

# NEW INSIGHTS ON WASTEWATER-BASED EPIDEMIOLOGY TO MONITOR COVID-19

*Ian Pepper*, Regents Professor  
The University of Arizona  
Water and Energy Sustainable Technology Center (WEST)



**BIOFEST**  
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# BENEFITS OF WBE

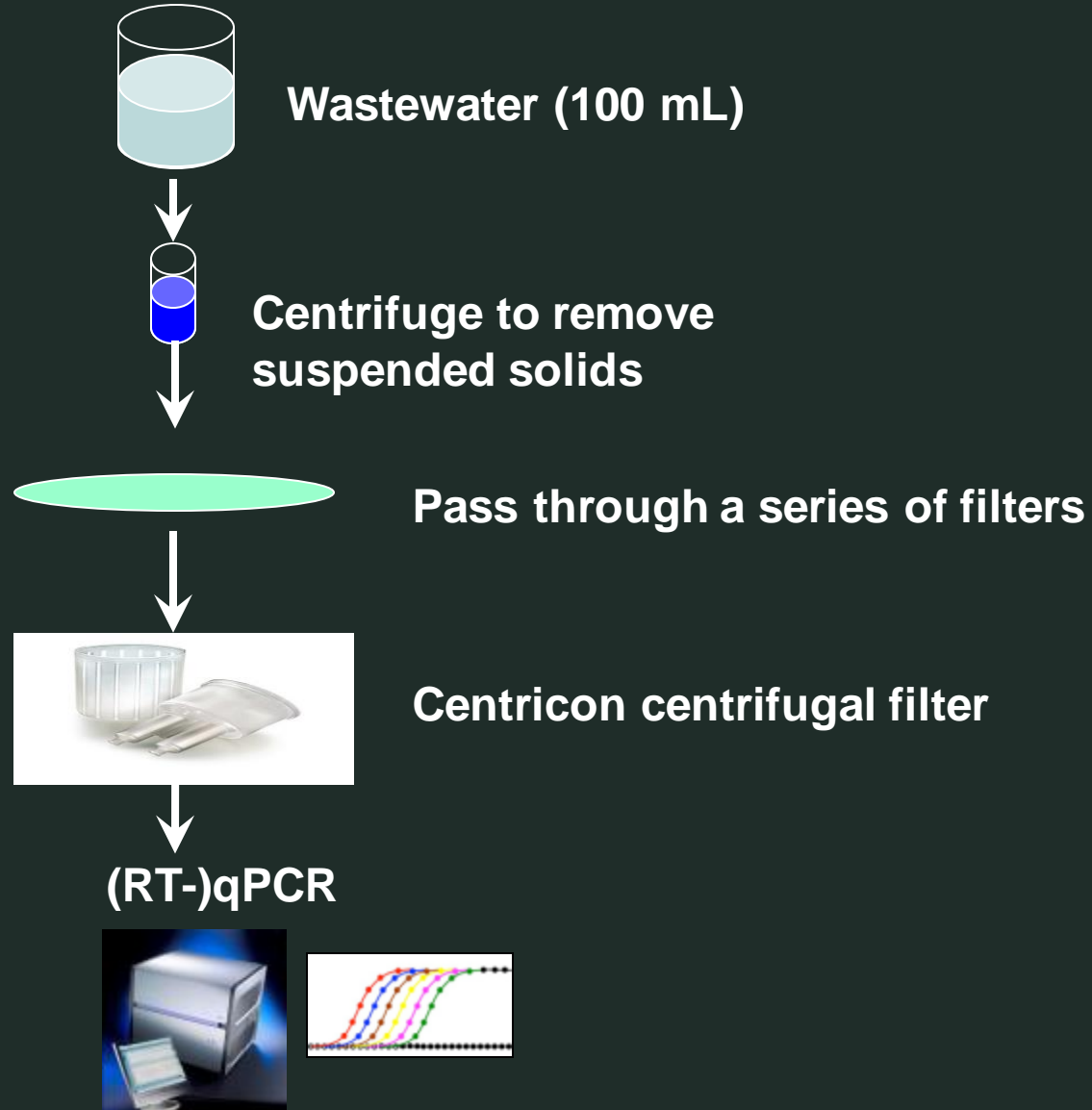
- One test monitors defined community such as wastewater treatment plant service area or student dorm
- Highly sensitive: can detect 1 infection in 10,000 individuals
- Gives total virus load shed into wastewater including virus from symptomatic and asymptomatic individuals
- Is a leading indicator – can be detected in sewage 4-7 days prior to symptoms developing

# ADDITIONAL BENEFITS OF WBE

- Useful for detecting onset of a pandemic
- *Quantitative* data over time determines if pandemic is ↑ or ↓
- Allows determination of whether or not a community could/should return to work
- Can be used to evaluate the success (or lack thereof) of interventions such as mandated mask usage or social distancing
- Correlation of virus wastewater concentration (gene copies) with the number of clinical cases allows for future predictions of #s of infections

# METHODS

## Detection of Coronavirus in Raw Wastewater



# SPRING 2020

- Pandemic begins
- Spring Break (March) University of Arizona shuts down
- Students leave
- All classes online
- **Costs UA  $\approx$  \$100m**

# UNIVERSITY OF ARIZONA CAMPUS RE-ENTRY PLANS FOR FALL 2020

- 7 teams established June 2020
- COVID-19 testing of humans (RT PCR)
- Antibody testing (Elisa IgG Antibody Test)
- Contact tracing (In person and app. Based)
- Isolation (segregated dorms or hotels)
- Health Data Management and Communication (HIPAA and FERPA compliant data management)
- Thermometry (temperature measurement of individuals)
- **WBE: US! (Dormitory testing for early detection of in-house infections)**

# DORMS TESTED

- Maricopa
- Kaibab/Huachuca/Arizona
- Sonora
- Arbol de la Vita
- Graham/Greenlee
- La Paz
- La Cienega
- San Pedro
- Santa Cruz
- **LIKINS**

# Collecting Wastewater from Dorms





# UNIVERSITY OF ARIZONA CAMPUS RE-ENTRY PLANS FOR FALL SEMESTER 2020

- 7 teams met and planned from June → August
- Discussions on how often to clinically test students
- Discussions on how often to test dorm wastewater
- Discussions on how to respond to a positive wastewater result

# 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

- The two infected students were asymptomatic
- Without WBE detection and isolation, they would have spread COVID-19 to other students
- This scenario has been repeated  $\approx 80$  times
- University has successfully remained open
- Influence of “Shelter in Place” reflected in wastewater virus concentrations

# OVERALL STORY RESULTED IN MEDIA FRENZY!

- Broadcasts with CNN, NPR, CBS, NBC, ABC
- Publications in “The Atlantic” and “Politico”
- 300 media hits in September

# NATIONAL HEADLINES

*The University of Arizona says it caught a dorm's covid-19 outbreak before it started. Its secret weapon: Poop.*

**How the University of Arizona used No. 2 to solve its No. 1 problem: The coronavirus**

**University of Arizona's wastewater testing halts potential surge in COVID-19 cases at dorm**

**University of Arizona wastewater testing finds virus at dorm, prevents outbreak**

**Wastewater helps find positive COVID-19 cases at UA dorm**

**Poop tests stop COVID-19 outbreak at University of Arizona**

**UA wastewater testing finds COVID-19 cases in dorm**

**Researchers at the University of Arizona say they stopped a coronavirus outbreak before it spread by testing students' poop**

**University of Arizona catches asymptomatic coronavirus cases through wastewater testing**

# 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%)

# META DATA FOR STUDENT DORMS

Dorm	Fall 2020 Occupancy	Capacity	Room Type	Bathrooms
A	611	722	Single, double	Community, all-gender
B	342	400	Single, double	Community
C	123	181	Single, double, triple	Community
D	623	731	Single, double, suite-style	Suite
E	206	300	Single, double	Community, all-gender
F	56	60	Single	Community
G	231	300	Apartments	In-room (1 per bedroom)
H	195	238	Single, double	Community, all-gender
I	181	238	Single, double	Community, all-gender
J	424	482	Single, double	Community
K	328	369	Double	Community, all-gender
L	76	106	Single, double, triple	Community, sink-in-room
M	132	152	Single, double	Community

# CLINICAL TESTING

- Antigen tests from nasal swab samples
- RT-PCR tests from nasopharyngeal swab samples

## Campus Health Services (CHS) Testing

- Used for individuals with symptoms

## Test All Test Smart (TATS)

- Used for non self reporting individuals (asymptomatic and sub-clinical)
- Used at dorms with positive wastewater detection of SARS-CoV-2



# CLINICAL POSITIVES FOR COVID-19 IN DORMS

Dorm	Clinical	Symptomatic (CHS)		Asyptomatic (TATS)	
	Positives	Total	Percent	Total	Percent
A	164	35	21.3	129	78.7
B	82	16	17.4	76	82.6
C	10	3	30.0	7	70.0
D	171	34	19.9	137	80.1
E & F	16	8	50.0	8	50.0
G	2	0	0.0	2	100.0
H & I	74	17	23.0	57	77.0
J	111	16	14.4	95	85.6
K	66	15	22.7	51	77.3
L	0	0	--	0	--
M	5	4	80.0	1	20.0
<b>Total</b>	<b>711</b>	<b>148</b>	<b>20.8</b>	<b>563</b>	<b>79.2</b>

# WBE AS A TOOL TO PREDICT THE TOTAL NUMBER OF INFECTIONS IN A COMMUNITY

**Approach:** *Use the Curtis Equation*

**Predicted # Infections:**

$$\frac{\text{virus wastewater concentration} \times \text{wastewater flow rate}}{\text{amount of feces per person} \times \text{community fecal shedding rate}}$$

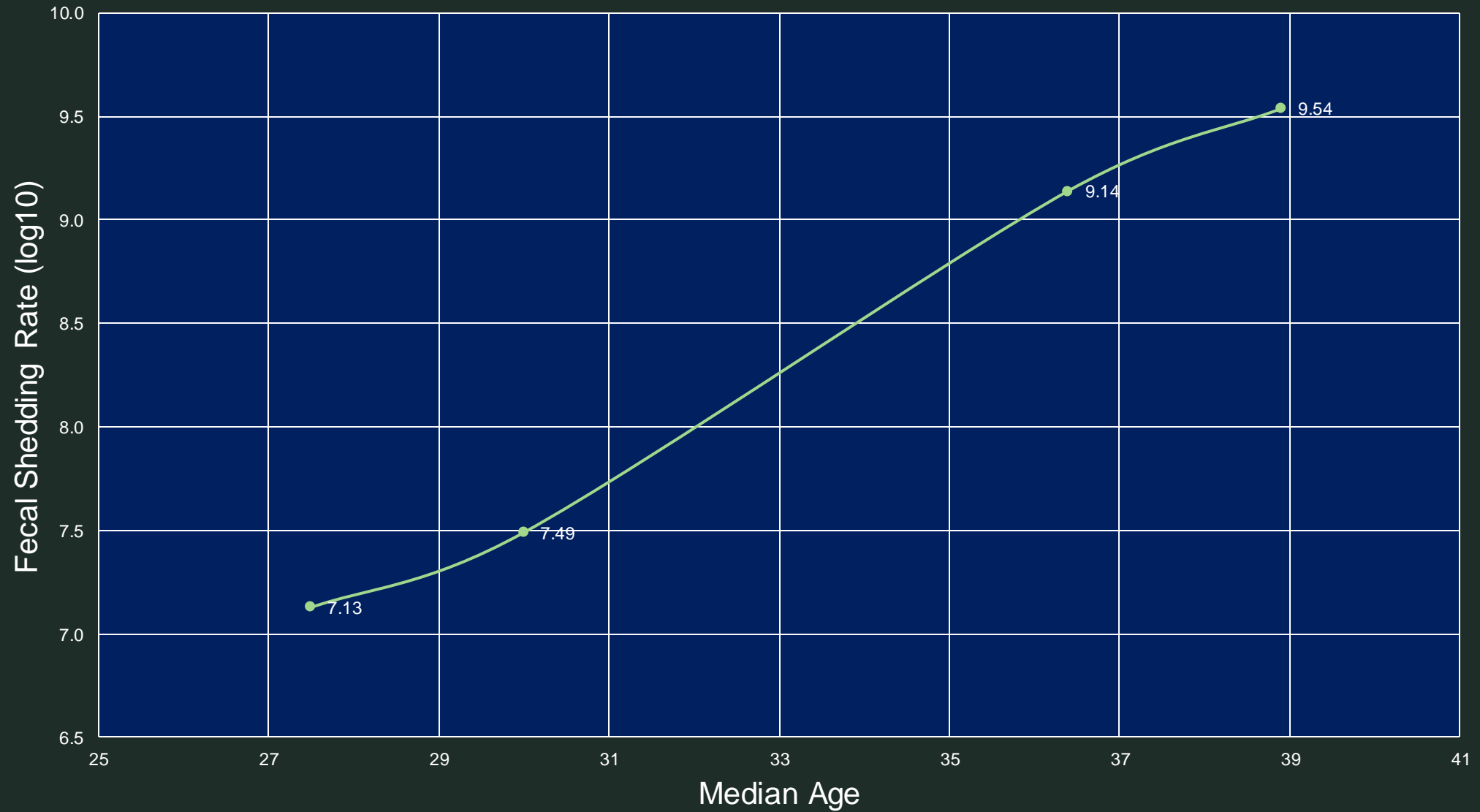
Two unknown in the equation:

- i) Predicted # infections in the community
- ii) Community fecal shedding rate

# COMMUNITY FECAL SHEDDING RATE

- Community fecal shedding rate different for different communities e.g., student dorm vs wastewater treatment plant service area
- Depends on demographics of the community
- Shedding rate increases as median age increases

# Fecal Shedding Rate (log10) vs Median Age



# DETERMINATION OF COMMUNITY SHEDDING RATE

- Measure SARS-CoV-2 concentration in wastewater from a utility, on 20-30 different days
- For each day get reported # new cases
- For total number of infections use EPA Best Estimate:

EPA Best Estimate = Reported # cases x 4.3

This is equivalent to 72% asymptomatic cases

- Use Curtis Equation for utility service area

Fecal Shedding Rate =

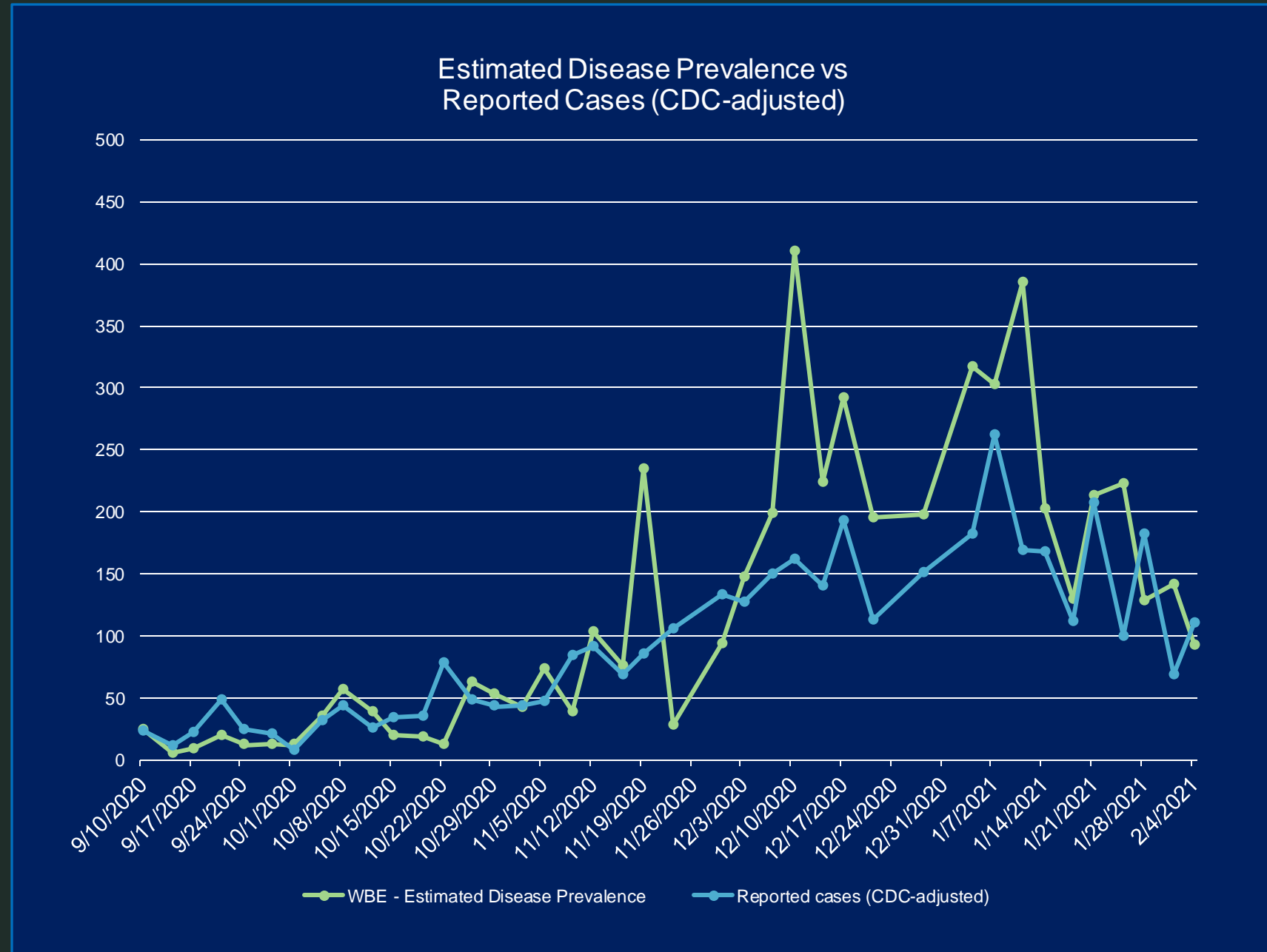
$$\frac{\text{virus concentration} \times \text{wastewater flow rate}}{\text{amount of feces per person} \times \text{Best Estimate of infections}}$$

- Calculate shedding rate 20-30 times to get mean shedding rate

# PREDICTION OF INFECTIOUS CASES

- Community shedding rate now known
- Measure virus concentration in new wastewater samples
- Now only one unknown (same day)
- Use Curtis Equation to calculate predicted number of infections

# Wastewater-Based Epidemiology (WBE) for Estimation of Disease Prevalence



# MONITORING FOR CORONAVIRUS VARIANTS

## 1) Variants of concern (VOC):

British B.1.1.7

South African B.1.351

Brazilian P.1

California B.1.427/B.1.429

India B.1.617

- Out of control in many parts of the world such as India
- VOCs
  - more transmissible
  - more deadly

## 2) PCR based detection of variants:

### GT Molecular

- N501Y mutation = Variant present (B.1.1.7, P.1, and/or B.1.351)
- 69-70 deletion = B.1.1.7

### Bio-Rad 3-Plex

- N501Y mutation = Variant present (B.1.1.7, P.1, and/or B.1.351)
- E484K mutation P.1 and/or B.1.351

### GT Molecular 4-Plex

- L452R mutation = B.1.427 / B.1.429
- E484Q mutation = B.1.617

### GT Molecular 5-Plex

- N501Y mutation = Variant present (B.1.1.7, P.1, and/or B.1.351)
- E484K mutation = P.1 and/or B.1.351

Note that sequencing may be required to distinguish which specific variant(s) is present.



# MONITORING FOR INFLUENZA

- Already collecting wastewater samples for COVID-19 monitoring
- Already processing samples for PCR analysis for COVID
- Cost effective to also monitor for influenza



# **WASTEWATER-BASED EPIDEMIOLOGY**

***POOP NEVER LIES!***

**University of Arizona**