Multisectoral approaches as a tool to determine the impact of social determinants of health:

Linking SARS-CoV-2 wastewater and clinical epidemiology with socio-economic indicators

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NATIONAL INSTITUTE FOR COMMUNICABLE DISEASES
Division of the National Health Laboratory Service

GCRO | Gauteng City-Region Observatory

The Gauteng City-Region Observatory (GCRO)

Who we are and what we do

- **GCRO helps to build the knowledge base** that government, business, labour, civil society and residents all need to shape appropriate strategies that will advance a competitive, integrated, sustainable and inclusive Gauteng City-Region.

- **GCRO is an institutional collaboration** between:
  - University of Johannesburg (UJ),
  - University of the Witwatersrand (Wits),
  - Gauteng Provincial Government, and
  - Organised local government in Gauteng

- A purpose-designed vehicle for **policy-oriented research**.

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Introduction

Project history

- GCRO was extensively involved in response planning and research for Gauteng Provincial Government during the pandemic
  - Had access to Gauteng linelist data for a time and could see some spatial and social trends as well as issues with the data
  - Most outputs available: https://gcro.ac.za/research/project/detail/responding-covid-19-pandemic-gauteng/
  - Collected QoL data on the impact of the pandemic on respondents an households. Published as GCRO databrief

- Approached by NICD early 2022 to help understand socio-economic dynamics of wastewater surveillance for WRC funding proof of concept project

- Later in 2022 BMGF funding received for 3 year period in partnership with London School of Hygiene and Tropical Diseases, SACEMA, NICD and GCRO

What is wastewater-based epidemiology?

- Wastewater-based epidemiology (WBE) is a complementary surveillance tool that supports clinical surveillance

- WBE has shown correlation with clinical case levels of SARS-CoV-2 and several use-cases exist
  - entrance of virus into a community
  - early warning
  - correlation with burden and distribution of disease
  - genomic characterisation of circulating population strains

- However, as patient level testing rates decrease, public health and disease experts are more reliant on WBE to gain insight into population burden of disease
- In the light of the above, we are looking at the relationship between WBE, clinical surveillance and population demographics/socioeconomic indicators in order to better interpret WBE findings
- There are few examples interrogating the above relationships, and none in LMICs

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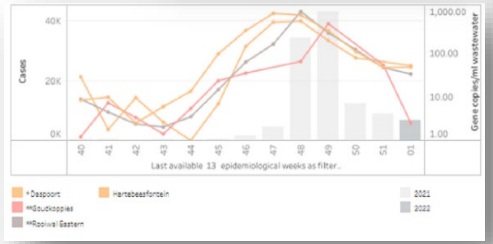
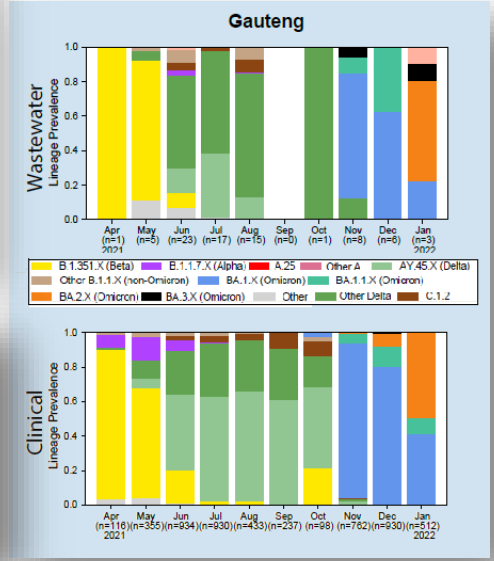
Wastewater-based epidemiology: a new complementary for communicable disease surveillance

During the COVID-19 pandemic, wastewater-based epidemiology proved to be a helpful complementary tool to support clinical surveillance for SARS-CoV-2 in South Africa and globally.

- Wastewater levels of SARS-CoV-2 track clinical case burden
- Case burden can be inferred
- Increases in wastewater levels predict increases in clinical cases.
- Genomic variants of SARS-CoV-2 can be identified in wastewater and signs of new variants detected



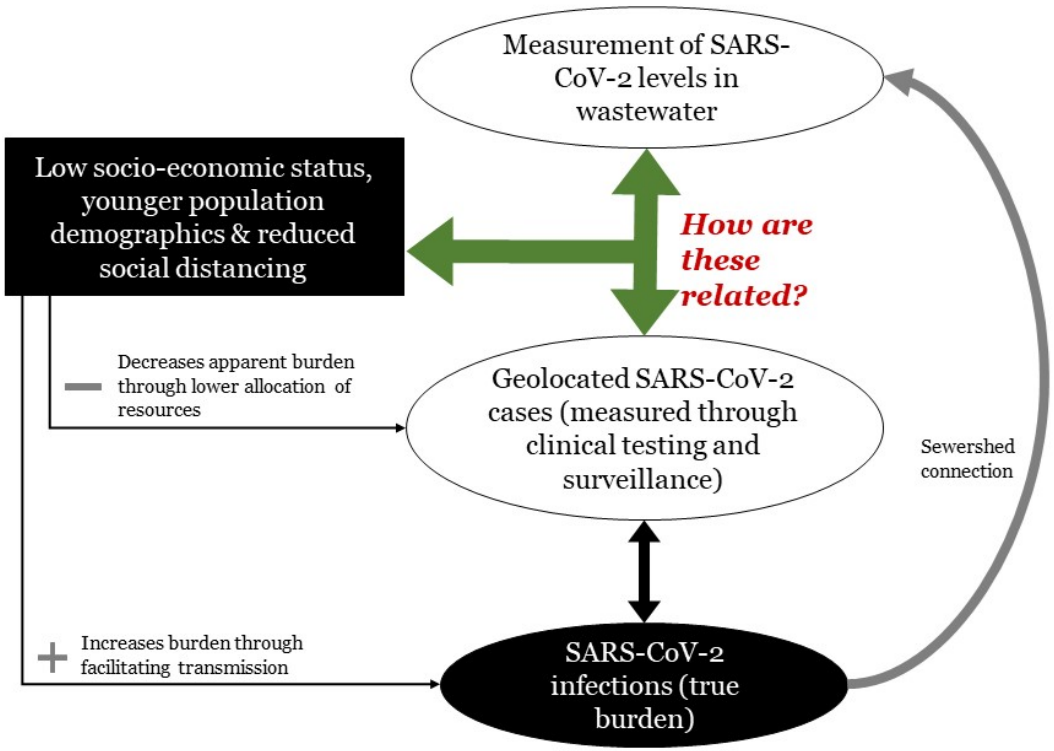
Iwu-Jaja et al, Science of the Total Environment, 2023



Yousif et al, Nature communications, 2023

Research is expanding to monitor for other pathogens (Influenza A & B, Hepatitis A & E, measles and rubella)

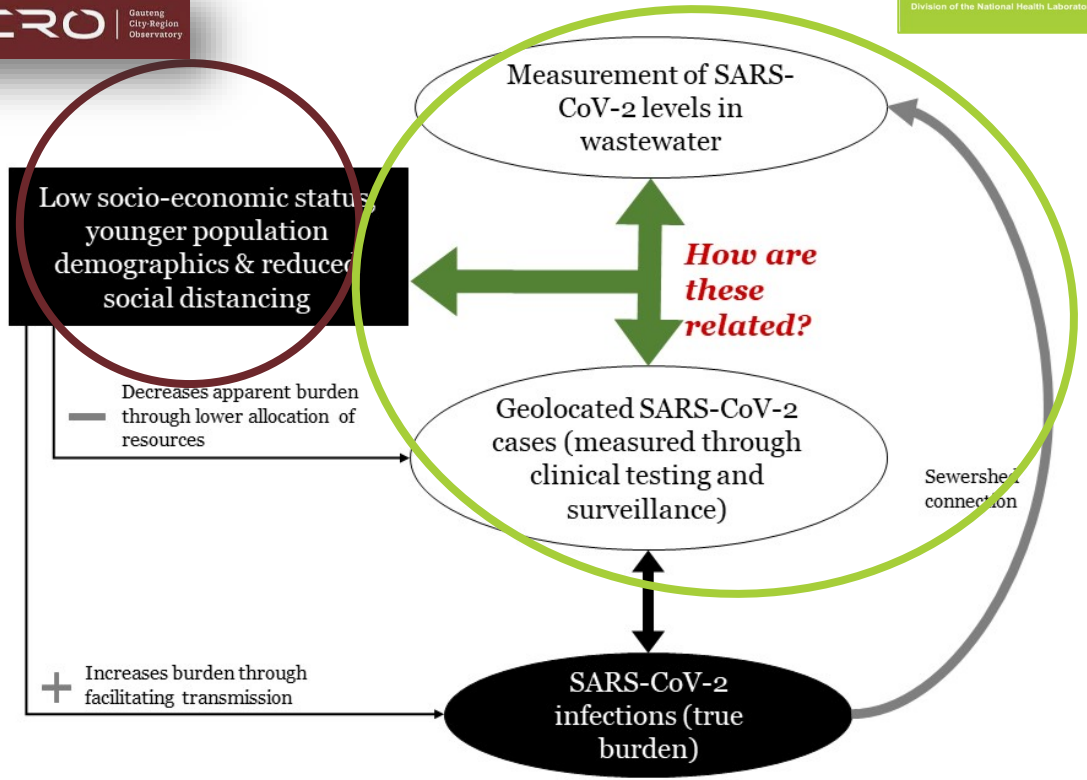
Conceptual framework indicating the relationship between key variables to understand true burden of disease from wastewater



We want to understand:

1. Demographic, socioeconomic and health characteristics
2. SARS-CoV-2 clinical data: testing, incidence and positivity rate
3. Relationship between clinical case data and socioeconomic status
4. Quantitative SARS-CoV-2 surveillance in wastewater and relate to clinical data
5. Comparison of estimated (wastewater) and actual SARS-CoV-2 case burden

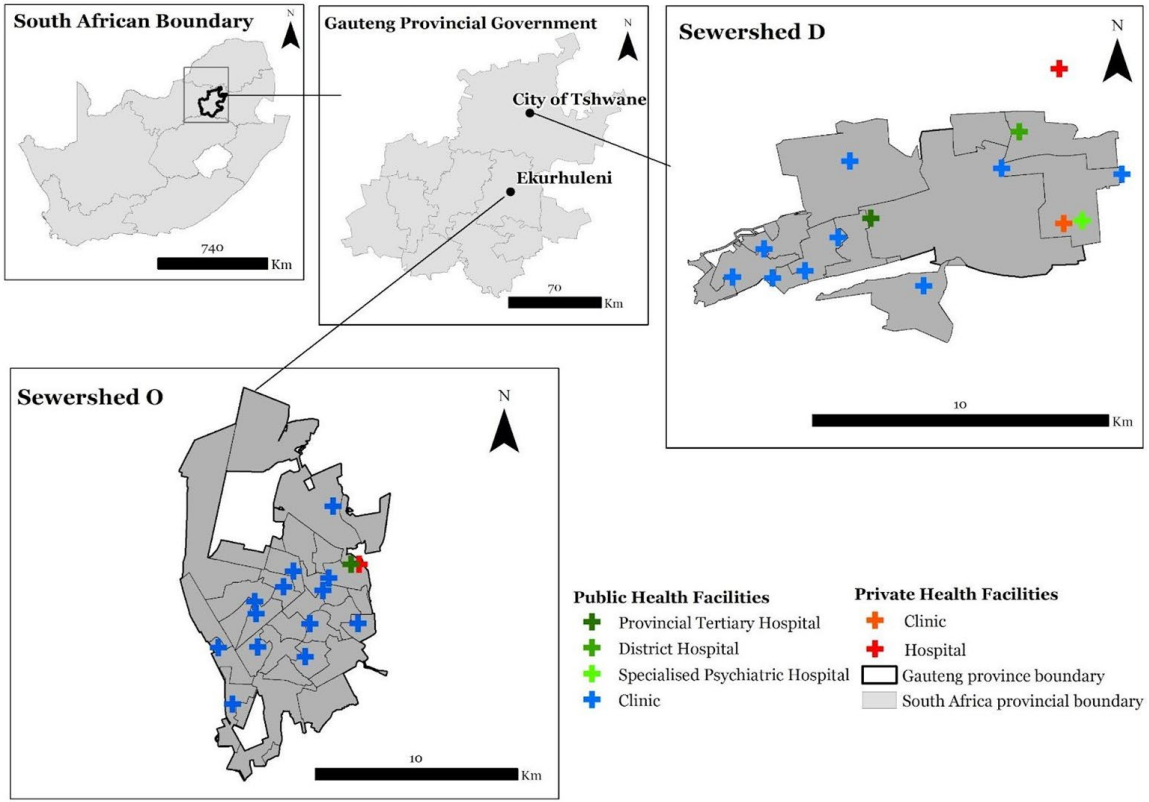
Conceptual framework indicating the relationship between key variables to understand true burden of disease from wastewater

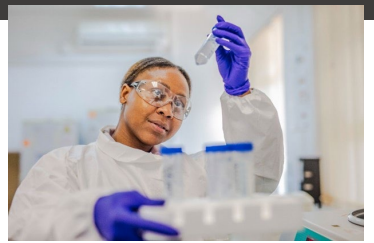


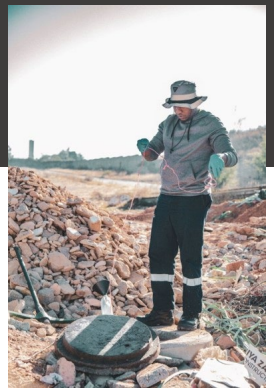
- We set up a collaboration to bring together
  - GCRO Quality of Life survey data
  - GCRO mapping and analytic expertise
  - NICD geolocated SARS-CoV-2 case data and SARS-CoV-2 wastewater data
  - NICD surveillance epidemiological experience

Sewersheds: Monitoring wastewater for SARS-CoV-2

Methods: Wastewater reticulation maps in case-study areas





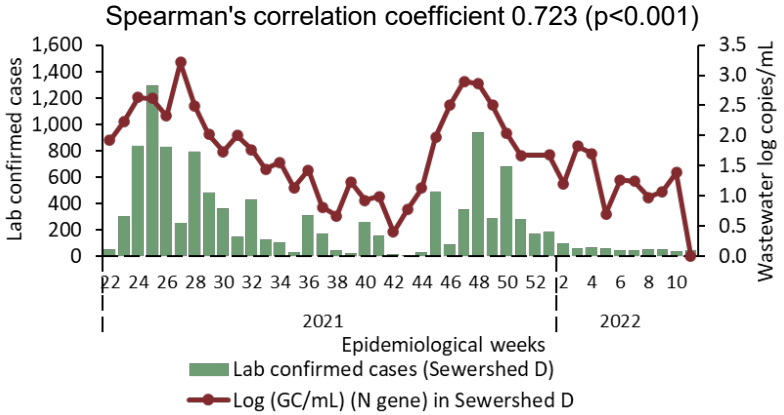


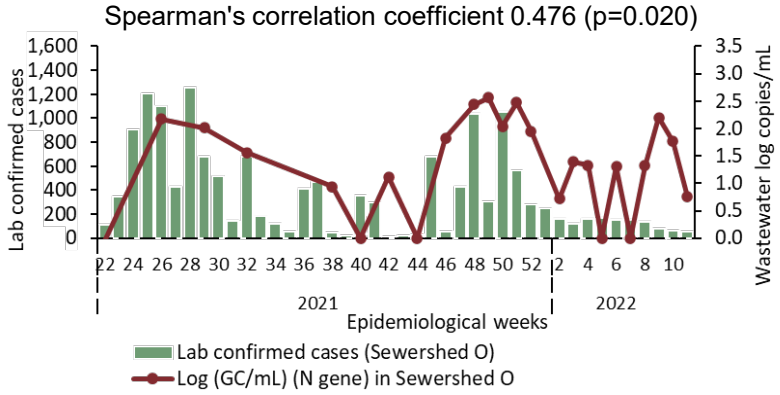
	Sewershed D	Sewershed O
Sewershed area	61.99km^2	120.69km^2
Total population	245,935	905,996
Population density	3.97 people per km^2	7.51 people per km^2
Number of wards	15	28

City of Ekurhuleni

CITY OF TSHWANE

SARS-CoV-2 concentrations in wastewater in log-transformed genome copies per millilitre (right axis) and the number of laboratory-confirmed cases in the sewershed by epidemiological week for sewersheds D (left) and O (right).





	Sewershed D	Sewershed O
Total Population (people/km²)	245,935 (3.97)	905,996 (7.51)
Quality of Life	64	59
Total recorded SARS-COV-2 cases	11,026	15,293
Mean positivity rate (%, sd)	17 (12.8)	14 (9.9)
Cumulative incidence rate (cases /100 000 population)	4483.3	1,688.0
Testing rate (tests/100 000 population)	23,696	10,580

- Wastewater concentrations (log genome copies per millilitre) for both sewersheds ranged between 0.5 and 3,5 log copies/mL and were at similar concentrations.
- **The two catchments followed a similar pattern and case count over time for laboratory-confirmed cases despite there being very different population sizes in the two catchments.**

Quality of life and cumulative incidence of SARS-CoV-2 by catchment for the period 1 March 2020 31 December 2021 during Delta and Omicron waves

Access to SARS-CoV-2 testing:
Households were asked if they had tried to access testing for SARS-CoV-2 and were refused

Crowding index:
Defined as 3 or more people per functional room, expressed as the percentage of households per catchment

Degree of difficulty preventing COVID-19:
- Ability to maintain social distancing and practice preventative hygiene.
- Components include crowding, access to sanitation, water, health facilities, electronic communication and public transport
- **HIGH score = RISKY**

COVID-19 vulnerability:
- Risk factors that increase health and social vulnerability.
- Components include pre-existing health risk factors, difficulty saving money, face hunger, not medically insured, current poor health.
- **HIGH score = RISKY**

	Sewershed D (Std err)	Sewershed O (Std err)	p-value*
Population served by WWTP (# people)	215,265	905,996	
Cumulative incidence (lab-confirmed SARS-CoV-2 cases/100,000	4483.3	1,688.0	
QoL (n respondents)	375	652	
Overall index	**64 (6)**	**59 (6)**	0.008
Services	95 (1)	84 (2)	<0,001
Socio-economic status	42 (1)	29 (1)	<0,001
Government satisfaction	40 (2)	44 (1)	<0,001
Life satisfaction	64 (1)	60 (1)	<0,001
Health	74 (2)	72 (1)	<0,001
Safety	53 (1)	48 (1)	<0,001
Participation	68 (1)	75 (1)	<0,001
Tried to test for SARS-CoV-2 but were refused	4 (1)	3 (1)	<0,001
Crowding index	8 (1)	**22 (1)**	<0,001
COVID-19 prevention capacity	18 (0,06)	**29 (0,05)**	<0,001
COVID-19 vulnerability	34 (0,08)	**42 (0,05)**	<0,001

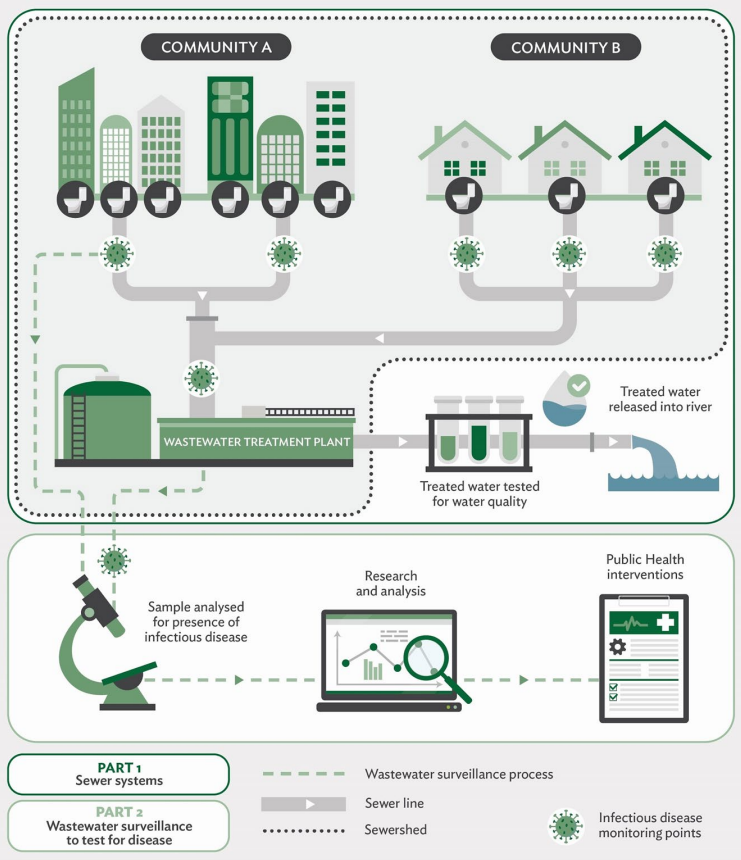
Daspoort has
- **Less people**
- **Higher quality of life**
- **Better access to testing**
- **Less crowding**
- **More capacity to prevent SARS-CoV-2**
- **Lower vulnerability to COVID-19**

*Student t-test

De Kadt et al, 2021 and Maree et al, 2021
Data briefs available on www.gcro.ac.za

Building a use-case scenario for WBE

- Establishing a use-case for wastewater surveillance in South Africa context - we can now quantify the relationships.
- This research helps develop methods where the quality of data can be variable and difficult to connect discrete datasets on disease, demographics and socioeconomics. This makes decision making difficult during a crisis.
- Our findings provide evidence to support intuitive thinking that WBE can overcome testing biases particularly in situations where
    - Testing rates are low or
    - where clinical disease monitoring is costly, resource intensive and difficult in large communities.
- Broadly applicable to all communicable disease surveillance programmes



Outputs and activities

1. Academic outputs:

- PlosONE academic paper
- Non-sewered wastewater surveillance
- Spatial methods for public health
- Vaccine hesitancy

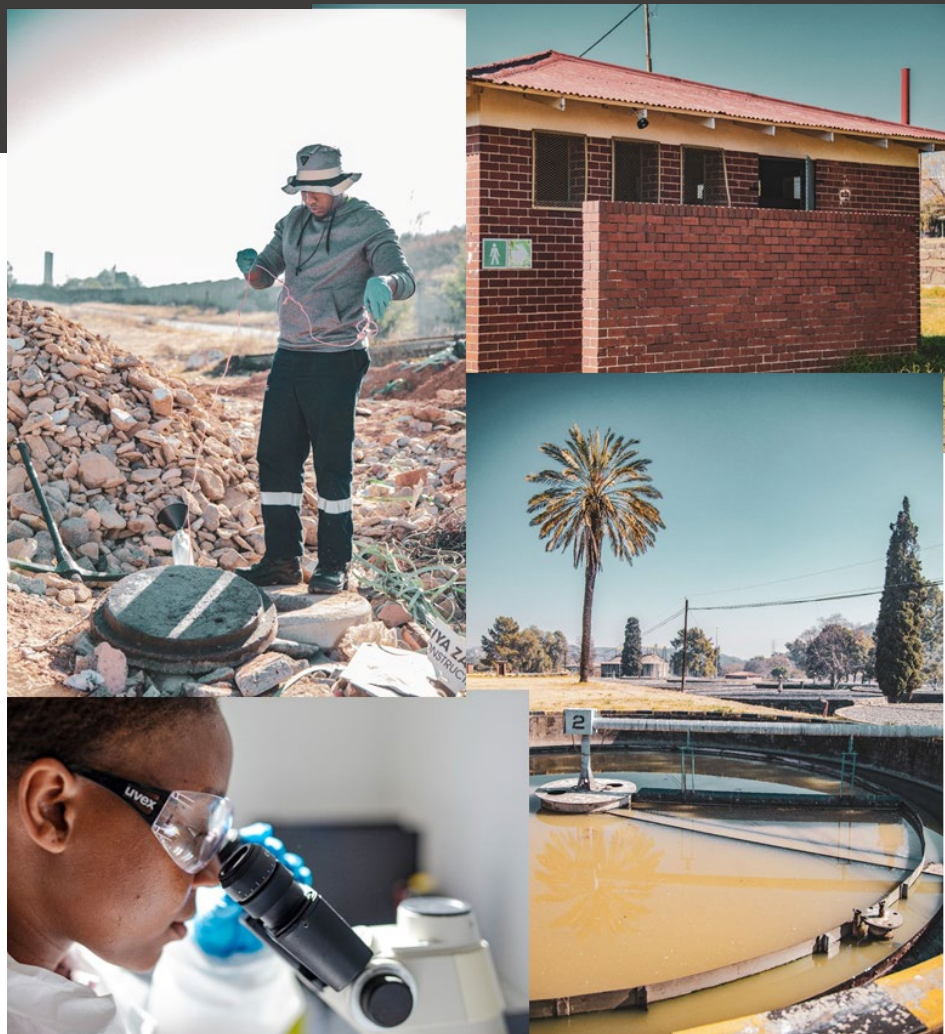
Large bank of research from the NICD on validation of laboratory validations of wastewater samples

2. GCRO outputs:

- Photo essay: GCRO output for September 2023
- COVID-19 Vaccination MotM
- Vaccination Databrief
- Sets of infographics

3. QoL – bank of questions included to support work in sewersheds as well as to understand vaccine hesitancy

https://gcro.ac.za/research/project/detail/sewersheds-wastewater-surveillance-disease-monitoring/



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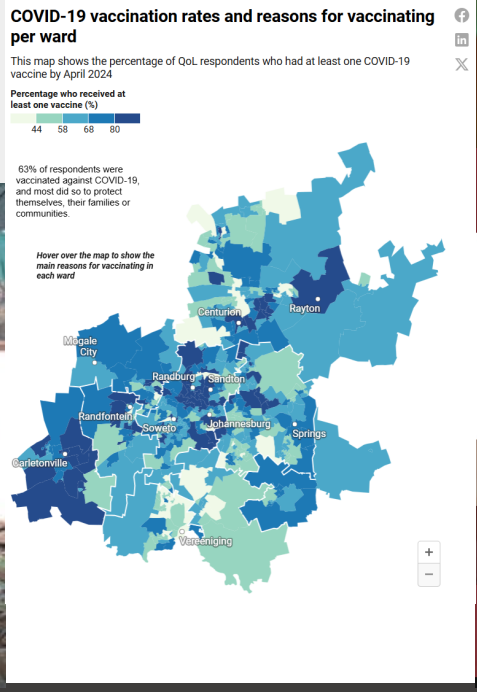

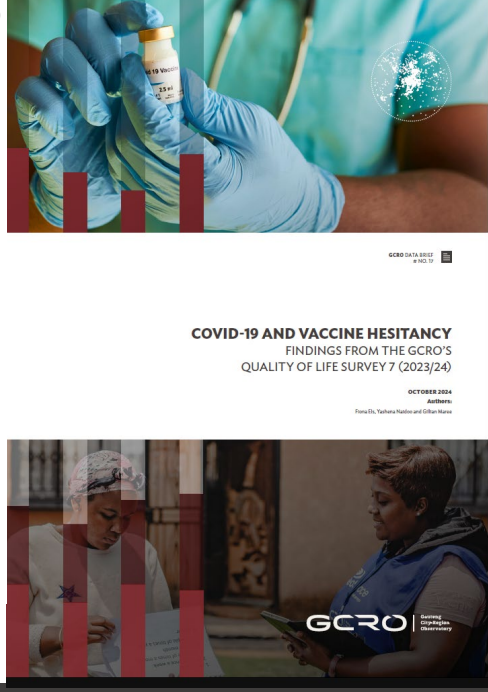

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