WRF Webcast
Coronavirus Disease 2019 (COVID-19) Latest Research Update

April 16, 2020

3:30 pm – 5:00 pm ET USA

Webcast Host

Lola Olabode, MPH, BCES

The science is rapidly moving, and the technical recommendations are changing!

Housekeeping Items

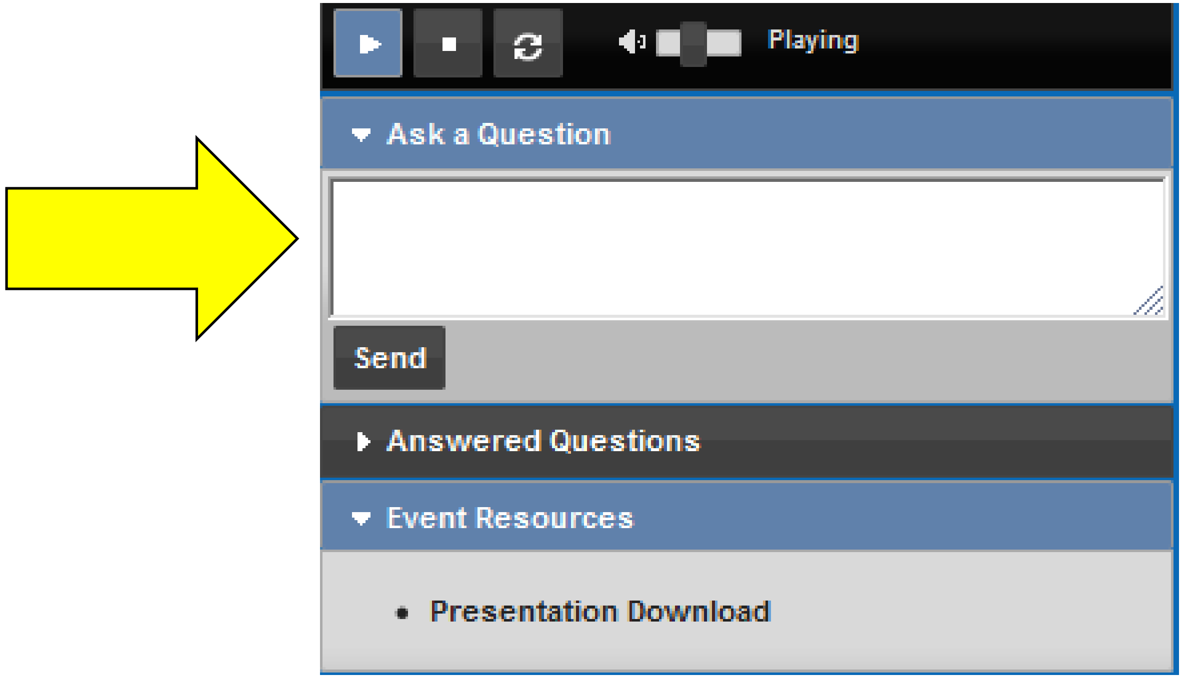
- Submit questions through the question box at any time! We will do a Q&A near the end of the webcast.

- Slides and a recording of the webcast will be available at www.waterrf.org.

- Send an email to Michelle Suazo at msuazo@waterrf.org for a PDH certificate.

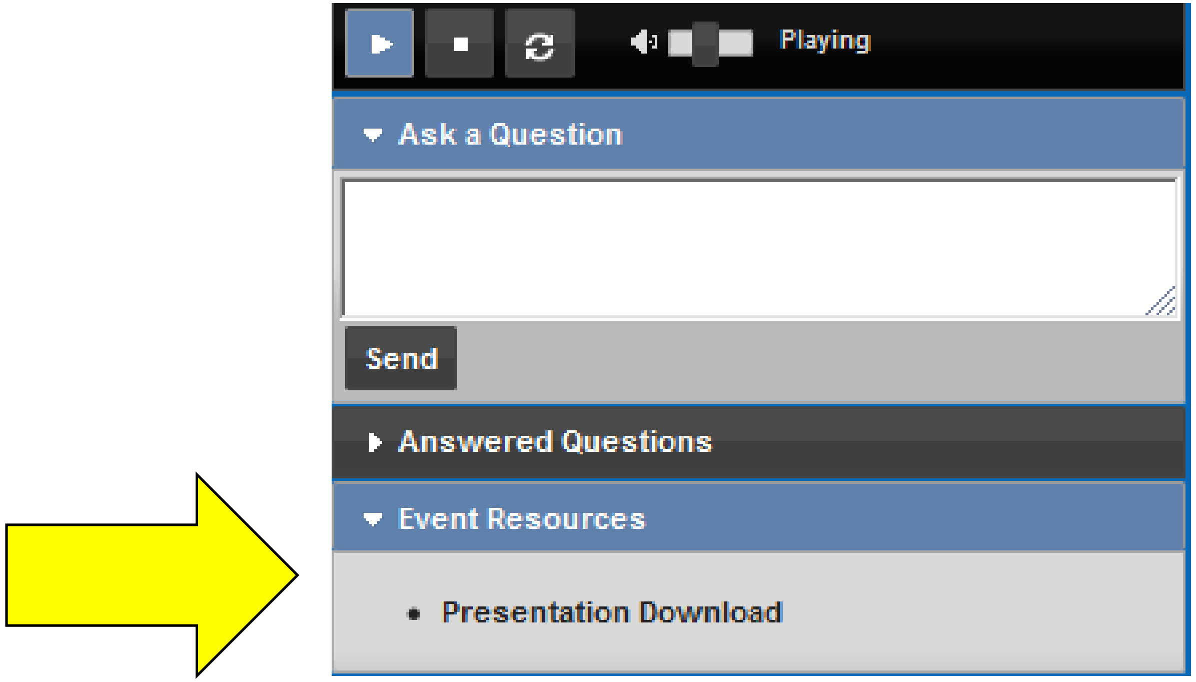
- Survey at the end of the webcast.

Input your webcast questions here



Q&A at end of webcast

Download presentation



Slides and recording will be available within 24 hours after the webcast

Webcast Agenda

TIME	Content	Presenter
3:30 – 3:40p	Webcast Host – Introductions, Live Poll	Lola Olabode, MPH, BCES The Water Research Foundation
3:40 – 3:45p	WRF CEO Welcome	Peter Grevatt, PhD The Water Research Foundation
3:45 - 3:50p	Technical Moderator and A Risk Assessment Update and Perspective	Charles Haas, PhD Drexel University, WRF Academic Council
3:50 – 4:00p	CDC's Current Update on COVID-19	Matthew Arduino, DrPH Centers for Disease Control and Prevention
4:00 – 4:10p	The Survivability of the COVID-19 Virus in Air, Water, Wastewater, and Various Surfaces	Charles Gerba, PhD University of Arizona
4:10 – 4:20p	Overview of the COVID-19 Virus Loads in Human Samples and Using Predictive Models to Predict Fate in the Environment	Krista Wigginton, PhD University of Michigan
4:20 – 4:30p	The Dutch Case Study on Sewage Surveillance of COVID-19	Gertjan Medema, PhD KWR Water Research Institute in Nieuwegein, the Netherlands
4:30 – 4:40p	Overview of PPEs and the Current Implications and Applicability to COVID-19	Mark LeChevallier, PhD Dr. Water Consulting, LLC
4:40 – 5:00p	Q&A	Dr. Haas and Lola Olabode

Live Poll #1: What geographical location are you calling in from today?

- Eastern US
- Midwest US
- Western US
- Canada
- Mexico
- Central America and the Caribbean
- South America
- Sub-Saharan Africa
- Middle East, North Africa and Greater Arabia
- Europe
- Asia
- Australia and Oceania

Live Poll #2: Please identify your affiliation:

- Academia
- Utilities
- Government
- Media
- Consultant/Industry
- Non-profit or Non government organization
- Health care
- Private citizen

Live Poll #3: Why are you interested in today's webcast? (Multiple Choices Allowed)

- I want the most up-to-date research on COVID-19 to remain informed.
- I want to know what measures exist to protect both workers and public health in general.
- We have cases in my area.
- I am a first-line responder and I'm not sure what to do.
- I travel often and worried about safety.
- I want to know the latest public health recommendations as of April 16, 2020 (today).
- I want to know more about containing and combating community spread.

WRF CEO Welcome

Peter Grevatt, PhD

A Risk Assessment Update and Perspective

Charles Haas, PhD
Drexel University, WRF Academic Council

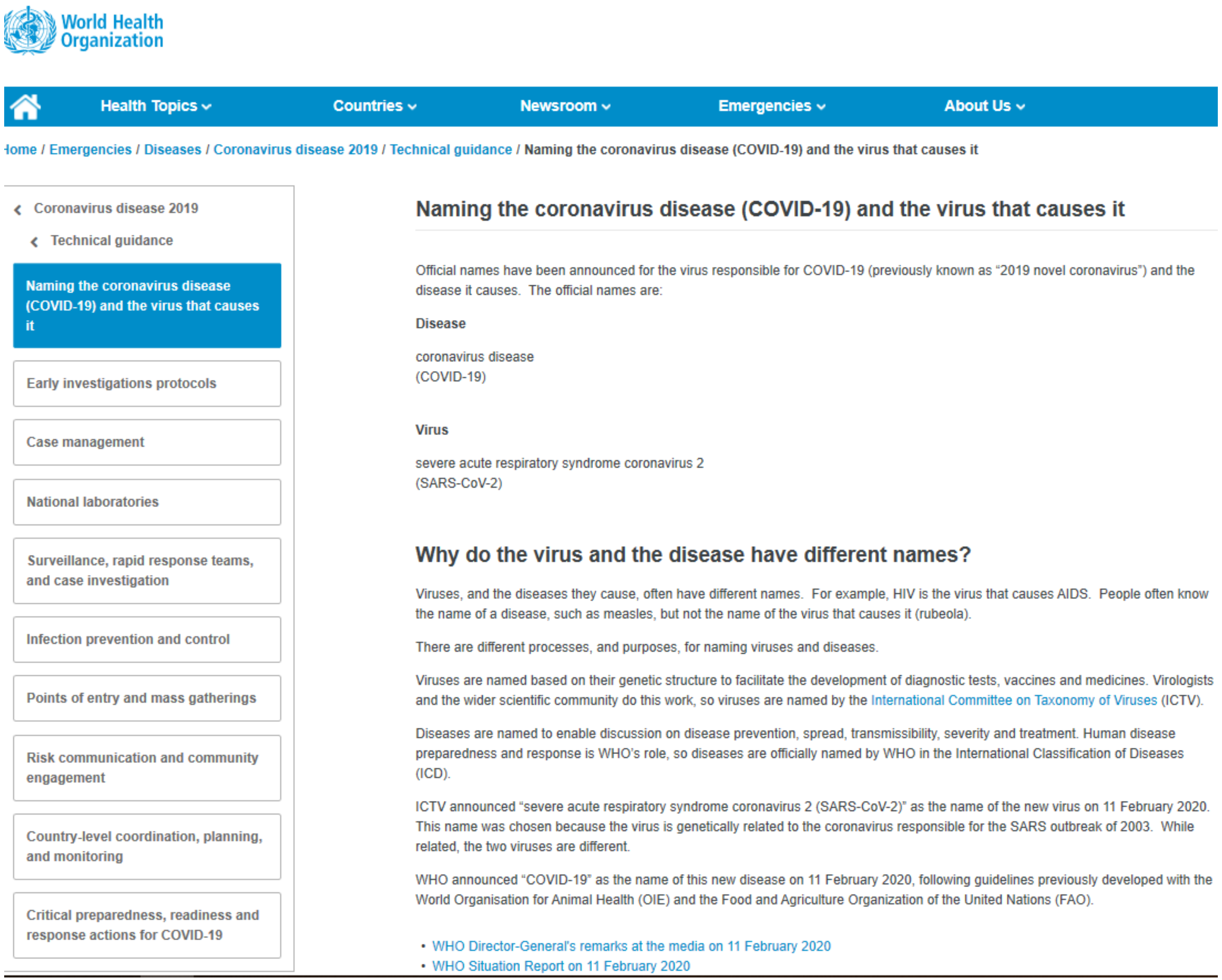
Nomenclature

COVID-19

- COVID-19 refers to the disease

SARS-CoV-2
2019-nCoV and COVID-19 virus

- All refer to the virus that results in COVID-19



World Health Organization

Health Topics | Countries | Newsroom | Emergencies | About Us

Home / Emergencies / Diseases / Coronavirus disease 2019 / Technical guidance / Naming the coronavirus disease (COVID-19) and the virus that causes it

- Coronavirus disease 2019
- Technical guidance
- Naming the coronavirus disease (COVID-19) and the virus that causes it
- Early investigations protocols
- Case management
- National laboratories
- Surveillance, rapid response teams, and case investigation
- Infection prevention and control
- Points of entry and mass gatherings
- Risk communication and community engagement
- Country-level coordination, planning, and monitoring
- Critical preparedness, readiness and response actions for COVID-19

Naming the coronavirus disease (COVID-19) and the virus that causes it

Official names have been announced for the virus responsible for COVID-19 (previously known as “2019 novel coronavirus”) and the disease it causes. The official names are:

Disease

coronavirus disease
(COVID-19)

Virus

severe acute respiratory syndrome coronavirus 2
(SARS-CoV-2)

Why do the virus and the disease have different names?

Viruses, and the diseases they cause, often have different names. For example, HIV is the virus that causes AIDS. People often know the name of a disease, such as measles, but not the name of the virus that causes it (rubeola).

There are different processes, and purposes, for naming viruses and diseases.

Viruses are named based on their genetic structure to facilitate the development of diagnostic tests, vaccines and medicines. Virologists and the wider scientific community do this work, so viruses are named by the International Committee on Taxonomy of Viruses (ICTV).

Diseases are named to enable discussion on disease prevention, spread, transmissibility, severity and treatment. Human disease preparedness and response is WHO’s role, so diseases are officially named by WHO in the International Classification of Diseases (ICD).

ICTV announced “severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)” as the name of the new virus on 11 February 2020. This name was chosen because the virus is genetically related to the coronavirus responsible for the SARS outbreak of 2003. While related, the two viruses are different.

WHO announced “COVID-19” as the name of this new disease on 11 February 2020, following guidelines previously developed with the World Organisation for Animal Health (OIE) and the Food and Agriculture Organization of the United Nations (FAO).

- WHO Director-General's remarks at the media on 11 February 2020
- WHO Situation Report on 11 February 2020

https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/naming-the-coronavirus-disease-(covid-2019)-and-the-virus-that-causes-it

Knowns and Unknowns

Unknowns

- Concentration of viable virus in wastewater (and its variability)
- Is SARS dose response relationship applicable?
- We believe WWTP's can adequately control, but needs confirmation
  - Fate & transport in biosolids

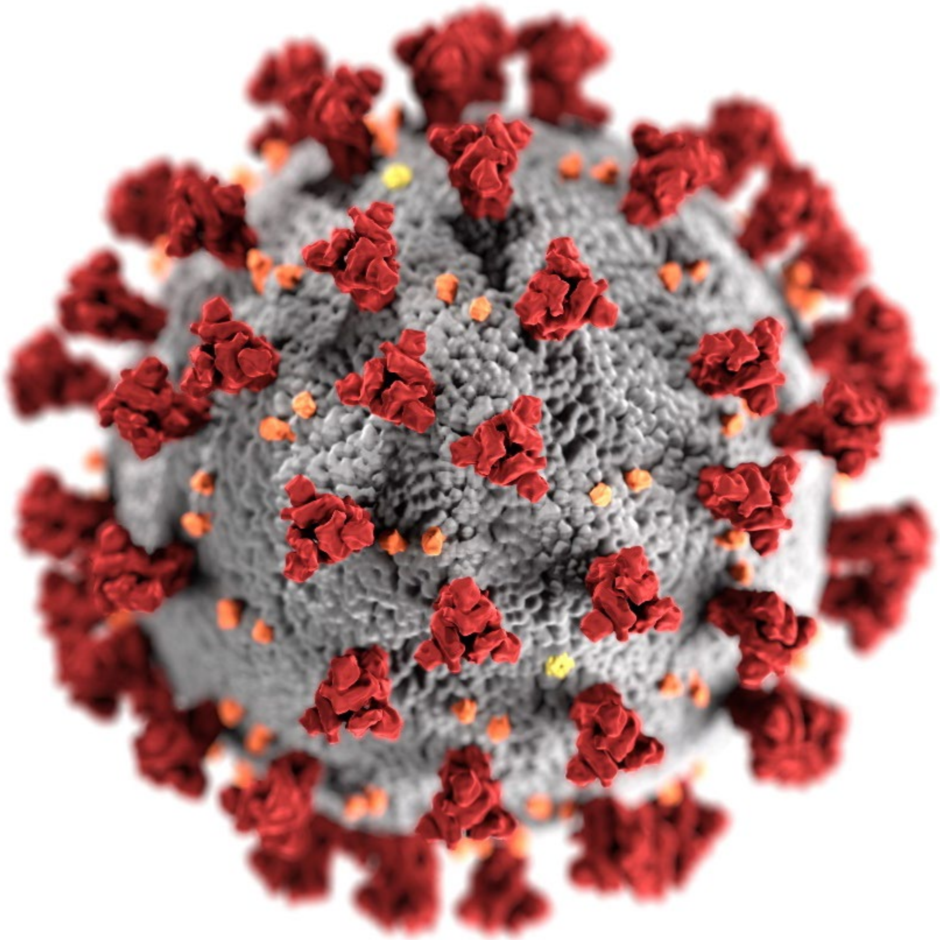
Knowns

- Framework for risk to sewer collection workers has been established
- No oral route (aspiration?)

CDC's Current Update on COVID-19

Matthew Arduino, DrPH
Centers for Disease Control and Prevention

Novel Coronavirus for Water Professionals



Matthew J Arduino, MS, DrPH, FSHEA, M(ASCP)

April 16, 2020

COVID-19: Situation Overview

- As of 15 April 2020:
  - WHO reports 1,914,916 cases and 123,010 deaths from the 6 WHO Regions; (Africa, Americas, Eastern Mediterranean, Europe, South-East Asia, and Western Pacific) (WHO SITUATION REPORT 86 WHO COVID-2019 SIT REPS)
  - As of 15 April 2020 (16:00 EST) in the US and Territories: (Daily Report)
    - Total cases: 605,390
    - Total deaths: 24,582
    - Jurisdictions reporting cases: 55 (50 States, District of Columbia, Guam, Puerto Rico, the Northern Mariana Islands, and the U.S. Virgin Islands)
  - COVID-19 Weekly Surveillance Summary

COVID-19: Social Distancing

- Also called "physical distancing"; keep space between yourself and others
- Can help slow ongoing spread of respiratory illnesses, like COVID-19
- This can include:
  - Personal protective measures
    - Maintain 6 ft. from others in public
    - Stay home if exposed or sick
  - Community measures
    - Postpone or cancel mass gatherings
    - Dismissal of schools
    - Encourage telework

Use of Cloth Face Coverings to Help Slow the Spread of COVID-19

- Wear a cloth face covering to cover their nose and mouth in the community setting
- In situations where you may be near people
- Not a substitute for social distancing
- Not intended to protect the wearer, but it may prevent the spread of virus from the wearer to others

https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/diy-cloth-face-coverings.html

COVID-19: Shedding

– Patients shed virus into their environment:
  - Primarily from respiratory tract
  - Stools have high PCR positivity (two reports from China have recovered culturable virus from small number of patients, but these have not been reproducible)
  - All healthcare contamination studies have been PCR based both air samples and surface samples. U Nebraska included culture in an attempt to recover infections virus but has not been successful to date.
  - Recent report from the Netherlands of RNA detected in wastewater and the possibility of using PCR as a surveillance tool

Fecal Shedding From Patients

- The combination of very high virus RNA concentrations and occasional detection of sgRNA-containing cells in stool indicate active replication in the gastrointestinal tract
- Our failure to isolate live SARS-CoV-2 from stool may be due to the mild courses of cases, with only one case showing intermittent diarrhea
- Further studies should therefore address whether SARS-CoV-2 shed in stool is rendered non-infectious though contact with the gut environment
- Initial results suggest that measures to contain viral spread should aim at droplet-, rather than fomite-based transmission.

Article

Virological assessment of hospitalized patients with COVID-2019

https://doi.org/10.1038/s41586-020-2196-x
Received: 1 March 2020
Accepted: 24 March 2020
Published online: 1 April 2020

Roman Wölfel[1,6], Victor M. Corman[2,6], Wolfgang Guggemos[3,6], Michael Seilmaier[3], Sabine Zange[1], Marcel A. Müller[2], Daniela Niemeyer[2], Terry C. Jones[2,4], Patrick Vollmar[1], Camilla Rothe[5], Michael Hoelscher[5], Tobias Bleicker[2], Sebastian Brünink[2], Julia Schneider[2], Rosina Ehmann[1], Katrin Zwirglmaier[1], Christian Drosten[2,7]✉ & Clemens Wendtner[3,7]✉

Coronavirus disease 2019 (COVID-19) is an acute respiratory tract infection that emerged in late 2019[1,2]. Initial outbreaks in China involved 13.8% cases with severe, and 6.1% with critical courses[3]. This severe presentation corresponds to the usage of a virus receptor that is expressed predominantly in the lung[2,4]. By causing an early onset of severe symptoms, this same receptor tropism is thought to have determined pathogenicity, but also aided the control, of severe acute respiratory syndrome (SARS) in 2003[5]. However, there are reports of COVID-19 cases with mild upper respiratory tract symptoms, suggesting the potential for pre- or oligosymptomatic transmission[6–8]. There is an urgent need for information on body site-specific virus

Wölfel R, et al. Virological assessment of hospitalized patients with COVID-2019. Nature 2020 [Published on line 1 April 2020] https://doi.org/10.1038/s41586-020-2196-x

Is Feces Infectious?

- The risk of transmission of the virus that causes COVID-19 from the feces of an infected person is also unknown.
- The risk is expected to be low based on data from previous outbreaks of related coronaviruses, such as severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS).
- There has been no confirmed fecal-oral transmission of COVID-19 to date.

Disease among Healthcare Workers

Centers for Disease Control and Prevention
MMWR
Morbidity and Mortality Weekly Report
Early Release / Vol. 69
April 14, 2020

Characteristics of Health Care Personnel with COVID-19 — United States, February 12–April 9, 2020

CDC COVID-19 Response Team

As of April 9, 2020, the coronavirus disease 2019 (COVID-19) pandemic had resulted in 1,521,252 cases and 92,798 deaths worldwide, including 459,165 cases and 16,570 deaths in the United States (*1*,*2*). Health care personnel (HCP) are essential workers defined as paid and unpaid persons serving in health care settings who have the potential for direct or indirect exposure to patients or infectious materials (*3*). During February 12–April 9, among 315,531 COVID-19 cases reported to CDC using a standardized form, 49,370 (16%) included data on whether the patient was a health care worker in the United States, including 9,282 (19%) who were identified as HCP. Among HCP patients with data available, the median age was 42 years (interquartile range [IQR] = 32–54 years), 6,603 (73%) were female, and 1,779 (38%) reported at least one underlying health condition. Among HCP patients with data on health care, household, and community exposures, 780 (55%) reported contact with a COVID-19 patient only in health care settings. Although 4,336 (92%) HCP patients reported having at least one symptom among fever, cough, or shortness of breath, the remaining 8% did not report any of these symptoms. Most HCP with COVID-19 (6,760, 90%) were not hospitalized; however, severe outcomes, including 27 deaths, occurred across all age groups; deaths most frequently occurred in HCP aged ≥65 years. These preliminary findings highlight that whether HCP acquire infection at work or in the community, it is necessary to protect the health and safety of this essential national workforce.

Data from laboratory-confirmed COVID-19 cases voluntarily reported to CDC from 50 states, four U.S. territories and affiliated islands, and the District of Columbia, during February 12–April 9 were analyzed. Cases among persons repatriated to the United States from Wuhan, China, and the Diamond Princess cruise ship during January and February were excluded. Public health departments report COVID-19 cases to CDC using a standardized case report form* that collects information on patient demographics, whether the patient is a U.S. health care worker, symptom onset date, specimen collection dates, history of exposures in the 14 days preceding illness onset, COVID-19 symptomology, preexisting medical conditions, and patient outcomes, including hospitalization, intensive care unit (ICU) admission, and death. HCP patient health outcomes, overall and stratified by age, were classified as hospitalized, hospitalized with ICU admission, and deaths. The lower bound of these percentages was estimated by including all cases within each age group in the denominators. Upper bounds were estimated by including only those cases with known information on each outcome as denominators. Data reported to CDC are preliminary and can be updated by health departments over time. The upper quartile of the lag between onset date and reporting to CDC was 10 days. Because submitted forms might have missing or unknown information at the time of report, all analyses are descriptive, and no statistical comparisons were performed. Stata (version 15.1; StataCorp) and SAS (version 9.4; SAS Institute) were used to conduct all analyses.

Among 315,531 U.S. COVID-19 cases reported to CDC during February 12–April 9, data on HCP occupational status were available for 49,370 (16%), among whom 9,282 (19%) were identified as HCP (Figure). Data completeness for HCP status varied by reporting jurisdiction; among 12 states that included HCP status on >80% of all reported cases and reported at least one HCP patient, HCP accounted for 11% (1,689 of 15,194) of all r eported cases.

Among the 8,945 (96%) HCP patients reporting age, the median was 42 years (IQR = 32–54 years); 6,603 (73%) were female (Table 1). Among the 3,801 (41%) HCP patients with available data on race, a total of 2,743 (72%) were white, 801 (21%) were black, 199 (5%) were Asian, and 58 (2%) were

* https://www.cdc.gov/coronavirus/2019-ncov/php/reporting-pui.html.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

- Healthcare Workers account for 20% of all US acquired infections
- 9,282 cases, 27 deaths
- Median age 42 years, 73% female
- 38% had at least 1 underlying condition

https://www.cdc.gov/mmwr/volumes/69/wr/pdfs/mm6915e6-H.pdf

CDC Updates

- Symptoms
- Interim Guidelines for Collecting, Handling, and Testing Clinical Specimens for Coronavirus Disease 2019 (COVID-19)
- Testing in the United States
- Groups at Higher Risk for Severe Illness
- Cleaning and Disinfecting Your Facility
- Use of Face Coverings to Slow the Spread
- How to Protect Yourself
- Resources for Businesses and Employers

https://www.cdc.gov/coronavirus/2019-ncov/whats-new-all.html

SARS CoV-2 RNA in Wastewater

SARS-CoV-2 in wastewater: potential health risk, but also data source. The Lancet Gastroenterology and Hepatology 1 April 2020, DOI: https://doi.org/10.1016/S2468-1253(20)30087-X

Medema G, Heijnen L, Elsinga G, Italiaander R, Brouwer A. Presence of SARS-Coronavirus-2 in sewage. medRxiv 2020.03.29.20045880 doi: https://doi.org/10.1101/2020.03.29.20045880

- Data like most other environmental data is PCR based.
- PCR data alone from environmental samples means you found a sequence
- Does not indicate presence of intact virus
- Does not indicate presence of infectious virus.
- Authors suggest use for surveillance purposes

Strategies to Optimize PPE

https://www.cdc.gov/coronavirus/2019-ncov/hcp/ppe-strategy/index.html

Strategies to Optimize the Supply of PPE and Equipment

Personal protective equipment (PPE) is used every day by healthcare personnel (HCP) to protect themselves, patients, and others when providing care. PPE helps protect HCP from potentially infectious patients and materials, toxic medications, and other potentially dangerous substances used in healthcare delivery.

PPE shortages are currently posing a tremendous challenge to the US healthcare system because of the COVID-19 pandemic. Healthcare facilities are having difficulty accessing the needed PPE and are having to identify alternate ways to provide patient care.

CDC's optimization strategies for PPE offer options for use when PPE supplies are stressed, running low, or absent. Contingency strategies can help stretch PPE supplies when shortages are anticipated, for example if facilities have sufficient supplies now but are likely to run out soon. Crisis strategies can be considered during severe PPE shortages and should be used with the contingency options to help stretch available supplies for the most critical needs. As PPE availability returns to normal, healthcare facilities should promptly resume standard practices.

- Eye Protection
- Isolation Gowns
- Facemasks
- N95 Respirators
- Decontamination and Reuse of Filtering Facepiece Respirators
- Ventilators

Decontamination and Reuse of Filtering Facepiece Respirators

- **UVGI**
- **Vapor phase hydrogen peroxide**
  - Battelle Decontamination System
  - Bioquelle
  - Vaprox
- **Hydrogen peroxide plasma**
  - Sterrad
- **Moist heat (microwave; steam bag; without bag); moist heat incubation**
- **Ethylene oxide**

Decontamination and Reuse of Filtering Facepiece Respirators

Disposable filtering facepiece respirators (FFRs) are not approved for routine decontamination and reuse as standard of care. However, FFR decontamination and reuse may need to be considered as a crisis capacity strategy to ensure continued availability. Based on the limited research available, ultraviolet germicidal irradiation, vaporous hydrogen peroxide, and moist heat showed the most promise as potential methods to decontaminate FFRs. This document summarizes research about decontamination of FFRs before reuse.

Introduction

Reusing disposable filtering facepiece respirators (FFRs) has been suggested as a crisis capacity strategy to conserve available supplies for healthcare environments during a pandemic. Strategies for FFR extended use and reuse (without decontamination of the respirator) are currently available from CDC's National Institute for Occupational Safety and Health (NIOSH).

The surfaces of an FFR may become contaminated while filtering the inhalation air of the wearer during exposures to pathogen-laden aerosols. The pathogens on the filter materials of the FFR may be transferred to the wearer upon contact with the FFR during activities such as adjusting the FFR, improper doffing of the FFR, or when performing a user-seal check when redoffing a previously worn FFR. A study evaluating the persistence of SARS-CoV-2 (the virus that causes COVID-19) on plastic, stainless steel, and carboard surfaces showed that the virus is able to survive for up to 72-hours [1]. One strategy to mitigate the contact transfer of pathogens from the FFR to the wearer during reuse is to issue five respirators to each healthcare worker who may care for patients with suspected or confirmed COVID-19. The healthcare worker will wear one respirator each day and store it in a breathable paper bag at the

Elastomeric Respirators for U.S. Healthcare Delivery

This webinar provides an overview of respiratory protection and guidance surrounding supply shortages. This webinar also provides information on infection prevention measures, strategies for optimizing the supply of N95 respirators, and a broad overview

https://www.cdc.gov/coronavirus/2019-ncov/hcp/ppe-strategy/decontamination-reuse-respirators.html

COVID-19: Infection Prevention and Control

- There are steps HCP can take to prepare for arrival, elevation and transportation of patients.
  - Healthcare Personnel Preparedness Checklist for COVID-19
  - https://www.cdc.gov/coronavirus/2019-ncov/hcp/hcp-personnel-checklist.html

Healthcare Personnel Preparedness Checklist for 2019-nCoV

Front-line healthcare personnel in the United States should be prepared to evaluate patients for 2019 novel coronavirus (2019-nCoV). The following checklist highlights key steps for healthcare personnel in preparation for transport and arrival of patients potentially infected with 2019-nCoV.

☐ Stay up to date on the latest information about signs and symptoms, diagnostic testing, and case definitions for 2019-nCoV disease (https://www.cdc.gov/coronavirus/2019-nCoV/summary.html).

☐ Review your infection prevention and control policies and CDC infection control recommendations for 2019-nCoV(https://www.cdc.gov/coronavirus/2019-nCoV/infection-control.html) for:

- ☐ Assessment and triage of patients with acute respiratory symptoms
- ☐ Patient placement
- ☐ Implementation of Standard, Contact, and Airborne Precautions, including the use of eye protection
- ☐ Visitor management and exclusion
- ☐ Source control measures for patients (e.g., put facemask on suspect patients)
- ☐ Requirements for performing aerosol generating procedures

☐ Be alert for patients who meet the persons under investigation (PUI)(https://www.cdc.gov/coronavirus/2019-nCoV/infection-control.html) definition

☐ Know how to report a potential 2019-nCoV case or exposure to facility infection control leads and public health officials

☐ Know who, when, and how to seek evaluation by occupational health following an unprotected exposure (i.e., not wearing recommended PPE) to a suspected or confirmed nCoV patient

☐ Remain at home, and notify occupational health services, if you are ill

☐ Know how to contact and receive information from your state or local public health agency

COVID-19: Tools and Resources

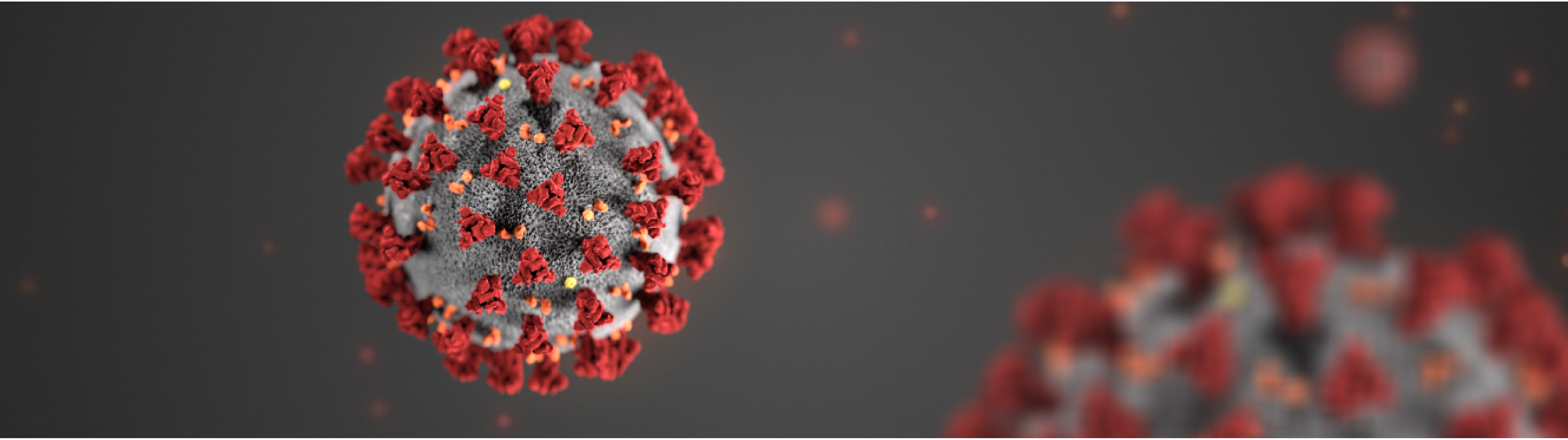
- **Water and COVID FAQs**
  - **https://www.cdc.gov/coronavirus/2019-ncov/php/water.html**
- **Healthcare Facilities**
  - Ambulatory Care Services
  - Guidance for Dental Settings
  - Guidance for Nursing Homes and Long-Term Care Facilities
  - Guidance for Dialysis Facilities
  - Blood and Plasma Facilities
- **Supply of Personal Protective Equipment (PPE)**
  - Healthcare Supply of Personal Protective Equipment
  - Strategies for Optimizing Supply of N95 Respirators
  - Decontamination and Reuse of Filtering Facepiece Respirators
  - FAQ about Respirators

COVID-19: Tools and Resources (cont'd.)

- **Home Care**
  - Implementing Home Care of People Not Requiring Hospitalization
  - Preventing COVID-19 from Spreading in Homes and Communities
  - Disposition of Non-Hospitalized Patients with COVID-19 (ending home isolation)

https://www.cdc.gov/coronavirus/2019-ncov/index.html

COCA Calls/Webinars:
https://emergency.cdc.gov/coca/calls/index.asp



For more information, contact CDC
1-800-CDC-INFO (232-4636)
TTY: 1-888-232-6348 www.cdc.gov

The Survivability of the COVID-19 Virus in Air, Water, Wastewater, and Various Surfaces

Charles Gerba, PhD
University of Arizona

Survival of Coronaviruses in Air, Water and Wastewater

Walter Betancourt
Charles P. Gerba
Ian Pepper
Department of Environmental Science

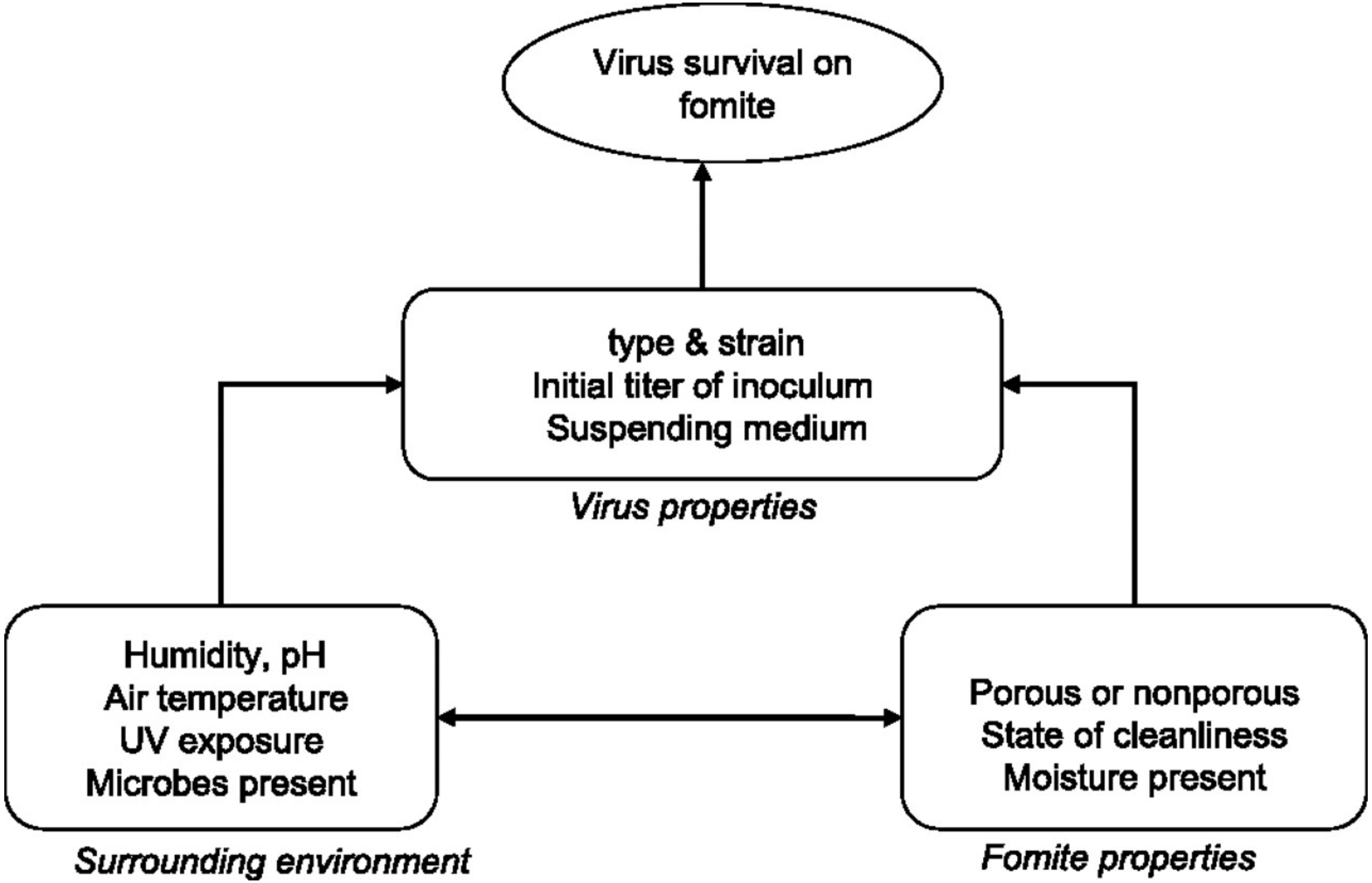
ARIZONA

THE UNIVERSITY OF ARIZONA
WEST CENTER
WATER & ENERGY SUSTAINABLE TECHNOLOGY

Human Coronaviruses

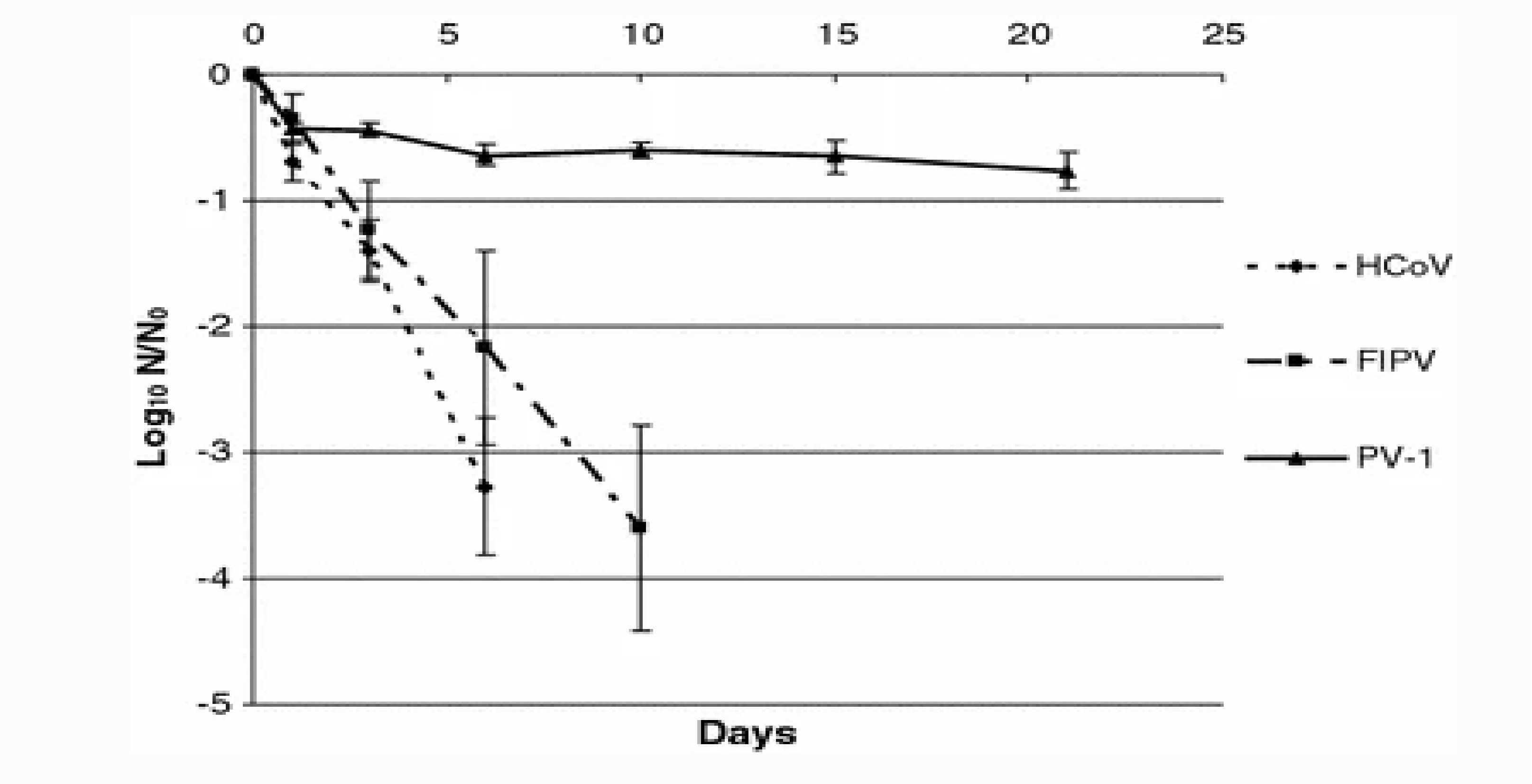
• HCoV- OC43	common cold
• HCoV-229E	common cold
• SARS-CoV	Severe Acute Respiratory Syndrome
• MERS-CoV	Middle East Respiratory Syndrome
• SARS-CoV-2	HCoV-19

Factors influencing virus survival on fomites.



Stephanie A. Boone, and Charles P. Gerba Appl. Environ. Microbiol. 2007; doi:10.1128/AEM.02051-06

Survival of human coronavirus 229E in tap water at 23 °C



HCoV = coronavirus 229E; FIPV = Feline coronavirus; PV-1 = poliovirus type 1

From Gundy, Gerba and Pepper 20008 FEV

Average $\log_{10}$ reduction of study viruses in primary effluent and secondary effluent at room temperature (23°C)

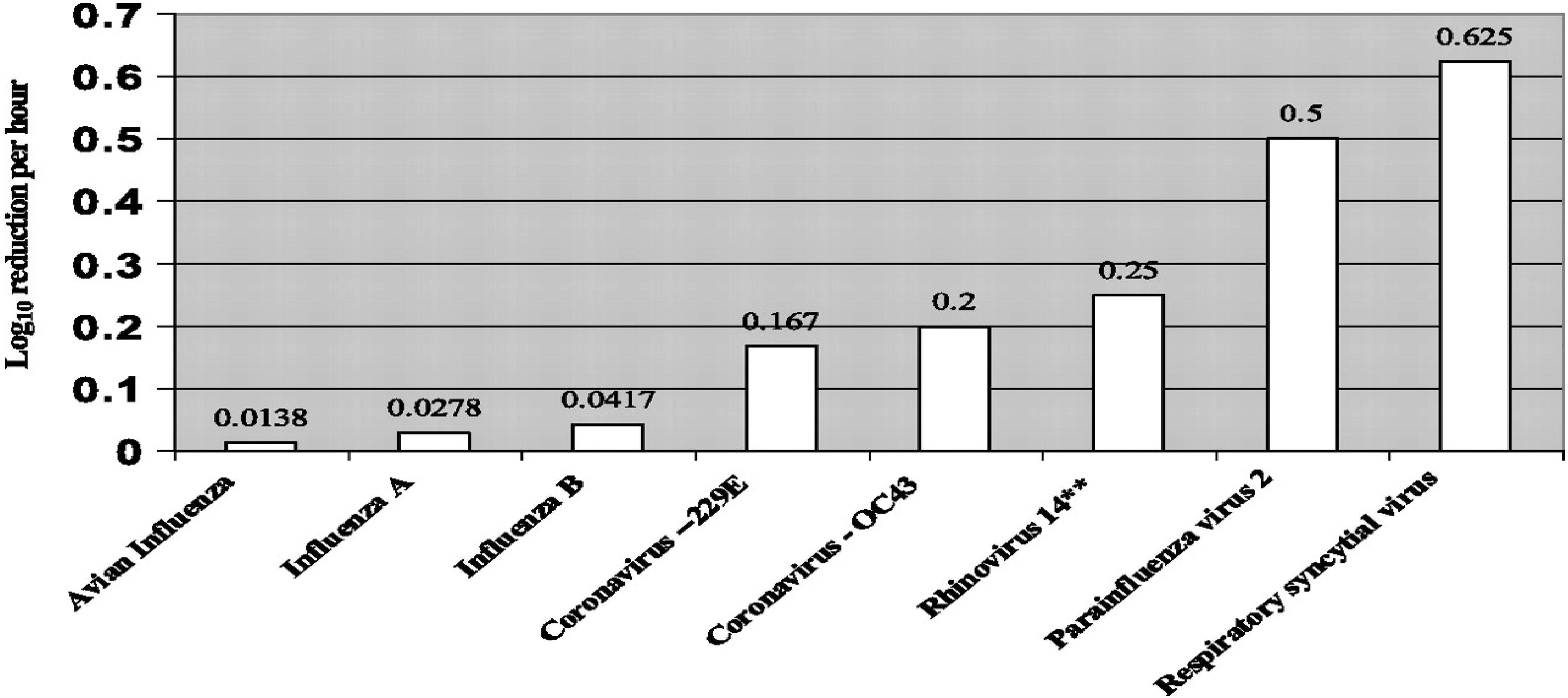
Day	Primary effluent (filtered)			Primary effluent (unfiltered)			Secondary effluent (unfiltered)		
	HCoV	FIPV	PV-1	HCoV	FIPV	PV-1	HCoV	FIPV	PV-1
1	>2.0 ± 0.88	1.7 ± 1.1	0.04 ± 0.09	>1.8 ± 0.54	>1.8 ± 1.0	0.2 ± 0.19	1.1 ± 0.80	1.1 ± 1.0	0.96 ± 0.26
2	>2.9 ± 0.21	>2.5 ± 0.62	0.11 ± 0.17	>2.0 ± 0.86	>2.7 ± 0.85	0.54 ± 0.46	>2.7 ± 0.54	>2.6 ± 0.85	1.5 ± 0.65
3	>3.4 ± 0.66	>3.6 ± 0.17	0.25 ± 0.24	>2.0 ± 1.5	>3.1 ± 0.62	0.69 ± 0.51	>2.9 ± 0.80	>3.7 ± 0.62	2.1 ± 1.1
6	ND	ND	0.58 ± 0.26	ND	ND	1.6 ± 0.32	ND	ND	3.8 ± 1.1
10	ND	ND	1.03 ± 0.54	ND	ND	2.5 ± 0.58	ND	ND	4.6 ± 1.5
15	ND	ND	1.31 ± 0.54	ND	ND	4.3 ± 0.58	ND	ND	3.6 ± 1.5
21	ND	ND	1.64 ± 0.37	ND	ND	4.7 ± 1.2	ND	ND	ND

ND not determined

HCoV = coronavirus 229E; FIPV = Feline coronavirus; PV-1 = poliovirus type 1

From Gundy, Gerba and Pepper 20008 FEV

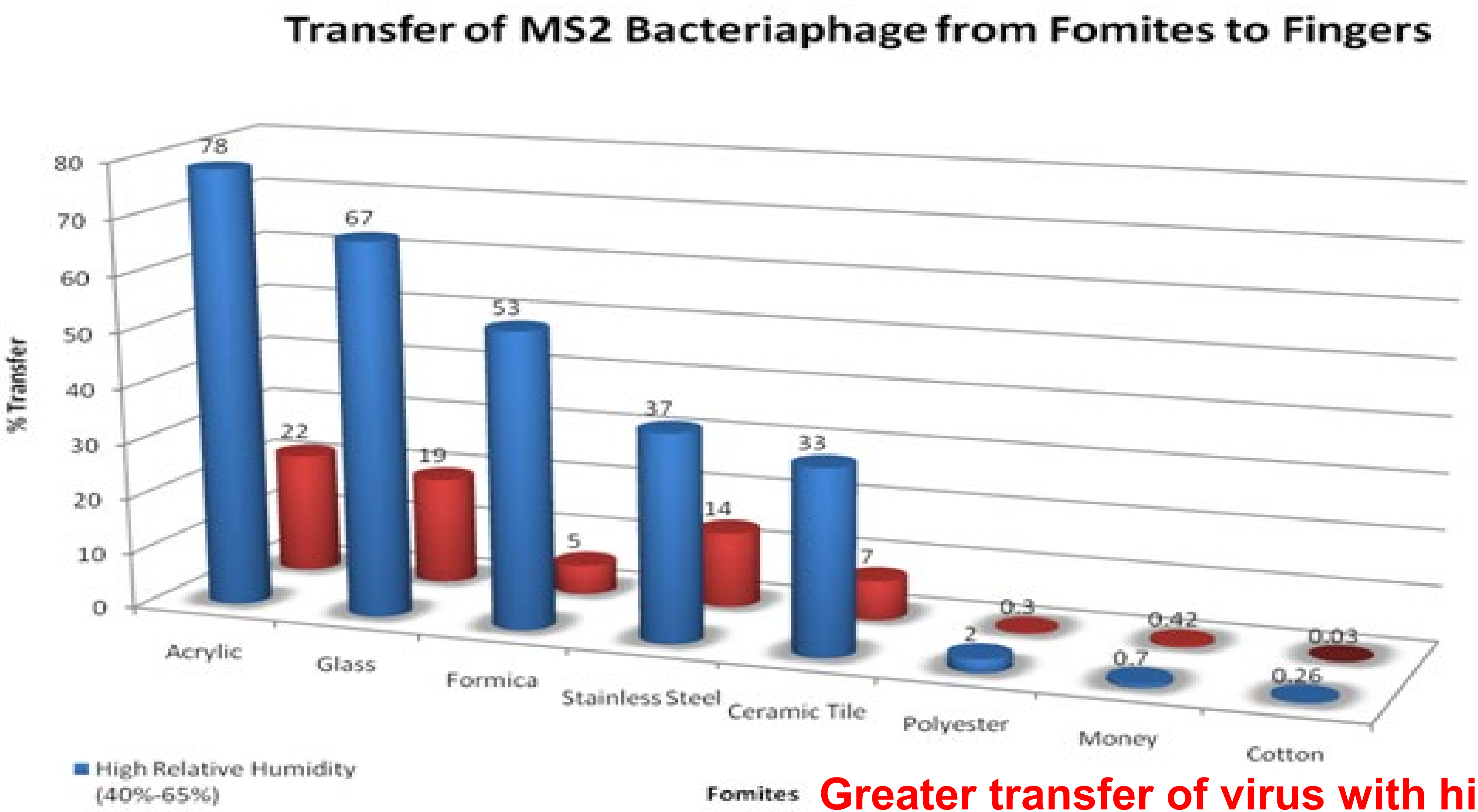
Inactivation Rates of Respiratory Viruses on Hard Surfaces



From Boone and Gerba AEM 2007

How Efficient is Transfer?
(Lopez et al, 2009)

- Type of suspending media
  - Greater transfer when suspended in feces than phosphate buffered saline
- Hand/object contact
  - Type of interaction with object (i.e. doorknob vs. push button)
  - Finger vs. hand



Red = low relative humidity (15% - 32%)

Greater transfer of virus with high relative humidity and non- porous surfaces

HCoV-19

- Infectious virus detected in feces of patients up to five weeks after infection
- Survival (Relative humidity 40% R.H. - 23 ^{o} C) (Morris et al 2020)
  - 2-3 days on plastic and stainless-steel surfaces
  - 4 hours on copper surface
  - 24 hours on cardboard
  - 3 hours in aerosols
- No evidence for transmission by feces or fomites or presence of infectious virus sewage

Current Needs

- Survival of the SARS – CoV-2
  - Wastewater
  - Sewage sludge
  - Treatment processes
  - Ct times for chloramines and UV light

Overview of the COVID-19 Virus Loads in Human Samples and Using Predictive Models to Predict Fate in the Environment

Krista Wigginton, PhD
University of Michigan

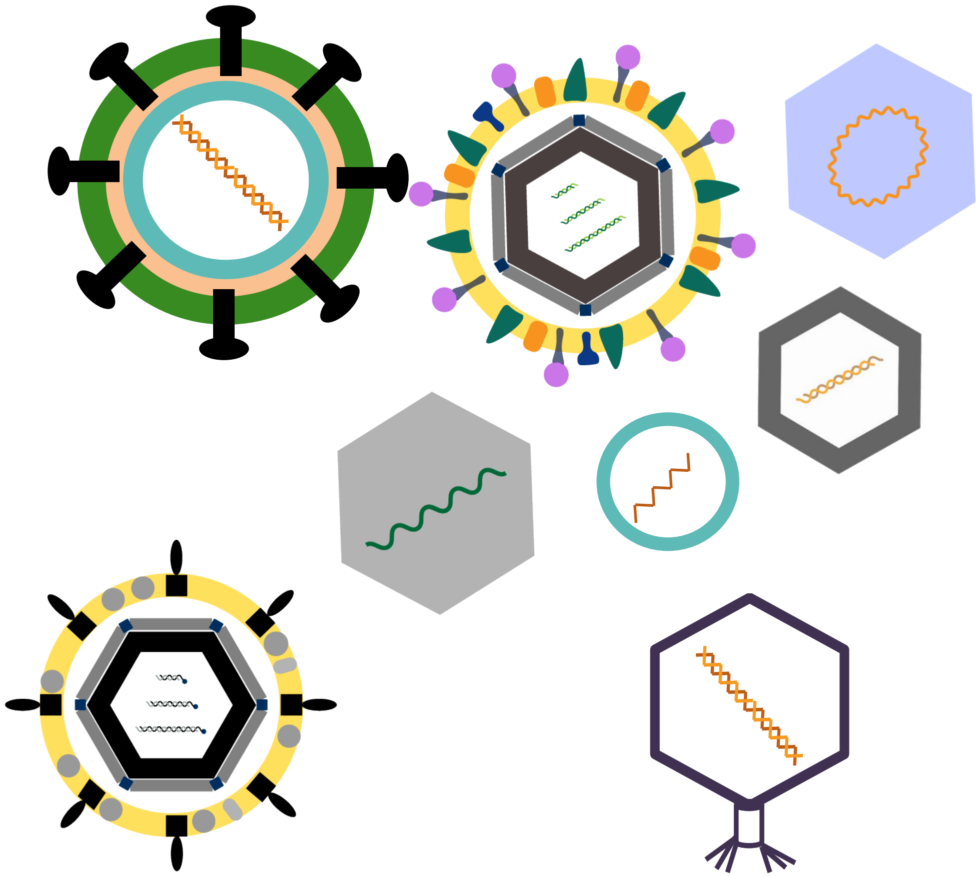
SARS-CoV-2 RNA in fecal samples

- RNA in feces detected in multiple studies
- Between 30% to 60% sampled stool samples positive for COVID-19 Virus RNA
- Excreted for weeks after onset of symptoms.
- Loose stool and diarrhea reported in some studies
- Mean Ct values for positive stool samples typically >30, but some as low as 25

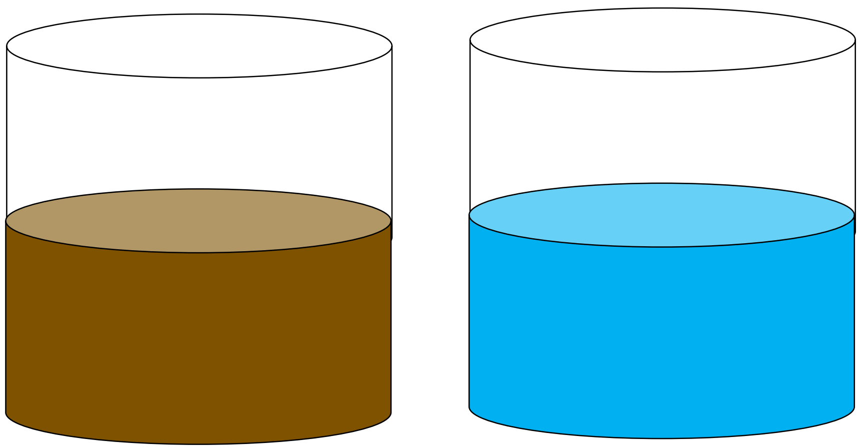
Infective SARS-CoV-2 in fecal samples?

- Virus particles detected in 2 of 4 tested fecal samples by TEM analysis
- At least one study tried to culture 13 stool samples that tested positive for RNA and failed
- Chinese CDC reported that viruses were cultivated from feces
- No cases of transmission via the fecal–oral route have been reported

Can we use virus and media characteristics to predict virus fate in the environment?



e.g., envelope, genome type and sequence, protein composition



e.g., temperature, pH, suspended solids, etc.

2017 study developed model for predicting virus inactivation in wastewaters

Environmental Science & Technology
Article
pubs.acs.org/est

Censored Regression Modeling To Predict Virus Inactivation in Wastewaters

Julii Brainard,[†] Katherine Pond,[‡] and Paul R. Hunter*,[†]

[†]Norwich Medical School, University of East Anglia, Norwich NR4 7TJ, United Kingdom
[‡]Department of Civil and Environmental Engineering, Robens Centre for Public and Environmental Health, University of Surrey, Guildford GU2 7XH, United Kingdom

Extracted data: RNA or DNA genome, enveloped or not, primary transmission pathway (airborne, body contact/fluids, fecal-oral, insect vector, respiratory, rodents, or multiple), temperature, pH, light levels, matrix level of contamination (high, medium, or low level of fecal contamination), genus, and taxonomic family.

Chosen model for predicting T_{90} includes both virus characteristics and water characteristics

Table 1. Model 1 Coefficients and Attributes, Censored Regression To Predict sqrt(T90secs)[a]

		95% CI for coeff values		
	coefficient	lower bound	upper bound	p-value
model constant	2.56883	2.49456	2.64310	<0.001
fecal oral transmission pathway (y)	0.12877	0.07305	0.18448	<0.001
enveloped virus (y)	−0.09392	−0.15091	−0.03925	0.001
DNA virus (y)	0.01523	−0.02873	0.05918	0.496
temperature in °C	−0.00971	−0.01136	−0.00805	<0.001
low contamination	0	na	na	Na
medium contamination	0.00428	−0.04468	0.05323	0.864
high contamination	−0.11271	−0.15790	−0.06752	<0.001

[a] sqrt(T90 s) = square root[$\log_{10}$(T90 in seconds)]. Enveloped virus (y) = 1 when enveloped, else 0. fecal oral (y) = 1 when fecal oral is primary transmission pathway, else 0. DNA virus (y) = 1 for DNA virus, else 0. Model default is when level of contamination = low, else model adjusts for when contamination is medium or high as indicated.

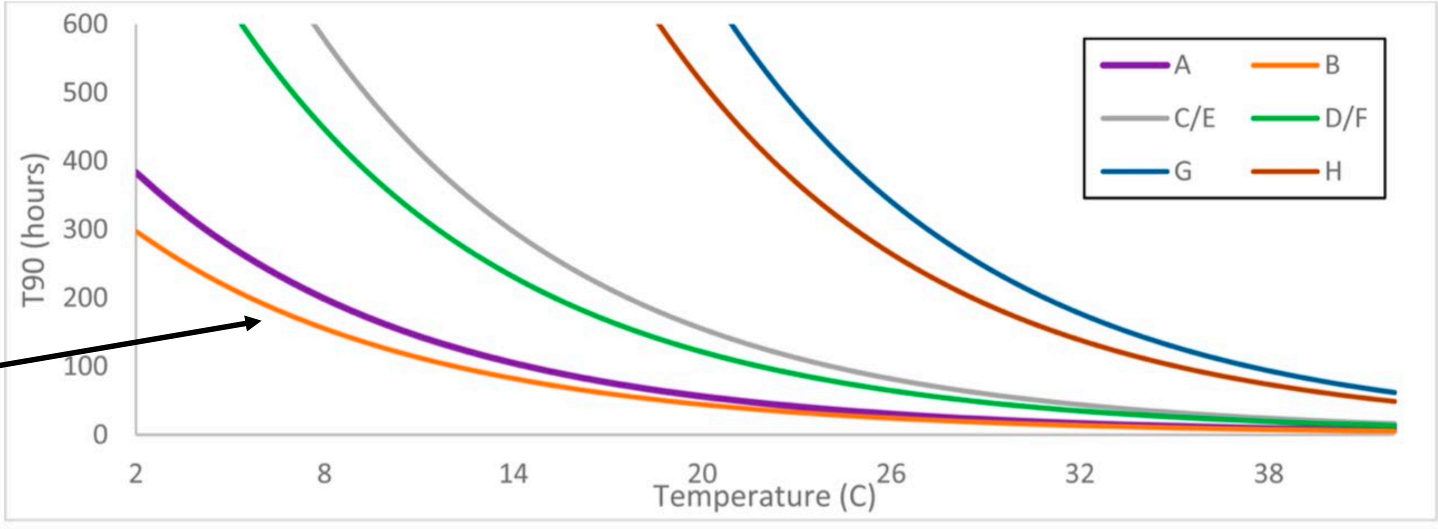
Data from 52 articles with 464 data records to build regression model

COVID-19 Virus T_{90} at 20 C in high contamination water: 13.9 hr

95% CI Range: 1.9 - 122 hr

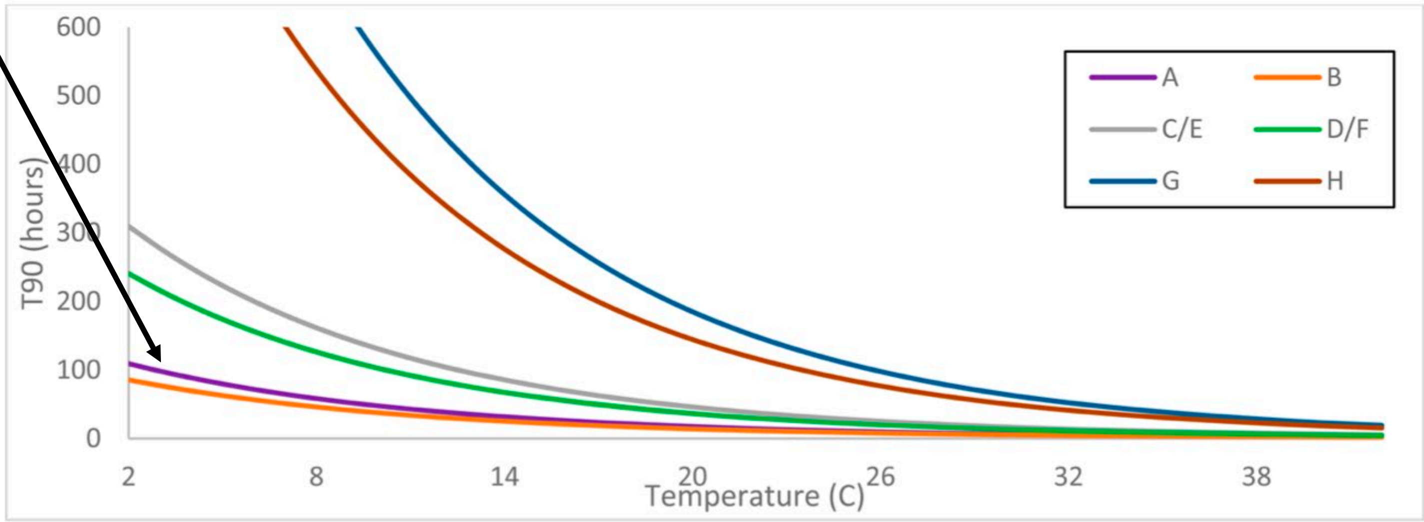
The contamination level of water has large impact on T_{90} values

COVID-19 Virus



3

Low contamination



3c

High contamination

2005 study by Lytle and Sagripanti uses genome size and virus family to predict inactivation from sunlight

JOURNAL OF VIROLOGY, Nov. 2005, p. 14244–14252 Vol. 79, No. 22
0022-538X/05/$08.00+0 doi:10.1128/JVI.79.22.14244–14252.2005

Predicted Inactivation of Viruses of Relevance to Biodefense by Solar Radiation

C. David Lytle and Jose-Luis Sagripanti*

Research and Technology Directorate, Edgewood Chemical Biological Center, U.S. Army, Aberdeen Proving Ground, Maryland 21010-5424

Received 27 June 2005/Accepted 22 August 2005

Genome size and virus family used to predict virus inactivation by UV_{254} and solar radiation.

Predictive model based on literature inactivation rates for viruses in same family and genome size.

$D_{37} = SnS/kb$

$D_{37} = 1/k$

COVID-19 Virus

$k = 3.8\ cm^2/mJ$

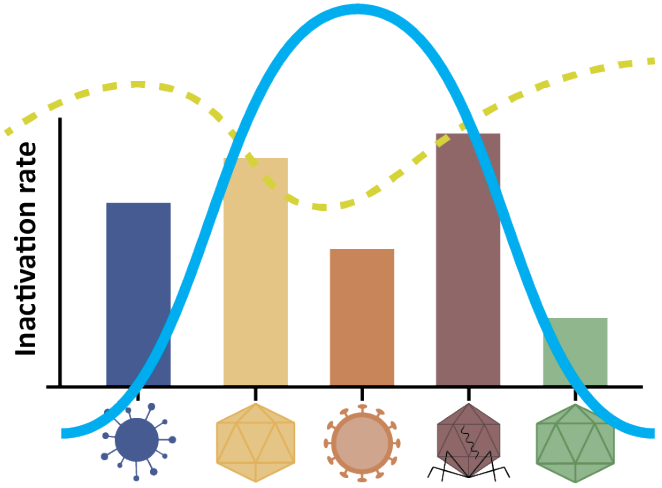
$D_{90} = 0.6\ mJ/cm^2$

TABLE 2. Measured and predicted UV_{254} sensitivities for RNA-containing virus families whose hosts are vertebrates[a]

Family[b]	Measured D_{37} (J/m^2)	Genome size range	Measured or predicted SnS ($J/m^2 \cdot kb$)	Representative virus(es)	Predicted D_{37} range for entire family (J/m^2)	Reference(s)
dsRNA viruses						
Birnaviridae	120 (110–170)	5.7–6.2	1,400 (1,300–1,900)	1PNV	110–120	32, 50, 63
Reoviridae	89 (46–123)	18.6–26.4	3,800 (1,700–5,800)	MRV-1, -2, -3, RV-A, KEMV-10, -91	72–100	3, 18, 19, 39, 55, 68, 87
ssRNA viruses						
*Arenaviridae**		11	*140 p*		*13*	
*Bornaviridae**	34	8.9	300	BDV	34	8
*Bunyaviridae**		11–19	*140 p*		*7.4–13*	
*Deltavirus**		1.7	*140 p*		*82*	
*Filoviridae**		19	*140 p*		*7.4*	
*Orthomyxoviridae**	7.5 (4.8–10)	10–15	110 (70–140)	FLUAV, ISAV	7.3–11	50, 54
*Paramyxoviridae**	11 (10–12)	15–16	170 (150–190)	NDV, MeV	11	10, 29, 31
*Rhabdoviridae**	4.3 (1.1–23)	11–15	51 (12–260)	VSV, RABV, VHSV	3.4–4.6	2, 4, 8, 50, 63, 79
*Arterioviridae***		13–16	*295 p*		*18–23*	
*Astroviridae***		6.8–7.9	*295 p*		*37–44*	
*Caliciviridae***		7.4–8.3	*295 p*		*36–40*	
*Coronaviridae***	3.1	20–31	78	BEV	2.5–3.9	79
*Flaviviridae***		9.6–12	*295 p*		*25–31*	
"HEV-like" viruses**		7.2	*295 p*		*41*	
*Nodaviridae***	140	4.5	630	SBNN	140	11
*Picornaviridae***	48 (25–70)	7–8.5	370 (190–540)	PV-1, -2, -3, E-1, -11, CV-A9, -B1, -B5, HHAV, EMCV	44–53	3, 6, 18, 19, 42, 43, 47, 55, 78, 86
*Togaviridae***	19 (7.3–23)	9–12	220 (83–260)	SINV, VEEV, SFV	18–24	69, 79, 86
*Retroviridae****	89 (88–120)	7–11	740 (620–980)	MLV, FeLV, MoMSV, RSV	67–110	5, 25, 31, 46, 49, 70, 83–85

[a] See footnotes to Table 1 for explanations of columns. In addition, ssRNA viruses are listed according to sense of genetic information and/or mode of replication.
[b] *, family has negative-sense ssRNA; **, family has positive-sense ssRNA; ***, family replicates via reverse transcriptase.

We are developing predictive models through disinfection using multiple virus characteristics that we suspect drive inactivation



$$\boxed{k \sim \beta_0 + \beta_{U,i} \times U_i + \beta_{C,i} \times C_i + \ldots \varepsilon}$$

Inactivation rate of a virus

$\ln(C/C_0) = \mathbf{k} \times \text{UV Dose}$

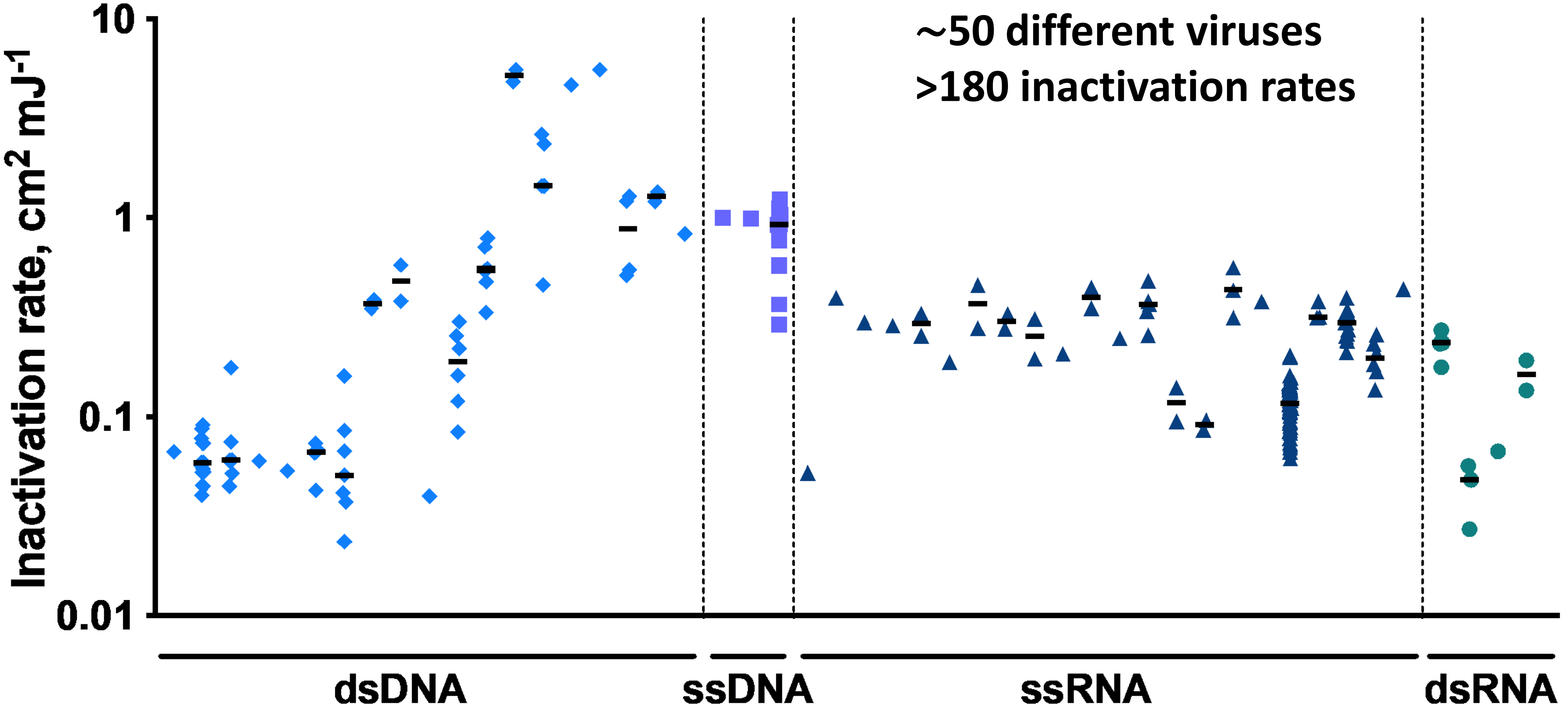
Independent variables included:

- Genome attributes:
  - Uracil bases
  - Cytosine bases

Model types:

- Multiple linear regression
- Elastic net regularization
- Boosted trees
- Random forest

We conducted a systematic review of UV_{254} inactivation rates and culled the data based on quality what was reported in the manuscript.



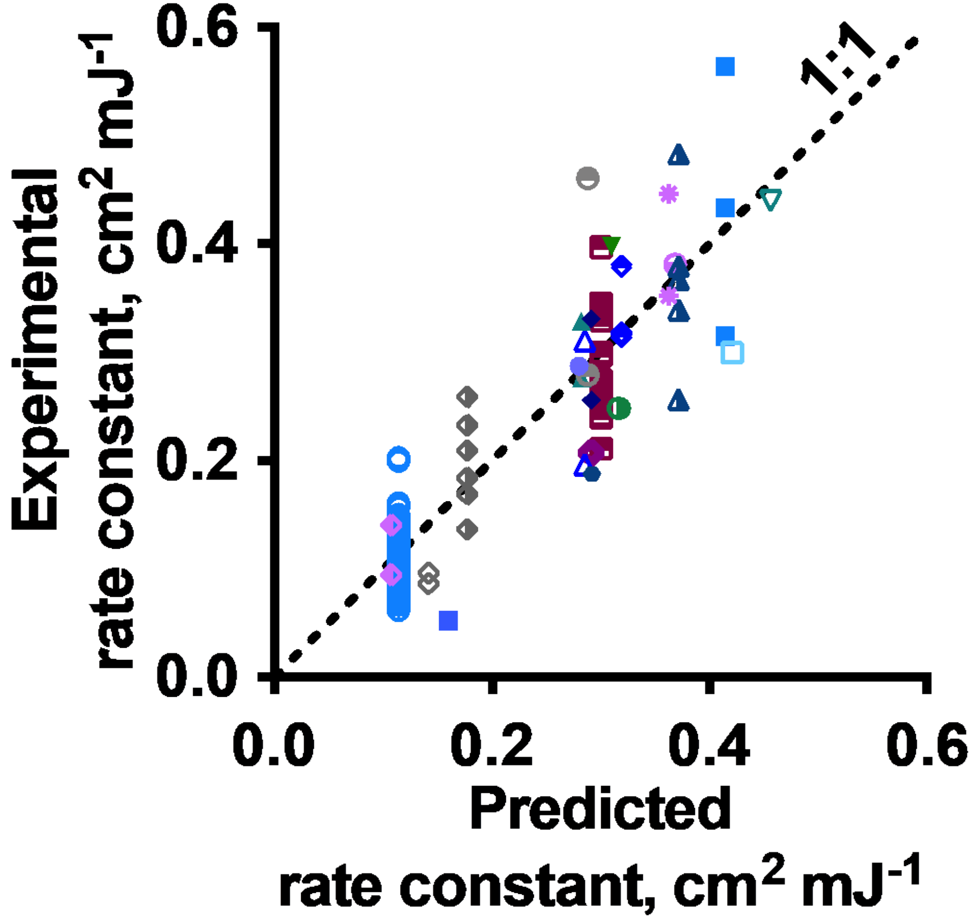
Amount of inactivation data is skewed to certain viruses.

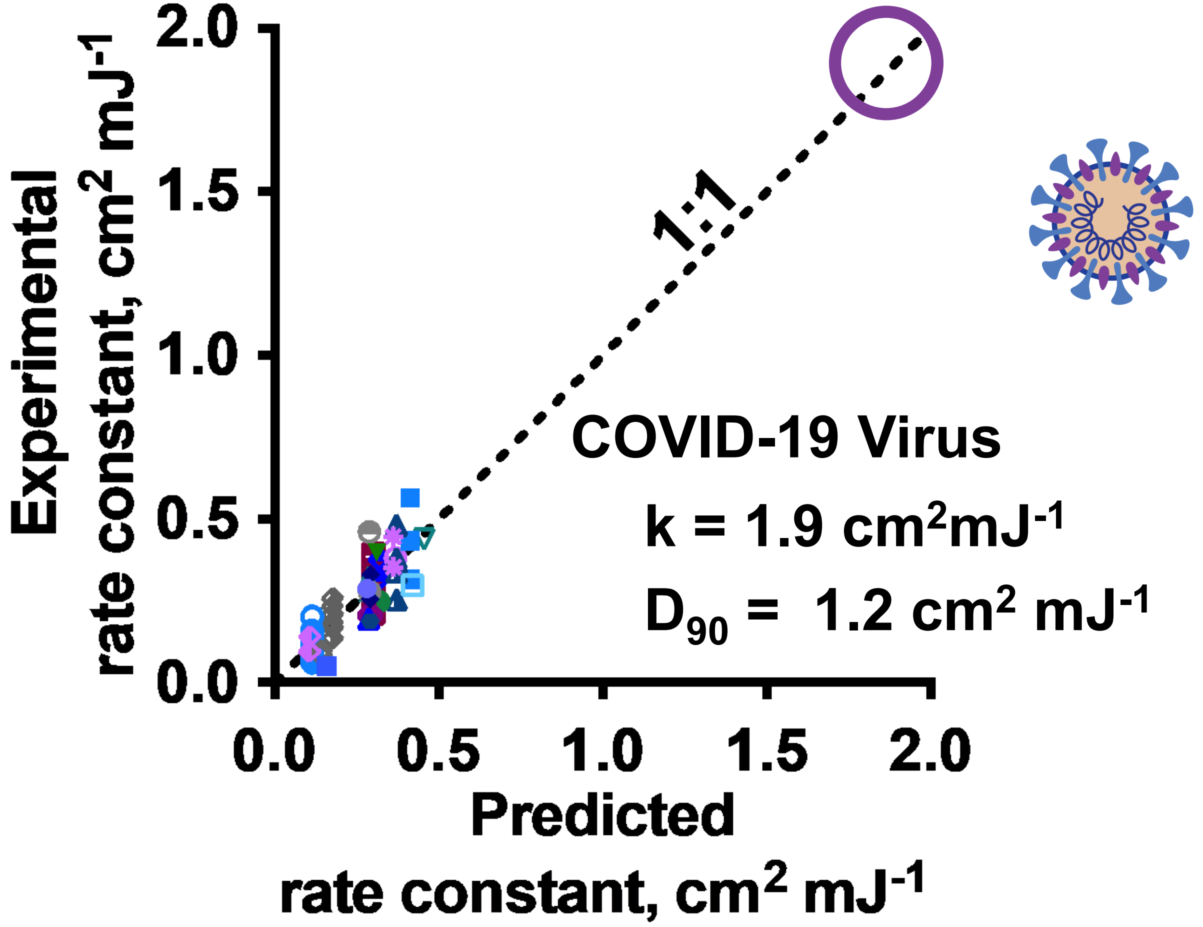
We need more data for a wider range of virus types.

We can use these models to predict UV_{254} inactivation of viruses of interest

Mouse CoV inactivation (predicted): k_{pred} = 1.85 cm^2 mJ^{-1}

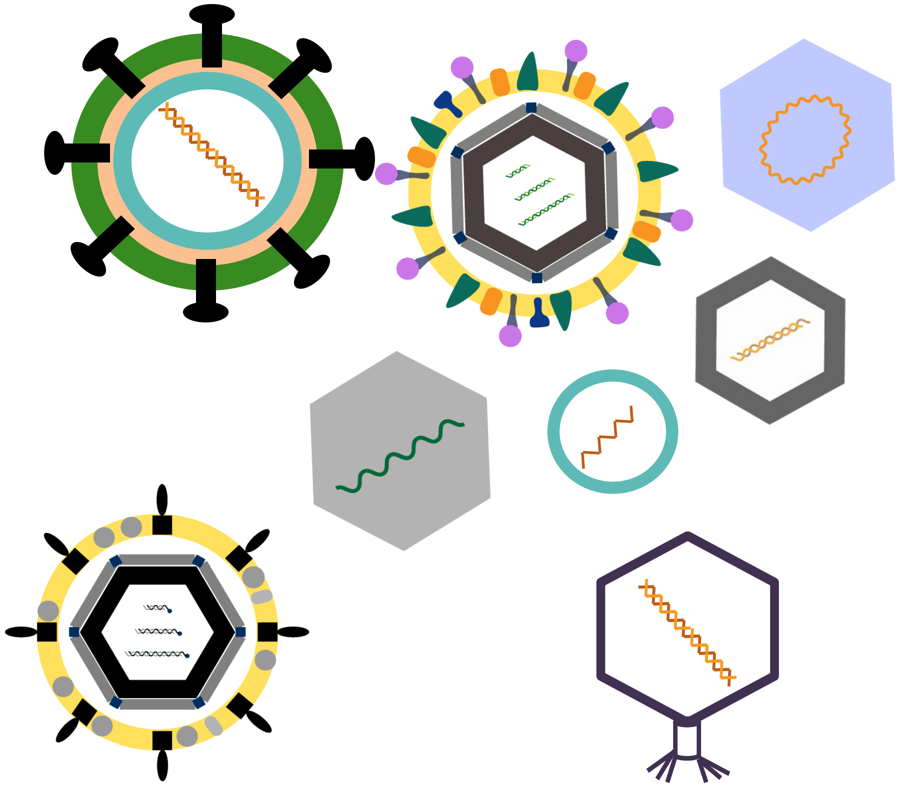
Mouse CoV inactivation (experimental): k_{exp} = 1.7 cm^2 mJ^{-1}



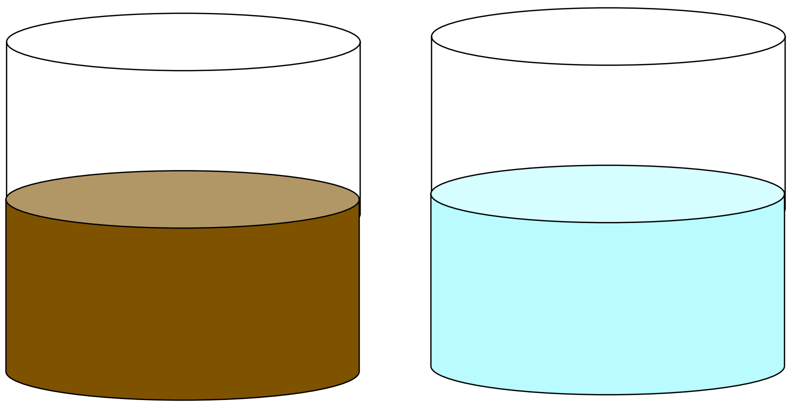


Rockey et al, in prep

To expand this approach to COVID-19 virus and more conditions, we need more measured inactivation data for a broader group of viruses under various environmental conditions.



e.g., envelope, genome type and sequence, protein composition



e.g., temperature, pH, suspended solids, etc.

The Dutch Case Study on Sewage Surveillance of COVID-19

Gertjan Medema, PhD
KWR Water Research Institute in Nieuwegein, the Netherlands

16-04-2020

WRF second coronavirus webcast

Dutch case study on sewage surveillance

KWR Watercycle Research Institute

MICHIGAN STATE UNIVERSITY

TU Delft Delft University of Technology

Contents

- COVID-19 Virus in sewage
- The value of sewage surveillance for COVID-19 Virus
- Knowledge needs

COVID-19 pandemic 2019/20

Proportion of people with COVID-19 have diarrhea and shed virus with stool

SARS Coronavirus 2 detectable in sewage?

Sewage surveillance to complement health surveillance?

Sewage surveillance to track virus circulation

- Proven for other viruses
- Sensitive instrument
- Complements health surveillance
- Early warning for re-emergence
- Understanding virus circulation in the population

REVIEW ARTICLE

Role of environmental poliovirus surveillance in global polio eradication and beyond

T. HOVI[1]*, L. M. SHULMAN[2], H. VAN DER AVOORT[3], J. DESHPANDE[4], M. ROIVAINEN[1] AND E. M. DE GOURVILLE[5]

[1] *National Institute for Health and Welfare (THL), Helsinki, Finland*
[2] *Central Virology Laboratory (CVL), Ministry of Health, Sheba Medical Center, Tel-Hashomer, Israel*
[3] *National Institute of Public Health and the Environment (RIVM), Bilthoven, The Netherlands*
[4] *Enterovirus Research Centre (ERC), Mumbai, India*
[5] *Global Poliomyelitis Eradication Initiative, WHO, Geneva, Switzerland*

(*Accepted 21 December 2010*)

AEM Journals.ASM.org

Detection of Pathogenic Viruses in Sewage Provided Early Warnings of Hepatitis A Virus and Norovirus Outbreaks

Maria Hellmér,[a] Nicklas Paxéus,[b] Lars Magnius,[c] Lucica Enache,[b] Birgitta Arnholm,[d] Annette Johansson,[b] Tomas Bergström,[a] Heléne Norder[a,c]

Department of Clinical Microbiology, Sahlgrenska Academy, Gothenburg University, Gothenburg, Sweden[a]; Gryaab AB, Gothenburg, Sweden[b]; MTC, Karolinska Institutet, Stockholm, Sweden[c]; Department of Communicable Disease Control, Västra Götaland Region, Sweden[d]

Eurosurveillance Europe's journal on infectious disease surveillance, epidemiol

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Home / Eurosurveillance / Volume 23, Issue 7, 15/Feb/2018 / Article

Research article Open Access

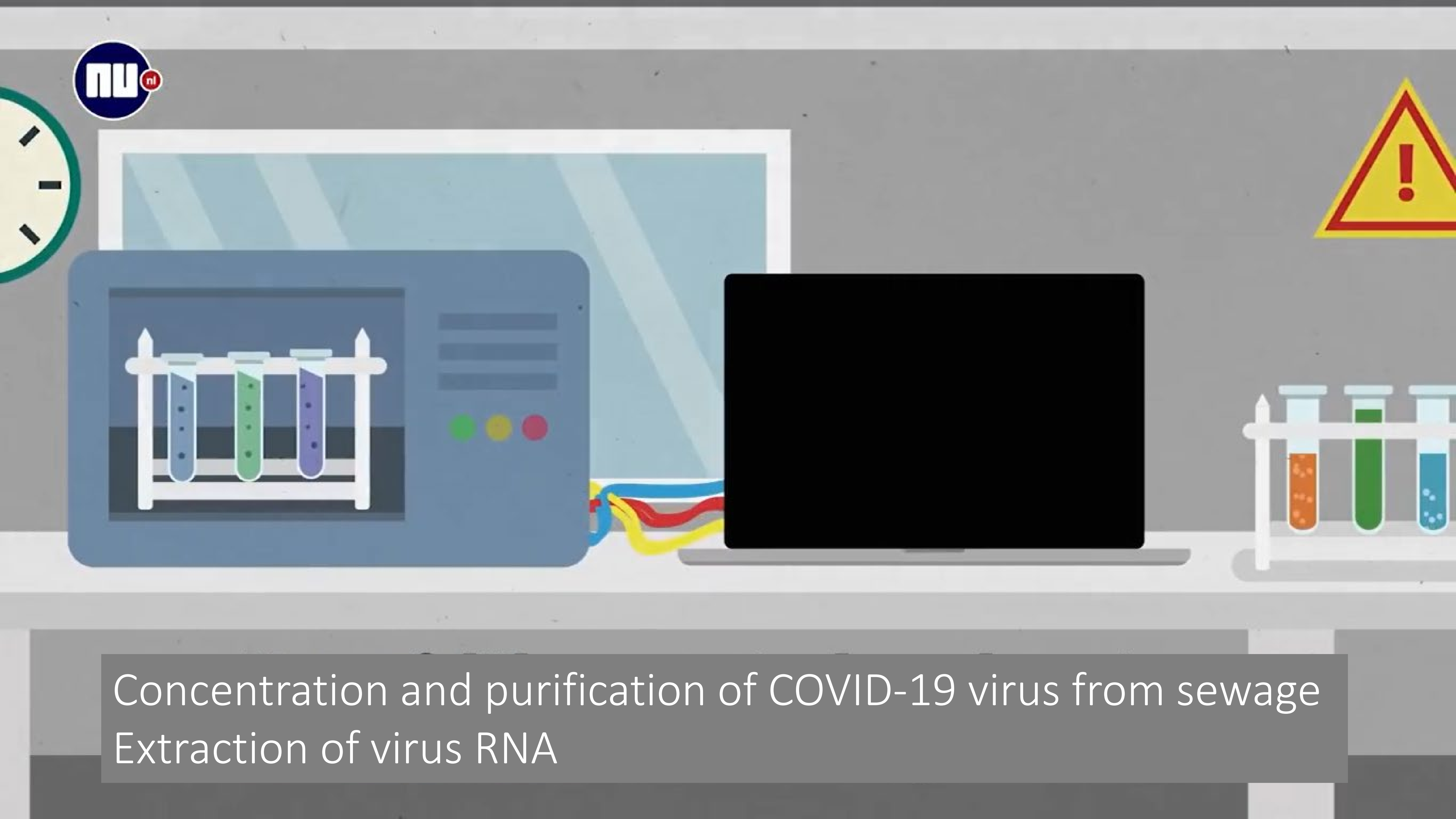
Monitoring human enteric viruses in wastewater and relevance to infections encountered in the clinical setting: a one-year experiment in central France, 2014 to 2015

Maxime Bisseux[1,2], Jonathan Colombet[1], Audrey Mirand[1,2], Anne-Marie Roque-Afonso[3], Florence Abravanel[4], Jacques Izopet[4], Christine Archimbaud[1,2], Hélène Peigue-Lafeuille[1,2], Didier Debroas[1], Jean-Luc Bailly[1], Cécile Henquell[1,2]

Images produced by Wesley Oudijk for NU.nl

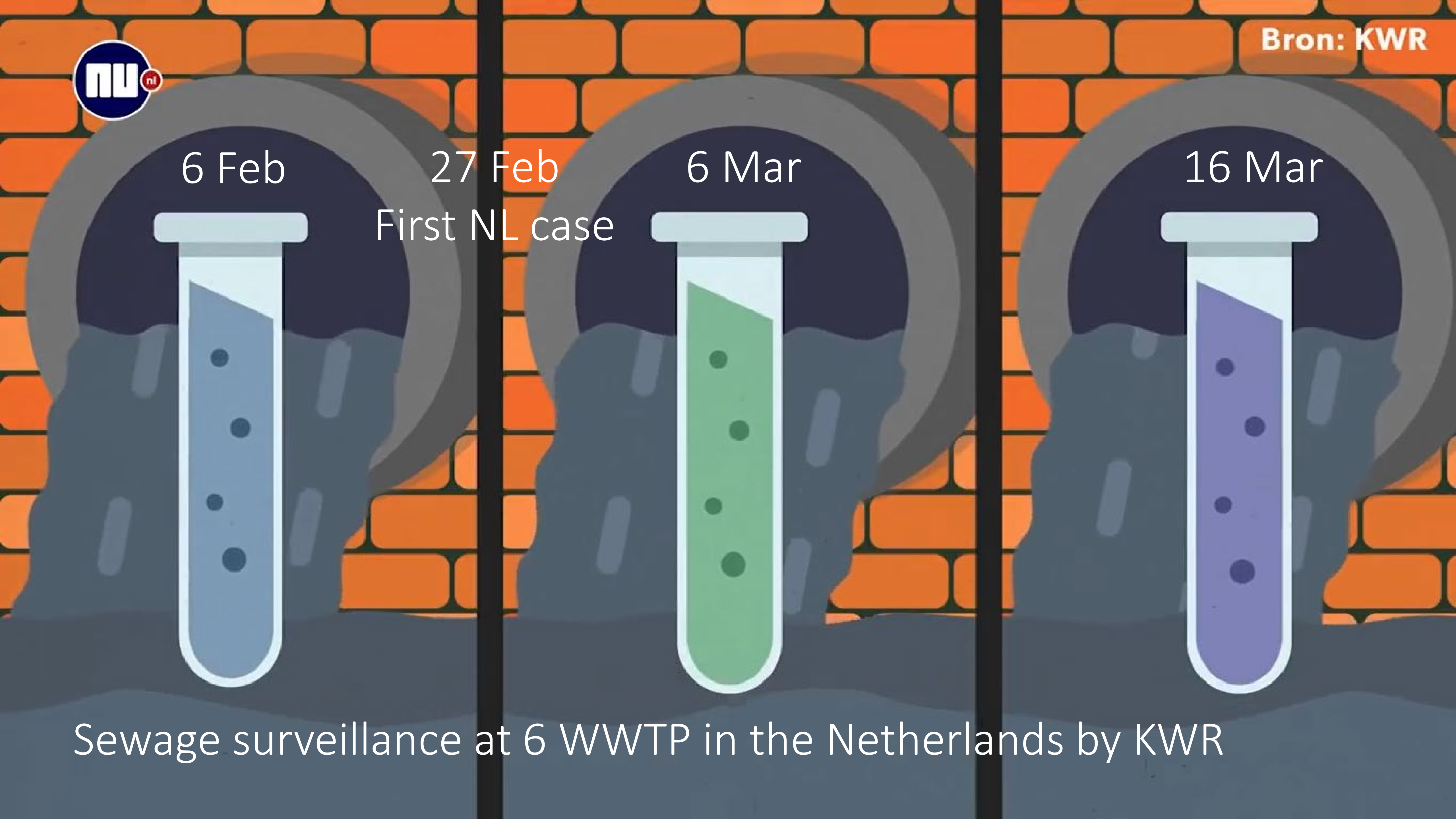
Sewage surveillance: tool to study virus circulation? Early warning?

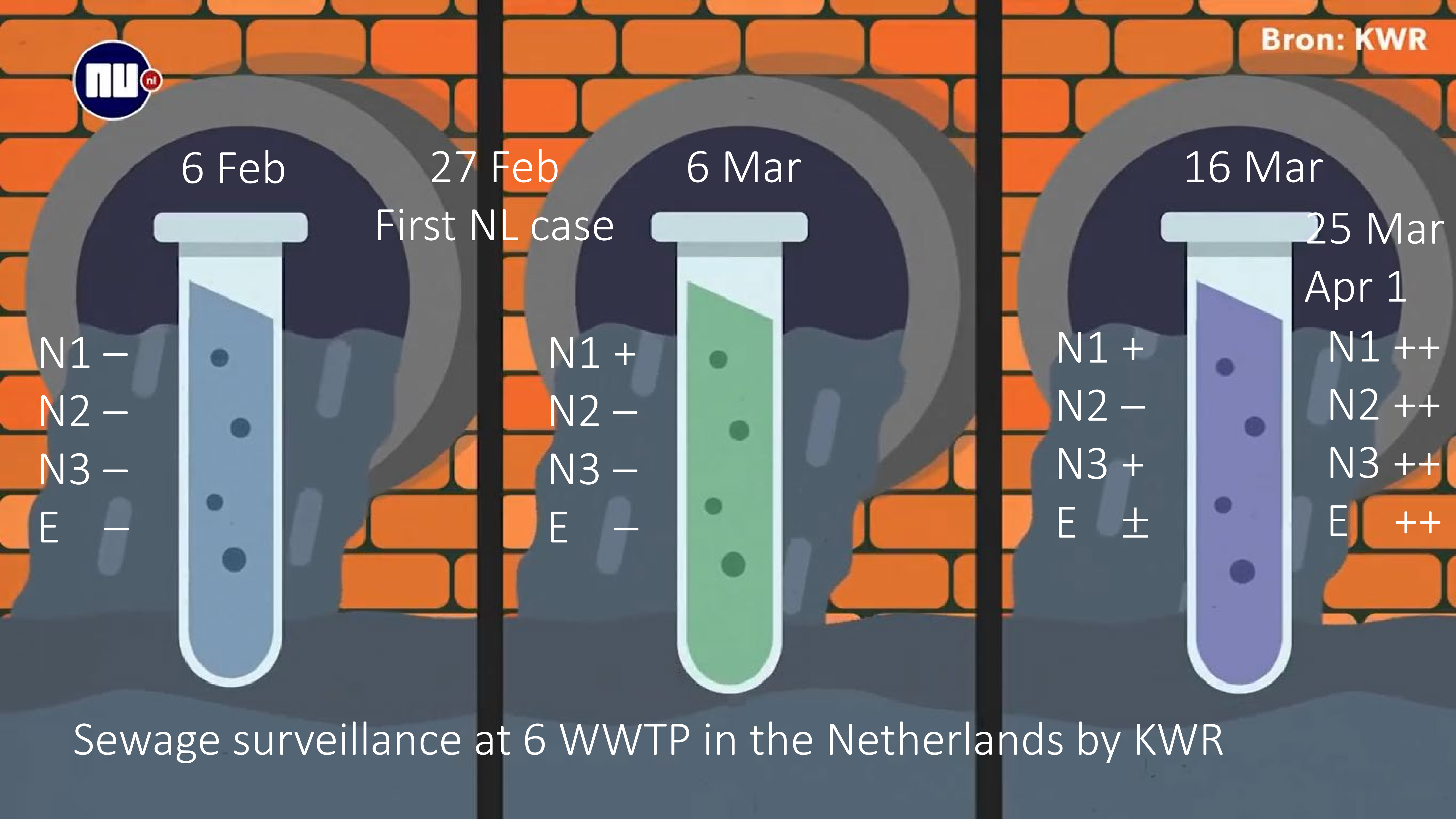
Sewage sampling at WWTP inlet: surveillance of large populations
Is it sensitive enough?



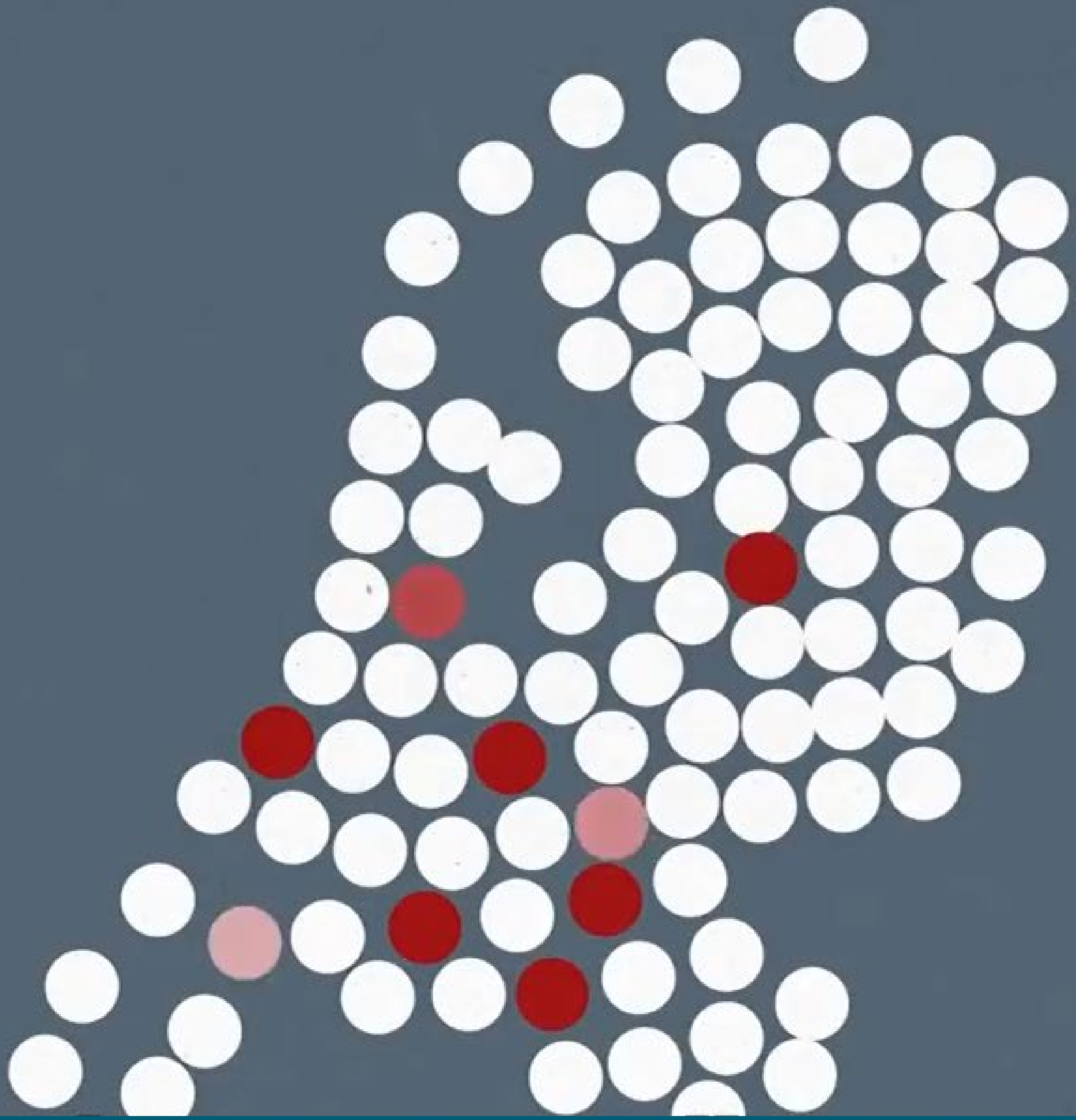
Concentration and purification of COVID-19 virus from sewage
Extraction of virus RNA

RT-qPCR against 4 targets (CDC N1, N2, N3; Corman ea 2020 E)
Concentration and RT-PCR controls


Bron: KWR
6 Feb
27 Feb
First NL case
6 Mar
16 Mar
Sewage surveillance at 6 WWTP in the Netherlands by KWR



Sewage surveillance at 6 WWTP in the Netherlands by KWR



Clinical surveillance: only cases with severe symptoms
Sewage surveillance: understanding of virus circulation

Clinical surveillance: only cases with severe symptoms
Sewage surveillance: understanding of virus circulation

Early warning?

Sensitivity?

Sewage signal already shows when COVID-19 prevalence is low (1-3 reported cases per 100,000)

Two WWTP: sewage signal several days to a week before first reported case

First results indicate sewage surveillance is a sensitive tool to detect virus circulation in cities

Knowledge needs
Sewage Surveillance
where water sector may support health sector

- Shortage of supplies in health sector!!

- Quantitative method
- Harmonised protocols/controls GWRC
- Comparative testing between GWRC labs
- Smart design of sewage surveillance
- Compare Sewage vs Clinical surveillance:
  - same trends?
  - sensitivity?
  - early warning?

Thank you for your attention

16-04-2020

WRF second Coronavirus webcast

Bridging Science to Practice

Towards a Water-wise World

Overview of PPEs and the Current Implications and Applicability to COVID-19

Mark LeChevallier, PhD
Dr. Water Consulting, LLC

Contact
Recommendations
Approach
Regulations
Challenge
Background

An Overview of PPE and the current implications and applicability to COVID-19

Mark W. LeChevallier, Ph.D.
Dr. Water Consulting, LLC

Contact
Recommendations
Approach
Regulations

The COVID-19 virus may be present in US Wastewaters, but many other infectious viruses are commonly present!

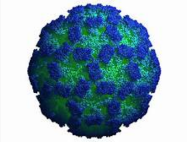
Norovirus 1

Highly contagious

Vomiting and diarrhea

Transfer from contaminated surfaces

High concentrations in wastewater

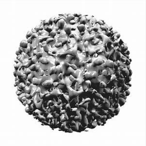


HEP A 2

Highly contagious

Nausea, vomiting
Abdominal pain
fever
Dark urine
Joint pain
Yellowing of the skin and eyes

Infects liver cells



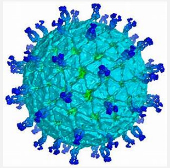
Rotavirus 3

Highly contagious

Affects Infants and young children

Severe watery diarrhea, vomiting, fever, abdominal pain

Severe dehydration

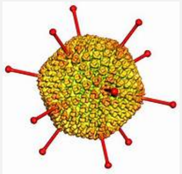


Adenovirus 4

Common in wastewater

Causes a range of illnesses

cold-like symptoms, sore throat, bronchitis, pneumonia, diarrhea conjunctivitis



Challenge
Background

Thorn and Kerekes, 2001 — **1**

Increased prevalence of hepatitis A antibodies in wastewater workers, with odds ratios ranging from 2.0 to 3.73

Oppliger et al., 2005 — **2**

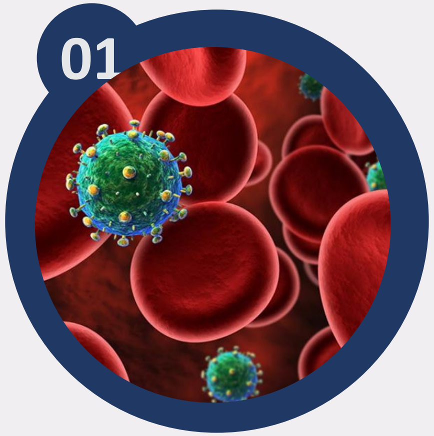
Workers carrying out special tasks such as cleaning raw sewage tanks, aeration grids, or sludge rakes were exposed to very high levels of endotoxins (>500 EU m^3) compared to routine work

Al-Batanony and El-Shafie, 2011 — **3**

Antibody levels against hepatitis A virus (HAV) and hepatitis A virus (HEV) and stool results for *L. spirochete* were significantly higher among WWTPs workers than in a comparison group

The Occupational Safety and Health Administration

01



Bloodborne Pathogen Standard

Applies to wastes containing blood or other potentially infectious materials

02

Hazardous Waste

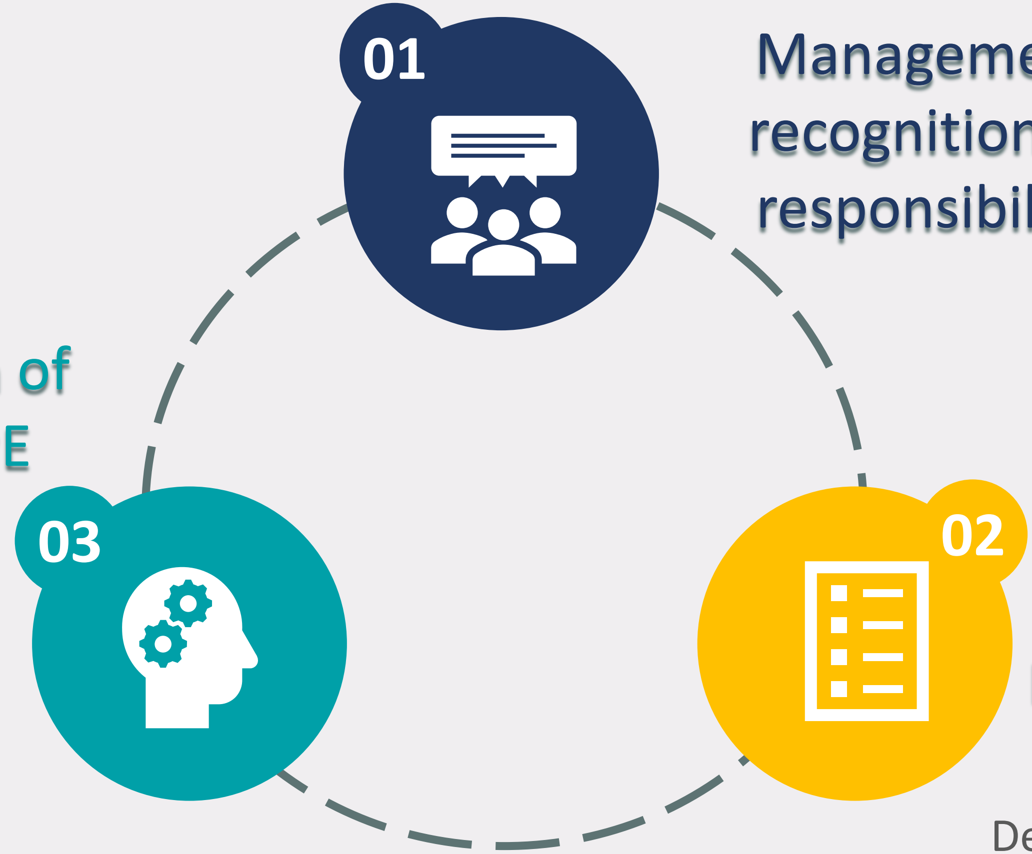
Extensive worker protection requirements at hazardous waste sites.

03

General Duty Clause

Makes employers responsible for worker safety. Free from recognized hazards likely to cause serious harm to employees

Hazzard Identification and Remediation



Management recognition of responsibility

Identification of hazards

Development of Job Safety Analysis

Implementation of job-specific PPE

Provision of PPE
Training on PPE use

Job Safety Analysis

What are the specific tasks for each job?

Identify each step, define what are the hazards, outline critical safety practices.
Include physical, chemical, biological, electrical, radiological, gas/emissions

Rank potential hazards of the job

Each hazard is ranked by probability, severity, and potential consequence.

- Probability is ranked low, medium, high
- Severity is ranked very low, low, medium, high, very high
- Consequence considers all possible outcomes

Identify hazard control measures

- Administrative controls
- Engineering controls
- Required PPE
- Required training
- Required permits
- Other information

PPE Selection Matrix

AREA / LOCATION	ACTIVITY	Contact Transfer	Splash - Eye/Face	Whole Body Contact	Abrasion, Cut, Puncture	Respiratory
Collection System	Lift Station Inspection	X				
	Vac/Jetter Truck Operation	X	X			C
	Netting Facility/Storm Drain Pretreatment O&M	X	X		X	
	CCTV or Line Cleaning	X	X		X	
	Field Wastewater Sampling	X				
	Sewer Entry (Live)	X	X	X	X	X
	Sewer Entry (By-pass)	X	X		X	
	Man-hole Maintenance	X			X	
	Sewer Pipe Repair Work (Live)	X	X	X	X	X
	Sewer Pipe Repair Work (By-pass)	X	X		X	
	Spill Response/SSO/CSO	X	X		X	

Key:

X = recommended, C = conditional depending on specifics of the task

Contact transfer PPE includes gloves, boots, and uniform/coveralls

Splash hazards PPE includes protection of the eyes/face through safety glasses, face shield or goggles

Whole body contact hazards PPE includes Tyvek suits or coveralls

Abrasion, cut, or puncture hazards PPE includes durable gloves designed for protection from cuts or punctures

Respiratory hazards come from sprays, mists, or dust and PPE includes use of a N95 respirator or dust mask

PPE Selection Matrix

AREA / LOCATION	ACTIVITY	Contact Transfer	Splash - Eye/Face	Whole Body Contact	Abrasion, Cut, Puncture	Respiratory
Routine WWTP Operator Activities	Visual Process/Plant Inspections	X				
	Pushbutton Equipment Operation	X				
	Manual Valve Operation	X			X	
	WW Sample Collection (auto)	X				
	WW Sample Collection (grab)	X				
	Field Instrument Calibration (DO)	X	X			
	Sludge Judge	X	X			
	General housekeeping (hose down)	X	X			C
	Dry Sweeping, high pressure power wash	X	X			C
	Lab Activities	X	X		X	
	Hand Held DO	X	X			

Key:	X = recommended, C = conditional depending on specifics of the task
	Contact transfer PPE includes gloves, boots, and uniform/coveralls
	Splash hazards PPE includes protection of the eyes/face through safety glasses, face shield or goggles
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PPE Selection Matrix

AREA / LOCATION	ACTIVITY	Contact Transfer	Splash - Eye/Face	Whole Body Contact	Abrasion, Cut, Puncture	Respiratory
Maintenance	Facility maintenance/ Daily Rounds	X				
	Active Pump and Line Maintenance	X	X	X	X	C
	Process and Equipment Maintenance with Sewage Contact	X	X			
	Tank Entry (Empty Tank) - Maintenance Activities	X	X	X		C
Preliminary Equipment	Cleaning Bar Screens	X	X		C	C
	Screenings Handling	X	C		C	
	Grit Handling	X	C			
UV Disinfection	Routine Inspection	X				
	Routine Maintenance	X				
	Bulb Replacement	X	X		X	
	Ballast Replacement	X	X			

Key:

X = recommended, C = conditional depending on specifics of the task

Contact transfer PPE includes gloves, boots, and uniform/coveralls

Splash hazards PPE includes protection of the eyes/face through safety glasses, face shield or goggles

Whole body contact hazards PPE includes Tyvek suits or coveralls

Abrasion, cut, or puncture hazards PPE includes durable gloves designed for protection from cuts or punctures

Respiratory hazards come from sprays, mists, or dust and PPE includes use of a N59 respirator or dust mask

PPE Selection Matrix

AREA / LOCATION	ACTIVITY	Contact Transfer	Splash - Eye/Face	Whole Body Contact	Abrasion, Cut, Puncture	Respiratory
Biosolids Handling Processes	Gravity Thickening Operation	X				
	Other Thickening (DAF, GBT, Drum) Op	X	X			
	Open Dewatering Eqpt Operation	X	X			
	Enclosed Dewatering Eqpt Operation	X				
	Liquid & Cake Sampling	X				
	Septage/Waste Receiving	X	X			C
	Compost Handling	X				C
	Dewatered Class B Biosolids Handling	X				C
	Dewatered Class A Biosolids Handling	X				
	Thermally Dried Biosolids/Ash Handling	X				

Key:	X = recommended, C = conditional depending on specifics of the task
	Contact transfer PPE includes gloves, boots, and uniform/coveralls
	Splash hazards PPE includes protection of the eyes/face through safety glasses, face shield or goggles
	Whole body contact hazards PPE includes Tyvek suits or coveralls
	Abrasion, cut, or puncture hazards PPE includes durable gloves designed for protection from cuts or punctures
	Respiratory hazards come from sprays, mists, or dust and PPE includes use of a N59 respirator or dust mask

Knowledge Gaps

Conduct a prospective epidemiological study of infectious disease incidence among wastewater and collection system workers

- Rigorous statistical data for US wastewater workers is limited
- Compare health outcomes/biomarkers of wastewater workers comparable cohorts
- Examine health outcomes with respect to reported levels of PPE use

Characterize respiratory exposure for typical tasks performed by workers in wastewater collection and treatment operations

- Aerosol exposures in real-world environments is poorly characterized
- Ambient concentrations of aerosols should be measured real work environments
- Time-activity patterns of workers should be assessed to determine exposures

Characterize contact exposure for typical tasks in wastewater collection and treatment operations

- Numerous exposure pathways in water resource recovery facilities and collection systems
- Viable pathogens should be measured on a range of surfaces
- Time-activity patterns of workers can assess cumulative daily contact exposure

Knowledge Gaps

Perform cost-benefit analyses of PPE for wastewater and collection system workers

- Risk assessment models should be applied to estimate the costs and benefits of recommended PPE practices
- Monetize health benefits of reductions in infectious disease risks when using PPE

Refine guidance and develop best practices for wastewater and collection system worker PPE

- Workforce education and training
- Translational research will be needed to support effective implementation of PPE
- Guidance regarding special worker limitation rules for certain medical conditions
- Development of training materials and dissemination of best practices

LeChevallier M.W., T.J. Mansfield, J. MacDonald Gibson. 2019. Protecting wastewater workers from disease risks: Personal protective equipment guidelines. Water Environment Research, Sep 27 2019, 1–10. https://doi.org/10.1002/wer.1249

Mark LeChevallier

Principal

Dr. Water Consulting

lechevallier1@comcast.net

www.drwaterconsulting.com

Contact
Recomendations
Approach
Regulations
Challenge
Background

Poll #4: What kind of research does the water sector need to be conducting immediately in response to the COVID-19 virus outbreak?

- Persistence and viability of the COVID-19 virus in the environment.
- Dose response of the COVID-19 virus in wastewater and feces.
- Airborne exposure and spread from bioaerosols of COVID-19 virus.
- Disinfection efficacy of the COVID-19 virus.
- Understanding the spread of COVID-19 through the use of environmental surveillance of wastewater.
- Other

Q&A

Dr. Haas and Lola Olabode

THE Water Research FOUNDATION

Thank You

Comments or questions, please contact:

lolabode@waterrf.org

For more information, visit

www.waterrf.org

Monday, April 27th

3pm – 5pm ET

Virtual International Water Research Summit on COVID-19

Upcoming: APR 27, 2020

Event Type CONFERENCE

Sha

The Water Research Foundation (WRF) is proud to host a groundbreaking Virtual International Water Research Summit on Environmental Surveillance of COVID-19 Indicators in Sewersheds. The summit will address several technical issues to further advance the work researchers are performing throughout the world,