

Use cases of sewage surveillance for COVID-19

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



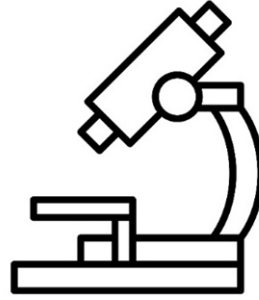
Rotterdam-Rijnmond

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



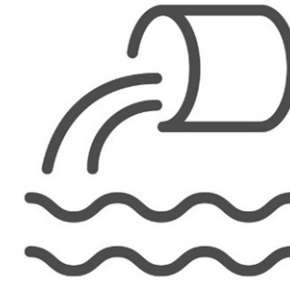
**Royal
HaskoningDHV**
Enhancing Society Together

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

wateronnet

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



HOOGHEEMRAADSCHAP
**DE STICHTSE
RIJNLANDEN**

Mark Stevens

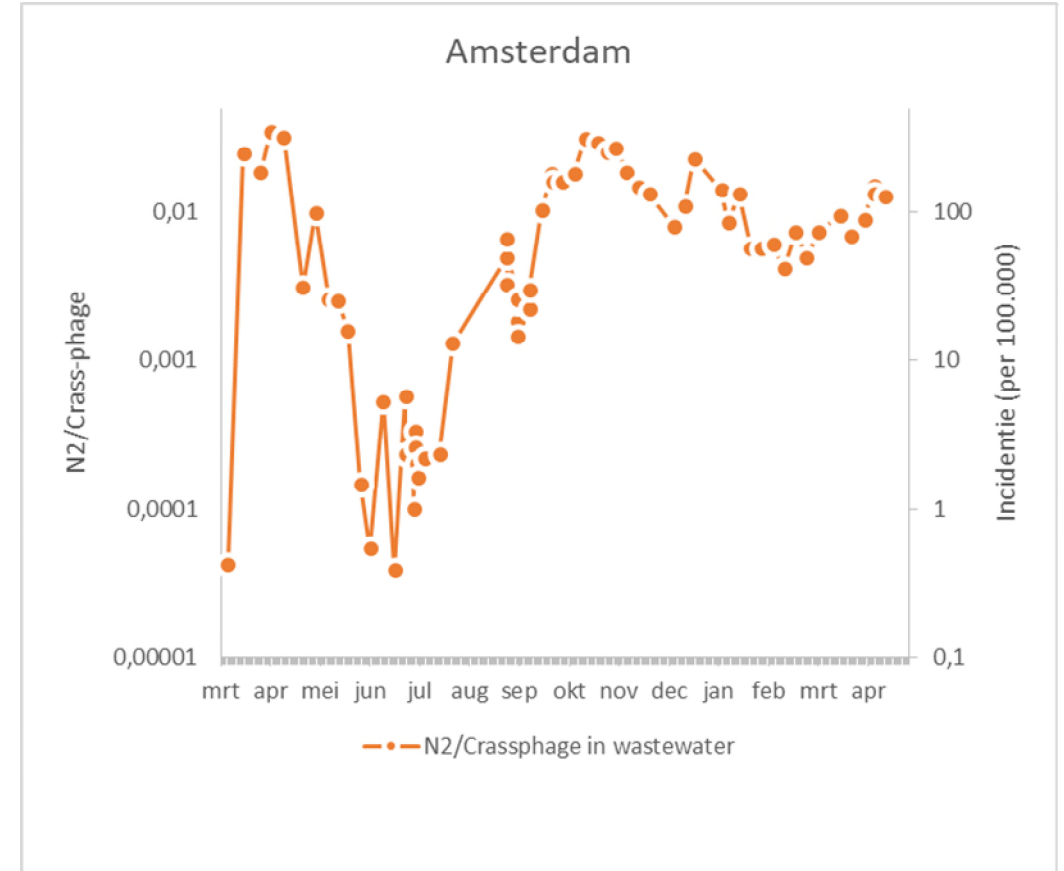


TOPSECTOR
**WATER &
MARITIEM**

Sewage surveillance

Added value of wastewater information

SARS-CoV-2 circulation in city population



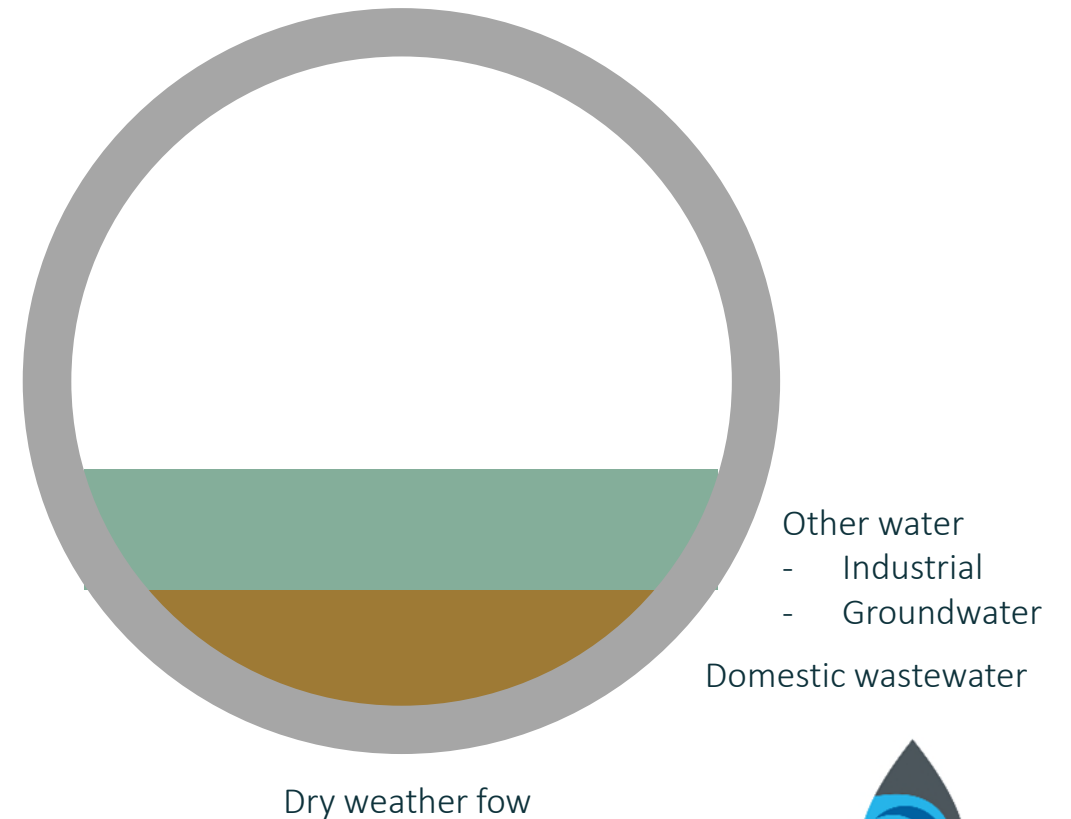
Normalization of SARS-CoV-2 signal

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



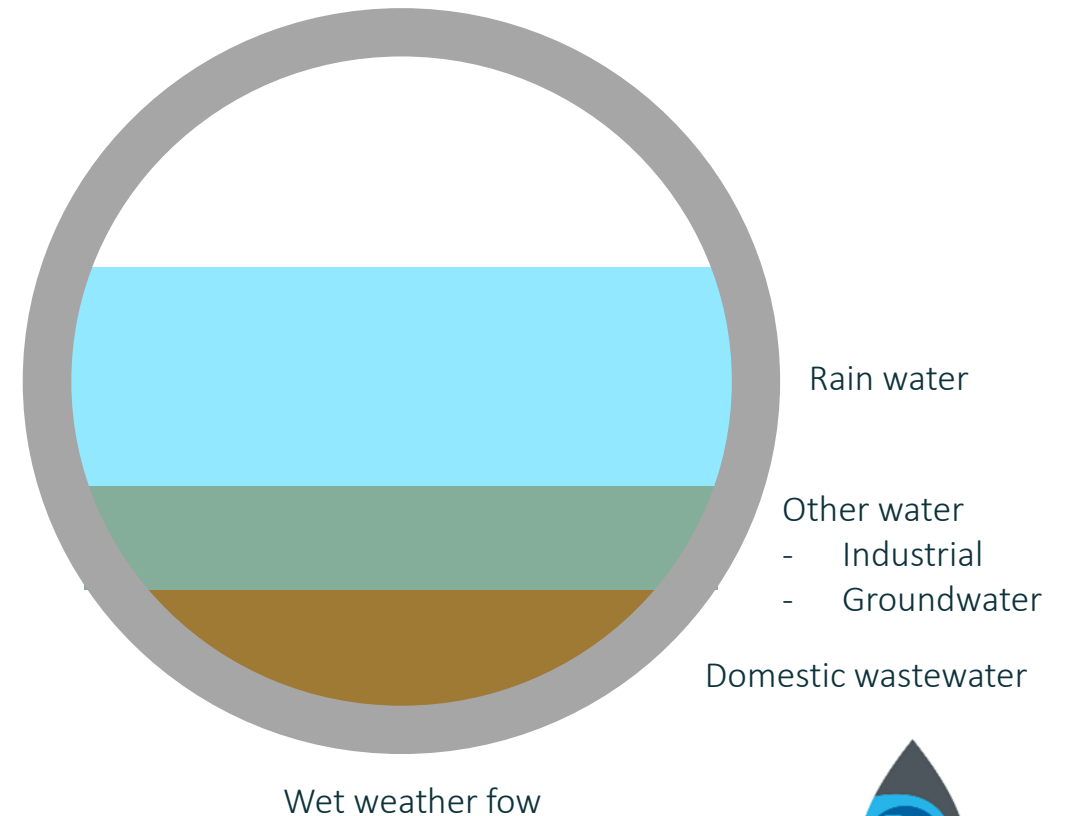
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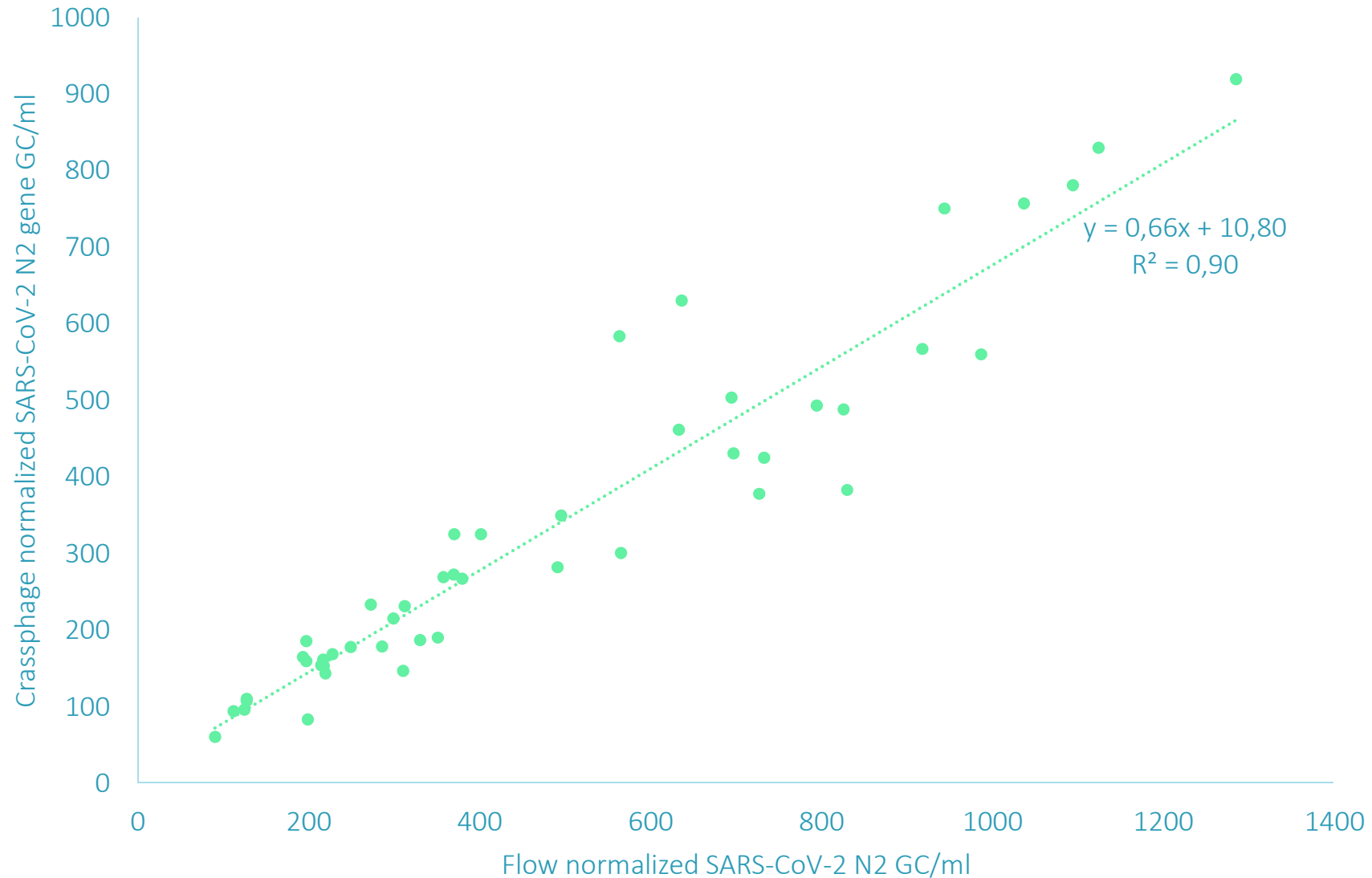
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Normalization with flow vs Crass-phage



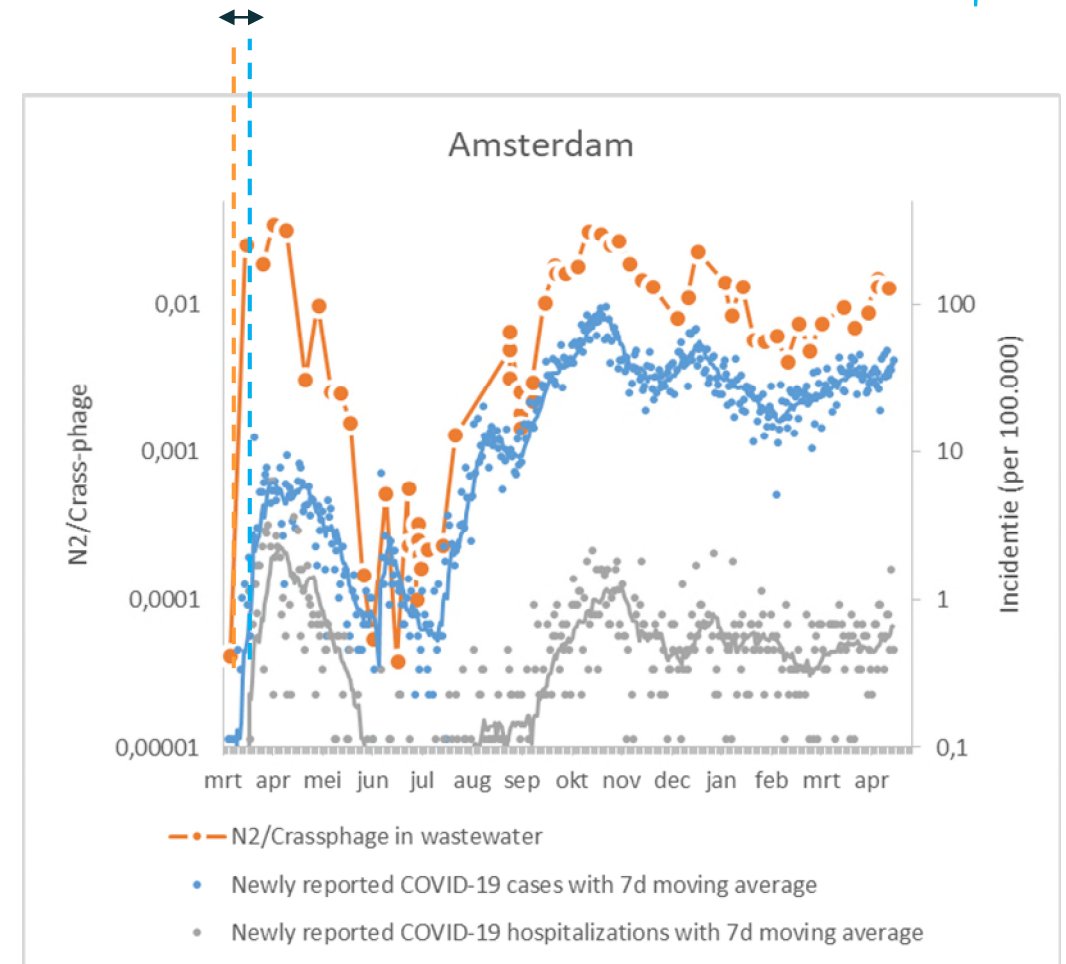
Use case: early warning



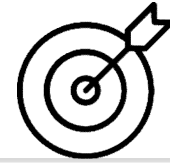
Added value of wastewater information

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

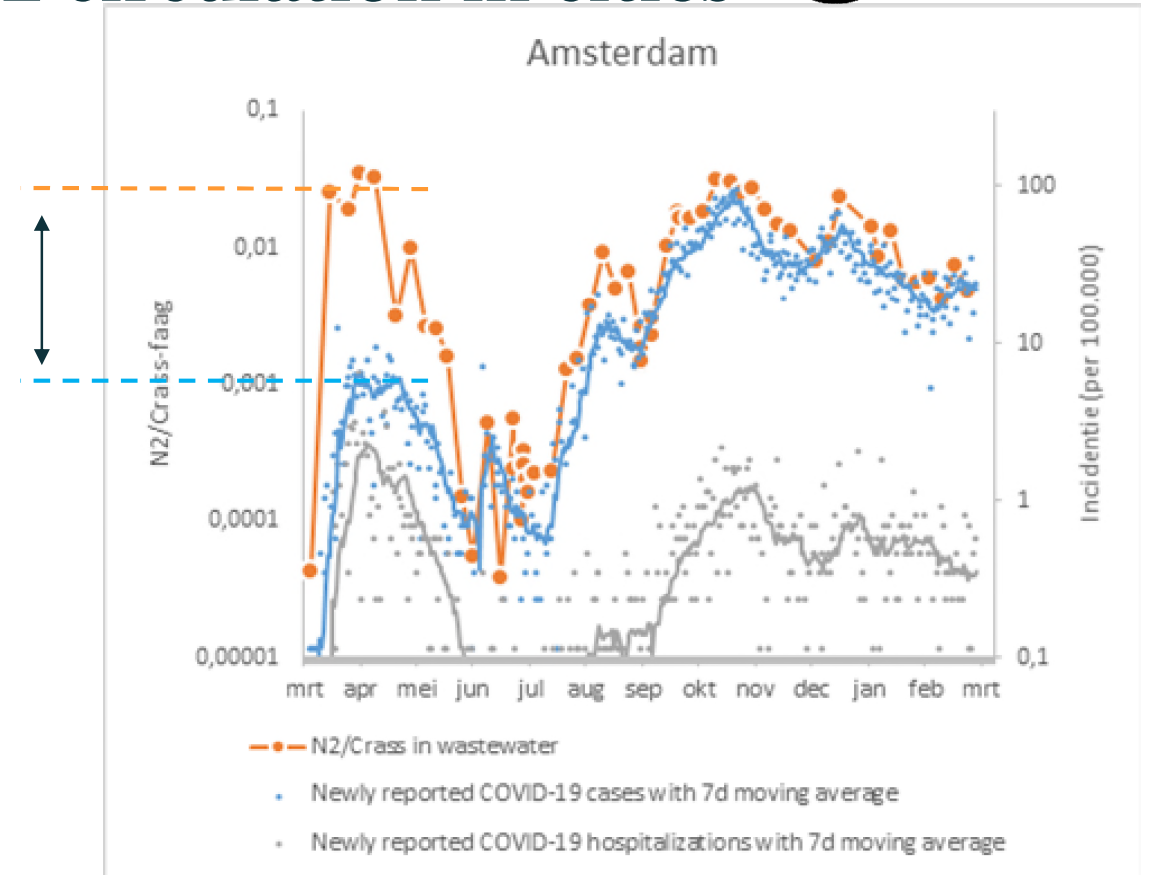


Use case: objective SARS-CoV-2 circulation in cities

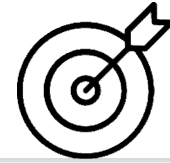


Added value of wastewater information

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



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

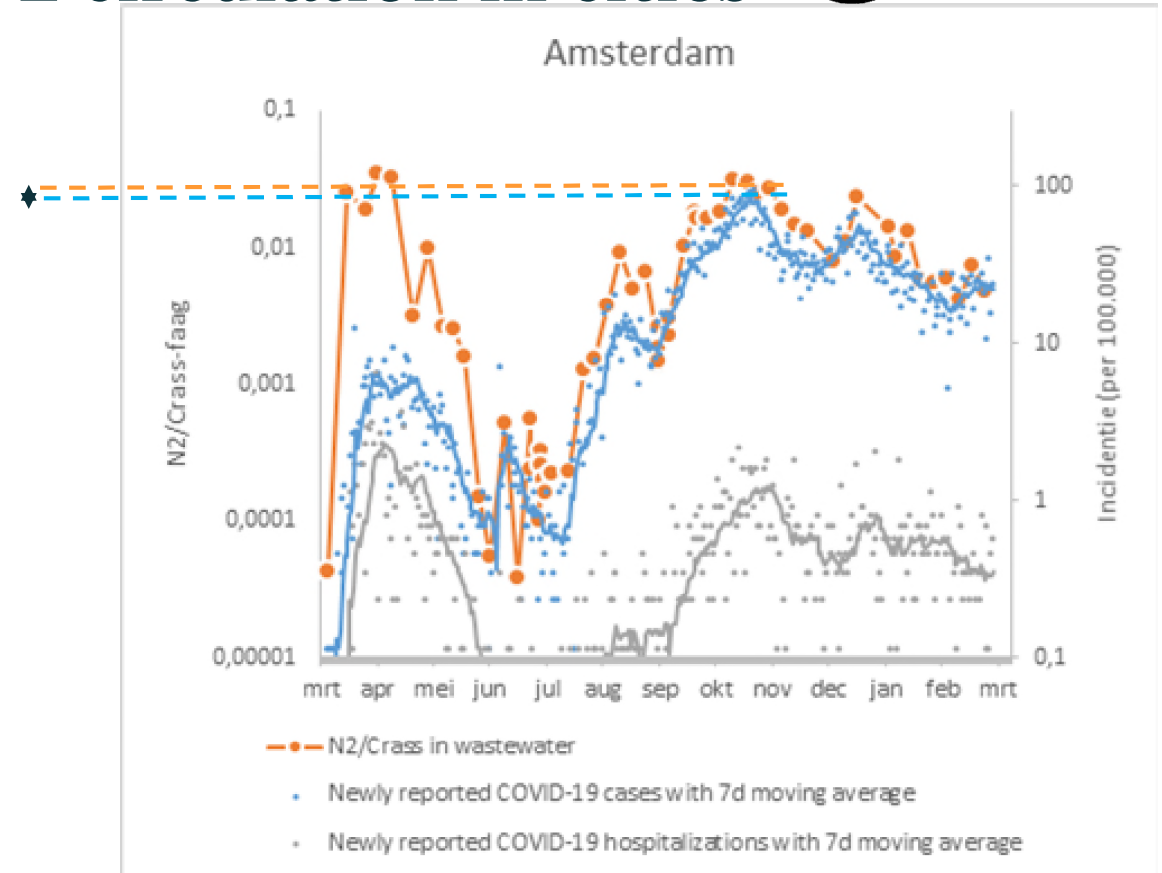


Added value of wastewater information

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

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

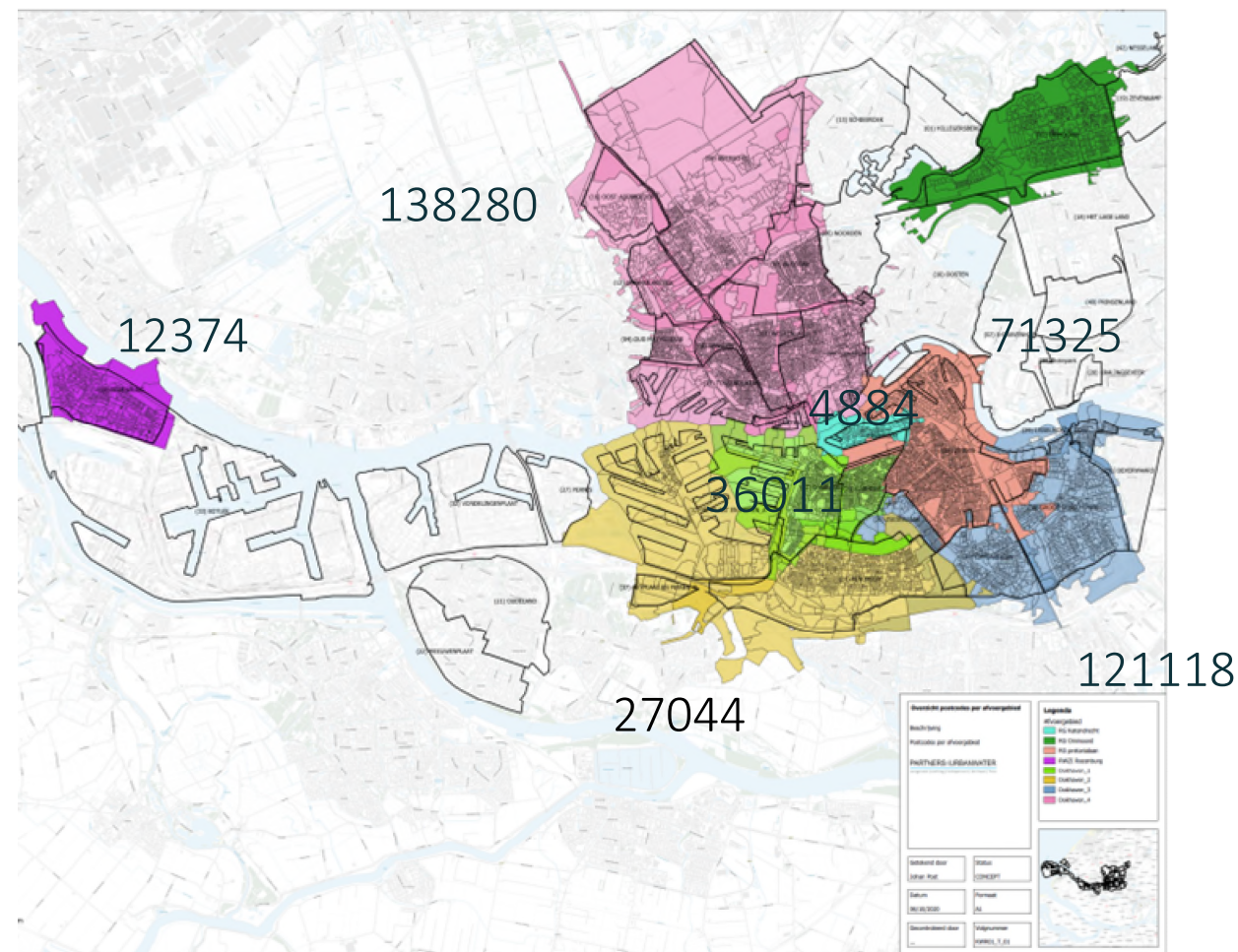
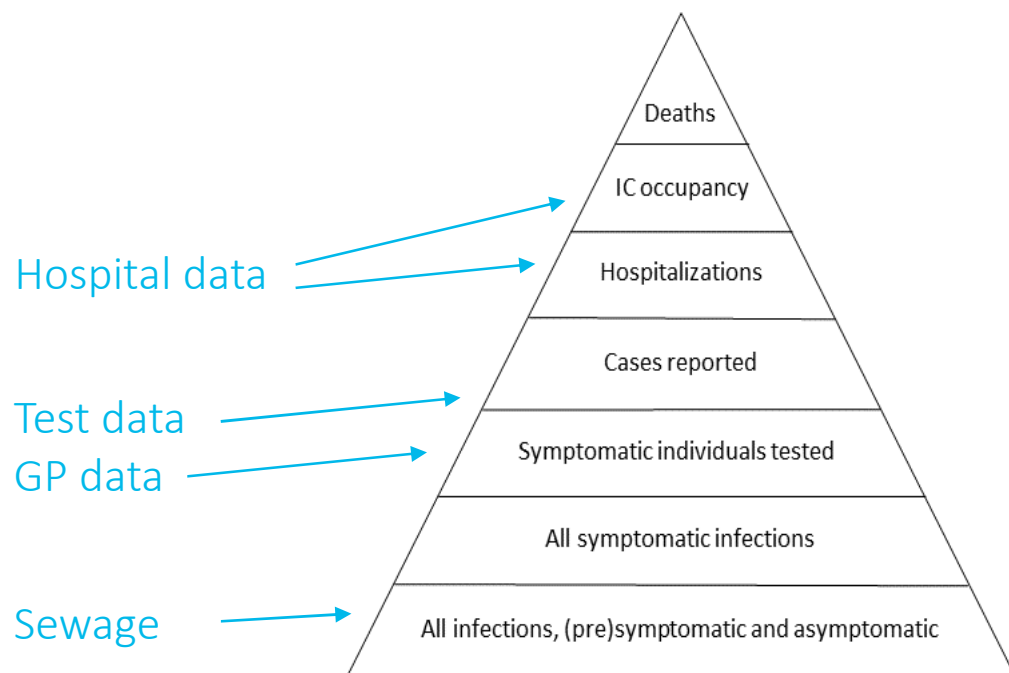
- test availability
- testing strategy
- testing williness
- asymptomatic 'case'



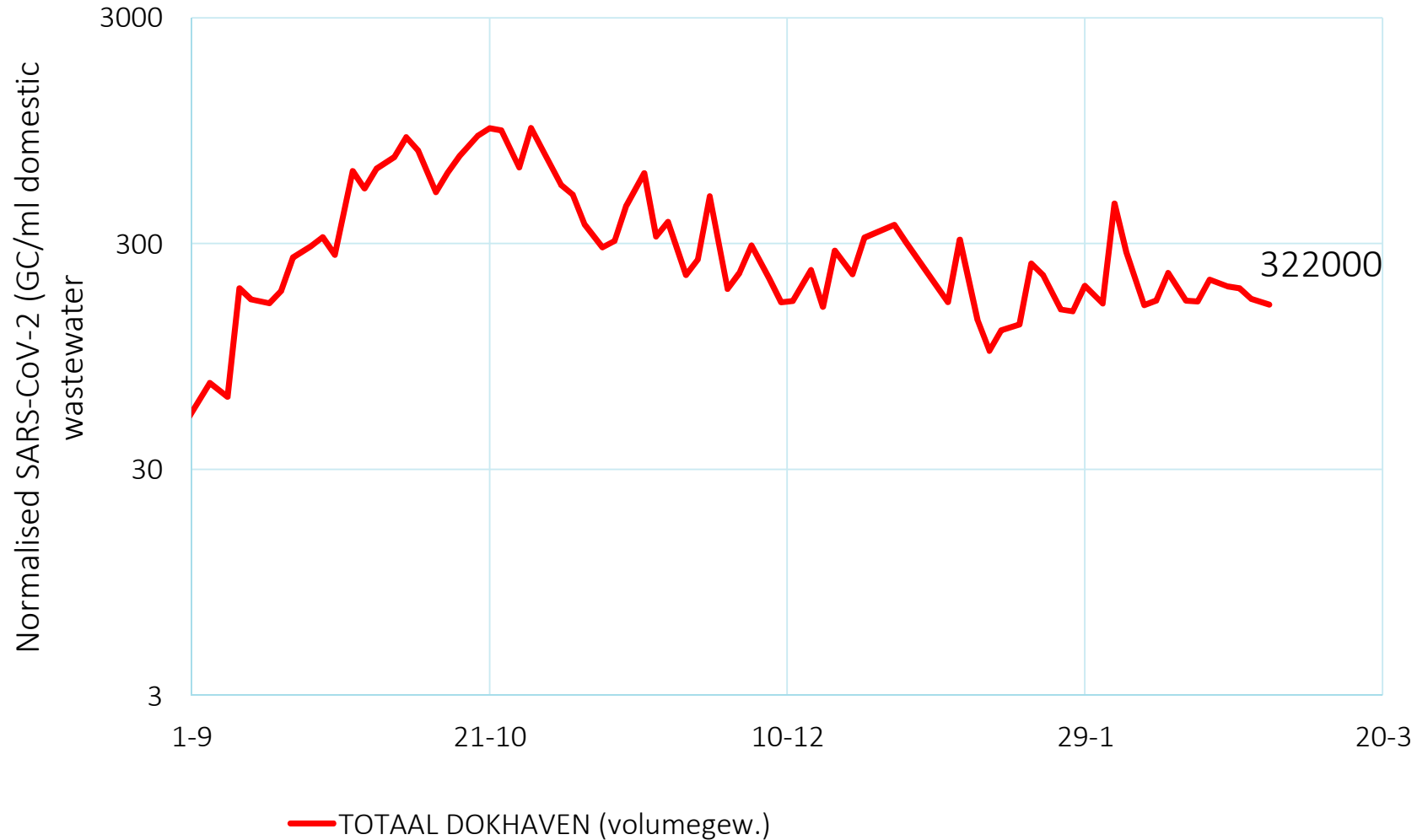
Use case: understand COVID-19 dynamics

High resolution:

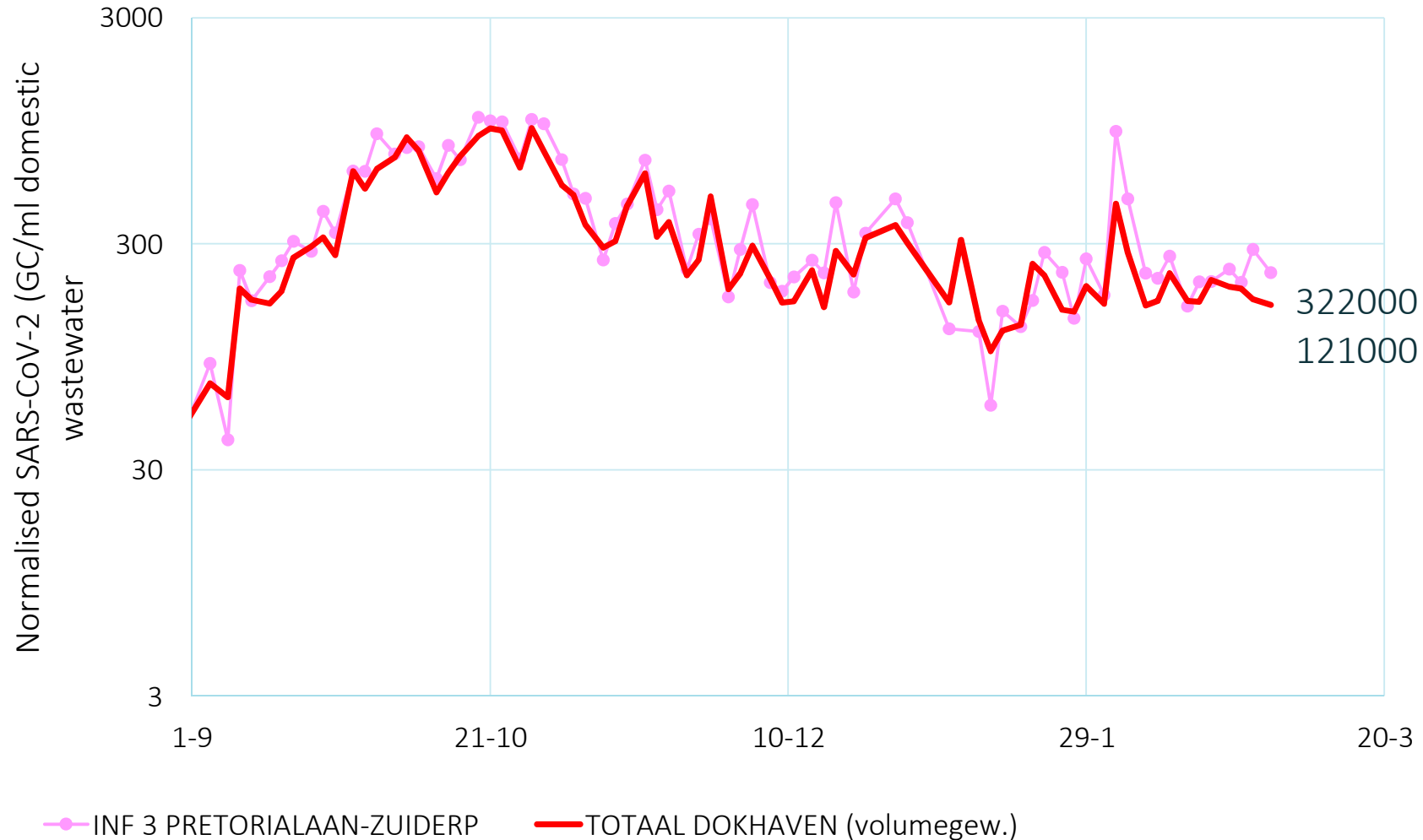
- Time: 3/week
- Space: city districts
- Matched population



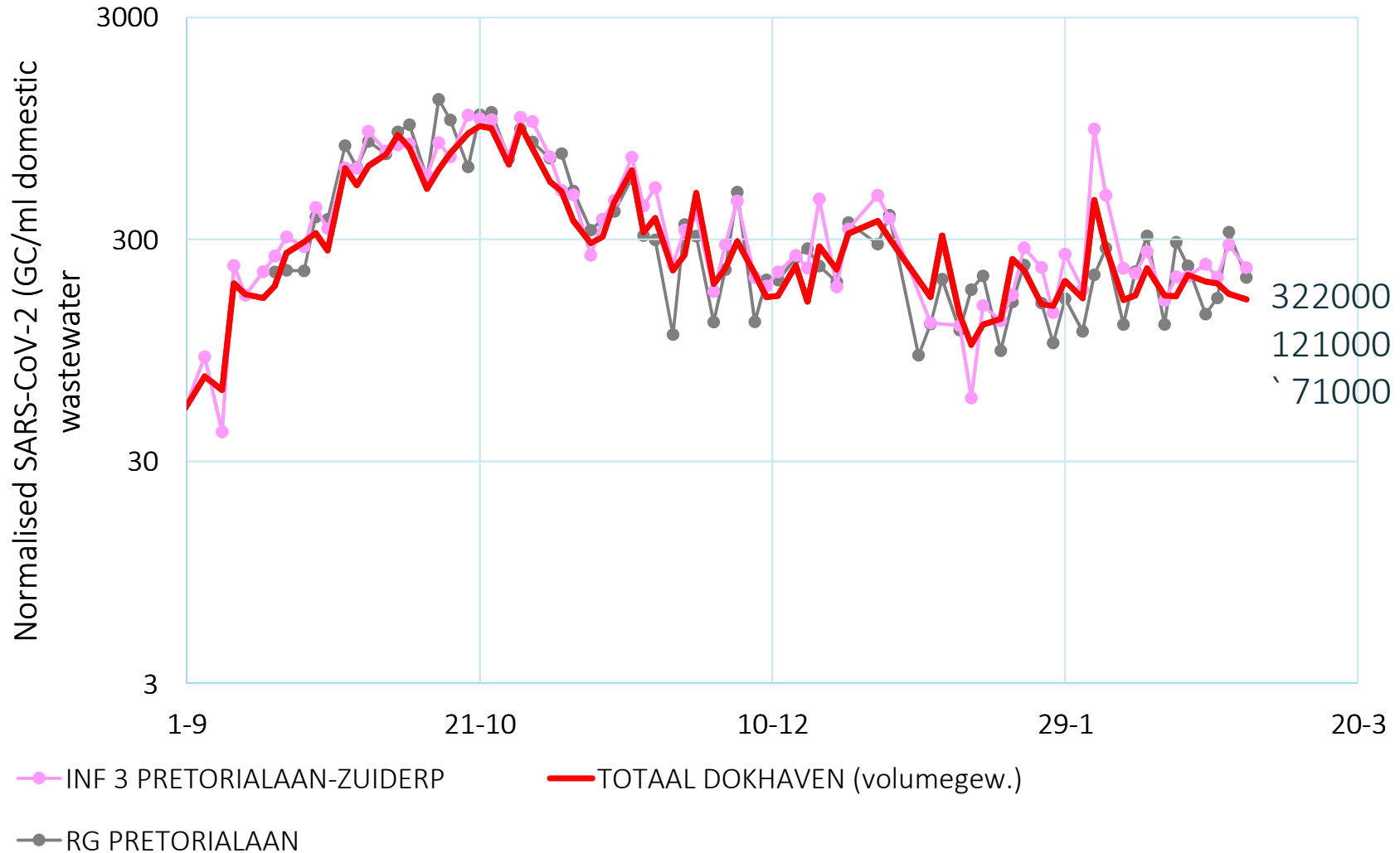
Population size affects sewer signal dynamics



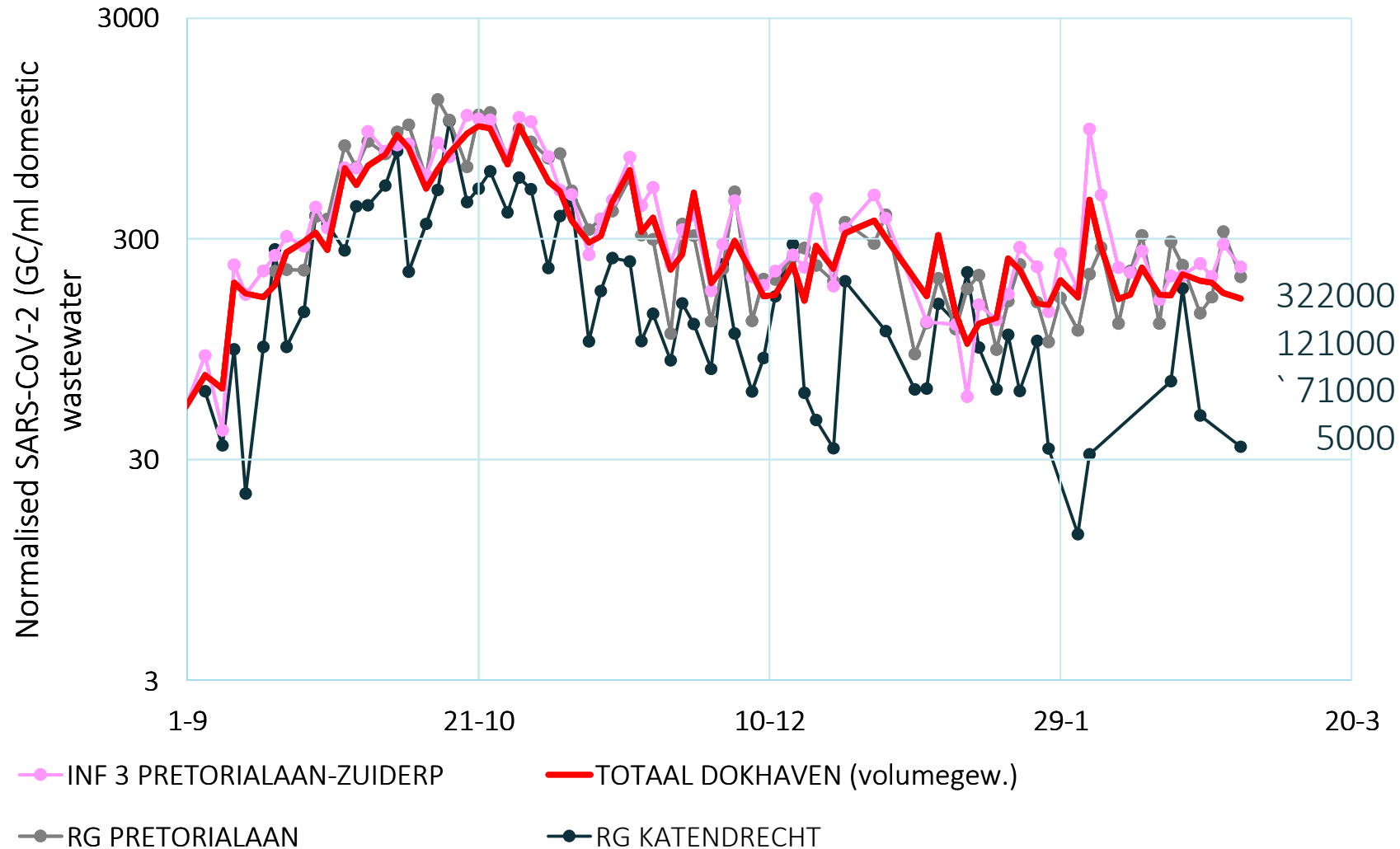
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Population size affects sewer signal dynamics



Population size affects sewer signal dynamics



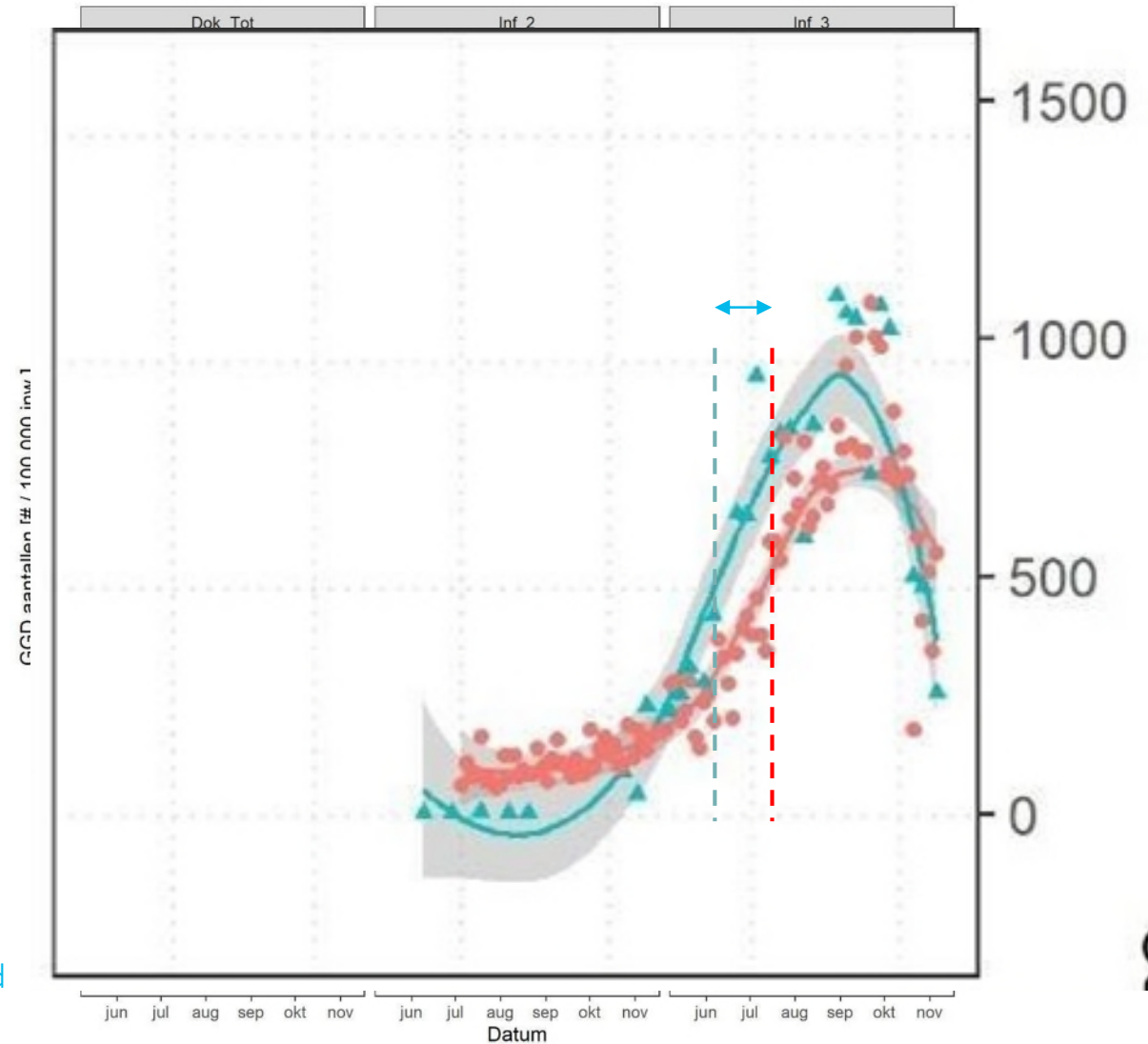
Data analysis Rotterdam



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 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



jun jul aug sep okt nov jun jul aug sep okt nov jun jul aug sep okt nov
Datum

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

Emergence of Variants of Concern (VoC)

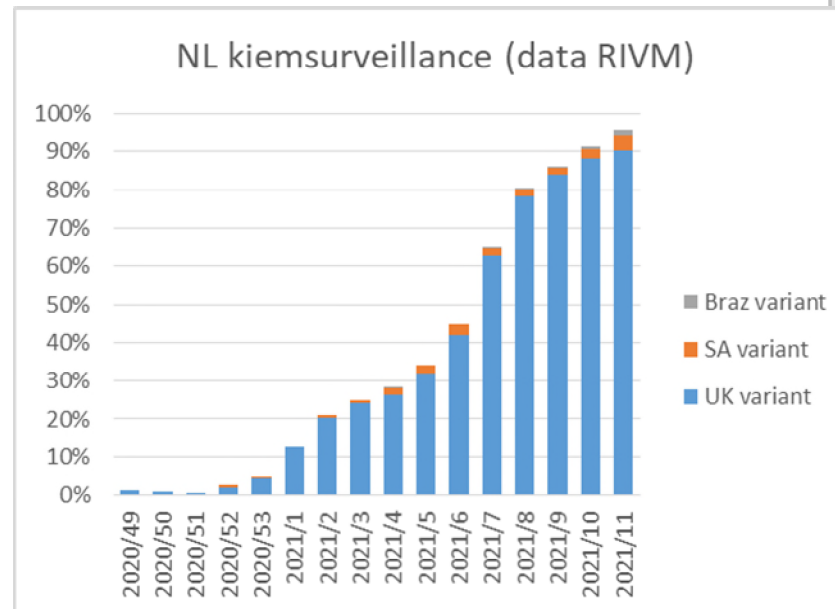
Observe emergence/circulation of new VoC

Understand disease, transmission dynamics

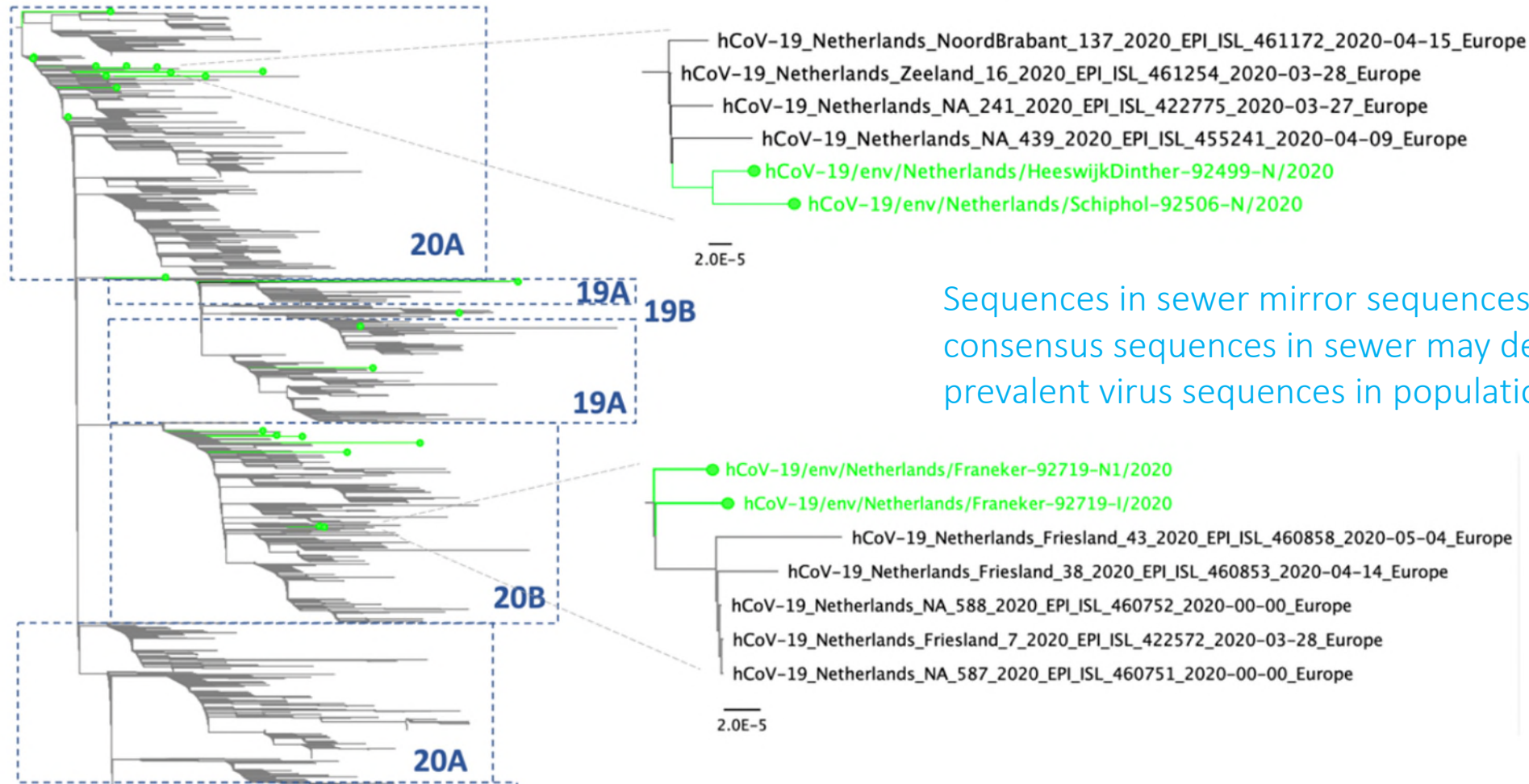
Observe vaccination efficacy to VoC



Image: RIVM



NGS for variant circulation in wastewater



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

UK variant mutations/deletions in Rotterdam wastewater

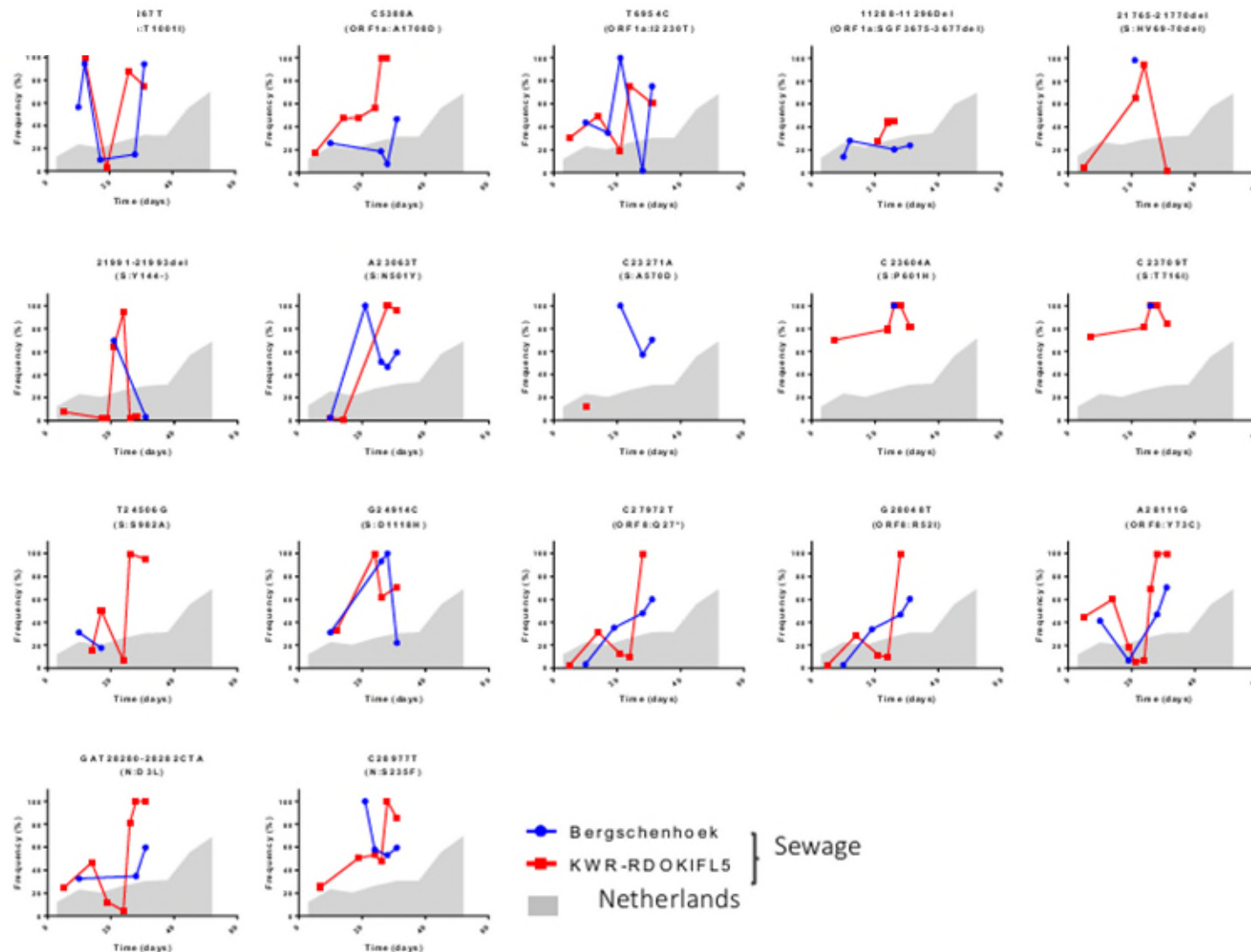
gene **nucleotide** **amino acid**
 ORF1ab C3267T T1001I
 C5388A A1708D
 T6954C I2230T
 11288-11296
 deletion SGF 3675-3677
 deletion

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



VEO1802005-18-30



VoC signature mutation multiplex ddPCR

Spike protein

Subunit 1: attachment

Subunit 2: fusion



	K	E	N	D
A Wuhan	417	484	501	614
B.1	417	484	501	614
B.1.1.7 UK variant	417	484	501	614
		(K)	Y	G
B.1.351 SA variant	417	484	501	614
	N	K	Y	G
B.1.1.248 (P.1) Brazil variant	417	484	501	614
	T	K	Y	G

~ Simultaneous detection of N501Y and Wild Type with multiplex ddPCR

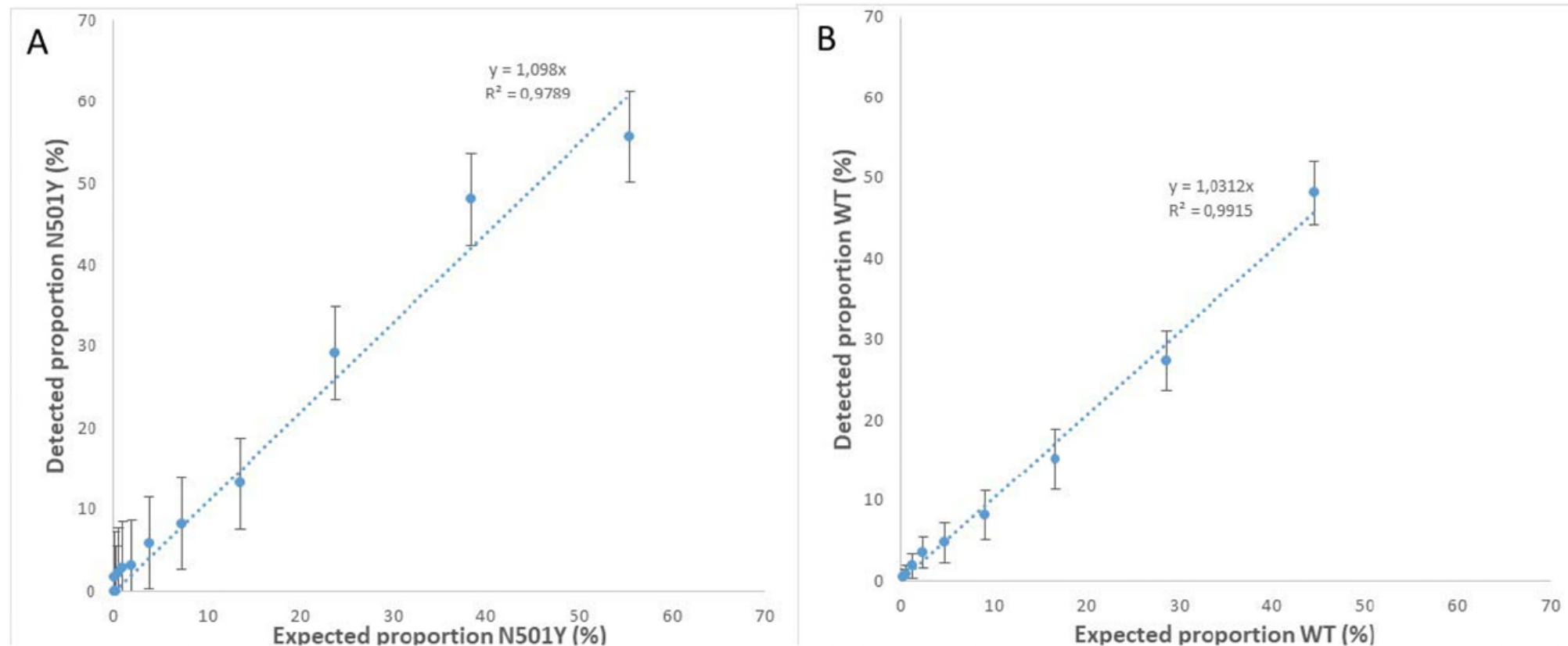
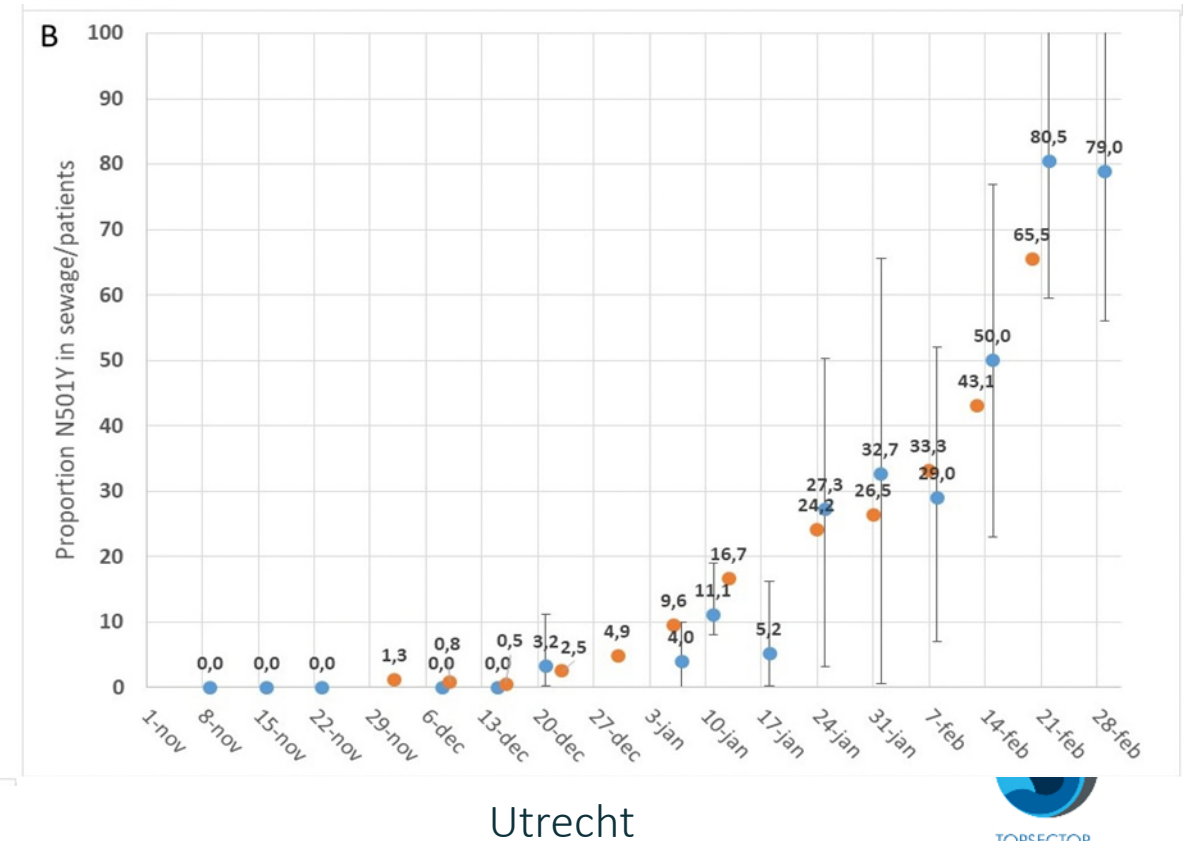
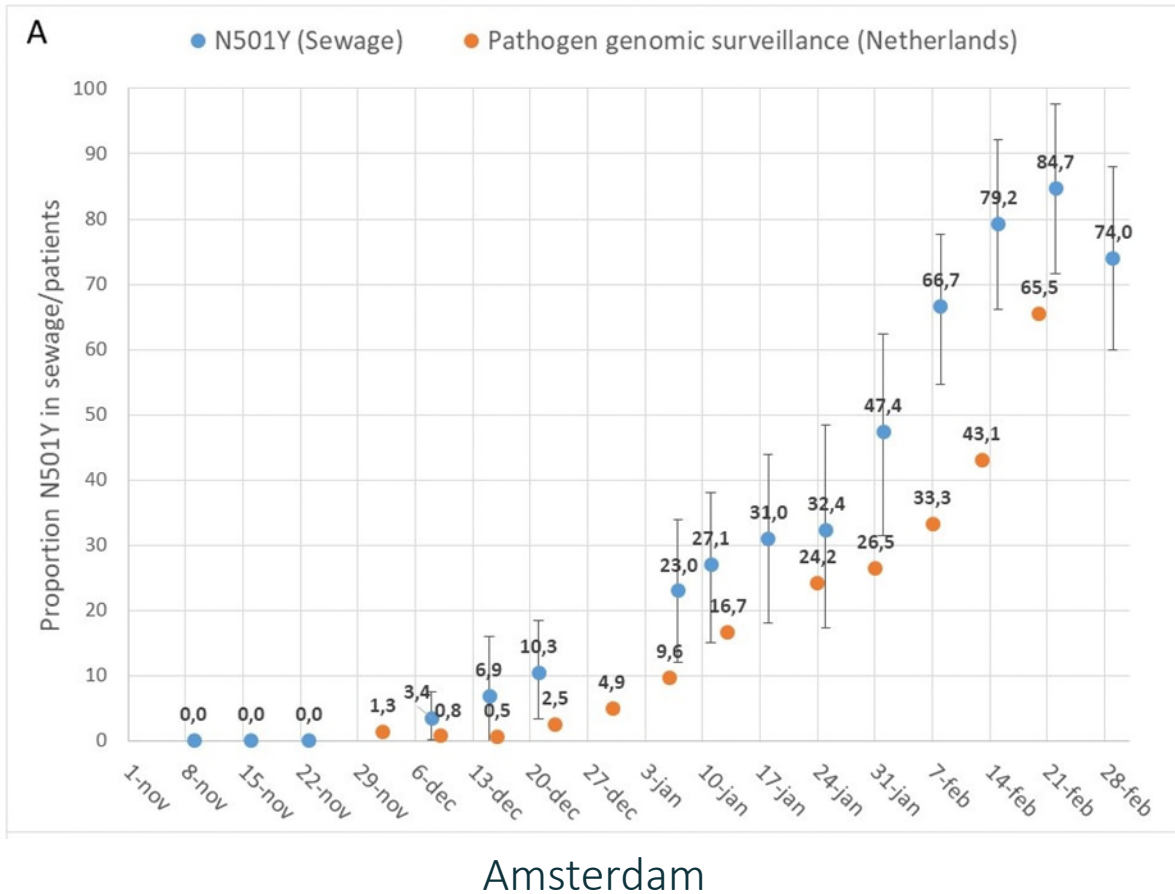


Figure 3. The expected and detected proportion of N501Y (A) and WT (B) in artificial mixtures of WT and lineage B.1.351 as detected by ddPCR.

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



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



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

The Global Water Pathogens Project (GWPP) is a knowledge resource on pathogens supporting sanitation and safe water and promoting quantitative information via monitoring of sewage, fecal sludges and freshwaters to inform public health measures.
[Read more...](#)

BOOK **TOOLS** **COVID19**

 **Wastewater SPHERE**
The mission of Wastewater SPHERE is to advance environmental surveillance of sewage to inform local and global efforts for monitoring and supporting public health measures to combat COVID19.

[Learn More](#) [Visit the Data Center](#)

www.waterpathogens.org

Learn more about our work on mapping global efforts on SARS Environmental Surveillance >





W-SPHERE Website

The screenshot displays the W-SPHERE website interface. At the top left is the W-SPHERE logo, and to its right is a navigation menu with links for GLOBAL MAP, DATA, CASE STUDIES, and ABOUT. The main content area features a world map with various cities marked by colored dots (grey, blue, and green). A prominent yellow 'UNDER CONSTRUCTION' sign is overlaid on the left side of the map. Below the map, a call-to-action section reads 'Contribute to the Wastewater SPHERE data center' with a 'CONTRIBUTE' button. At the bottom, three dark teal boxes provide statistics: '6 Datasets', '171 Sites', and '6 Countries'. The footer includes 'VectorStock' branding, a copyright notice for the Global Water Pathogens Project 2021, and a 'User area' link.



Thank you
for your
attention

Bridging Science to Practice

Towards a Water-wise World