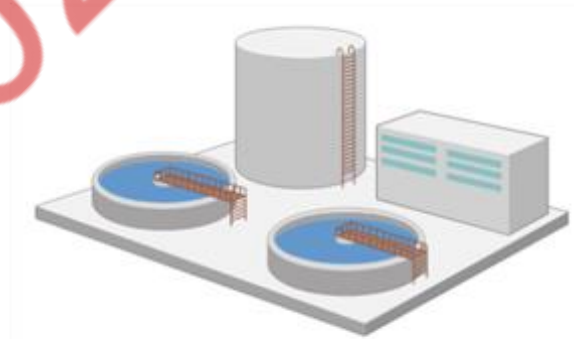
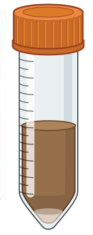
Wastewater-based Surveillance
for infectious diseases

Tim Julian | WAidid | 28 November 2024

Wastewater systems are biological sample collection and transportation systems for people



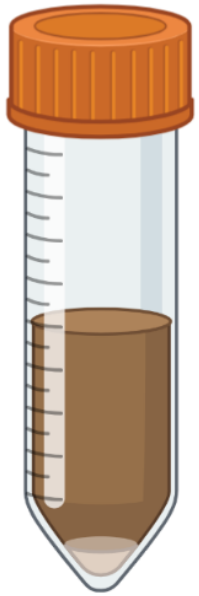


1 wastewater sample

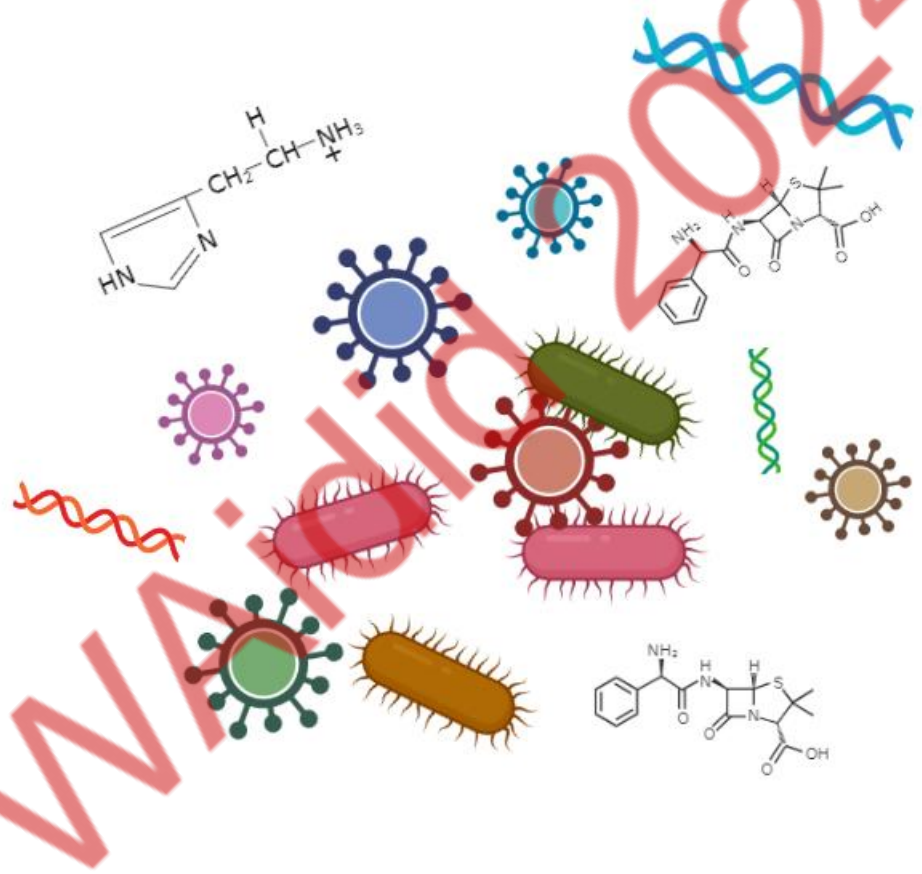
=

A population

A single sample contains a wealth of data on a community's health



Wastewater Sample



Wastewater used to inform microbial contaminants

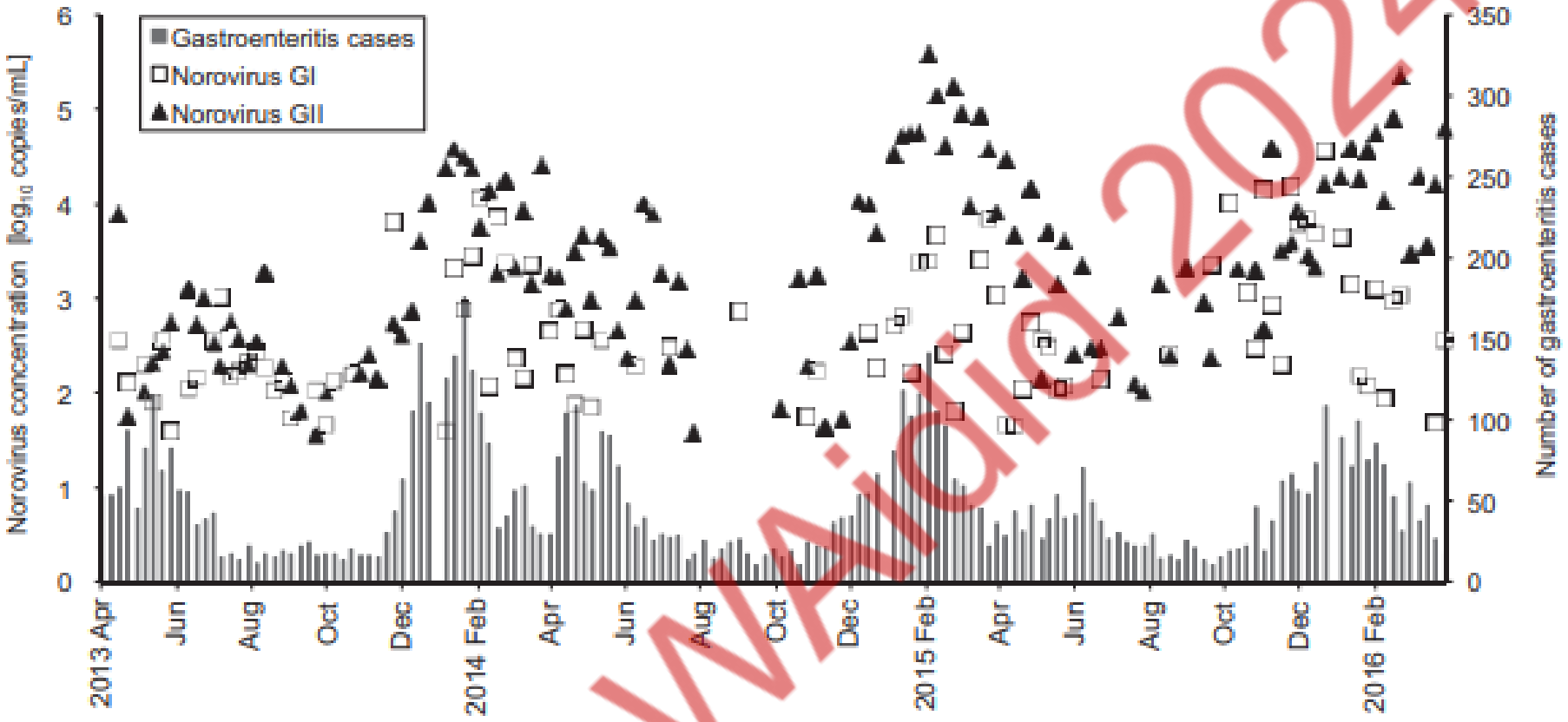


FIG 1 Concentrations of norovirus GI and GII in sewage and numbers of gastroenteritis cases reported in the study area. The norovirus GI and GII detection limits are 1.5 and 1.6 $\log_{10}$ copies/ml, respectively.

Norovirus: 10^7-10^{12} gc/g feces

Kazama et al. (2017) *Applied and Environmental Microbiology.* DOI: 10.1128/AEM.03406-16

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Covid-19 offered an unprecedented opportunity to highlight the utility of wastewater-based epidemiology for infectious diseases

Why WBE works for Covid-19

SARS-CoV-2 RNA Shed in Feces (*10^2-10^5 particles per day?*)

Large susceptible population

Most highly surveilled pathogen in history

Switzerland and Liechtenstein	
Tests / 100 000 inh.	242 836,05
Tests	21 149 454
Share of positive PCR tests	21,7%
Share of positive rapid antigen tests	11,4%

hCoV-19 data sharing via GISAID

10,434,153

genome sequence submissions

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Benchmark WBE

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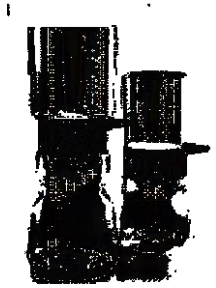
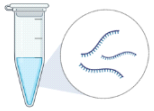
How Wastewater-based Surveillance Works

Methods



Concentrated Nucleic Acids



Wastewater collection, Storage, and transport

Spike-in controls Pre-processing

Concentration, DNA/RNA Extraction

Inhibitor removal

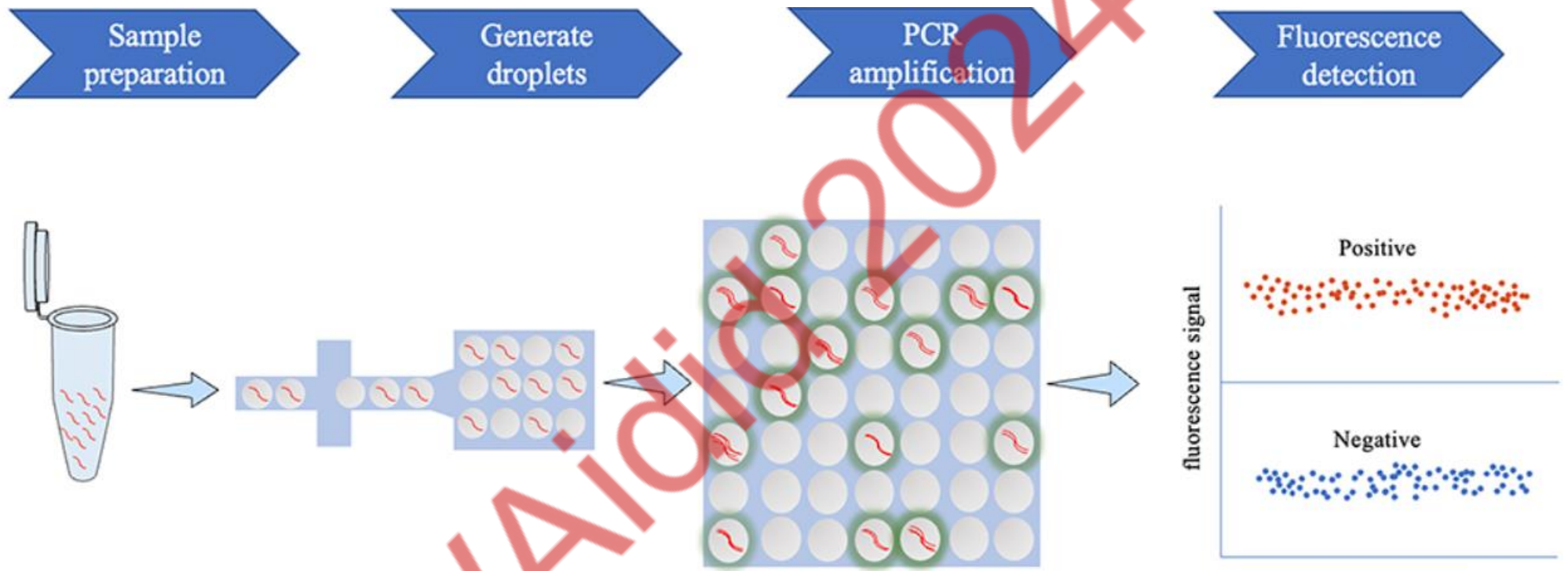
Detection of SARS-CoV-2 and other targets

40 ml (or more)
24-hr flow composite

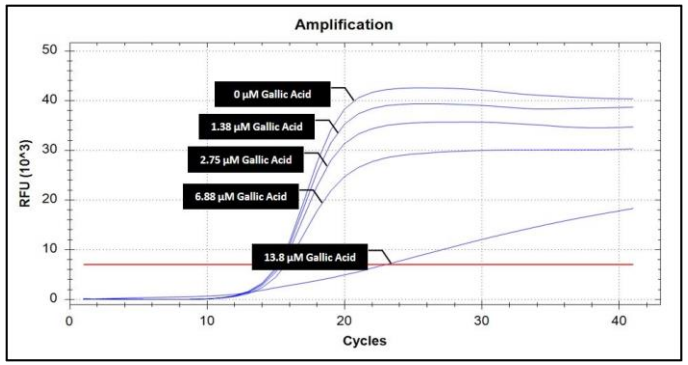
80ul
(500x concentration)
recovery est. ~10%

5ul
(32x concentration)
dilution
(10x concentration)

Why we use digital PCR

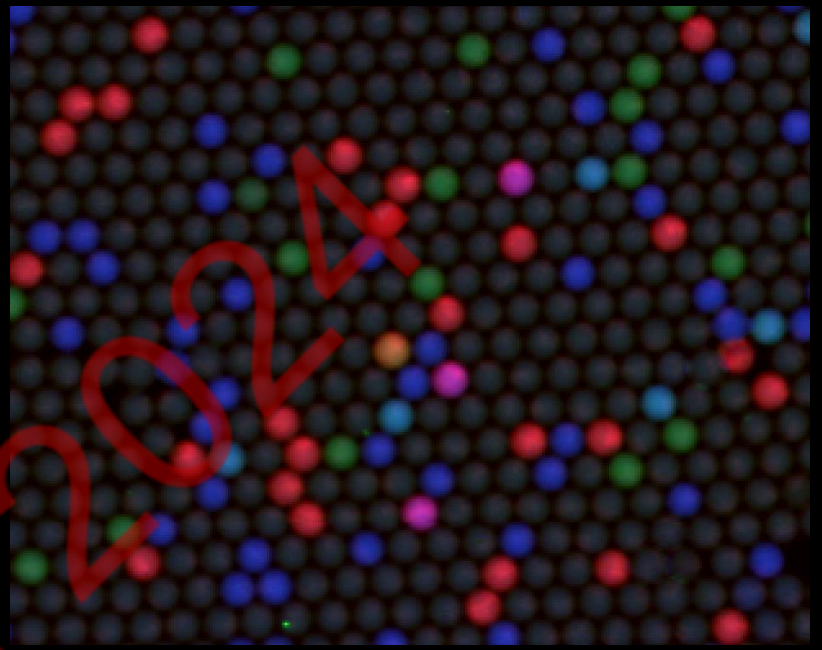


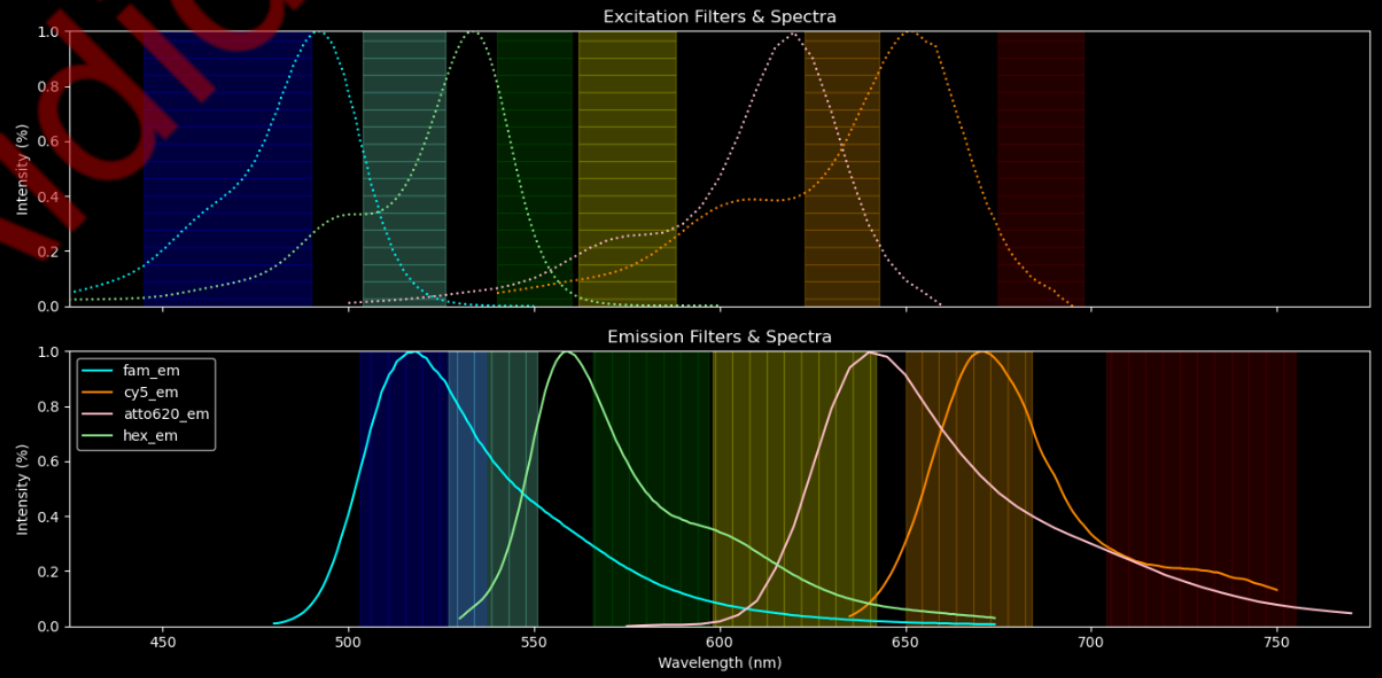
- **Quantitative without a standard curve**
- More robust to inhibition
- Ability to Multiplex



Fan et al. 2021

Multiplexing with Digital PCR





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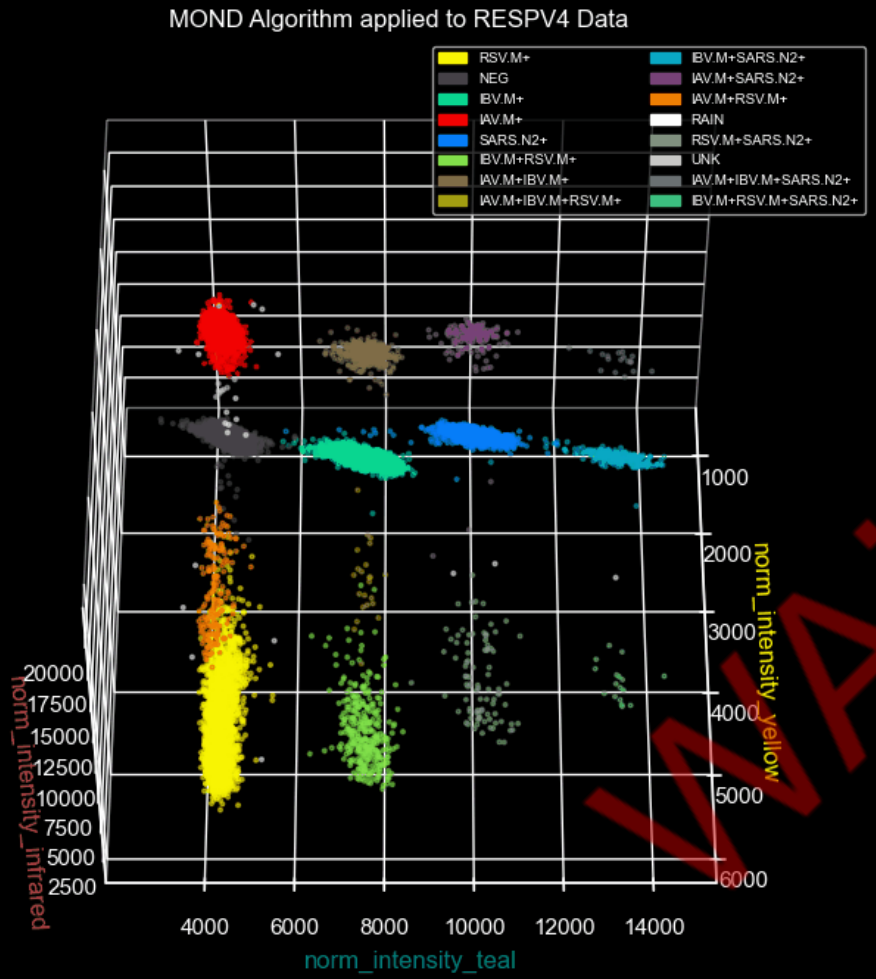

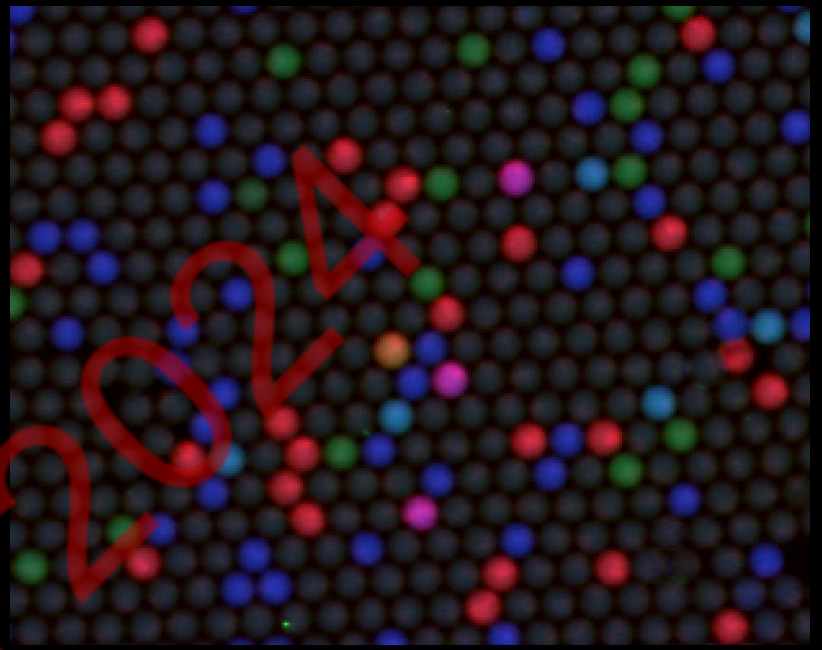

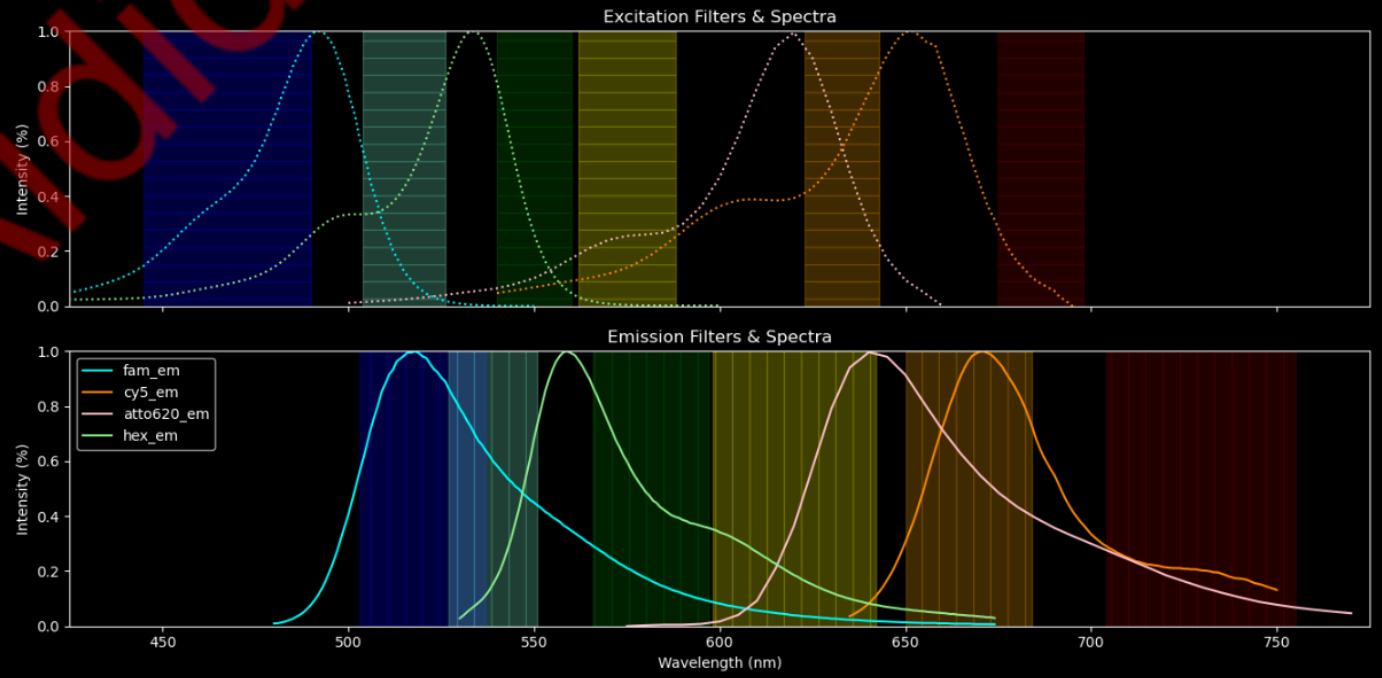

Wastewater-based Surveillance Tracks Disease Dynamics

Wastewater data tracks disease dynamics

independent of clinical surveillance

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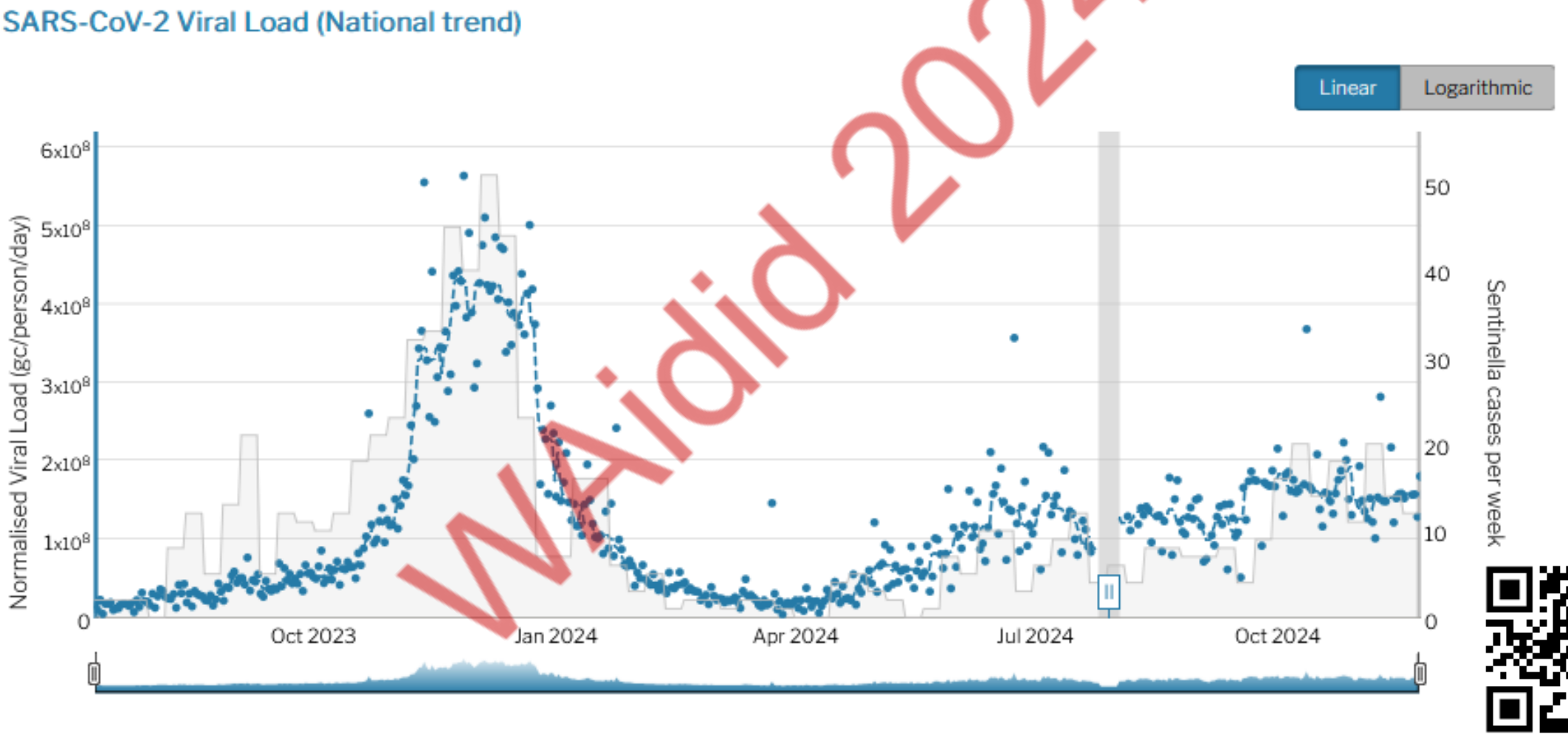
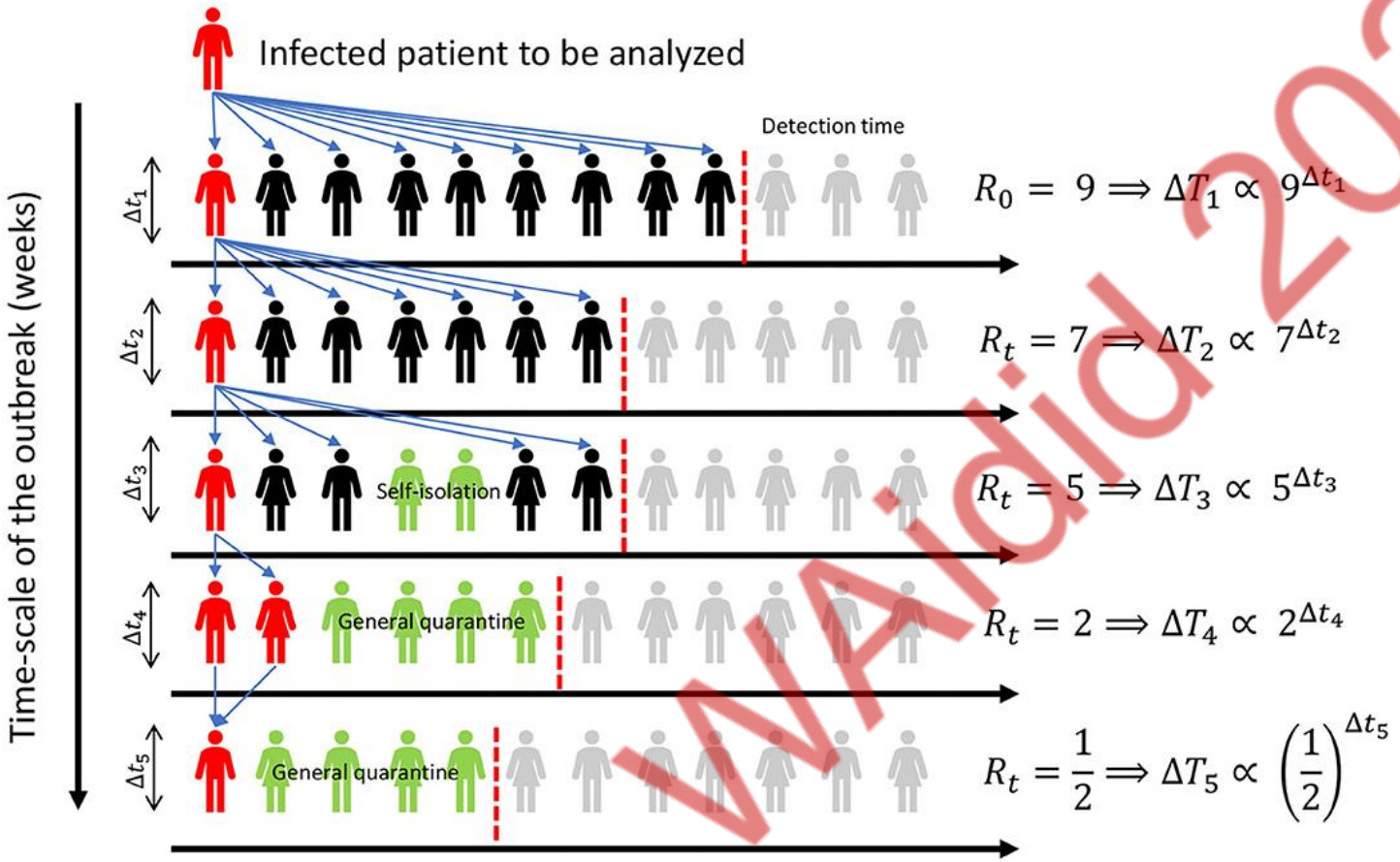


https://wise.ethz.ch/

Translate to Policy-Relevant Indicators (R_{eff} Estimates)



Contreras et al. 2020.

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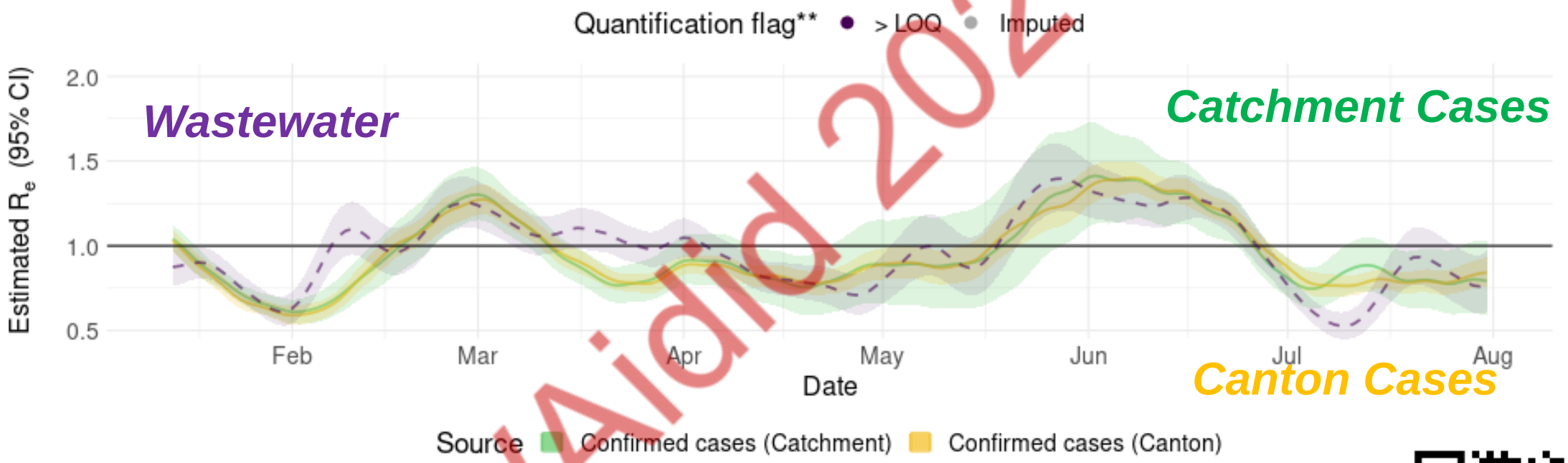
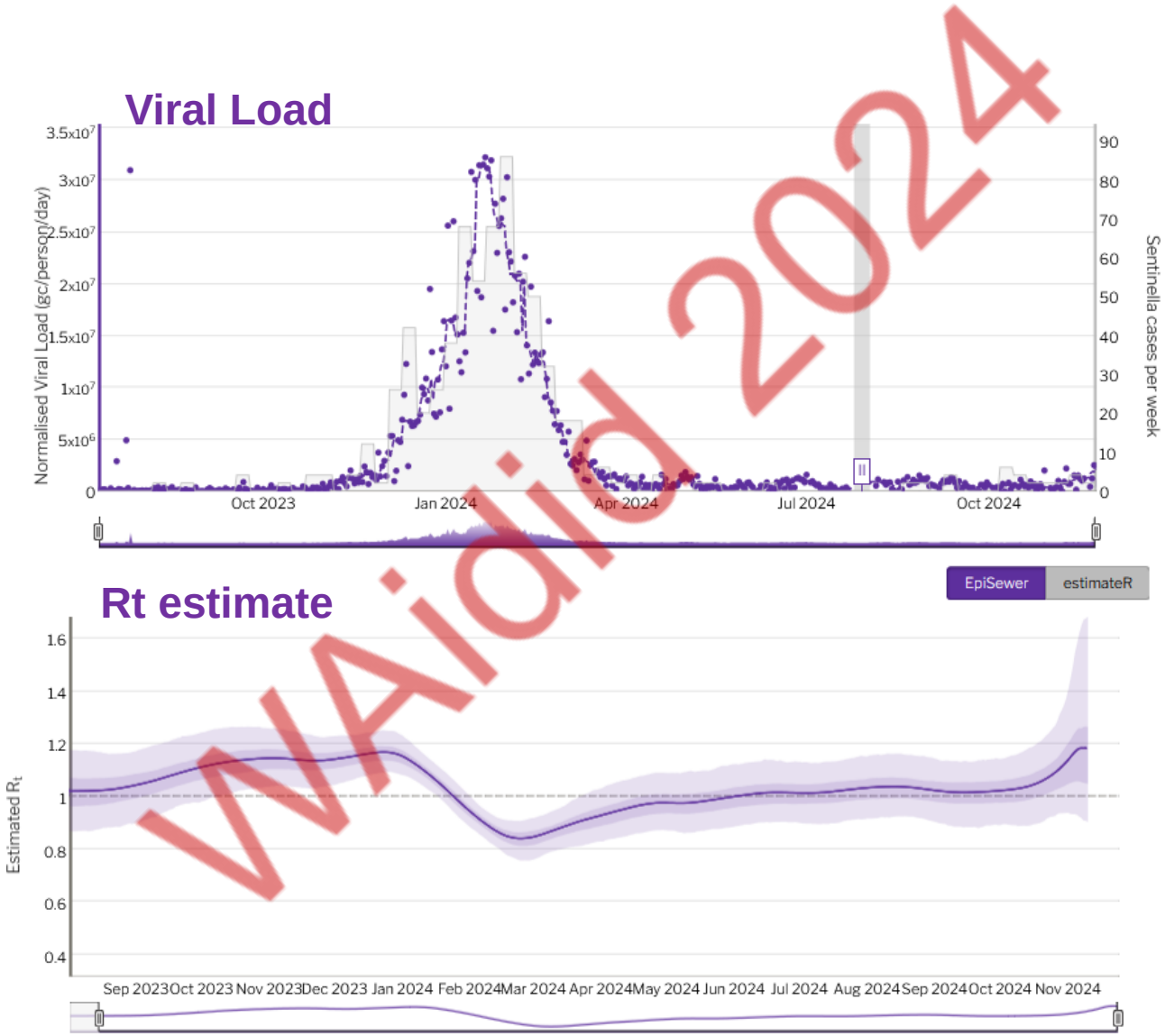


Contreras et al. 2020.

Wastewater data tracks disease dynamics

Influenza A



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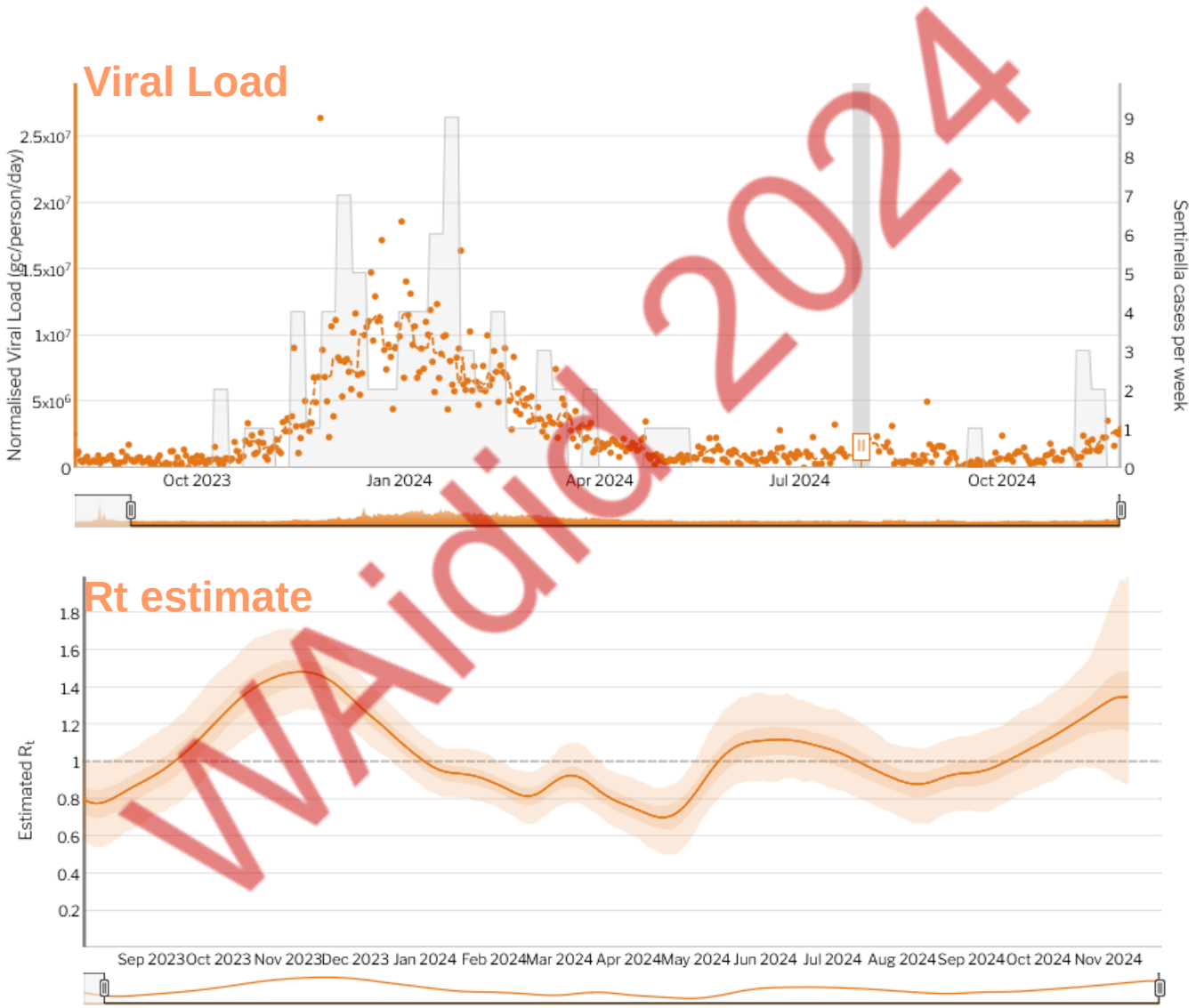
Wastewater data tracks disease dynamics

RSV



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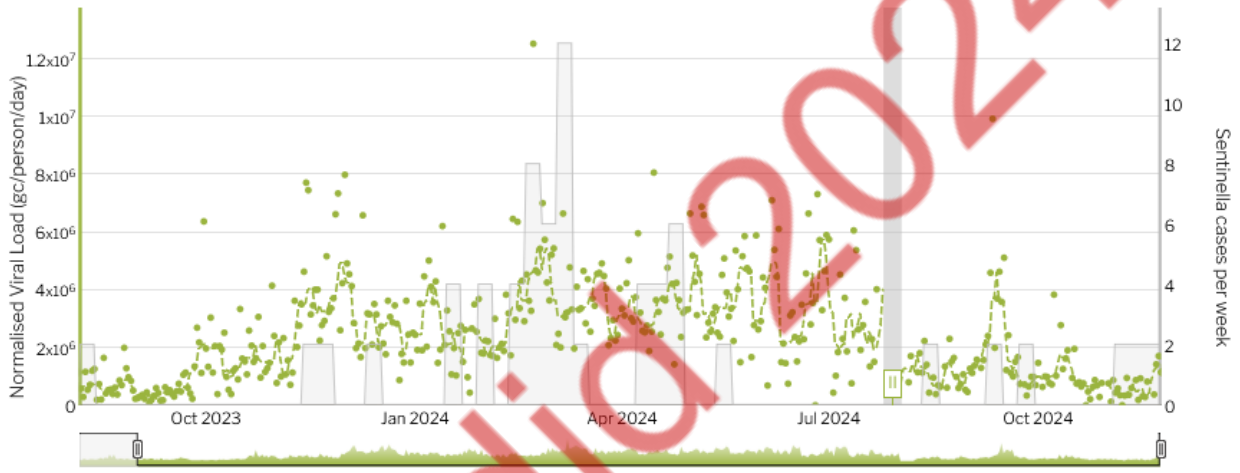
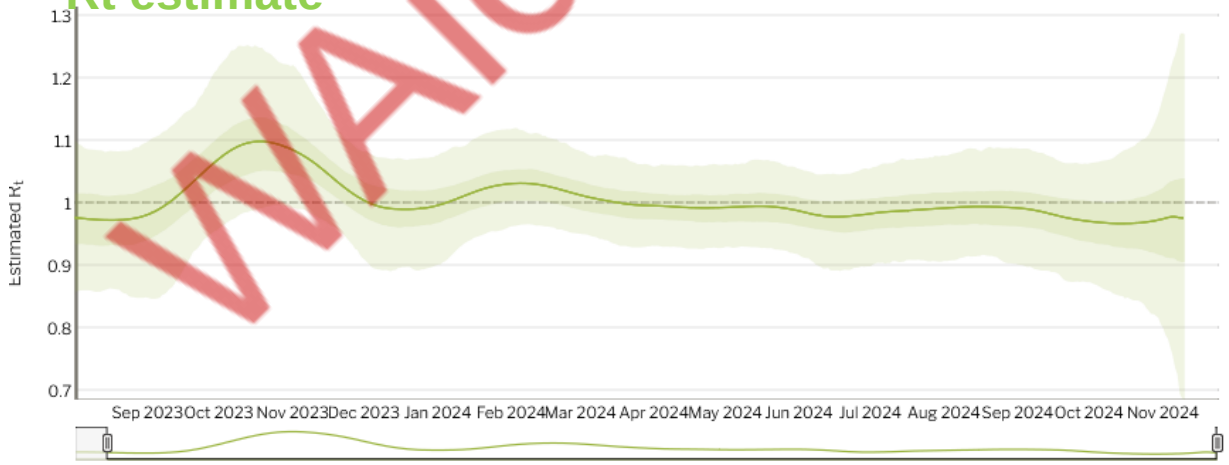
Wastewater data tracks disease dynamics

Influenza B

Viral Load



Rt estimate



https://wise.ethz.ch/

Data integrated with clinical data by Federal Office of Public Health

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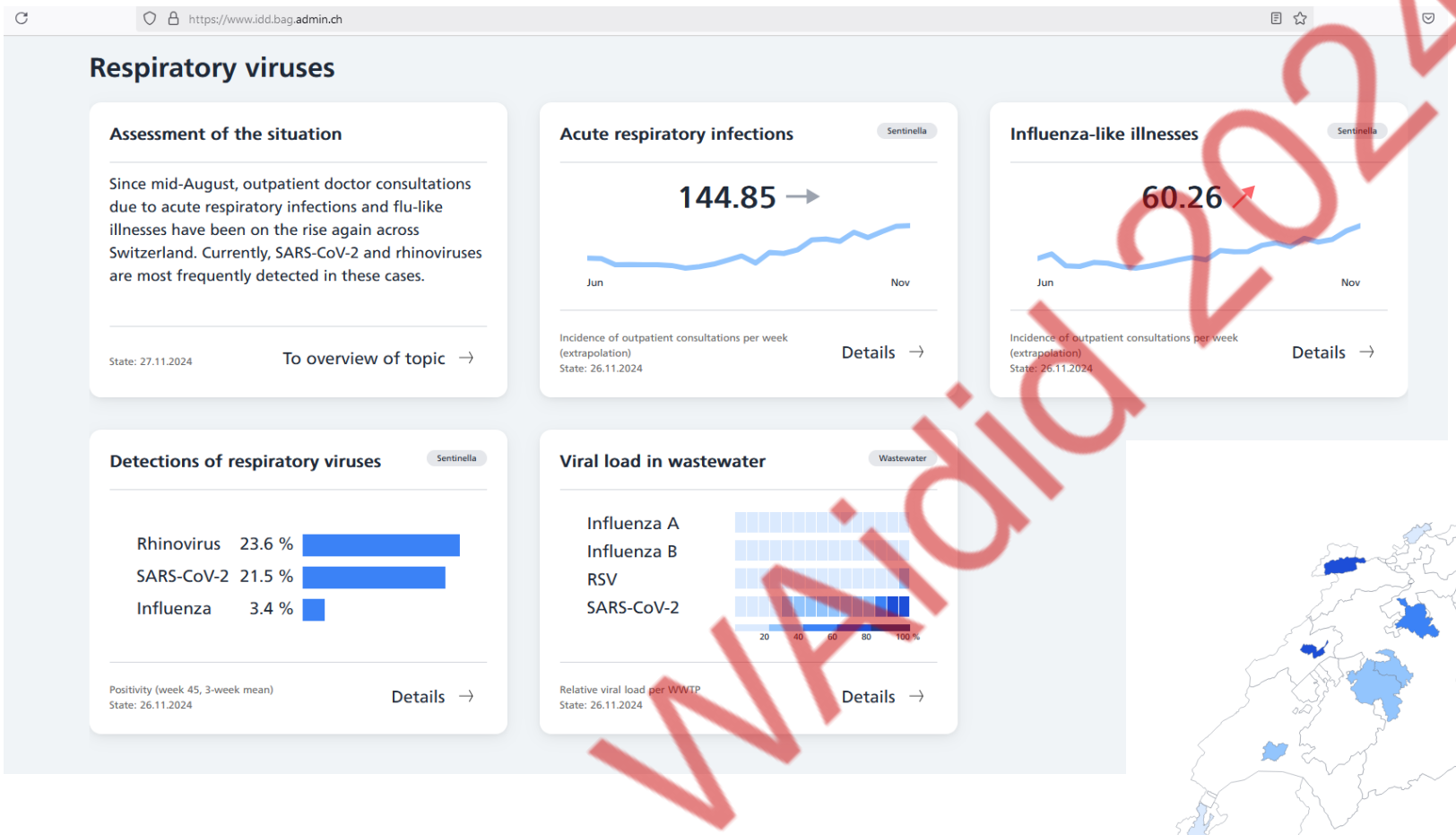
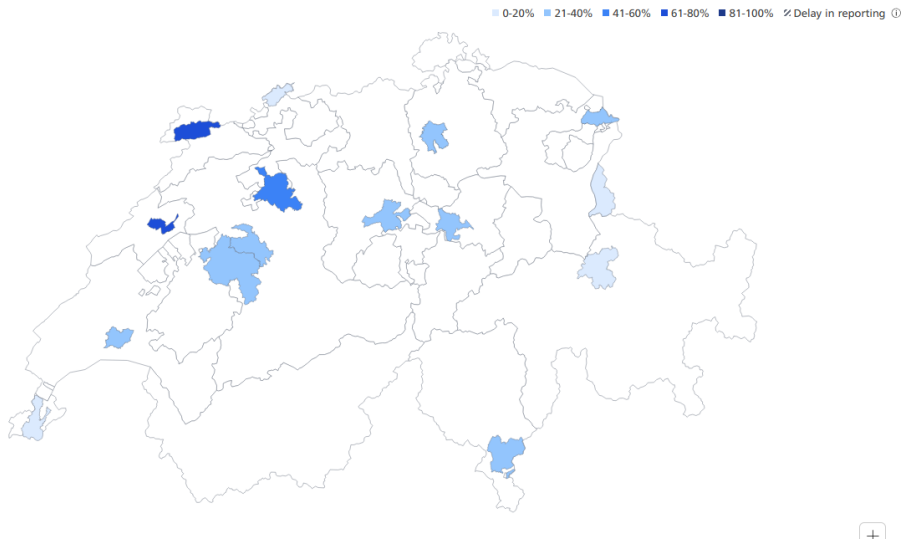
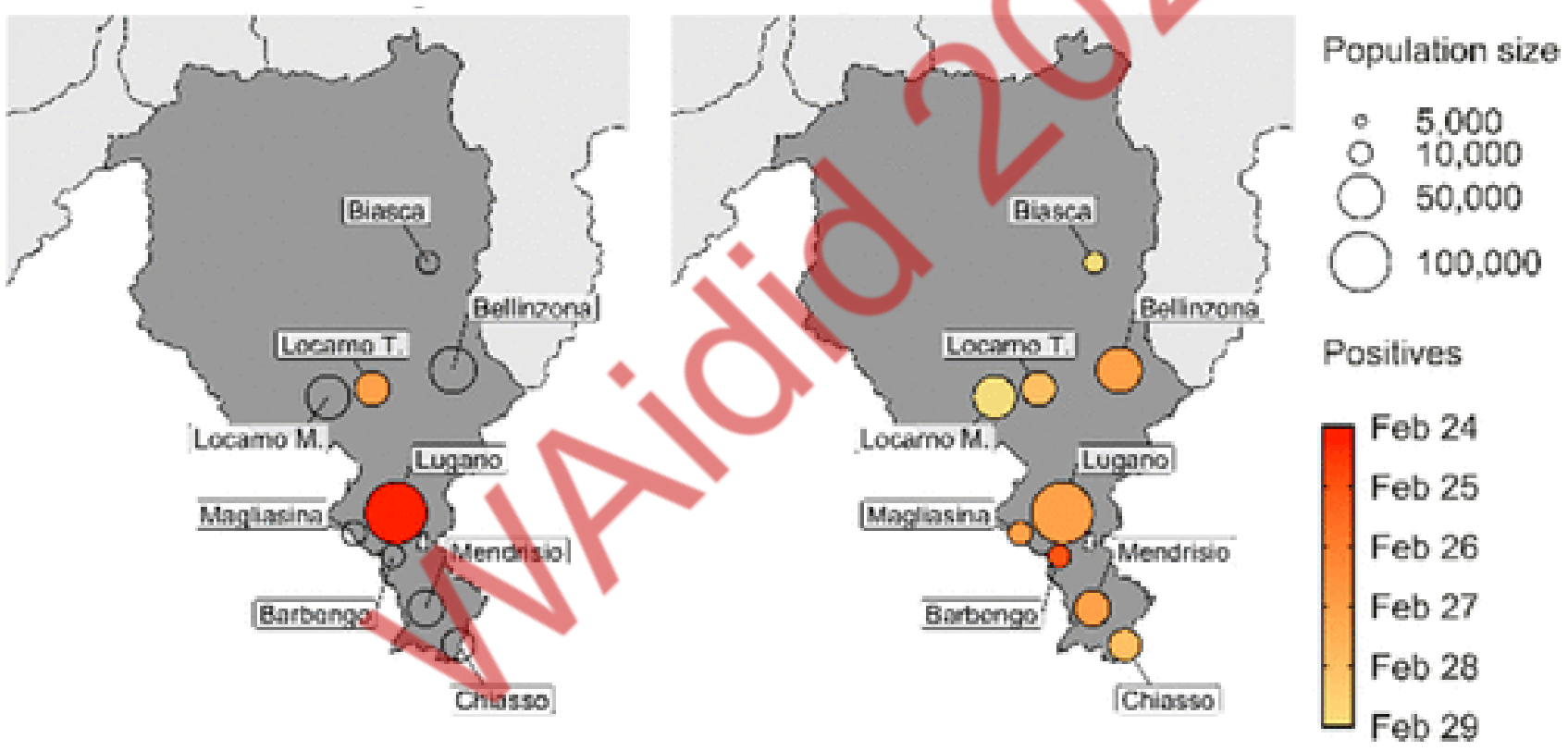




https://www.idd.bag.admin.ch/

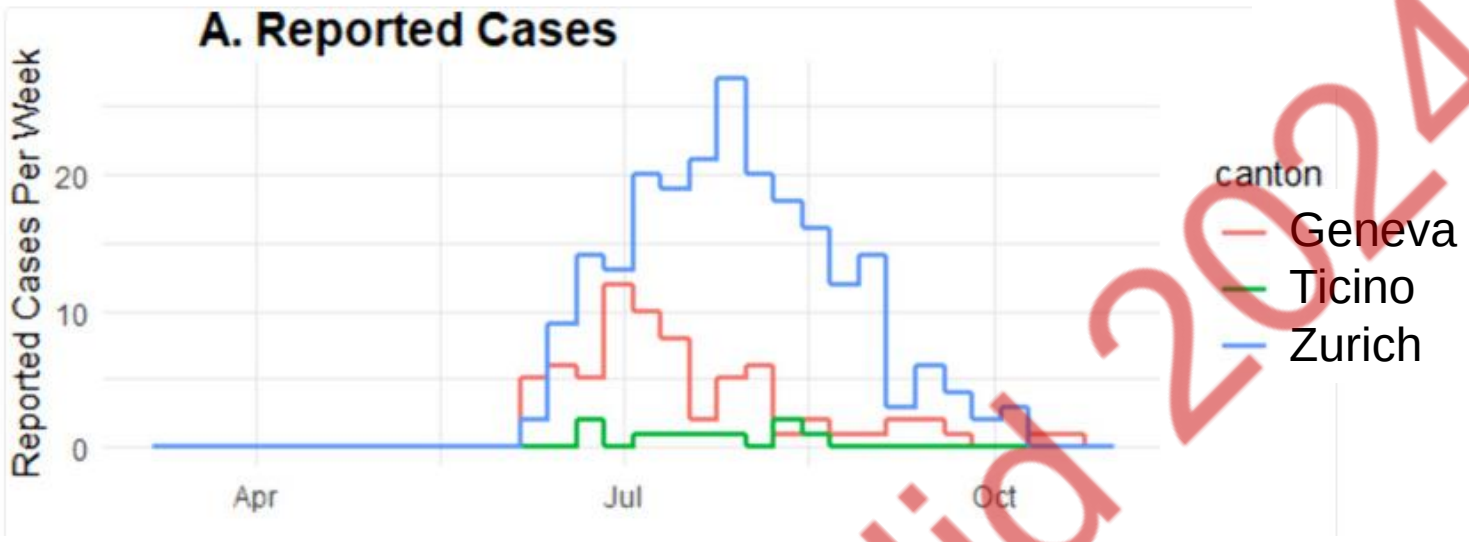
Wastewater-based Surveillance Tracks Emergence of Novel Diseases

Wastewater Signals Preceded Clinical Covid-19 Cases in Feb 2020, Switzerland



Cariti et al. 2022. *ACS EST Water*

Tracking monkeypox in wastewater, Switzerland, 2022



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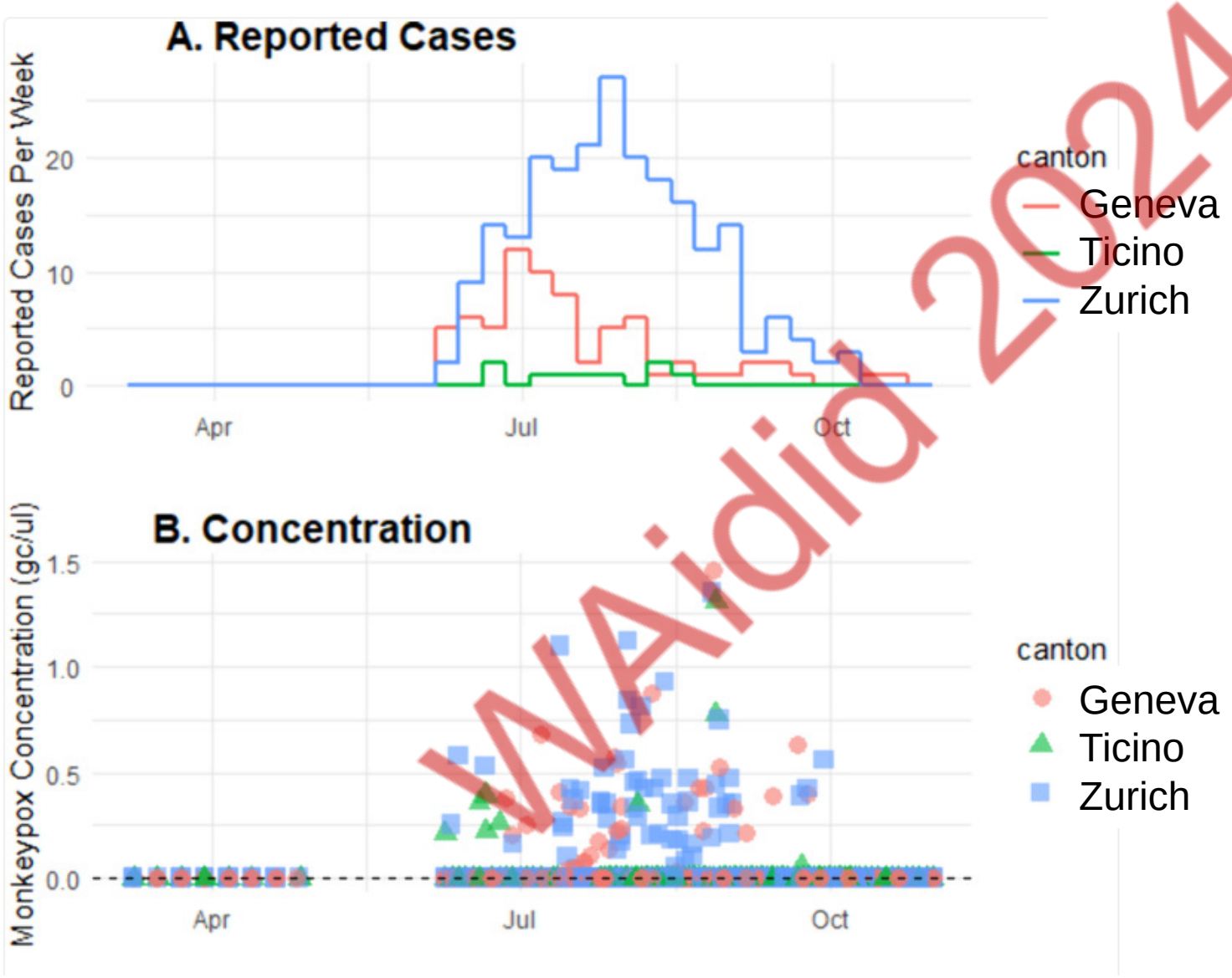
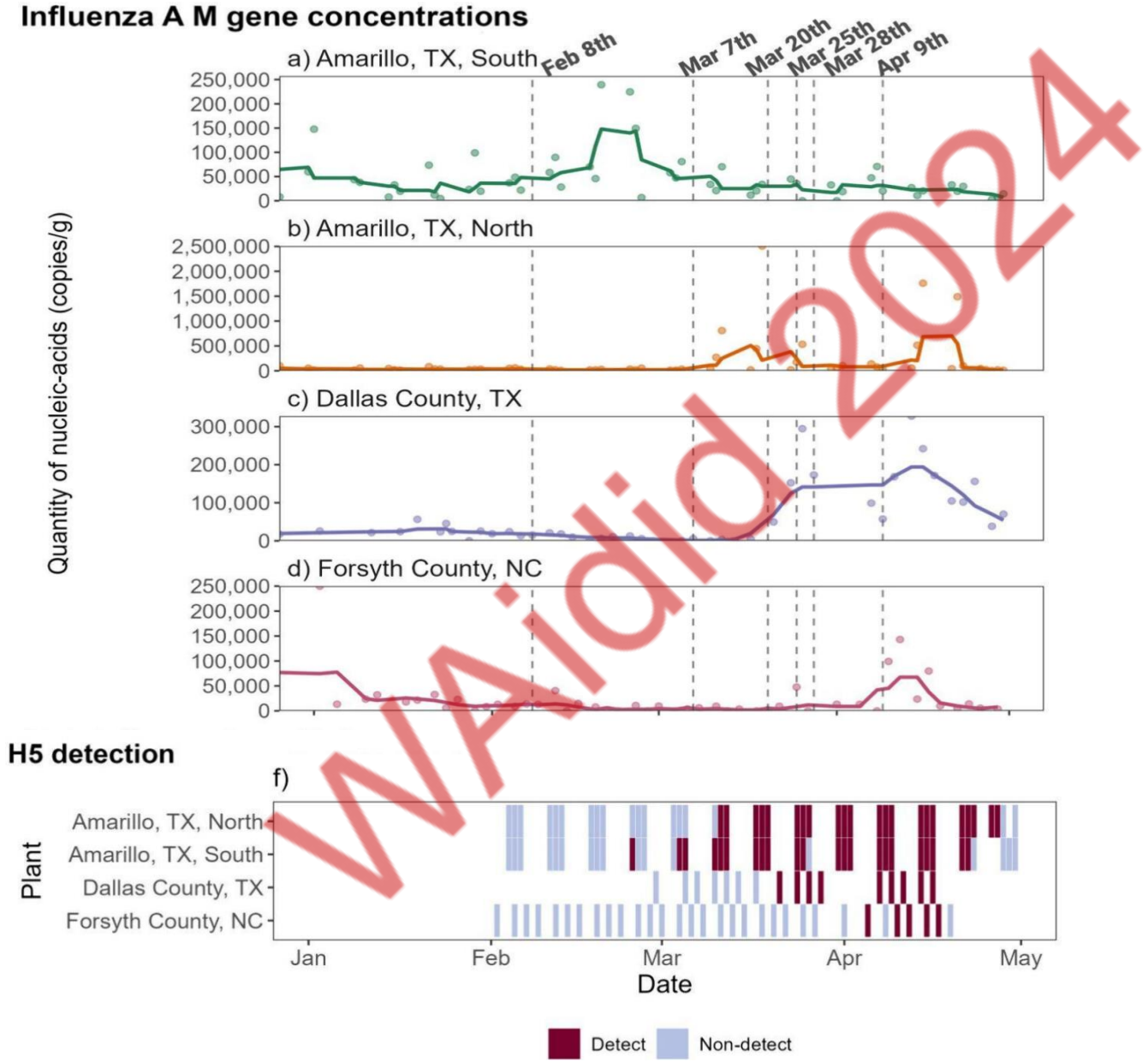


Monitoring for H5N1 in Wastewater (USA)



Wolfe et al. 2024. *EST Letters*

Monitoring for H5N1 in Wastewater (USA)

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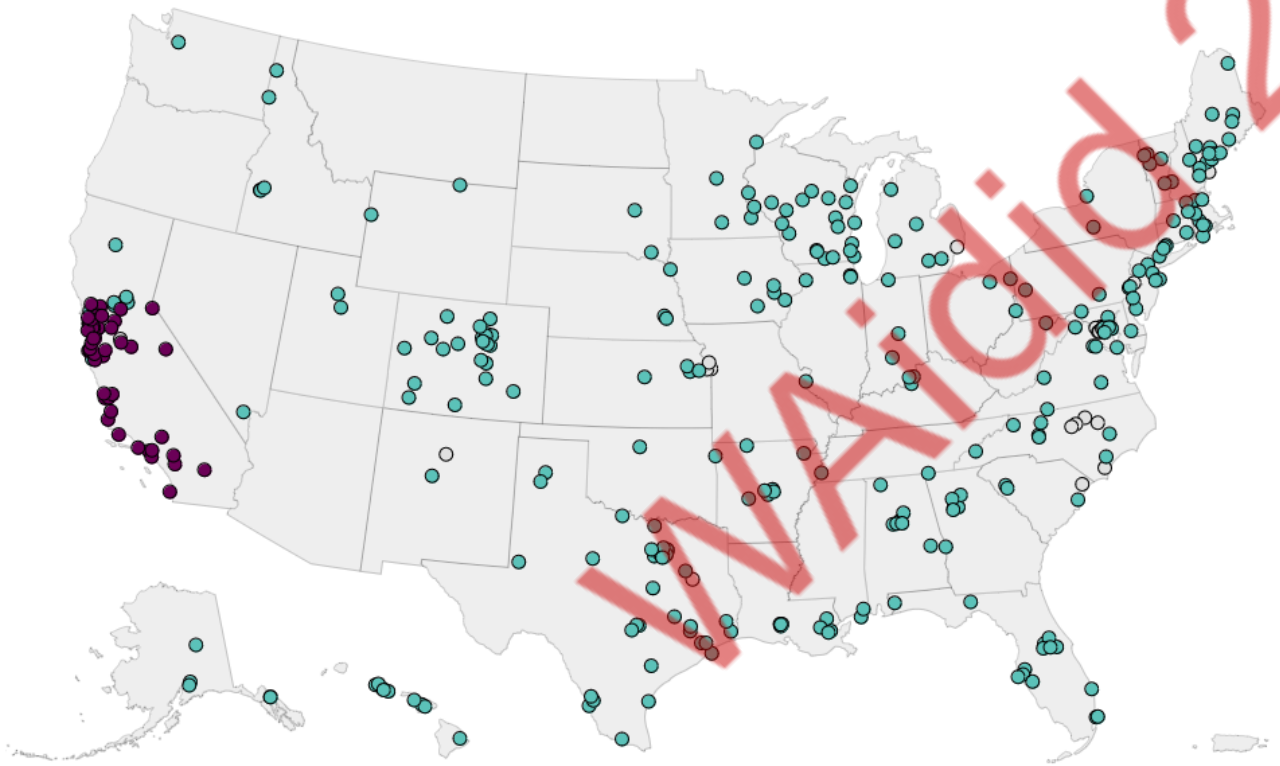
H5 Detection	No Detection	No samples in last week
46 sites (14.2%)	279 sites (85.8%)	24 sites

Click on the legend below to see detections.



CDC Newsroom

EXPLORE TOPICS SEARCH

ESPAÑOL

CDC confirms H5N1 Bird Flu Infection in a Child in California

RELEASE

For immediate release: November 22, 2024

CDC Media Relations
(404) 639-3286
media@cdc.gov
https://www.cdc.gov/media/

https://www.cdc.gov/nwss/rv/wwd-h5.html

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Wastewater-based Surveillance Tracks Genomic Landscapes of Pathogens

Amplicon-based Sequencing Reveals Variants:

Case Study B.1.1.7 (Alpha), 2020-2021

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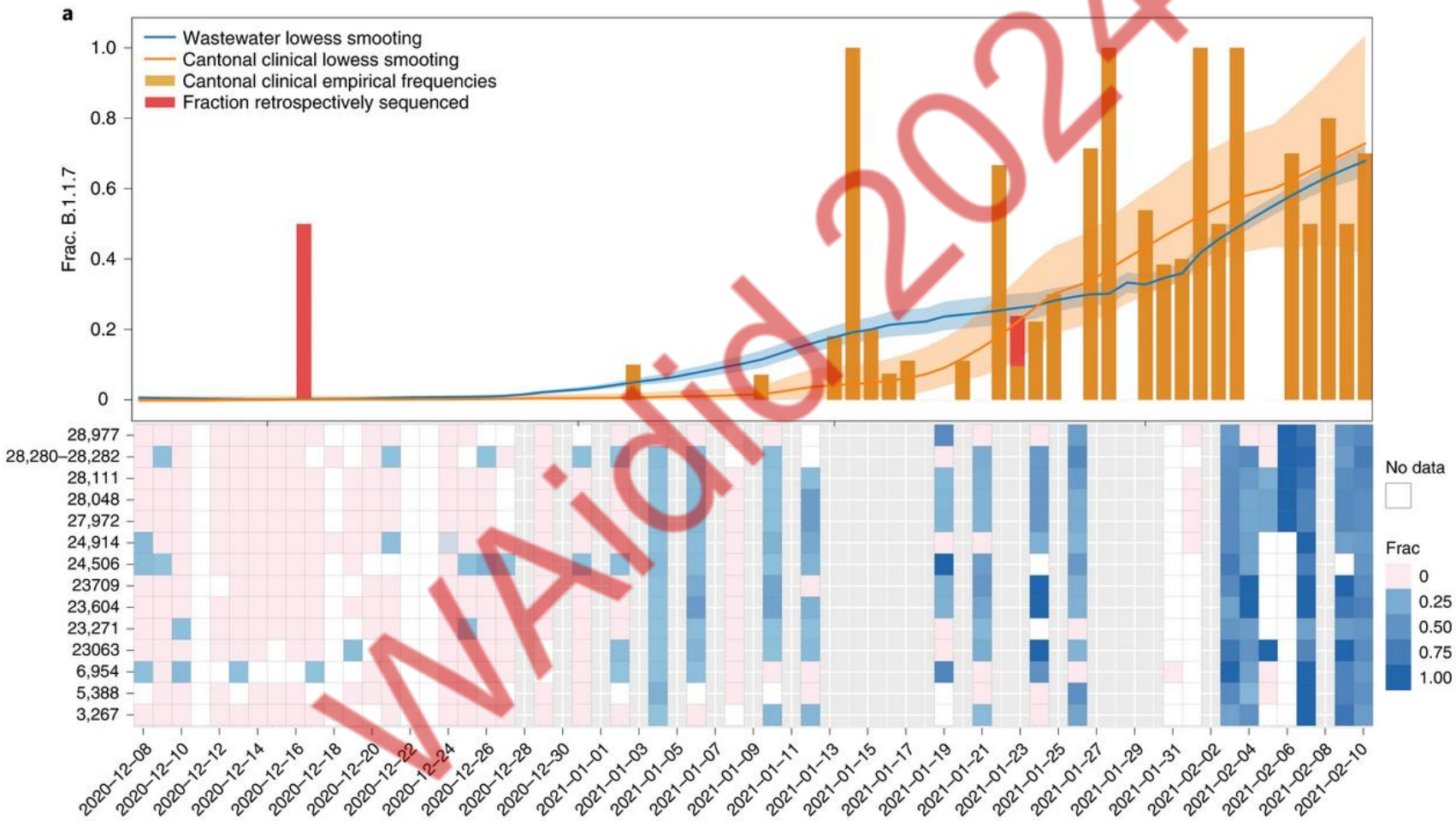
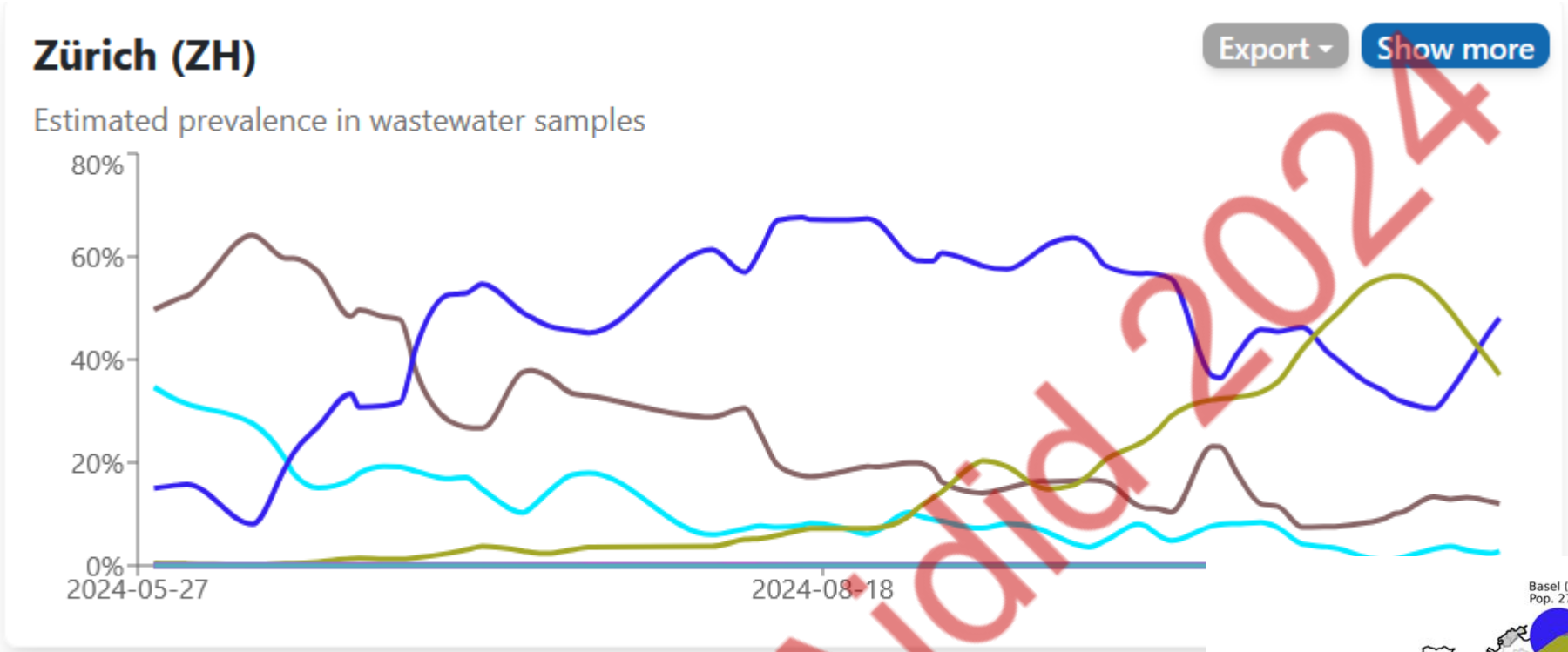
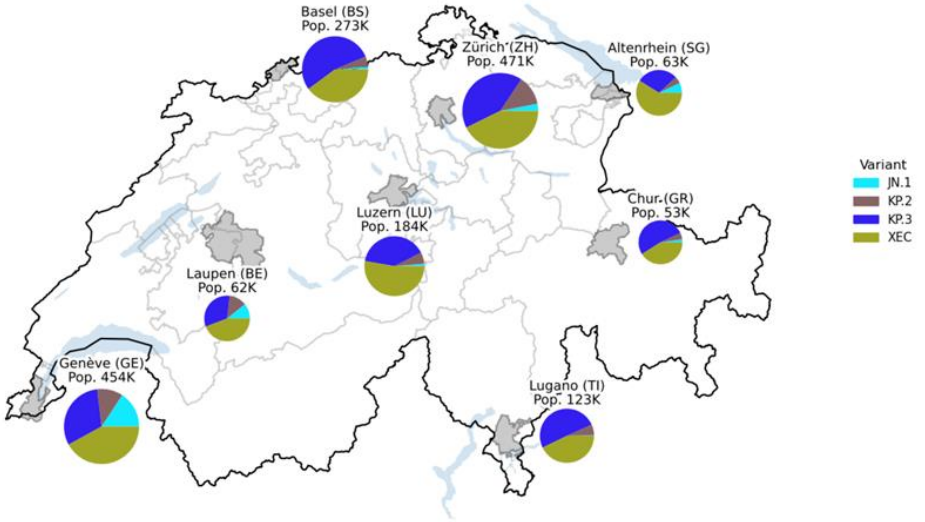


Jahn et al. 2022 *Nature Microbiology*

Track Variants and Monitor Genomic Landscape





https://cov-spectrum.org/stories/wastewater-in-switzerland

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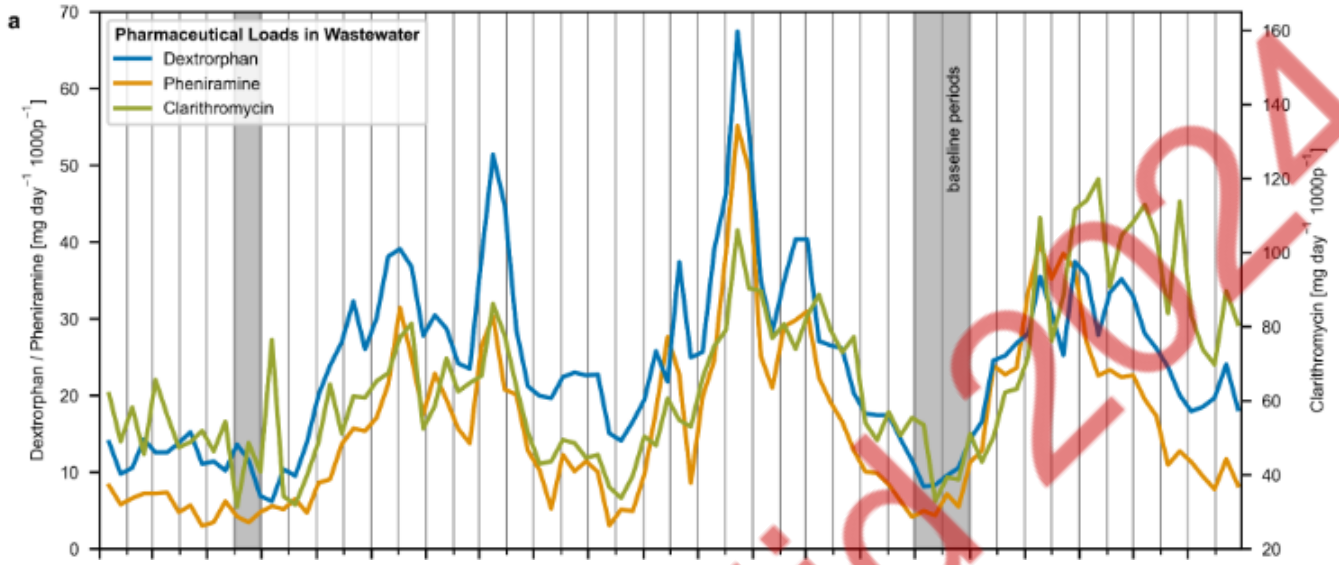
Wastewater-based Surveillance Tracks Symptoms of Diseases

Tracking pharmaceuticals as indicators of symptoms



www.coopvitality.ch

Baumgartner et al. 2024 *preprint*

Tracking pharmaceuticals as indicators of symptoms

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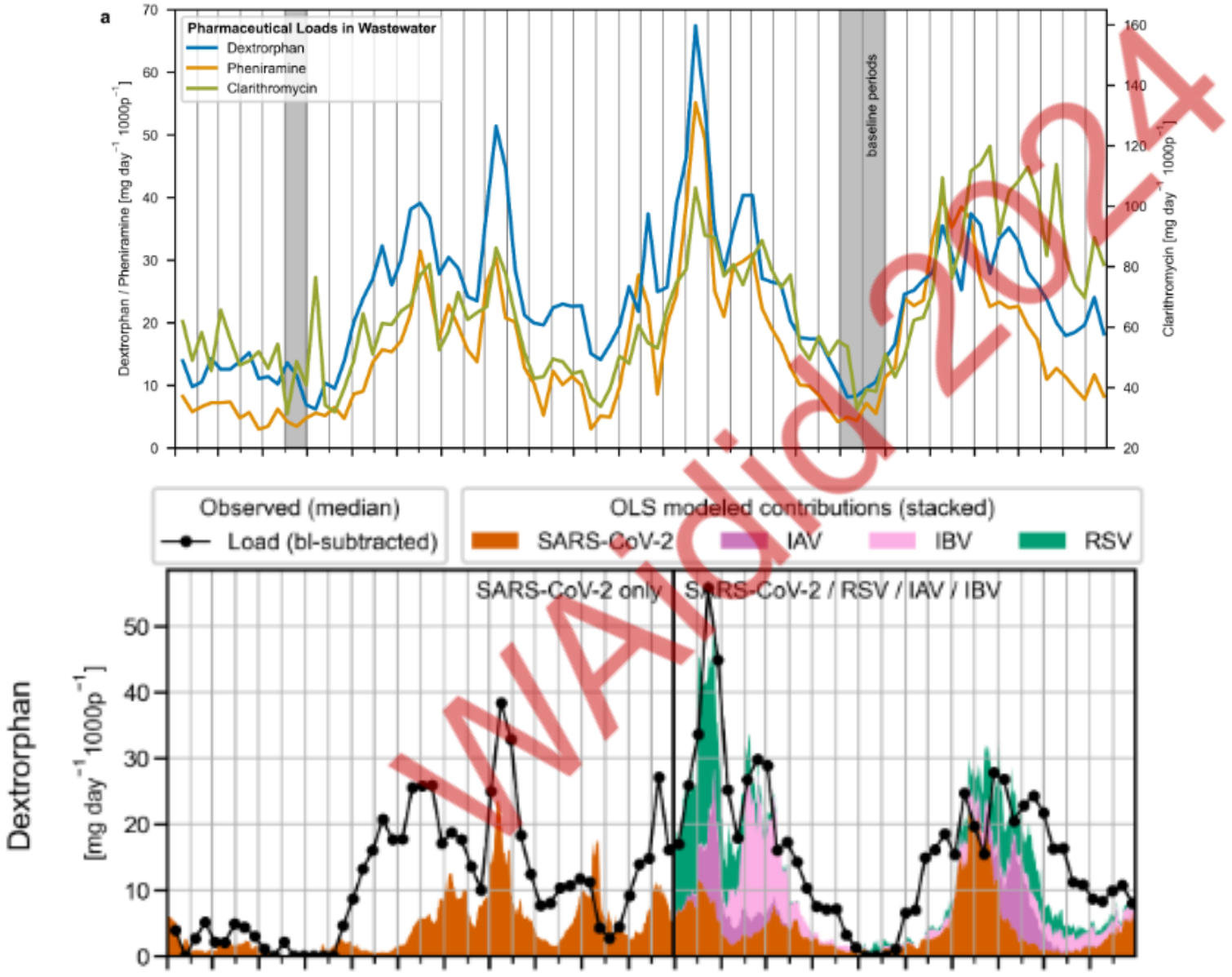

Baumgartner et al. 2024 *preprint*

Wastewater-based surveillance has a bright future

- Requires new method development
  - *Processing, Detection, and Bioinformatics*

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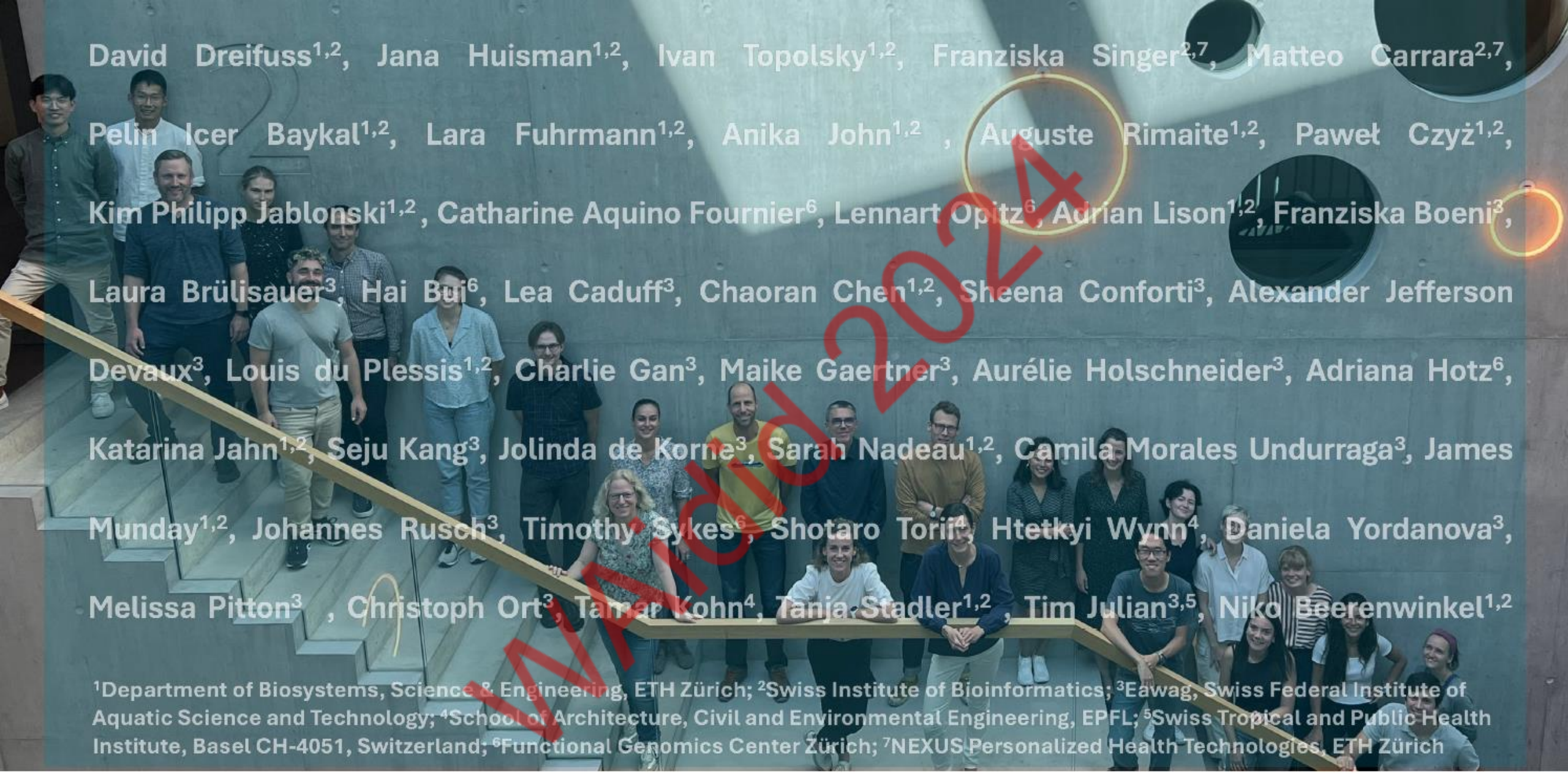
- Integration into Clinical Surveillance Networks

Wastewater-based surveillance has a bright future

- Requires new method development
  - *Processing, Detection, and Bioinformatics*
- Integration into Clinical Surveillance Networks
- Strong relationships with clinicians, public health officials.
  - *Actionable public health outcomes*



David Dreifuss[1,2], Jana Huisman[1,2], Ivan Topolsky[1,2], Franziska Singer[2,7], Matteo Carrara[2,7], Pelin Icer Baykal[1,2], Lara Fuhrmann[1,2], Anika John[1,2], Auguste Rimaite[1,2], Paweł Czyż[1,2], Kim Philipp Jablonski[1,2], Catharine Aquino Fournier[6], Lennart Opitz[6], Adrian Lison[1,2], Franziska Boeni[3], Laura Brülisauer[3], Hai Bui[6], Lea Caduff[3], Chaoran Chen[1,2], Sheena Conforti[3], Alexander Jefferson Devaux[3], Louis du Plessis[1,2], Charlie Gan[3], Maike Gaertner[3], Aurélie Holschneider[3], Adriana Hotz[6], Katarina Jahn[1,2], Seju Kang[3], Jolinda de Korne[3], Sarah Nadeau[1,2], Camila Morales Undurraga[3], James Munday[1,2], Johannes Rusch[3], Timothy Sykes[6], Shotaro Torii[4], Htetkyi Wynn[4], Daniela Yordanova[3], Melissa Pitton[3], Christoph Ort[3], Tamar Kohn[4], Tanja Stadler[1,2], Tim Julian[3,5], Niko Beerenwinkel[1,2]

[1]Department of Biosystems, Science & Engineering, ETH Zürich; [2]Swiss Institute of Bioinformatics; [3]Eawag, Swiss Federal Institute of Aquatic Science and Technology; [4]School of Architecture, Civil and Environmental Engineering, EPFL; [5]Swiss Tropical and Public Health Institute, Basel CH-4051, Switzerland; [6]Functional Genomics Center Zürich; [7]NEXUS Personalized Health Technologies, ETH Zürich