

THE CHELSEA PROJECT



How an adaptive, multidisciplinary approach brought COVID-19 numbers from among the nation's highest to among the nation's lowest in Chelsea, MA.

**CENTER FOR
COMPLEX INTERVENTIONS**

SAMANTHA BATES
KARTHIK DINAKAR



Abstract

The small city of Chelsea, Massachusetts had one of the highest COVID-19 transmission rates in New England in the summer of 2020. Many factors contributed to the spread of COVID-19 in Chelsea including overcrowded living conditions, a high proportion of residents working in essential jobs, and misinformation about COVID-19 and testing.

The Center of Complex Interventions (CCI), a nonprofit organization that specializes in scientific research for public health, initially started The Chelsea Project to address testing hesitancy in Chelsea. The Chelsea Project is now a collaborative effort that includes government entities in Chelsea, local nonprofits, and startups that have partnered to deploy three different interventions: city-wide wastewater analysis, targeted PCR testing, and a community-led communications strategy. The unique combination of these interventions helped increase both testing and vaccination rates in Chelsea. As of November 2021, Chelsea has one of the highest vaccination rates among cities with comparable demographics in the U.S.

Key learnings from The Chelsea Project include

- **Health equity is an attainable goal.** The Chelsea Project is an example of health equity in action. Improving quality of care and access to healthcare in vulnerable communities is extremely challenging due to language barriers, lack of trust and lack of resources. However, taking the time to understand these specific barriers in Chelsea and how trust networks in the community operate enabled The Chelsea Project to implement interventions that actually addressed these barriers and improved access to health resources.
- **Understanding the reality on the ground is essential for effective intervention and adoption.** The Chelsea Project team carefully considered how Chelsea's unique challenges would impact adoption of potential interventions.
- **The ultimate impact should be long-term change.** In systems with many moving parts and different actors, connecting existing entities in new ways is more likely to result in long-term change. The new partnerships and funding opportunities enabled by The Chelsea Project will ensure that this public health work will continue even if CCI and The Chelsea Project no longer operate in Chelsea.
- **An iterative approach will produce better outcomes.** The Chelsea Project went through many cycles of research, development of interventions, implementation, and synthesis. Taking the time to synthesize the outcome of each intervention we implemented helped the team reevaluate the problem and develop more effective interventions. This iterative approach resulted in three different focus areas—wastewater, testing, and communication—that, when combined, were extremely effective at increasing testing and vaccination rates.
- **Flexible funding is necessary for an iterative approach.** Flexible funding allowed the Chelsea Project the time necessary to tailor interventions to current obstacles and enabled the team to adapt in real-time to unpredictable on-the-ground developments. This iterative approach would not have been possible without flexible funding.

Despite higher vaccination rates and a decrease in COVID-19 infections, our work is not done. The next phase of The Chelsea Project focuses on providing education and tools that will empower Chelsea residents and city policy makers to prevent future outbreaks of COVID-19 and address other health issues in the city.

The Pandemic in Chelsea, MA

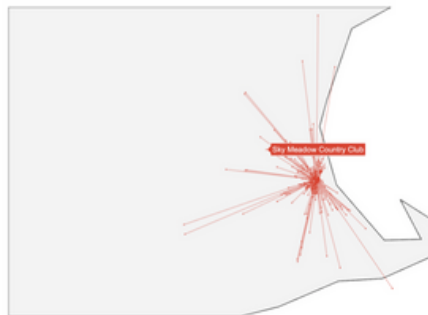
In April 2020, all eyes in New England were on the city of Chelsea, Massachusetts. Media sources called it “the epicenter of coronavirus” as the number of positive cases, hospitalizations, and deaths continued to increase each week despite social distancing measures and shelter in place orders. Although a small city (2.21 square miles), the rate of positive cases in Chelsea was six times the average in Massachusetts and comparable to much larger cities like New York City [1].

A variety of factors fueled Chelsea’s high transmission rate

- Chelsea has a severe overcrowding problem, which greatly contributed to the rapid spread of the virus because residents could not social distance easily. U.S. census data reports that the city is home to roughly 40,700 residents [2]; however, according to several city officials, Chelsea’s population in reality is closer to 55,000 people [3]. 55,000 people in a 2.21 square mile city equals an urban population density of 24,886.8 which would place Chelsea as number seven on the list of most populated cities in the U.S., just one rank below New York City [4].
- The majority of employed Chelsea residents are essential workers, so a significant portion of the population continued to work outside their homes during the pandemic. Furthermore, many of these essential workers travel to jobs located outside of Chelsea, increasing their exposure risk [5].

Home to work/visits for the week of June 14, 2021

Figure 1. Anonymized mobility data shows that Chelsea residents commute throughout eastern Massachusetts for work.



- Most Chelsea residents use public transportation to commute to work, which again made social distancing difficult and introduced more potential vectors of the disease [6].
- The city’s location contributed to residents’ risk. Chelsea’s proximity to the Tobin bridge and Logan Airport exposes residents to high amounts of air pollution [7]. As we learned early on in the pandemic, long term exposure to air pollution correlates with more severe outcomes in COVID-19 patients [8].

- Finally, we learned through surveys that Chelsea residents were not well informed about COVID-19. Language barriers only exacerbated this issue as Chelsea has a primarily Spanish-speaking population. Critically, we found that the guidance residents received from the Centers for Disease Control and Prevention (CDC) and national media sources was not actionable in the context of their day-to-day lives. How could they social distance when they had no choice but to take public transportation to work? How could they protect the more vulnerable members of their household when there was not enough room to isolate? [9]

Chelsea's unique combination of characteristics made its residents particularly vulnerable to the coronavirus. However, all of these factors contribute to other public health issues as well. Just as COVID-19 spread more quickly in Chelsea compared to other cities of its size, influenza and other communicable diseases likely spread at a similarly elevated rate. The COVID-19 pandemic highlighted and exploited existing weaknesses in our entire public health system, not just in Chelsea. Chelsea is far from the only city in the United States that suffers from overcrowding and air pollution.

The Center of Complex Interventions (CCI) [10], a Boston-based nonprofit, started working with the city of Chelsea in the summer of 2020 to improve COVID-19 testing and, later, vaccination rates in the city. CCI combines high-level research in the sciences and social sciences with on-the-ground action in order to address society's most multifaceted problems. This report tells the story of CCI's Chelsea Project: what the project has accomplished so far and what lessons we can take from this work and apply to other complex problems.

Public Health is a Complex System

As documented in a 2019 report prepared by the Massachusetts Special Commission on Local and Regional Public Health, "no other government agencies are as far-reaching—and invisible — as local public health departments." [11] In 2021, public health is no longer "invisible." The COVID-19 pandemic has revealed that our lower prioritization of public health in the past was extremely shortsighted. While containing the spread of a new, highly contagious virus would be challenging even in the best of circumstances, the U.S. pandemic experience has been fraught with the spread of misinformation through social media, a slow and inadequate response from the federal government to contain the spread of COVID-19 earlier, the politicization of health practices such as mask wearing that protect against transmission, and an exposure of glaring weaknesses in our national public health system caused by budget cuts [12]. COVID-19 has provided a catalyst to invest resources in our public health infrastructure, hopefully preventing us from repeating the same mistakes in future crises. In order to do so effectively, it is imperative to understand the many factors that make public health in the U.S. challenging.

At a high level, public health straddles multiple disciplines. The core of public health stems from the medical and scientific fields; however, public health also aims to implement programs at scale. For that reason, public health initiatives must take into consideration societal and cultural factors. The way medical guidance is communicated must adapt depending on the intended audience and the resources available to that group. Because public health is concerned with community-level health and not just individual health, it attempts to set cultural norms with the goal of changing the behavior of an entire society. This is an extremely challenging task, particularly in the United States where individual freedom is so highly valued [13]. Public health is also both proactive and reactive. Enforcing guidelines around food safety and promoting flu vaccinations are proactive measures that will help prevent illness, but as we've seen during the COVID-19 pandemic, public health departments must also be able to adjust their approaches as they learn more about new diseases. In addition to these broader challenges, public health departments at the local level face significant obstacles specific to the populations they serve.

Massachusetts Local Public Health

There are 351 cities and towns in Massachusetts, each with its own Board of Health and public health department. These small, independent bodies are responsible for providing public health services that address an ever-growing list of health concerns, including “communicable diseases, food safety, housing, sewage, well water, [...] environmental hazards [...], planning for natural and manmade disasters, preventing new insect and tick-borne diseases, reducing substance addiction, reducing the prevalence of chronic diseases, and improving mental health [14]. Unlike cities in other states that combine public health departments to pool resources, each Massachusetts town is responsible for supporting their own public health department financially with very little assistance from the state [15]. According to the 2019 report, few local public health systems in Massachusetts are able to keep up with current health demands or meet national standards set by the CDC due to budget constraints and lack of clarity around expectations and priorities [16].

Strengthening local public health systems will significantly reduce health care costs in Massachusetts and improve the lives of individual residents as well as the overall health of communities [17]. CCI's Chelsea Project started as an effort to aid the city's COVID-19 response strategy, but the programs implemented through this work have the potential to improve Chelsea's overall public health system as well. If made sustainable, this new infrastructure would provide support in the form of on-the-ground data collection about public attitudes regarding health issues, community level data that reports the overall health of the population, and multiple communication channels to circulate actionable health guidance among different groups in the community.

The Chelsea Project

CCI's Chelsea Project provided the mechanism to unite many different entities in Chelsea in a coordinated COVID-19 response. The project currently involves a long list of partners including the City of Chelsea, Chelsea's Department of Health, Chelsea's Board of Health, the Chelsea Police Department and The Chelsea Hub, Chelsea's Department of Public Works, medical researchers at MIT and Mass General Hospital, Dewberry (an engineering company), BioBot (a wastewater analysis company), La Colaborativa (a local nonprofit), and the Metropolitan Area Planning Council (MAPC) [18]. All of these partners are involved in different aspects of the project and together they have successfully increased both COVID-19 testing and vaccination rates in the city.

To date, The Chelsea Project has implemented three different interventions: city-wide wastewater analysis, targeted PCR testing, and a community-led communications strategy. The project's initial goal was to increase the number of residents getting tested and reduce the positive test rate to less than 1%. As we gained a better understanding of Chelsea's specific public health challenges, the project's focus shifted to address cultural and infrastructure changes to support broader, long-term public health initiatives.

Intervention #1: Wastewater Analysis

When we started The Chelsea Project in the summer of 2020, free COVID-19 testing in Chelsea was available through Stop the Spread sites [19], but we observed that the majority of residents were not getting tested despite the availability of free testing. Chelsea Project team member Cristina Alonso, a PhD at the Harvard School of Public Health and the Director of Health Equity at La Colaborativa, conducted several surveys of Chelsea's most vulnerable community members to understand their beliefs about COVID-19 and how the pandemic had impacted their daily lives. The surveys conducted over the summer of 2020 demonstrated that misinformation about COVID-19 and the testing procedure was a major reason why residents did not test. An alarming 53% of participants believed in some form of conspiracy theory regarding COVID-19 including that it did not exist, was designed by pharmaceutical companies to make money, or was created by politicians to influence the 2020 election. At the time of these surveys, a vaccine was still months away; however, respondents already had concerns that the vaccine would be used by pharmaceutical companies to implant a chip to extract our personal information. The surveys also revealed that of those who had never been tested for COVID-19, the majority believed they only needed to test if they experienced symptoms. In this group, 9% cited fear of pain and being afraid to go to a testing site as the reason they did not test, and 1% reported they feared they would lose their job if they were tested and the test result was positive [20].

Testing hesitancy made it challenging for the city to make policy decisions because it was difficult to know how many residents were infected and how quickly the virus was being transmitted. Although the city estimated that far more residents were infected than the number reflected in the testing results, the city was frequently put in a reactive position. By the time residents decided to get a test because they were experiencing symptoms, they had already spread the virus to others.

To address testing hesitancy in Chelsea, we implemented wastewater analysis. In the course of our research, we learned that COVID-19 patients started to shed the virus in their stool before they developed symptoms [21]. In the fall of 2020, universities started to test sewage of student dorms on their campuses. If COVID-19 was present in any of the collected samples, universities next tested students in the affected dorms to identify infected individuals before they transmitted the virus to others [22]. CCI hypothesized that we could use wastewater sampling at a much larger scale in Chelsea to determine which areas of the city were likely to experience an increase in positive cases. In collaboration with a sewage engineering company, Dewberry, Chelsea's Department of Public Works, and the Metropolitan Area Planning Council (MAPC), we divided the most heavily populated part of the city into four areas and installed an automatic wastewater sampler in each.

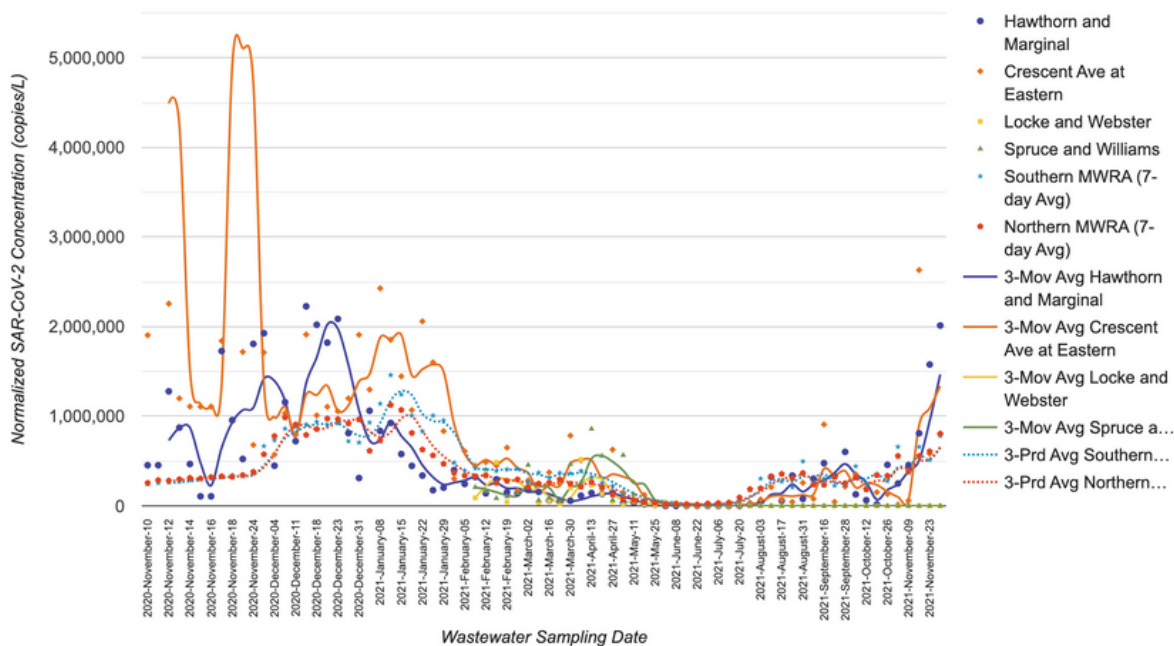


Figure 2. Wastewater readings in Chelsea and MWRA's Deer Island Monitoring: This chart shows normalized SARS-CoV-2 virus concentration and their 3-day moving averages for each sewage watershed area in Chelsea. The chart also includes the normalized virus concentration for Northern and Southern Massachusetts [23].

Twice a week, Chelsea's Department of Public Works collected samples in each of the four areas and sent them to a wastewater testing company, BioBot, for analysis. BioBot's weekly reports showed if COVID-19 was detected in any of the samples and the amount of COVID-19 detected. These reports also compared the results in Chelsea to wastewater results for the state of Massachusetts. From November 2020 through February 2021, Chelsea's wastewater consistently showed higher levels of COVID-19 than the entire state. Critically, wastewater provided a way to collect COVID-19 infection data without testing residents individually. Since wastewater data is anonymous and everyone contributes, it did not trigger the same fears and concerns in the community as individual testing. At the same time, it provided a high-level view of the prevalence of COVID-19 in the city, which better informed the city's pandemic policy decisions. Lastly, wastewater analysis presented an opportunity to develop more targeted testing strategies.

Intervention #2: Targeted Testing

Based on our research of wastewater analysis and what we had observed so far in Chelsea, we hypothesized that wastewater was predictive of COVID-19 cases. We connected with a mobile testing team from Mass General Hospital (MGH) to deploy a targeted testing strategy in Chelsea. Rather than simply parking the testing van in high-traffic areas in the city, we used wastewater reports to determine where in Chelsea the van should go each week. Starting in January 2021, the Chelsea Project team shared weekly BioBot reports with the MGH testing team in order to prioritize areas that showed high concentrations of the virus in wastewater.

Through this partnership we confirmed that wastewater analysis is predictive of COVID-19 cases. In areas where we observed high levels of COVID-19 in wastewater, MGH recorded an increase in positive COVID-19 cases roughly 1.5-2 weeks later [24].

Intervention #3: Community-led Communications

Although wastewater enabled more targeted testing to prioritize residents who were most likely to be infected, we still needed to convince more individuals to test. The surveys conducted by Cristina Alonso in 2020 showed that residents did not have accurate information about COVID-19, how it was transmitted, and the importance of getting tested. Although residents received guidance from the city government, the state, and the CDC, low testing rates demonstrated that residents were not adopting suggested health practices.

We hypothesized that several factors contributed to the spread of misinformation despite efforts to improve communication about COVID-19:

1. Low level of education: From the surveys conducted, almost half (47%) of the respondents did not complete high school and 4% of respondents had no formal education. 36% had a high school diploma and 13% had a degree above the high school level. This low level of education likely reduced access to information about COVID-19 [25].

2. Most residents in Chelsea identify as Hispanic/Latino and therefore Spanish is a dominant language in the city. 17% of survey respondents did not speak any English and 28% said they have a very basic understanding of English. Communications about COVID-19 and health guidelines needed to be circulated in both Spanish and English. Given the language barrier and education level, we hypothesized that communications in an oral format would be most effective [26].

3. The surveys also revealed that during this stressful time, residents had turned to community organizations and religious communities for support. When asked if anything good had come from the pandemic, 15% stated that it had brought them closer to God and nearly 10% reported that it had deepened their appreciation of their community in Chelsea. We observed that communication about the pandemic continued to originate from government bodies; however, the survey results suggested that tapping into Chelsea's community networks might be a more effective way to circulate health information [27].

Based on these insights, the Chelsea Project team realized that to increase individual testing, we needed to change the community's perspective on COVID-19 and testing. The survey responses clearly showed that Chelsea has a tight-knit community. We learned that residents, especially those in the large Hispanic community in Chelsea, connected with one another through local nonprofits and churches. We hypothesized that residents were more likely to rely on information if it was communicated to them through known, trusted members of the community.

The Promotores Program

The Chelsea Project also drew inspiration from The Chelsea Hub, an initiative run by the Chelsea Police Department to identify at-risk individuals in the community and connect them to services before emergencies occur. Although led by the Chelsea Police Department, The Hub includes 25 different entities in Chelsea.

This group meets every week to evaluate new and ongoing cases as well as discuss what the next steps will be in each situation and which entity will take the lead [28]. Dan Cortez, a member of The Chelsea Project team, started The Hub in Chelsea and proposed to the team that a similar model could be used to mobilize individuals in the community to encourage others to get tested.

In collaboration with La Colaborativa, The Chelsea Project selected and funded ten “promotores de salud” to educate Chelsea residents about COVID-19 [29]. Cristina Alonso met with the promotores each week to review that week’s wastewater data and discuss the latest COVID-19 research. She coached the promotores on how to present scientific information to residents in either Spanish or English, in a succinct way that also made the information actionable. The group also discussed what questions residents were likely to ask and how to respond. Based on the wastewater results each week, the promotores also strategized where in the city they would go to speak with residents that week. They frequently traveled to the same location as the MGH testing van so that they could encourage residents to get tested right away [30]. In addition to stopping residents passing by on the street, the promotores went door-to-door, and used social media channels to encourage residents to get tested and once eligible, to sign up for vaccination appointments [31].



The Promotores traveled with the MGH testing van to talk to residents about COVID-19 and encourage them to get tested.

Removing Barriers to Vaccination

We started the promotores program in January 2021 and it proved to be an essential part of the city-wide effort to encourage residents to sign up for a COVID-19 vaccine once they became eligible. Just as with COVID-19 testing, the promotores communicated directly to residents the reasons they should sign up for a vaccine. Critically, our ability to arm the promotores with the most up-to-date research on COVID-19 vaccines through CCI's extensive academic and medical networks, meant that the promotores could immediately dispel misinformation about the risks of vaccines.

At the same time, the promotores also helped The Chelsea Project team understand why residents were reluctant to get vaccinated. In one instance, the promotores reported that women they spoke with told them that they hesitated to get the vaccine because they heard it could cause fertility issues for women. This led to a discussion among The Chelsea Project team about recent studies on the effects of the vaccine on women. We were ultimately able to provide, through the promotores, assurance that scientific studies showed that the vaccine would not cause any long-term reproductive harm in women [32]. This two-way communication channel brought the latest scientific data directly to residents so they could make informed decisions about their health while also enabling The Chelsea Project team to understand and formulate ways to address residents' concerns about COVID-19 and the vaccine.

The promotores program also played an essential role in removing logistical barriers to making vaccination appointments. When vaccines first became available, residents were required to sign up for appointments on the Massachusetts Vaccine appointment website [33] or by calling the East Boston Neighborhood Health Center. It quickly became clear that these approaches posed significant obstacles for Chelsea residents. Many residents were not able to navigate the vaccine website and the East Boston Center phone line had a four hour wait time. With help from La Colaborativa and the East Boston Health Center, Cristina Alonso and the promotores devised a process to make appointment sign up easier for residents. Promotores created a list of Chelsea residents who were eligible for the vaccine and were seeking an appointment. This list was then passed to an operator at the East Boston Health Center who called residents on the list and gave them appointment times. Ultimately, this list evolved into a centralized list that many Chelsea entities added to. Through this community-led appointment system, the promotores made an average of 1,000 vaccine appointments for residents per month during the spring of 2021 [34].

The Chelsea Project team also kept a close eye on vaccination rates for different age groups and different ethnicities in order to prioritize communications with groups that appeared to be hesitant to get vaccinated. According to data from Mass.gov, 95% of residents over the age of 30 have received at least one dose of the vaccine and over 90% of this group have also received the second dose. Although 90-95% of residents in the younger age groups (12-29) have received the first dose of the vaccine, a lower percentage (85.8% of 12-15 year olds, 87% of 16-19 year olds, and 77.6% of 20-29 year olds) have received a second dose [35]. When vaccines first became available for this younger age group, the promotores and La Colaborativa's Youth RIOT team organized COVID-19 health and vaccination fairs on May 21st, June 11th, and July 9th specifically to encourage vaccination among this younger cohort. At these events, there was music, food, and activities as well as educational materials about COVID-19 and a vaccination tent where attendees could get their shot. The subsequent vaccination fairs on June 11th and July 9th were scheduled to align with the timing of the second dose [36].

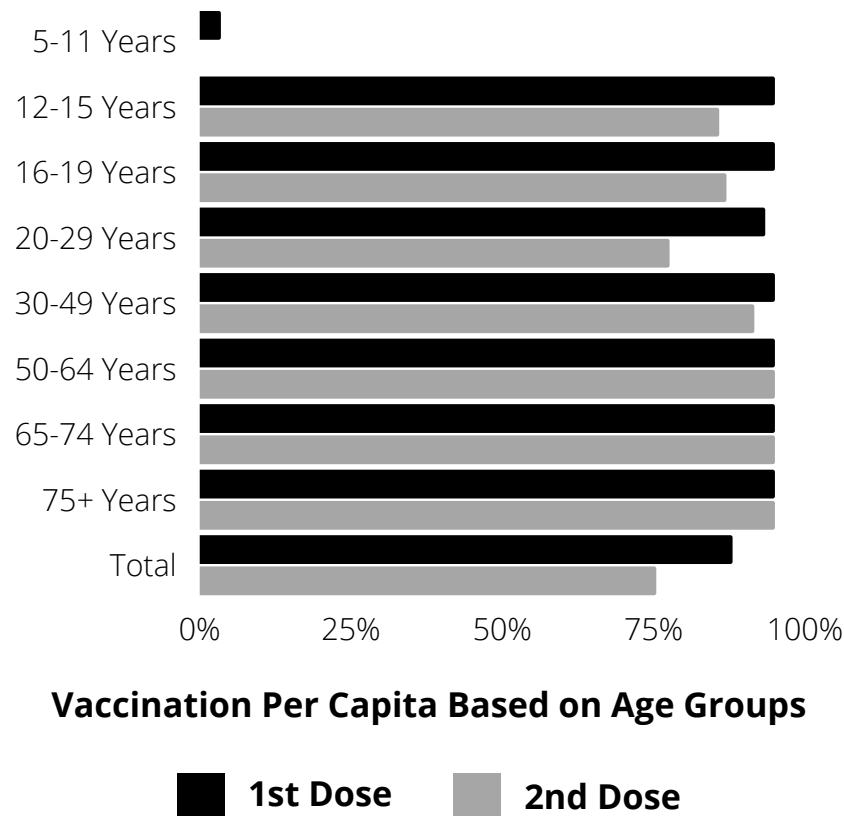


Figure 3. Chelsea vaccination data based on age group last updated on December 1, 2021 [37].

Broader Communication Efforts

In addition to the promotores program, The Chelsea Project also relied on community relationships to circulate important COVID-19 information at a larger scale. In late 2020, Cristina Alonso conducted a second survey to measure the impact of the second surge of COVID-19 cases in Chelsea and gauge the success of public health messaging efforts in the fall of 2020. Although the analysis showed a decrease in deaths and hospitalizations, Cristina Alonso observed that the majority of cases had shifted from retired residents to younger essential workers [38]. Unlike in the spring of 2020, a quarter of the cases in Chelsea from September to December 2020 were among children [39]. These results indicated to The Chelsea Project team that public health messaging must emphasize that although younger people are less likely to experience severe outcomes if they are infected, they are part of multigenerational families and must protect themselves in order to keep relatives healthy [40]. This continued trend of high transmission rate also highlighted the need for proactive communication about the COVID-19 vaccine to ensure that residents would not hesitate to get vaccinated once they became eligible [41].

CCI hired a local filming company to create several public health videos about the COVID-19 vaccine that featured respected members of the Chelsea community: a local priest, a local doctor, a Chelsea business owner, and a member of La Colaborativa's leadership team. These videos were recorded in Spanish and emphasized to viewers that vaccines would lower the risk for the entire community. The speakers asked viewers to "get their vaccine for Chelsea" because "we are all in this together." We released the videos at the beginning of February 2021 and circulated them on Facebook [42].

Both the promotores program and the public health videos utilized trusted relationships within the community to improve communication and education about COVID-19. In a city with such strong community networks, empowering the community to educate themselves and one another was the most effective way to increase testing and vaccination rates.

Table 1. Interventions and Learnings

Summary of Chelsea Project Interventions: overview of each intervention, collaborators, and learnings.

Intervention	Wastewater Analysis	Mobile Testing	Communications (community videos and promotores program)
Collaborators	BioBot, Chelsea Department of Works, MAPC, Dewberry	MGH, La Colaborativa, MAPC, The Hub/Chelsea Police Department	La Colaborativa, The Hub/Chelsea Police Department, MAPC
Timeframe	November 2020- present	January 2021- April 2021	January 2021- present
Learnings	<ol style="list-style-type: none"> 1. Chelsea had much higher rates of COVID-19 in wastewater than the state as a whole. 2. Wastewater included the majority of the population in Chelsea and provided the city with high level monitoring data on transmission. 3. Wastewater was predictive of spikes in positive cases. Two weeks after we observed an increase in COVID-19 concentrations in wastewater, we saw a rise in COVID-19 cases. 	<ol style="list-style-type: none"> 1. Based on COVID-19 concentrations in wastewater data, we could predict where in the city there would likely be positive cases. The MGH mobile testing van used this information to strategize which areas in the city they would target each week. 2. Residents still needed to be persuaded to test. Bringing the testing to them was not sufficient to increase testing. 	<ol style="list-style-type: none"> 1. We confirmed through the success of the communications strategy (promotores and videos) that residents would listen to their neighbors and friends about COVID-19. 2. The promotores program was an effective way to both provide the community with accurate scientific data that they could act on as well as learn from residents directly why there was fear and anxiety about testing and later vaccination. 3. The promotores broke down barriers to testing and vaccinations. They could immediately correct misinformation and they could circumvent logistical barriers to vaccination by making appointments for residents.

Results

At the beginning of The Chelsea Project, Chelsea had one of the highest COVID-19 infection rates in all of New England. In the fall of 2021, the Governor of Massachusetts pointed to Chelsea as a model of success because of its high vaccination rates [43].

Taking into account that Chelsea has a larger population than reported in the census, Chelsea city officials estimate the vaccination rate for eligible residents is somewhere between 80-90% [44], which is one of the highest vaccination rates in the country for cities with similar demographics [45].

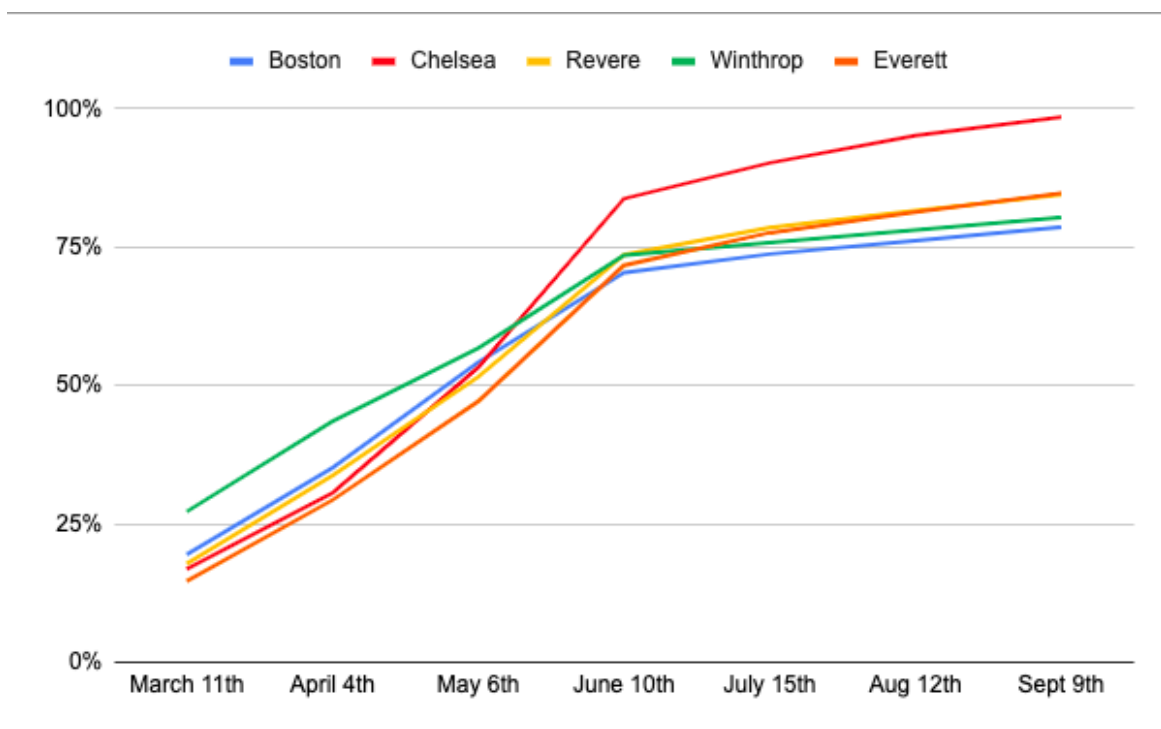


Figure 4. Vaccination rates for the first dose in Suffolk county from March 11th through September 9th clearly show that Chelsea's vaccination rate is much higher than in neighboring cities [46].

As vaccination rates continue to increase, we've observed a downward trend in test positivity rates and COVID-19 concentrations in wastewater. Once more Chelsea residents became eligible for the vaccine in April and May of 2021, the positive test rate experienced a significant decrease. From June through the end of July, the test positivity rate was below 1% [47]. Similarly, the wastewater data shows that COVID-19 concentrations in sewage have remained below 1,000,000 copies per milliliter since the spring. However, we've observed upticks in COVID-19 concentrations in wastewater samples in November 2021. As a result of this information and concern about increased transmission over the upcoming holidays, the city and Board of Health approved a mask mandate on December 1, 2021 [48].

Other forms of Impact

Perhaps most importantly, The Chelsea Project's work has created new partnerships that will contribute to a stronger public health system for the city in the long term. From the beginning of this project, The Chelsea Project has collaborated with existing entities in the city in order to ensure that the interventions we've deployed continue to inform and support public health initiatives in Chelsea beyond the COVID-19 pandemic.

Partnerships that have resulted from this project include:

- BioBot and the City of Chelsea: To start measuring COVID-19 concentrations in wastewater, The Chelsea Project purchased four automatic wastewater samplers for the city. We believed that the city could use wastewater sampling to collect additional, non-COVID-19 health data in the future. Now, BioBot is partnering with the city to launch a pilot program on wastewater monitoring of illicit substances. This project, which will support Chelsea's efforts to respond to drug addiction in the city, would not be possible without the wastewater sampling infrastructure provided by The Chelsea Project or the relationships built through this collaboration.
- Mass General Hospital and La Colaborativa: An essential part of the COVID-19 response was combining MGH's testing van efforts and the 1-on-1 conversations about COVID-19 between residents and the promotores. This relationship between MGH and La Colaborativa has developed into a new project to continue the promotores program along with other health equity initiatives.

- **Connecting Scientific Researchers and Chelsea's Board of Health:** By heavily involving Chelsea's Director of Public Health and Chelsea's Board of Health in The Chelsea Project, we've connected public health decision makers in Chelsea with researchers at MGH and MIT who can answer their questions about the latest scientific data regarding COVID-19. Due to the independent nature of public health departments in Massachusetts, Chelsea's Board of Health is responsible for making policy decisions, such as instituting a mask mandate, for the city. By providing the Board with these additional scientific advisors, the Board can make more informed decisions and feel confident that they have the most up-to-date information about COVID-19. For example, a recent conversation with a member of the Board of Health, Director of Public Health, and The Chelsea Project about rising levels of COVID-19 concentrations in wastewater led to the Board of Health's decision to approve a mask mandate in December 2021 [49].

CCI is excited to see these new partnerships form because it demonstrates that our collaborators have taken ownership of the interventions we've implemented and aim to develop new projects that will continue this work [50]. Early on in the project, The Chelsea Project team realized that wastewater testing and the promotores program could support broader public health efforts in addition to COVID-19 responses. By connecting the interventions we deployed through The Chelsea Project with other initiatives in the city we encouraged new projects and partnerships that will prevent Chelsea's public health system from regressing to its pre-pandemic state [51].

Next Steps for the Chelsea Project

Despite higher vaccination rates and a decrease in COVID-19 infections, our work is not done. The next phase of The Chelsea Project focuses on providing education and tools that will empower Chelsea residents and city policy makers to prevent future outbreaks of COVID-19 and to address other health issues in the city.

Rapid Testing

The data clearly show that individuals can still contract COVID-19 and transmit it to others even if they are fully vaccinated [52]. Although the risk of severe disease and transmission is significantly lower in vaccinated individuals, regular testing is key especially during the colder months when the holidays bring multi-generational families together and outdoor events are less feasible. As society gradually transitions to a "new normal," 15-minute, rapid antigen tests that patients can administer themselves will be the most effective way for individuals to know if they are infected [53]

Frequent rapid testing will be particularly important to prevent COVID-19 transmission in Chelsea moving forward because overcrowding is such a big issue for the city. The Chelsea Project has partnered with the Chelsea Housing Authority and an MIT virologist, Irene Bosch, to organize a rapid antigen testing study at three senior housing units that recently experienced a COVID-19 outbreak. This study will include 300-500 participants and will involve weekly testing. In addition to preventing infections, the study will also familiarize participants with the testing procedure so they can learn to perform the test themselves and teach them how frequent testing can serve as an additional layer of protection, along with masks and physical distancing, against COVID-19.

COVID-19 Policy Simulator

In an effort to capture learnings from Chelsea's pandemic response efforts CCI researcher, Dhaval Adjodah, has built an empirical Bayes agents-based policy simulator for the city [54]. This tool uses anonymized mobility data of Chelsea residents, COVID-19 testing and death data collected by the state to simulate COVID-19 transmission in Chelsea [55]. Chelsea city officials can use the tool to retrospectively understand the effects of different policy interventions on COVID-19 outcomes. For example, the policy simulator can show what would have happened if the city had delayed mask mandates in 2020 or how reducing overcrowded living conditions would have impacted the number of COVID-19 cases and deaths in 2020. By mapping out alternate scenarios, the policy simulator can be used as an educational tool for policy makers and to help the city advocate for resources that may prevent future public health crises [56].

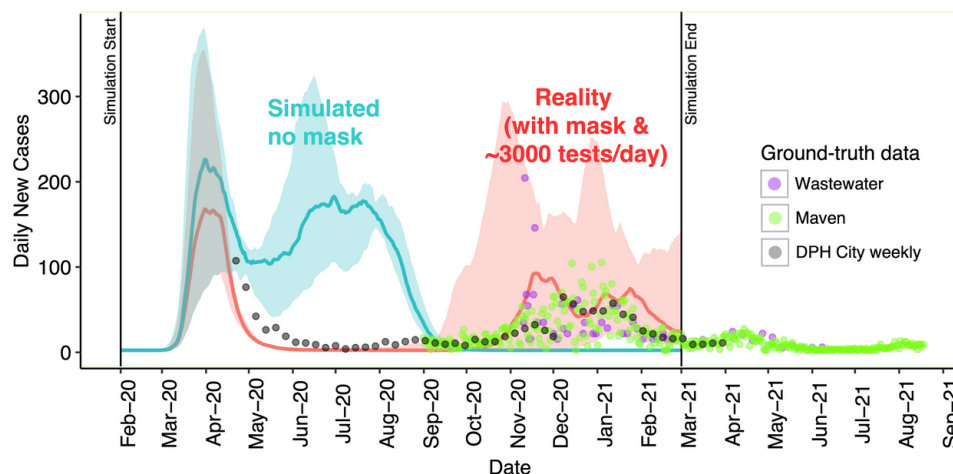


Figure 5. The Policy Simulator shows what the number of daily cases in Chelsea would have been without a mask mandate (blue line) in comparison to what occurred in reality (red line). Note that the simulation does not yet account for vaccinations or variants so the number of cases goes to zero in September 2020 as the model assumes all residents have been infected.

Chelsea Health Equity Forum

In July 2021, The Chelsea Project convened all of the collaborators on The Chelsea Project and leaders of other ongoing COVID-19 response efforts in Chelsea to share what they had worked on and what they had learned from this experience.

The meeting included researchers from MGH who had studied how the virus mutated to produce multiple variants, how it was transmitted, and the most effective treatments for severe COVID-19 cases; MGH testing teams that used wastewater analysis to determine where to deploy testing efforts; the city government that handled public health messaging and policy decisions for the city; and local nonprofits such as La Colaborativa, GreenRoots, and the Chelsea Black Community, that led COVID-19 safety efforts in their own communities. This gathering was the first time that we connected all of the actors—from COVID-19 research, to testing, to public health messaging, to COVID-19 education at the local level—contributing to Chelsea’s COVID-19 response efforts. The July meeting demonstrated to The Chelsea Project team that regular communication among these groups will be essential to coordinate a response to any public health crisis in the future. The team has developed a proposal to create the Chelsea Health Equity Forum that will regularly convene these same actors to discuss pressing public health concerns in Chelsea. Based on The Chelsea Hub model, Forum participants will prioritize concerns and assign action items to participants depending on the situation and expertise.

Key Learnings from The Chelsea Project

Although the Chelsea Project is an intervention focused on improving public health, there are many broader lessons we can take from this work and apply to other complex problems.

- **Understanding the reality on the ground is essential for effective intervention and adoption.** The Chelsea Project team carefully considered how Chelsea’s unique challenges would impact adoption of potential interventions. For example, we implemented wastewater testing because we learned that it was unrealistic to convince everyone in Chelsea to test more as there was too much misinformation about COVID-19 and testing at the beginning of the pandemic. Wastewater analysis made testing more efficient by helping us identify the people likely to be infected. Similarly, we devised a communications strategy that was inclusive of Chelsea’s large Spanish speaking community and utilized existing, trusted community networks.
- **The ultimate impact should be long-term change.** In systems with many moving parts and different actors, connecting existing entities in new ways is more likely to result in long-term change. Conversely, choosing not to involve existing entities may cause systems to revert to the status quo or collapse once the intervention is complete. The new partnerships and funding opportunities enabled by The Chelsea Project will ensure that this public health work will continue even if CCI and The Chelsea Project no longer operate in Chelsea.

- **An iterative approach will produce better outcomes.** The Chelsea Project went through many cycles of research, development of interventions, implementation, and synthesis. Taking the time to synthesize the outcome of each intervention we implemented helped the team reevaluate the problem and develop more effective interventions. This iterative approach resulted in three different focus areas—wastewater, testing, and communication—that, when combined, were extremely effective at increasing testing and vaccination rates.
- **Flexible funding is necessary for an iterative approach.** The process of moving through the four steps of research, hypothesis, implementation, and synthesis takes time and frequently changes one's perspective on the problem. Most funding mechanisms require project proposals that detail what the team plans to do, the expected outcomes, and how success will be measured. Once funding is approved, it can be difficult to pivot the approach or focus of the project because funding was approved for a specific proposal. Funders may also have expectations around when they will see results, which introduces time constraints. The Chelsea Project changed course several times throughout the project as we learned more about COVID-19 and circumstances on the ground shifted. Flexible funding allowed The Chelsea Project the time necessary to tailor interventions to current obstacles and enabled the team to adapt in real-time to unpredictable on-the-ground developments, neither of which would have been possible had funding been tied to a specific project proposal.

Through The Chelsea Project, we've learned firsthand how complex public health systems can be at both the national and local level. The COVID-19 pandemic exposed serious weaknesses in our current system that must be addressed if we are going to prioritize health in the future.

Moreover, The Chelsea Project is an example of health equity in action. As we've seen in Chelsea, improving quality of care and access to healthcare in vulnerable communities is extremely challenging due to language barriers, lack of trust and lack of resources. However, taking the time to understand these specific barriers in Chelsea and how trust networks in the community operate enabled The Chelsea Project to implement interventions that addressed these barriers and improved access to health resources.

It has been a privilege to collaborate with so many organizations and individuals who share the same passion to improve the lives of Chelsea residents. Our work in Chelsea proves that through iteration and partnerships, we can implement interventions that move the needle on multifaceted and complex problems like health equity and COVID-19. The real challenge is sustaining those efforts and making sure the lessons we've learned so far don't go to waste. We hope the Chelsea Project inspires leaders of other communities to apply our methods to address their own public health challenges.

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Karthik Dinakar

Chelsea Project Founder & Research Lead and Machine learning and clinical medicine researcher, the Massachusetts Institute of Technology (MIT) and Brigham and Women's Hospital

Barry Keppard

Chelsea Project Lead and Director of the Public Health Department, Metropolitan Area Planning Council (MAPC)

Dan Cortez

Chelsea Project Lead and Community Engagement Specialist, The Chelsea Hub and Chelsea Police Department

Samantha Bates

Executive Director, Center of Complex Interventions

Flor Amaya

Director of Public Health, Chelsea

Cristina Alonso

Health Equity Director, La Colaborativa.

The Chelsea Project Advisors

Joe DeRisi

Molecular biologist and biochemist at University of California, San Francisco.

Kate McCall-Kiley

White House Presidential Innovation Fellow focusing on policy design and strategy

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- [1] Ellen Barry, “In a Crowded City, Leaders Struggle to Separate the Sick From the Well” The New York Times (April 25, 2020) <https://www.nytimes.com/2020/04/25/us/coronavirus-chelsea-massachusetts.html>. See also Nik DeCosta-Klipa, “Why the city of Chelsea has been so hard hit by coronavirus” Boston.com (April 10, 2020) <https://www.boston.com/news/local-news/2020/04/10/chelsea-massachusetts-coronavirus/>
- [2] United States Census Bureau, <https://data.census.gov/cedsci/all?q=Chelsea,%20Massachusetts>
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- [5] Data analysis and visual prepared by CCI researcher Dhaval Adjodah.
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- [9] Cristina Alonso, “Community Impact Survey: The Impact of COVID-19 in Chelsea, August-December 2020,” 6-7 and 12-13.
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- [13] Ellen Barry, “In a Crowded City, Leaders Struggle to Separate the Sick From the Well” The New York Times (April 25, 2020) <https://www.nytimes.com/2020/04/25/us/coronavirus-chelsea-massachusetts.html>
- [14] “Blueprint for Public Health Excellence,” 5.
- [15] Local public health departments are primarily supported by municipal property taxes and fees and public health departments have to compete with the needs of other departments. Most municipalities are already struggling to provide services to their community. See “Blueprint for Public Health Excellence,” 12-13.
- [16] “Blueprint for Public Health Excellence,” 5 and 7.
- [17] “Blueprint for Public Health Excellence,” 5.
- [18] See list of The Chelsea Project partners on The Chelsea Project website: <https://www.thechelseaproject.org/partners/>

[19] COVID-19 tests at Stop the Spread sites will be available in Chelsea through the end of 2021. See City of Chelsea website, Coronavirus Updates, <https://www.chelseama.gov/FreeTestings>

[20] Cristina Alonso, “Community Impact Survey: The Impact of COVID-19 in Chelsea, August-December 2020,” 11.

[21] Walter Randazzo, Enric Cuevas-Ferrando, Rafael Sanjuán, Pilar Domingo-Calap, Gloria Sánchez, “Metropolitan wastewater analysis for COVID-19 epidemiological surveillance,” *International Journal of Hygiene and Environmental Health*, Volume 230, 2020, 113621, ISSN 1438-4639, <https://doi.org/10.1016/j.ijheh.2020.113621> (<https://www.sciencedirect.com/science/article/pii/S1438463920305678>).

[22] The University of Arizona caught two asymptomatic cases of COVID-19 in one of their campus dorms using wastewater analysis in August 2020. See Paulina Pineda and Rachel Leingang, “University of Arizona wastewater testing finds virus at dorm, prevents outbreak,” *azcentral*, August 27, 2020, <https://www.azcentral.com/story/news/local/arizona-education/2020/08/27/university-arizona-covid-19-outbreak-prevented-dorm-wastewater-testing/5649579002/>.

[23] The Chelsea Project currently tests wastewater in the two most populated areas of Chelsea, Hawthorn and Crescent once per week so we can continue to monitor the overall prevalence of COVID-19 in Chelsea. We may return to testing all four wastewater collection sites if we see an increase in COVID-19 cases. See <https://www.thechelseaproject.org/data/wastewater-testing/>

[24] The Mass General Hospital testing team led by Dr. Priya Sarin Gupta, with input from the Chelsea Project team, has submitted for publication a paper titled, “Implementation of a community-based, mobile testing program for SARS-CoV-2 guided by wastewater surveillance data” documenting this relationship between wastewater and COVID-19 cases. The paper is currently under review at *American Journal of Public Health*.

[25] Cristina Alonso, “Community Impact Survey: The Impact of COVID-19 in Chelsea, August-December 2020,” 7-8.

[26] Cristina Alonso, “Community Impact Survey: The Impact of COVID-19 in Chelsea, August-December 2020,” 7-8 and 24.

[27] Cristina Alonso, “Community Impact Survey: The Impact of COVID-19 in Chelsea, August-December 2020,” 16-17.

[28] See Chelsea Police Department: The Chelsea Hub website, <https://chelseapolice.com/chelsea-hub/>.

[29] La Colaborativa had supported health community workers earlier in the pandemic with support from ASG, but the expertise and leadership provided by Cristina Alonso and the Chelsea Project enabled the promotores to play a much larger role in COVID-19 education efforts.

[30] Cristina Alonso, “The Chelsea Project: Community Outreach, Transforming Chelsea from the Epicenter of the Pandemic to a model of effective community participation and response” (June 10, 2021), 3 and 10-11, 13-14.

[31] The promotores produced 3-5 TikTok videos per week about COVID-19 testing and vaccines. Each video received approximately 600 views. See Cristina Alonso, “The Chelsea Project: Community Outreach, Transforming Chelsea from the Epicenter of the Pandemic to a model of effective community participation and response” (June 10, 2021), 9.

[32] Cristina Alonso, “The Chelsea Project: Community Outreach, Transforming Chelsea from the Epicenter of the Pandemic to a model of effective community participation and response” (June 10, 2021), 4-5.

[33] See Massachusetts Vaccine Appointment website: <https://www.macovidvaccines.com/>.

[34] Cristina Alonso, “The Chelsea Project: Community Outreach, Transforming Chelsea from the Epicenter of the Pandemic to a model of effective community participation and response” (June 10, 2021), 14-15.

[35] These vaccination rates were last updated on December 1, 2021. See the most up to date vaccination data on the Chelsea Project website: <https://www.thechelseaproject.org/vaccinations-data/>.

[36] Cristina Alonso, “The Chelsea Project: Community Outreach, Transforming Chelsea from the Epicenter of the Pandemic to a model of effective community participation and response” (June 10, 2021), 16-17.

[37] Vaccination data for Chelsea is sourced from “Archive of COVID-19 Vaccination Reports” on Mass.gov <https://www.mass.gov/info-details/archive-of-covid-19-vaccination-reports>.

[38] Cristina Alonso, “Data Analysis Report to the City of Chelsea, COVID-19 positive cases: September 1, 2020 through January 19, 2021” (January-February 2021), 12-15.

[39] Cristina Alonso, “Data Analysis Report to the City of Chelsea, COVID-19 positive cases: September 1, 2020 through January 19, 2021” (January-February 2021), 19.

[40] Cristina Alonso, “Data Analysis Report to the City of Chelsea, COVID-19 positive cases: September 1, 2020 through January 19, 2021” (January-February 2021), 12-15 and 18.

[41] Cristina Alonso, “Data Analysis Report to the City of Chelsea, COVID-19 positive cases: September 1, 2020 through January 19, 2021” (January-February 2021), 20.

[42] See videos on the Chelsea Project website: <https://www.thechelseaproject.org/resources/>

[43] See Governor Baker’s tweet congratulating Chelsea on its high vaccination rate: <https://twitter.com/MassGovernor/status/1449048694016430085> (October 15, 2021). Governor Baker’s tweet reported that 99% of all eligible residents in Chelsea have received at least one dose of the vaccine. However, Chelsea’s Department of Health believes the vaccination rate is slightly lower due to inaccurate census data. The 99% vaccination rate is based on census data that shows that Chelsea has a population of 40,700 when in reality the population is closer to 55,000.

[44] Based on conversations with Chelsea’s Director of Public Health, Flor Amaya.

[45] Chelsea is located in Suffolk County which also includes Boston, Revere, and Winthrop. When we removed the vaccination rates for the other cities in the county, Chelsea had a higher vaccination rate than Miami-Dade county in Florida. See “See How Vaccinations Are Going in Your County and State” The New York Times (last updated November 19, 2021) <https://www.nytimes.com/interactive/2020/us/covid-19-vaccine-doses.html#vulnerable>.

[46] Vaccination data is from Mass.gov. See <https://www.mass.gov/info-details/massachusetts-covid-19-vaccination-data-and-updates>.

[47] See the Chelsea Project website: <https://www.thechelseaproject.org/positive-case-data/>

[48] See the Chelsea Project website: <https://www.thechelseaproject.org/data/wastewater-testing/>. See also “Board of Health Implements Mask Mandate for all Indoor Public Spaces” City of Chelsea, Massachusetts (December 1, 2021) <https://www.chelseama.gov/home/news/board-health-implements-mask-mandate-all-indoor-public-spaces>.

[49] See “Board of Health Implements Mask Mandate for all Indoor Public Spaces” City of Chelsea, Massachusetts (December 1, 2021) <https://www.chelseama.gov/home/news/board-health-implements-mask-mandate-all-indoor-public-spaces>.

[50] This Boston Globe article features La Colaborativa’s work on the promotores program and discusses ways this program may continue. See Felice J. Freyer, Bianca Vazquez Toness, and Diana Bravo, “Chelsea, a city hit hard by COVID, has become a vaccination standout,” The Boston Globe (October 24, 2021) <https://www.bostonglobe.com/2021/10/23/metro/what-went-right-chelsea/>.

[51] John Kania, “Preventing System ‘Snap Back,’” Stanford Social Innovation Review (June 15, 2021) https://ssir.org/articles/entry/preventing_system_snap_back.

[52] Einav G. Levin, M.D., Yaniv Lustig, Ph.D., Carmit Cohen, Ph.D., Ronen Fluss, M.Sc., et al. “Waning Immune Humoral Response to BNT162b2 Covid-19 Vaccine over 6 Months” The New England Journal of Medicine, October 6, 2021, DOI: 10.1056/NEJMoa2114583 (<https://www.nejm.org/doi/full/10.1056/nejmoa2114583>). See also Eyal Leshem, Kristin Nelson, and Benjamin Alan Lopman, “Severe breakthrough COVID-19 infections in Scotland - implications for immunisation programmes” The Lancet: Respiratory Medicine, September 29, 2021, [https://doi.org/10.1016/S2213-2600\(21\)00413-6](https://doi.org/10.1016/S2213-2600(21)00413-6) ([https://www.thelancet.com/journals/lanres/article/PIIS2213-2600\(21\)00413-6/fulltext](https://www.thelancet.com/journals/lanres/article/PIIS2213-2600(21)00413-6/fulltext)) and Yair Goldberg, Ph.D., Micha Mandel, Ph.D., Yinon M. Bar-On, M.Sc., Omri Bodenheimer, M.Sc., Laurence Freedman, Ph.D., Eric J. Haas, M.D., Ron Milo, Ph.D., Sharon Alroy-Preis, M.D., Nachman Ash, M.D., and Amit Huppert, Ph.D. “Waning Immunity after the BNT162b2 Vaccine in Israel” The New England Journal of Medicine, October 27, 2021, DOI: 10.1056/NEJMoa2114228 (<https://www.nejm.org/doi/full/10.1056/NEJMoa2114228>).

[53] Kevin L. Schwartz, Allison J. McGeer and Isaac I. Bogoch, CMAJ, March 29, 2021, 193 (13) E449-E452; DOI: <https://doi.org/10.1503/cmaj.210100> (<https://www.cmaj.ca/content/193/13/E449>). See also Michael J. Mina, Tim E. Peto, Marta García-Fiñana, and Iain E Buchan, “Clarifying the evidence on SARS-CoV-2 antigen rapid tests in public health responses to COVID-19,” The Lancet, 397(10283) P1425-1427, April 17, 2021, DOI: [https://doi.org/10.1016/S0140-6736\(21\)00425-6](https://doi.org/10.1016/S0140-6736(21)00425-6) ([https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(21\)00425-6/fulltext](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(21)00425-6/fulltext)) and Michael J. Mina and Kristian G. Andersen, “COVID-19 testing: One size does not fit all,” Science, January 8, 2021, 371(6525) pp. 126-127 DOI: 10.1126/science.abe9187 (<https://www.science.org/doi/full/10.1126/science.abe9187>).

[54] To start Dhaval built the simulator to model all of Massachusetts. It uses mobility data from Safegraph (https://shop.safegraph.com/?tab=datasets&cart=sg_p-202000-202107), disease dynamics (see <https://www.nature.com/articles/s41467-021-23276-9>), social distancing and masking data collected by the University of Maryland (see <https://data.covid.umd.edu/about/index.html>), demographic and census data (see <https://data.census.gov/cedsci/>) and data on relative time spent at home (see <https://www.google.com/covid19/mobility/>).

[55] The model was first calibrated at the state level, after which we used a variety of posterior predictive checks to verify the accuracy of our models in Chelsea against three “ground-truth” measures of COVID-19 cases in the city: MAVEN hospital data (see <https://www.mass.gov/lists/infectious-disease-data-reports-and-requests>), Biobot wastewater data (see <https://www.thechelseaproject.org/data/wastewater-testing/>), and the DPH city-level Public Health Reports (<https://www.mass.gov/info-details/archive-of-covid-19-weekly-public-health-reports#november-2020->).

[56] See the Chelsea Project website for more information about the tool: <https://www.thechelseaproject.org/modeling-simulation/>.