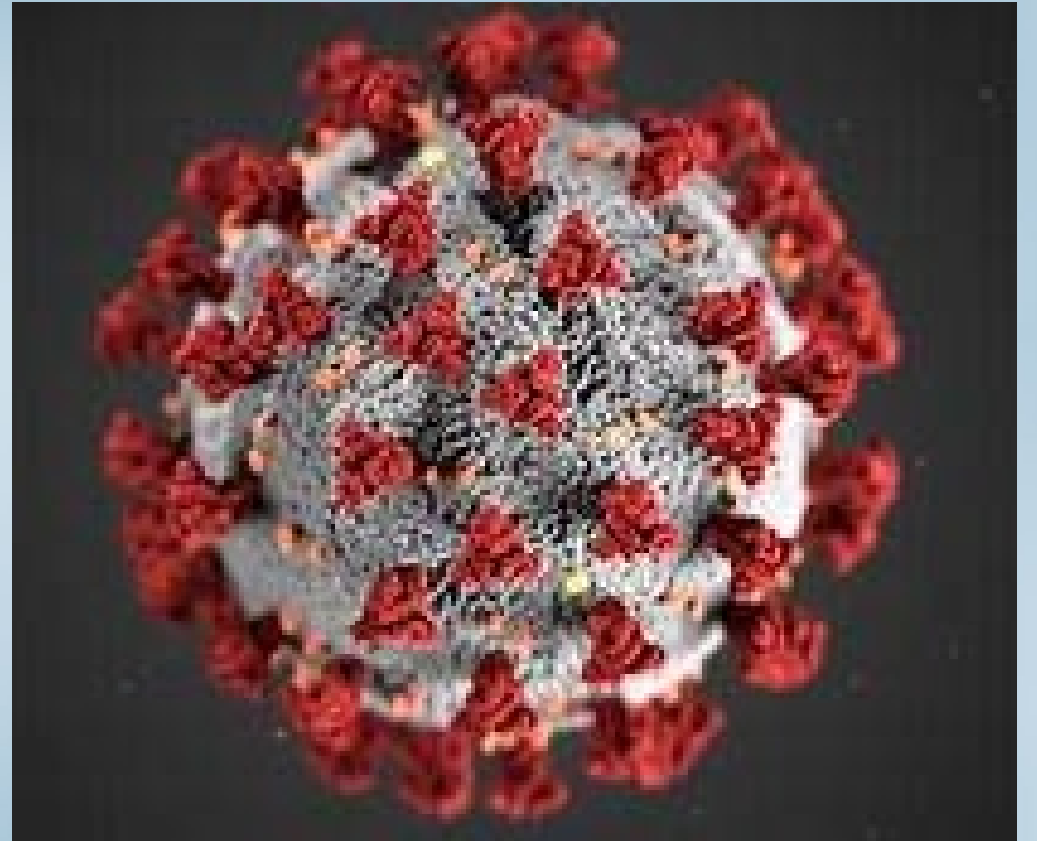


HUMAN CORONAVIRUSES

- HCoV- OC43 common cold
- HCoV-229E common cold
- SARS-CoV severe Acute Respiratory Syndrome
- MERS-CoV Middle East Respiratory Syndrome
- SARS-CoV-2 COVID-19

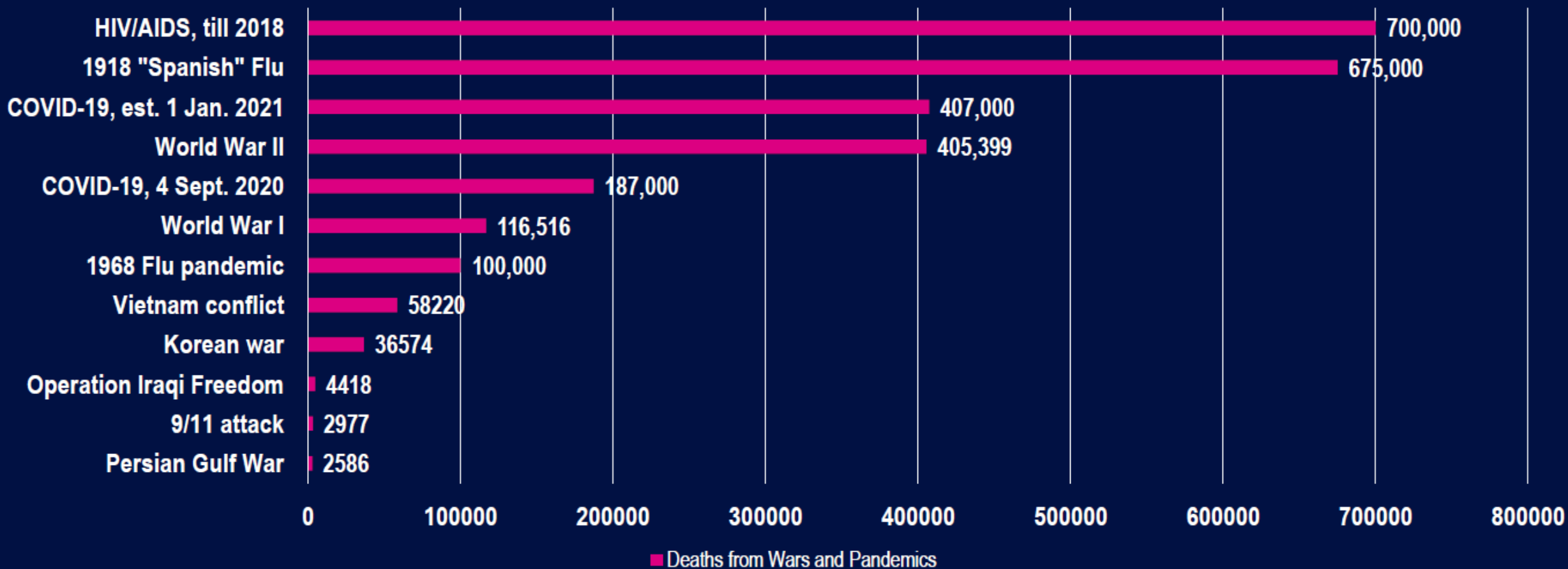
Coronaviruses

- An enveloped virus
- ssRNA
- Survives several days in wastewater/ water
- Excreted in both the urine and feces



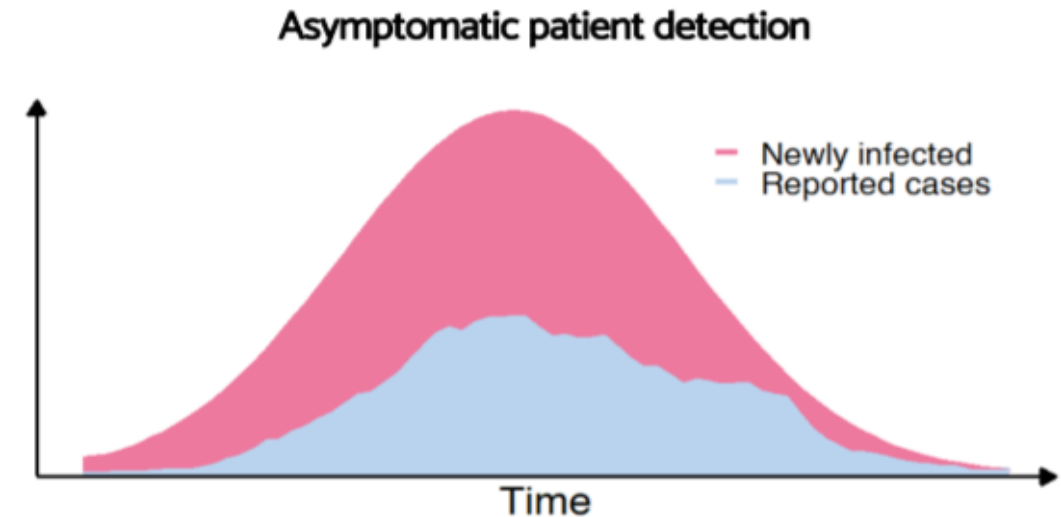
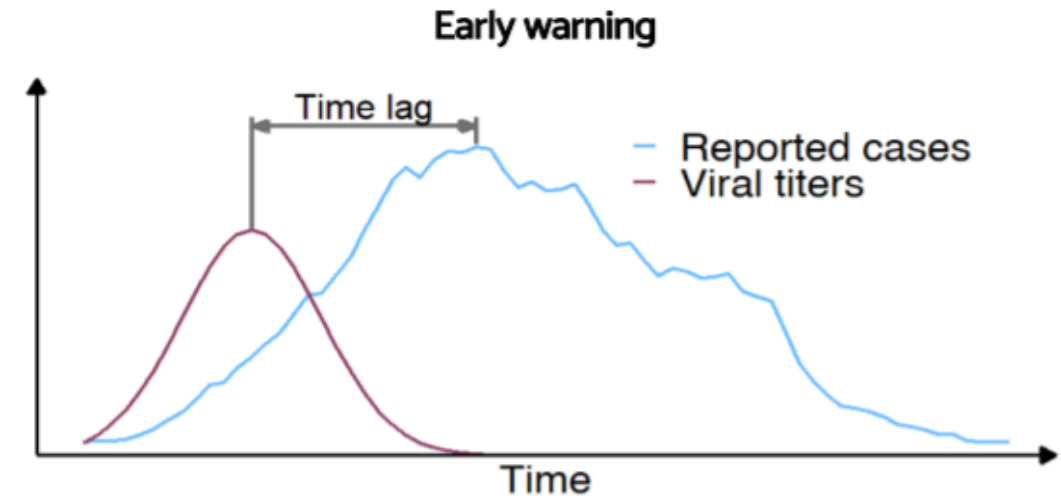
DEATHS FROM COVID-19 AND OTHER PANDEMICS AND WARS, US

Deaths from Wars and Pandemics

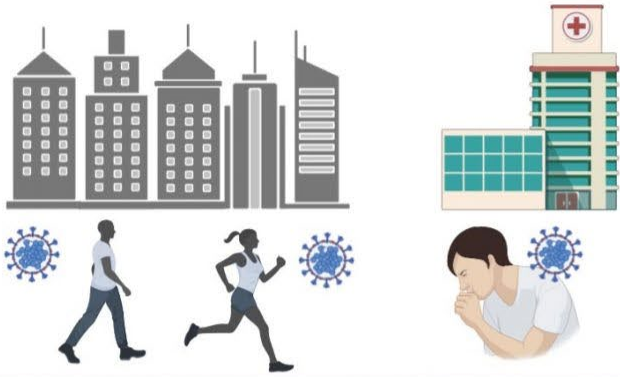


Advantages of Wastewater Epidemiology

	Diagnose-based	Wastewater-based
Coverage	Individual	Community
Potential bias	High, depending on the testing policy	Low
Operational cost	High	Low
Early warning	Not supported	Supported
Asymptomatic patient detection	Not supported	Supported
Testing capacity requirement	High	Low



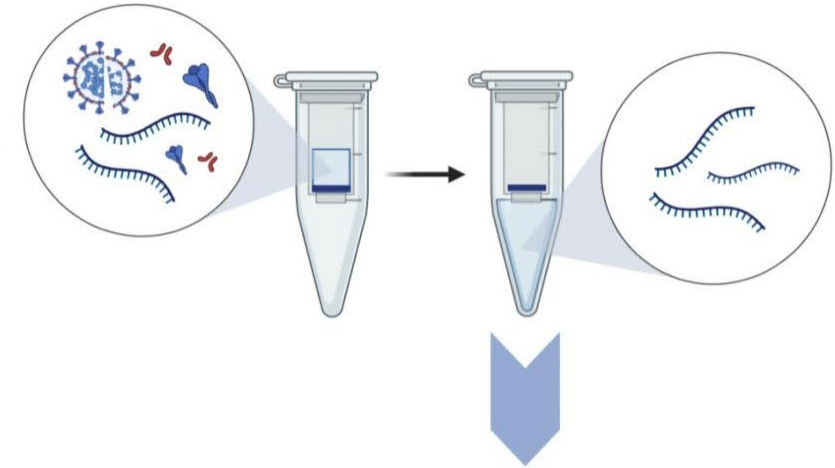
COVID-19 prevalence



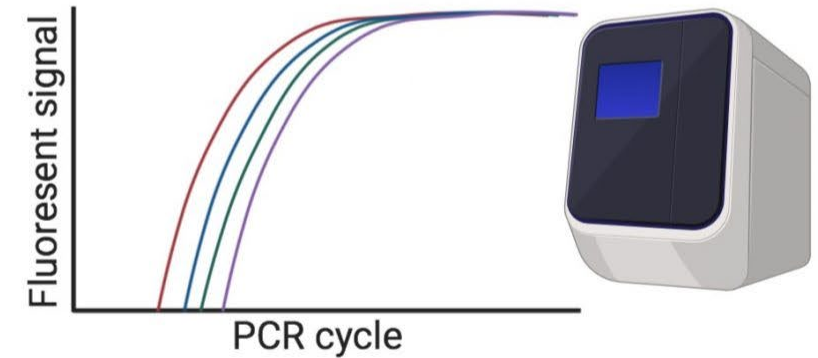
Virus concentration



Viral RNA extraction



Quantitative PCR



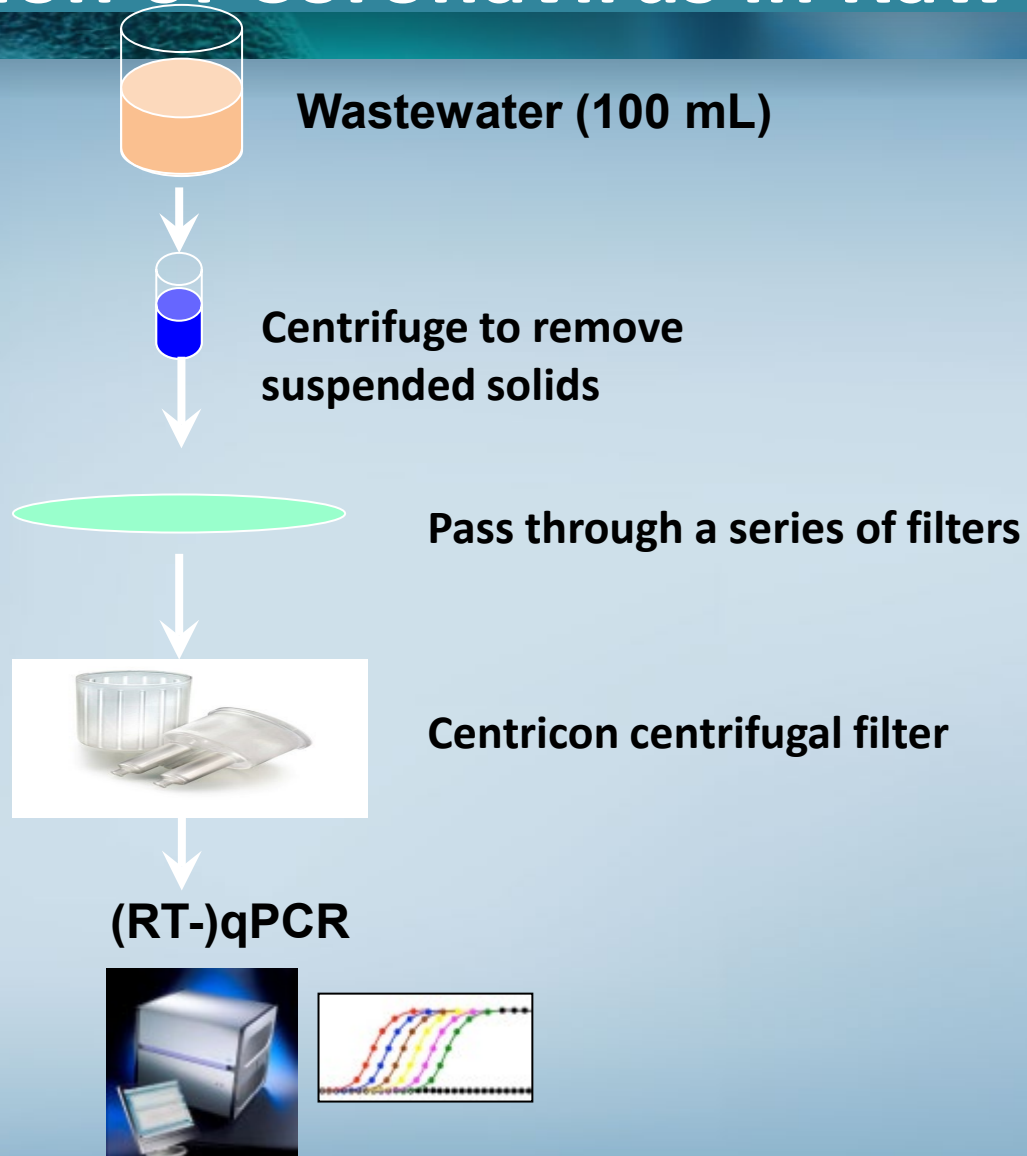
Wastewater treatment plant

SARS-CoV-2 in wastewater

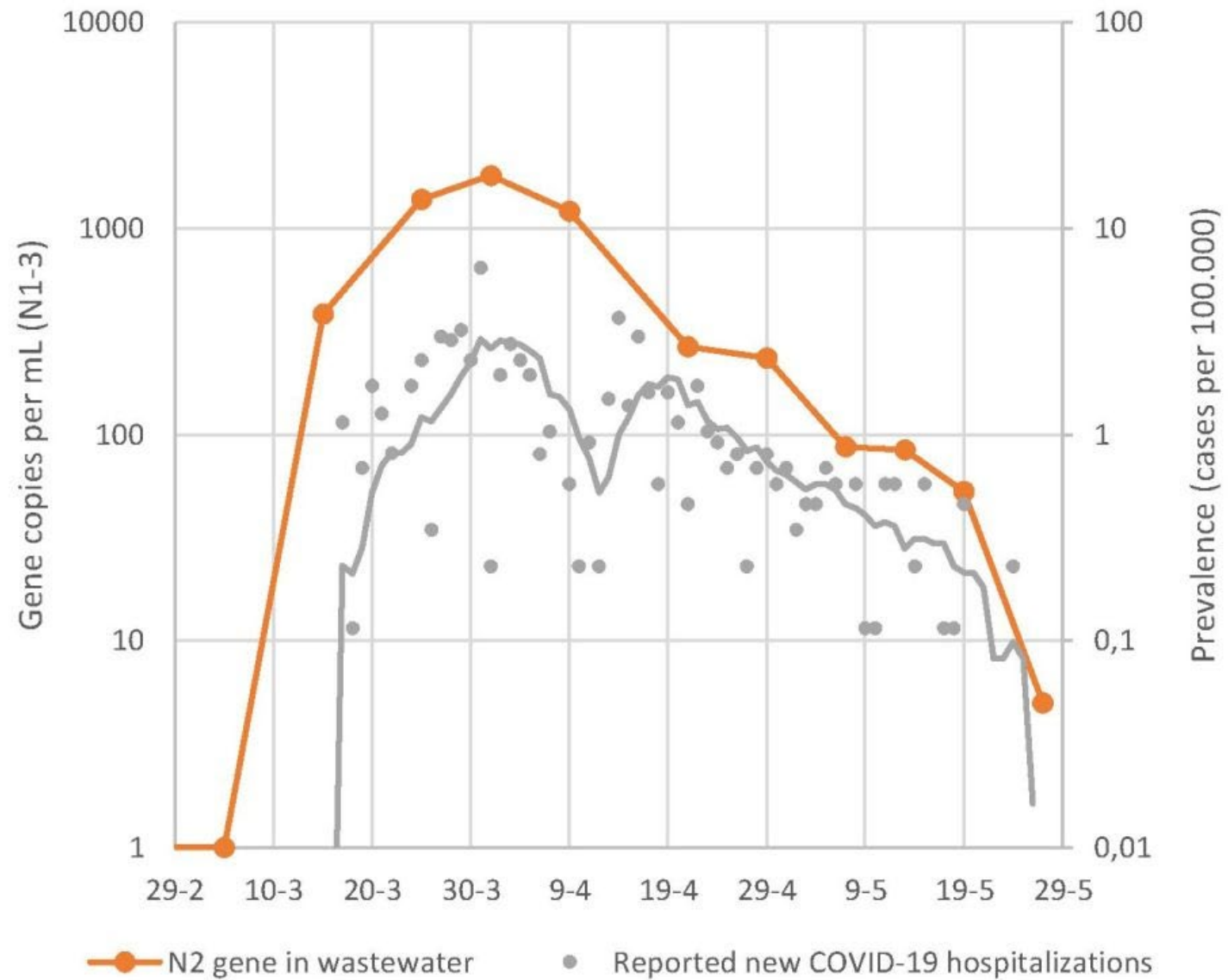
Detection & quantification of SARS-CoV-2 RNA

METHODS

Detection of Coronavirus in Raw Wastewater



Amsterdam



SENSITIVITY OF WBE: AGUA NUEVA WWTP

- “Stay at home” order in Arizona
 - Approximately 2-4 weeks later, virus concentrations and case count decrease
- “Re-open economy” order in Arizona
 - Approximately 7 days later virus concentrations increase
 - Approximately 2 weeks later, case count increases
- Three National holidays: Memorial Day, Independence Day, Labor Day
 - Approximately 1 week after each holiday virus concentrations increase
 - Approximately 2 weeks after each holiday case count increases

Epidemiological Modeling Assistance

Bradley Schmitz, PhD

Environmental Scientist
Water Resources



LOUDOUN WATER

LOUDOUN WATER

Modeling SARS-CoV-2 data

Bradley Schmitz, PhD
Environmental Scientist

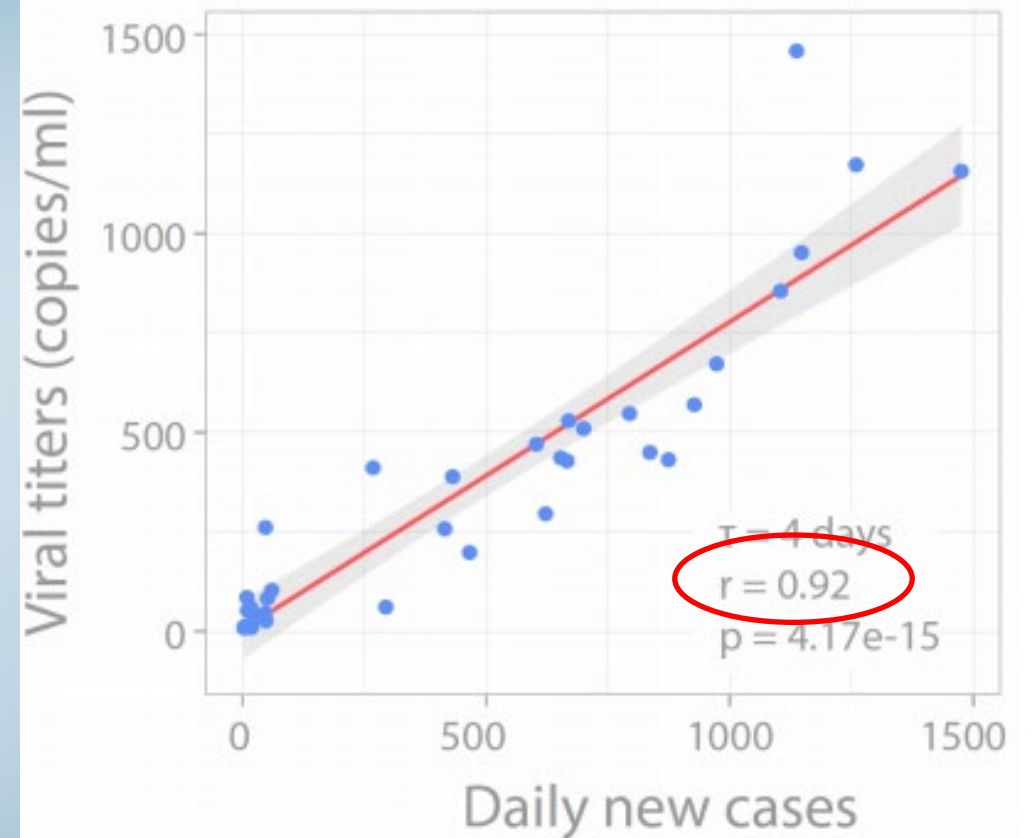
Pima County Data Modeling Efforts

Correlations

LOUDOUN WATER

Compare		tau	p	z
conc	model	0.898933	0.000328	3.5921
conc	infection	0.6	0.01667	36
model	infection	0.595437	0.007348	2.6806
conc	new	0.466667	0.07255	33
model	new	0.473296	0.03311	2.1308

- Modeled data is synonymous with observed data 👍
- Modeled data positively correlates with total infections 👍
- Model data positively correlates with new cases 👍
 - Observed RT-qPCR does not correlate with new cases, modeled data is more 'accurate'



CORRELATIONS

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Collecting Wastewater from Dorms





From 100 samples/year to 100 samples/Week

Level of Concern	Wastewater Virus Concentration	Action Item
	(gene copies/L)	
0	Non-detect	No action item
1	$10^1 - 10^2$	Enhanced awareness and disinfection
2	$10^3 - 10^4$	20% random testing
3	$10^5 - 10^6$	40% random testing
4	10^7	All residents tested

FALL CAMPUS RE-ENTRY BEGINS AUGUST 2020

- **Aug 18-24** Students begin returning
- **Aug 24** Fall semester begins
- **Aug 25** Wastewater positive from Likins Hall

All hell breaks loose

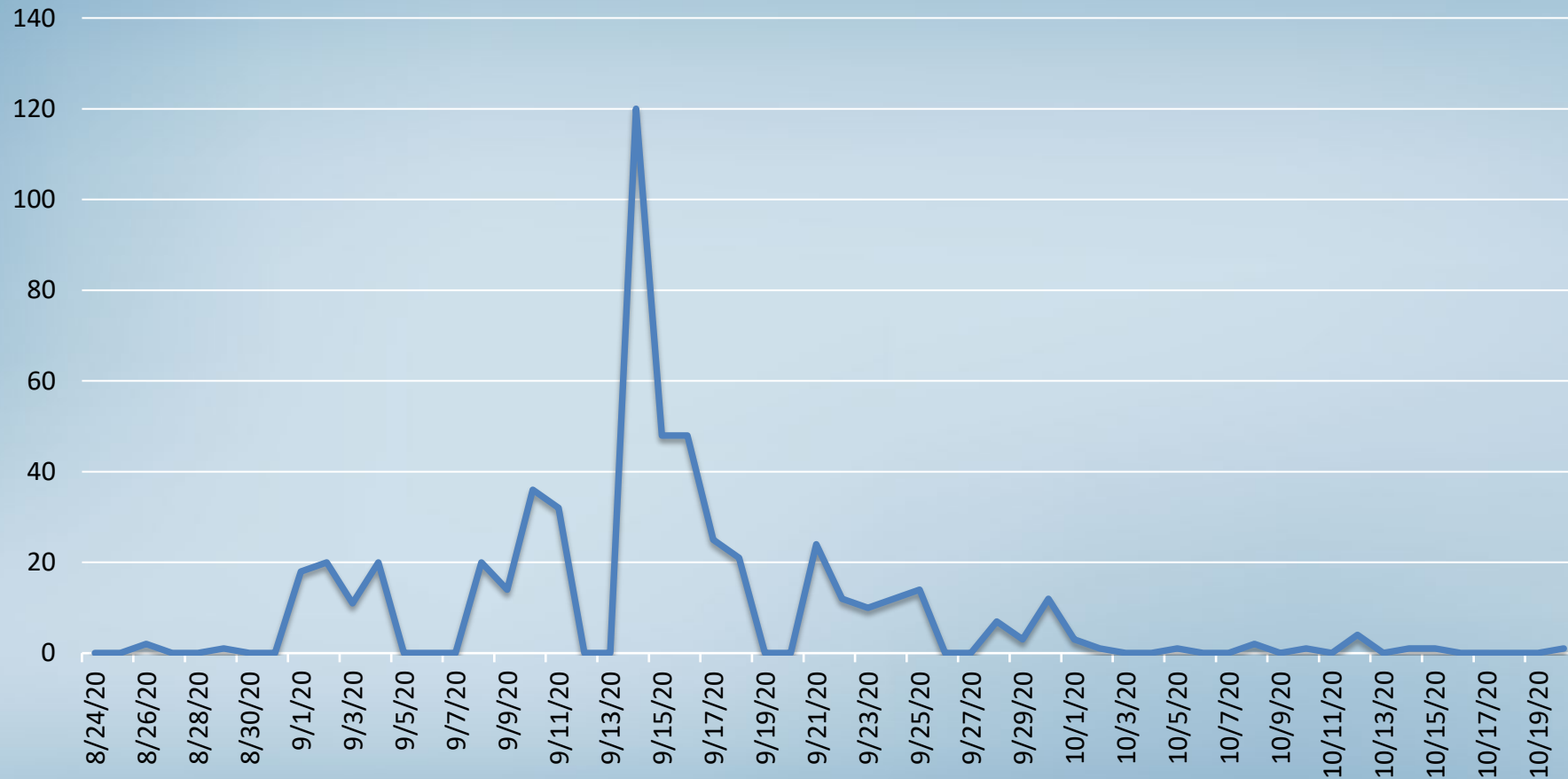
- **Aug 25**
 - 6:00pm results reported
 - 11:00pm Dr. Pepper awoken by President Robbins phone call
- Decisions made to retest wastewater and clinically test all students for COVID-19
- **Aug 26**
 - 5 wastewater samples collected – all positive
 - Clinical COVID tests identify two asymptomatic, but infected students

HOW WBE REDUCED EXPONENTIAL SPREAD OF COVID-19



Effectiveness of the COVID-19 Containment Strategy at the University of Arizona

Clinical Cases in Monitored Dorms



No new cases from 10/17 To 11/30

WBE accuracy as an early-warning diagnostic for new cases of COVID-19

			Clinical Results	
			Positive	Negative
Wastewater Results	↕	Positive	91	20
		Negative	23	185

Sensitivity (79.8%)

Specificity (90.2%)

Positive predictive value (82.0%)

Negative predictive value (88.9%)

What have we learned – sewage monitoring for SARS-CoV-2 at the University of Arizona and Tucson

- Grab samples collected in the morning works in identifying cases
- Can identify as few as 2 infected students in a dorms of ~327
- No viruses detected in sewage after infected students removed
- Four-day lead on identifying cases before positive clinical test by student health center
- Concentration of virus increases in community sewage after Memorial day, 4th of July, Labor, Thanksgiving and New Year day before increase seen in clinical cases
- Social distancing, use of masks, and stay in place decreased concentration of virus in sewage
- Virus concentrations in dorm sewage with infected individuals range from 1e3 to 1e9 per liter

What is needed

- Development of standard methods
 - Several companies are producing SARS-CoV-2 test kits for wastewater testing
- Tools for data analyses
- Education and training
 - Most health departments do not know how to use the data
 - Many potential applications
 - » – quantifying successes of interventions
 - » -targeting interventions to greatest number of cases with a region
- National network data collection
 - 100 treatment systems will be in a nationwide network in the U.S. (NIH/CDC)

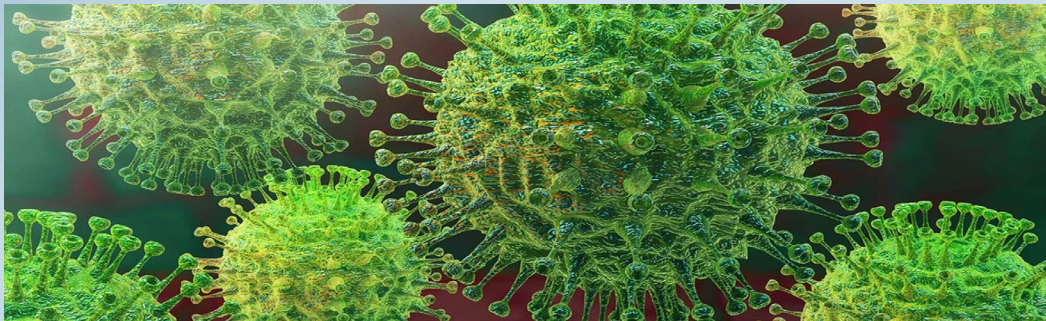
Life in the 21st Century

- More people work in offices than ever before
- We travel more than ever before
- We spend less time cleaning than the last generation (50% less than 50 years ago)
- We spend more time in public places (and larger ones)

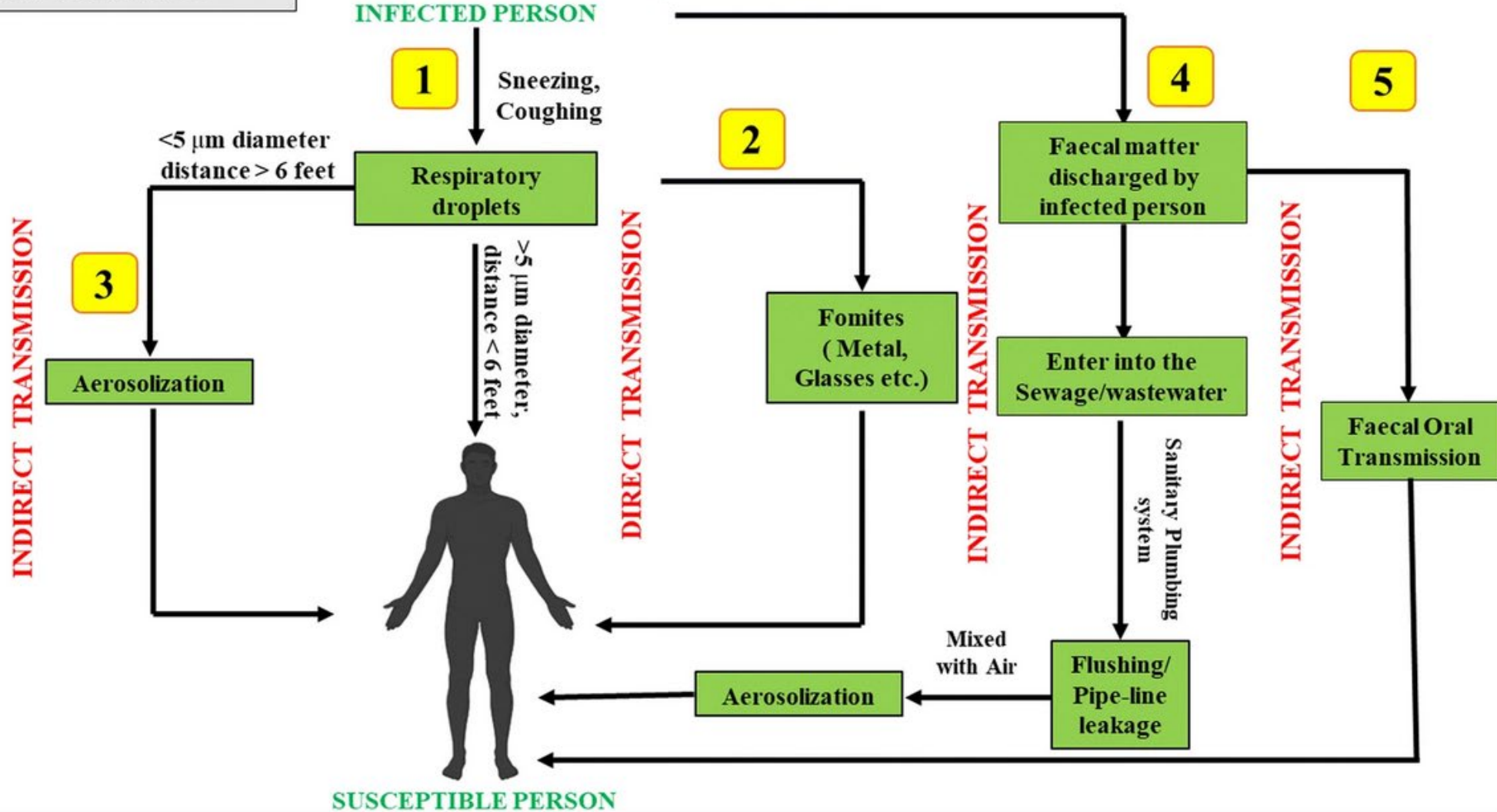
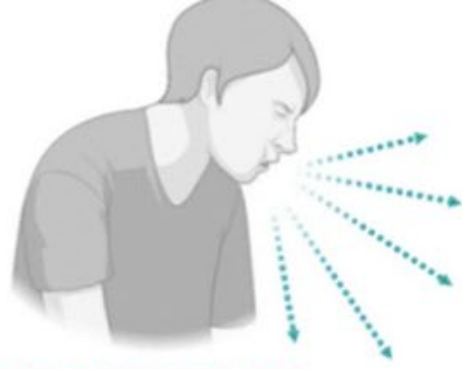


Life in the 21st Century

- We share more common surfaces (fomites) with more different people than ever before in history
- As a result, we share more germs with more people than at any time in history
- The “perfect storm” for transmission of CoVid-19



1. Human to human direct Transmission
2. Indirect transmission via fomites
3. Airborne Transmission
4. Transmission via contaminated water
5. Faecal Oral Transmission



Studies on transfer of Coronavirus (229E) from surfaces to fingers

- For use in quantitative microbial risk assessment
- No previous data on finger transfer of enveloped viruses
 - Laminate 6.5%
 - Glass 4%
 - Glazed Porcelain 49%
 - Formica 26%



Boeing Aircraft – Confident Travel Project

Issue

- Provide solutions to prevent the spread of SARS-Co-V 2 in commercial aircraft and airports
- Wanted an outside university partner to build consumer confidence

Solutions

- Developed a “pandemic toolbox” of innovative interventions to control SARS-CoV-2



Developing a “Toolbox” of environmental interventions



Persistent quats

Anti-viral
Polymeric
Silinated
Quats – last
from 48 hrs to
90 days



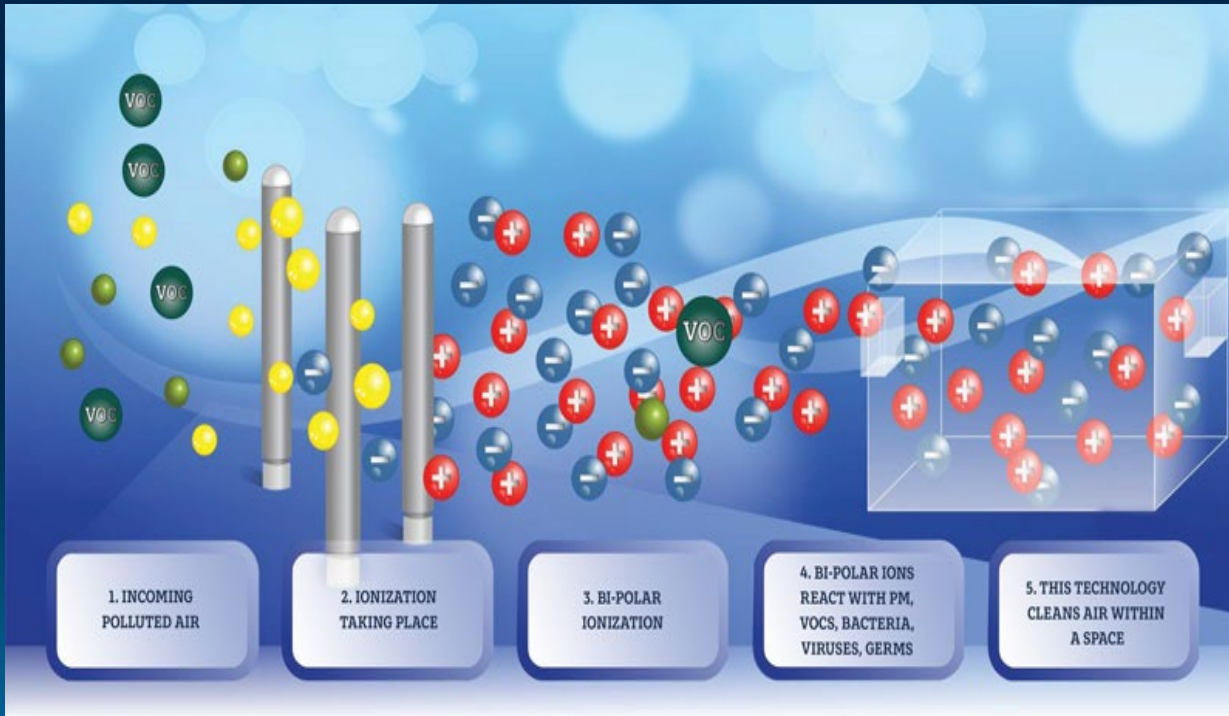
Coatings and paints



Anti-viral
copper
containing
paints

Developing a “Toolbox” of environmental interventions for Aerosols

- Bi-polar ionization can be used to disinfect air when people in the rooms
- 254 vs 222 nm
- 222 nm can be used with people in the room



Bi-polar Ionization

Skin Absorption Penetration Showing 222nm vs. 254nm

Structure of the Epidermis

The diagram shows a cross-section of the epidermis with layers: Stratum corneum, Stratum lucidum, Stratum granulosum, Stratum spinosum, and Stratum basale. The Dermis is shown below. A 222nm UV light beam is shown penetrating through the Stratum corneum and Stratum lucidum, being absorbed in the Stratum granulosum. A 254nm UV light beam is shown penetrating through the Stratum corneum, Stratum lucidum, and Stratum granulosum, being absorbed in the Stratum spinosum. An arrow indicates that skin becomes 'YOUNG' as the 222nm light penetrates deeper.

Care 222

222nm light is absorbed by dead skin cells

UV light

Studies on thermal disinfection of SARS-CoV-2 on different surfaces – How do you inactivate SARS-CoV2 in a Flight Deck ?

- Greater inactivation on metal surfaces vs plastic
- Greater inactivation at 50-60% RH than at <20% RH
- Temperatures of 40 to 55 C for 1 to 2 hours



The background of the slide is a microscopic view of numerous rod-shaped bacteria. The bacteria are rendered in shades of blue and teal, with a highly textured, almost fibrous surface. They are scattered across the frame, some in sharp focus and others blurred, creating a sense of depth. The lighting is soft, highlighting the three-dimensional structure of the organisms.

Questions

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