





Innovative Approaches to COVID-19 Case Investigation and Contact Tracing

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1–6

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Until COVID-19, the greatest national public health crisis was the 1918 influenza pandemic, which was covered extensively by *Public Health Reports*.^{1–6} Extrapolating from their knowledge of tuberculosis, public health authorities at that time exhorted ill people to remain home to break the chain of respiratory transmission.⁷ Other contemporaneous appeals that reverberate a century later include “avoid needless crowding,” “stay in the open air,” “wear a gauze mask over the nose and mouth,” and “keep away from houses where there are influenza cases.”²

In 2020, COVID-19 spurred case investigation and contact tracing at levels never seen in the United States.^{8–12} Until vaccines, therapeutics, and SARS-CoV-2 tests became available, mitigation measures were strictly nonpharmaceutical. These included physical distancing, wearing face masks, and enhancing ventilation. In this context, state, tribal, local, and territorial health departments relied on asking people with COVID-19 to isolate and share information about close contacts (ie, case investigation) so that exposed people could be notified and asked to quarantine, ideally before they themselves became infectious (ie, contact tracing).^{13–17}

This supplemental issue of *Public Health Reports* provides firsthand examples of how public health departments across the United States reprioritized workflow and redirected staff to accommodate fluctuating COVID-19 incidence during 2020–2021, incorporated new partners to augment case investigation and contact tracing, evolved processes to improve outreach to disproportionately affected community groups, used digital tools for case and contact management and for proximity technology or exposure notification, and evaluated the effectiveness of these innovative strategies.

Public Health Workforce

Human Resources

Initially, health departments diverted staff who worked as disease investigators for other communicable diseases to

perform COVID-19 case investigation and contact tracing. However, the increased workload quickly became overwhelming.^{12,18–21} The March 2020 US Coronavirus Aid, Relief, and Economic Security Act included an infusion of resources to hire additional public health personnel, including contact tracers.^{9,16} As described in the case study from Michigan, the CDC Foundation’s COVID-19 Corps expedited the recruitment of contracted telephone-based contact tracers, including people who speak languages other than English, based on the needs of that jurisdiction.²⁰ Ensuring staff fluency in additional languages also characterized effective community outreach in New York City, Phoenix, and Salt Lake City.^{19–22}

Staff Roles

Unlike the approach often used in other disease investigations, national guidance for COVID-19 distinguished between the tasks of case investigation and contact tracing. This bifurcated model, which streamlined staff training, was also proposed in anticipation that each case interview would yield multiple close contacts for follow-up.¹⁵ In jurisdictions opting to use telephone-based contact tracing, the bifurcated model appeared more common.^{19,20} Other jurisdictions used a joint staffing approach.¹² At one city’s drive-through rapid testing site, for example, if one car occupant received a positive test result, both case investigation for that person and contact tracing for all other car occupants began concurrently.²² In another community, integrating

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these tasks and cross-training field workers to collect nasopharyngeal swab specimens among household contacts also helped improve timeliness and new case detection.²³

Training

With the contact tracing workforce projected to expand from approximately 2200 to >100 000 personnel nationwide, asynchronous online trainings, such as those offered by the Association of State and Territorial Health Officials (ASTHO)²⁴ and Johns Hopkins University,²⁵ helped orient new staff. ASTHO's no-cost *Making Contact* training was completed by 90 643 people during April–December 2020, demonstrating the feasibility of this method of instruction for rapidly educating a workforce responding to emergent threats.²⁶

Novel Digital Tools

Exposure Notification

Piloted in August 2020 by the University of Alabama at Birmingham and eventually offered in 26 states, the exposure notification mobile application (app) programming interface developed by Google LLC and Apple Inc emerged as a technology to alert smartphone users who had opted to activate the app about potential SARS-CoV-2 exposures, generally before the health department was able to conduct the case interview and elicit close contact names.^{27,28} In California, which had the highest public uptake of this technology, app users anonymously notified their potential contacts a median of 4 days after COVID-19 symptom onset or diagnostic testing date.²⁹ In one state that chose not to offer exposure notification to the public, a university developed its own on-campus proximity technology smartphone app for the 2020–2021 academic year.³⁰

Symptom Monitoring

Modeled after Ebola virus quarantine protocols,³¹ another key principle in early COVID-19 guidance was the concept of daily symptom monitoring of people with COVID-19 and their close contacts. This ongoing interaction by telephone, text, or other means allowed the health department to assess whether people under isolation and quarantine could safely remain at home. For example, an initially asymptomatic close contact might develop symptoms and need assistance in seeking medical attention and, if diagnosed with COVID-19, timely case investigation. Other people under isolation and quarantine might benefit from support services, such as food and medicine delivery, to be able to stay home.^{12–15} Digital tools for daily symptom monitoring also had utility for schools and other settings when in-person gatherings resumed. At least two-thirds of states adopted digital tools to support automation of daily symptom monitoring.²⁸

Data Integration and Systems Interoperability

Each state and territory has a list of notifiable diseases required to be reported to public health officials, and every health department has a case-based surveillance system to gather information about those reports. For most diseases, the standard procedure is that only positive test results, along with certain patient-level data elements to enable follow-up, are reportable. Therefore, few public health surveillance systems had an existing infrastructure with the technological capacity to manage the volume of reports generated by the August 25, 2020–April 3, 2022, requirement that laboratories report not only each positive test result but also all negative SARS-CoV-2 test results to their respective state, tribal, local, or territorial health department.^{32–34} Although interoperability across surveillance, case investigation, and contact tracing systems is ideal,¹⁵ most states appeared to have used different platforms for each step in the process, often relying on vendors that had not previously supported public health workflows.²⁸

Several case studies in this supplemental issue of *Public Health Reports* describe how surveillance coordinators, epidemiologists, and program managers successfully incorporated technology to accommodate and organize the additional workload that COVID-19 generated for their health departments. During Arizona's July 2020 COVID-19 surge, Maricopa County received a median of 1415 positive SARS-CoV-2 test results through the statewide communicable disease database each day, yet 88% of residents with positive test results were contacted by text message within 1 day. The county health department credits its ability to pivot quickly to use of preexisting, familiar, and locally customizable information technology resources.²⁰ In Michigan, on the other hand, the state health department worked with an outside consulting firm to build a new platform using commercial software, which enabled the state to manage contact tracing and symptom monitoring during a September–November 2020 COVID-19 surge.¹⁹ The Chicago Department of Public Health also used software to ensure that starting in December 2020, everyone with a positive test result received an automated telephone call or text message that provided instructions about isolation and when to seek medical attention or additional support.³⁵

A successful example of system interoperability at the national level was the implementation of infrastructure supporting the COVID-19 exposure notification mobile app programming interface. The Association of Public Health Laboratories, through a collaboration with Google LLC, Apple Inc, and Microsoft Corporation, provided the infrastructure to connect all statewide implementations via a nationwide multitenant verification server. This nationwide server allowed states and territories to offer exposure notification without encumbering their own servers. In addition, smartphone users who opted to use the technology could be notified of potential SARS-CoV-2 exposures in any of the 26

states offering exposure notification, provided their smartphone app was activated when the exposure occurred.²⁷

Face-to-Face Interactions

Although the use of technology produced efficiencies, the value of in-person human interaction, particularly in communities where telecommunication can be unreliable or other access barriers exist, is explored in other articles in this issue. In contexts as disparate as an American Indian reservation in rural Arizona and 50 neighborhood cohorts in New York City, public health field teams visited homes, offering in-person education and assessment.^{21,23} This in-person outreach resulted in same-day case investigation and contact notification at the reservation in Arizona²³ and successful home visits for more than two-thirds of New York City residents with COVID-19 and close contacts who could not be reached by telephone.²¹ In Chicago, the health department subcontracted federally qualified health centers and community-based organizations serving areas of economic hardship to hire community members to serve as on-site case investigators and contact tracers, resulting in twice as much completeness of these activities when compared with case investigations and contact notifications assigned to the health department.³⁵ The free COVID-19 testing location situated in a demographically diverse part of Salt Lake City included staff who could discreetly initiate case investigation and contact tracing through the car window, in either English or Spanish, immediately after the positive test result; more than half of people who received these services self-identified as either Hispanic or non-White.²²

Institutions of Higher Education

Surge Staffing for Health Department Partners

Early in the pandemic—before health departments were able to hire new staff—undergraduate and graduate students in the United States volunteered to serve as case investigators and contact tracers.^{19,20,22,36,37} Their willingness to work outside traditional business hours and to staff virtual call centers was particularly valuable to the health departments that they supported. One recommendation for more efficient deployments during future public health emergencies is to have pre-existing service/learning programs and memoranda of understanding between public health entities and academic partners that include credentialing public health students to train with student response teams and assist health departments with data entry, epidemiologic analyses, or other short-term needs.^{20,36,37}

On-Campus Innovations

As colleges and universities prepared to resume in-person learning for the fall 2020 semester, some formed response

teams to assist with the anticipated demand for on-campus COVID-19 case investigation and contact tracing.^{37,38} Harrington et al describe how one university's multidisciplinary team ensured compliance with isolation and quarantine in residential housing. Network visualizations also helped target interventions based on transmission links rather than unnecessarily disrupting in-person classes.³⁸ An example of innovation on another university campus was a smartphone app that created a personalized “radar” of recent proximity to other app users, including the proportion who later received a positive test result or were contacts of someone who had received a positive test result for SARS-CoV-2.³⁰

Public Acceptability

As the COVID-19 pandemic stretched on, public goodwill to follow public health recommendations lagged.¹² Self-described political ideology, for example, was associated with the likelihood to support using smartphones for public health purposes.³⁹ Nevertheless, a spring 2021 national survey found high levels of willingness to participate in COVID-19 contact tracing, quarantine, and exposure notification, provided that public health communications were perceived as coming from trusted sources, most notably the personal health care providers with whom people had an established relationship before the pandemic.⁴⁰ Building stronger relationships and better coordination between the multifaceted health care delivery systems and their public health counterparts should be a focus in planning for future public health challenges.

Effectiveness and Evaluation

Because COVID-19 case investigation and contact tracing had to be implemented rapidly, public health jurisdictions generally devised their own approaches,⁸⁻¹⁷ limiting later assessments of their effectiveness in curtailing SARS-CoV-2 spread to metrics such as the proportion of people with positive test results who completed a case interview within a certain time frame or the number of close contacts elicited per interview.^{9,12,19-23,35,38,41} Many case interviews appear to have resulted in no or few named close contacts^{9,35,41}; whether a bifurcated or joint staffing model was more productive remains unclear.^{12,15} Even less is known about whether this resource-intensive activity affected isolation and quarantine decisions or, ultimately, reduced transmission. The impact of case investigation and contact tracing on COVID-19 incidence and hospitalizations is, thus, generally estimated through modeling studies.^{11,42}

Measuring the effectiveness of exposure notification is even more challenging. As multiple authors in this supplemental issue point out,^{27,29,43,44} the anonymity features of this technology preclude assessment of the degree to which smartphone app users are representative of the underlying population giving rise to COVID-19 cases, how consistently

they choose to notify potential contacts of a positive test result through the app, and whether contacts became more likely to stay home, seek testing, wear face masks, or otherwise change behavior upon receiving such a notification. The SimAEN modeling tool allows public health authorities to forecast the expected effect that implementing exposure notification could have on the effective reproduction number in their jurisdiction.⁴³ The convenience sample of exposure notification users in Washington State⁴⁴ and the key performance indicators from California²⁹ confirmed the expectation that this technology was nearly always more timely than conventional contact tracing. Respondents in Washington State also provided the helpful insight that 84% of notified close contacts were more likely to self-monitor for COVID-19 symptoms after receiving a notification, although only 39% of close contacts reported staying home while awaiting test results.⁴⁴

Conclusions and Lessons Learned

At the start of the COVID-19 pandemic in the United States, national guidance conveyed an expectation that every positive test result be routed for timely case investigation and contact tracing by public health authorities. Even with an influx of additional staffing and technology innovations, however, investigation of each case proved too resource-intensive to sustain; revised guidance gave health departments the latitude to prioritize those diagnosed in the past 5 or 6 days and cases occurring among household contacts, in congregate facilities, or in other groups locally defined as having an increased risk of severe COVID-19 outcomes.^{12-15,45} Despite additional flexibilities, including reduced duration of isolation and quarantine, public support for contact tracing continued to decline. Given the widespread availability of vaccination, at-home antigen test kits, face masks, and other prevention tools, public health strategies changed, endeavoring to empower individuals with messages such as “help protect yourself and others” and “how to talk to your close contacts” (ie, case-driven notification).^{12,46,47} New websites aimed directly at members of the public included a quarantine and isolation calculator⁴⁸ and a mechanism to alert close contacts anonymously via email or text (<https://tel-yourcontacts.org>).

During the first 2 years of the COVID-19 pandemic, most publications focused on describing this new pathogen and the spectrum of disease that it causes, diagnostic and treatment tools, and development and effectiveness of vaccines. Few publications have focused on how state, tribal, local, and territorial health departments worked to protect the communities they serve. This supplemental issue of *Public Health Reports* highlights how health departments quickly adapted and used innovative approaches to implement case investigation and contact tracing under rapidly changing

circumstances and often challenging work conditions. Although COVID-19 revealed multiple fault lines in our public health infrastructure, health departments benefited from an influx of new personnel, strengthened partnerships with health care facilities and institutions of higher education, and developed new collaborations with industry, particularly in the development and deployment of digital tools. Adoption of new technology has introduced efficiencies that will ideally remain in place and continue to support health departments as they refocus on traditional core services. The months and years between major threat events—when health departments and health care delivery systems are not in crisis mode—is the time to hone communication channels and address interoperability challenges.

Case investigation and contact tracing, including additional services to support isolation and quarantine, might be viewed as relics of the COVID-19 response, but these valuable public health activities continue every day for tuberculosis, HIV, sexually transmitted infections, and other communicable diseases, as they did before. It is our hope that some of the innovative strategies and tools developed for the COVID-19 response will bolster those activities, particularly for diseases that disproportionately affect certain communities. Some of the COVID-19 contact tracing workforce could be cross-trained and transitioned to work on contact tracing for other diseases. Finally, we hope that incorporating the enthusiasm and talents of students and other community members into more aspects of a health department’s day-to-day work will help build understanding and support for the role of public health in society, as well as propel more people into careers in public service.

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