Sewer Monitoring for Antimicrobial Resistance Trends (SMART) Project

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Co-Investigators: Stefan Green, PhD (Rush), Mary Hayden, MD (Rush), and Rachel Poretsky, PhD (Site PI, UIC/Discovery Partners Institute)

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Rush University Medical Center, University of Illinois at Chicago, Chicago Department of Public Health, and Centers for Disease Control and Prevention

Overview

- Chicago is one of three regions funded by CDC (through SHEPheRD contract) to evaluate wastewater surveillance of MDROs at high risk facilities
- In 2023, we evaluated the feasibility and logistics of wastewater sampling at a single long term acute care hospital (LTACH) caring for patients at high risk for CRE and *C. auris* colonization
- The goal of this presentation is to review our first year's experience with wastewater surveillance, and plan for upcoming years

SMART Project Team

Michael Lin
Project Lead (PI)

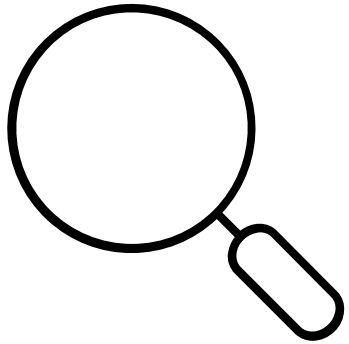
Rachel Poretsky
Wastewater Sampling, Lab Processing, Molecular Testing (UIC site PI)

Stefan Green
Molecular and Metagenomic Testing

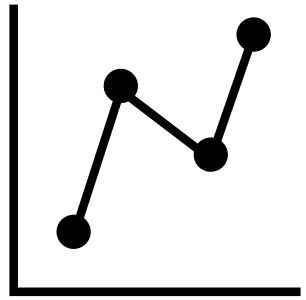
Mary Hayden
Culture-based Testing

Mike Schoeny
Biostatistics

Public health needs a regional surveillance system to…



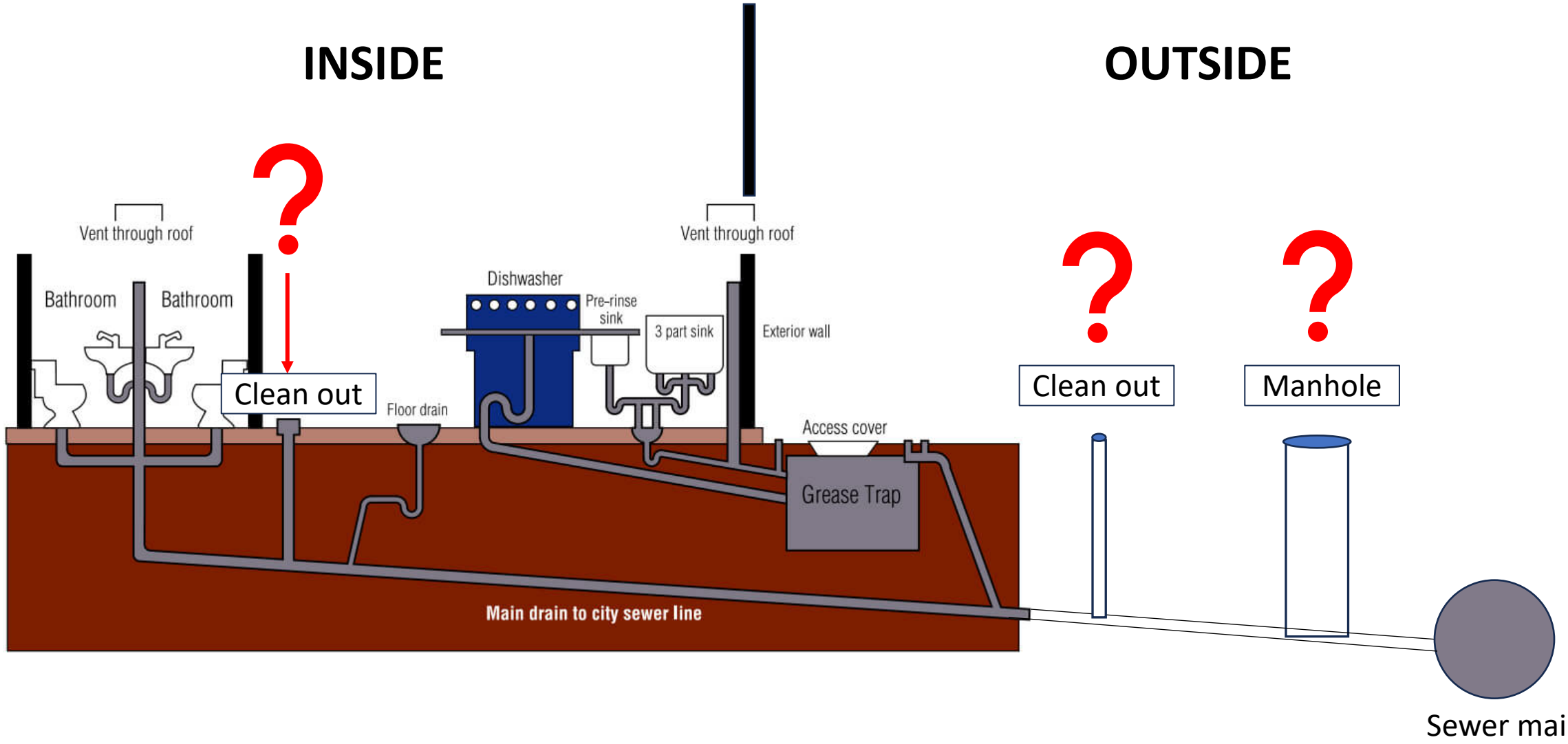
Identify emergence of **novel** organisms



Track trends of **established** organisms

Can wastewater surveillance at the level of the healthcare facility serve those roles for MDROs?

Is wastewater accessible in healthcare facilities?



Manholes are most practical

- Designed with a removable cover
- Larger size allows for multiple collection options and room for water meters

Most (But Not All) LTACHs have WW Access

- 5 of 6 LTACHs surveyed in Chicago region
- Average building age 48 years (range, 0 to 71)
- Patient census range: 28 to 98

Number of Access Points for LTACHs Surveyed (N=5)

One access point (manhole)	Two access points (manhole, lift station)	No access
3	1	1

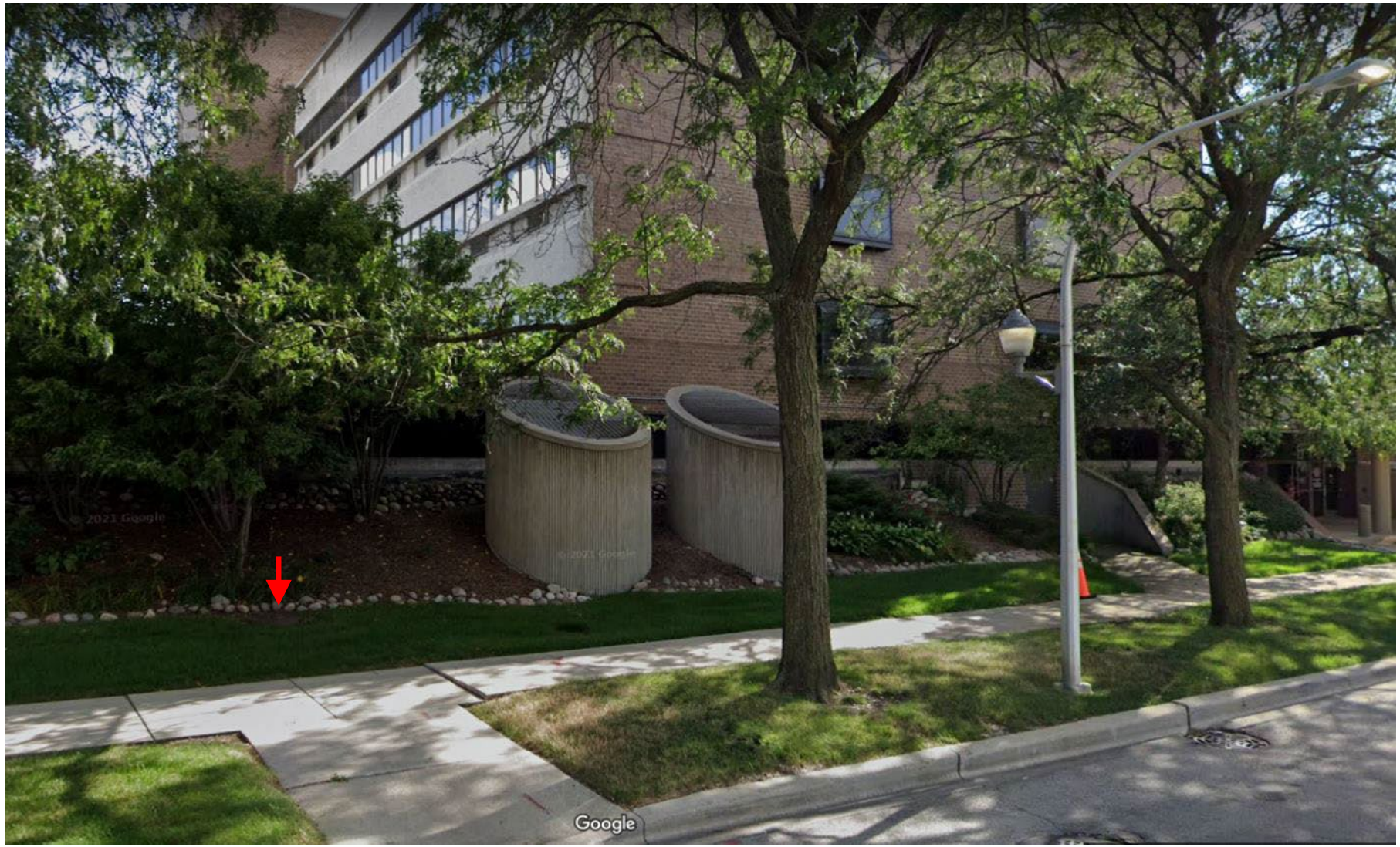
FINDINGS: (1) External wastewater access points are available for most, but not all buildings. (2) Internal access points not feasible.

What have we learned from our first year of surveillance at an LTACH?

LTACH A: Our Base Year Partner

- 5 floors, 86 licensed beds
- Average census 37
- Baseline estimated prevalence at start of surveillance, June 2023:
  - Carbapenem-resistant Enterobacterales (KPC, NDM), 13/35 (35%)
  - *Candida auris,* 13/35 (35%)
- Toileting status of patients
  - 33% of patients had stool entering toilet stream (eg, bed pan, bedside commode, toilet)
  - 67% of patients used bed pad (solid waste)

LTACH A



LTACH A Sewer Access

- Two inflows
- Depth 11 ft
- Hole in manhole cover

Flushing Fluorescent Dye down Toilet is Useful to Confirm that the Manhole is Correct Sampling Site

(Dye test image from different facility)

Manhole with Auto-Sampler on Right

Passive Sampler Set-Up

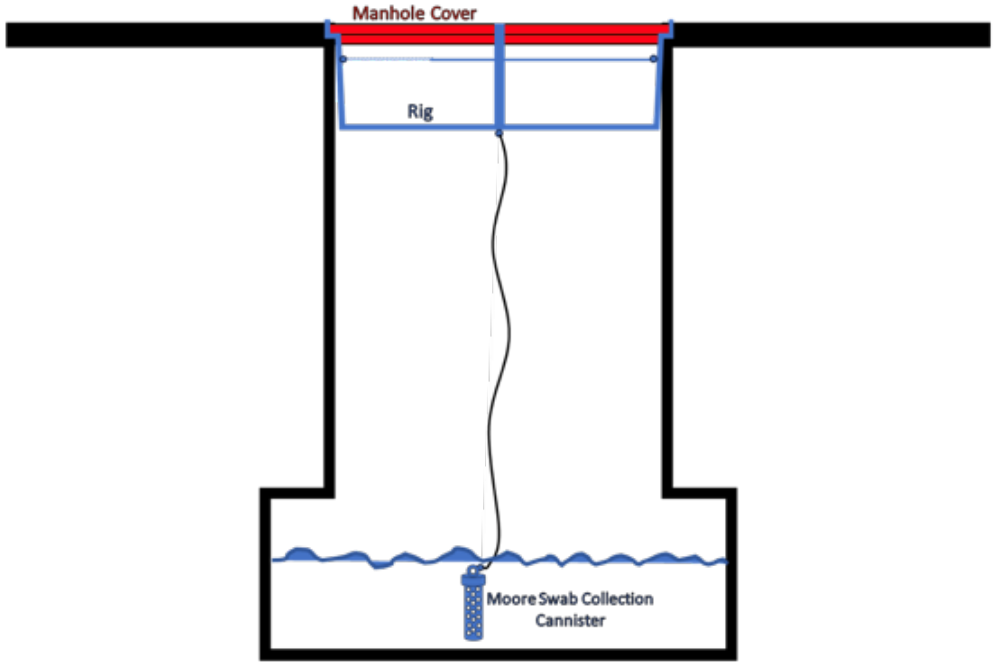


Figure: Schematic of passive sampling device as deployed in the manhole, with rig bracket manufactured in the UIC instrument shop

Base Year Protocol and Experiments: Twice-Weekly Wastewater Samples(50 samples)

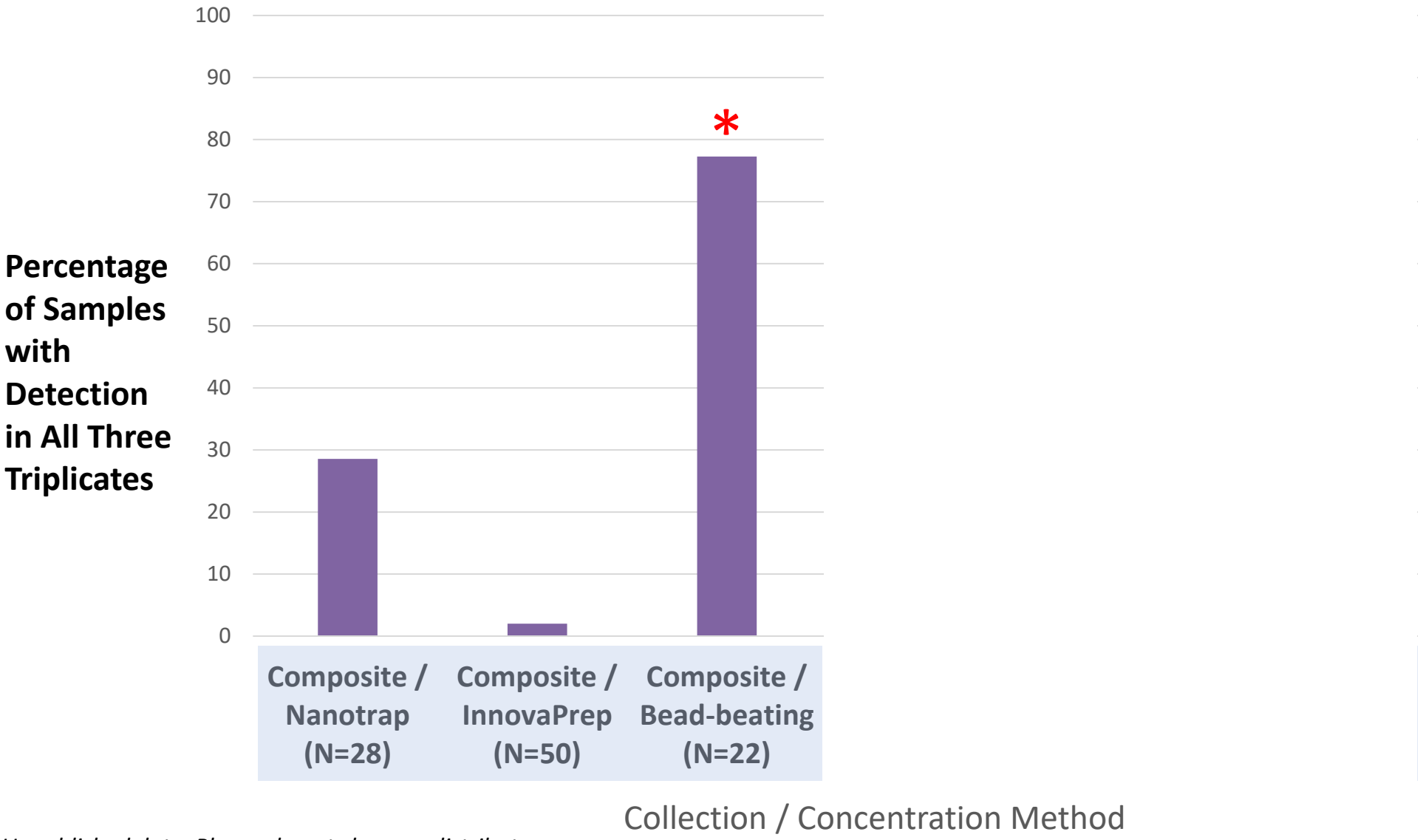
Step	Options	
Collection	**Composite (autosampler)*** | **Grab** | **Passive Sampling***	
Concentration Method	*Period 1* **Nanotrap** | **InnovaPrep**	*Period 2* **InnovaPrep** | **Bead-Beating**
Detection	**dPCR** | **qPCR**	

* 24-hour sampling

Nanotrap particles (Ceres Nanosciences, Manassas, VA)
InnovaPrep Concentrating Pipette (InnovaPrep, Drexcel, MO)

dPCR (GT Molecular, Fort Collins, CO)
qPCR (CDC methods)

Bead-beating Improves Consistency of dPCR Detection for *Candida auris*



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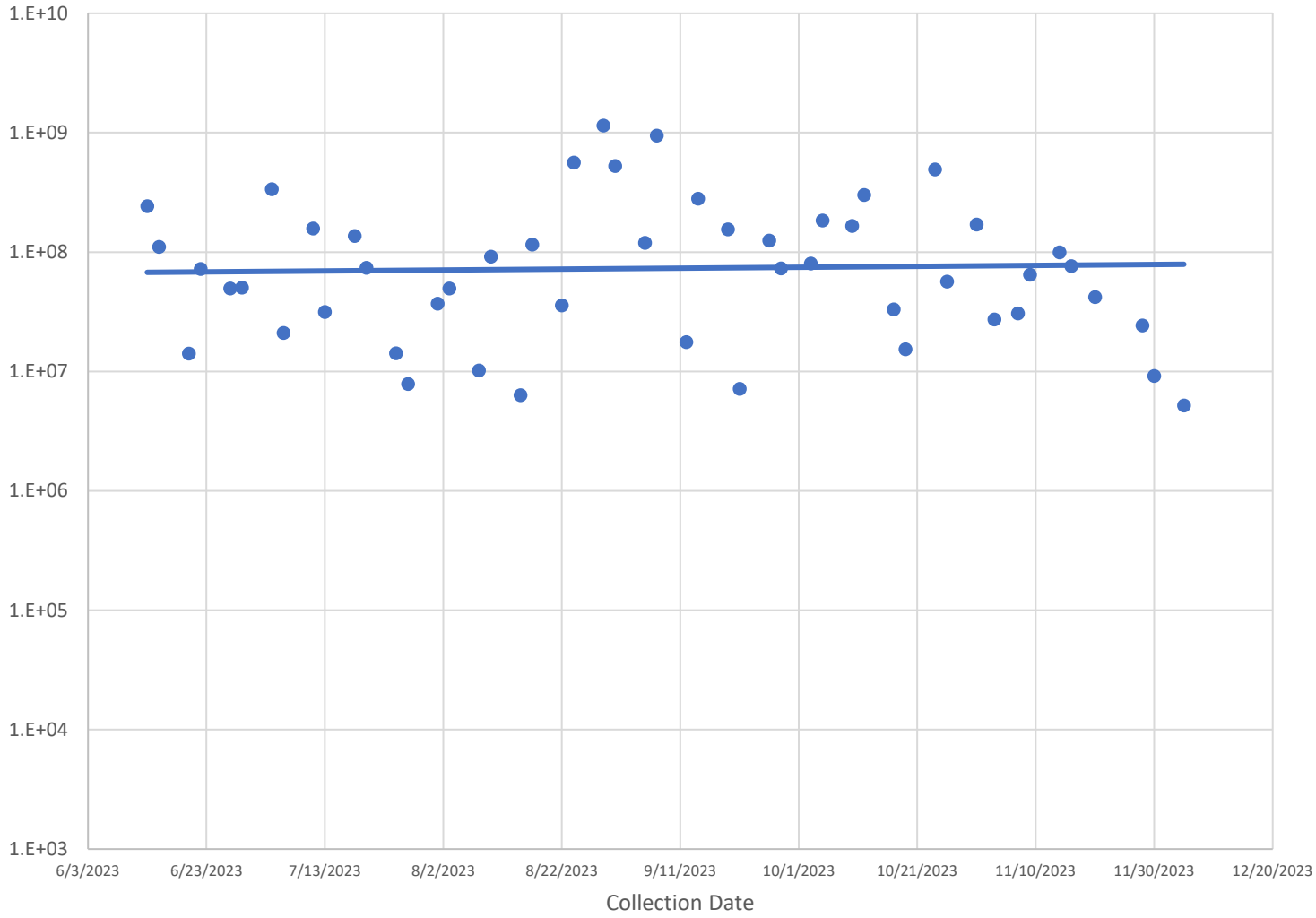
Linear Trends for Level of **KPC** dPCR detection (June – December 2023)

Quantitative Level (copies / L raw wastewater)



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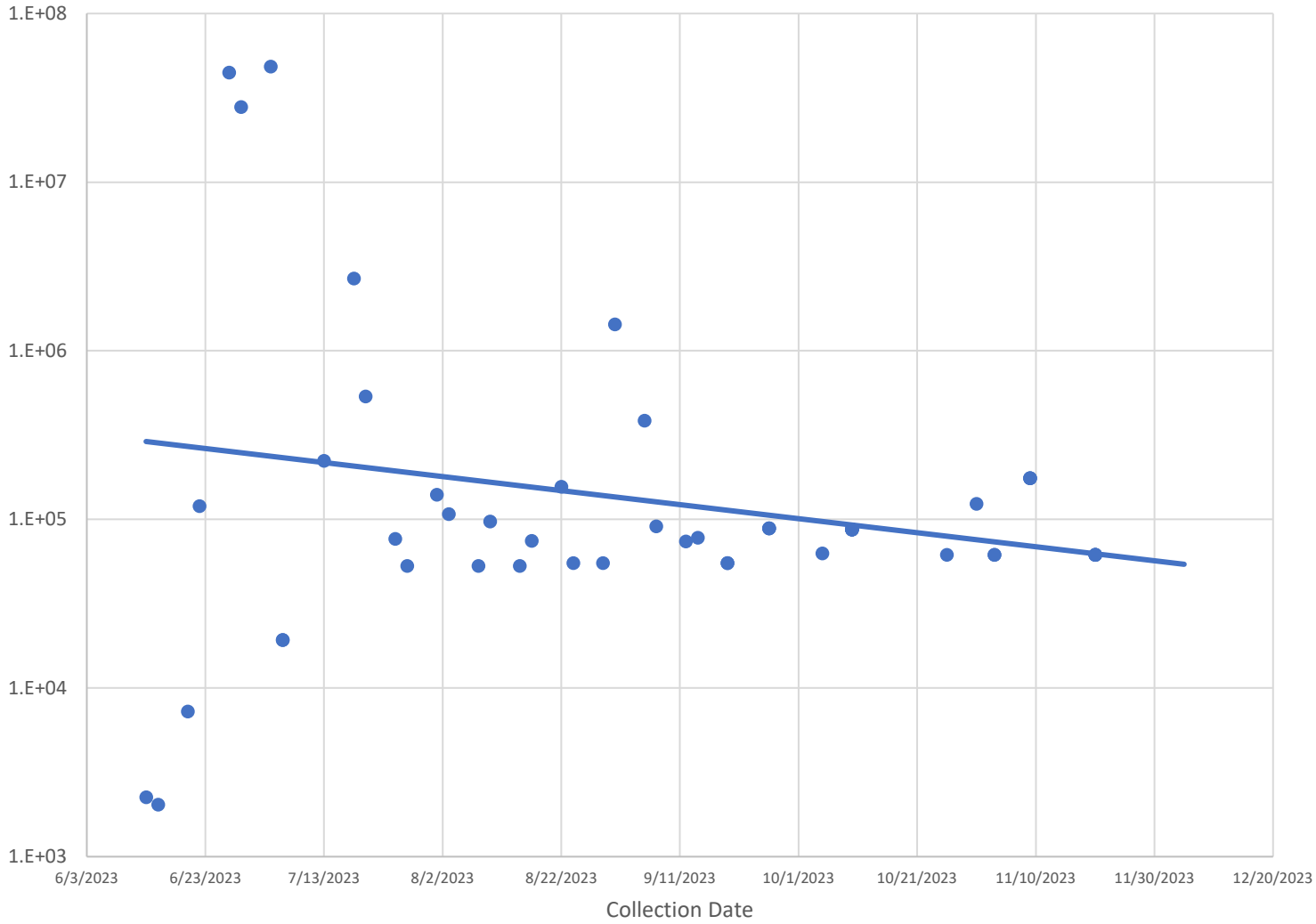
Composite/InnovaPrep

Linear Trends for Level of **NDM** dPCR detection (June – December 2023)

Quantitative Level (copies / L raw wastewater)



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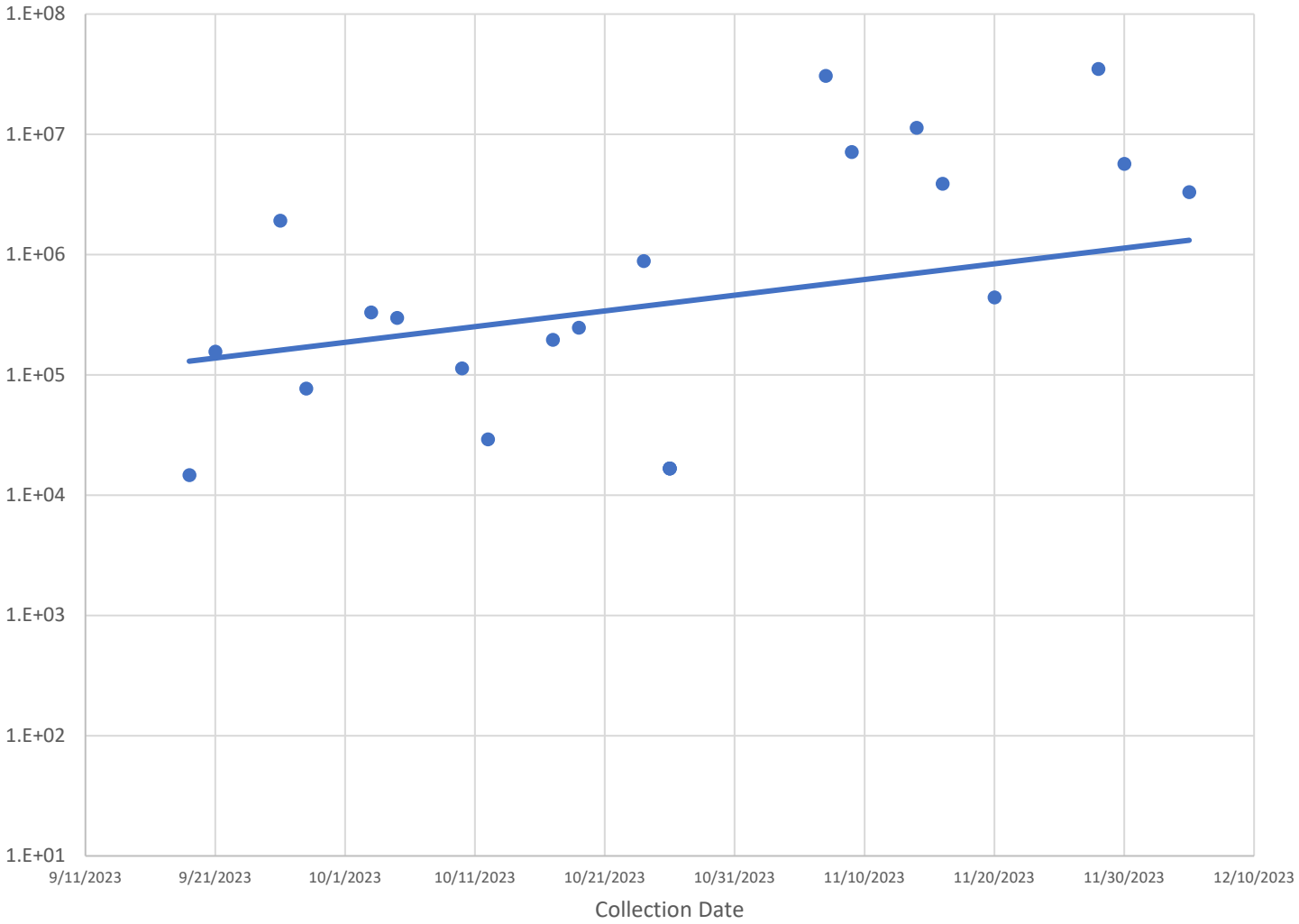
Composite/InnovaPrep

Linear Trends for Level of *Candida auris* dPCR detection (September – December 2023)

Quantitative Level (copies / L raw wastewater)



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Composite/Bead-beating

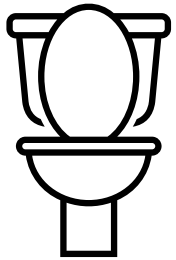
Culture of Wastewater Samples Reveals a Diverse Mix of Clinical and Non-Clinical Organisms Harboring Carbapenemase Genes

Table 1: Organisms and Gene Identified from Wastewater Collected from 10/17/2023 - 11/20/2023											
Organisms Isolated			Collection Days								
Genus species	Gene (if applicable)	Proportions	10/17/2023	10/19/2023	10/24/2023	10/26/2023	11/3/2023	11/7/2023	11/9/2023	11/14/2023	11/16/2023	11/20/2023
Acinetobacter baumannii	VIM	1/10 (10%)								X		
Aeromonas hydrophila	KPC	10/10 (10%)	X	X	X	X	X	X	X	X	X	X
Aeromonas media	KPC	3/10 (30%)				X		X			X	
Aeromonas punctata (caviae)	KPC	3/10 (30%)	X	X	X							
Aeromonas punctata (caviae)	VIM	2/10 (20%)						X	X			
Candida auris	N/A	9/10 (90%)		X	X	X	X	X	X	X	X	X
Citrobacter amalonaticus	KPC	5/10 (50%)	X	X	X						X	X
Citrobacter braakii (Citrobacter freundii complex)	KPC	10/10 (100%)	X	X	X	X	X	X	X	X	X	X
Citrobacter farmeri	KPC	5/10 (50%)		X	X	X			X			X
Citrobacter freundii (Citrobacter freundii complex)	KPC	7/10 (70%)	X	X	X	X	X		X		X	
Citrobacter freundii (Citrobacter freundii complex)	KPC +VIM	1/10 (10%)						X				
Enterobacter cloacae (Enterobacter cloacae complex)	KPC	9/10 (90%)	X	X	X	X	X	X	X		X	X
Enterobacter cloacae (Enterobacter cloacae complex)	NDM	3/10 (30%)								X	X	X
Enterobacter hormaechei (Enterobacter cloacae complex)	NDM	3/10 (30%)								X	X	X
Enterobacter kobei (Enterobacter cloacae complex)	KPC	5/10 (50%)	X	X	X		X				X	
Escherichia coli	KPC	1/10 (10%)					X					
Klebsiella oxytoca	KPC	1/10 (10%)									X	
Klebsiella pneumoniae	KPC	5/10 (50%)	X	X	X		X				X	
Pseudomonas putida	VIM	9/10 (90%)	X		X	X	X	X	X	X	X	X
Pseudomonas putida	KPC	1/10 (10%)					X					

No growth of organism
Organism identified in 1 triplicate
Organism identified in 2 triplicates
Organism identified in all 3 triplicates

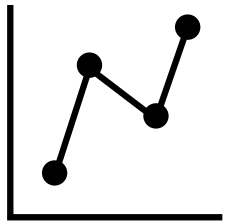
Unpublished data. Please do not share or distribute.

Conclusions



- Longitudinal wastewater sampling for multidrug-resistant organisms (MDROs) is possible in healthcare facilities with sewer access

- Detecting the presence or emergence of target MDROs (e.g., *C. auris*) appears to be feasible at a facility level



- Background MDROs in wastewater may complicate the longitudinal correlation of wastewater with patient MDRO burden in healthcare facilities. This is under active investigation.

Next Steps

- Wastewater surveillance continues at 3 LTACH facilities
  - Twice-a-month wastewater surveillance
  - Quarterly patient point prevalence surveys
- Timeline: 2-3 years
- If successful, wastewater surveillance may augment traditional MDRO surveillance across large numbers of facilities

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