May 11, 2018

Travis Sanchez
Editor-in-Chief
JMIR Public Health and Surveillance

Dear Dr. Sanchez,

My colleagues and I are pleased to submit the manuscript entitled “Piloting and Evaluation of Text-Based Illness Monitoring for Detection of Novel Influenza A Virus Infections during an Influenza A(H3N2)v Virus Outbreak in Michigan, 2016” for publication as an original article in JMIR Public Health and Surveillance.

In August 2016, an outbreak of variant influenza virus infections was detected among fair attendees in Michigan. Within weeks of the initial detection, we deployed a newly developed text-based surveillance platform to enhance detections of influenza infections. We used the deployment of this newly developed system during an outbreak to evaluate the feasibility and acceptability of the system for use in future outbreaks of novel influenza viruses. We enrolled 87 households at nine fairs, representing 392 people under active surveillance. Through our system, we detected additional variant virus infections. We identified several areas for system improvement and developed recommendations for future system deployments. This manuscript highlights how innovative tools can enhance traditional public health surveillance during an outbreak.

This manuscript has not been previously published and is not being considered for publication anywhere other than JMIR Public Health and Surveillance. All authors have seen and approved the manuscript and contributed significantly to the work and no authors report any conflicts of interest. No writing assistance was provided in the preparation of the manuscript.

Correspondence regarding this manuscript should be directed to: Rebekah J. Stewart, CDC, 1600 Clifton Road, Mailstop A-10, Atlanta, GA 30333; Phone: (404)718-4580; Email: yxp5@cdc.gov

Thank you for your consideration of this manuscript. I look forward to hearing from you.

Sincerely,

Rebekah J. Stewart, MSN, MPH, APRN
Piloting and Evaluation of Text-Based Illness Monitoring for Detection of Novel Influenza A Virus Infections during an Influenza A(H3N2)v Virus Outbreak in Michigan, 2016

Authors:

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\textsuperscript{6}Compliant Campaign, Scottsdale, AZ, USA

\textsuperscript{7}Michigan State University Extension, East Lansing, MI, USA

ABSTRACT

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Phone: 404-718-4580. Email: yxp5@cdc.gov

ABSTRACT
Background: Rapid reporting of human infections with novel influenza A viruses accelerates detection of viruses with pandemic potential and implementation of effective public health responses. After detection of human infections with influenza A(H3N2) variant viruses (“H3N2v”) associated with agricultural fairs during August of 2016, the Michigan Department of Health and Human Services worked with Centers for Disease Control and Prevention (CDC) to identify infections with variant influenza viruses using a text-based illness monitoring system.

Objective: To enhance detections of influenza infections using text-based monitoring and evaluate the feasibility and acceptability of the system for use in future outbreaks of novel influenza viruses.

Methods: During an outbreak of H3N2v virus infections among agricultural fair attendees, we deployed text-illness monitoring (TIM) to conduct active illness surveillance among households of youth who exhibited swine at fairs. We selected fairs with suspected H3N2v virus infections and fairs without suspect infections that met predefined criteria. Eligible respondents were identified and recruited through email outreach and/or on-site meetings at fairs. During and for 10 days after selected fairs, enrolled households received daily, automated text-messages inquiring about illness; reports of illness were investigated by local health departments. To understand the feasibility and acceptability of the system, we monitored enrollment and trends in participation and distributed a web-based survey to households of exhibitors from 5 fairs.

Results: Among an estimated 500 households with a member who exhibited swine at one of 9 selected fairs, representatives of 87 (17%) households were enrolled, representing 392 household members. For fairs that were ongoing when TIM was deployed, the number of respondents peaked at 56 on the third day of the fair and then steadily declined throughout the rest of the monitoring period; 26 (30%) of 87 household representatives responded through the end of the 10-day monitoring period. We detected 2 H3N2v virus infections using TIM, which represents 17% (2/12) of all H3N2v virus infections detected during this outbreak in Michigan. Of the 70 survey respondents, 16 (23%) had participated in TIM. Of...
those, 73% (11/15) participated because it was recommended by fair coordinators and 80% (11/15) said they would participate again.

Conclusions: Using a text-message system, we were able to monitor a large number of individuals and households for illness and detected H3N2v virus infections through active surveillance. Text-based illness monitoring systems are useful to detect novel influenza virus infections when active monitoring is deemed necessary. Participant retention and testing of persons reporting illness are critical elements for system improvement.

KEYWORDS: Influenza, Surveillance, Novel, Agricultural, Fairs, Texting
INTRODUCTION

Novel influenza A viruses are different from currently circulating human influenza A/H1 and A/H3 viruses and have the potential to cause a pandemic if viruses gain the capacity to infect and transmit efficiently from person to person and cause clinical illness in humans [1]. In the United States, human infection with a novel influenza A virus is nationally notifiable [1]. In the United States, swine are the primary source of reported novel influenza A virus infections in humans, and the vast majority of persons are infected after swine exposure at an agricultural fair [2-9]. Some influenza A viruses are endemic pathogens in swine populations [10-13] and swine can be infected without displaying clinical signs of illness [14]. Monitoring for novel influenza virus infections in humans is important to quickly identify viruses with pandemic potential and to speed implementation of an effective public health response. However, traditional forms of active monitoring for illness (e.g., through daily phone calls of persons with possible exposure) can be very labor-intensive for health department staff, and during an outbreak, the need for monitoring may overwhelm a health department’s ability to respond in a timely manner. CDC recommends that people participating in avian influenza outbreak response efforts be monitored during the response and for 10 days after their last possible exposure to infected birds or potentially-contaminated environments [15], which could result in a substantial number of responders per state. For example, during an avian influenza outbreak in 2014–15, Minnesota conducted active post-exposure symptom monitoring for 459 responders by making daily phone calls for 10 days (Karen Martin, Epidemiologist in Minnesota, Personal Communication). Text messaging has been used previously in research [16] and outbreak settings [17] to facilitate the monitoring of multiple individuals for respiratory illness.

To assist states with monitoring individuals at potential risk of a novel influenza virus infection, CDC, in coordination with the National Association of County and City Health Officials (NACCHO) and Compliant CampaignSM [Note: Use of trade names and commercial sources is for identification only and

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does not imply endorsement by the Centers for Disease Control and Prevention, the Public Health Service, or the U.S. Department of Health and Human Services], developed a text-message illness monitoring (TIM) platform. Although several state health departments had pilot tested the TIM system, none had previously used it among members of the public during an outbreak. On August 4, 2016, Michigan notified CDC of a laboratory-confirmed influenza A (H3N2) variant (“H3N2v”) virus infection in a 9-year-old child, who had been exhibiting swine at an agricultural fair in Michigan [18, 19]. Michigan reported a second infection the next day along with reports of ill swine at a second agricultural fair.

On August 9, 2016, the Michigan Department of Health and Human Services (MDHHS) asked CDC to pilot the deployment of TIM to monitor families of individuals exhibiting swine at county fairs and evaluate its functionality during an outbreak. The objectives of the pilot were to determine the ability of TIM to enhance detections of H3N2v virus infections and to evaluate the feasibility and acceptability of the TIM system for use in future outbreak investigations of novel influenza viruses.

**METHODS**

**Fair selection**

The details of the H3N2v variant outbreak have been described previously [18] (Supplemental Figure).

We targeted 2 groups of agricultural fairs for the TIM pilot: 1) fairs completed within the past 10 days where suspected H3N2v virus infections were reported and 2) ongoing or upcoming county fairs (to ensure illness follow-up and testing could be coordinated by a single county health department) with >50 swine in exhibit (as large numbers of swine increase the likelihood of swine influenza outbreaks) [20] (Figure 1).

Figure 1. Fair selection
Participant Recruitment

As studies have shown that young age and direct contact with swine are risk factors for variant influenza virus infection [4, 6, 9], we contacted coordinators of youth-agricultural clubs to invite households of swine exhibitors to participate. For fairs with reported infections, club coordinators sent recruitment information solely through email. For the fairs without reported infections, we attended exhibitor meetings or other fair events to describe variant influenza viruses and the text-messaging illness monitoring system. We also distributed informational flyers about TIM, and sent recruitment information by email (Table 1).
Table 1. Recruitment methods and enrollment by fair

<table>
<thead>
<tr>
<th>Fair</th>
<th>Primary Recruitment Method</th>
<th>Recruitment Occurred After Fair Conclusion</th>
<th>H3N2v\textsuperscript{a} Infections Associated with Fair</th>
<th>Swine Exhibitor No.</th>
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\textsuperscript{a} Influenza A(H3N2) variant virus infection  
\textsuperscript{b} Derived by dividing the number of reported swine exhibitors by 2, based on experts’ estimates of the maximum likely number of swine exhibitors per household  
\textsuperscript{c} Text-Illness Monitoring  
\textsuperscript{d} Local Health Department

**Illness Monitoring Enrollment and Questions**
Each fair was assigned a unique texting code word. Parents of swine exhibitors were asked to text in the unique code word using their mobile phone, which would automatically enroll them in the system (Figure 2a and Figure 2b). After texting the code word, enrollees were asked how many household members were attending or planning to attend the county fair. They were then asked if any fair attendees had a fever, cough, sore throat, or other symptoms. Respondents who replied “No” were advised to contact the health department if anyone started to have symptoms. Respondents who replied “Yes” were advised that a representative from the health department would contact them to learn more about the illness. If a response was not received by 6pm, a reminder text was automatically sent. Texts asking...
about illness were sent daily at noon during the fair and for 10 days following the fair. Because CDC does not recommend a specific monitoring period for persons exposed to variant influenza viruses, we used the monitoring period recommended by CDC for avian influenza responders (https://www.cdc.gov/flu/avianflu/h5/infected-birds-exposure.htm).

Alerts, Follow-up, and Testing
“Yes” responses and any response other than “No” (e.g., “OK”) generated an immediate email alert to designated local health department staff to follow up with the respondent and determine if additional follow-up was necessary. Health department staff were asked to refer anyone for respiratory testing who reported any symptoms associated with variant influenza virus infection (including mild symptoms such as runny nose and less common symptoms such as vomiting) and who had swine exposure or contact with a person with confirmed H3N2v virus infection during the week prior to illness onset [6]. Collected specimens underwent real-time reverse-transcription polymerase chain reaction (rRT-PCR) or genetic sequencing at CDC or the state public health laboratory to confirm H3N2v virus isolation.

Retention
We monitored retention of respondents throughout the monitoring period and assessed the impact of reminder texts on daily participation. To understand the impact of the type of texting language on respondent retention, we randomly assigned fairs to receive texts with either more formal or less formal language (Figure 2a and 2b).

Web-Based Survey
We developed a web survey to evaluate the use and acceptability of the TIM system using Epi Info™ software (version 7.2.0.1). The youth program club coordinators distributed a link to the survey by email to all swine exhibitor families after the conclusion of the fair season. Questions included reasons for participating or not participating in the TIM system and likelihood of participating again if given the opportunity.
Health-Department Interviews
We conducted unstructured interviews with health officials at participating health departments to
determine how much time was spent following up on alerts generated by the system and to determine
how many respondents with reports of illness sought care and were tested for influenza.

RESULTS
Enrollment, Retention, and Illness Detections
From August 1 to September 1, 2016, we identified 3 fairs with suspect H3N2v virus infections and
approached fair organizers about participating in the TIM pilot. Of those, organizers of 2 fairs agreed to
participate, and TIM was deployed (Figure 1). We identified 21 fairs occurring between August 15 and
September 9, 2016, from which no human H3N2v infections were reported. Of those, 13 were county
fairs, and 7 of those had large numbers of exhibition swine. Organizers of these 7 fairs agreed to
participate in the pilot, bringing the total number of fairs where TIM was deployed to 9 fairs (Figure 1).

Out of an estimated 500 households contacted, 87 individuals enrolled, reporting for 392 household
members (Table 1). Household participation rates varied by fair and by enrollment method (range: 3–
86%, median: 13%). The number of household respondents for ongoing fairs peaked at 56 on the third
day of the fair and then steadily declined throughout the rest of the monitoring period (Figure 3).

Approximately 30% (26/87) of household reporters responded through the end of the 10-day monitoring
period. Retention of respondents receiving informal texts declined faster than those receiving the formal
texting language, and 6% (2/29) of respondents receiving the informal texts remained enrolled through
the end of the monitoring period (Figure 3). The initial daily text generated 83% of all responses, while
17% of responses followed the second (reminder) text.

Figure 3. Respondent retention throughout monitoring period, total, and by texting language type
Of the 392 persons who were actively monitored, illness was reported for 22 (6%) through the TIM system. Nine (41%) of 22 sought care, 5 (56%) had a specimen tested, and 2 (40%) tested positive for H3N2v virus, representing 17% (2/12) of all H3N2v virus infections detected in Michigan during this outbreak [18]. Of the 13 symptomatic persons who did not seek care, 2 could not be reached by the health department, 1 was instructed not to seek care by the county medical director, 1 declined seeking care due to the cost, and 1 declined because another diagnosis was believed to be more likely; the other 8 did not provide a reason.

Web-Based Survey

Among 5 fairs that distributed the survey to swine exhibitor families through an estimated 500 email addresses, 70 households who exhibited swine responded (response rate: 14%). Respondents from 16 (23%) households reported participating in TIM. Among 15 respondents, 11 (73%) participated because it was recommended by the fair and 12 (80%) indicated that they would participate again. Among 50
respondents who reported not participating in TIM, 34 (68%) said it was because they had not heard about it, 7 (14%) said they did not understand the necessity, 2 (4%) said they did not have a phone to use, and 7 (14%) said they did not know why they chose not to participate.

Health Department Interviews
Health department staff reported spending between 3 minutes and 60 minutes per day following up on alerts generated through the system. Health systems interacting with respondents receiving the informal texting language indicated that they spent substantially more time following up on alerts than those interacting with respondents receiving the formal texting language, likely due to a substantial number of false alerts from respondents using colloquial language such as “Aok. All fine here” rather than using a system recognized response of “Yes” or “No.”

DISCUSSION

Principal Results
During an outbreak of variant influenza virus associated with swine at agricultural fairs, we successfully deployed a text-based system to monitor for illness among potentially exposed people over a 4-week period. Two H3N2v virus infections were detected among 392 individuals monitored for illness during this outbreak [18], suggesting that text-messaging for active surveillance was a valuable tool to complement traditional surveillance methods and enhance detections during this outbreak. Both H3N2v virus infections identified among persons monitored for illness using the TIM system were associated with fairs with confirmed H3N2v cases detected through passive surveillance; no H3N2v cases were identified among 7 county fairs selected for having large numbers of swine exhibited, suggesting that large numbers of variant influenza cases were not occurring at these fairs.

The investigation of novel influenza A virus infections is important for early detection, treatment, and prevention of influenza viruses with pandemic influenza, but traditional surveillance methods may miss many infections due to the large numbers of persons potentially exposed and requiring 10-day follow-
Multiplier models based on an H3N2v virus outbreak in 2011 estimated that for every pediatric H3N2v virus infection detected and reported to CDC, there were approximately 200 infections in the community and for every adult H3N2v virus infection, there were approximately 255 infections.

Reasons for the gap between reported and occurring infections were related to the low likelihood that someone who was ill would seek health care and be tested for a variant influenza virus [21]. Active surveillance increases the opportunity for an ill person to interact with health officials and the opportunity for ill persons to undergo appropriate testing for detecting variant influenza viruses. In our study, TIM was able to detect 2 additional H3N2v virus infections during an ongoing outbreak and was well accepted among county health department staff. In Australia, health officials also used short message service (SMS) to actively monitor responders to an outbreak of avian influenza virus on a poultry farm in 2013. Public health officials found the use of SMS to be less time consuming and 2.5 times more cost-effective than conducting telephone follow-up interviews [17]. Future outbreak investigations of novel influenza viruses may wish to utilize TIM or other similar methods as a less resource intensive way to actively monitor persons at risk.

While the TIM system was well accepted by both respondents and health departments, we identified 3 areas where improvements were needed. The first was with enrollment, which varied by fair and ranged from 3-86%. The vast majority of households that did not enroll had not heard about the system, and those that did enroll did so primarily because it was recommended by the agricultural club coordinator. This highlights the importance of effective communication by groups or people who can reach and are trusted by the intended target community. Future deployments of systems like TIM should focus on identifying trusted groups and individuals early and working with them to encourage enrollment. Holding meetings to describe the system and encouraging attendants to enroll during the meeting resulted in higher enrollment, perhaps due to the convenience and personal nature of the recommendation. While strategies to increase enrollment will differ by setting, using personal
communication to provide simultaneous rationale and enrollment information appeared to be an effective strategy that could be adapted and applied in most settings.

The second identified area for improvement was testing of symptomatic exposed persons; in our study, only about 20% of ill individuals were tested. Appropriate testing is the only way to confirm infection with a novel influenza virus as the symptoms are similar to those caused by other respiratory viruses, including seasonal influenza. There are many potential barriers to care-seeking including understanding the importance of influenza testing, the availability of testing at local health care centers or health departments, and the cost associated with visiting a health care provider, especially among people without insurance or with high out-of-pocket health costs. There are several ways to address these barriers, and the mechanism depends on the resources and capabilities of the state and local health care systems. In future situations where a TIM-like platform is deployed during an outbreak, health officials could consider offering testing for novel influenza virus infections free of charge at health departments or sending surveillance staff to collect specimens from ill persons in their homes; the latter is a strategy that has been shown to be effective in New York City for longitudinal surveillance of influenza-like illness [16, 22]. In addition, increased education among exposed persons about the risk of novel influenza infections and the importance of detection also may increase the likelihood of testing.

The third issue identified was with respondent retention. Monitoring for a novel influenza virus requires up to 10 days of monitoring after the last day of exposure, which in the case of a 10-day county fair may necessitate as many as 20 days of monitoring. Maintaining respondents throughout the monitoring period was a challenge in this pilot, and only 30% remained enrolled through the end of the recommended monitoring period. We deployed 2 types of texting language to see if the formality of the language could increase retention. We found that respondents receiving the informal language texts stopped responding sooner than those receiving the formal texting language and fewer remained enrolled through the end of the monitoring period. Respondents of the informal texting language also
responded to texts in a conversational tone, often with abbreviations or slang terms, which generated alerts through the system that required unnecessary follow-up by health department staff. This resulted in some health department staff reporting that they spent as much as 60 minutes per day following up on alerts versus 3–5 minutes for those interacting with respondents receiving the formal texting language. We recommend that future deployments of TIM-like platforms should use the formal texting language and consider the optimal length of monitoring that weighs the incubation of variant and avian influenza against the likelihood of attrition among the respondents.

**Limitations**

This investigation and evaluation has certain limitations. First, we conducted it in the middle of an outbreak response and relied on health departments and club coordinators to recruit participants in the middle of a busy fair season. In some situations, recruitment occurred solely through email or delivering flyers, which may have limited the number of people who were aware of the system and its importance. Second, this investigation involved adult participants who responded for the entire household. Other studies also have used this method with success [16]; however, we cannot be certain that the respondent was accurately reporting for all household members. Third, we had a low response rate to the web-based survey (14%) and respondents may not have shared the same opinions as those who did not respond. Fourth, our selection of fairs was a convenience sample based on timing and fair attributes. Findings from these fairs may not be representative of all agricultural fairs.

**Conclusions**

In summary, we successfully piloted a new text-based monitoring tool for detecting variant influenza virus infections and identified two H3N2v virus infections during an outbreak in Michigan. This pilot demonstrated how text messaging can be used to complement traditional surveillance methods during an outbreak. Future activations of the system should work to improve systematic testing of exposed persons who develop symptoms and continue exploring methods to improve participation and retention of respondents.
Acknowledgements

We gratefully acknowledge the many people who assisted with the outbreak response and the evaluation of this monitoring tool including James Averill, LaShondra Berman, Lenee Blanton, Andrew S. Bowman, Lori Cargil, Beth Ferry, Pat Fralick, Colleen Harns, Britney James, Yungo Jang, Kathy Kacynski, Lisa Koonin, Leah Lavanway, Debra Laws, Leslie Lee, Dian Liepe, Stephen Lindstrom, Amanda Lubit, Mark McCorkle, Michelle McDonald, Guy Miller, Anita Patel, Tracy Payne, Trevor Quinlan, Erin Radke, Carrie Reed, Ruby Rodgers, Mary-Grace Stobierski, Arlee Sutton, Susan Trock, Renee Tschrihart, Kristy VanSickle, Colleen Wallace, and David Wentworth.

Conflicts of Interest

None to declare

Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the official views of CDC.

REFERENCES


Tables and Figures

Figure 1. Fair Selection
3 recently concluded fairs with suspect cases

2 fairs agreed to participate

9 total fairs deployed TIM

21 fairs with start dates between 8/15/16–9/9/16

13 county fairs

7 fairs with >50 swine in exhibit

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<td>No</td>
<td>55</td>
<td>28</td>
<td>5 (18)</td>
<td>22</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>1052</td>
<td>528</td>
<td>87</td>
<td>392</td>
</tr>
</tbody>
</table>

<sup>a</sup> Influenza A(H3N2) variant virus infection

<sup>b</sup> Derived by dividing the number of reported swine exhibitors by 2, based on experts’ estimates of the maximum likely number of swine exhibitors per household

<sup>c</sup> Text-Illness Monitoring

<sup>d</sup> Local Health Department
We’re sorry to hear that someone is ill. Your health department will contact you to learn more. Seek care immediately for serious illness.

Thank you! If anyone starts to have symptoms, please contact your health department or text ‘phone’ to this number.

No response by 6PM EST

You have not responded to today’s check-in. Do any fair attendees within your household have any symptoms? Reply Yes or No.

Yes or No
Hi! It’s TIM. I’ll be sending you a daily text to how your family is feeling. If you need help, just text help.

I hope you are enjoying the fair! How many people in your household are planning to go?

Does anyone who went to the fair have a fever, cough, sore throat, or any other symptoms? Please text back yes or no.

I’m sorry to hear that. I’ll let your health department know so they can call and check on you. Get care right away if it’s serious.

Ok – great! Thanks for checking in. If anyone starts to have symptoms, you can call your health department or text ‘phone’ to me.

No response by 6PM EST

Hey, it’s TIM again. Is everyone feeling ok? Reply Yes or No.

Yes or No
Supplemental Figure 1. Epidemic curve of influenza A(H3N2) variant virus infections by date of symptom onset and detection method—Michigan, 2016
Text-illness monitoring

Traditional detection methods

Date of Symptom Onset

No. of Infections

[Bar chart showing number of infections over dates]