SARS-CoV-2 sewage surveillance; experiences from NL

Gertjan Medema

On behalf of a research consortium

Bridging Science to Practice

Towards a Water-wise World

Erasmus MC

Miranda de Graaf, Marion Koopmans, Evelien de Schepper, Izquierdo Lara, Claudia Schapendonk, Patrick Bindels, Johan van der Lei, Margreet Vos

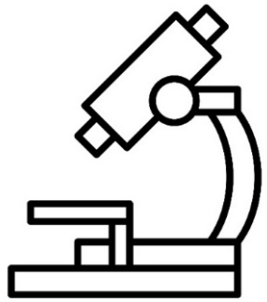
RIJNMOND GEZOND DATA BASE

GGD Rotterdam-Rijnmond

Ewout Fanoy

Rijksinstituut voor Volksgezondheid en Milieu
Ministerie van Volksgezondheid, Welzijn en Sport

Eelco Franz, Roan Pijnacker, Christian Carrizosa Balmont



KWR

Goffe Elsinga, Leo Heijnen, Frederic Been, Gertjan Medema

stowa

Bert Palsma, Imke Leenen

Royal HaskoningDHV
Enhancing Society Together

Stefanie Stubbé, Emma Weisbord

PARTNERS4URBANWATER
onderzoek & advies

Jeroen Langeveld, Remy Schilperoort, Johan Post

waterschap Hollandse Delta

Olaf Duin

Hoogheemraadschap van Delfland

Mariska Ronteltap

Hoogheemraadschap van Schieland en de Krimpenerwaard

Nick Ivens

waternet

Marco Dignum, Alex Veltman, Alice Fermont, Jan Peter van der Hoek

HOOGHEEMRAADSCHAP DE STICHTSE RIJNLANDEN

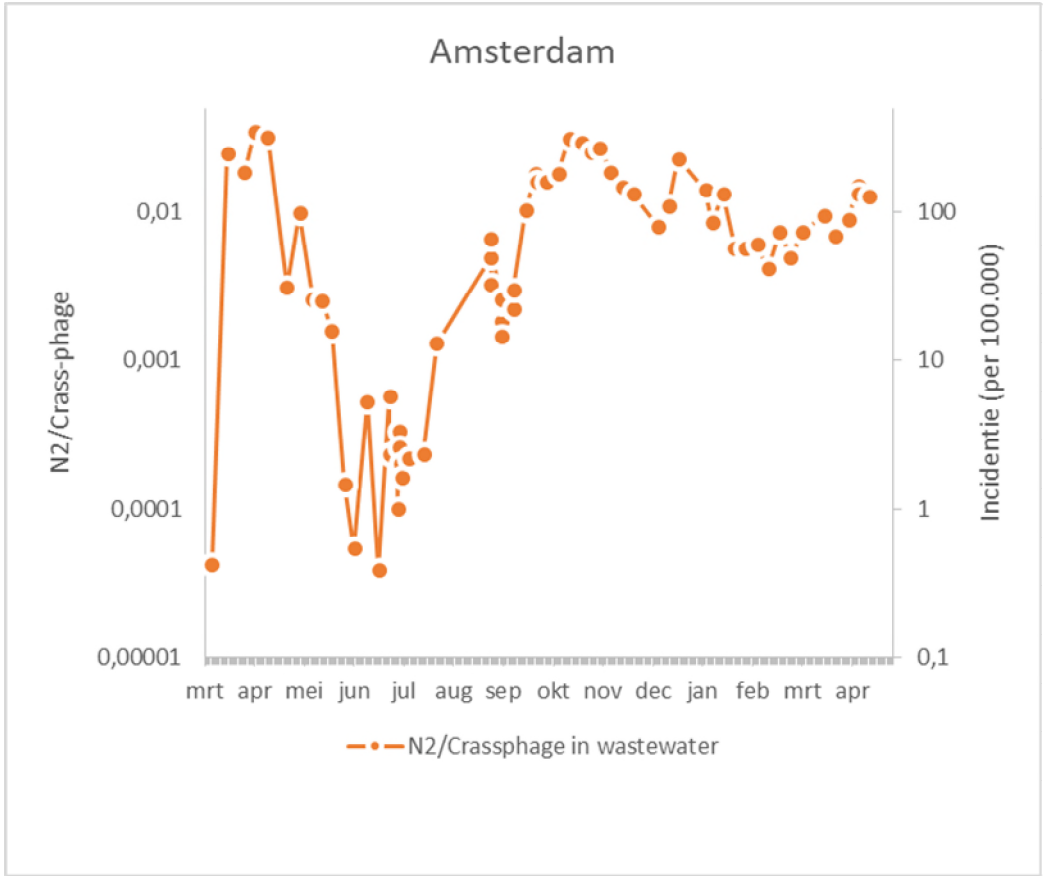
Mark Stevens

TOPSECTOR WATER & MARITIEM

Sewage surveillance

Added value of wastewater information

SARS-CoV-2 circulation in city population



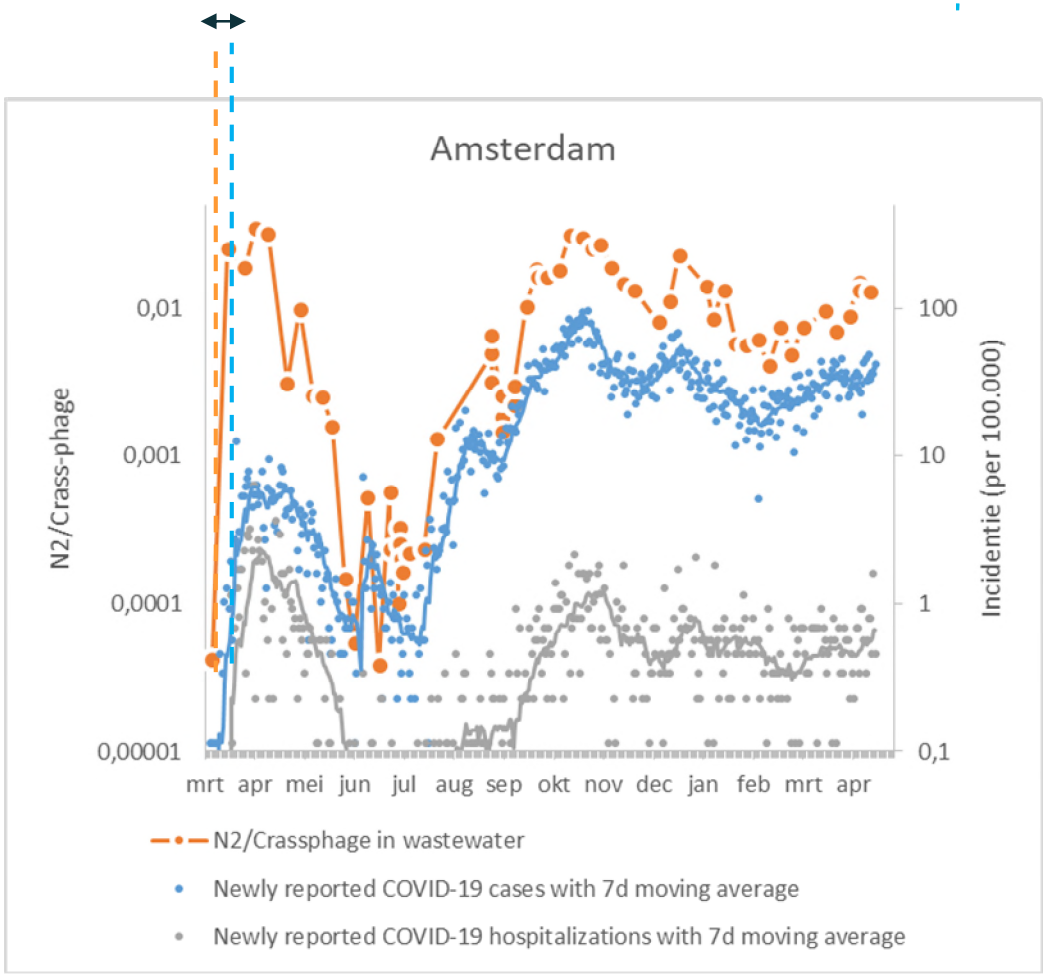
TOPSECTOR WATER & MARITIEM

Use case: early warning

Added value of wastewater information

Early warning of trends in SARS-CoV-2 circulation

In the first wave, we observed SARS-CoV-2 RNA in wastewater six days before the first cases were reported

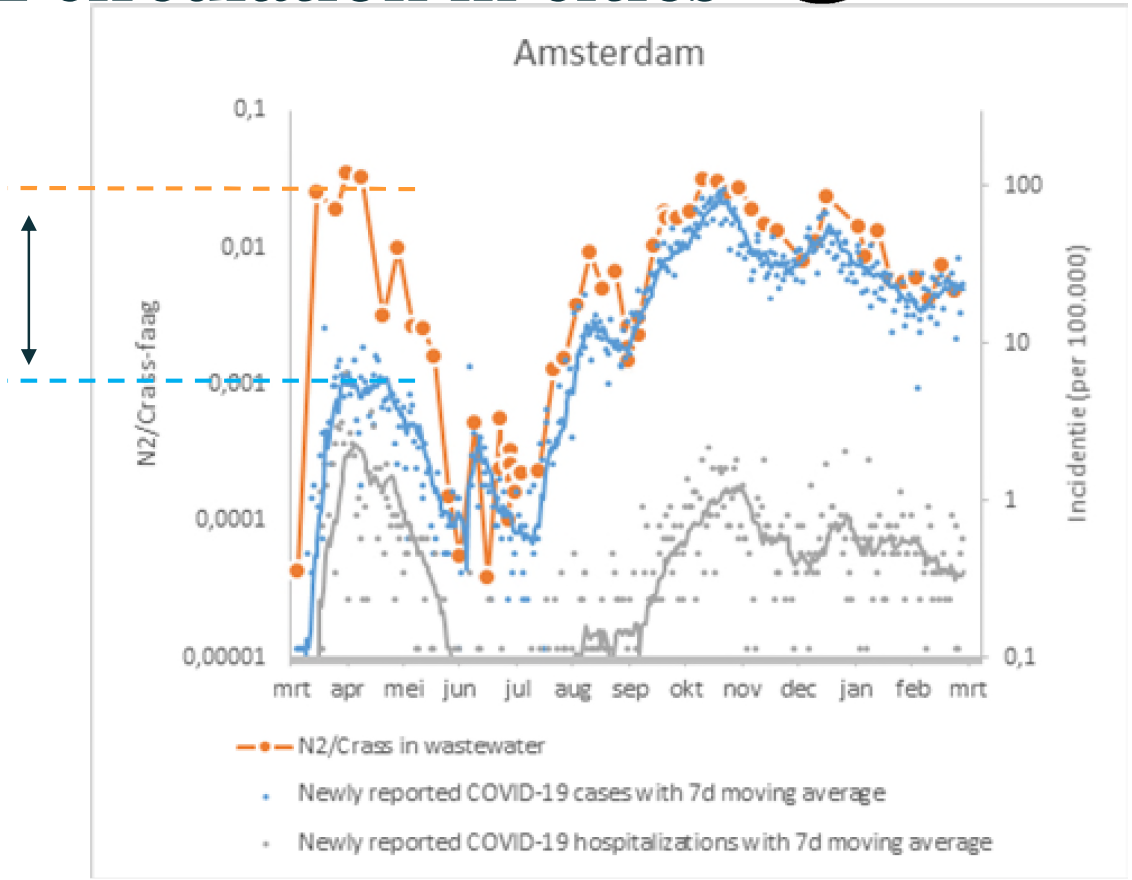


TOPSECTOR WATER & MARITIEM

Use case: objective SARS-CoV-2 circulation in cities

Added value of wastewater information

Objective indicator of SARS-CoV-2 circulation, independent of human testing



TOPSECTOR WATER & MARITIEM

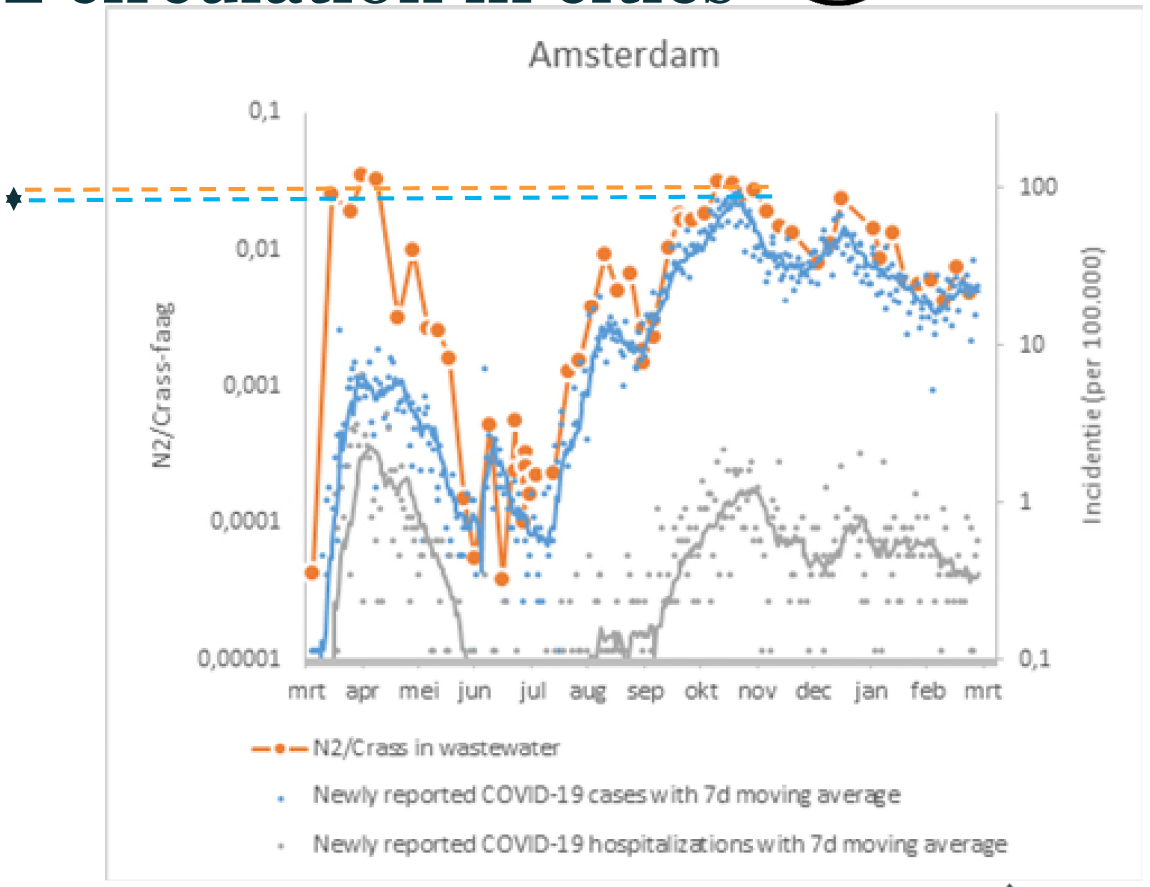
Use case: objective SARS-CoV-2 circulation in cities

Added value of wastewater information

Objective indicator of SARS-CoV-2 circulation, independent of human testing:

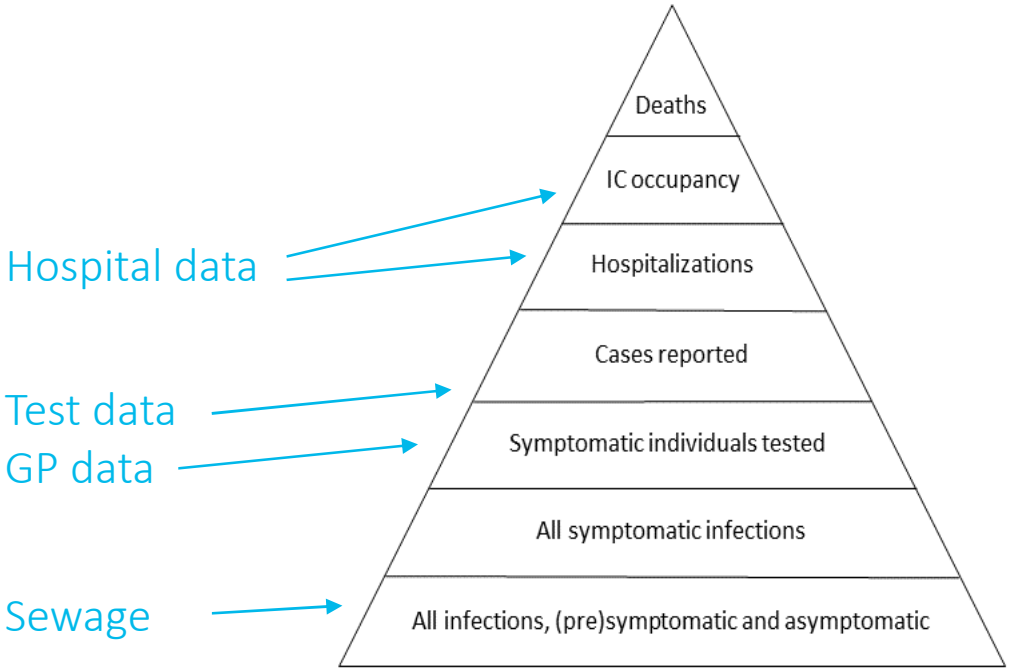
everybody is going to the toilet, not everybody is going to get tested

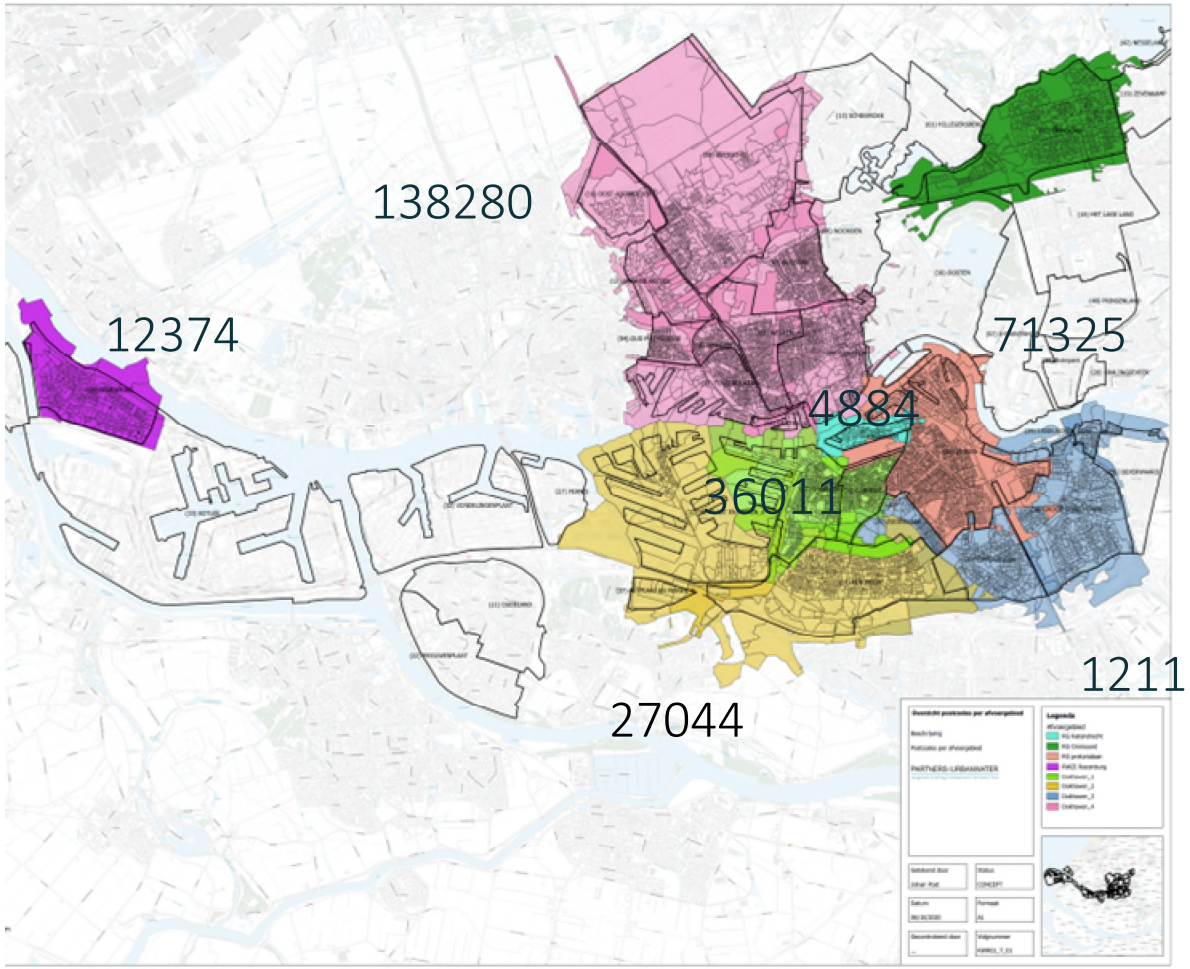
- test availability
- testing strategy
- testing willigness
- asymptomatic ‘case’



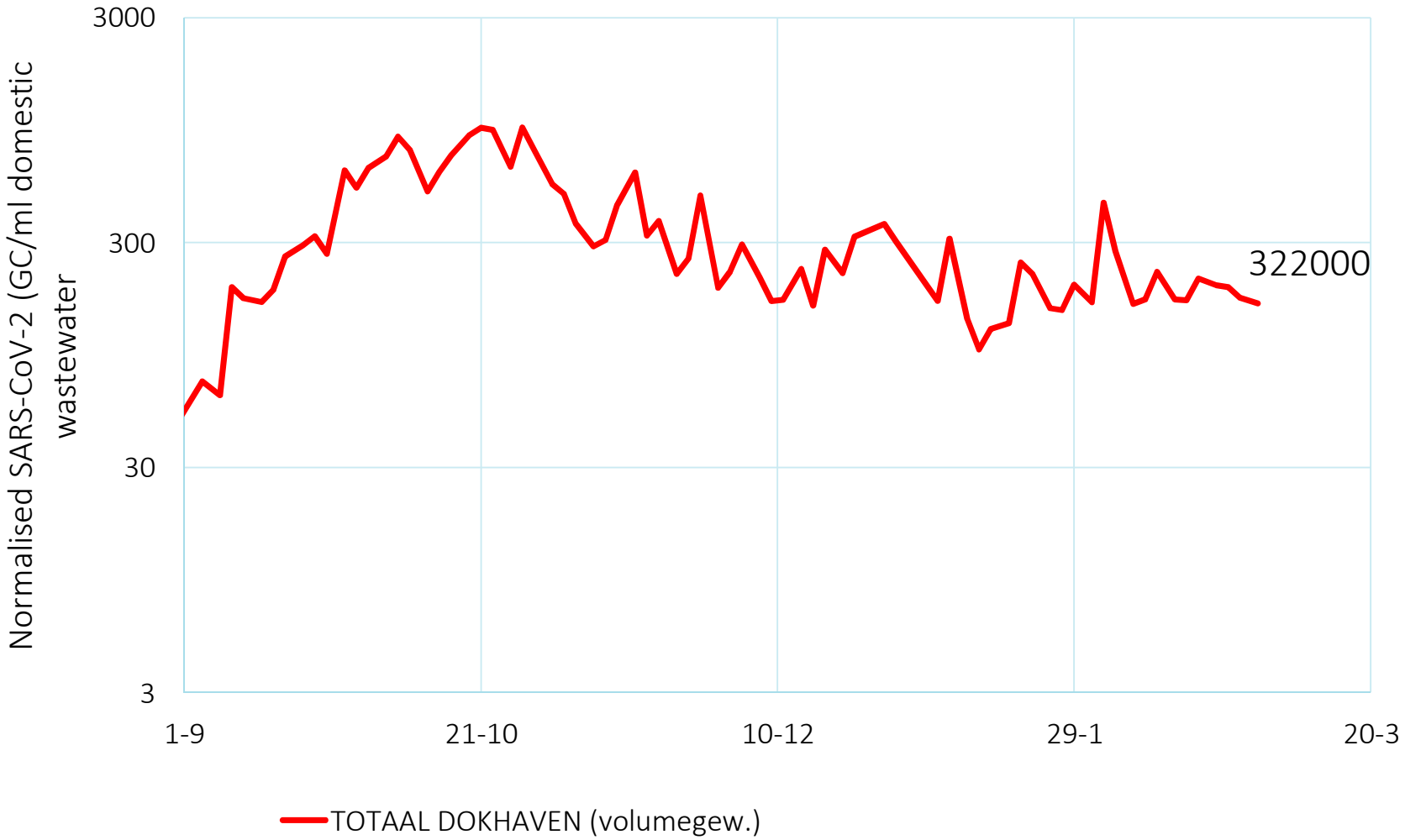
Use case: understand COVID-19 dynamics

High resolution:
- Time: 3/week
- Space: city districts
- Matched population

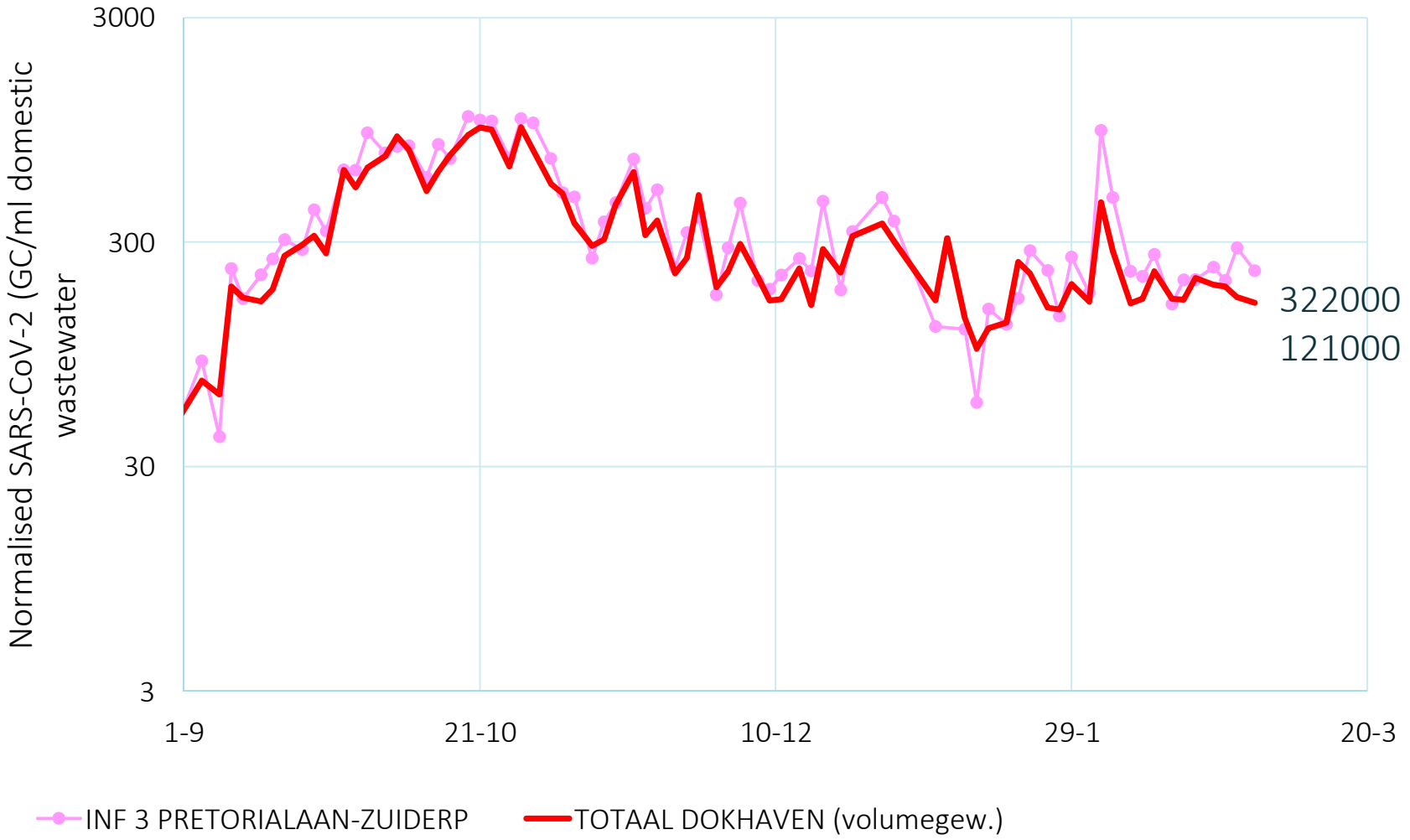




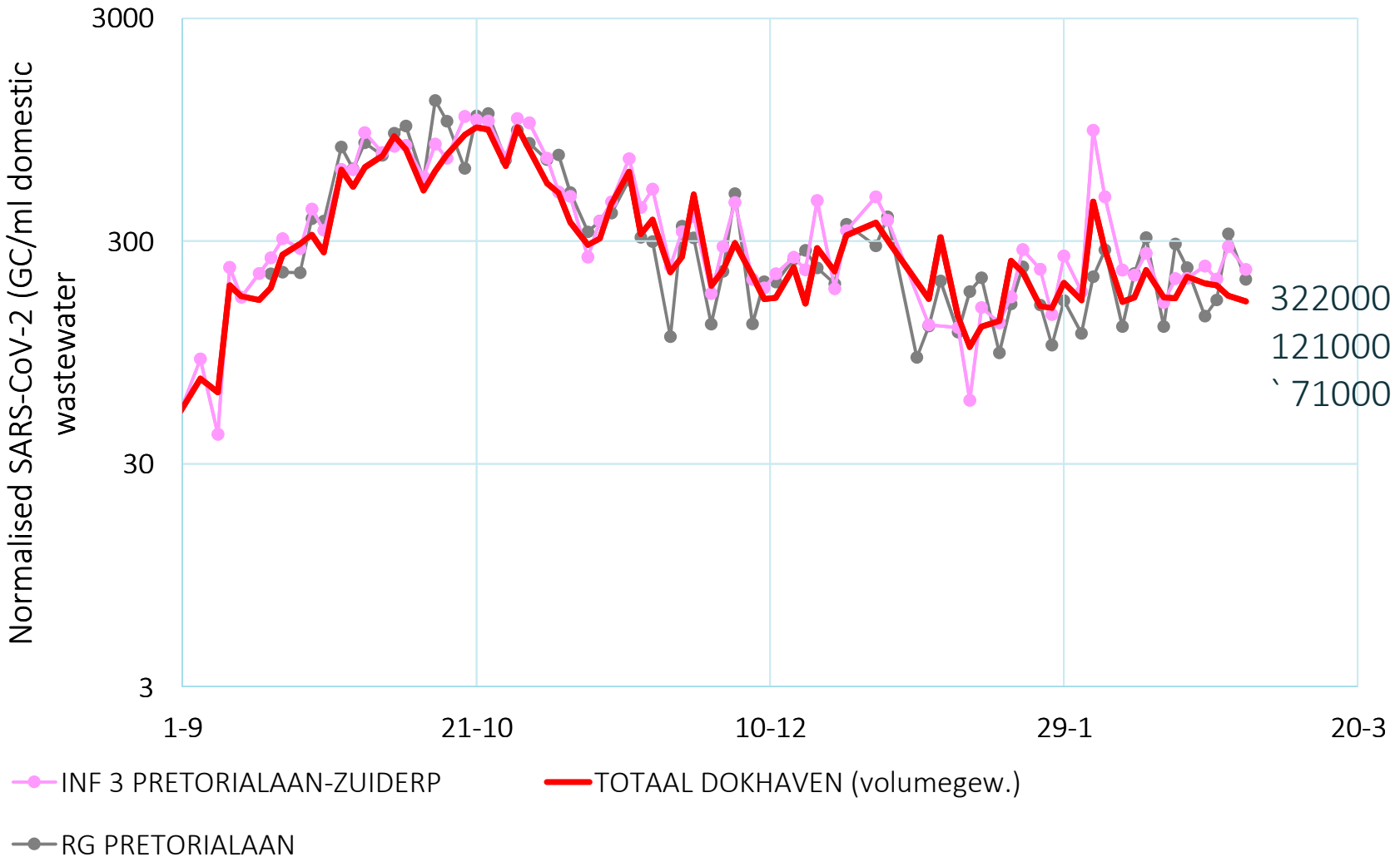
Population size affects sewer signal dynamics



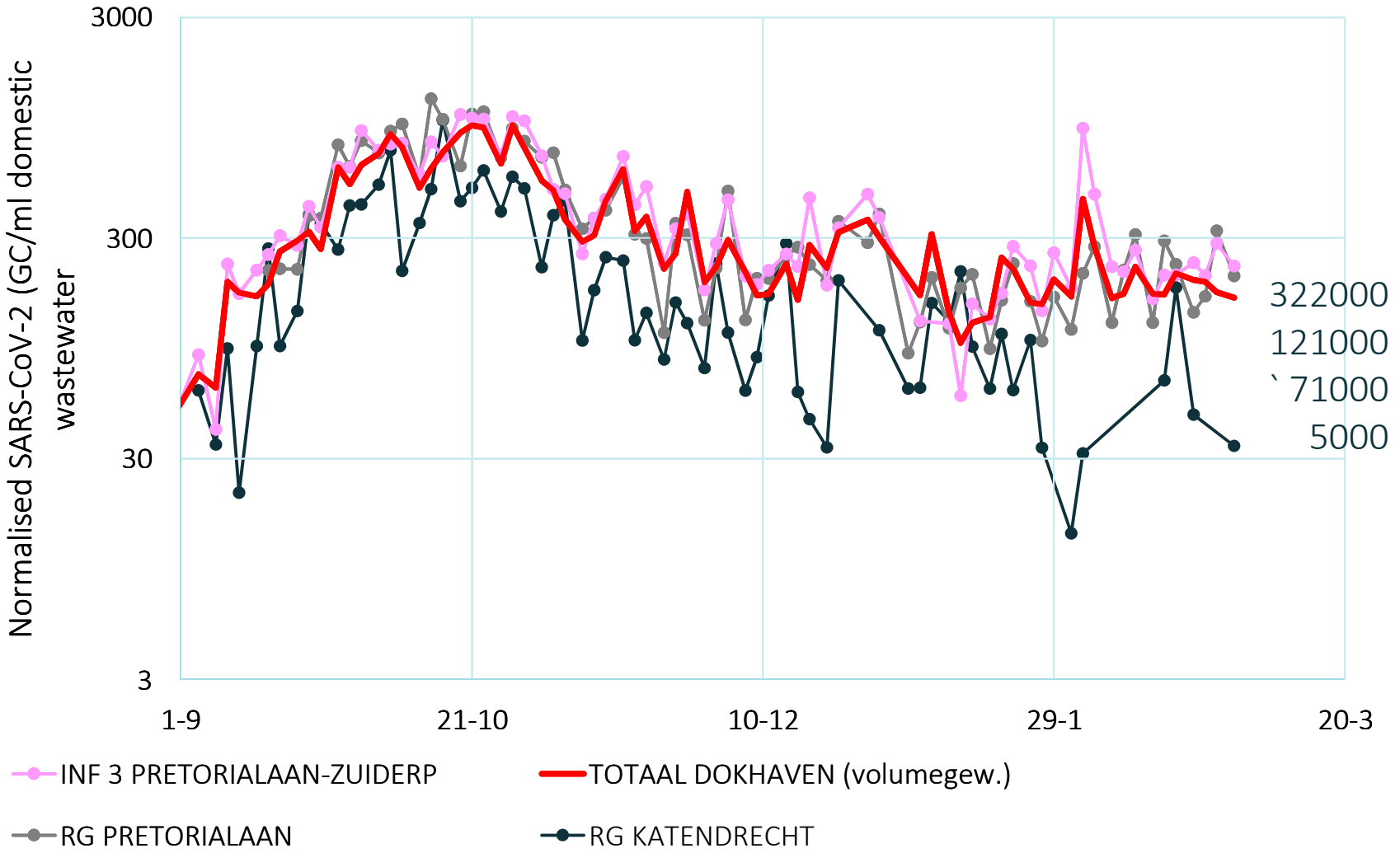
Population size affects sewer signal dynamics



Population size affects sewer signal dynamics



Population size affects sewer signal dynamics

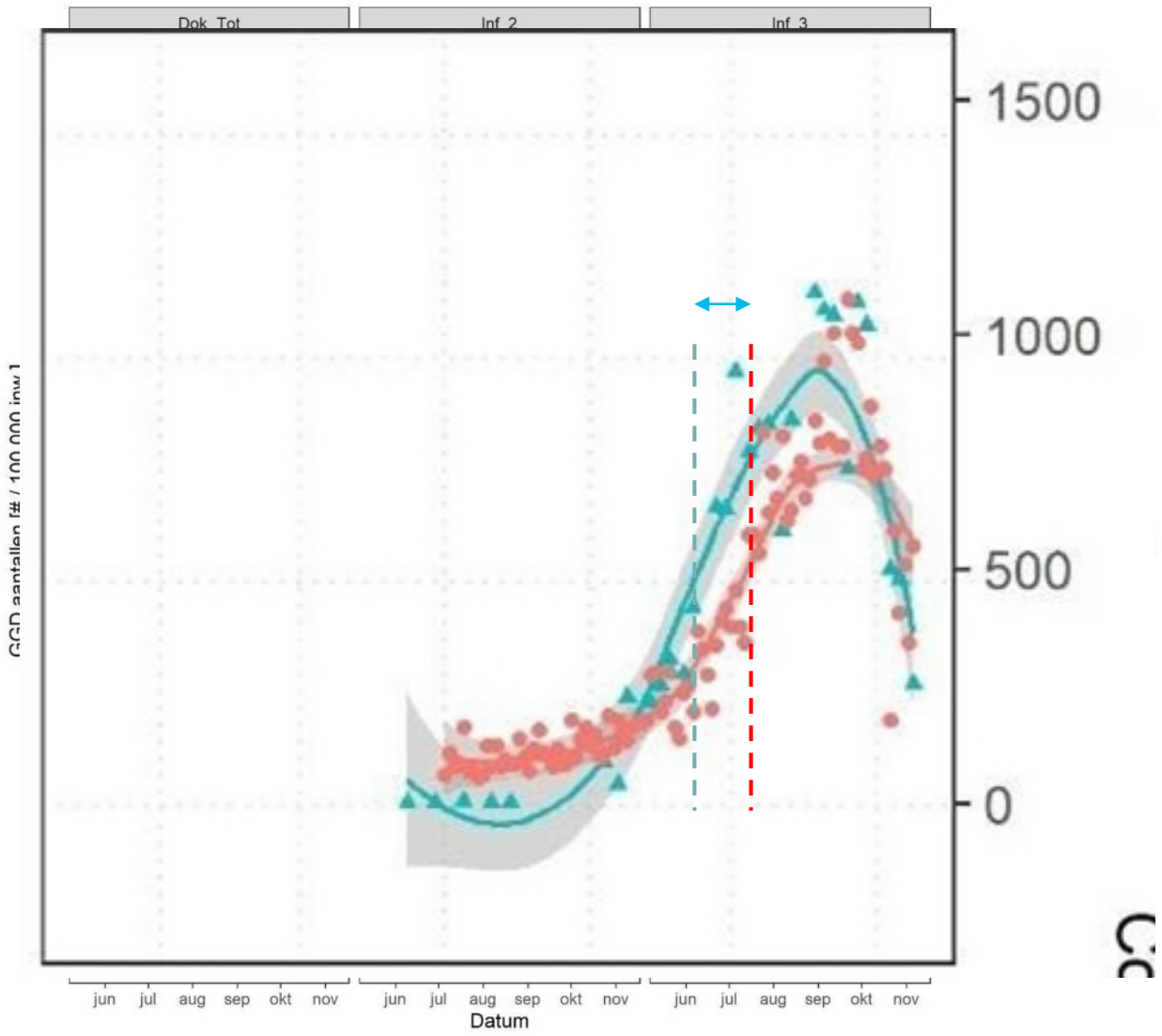


Data analysis Rotterdam

Early warning?

Depends largely on delay in human testing between disease onset and taking sample

Analysis conducted by Jeroen Langeveld & Johan Post



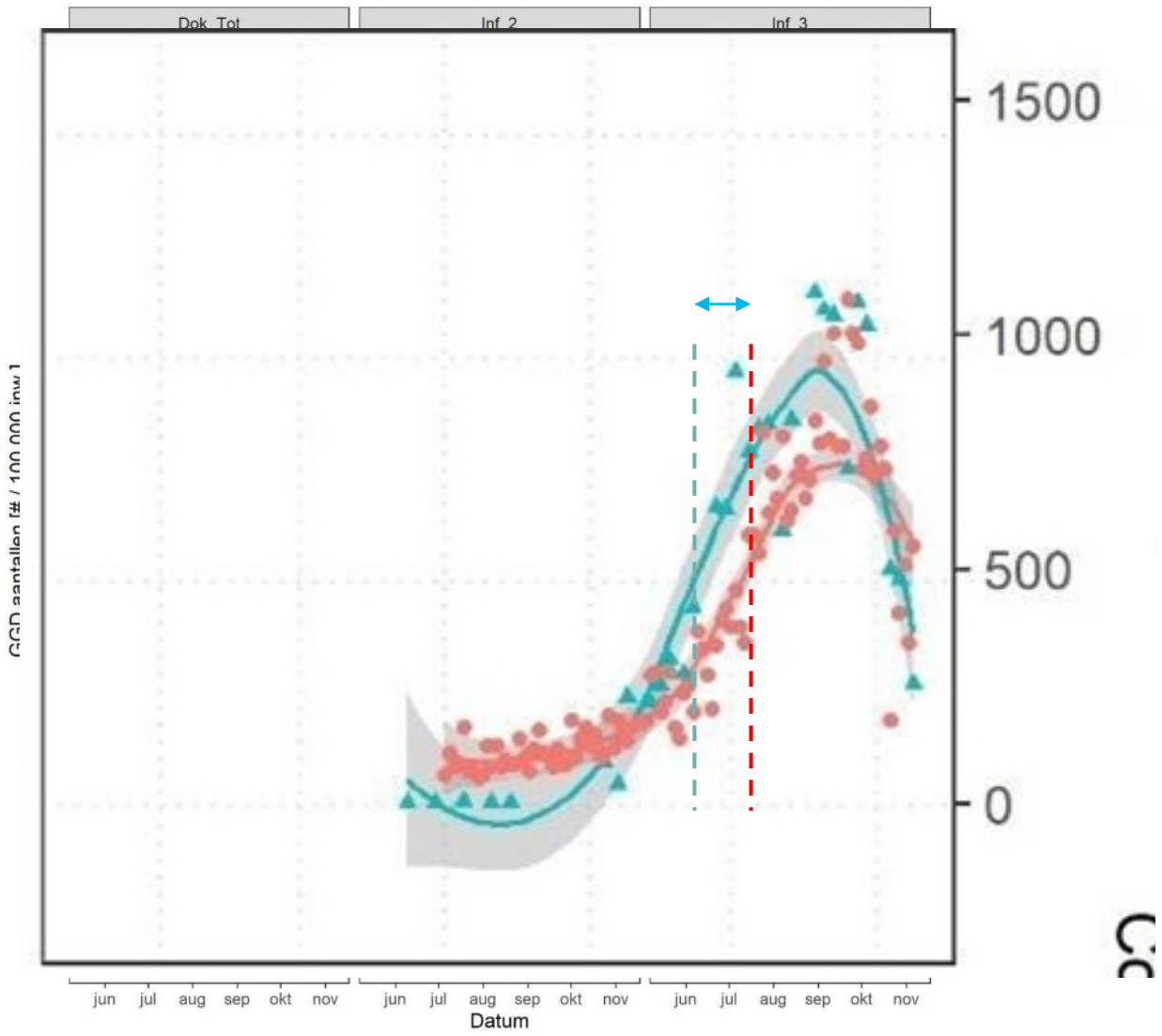
KWR, GGD Rotterdam, Erasmus MC, Partners4UrbanWater, RHDHV, RIVM, Water authorities: Hollandse Delta, Delfland, Schieland & Krimpenerwaard

Data analysis Rotterdam

Early warning?

Depends largely on delay in human testing between disease onset and taking sample

Analysis conducted by Jeroen Langeveld & Johan Post



KWR, GGD Rotterdam, Erasmus MC, Partners4UrbanWater, RHDHV, RIVM, Water authorities: Hollandse Delta, Delfland, Schieland & Krimpenerwaard

Data analysis Rotterdam data

Sewage as objective indicator of virus circulation

Undertesting of humans in certain city areas?

Sewage data used to mobilize testing facilities to city areas with low case number/sewer signal ratio

Linking sewage data to human testing data: correct for human testing behaviour via total number of tests

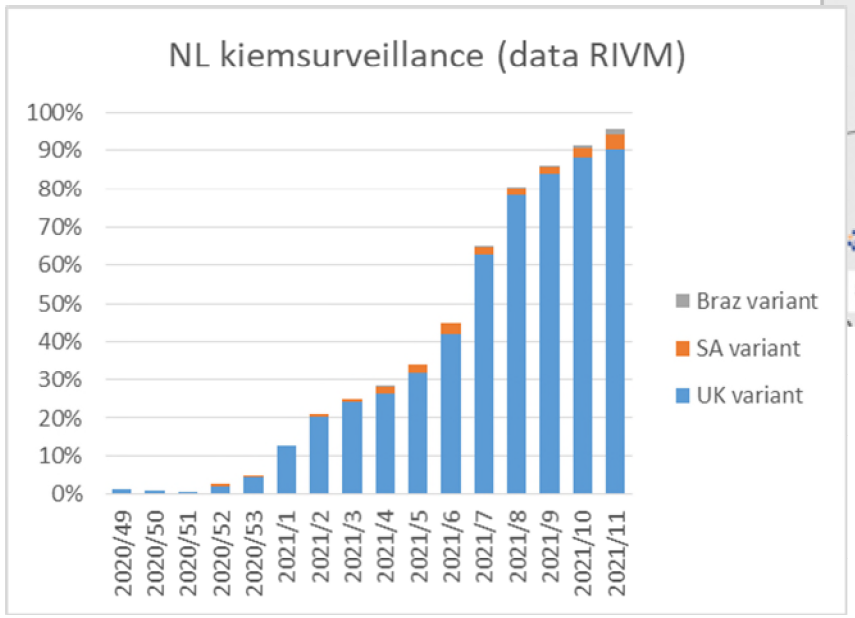
KWR, GGD Rotterdam, Erasmus MC, Partners4UrbanWater, RHDHV, RIVM, Water authorities: Hollandse Delta, Delfland, Schieland & Krimpenerwaard

Emergence of Variants of Concern (VoC)

Observe emergence/circulation of new VoC

Understand disease, transmission dynamics

Observe vaccination efficacy to VoC



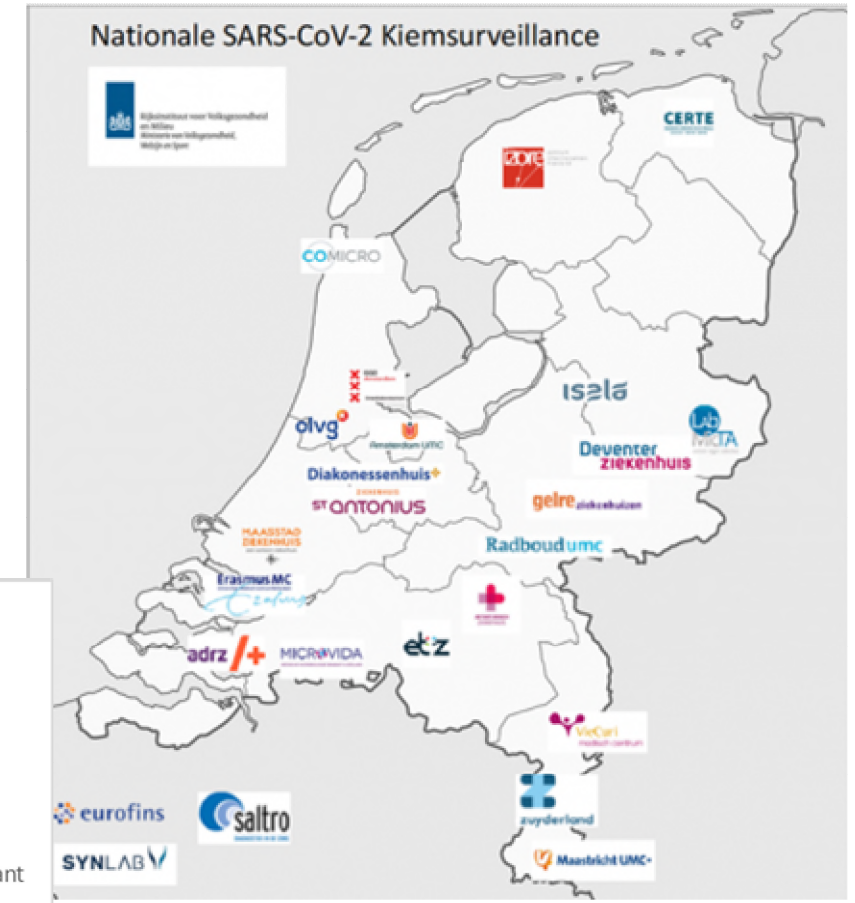
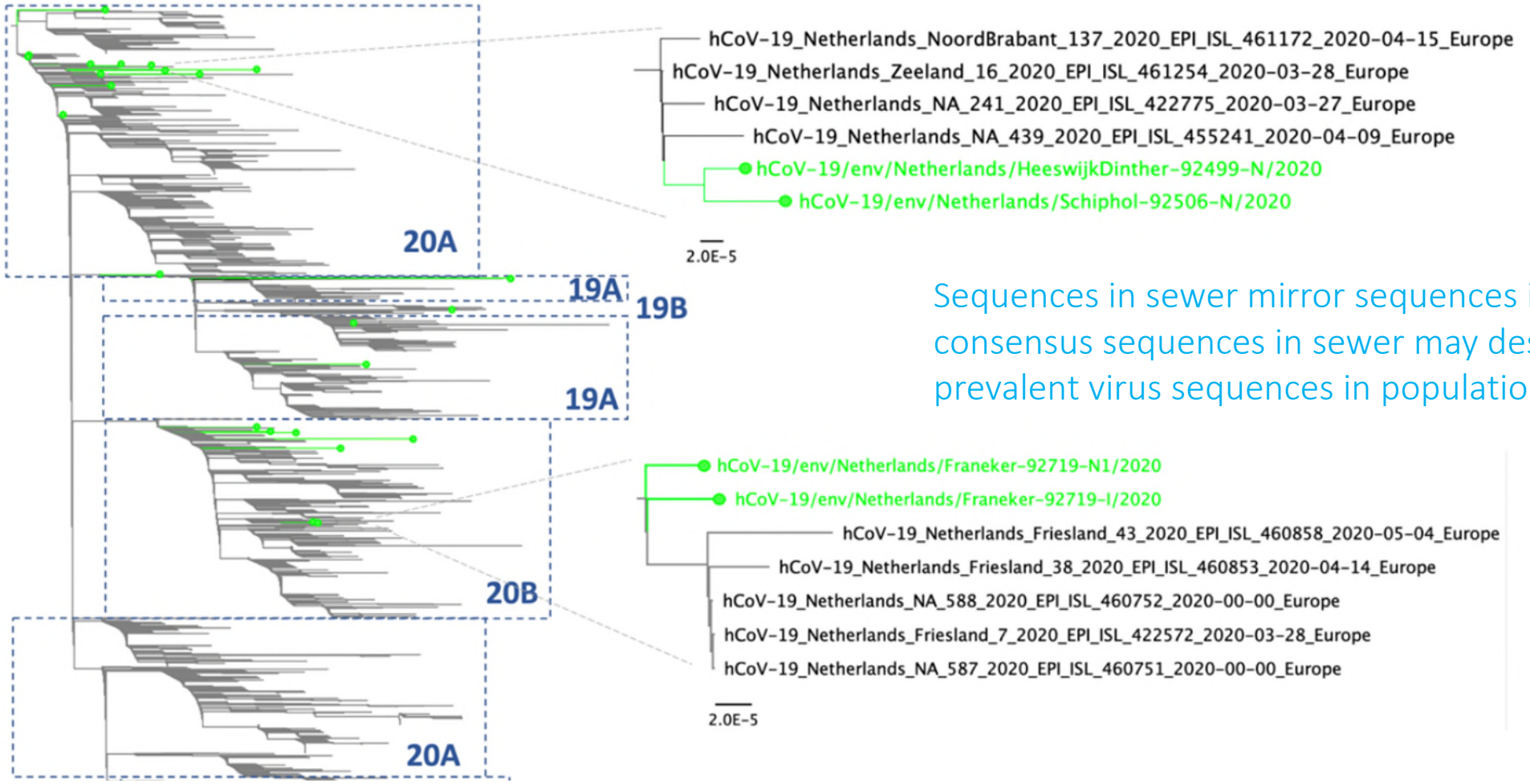


Image: RIVM

NGS for variant circulation in wastewater

Conducted by Viroscience at Erasmus Medical Centre



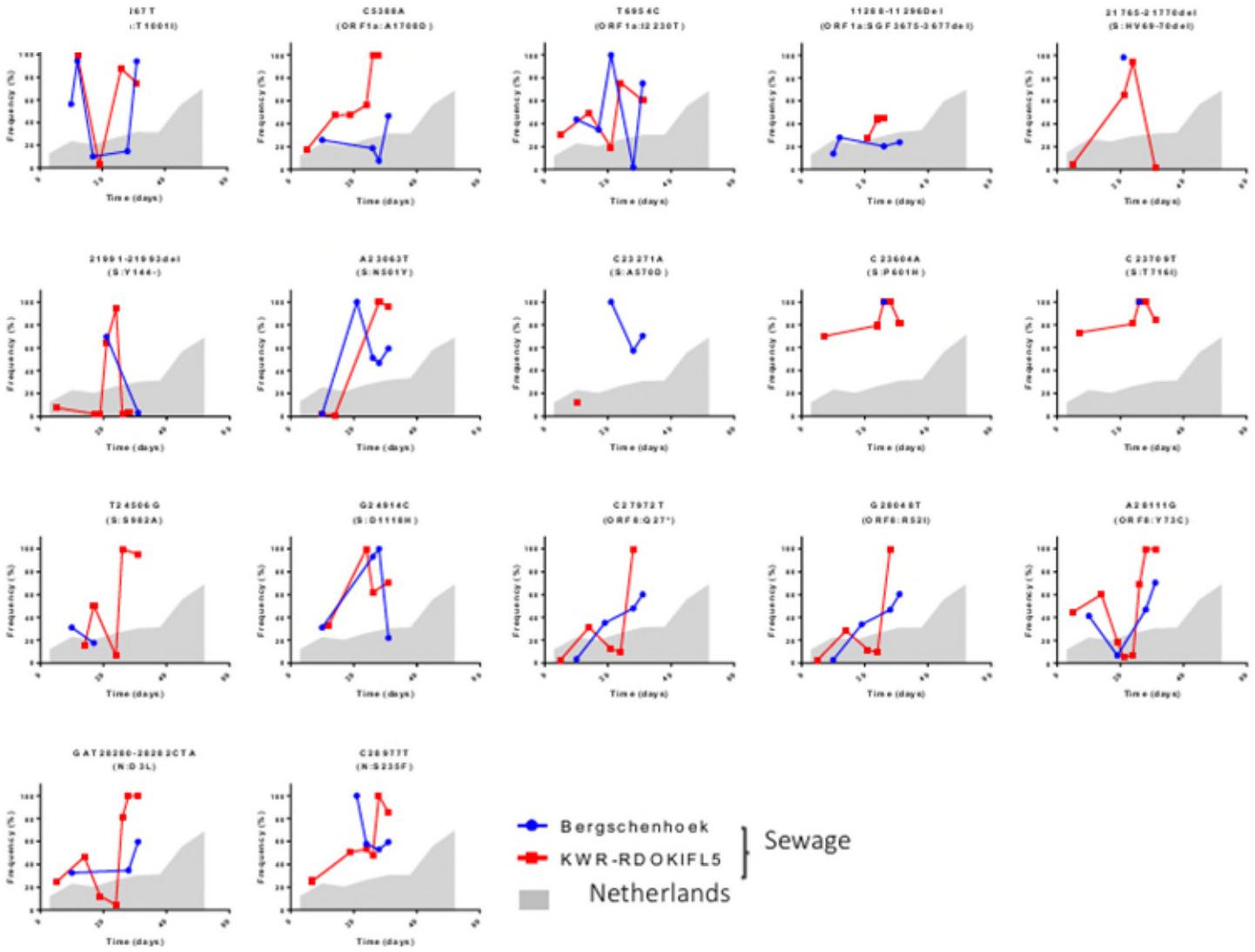
Sequences in sewer mirror sequences in population: consensus sequences in sewer may describe most prevalent virus sequences in population

Lara et al, 2021, EM INF DIS

UK variant mutations/deletions in Rotterdam wastewater

gene	nucleotide	amino acid
ORF1ab	C3267T	T1001I
	C5388A	A1708D
	T6954C	I2230T
	11288-11296 deletion	SGF 3675-3677 deletion
spike	21765-21770 deletion	HV 69-70 deletion
	21991-21993 deletion	Y144 deletion
	A23063T	N501Y
	C23271A	A570D
	C23604A	P681H
	C23709T	T716I
	T24506G	S982A
	G24914C	D1118H
Orf8	C27972T	Q27stop
	G28048T	R52I
	A28111G	Y73C
N	28280 GAT->CTA	D3L
	C28977T	S235F

Vanaf 01-01-2021

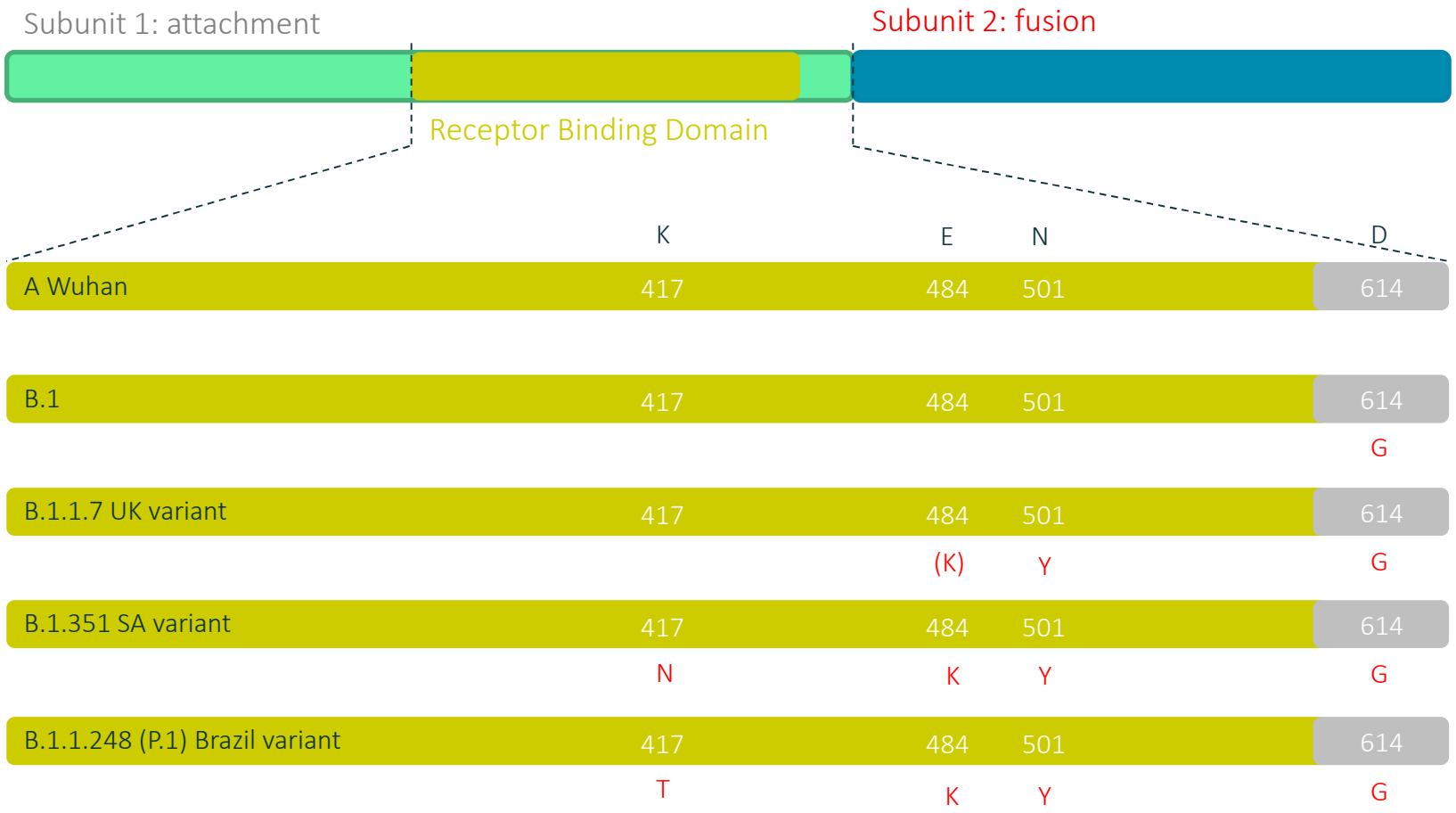


Versatile Emerging Infectious Disease Observatory

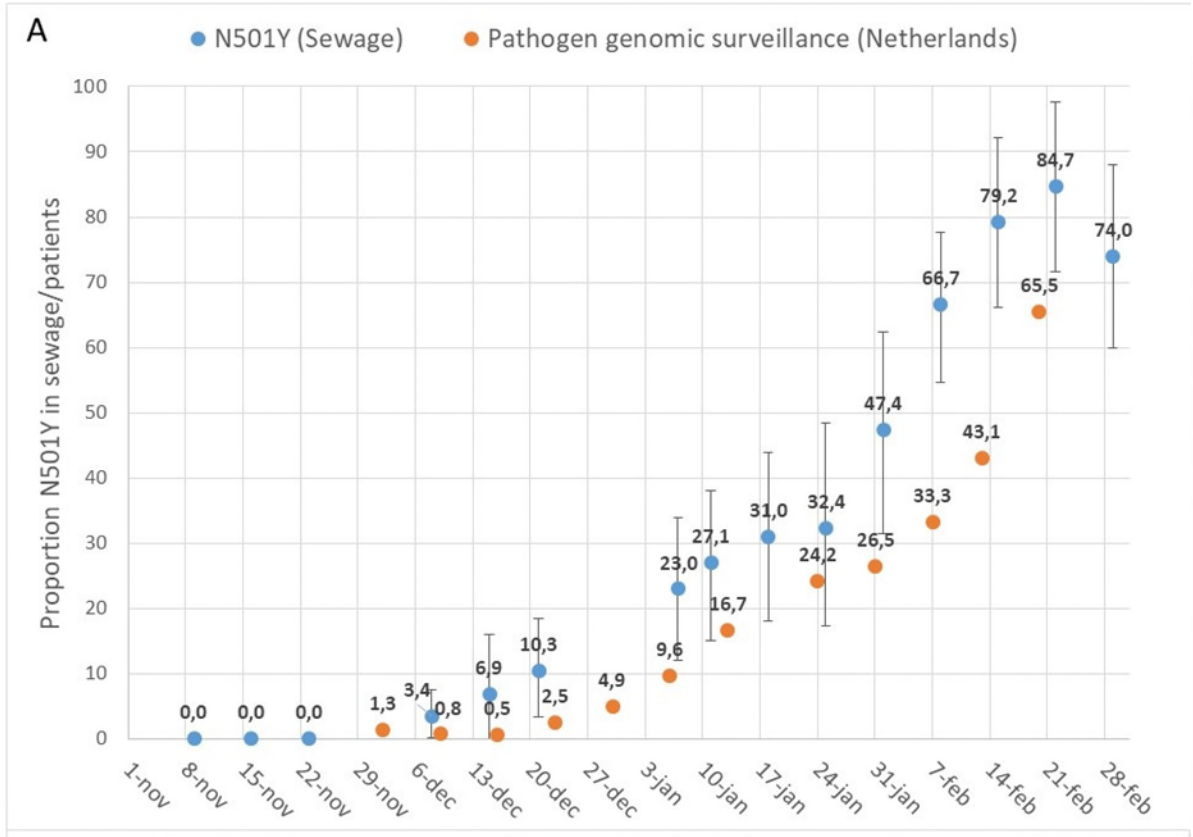
This work is supported by European Unio"s Horizaon 2020 research and innovation programme under Grant No.874735 (VEO).

VoC signature mutation multiplex ddPCR

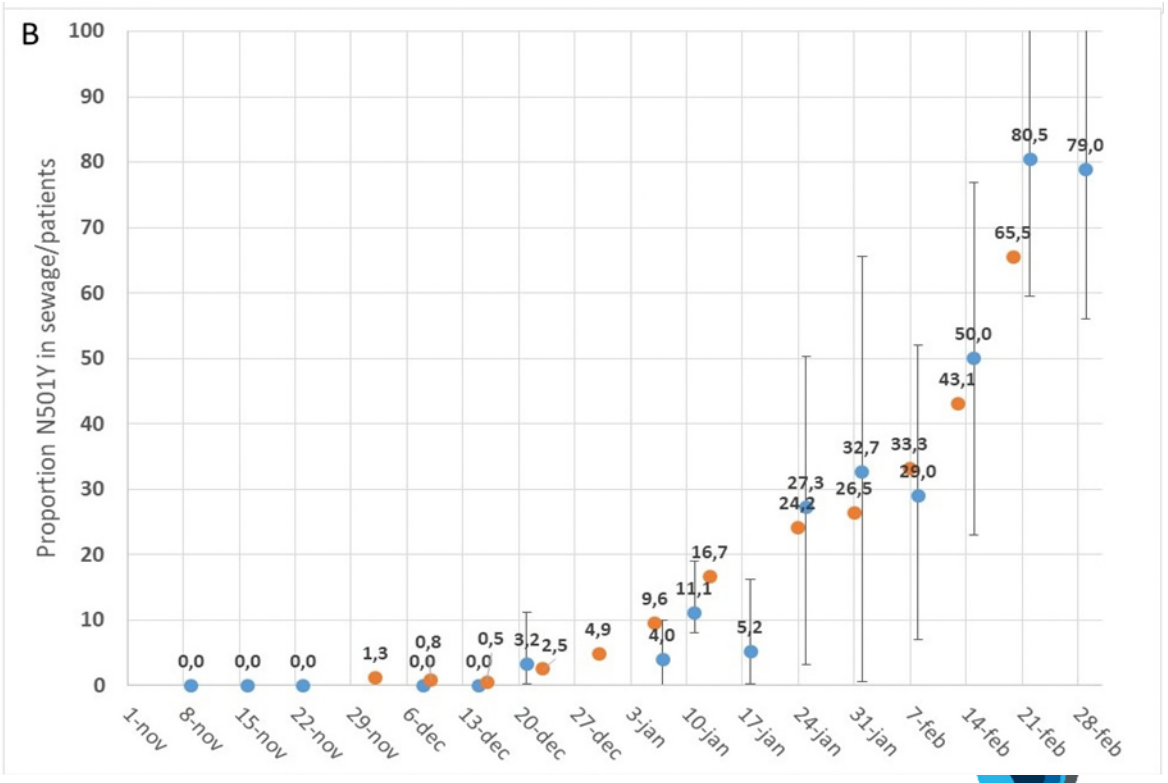
Spike protein



Use case: Variants of Concern introduction N501Y mutation vs 'wild type' by ddPCR



Amsterdam



Utrecht

Wastewater surveillance is of added value for COVID-19 surveillance

Early warning

Objective population surveillance, independent of human test behaviour

Feasible for emergence of (signature mutations of) VoC

Fast (with ddPCR within days, compared to 3-4 weeks for clinical surveillance with NGS)

Efficient: on population sample, allowing high resolution surveillance

National Sewage Surveillance Netherlands

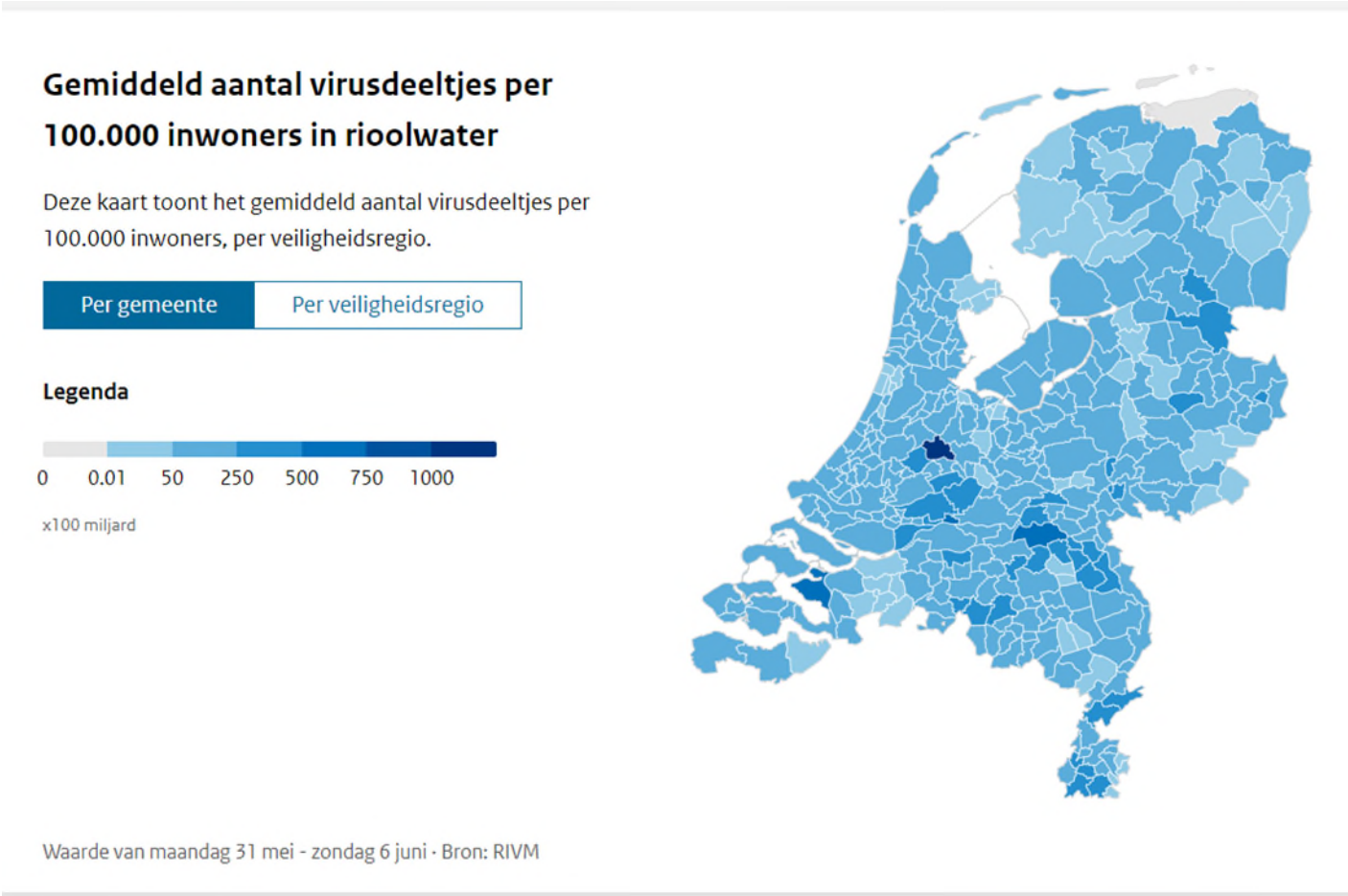
Ministry of Health

RIVM

From sentinel to all WWTP

Now 2x/week

National corona dashboard



EU Umbrella study under European Health Emergency Preparedness and Response Authority (HERA)

Objective:

Increase information/response to new variants

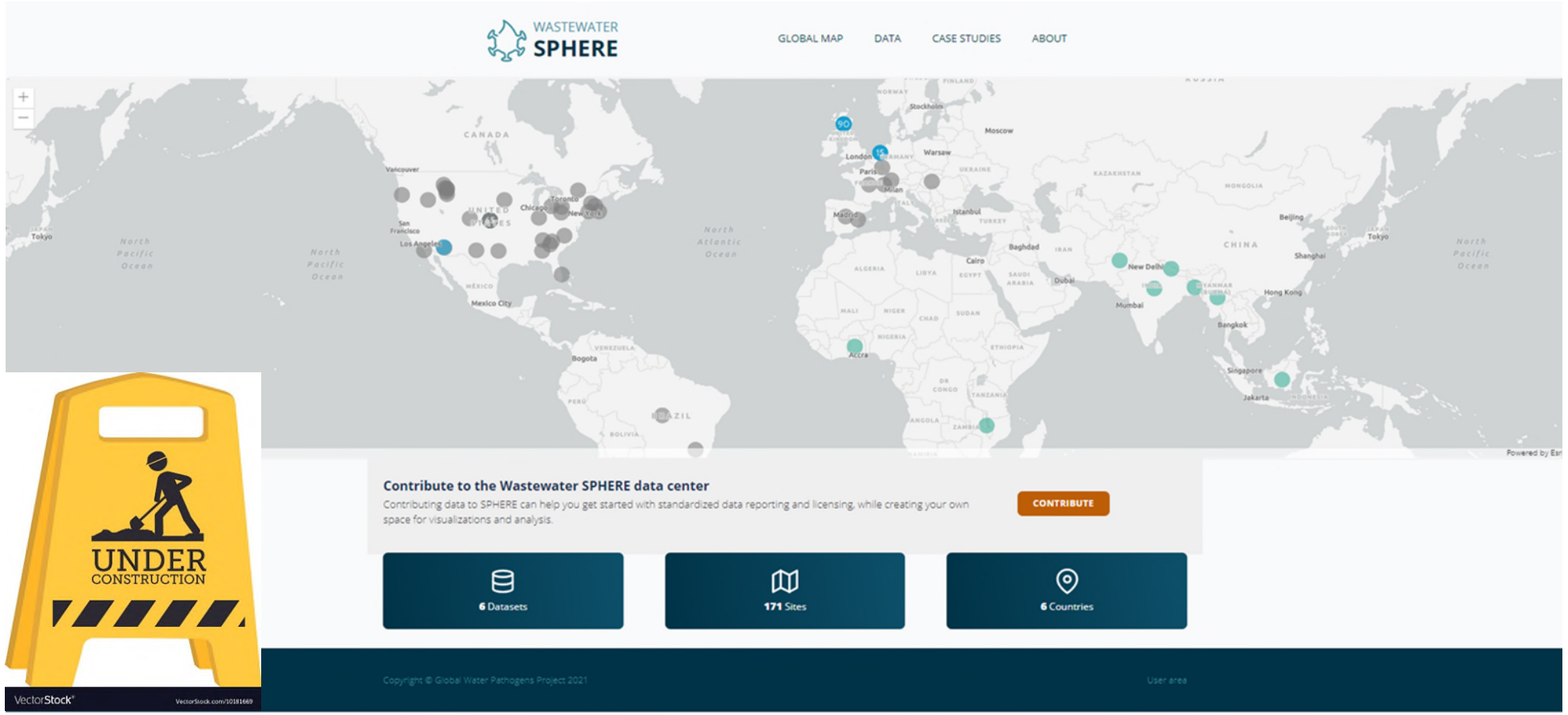
Currently: Round 3 EU sewage snapshot (Mar 2021)

Variant detection with sequencing and ddPCR

Recommendation to MS: variant surveillance via wastewater

In collaboration with:

Wastewater SARS Public Health Environmental REsponse



GWPP Global Water Pathogen Project

MICHIGAN STATE UNIVERSITY

KWR

UCMERCED UNIVERSITY OF CALIFORNIA

UENTHIC

PATH

you

r

on

Bridging Science to Practice

Towards a Water-wise World

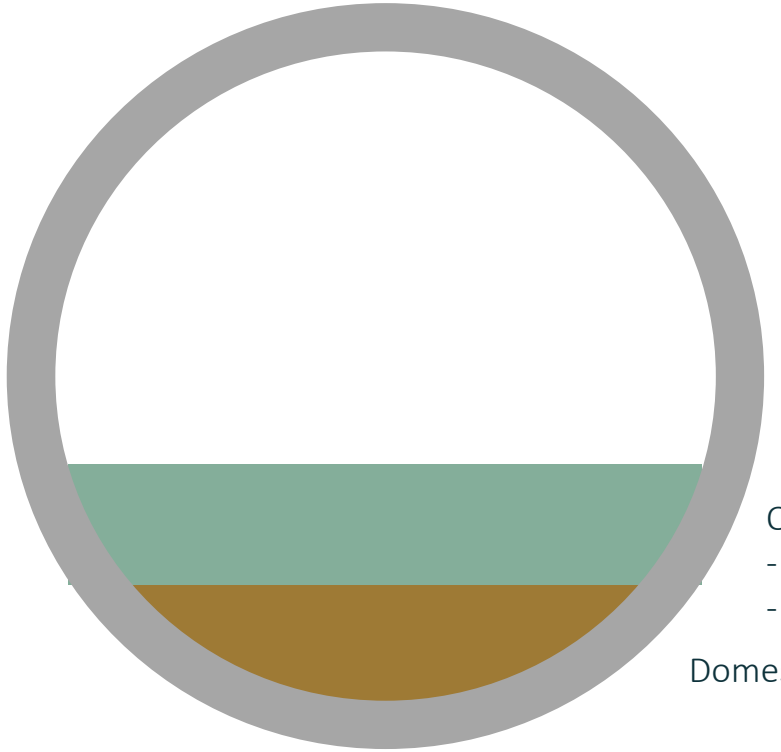
Normalization of SARS-CoV-2 signal

Human wastewater is diluted in sewer network by other water flows (rain, industrial, groundwater, …)

Dilution is dynamic, hence normalization of the SARS-CoV-2 concentration in wastewater is essential

1. Wastewater flow: virus load per day
2. Population size: virus load per 10,000 people per day
3. Check normalization with conductivity
4. Check normalization with Crassphage (virus that infects bacteria that are exclusively present in the human gut). Most people shed high concentrations of Crass-phage in their stool.

Crass-phage can be used as index for human faecal fraction of sewage



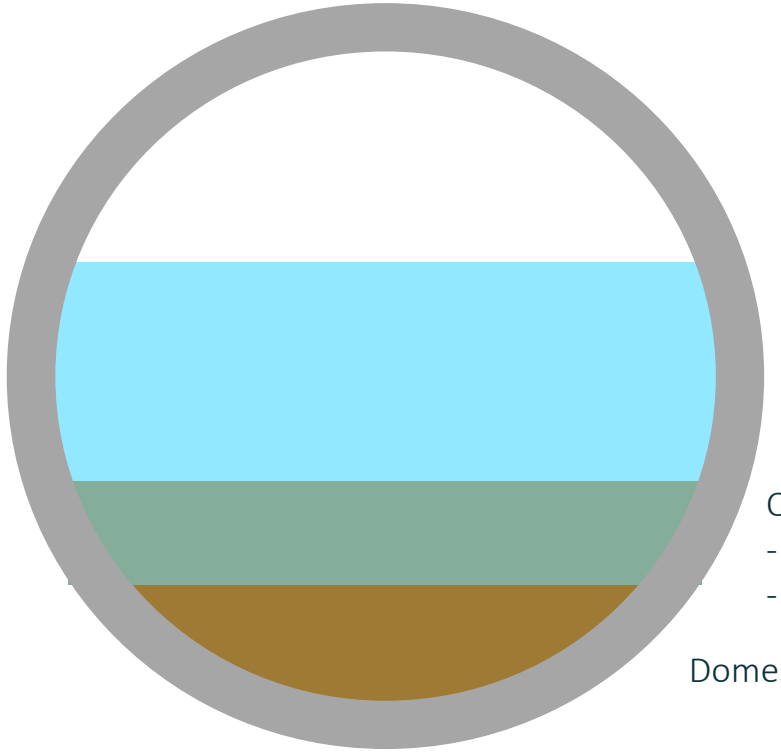
Normalization of SARS-CoV-2 signal

Human wastewater is diluted in sewer network by other water flows (rain, industrial, groundwater, …)

Dilution is dynamic, hence normalization of the SARS-CoV-2 concentration in wastewater is essential

1. Wastewater flow: virus load per day
2. Population size: virus load per 10,000 people per day
3. Check normalization with conductivity
4. Check normalization with Crassphage (virus that infects bacteria that are exclusively present in the human gut). Most people shed high concentrations of Crass-phage in their stool.

Crass-phage can be used as index for human faecal fraction of sewage



Normalization with flow vs Crass-phage