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Proactive Text Messaging for Public Health Surveillance During the COVID-19 Pandemic

Daria Kester
University of Missouri-St. Louis, dtkkt6@umsystem.edu

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Daria T. Kester, MS, BSN, RN

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Advisory Committee

Laura Kuensting, DNP, APRN, PCNS-BC, CPNP-PC, CPEN, Chair

Louise Miller, PhD, Co-chair

Cathy Koetting, DNP, APRN, CPNP, NP-C, Committee Member

Abstract

Problem

The Department of Public Health (DPH) of a suburban Midwestern county considers surveillance and control of COVID-19 to be sub-optimal, resulting in part from difficulties with completing case and contact interviews.

Methods

To increase the success rate of case investigation, proactive messaging using short message media (SMS) alerts is used in a quality improvement initiative based on the PDSA framework. Participants are sent text message alerts prior to receiving a call from a DPH case investigator. Results are recorded in a statewide database.

Results

Individuals who received text messages prior to receiving a case investigation interview phone call were more likely to complete the interview. In a sample of adults aged 18-50 years, participant age did not have an effect on the likelihood of SMS response. These findings suggest that SMS alerts are effective in improving the case investigation process.

Implications for Practice

Contacting members of the public via SMS alert prior to initiating COVID-19 case investigation phone calls was an effective strategy for increasing case investigation completion rates without significantly adding to operating costs. More broadly, these results herald growing importance of technology in health care communications, and health care providers should become accustomed to an increase in volume and frequency of electronic, out-of-office interactions.

On March 13, 2020, the department of public health (DPH) of a Midwestern suburban county reported its second case of Coronavirus disease 2019 (COVID-19), a respiratory syndrome caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Saint Louis Department of Health [StLDoH], 2020). The county DPH also conducting case surveillance, which consists of two fundamental, intertwined elements; namely, case investigation and contact tracing. Surveillance, when coupled with isolation and quarantine policies, is crucial to identifying and isolating cases to prevent the further spread of infection. Indeed, such non-pharmaceutical interventions are the only recourse in the absence of a cure and/or widespread vaccination leading to a "herd-immunity threshold," i.e. vaccine-conferred immunity of 60-70% of the population (Aschwanden, 2021).

Case investigation entails support and monitoring of a patient with a known diagnosis of the disease of interest, and is usually performed by local public health officials (World Health Organization [WHO], 2020). Contact tracing is the identification and monitoring of people who have been exposed to the infected patient, and therefore have an ostensibly higher risk of developing infection (World Health Organization [WHO], 2020). Through case investigation, members of the public are apprised of isolation protocols and offered resources should they need assistance in isolating properly or seeking further care. The consequent separation of confirmed and putative cases from the general population keeps more people from being exposed, thereby reducing the rate of new infections. High rates of cooperation and compliance from the general public are essential if case investigation and contact tracing are to be effective (CDC, 2020).

Through 2020, the DPH of a suburban Midwestern county considered surveillance and control of COVID-19 to be sub-optimal, stemming in part from difficulties with completing case and contact interviews. One reason for this was thought to be reluctance on the part of the public to answer a call from an unknown source (Fentem, 2020). This quality improvement (QI) project tested the hypothesis that SMS alerts sent to cases and contacts prior to phone interview initiation would significantly improve the case completion rate. The structure and progression of the project was be guided by the Model for Improvement framework as described by Langley et al. (2009), which develops and evaluates tests of change (interventions) using the Plan-Do-Study-Act (PDSA) cycle. This framework has been established as both effective at improving outcomes and conducive to swift action, a requirement in the evolving pandemic (Terhaar, 2020). PDSA was created to support continuous improvement through repeated small-scale changes and subsequent adjustments based on results, which is necessary in a dynamic setting where data gathering in ongoing and cannot be completed before action is taken (Terhaar, 2020). This project explored the use of text messaging in a novel context, making it relevant to both the immediate wellbeing of county residents, as well as future application in later pandemics.

In summary, the question for study was: Among confirmed and probable COVID-19 cases and their close contacts living within county limits, what is the impact of proactive text messaging by public health officials on the case completion rate? We sought to provide evidence for the impact of pre-notification with SMS alerts on case investigation completion rates in a Midwestern County. Based on our findings, proactive outreach via short media service (SMS) alert is effective in increasing responsiveness to

case investigation efforts, as measured by an increase in the case completion rate (i.e., the number of cases per day that successfully complete an interview with an DPH employee).

Review of Literature

A literature search was undertaken using the CINAHL, PUBMED/Medline, and SCOPUS databases for papers relating to large-scale disease outbreak, contact tracing and case investigation, and public health messaging. The goal of the literature search was twofold: 1) validate the role of case investigation and contact tracing in infection control; 2) examine the impact of text messaging on health behavior, especially in the context of COVID-19. The following search terms and Boolean operators were used:

a. (*Case investigation* OR *contact tracing* OR *contact screening* OR *contact investigation* OR *health compliance* OR *public health* OR *health management*) AND
b. (*SMS* OR *text messaging*) OR
c. (*SARS* OR *coronavirus* OR *Covid-19* OR *SARS-CoV* OR *SARS-CoV-2*)

To be included, studies had to be in English, published no earlier than 2015, peer-reviewed, and report on primary research with humans. Studies were excluded when if they were abstract-only or lacked a reference list. The initial search yielded 849 results. These were screened for relevancy, and fourteen articles were ultimately selected for full text review. Additionally, five more articles were identified using the reference scanning/ancestry method, resulting in a total of nineteen articles reviewed.

Past infectious disease outbreaks, such as the SARS epidemic of 2003— SARS-CoV-2 and the SARS coronavirus are similar in terms of pathogenicity and transmissibility (Abdelrahman, Li, & Wang, 2020)—influenced the global response to the

COVID-19 pandemic by providing evidence about the effectiveness of case investigation and contact tracing (Bernard-Stoecklin et al., 2020; Kwok et al., 2019). During the SARS epidemic, case investigation and contact tracing were successfully used by public health officials to surveil and control the rate of infection, as measured by mathematical parameters like the basic reproduction number (R_0), i.e. the average number of transmissions per infectious case (Riley et al., 2003). An outbreak is considered controlled when $R_0 < 1$.

Observational data collected from the SARS epidemic has also been used to make predictions and recommendations about future outbreaks using mathematical modeling. Although perforce imperfect at capturing the complexities of the real world, models are nonetheless useful and frequently used in epidemiology by experts attempting to anticipate the effects of public health interventions. For example, Fraser, Riley, Anderson, and Ferguson (2004) developed a model using data collected during the SARS epidemic to show that isolation of known/symptomatic cases alone is not sufficient to curtail disease spread when the parameter θ (the proportion of cases caused by infected individuals for whom isolation is delayed by various barriers and/or lack of symptoms) is greater than $1/R_0$. Efficient contact tracing can help offset high θ values (Fraser et al., 2004). SARS-CoV-2 appears to be both more infectious and to have a higher θ than the SARS coronavirus (Cheng, Jian, & Liu, 2020). Aleta et al. (2020) estimate that if 50% of cases and their household contacts *and* 40% of non-household contacts self-quarantine within 48 hours, then the COVID-19 R_0 can be effectively decreased.

As of this writing, the COVID-19 pandemic has entered its second year, and data about case investigation and contact tracing during the COVID-19 pandemic are

accumulating. While most nations report engaging in public health surveillance, some countries have succeeded better than others in controlling the spread of COVID-19 (Cheng et al. 2020). In the wake of the SARS epidemic, Taiwan worked to improve its capacity to respond to disease outbreak, leading to the development of a sophisticated nationwide network, including automated reporting programs and a centralized database, the National Notifiable Diseases Surveillance System (NNDSS) (Jian, Chen, Lee, & Liu, 2017). Days after the identification of SARS-CoV-2, Taiwan designated COVID-19 a reportable disease, designed a diagnostic test, and acted to increase testing capacity (Cheng, Li, & Yang, 2020). Test results, along with patient data, were then submitted to the NNDSS, allowing public health officials to more easily locate and interview confirmed cases, carry out comprehensive contact tracing, and thus achieve and maintain better control over R_0 (Cheng et al., 2020). Meanwhile, South Korea avoided "true" lockdown, allowing borders and most businesses to remain open, thanks to "aggressive" contact tracing (Choi, Cho, Kim, & Hur, 2020). Korean public health authorities supplemented case and contact interviews with more objective surveillance data, including mobile phone and credit card data, and security camera footage (Choi et al., 2020).

Some invasive tactics effectively employed in other countries are unlikely to be viable in the United States, a country whose public is accustomed to greater individual privacy (Skoll, Miller, & Saxon, 2020). A review of the American response to COVID-19 found that public skepticism and resistance fueled by misinformation, in tandem with an underpowered and fragmented approach to contact tracing, has undermined efforts to limit the infection (Skoll et al., 2020). Despite these challenges, researchers believe

containment of COVID-19 in the United States is possible if appropriate action is taken, including enhanced utilization of technology (Aleta et al., 2020).

Case investigation does not necessarily require complex assistive technologies. The short message service (SMS) alert or text message is a simple, economical, and widely available technology that has been successfully used in previous public health interventions to disseminate information and influence behavior (Dryden-Peterson et al., 2015). Sallis et al. (2019) reported that pre-notification via SMS render the arrival of a subsequent invitation more important to the receiver. Sanchez Antelo et al. (2020) described developing text messaging content to increase in-person follow-up rates among Argentinian women receiving positive human papillomavirus tests, in order to offset the burden on local healthcare workers of contacting each patient individually. Effective messages are brief, clear, and timely, while preserving patient confidentiality (Sanchez Antelo et al., 2020). Dryden-Peterson et al. (2015) found that the use of SMS alerts allowed more efficacious dissemination of test results to pregnant women infected with human immunodeficiency virus while reducing operational costs. However, the introduction of SMS alerts unfortunately did not improve rates of antiretroviral therapy initiation (Dryden-Peterson et al., 2015). Kiruparan, Kiruparan, and Dabnath (2020) reported a statistically significant decrease in clinic no-show rates after implementation of pre-appointment reminder text messages. Similarly, a randomized controlled trial conducted by Arora et al. (2015) demonstrated that English-speaking patients who received text message reminders of follow-up appointments after an emergency department discharge were significantly more likely to attend those appointments than those who did not (58% vs 46% for primary care follow-up; 84% vs. 61% for specialty

care). In a pediatric population, Bigna et al. (2014) showed that SMS alerts sent to caregivers of children infected with or exposed to HIV also increased attendance rate to follow-up appointments.

Evidence about the use of SMS alerts during the COVID-19 pandemic is still emerging, and some examples already exist. In South Korea, after an infection cluster was traced to a nightclub district, public health officials texted the 10,905 people that they suspected had been exposed, requesting they get tested and self-quarantine (Choi et al., 2020). Barrett et al. (2020) recount efforts by a department of public health in Ireland to actively surveil close contacts of known COVID-19 cases through text messaging. The response rate to daily texts was high (n = 10,300; 82.9%), allowing infections to be diagnosed in 2.6% of close contacts (Barrett et al., 2020). A similar study conducted on a smaller scale in the United States (n = 445) used text messages as part of an active surveillance campaign, along with telephone and in-person interaction (Burke et al., 2020). However, no data were provided regarding the comparative efficacy of texting versus other outreach strategies.

Available evidence demonstrates the importance of public health surveillance for infection control, and the necessity of technology as a component of that surveillance. Contact tracing and case investigation are tools of public health surveillance that have been successfully applied in the past, and whose utility are being further proven in the present. Unfortunately, the pandemic response in the United States has been hindered by disparate and inconsistent leadership responses, causing public confusion and reducing cooperation with public health authorities (Skoll et al., 2020). This environment has made it more difficult for public health officials to do the important work of disease

surveillance, and action is needed in order to improve the rate at which cases and contacts can be identified and interviewed. Text messaging is an inexpensive, accessible, and effective technology which has been already successfully used in health care to inform and influence patients. A review of the literature did not yield any previously published studies examining the effect of text messaging to facilitate case investigation. This project adds to the evidence supporting the use of text messaging to achieve meaningful improvements in public health processes and outcomes—particularly regarding surveillance—in a resource-limited setting.

Methods

Design

A QI approach (specifically, the PDSA framework) was used for this project, wherein the process being examined and tested for improvement was case investigation. This was an observational, repeated cross-sectional study with both retrospective and prospective elements. Data were collected and entered into the REDCap database by DPH case investigators and contact tracers, then reviewed by investigators over a nine-month span, from April 2020-January 2021.

Setting

A racially and socioeconomically diverse suburban county in the Midwestern United States with approximately one million residents. The public DPH maintains three permanent offices in the area, and hired over 300 new employees since April 2020 to assist in the COVID-19 response. Project data were collected by the largest of these centers.

Sample

Convenience sampling was used. Study participants were any and all individuals reported to the county DPH as confirmed or probable COVID-19 cases. A confirmed diagnosis required a positive COVID-19 polymerase chain reaction (PCR) test result, whereas a probable case lacked a positive PCR, but has a positive antigen test or clinical symptoms linked to an exposure history. The population was stratified into "buckets" according to contact priority level. Enrollment was automatic, and no recruitment was necessary.

- Inclusion criteria. Any county residents interviewed or expected to be interviewed by the county DPH in the context of COVID-19 case investigation or contact tracing.
- Exclusion criteria. Cases that were unable to be texted or unreachable because of a missing or inaccurate phone number; individuals who were hospitalized, incarcerated, or residing in long-term care facilities.

Procedures

The DPH COVID-19 task force was formed in March 2020 and since convened on a regular basis either in-person or virtually, switching exclusively to the latter format in November 2020. Within the larger task force, a department-employed medical doctor (MD) was assisted by the student investigator in SMS alert development, transmission, and data analysis. Resources included case investigators and contact tracers, both paid and volunteer, who interacted with the public and enter data into the REDCap database. SMS alerts were sent using a health department-provided phone. The SMS alert language was created and reviewed by DPH officials, with the final iteration as follows: "[County]

Dept of Public Health will be calling you today after [time] regarding recent test results. If you prefer you may call us at [number]. Thank you."

As is typical in the PDSA protocol, the SMS alert intervention evolved over several cycles. In the first cycle (August 2020-September 2020), alerts were manually sent to a small subset of cases in the order of contact priority. In the subsequent cycle (October 2020-December 2020), text messages were sent to a larger subset of cases in batches at designated times using an automated system. Text message recipients were also prioritized for contact by case investigators, to minimize instances of texts sent without phone follow-up. In January 2021, a process evaluation trial was conducted to more conclusively strengthen the evidence supporting the intervention. Lab-confirmed or probable COVID-19 cases who met the previously defined enrollment criteria, as well as the additional criteria of being aged 18-50 years and not having been the subject of a previous outreach attempt, were randomly assigned in a ratio of 2:1 to either receive or not receive a proactive SMS alert. Both groups were equally prioritized for case investigation on the date the message was sent; case investigators were not told to which group a given case belonged.

Data Collection and Analysis

Data were collected by DPH staff in the Research Electronic Data Capture (REDCap) database during the course of department-led case investigation interviews. Data from the REDCap database were de-identified using directory replacement or aggregation. The database was only accessed by users who had approval from the DPH. Anonymized datasets were stored as encrypted Excel workbooks on a password-protected laptop. Data included:

a. Number of cases/contacts who: 1) received text messages; 2) were called; 3) successfully completed phone interview; 4) were contacted but did not complete their phone interview.
b. Age of participants.

For analysis purposes, results were considered statistically significant at $p < .05$.

Approval Processes

Approval and support from the DPH and the student's doctoral committee was obtained in written form. The project was reviewed by both the DPH's Independent Regulatory Review Commission (IRRC) and the university's Internal Review Board (IRB) and deemed to be a QI project. Informed consent was not required since no additional clinical intervention was performed, and identifiable individual information was not shared. There were no known risks associated with this study. Indeed, case investigation has been proven beneficial and is considered a public good. There were no ethical concerns since participant privacy and confidentiality were respected.

Results

The first cycle of the SMS intervention was initiated in August 2020. By then, DPH case investigation efforts had been ongoing for several months. Data from May 2020-July 2020 reveal the average percentage of completed case investigations was 42.4%. After implementation of the SMS intervention, the average percentage of completed case investigations from August 2020-December 2020 increased to 54.3%. An independent samples *t*-test that compared the weekly averages of completed case interviews indicated a significant difference between means ($p < .001$).

Between 1/19/21 and 1/27/21, a total of 1541 participants were enrolled in the SMS intervention process evaluation. Participants were divided into two groups, SMS^+ (SMS received plus interview attempt made) and SMS^- (SMS not received plus interview attempt made). Participants whose numbers were not text-enabled or to whom SMS alerts were otherwise non-deliverable were retroactively added to the SMS^- group. Ultimately excluded from analysis were 178 cases, either because an interview attempt was not made, or because study protocol was otherwise not followed, resulting in final group sizes of 669 and 694 participants in the SMS^+ and SMS^- groups, respectively.

A χ^2 test for independence showed a significant relationship between receiving a SMS and completing an interview, $\chi^2(1) = 66.61$, $p < .001$. Same day interview completion rates were 44.4% (SMS) and 64.1% (SMS). The result of the two proportions *z*-test indicated that receiving a SMS alert had a significant impact on interview completion, $z = -7.41$, $p < .001$.

Ages were recorded for most participants. Additional demographic data were unable to be obtained due to administrative barriers within the DPH. Participants in the intervention group were divided into two sub-groups based on age, those 18-34 years and those 35-50 years. Subgroup analysis showed no significant difference in case investigation completion rates based on age ($p = .317$).

Discussion

Data collected during the course of this project provide evidence that among confirmed and probable COVID-19 cases living within county limits, proactive text messaging by a public health entity has a significantly positive impact on the case completion rate. When comparing case completion results before and after the

implementation of pre-interview texting, case completion rate rose overall. This promising initial finding led to a more targeted test of change conducted in January 2021 designed to ascertain whether or not this improvement was directly attributable to the introduction of SMS alerts, as opposed to, for example, increase in staffing numbers and staff interviewing skills. Analysis of these data revealed that individuals who received an intervention in the form of a SMS alert were significantly more likely to complete a case investigation interview than those who did not. This implies that receiving SMS alerts has a "priming" effect that predisposes individuals to respond more favorably to a subsequent invitation or stimulus. Participant age was not observed to have an effect on whether recipients responded to the SMS alert.

Not only was text messaging effective in improving case investigation, it also proved efficient in terms of cost and labor. Although texts were sent manually in initial stages, the process was later automated such that one employee was able to send hundreds of batched text messages per day in minutes. Also, the DPH in this study was able to implement the SMS alert program for very little additional cost by piggybacking on existing infrastructure already in place, i.e., a statewide emergency alert texting system. Adding this element did not impede the texting system in continuing to function as originally intended.

Limitations of the study include a single-center focus that may not readily transfer to other settings. Additionally, disagreements among leaders at various levels of government and DPH staff departures slowed some aspects of the project (particularly when it came to obtaining approvals). Further research should be done on factors that may influence response rates to SMS alerts, including other participant characteristics

such as gender, race, and socioeconomic status, and message timing *per se* as well as in relation to the phone call attempt. Nevertheless, these results add to the body of evidence supporting the use of SMS alerts in public health initiatives.

Conclusion

Contacting members of the public via SMS alert prior to initiating COVID-19 case investigation phone calls was an effective strategy for increasing case investigation completion rates in both younger and older adult age groups without significantly adding to operating costs. The project aim of 10% improvement to case investigation completion rate was not only met, but exceeded. This success suggests that public health departments and other healthcare entities should consider employing the use of SMS alerts as an effective way to enhance outreach efforts and improve invitation response. Larger implications include the increased integration of technology into health care communications, and health care providers should become accustomed to the idea of increased out-of-office interactions.

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