Boosting vaccination uptake using wastewater surveillance: a comparison-control trial

Utilizing wastewater surveillance data in a communications campaign as a driver behind COVID-19 vaccine uptake in New York State

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PROJECT SUMMARY

Goal	To determine the effect of a communications campaign sharing wastewater surveillance data to influence vaccine uptake in a metropolitan and non-metropolitan environment.
Intervention site	Onondaga and Cayuga counties in New York State
Populations	Individuals of all ages within the selected counties, located in metropolitan and non-metropolitan environments.
Evaluation study design	Comparison-control trial
Primary outcome measures	Proportion of vaccine-eligible individuals in the county that received the COVID-19 vaccine stratified by type of vaccine dosage and age group
Data collection and sampling method	Vaccination data will be aggregated to the county by the State Department of Health and shared with the research team. Wastewater data will be pulled from the wastewater surveillance network.
Statistical and analytic plan	A difference in differences analysis will be used to estimate the effect of the intervention on both the outcomes between intervention and comparison groups following the intervention, while adjusting for potential confounding factors.

RATIONALE AND BACKGROUND

Vaccinations are among the most successful and critical public health interventions. The expanded program for immunizations is responsible for preventing an estimated 4-5 million deaths globally, and capable of preventing an additional 1.5 million deaths with universal global coverage.[1,2] Despite the enormous protection that vaccines provide to public health, delays and refusals of vaccines (vaccine hesitancy) are on the rise.[3,4] Vaccine hesitancy leads to lower community-level vaccination rates which threaten resurgences of vaccine-preventable diseases such as polio or measles and increase the severity of seasonal infectious diseases such as influenza.[5,6] The drivers of vaccine hesitancy are complex, and can vary heavily between different demographic groups. Reasons for vaccine hesitancy tend to fit into three categories: 1) a lack of confidence in effectiveness, safety, system, or policy makers; 2) a perceived lower risk of acquiring a vaccine preventable disease; and 3) a lack of availability, accessibility, and convenience in obtaining a vaccine.[7,8]

Vaccines are now (as of 2023) the primary prevention intervention for the COVID-19 pandemic in the United States. As of September 2022, 83.4% of New Yorkers statewide have received at least one vaccination dose for COVID-19, and 75.4% have received a completed vaccine series (completed COVID-19 vaccine series and booster).[9] These percentages vary based on demographics such as race, ethnicity, age, and gender.[10] Rural and urban communities also vary greatly when it comes to COVID-19 vaccination coverage, with rural counties having lower vaccination rates than urban counties across the United States.[11] This disparity is present in New York counties as well, with rural counties having lower COVID-19 vaccination uptake (first dose, boosters, completed series) than urban counties.[9] There are various factors that could contribute to the vaccination coverage disparities between urban and rural counties. Accessibility to healthcare services continues to be a challenge in rural regions, such as a lack of healthcare providers and minimal information on how and where to seek out services.[12,13]

Given that low vaccination rates present both an individual and community risk, it is critical that public health departments take measures to increase vaccination uptake across New York State. Vaccination communication and education have the potential to change how individuals feel about vaccinations, clarify common and widespread misconceptions, and address vaccine hesitancy in the process. [8,12] The success of public health campaigns can vary depending on interactions between the message, material, and target communities of the campaign. [17,18] Therefore, it's important to create an effective communication plan that not only spreads the message of pro-vaccinations, but also caters to the communities that are involved. Vaccine uptake interventions and campaigns often use the health belief model in identifying levers that might motivate individuals to get vaccinated. We hypothesize that infectious disease surveillance data, specifically wastewater surveillance data, can act on the perceived susceptibility of vaccine-hesitant individuals in the health belief model (Figure 1).

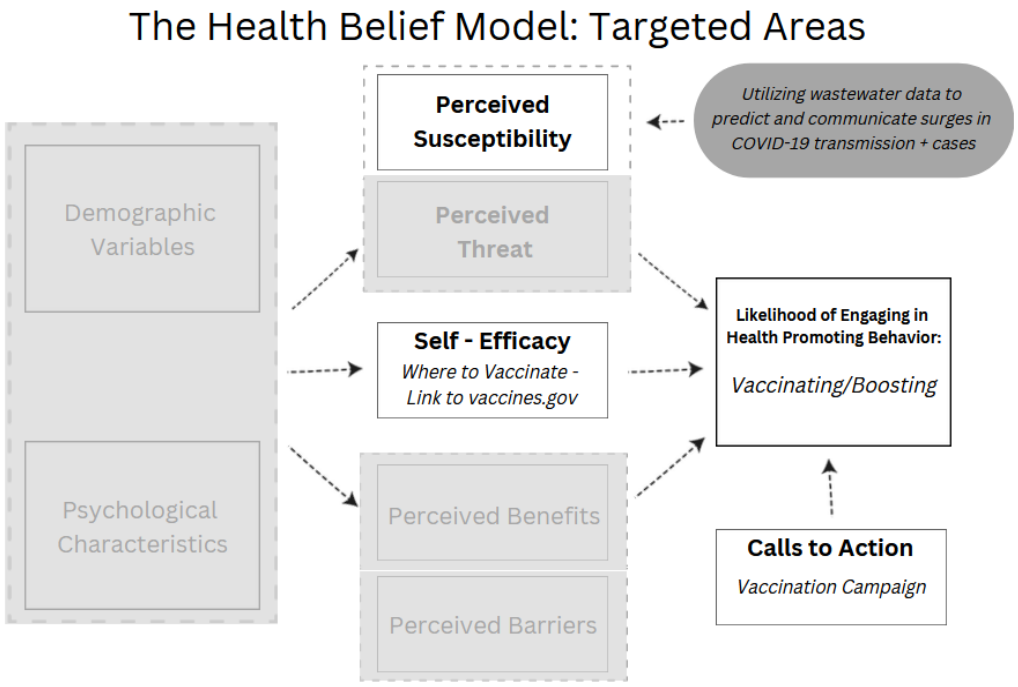

Figure 1: The health belief model as it relates to our hypothesis of using infectious disease surveillance to increase the perceived susceptibility of an individual to COVID-19.

Wastewater surveillance of SARS-CoV-2 has been shown to be a leading indicator of pending surges. Our work in New York State shows that the variability in wastewater data precedes surges in COVID-19 cases by about four weeks (Moran et al. in preparation). This study will examine whether a communications campaign based upon SARS-CoV-2 wastewater surveillance data with a 4-week lead time to surges can increase COVID-19 vaccine uptake.

Objectives

The goal of this trial is to test the effect of a communications campaign based upon wastewater surveillance data on COVID-19 vaccine uptake.

This protocol presents a plan for conducting a strategic communications campaign to identify the impact of sharing public health messaging based upon wastewater surveillance data on COVID-19 vaccination uptake. The specific objectives of this project are to:

1. Assess the impact of a communications campaign on the outcomes of COVID-19 vaccine uptake, including initial dose, complete series, booster dose, and bivalent booster dose by age group, following implementation of the communications campaign in selected metropolitan and non-metropolitan counties.
2. Strengthen the capacity of the New York State Department of Health and local health departments in determining how to apply their resources to disseminate wastewater surveillance data effectively with the general population.

INTERVENTION COUNTIES

The comparison control trial to assess a communications campaign using wastewater surveillance data will be conducted in Onondaga County (metropolitan) and neighboring Cayuga County (non-metropolitan) in New York State. Monroe and Seneca Counties will serve as a comparison to Onondaga and Cayuga Counties, respectively. These counties were selected based on similarities across population density, demographics (age, sex, race, ethnicity), wastewater surveillance population coverage, and vaccination rates.

INTERVENTION

In intervention communities we will deploy a COVID-19 vaccine communications campaign based upon the increasing variability in the amounts of SARS-CoV-2 RNA found in wastewater. (Increasing variability in the amounts of SARS-CoV-2 RNA in wastewater acts as a 4-week leading indicator, Moran et al. in preparation). Through the New York State Wastewater Surveillance Network, wastewater samples are analyzed to determine whether COVID-19 trends are increasing or decreasing in the community. This information is then shared with county health officials to better improve understanding of the underlying COVID-19 transmission risk.

Social media will be used to disseminate wastewater surveillance data and vaccination information to residents in Onondaga and Cayuga Counties. Social media platforms will not only allow for quick and cost-effective exposure, but also will allow for participation and interaction with participants. In addition, local health departments will be engaged to enhance their press releases and public health advisories to their communities.

EVALUATION

Study Design

We will use a difference-in-differences (DiD) method to assess the impact of the communications campaign on vaccine uptake. The DiD method observes the outcomes between a control and intervention group over pre- and post-intervention time periods.

Selection of control and treatment counties

The counties were selected based on the following criteria:

1. Population density: metropolitan vs. non-metropolitan area
2. Demographics (age, sex, race, ethnicity)
3. Wastewater surveillance coverage: population served and sampling frequency
4. COVID-19 vaccination rates

The U.S. Office of Management and Budget defines Monroe and Onondaga as metropolitan counties with an urban core of 50,000 or more people, while Seneca and

Cayuga are defined as non-metropolitan counties an urban core of 10,000-49,999 people or as being outside of metro areas. The metropolitan and non-metropolitan counties also shared similar demographics, wastewater surveillance coverage, COVID-19 vaccination rate.

COVID-19 vaccine coverage across the included counties is presented in Table 1. Table 1 also provides other county-level metrics that might be associated with vaccine uptake including the social vulnerability index, population density, number of corner-store pharmacies that serve as vaccine providers, and average income.

Table 1: County-level metrics with possible association with vaccine uptake.

		Metropolitan Counties		Non-Metropolitan Counties	
		Monroe	Onondaga	Seneca	Cayuga
COVID-19 vaccine coverage	Primary Series	74.0	74.0	53.9	60.8
	Up to Date	17.3	15.9	11.4	12.0
Social vulnerability index	Socioeconomic Status	0.4426	0.4918	0.4918	0.6066
	Household Characteristic	0.8525	0.7377	0.5738	0.3443
	Racial & Ethnic Minority Status	0.8361	0.7377	0.4754	0.4262
	Housing Type & Transportation	0.4754	0.7541	0.4098	0.7213
Pharmacies	per 10,000 People	1.87	2.21	1.46	2.08
Population	Number	743084	461591	34016	76958
	Density per sq mile	1125.1	590.2	105.81	110.47
Income	Median Household Income ($)	65,957	65,541	54,865	63,511

Vaccination data as of 11/18/22 from: https://coronavirus.health.ny.gov/vaccination-progress-date

People with primary series represents the total number of individuals who have completed the recommended initial series of a given COVID-19 vaccine product (e.g., 2 doses of the 2-dose Pfizer or Moderna vaccine; 1 dose of the single dose Johnson & Johnson vaccine).

People up to date represents the total number of individuals who have completed all COVID-19 vaccinations, including the bivalent booster, as appropriate per age and clinical recommendations (CDC At-A-Glance COVID-19 Vaccination Schedules).

Social Vulnerability Index from: https://www.atsdr.cdc.gov/placeandhealth/svi/interactive_map.html

Theme rankings: For each of the four themes, we summed the percentiles for the variables comprising each theme. We ordered the summed percentiles for each theme to determine theme-specific percentile rankings.

Population 2020 Estimates

Outcomes

The communications campaign will be evaluated using the change in vaccination status of residents of the treatment and control counties. Change in vaccination status will be

broken down by type of vaccine dose (e.g., initial series v. booster dose) and age because vaccine eligibility varies by age group (Table 2).[19]

Table 2: Proposed age and vaccine dose breakdown for vaccination outcomes.

Age group	Primary Series	Up to Date with bivalent booster
18+	85.2	12.3
12-17	73.1	4.2
5-11	39.6	1.9
Under 5	6.2	--

Notes: People with primary series represents the total number of individuals who have completed the recommended series of a given COVID-19 vaccine product (e.g., 2 doses of the 2-dose Pfizer or Moderna vaccine; 1 dose of the single dose Johnson & Johnson vaccine). People up to date represents the total number of individuals who have followed and completed the all COVID-19 vaccinations, including the bivalent booster, as appropriate per age and clinical recommendations (CDC At-A-Glance COVID-19 Vaccination Schedules). Vaccination progress tracking in New York was updated 11/30/22 to reflect the most current ACIP recommendations.
Data from https://coronavirus.health.ny.gov/demographic-vaccination-data

The change in vaccination coverage among residents of the counties in the study will be measured as the percent of the population that received a vaccine dose. Outcomes will also be compared between demographic groups including race and ethnicity because of differences in vaccination rates that have been already observed.[20]

Data to be collected

All data used in this study is routinely gathered and disseminated by the New York State Department of Health. No individual human data will be collected as part of the study.

Statistical analyses

We will use a difference-in-differences (DiD) method to evaluate the effectiveness of the communications campaign using the following equation:

$$DiD = E(Y_1^T - Y_0^T | T_1 = 1) - E(Y_1^C - Y_0^C | T_1 = 0)$$

The DiD is calculated from the differences between the treatment group ($T_1 = 1$) and the control group ($T_1 = 0$) from their initial condition at $t = 0$ or time zero. The change in each group is compared to determine if the intervention resulted in different outcome in the treatment group. In our study, the outcome is the percent of the county populations that received COVID-19 vaccines during the study period and whether the treatment counties had greater vaccination rates by the end of the study than the control counties. We will determine the statistical significance for DiD using a regression framework where the mean vaccination rate (Y) is predicted by whether the county received the treatment (the communications campaign) or not. The mean will be determined for the total vaccination rate as well as each of the age categories identified in Table 2.

TIMEFRAME

Table 3: Time frame for proposed activities

Project Years:	2022				2023			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Finalization of Communication Campaign Intervention								
Baseline Measures								
Communications Campaign								
Endline Measures								
Data Analysis								
Dissemination of results								

HUMAN SUBJECTS RESEARCH

Risks to subjects

No reasonably foreseeable risks, discomforts, hazards, or inconveniences are anticipated in relation to the communications campaign. All data used will be non-human data (aggregated County vaccine coverage for example).

Adequacy of protection against risks

We are requesting a waiver of informed consent for this project. Since we are using existing clinical testing and wastewater surveillance data, this study could not be practically carried out without a waiver of informed consent. A letter of cooperation signed by the local health departments overlooking the selected sewersheds/counties involved in this research will be provided.

Potential benefits of the proposed research to the subjects and others

Populations in the selected counties may expect increased vaccination rates, leading to herd immunity against SARS-CoV-2. Additionally, increased education and knowledge on the correlation between communications and vaccination rates will be made available.

Data and safety monitoring plan

We are continuing to collect wastewater surveillance data from the selected sewersheds for analysis and updating the New York State Wastewater Surveillance Network platform. At no point will any individual within the scope of surveillance be identified or exposed to any potential harm. Data monitoring to evaluate risks or harm to participants

will not be needed for this project. All data used in this study are de-identified and aggregated to county level.

Inclusion of women and minorities

We anticipate that half of the research subjects will be women, given the demographic composition of the population. Our study will be conducted in two non-metropolitan counties (Seneca and Cayuga) and two metropolitan counties (Onondaga and Monroe), where the racial and ethnic profile of the communities is homogenous. We do not expect to find significant race/ethnicity differences in the intervention effect.

Inclusion of children

Children are not a major focus of this research, but we do expect children between the ages of 1 month and 5 years of age to fall within the scope of the areas being considered for this study.

Trial Registration

To ensure external review of the protocol and to allow easy access for entry into subsequent systematic reviews, this trial will be registered with ClinicalTrials.gov prior to distribution of any communications materials. This is in accordance with the WHO statement that "The registration of all interventional trials is a scientific, ethical and moral responsibility" (http://www.who.int/ictrp/en/).

Protocol Accessibility

The complete protocol will be submitted to a peer-reviewed journal ahead of intervention delivery in the study site. This will prevent the likelihood of undeclared post-hoc changes to the protocol following IRB submission and of selective outcome reporting when the trial results are published. Additionally, this will provide peers and relevant partners working in the arena of wastewater surveillance and public health communications, advanced warning of a trial being planned for and provide opportunity not to duplicate similar intervention studies where the outcomes of this trial may hold external validity for their given wastewater-based epidemiology setting.

Funding Stream

The evaluation will be funded through the CDC Epidemiology and Laboratory Capacity program via funding awarded to NYSDOH. The funders will have a significant role in the study design. However, the funders will have no role in the data collection and analysis, decision to publish or preparation of the manuscript for protocol publication and trial outcome research article.

Conflict of Interest Statement

The Principal and Co-investigators along with other personnel involved with the implementation of this trial are not affiliated or employed by the funding organization. Additionally, none of the associated individuals are employed, affiliated or hold stocks or shares in the organizations, that through a competitive bidding tender process, will provide wastewater analysis, or vaccination data related to the primary outcomes in the trial.

Ethical approval

The trial will be submitted for ethical approval to the IRB at Syracuse University (USA) and the New York State Department of Health.

APPENDICES

Appendix 1 – Letter of Cooperation from New York State Department of Health

Appendix 2 – Letters of Cooperation from Local Health Departments

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