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Original Article

Development and deployment of tools for rapid response notification of Monkeypox exposure, exposure risk assessment and stratification, and symptom monitoring

Lynn A. Simpson MPH[1,2], Kaitlin Macdonald MSN, ANP-BC, COHN-S[3], Eileen F. Searle PhD, RN, CCRN[4,6], Jennifer A. Shearer MPH[4,5], Dimitar Dimitrov MSSE[2], Daniel Foley BA[2], Eduardo Morales PhD[2] and Erica S. Shenoy MD, PhD[6,7,8,9]

[1]Harvard Catalyst, The Harvard Clinical and Translational Science Center, Boston, Massachusetts, [2]Mass General Brigham Research Information Science & Computing, Boston, Massachusetts, [3]Mass General Brigham Occupational Health Services, Boston, Massachusetts, [4]Center for Disaster Medicine, Massachusetts General Hospital, Boston, Massachusetts, [5]Department of Emergency Preparedness and Business Continuity, Mass General Brigham, Boston, Massachusetts, [6]Regional Emerging Special Pathogens Treatment Center, Massachusetts General Hospital, Boston, Massachusetts, [7]Infection Control Unit, Massachusetts General Hospital, Boston, Massachusetts, [8]Division of Infectious Diseases, Department of Medicine, Massachusetts General Hospital, Boston, Massachusetts and [9]Harvard Medical School, Boston, Massachusetts

Abstract

Objectives: Public health authorities recommend symptom monitoring of healthcare personnel (HCP) after defined exposures to monkeypox. We report on the rapid development and implementation of mobile responsive survey solutions for notification of possible exposure, exposure risk assessment and stratification, and symptom monitoring.

Setting: An academic health center in Boston, Massachusetts, after admission of first diagnosed case of monkeypox in the United States during the current global outbreak.

Participants: Research Electronic Data Capture (REDCap) design and programmers, infection control, occupational health, and emergency preparedness specialists, and HCP with possible exposure to monkeypox.

Interventions: Design and deployment of REDCap tools to identify HCP with possible exposure to monkeypox, to perform exposure risk assessment and stratification for postexposure prophylaxis (PEP), and to conduct symptom monitoring during the exposure window. Project enhancements included dashboards for HCP tracking and short message service (SMS text) reminders for symptom monitoring.

Results: Tools to support the contact tracing and exposure investigation were deployed within 24 hours of identification of a patient with suspected monkeypox, with the full suite in production within 4 days of confirmation of the monkeypox diagnosis. Clinical follow-up of HCP was integrated into the design, and real-time versioning allowed for improvements in HCP symptom monitoring compliance and enhanced tracking.

Conclusions: During the current monkeypox outbreak, timely and comprehensive evaluation of potential HCP exposures is necessary but presents logistical challenges. Rapid development of monkeypox-specific solutions using REDCap facilitated flexibility in design and approach, and integration of targeted clinical support enhanced functionality.

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As the outbreak of monkeypox outside endemic areas continues,[1] healthcare facilities and public health authorities face the challenge of rapid identification of individuals with possible exposures to monkeypox and subsequent management. Although various definitions of exposure have been developed by the United Kingdom,[2] Centers for Disease Control and Prevention (CDC),[3] and World Health Organization,[4] the challenges of efficient notification of possible exposure, performance of a risk assessment to facilitate risk stratification, and symptom monitoring during the exposure window are substantial. Risk stratification is of immediate importance because individuals at higher risk may be offered postexposure prophylaxis (PEP) in the form of vaccination; however, the optimal window to offer vaccination is within 4 days of exposure.[5]

At Massachusetts General Hospital (MGH) and within the Mass General Brigham (MGB) system, REDCap technology was in use prior to the current monkeypox outbreak as part of planned monitoring of HCP caring for patients in our Biocontainment Unit and the Special Pathogens Unit at the Region 1 Emerging Special Pathogens Treatment Center. This technology was further developed

Author for correspondence: Erica S. Shenoy, E-mail: eshenoy@mgh.harvard.edu
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to support MGB during the COVID-19 pandemic, including additions for symptom attestation prior to on-site work for HCP[6] and symptom monitoring after COVID-19 vaccination[7–9] and survey tools for COVID-19 exposure notification, risk assessment, and stratification. REDCap is a secure, web-based software platform designed to support data capture for research studies.[10,11]

We report on the rapid development of monkeypox-specific solutions and early experience in deploying the technology including (1) notification of possible exposure, (2) exposure risk assessment and stratification, and (3) symptom check, as well as access to these tools for use by others. Each solution was additionally enhanced by clinical support teams who provided HCP with counseling and guidance.

Methods

Overall 3 tools were developed specific to monkeypox: (1) Notification of Possible Exposure, (2) Exposure Risk Assessment and Stratification, and (3) Symptom Check. The flow of data into and between these tools is depicted in Figure 1. The index patient had encounters over multiple days in ambulatory, emergency department, and inpatient settings prior to monkeypox being considered in the diagnosis and patient isolation. Although the exposure investigation included identification of exposed individuals in community settings and non-HCP in healthcare facilities, here we focus on HCP.

Determination of the at-risk population

HCP were initially identified as possibly exposed through preestablished standard processes used for contact tracing and exposure investigations at our institution, utilizing a trace within the electronic health record (EHR). This process was supplemented with interviews with managers conducted by infection preventionists (IPs) and occupational health services (OHS) clinicians. Individuals identified by the initial EHR-generated trace were cross referenced by managers with staffing schedules to identify individuals who should be added to or removed from the list. This included an assessment of individuals who do not access the patient record as part of their work responsibilities and thus would not appear on the EHR trace (eg, environmental services and nutrition services, among others). The data set included first and last exposure dates and was imported into a REDCap project and combined with additional HCP data using a custom MGB REDCap external module developed previously to support OHS operations. Additional HCP data included contact information such as e-mail address and phone numbers.

REDCap build

The tools were developed using all native REDCap version 12.0.19 software functionality except for 2 MGB custom external modules, Employee Data Sync and Custom Survey Login. External modules are individual software packages that are created and installed by a REDCap developer or administrator. REDCap provided technical support for the core project needs; however, due to the need for rapid assessment to deploy PEP and the complexity of exposure assessment, the establishment of a team of clinicians to support HCP use of all 3 tools was determined to be necessary, and a call center was established. The call-center staff were identified and trained via a labor pool that was established as part of the MGH hospital incident command system, which was mobilized to support this response. External modules extended the functionality of REDCap and, for this project, enhanced data workflow, and allowed call-center staff to login and initiate a record on behalf of the HCP.

The REDCap toolkit consisted of multiple surveys, e-mail and SMS notifications, and an advanced approach combining custom logic utilizing @CALCTEXT action tag with nested "if" statements for providing dynamic feedback to inform HCP of the results of their exposure risk assessment and stratification and symptom check. For symptom check compliance, the call center utilized an Excel file (Microsoft, Redmond, WA) that was updated daily with HCP data exported from REDCap via an application programmable interface (API).

Call-center staffing

The call center was staffed by clinicians identified through labor-pool efforts and included registered nurses and nurse practitioners. For HCP identified as eligible for PEP, a team of physicians supported the call center and provided one-on-one counseling to HCP. For initial risk assessment and stratification, the call center was staffed from 7:00 A.M. to 9:00 P.M. For symptom monitoring support (because employees were required to complete their survey anytime between 4:00 A.M. and 12:00 noon daily), the call center was staffed from 1:00 P.M. to 5:00 P.M., 7 days a week. For both activities, after hours on-call coverage through the infection control and occupational health department was available.

This project was conducted as part of infection control and occupational health services and was not subject to human subjects review.

Results

Within REDCap, 3 integrated modules were developed. Detailed specifications of the tools, including an implementation guide, have been provided in the Supplementary Material (online), including instructions on accessing the project at REDCap and GitLab.

Notification of Possible Exposure tool

To both identify HCP who could have been exposed to the index patient and to exclude HCP with no possible exposure, all HCP on the comprehensive trace list received the Notification of Possible Exposure survey tool.

The trace list included first and last exposure dates and was exported from the EHR to an Excel file and then imported into REDCap using the Data Import tool. These data were combined with additional HCP data, e-mail address, and phone numbers, using the custom MGB REDCap external module: Employee Data Sync. Once an e-mail address was available, REDCap automatically sent an e-mail to the HCP with information about the type of exposure, dates, and locations and allowed the HCP to answer a preliminary exposure question (yes or no). If the HCP answered "yes" to the preliminary question, they were enrolled in a symptom-monitoring tool, Symptom Check. This enrollment occurred prior to exposure risk assessment and stratification. Within ~24 hours of preliminary diagnosis of the patient with monkeypox, the Notification of Possible Exposure surveys were created and e-mailed to the first set of identified HCP, and HCP began to respond immediately.

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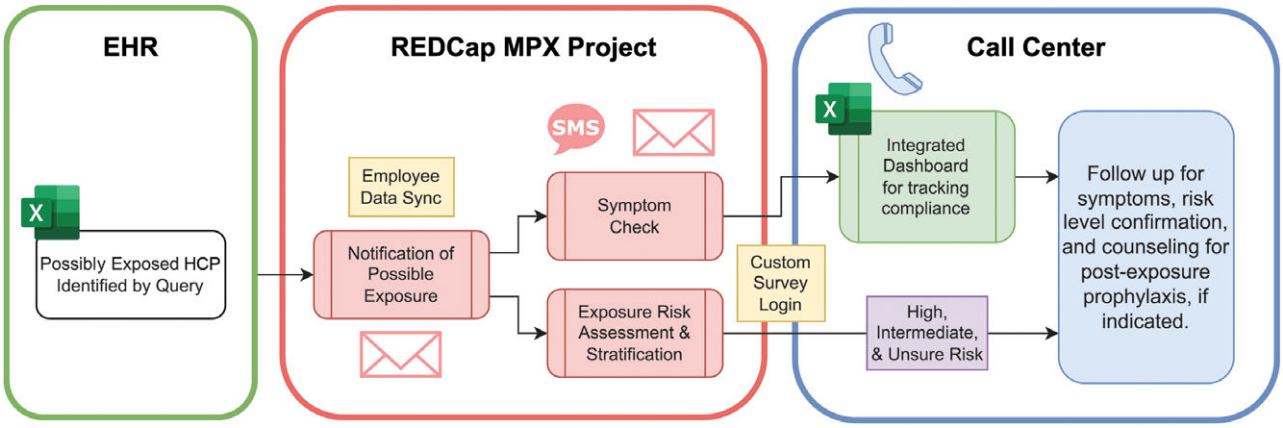

Fig. 1. Data architecture of MGH monkeypox REDCap tool kit. Contact trace data from the electronic health record (EHR) were extracted from MS Excel and imported into REDCap. HCP received the Notification of Possible Exposure survey. If they attested "yes," they proceeded to the Symptom Check and Exposure Risk Assessment and Stratification surveys. Call-center staff utilized the integrated dashboard to track compliance and establish follow-up for symptoms, as well as risk-level confirmation and counseling for postexposure prophylaxis, if indicated. The REDCap external modules Employee Data Sync and Custom Survey Login were used to enhance project functionality. EHR, electronic health record; HCP, healthcare personnel; MPX, Monkeypox; SMS, short message service.

Exposure risk assessment and stratification tool

Once HCP had been identified as meeting a preliminary definition of monkeypox exposure based on response to the Notification of Possible Exposure, the next step was risk assessment and classification. Applying a framework based on the CDC guidelines[3] and developed in collaboration with the Massachusetts Department of Public Health, the risk stratification was finalized on May 20, 2022, and was integrated into the REDCap design over the next day and a half to complete the addition on May 22, 2022. HCP were presented with a series of exposure scenarios and were asked to identify which one(s) applied to their interactions with the index patient. Based on their responses, each HCP was categorized as high, intermediate, or low or uncertain risk. Individuals who answered "no" to all questions were recategorized as no risk and were removed from the investigation and from the symptom check. Individuals categorized as unsure were contacted by the call-center staff to review their case and determine their risk classification.

The survey displayed each category's questions as a progression. Starting with the high-risk category questions, if HCP indicated "yes" or "unsure," they did not proceed to the next category and questions were not displayed for intermediate or low or uncertain risk. If HCP indicated "no" for the high-risk category, they proceeded to intermediate, and so on. Multiple hidden fields on the survey were used to calculate the risk category and number of days from last exposure (ie, the exposure window). These derived variables were used to display specific text to the HCP utilizing @CALCTEXT action tag with nested "if" statements (ie, whether PEP was recommended).

Symptom-check tool

Individuals identified in high, intermediate, and low or uncertain risk classifications required symptom monitoring for 21 days from their last exposure according to public health guidance. HCP at our healthcare facility were required to attest to be asymptomatic with respect to COVID-19 symptoms prior to on-site work.[6] However, the symptoms from monkeypox included those that were not part of our standard COVID-19 symptom screening, and the immediate actions based on a positive symptom screen differed.

The Symptom Check survey included information about symptom monitoring for monkeypox, the HCP symptom monitoring start and end date, and asked, "Since your last survey, have you had the following symptoms?" Symptom questions included fever, chills, new lymphadenopathy, and new skin rash. If the HCP answered yes to any symptom, the survey would display instructions to self-isolate and contact OHS immediately. This information was also automatically e-mailed to HCP. Reports were available in REDCap to OHS and the call-center staff to immediately identify any HCP reporting symptoms. Symptom-check compliance was encouraged using multiple methods such as e-mail, calls, and text messaging.

Compliance with symptom monitoring, which was required regardless of on-site work, was assessed: 67.0% of HCP were compliant with their symptom check 100% of surveyed days. Among the remaining HCP, the symptom check was missed, on average, for 4.1 days during the exposure window to date; these HCP received follow-up calls from call-center and OHS staff. The symptom-check start dates among employees varied, and many last-exposure dates were before the survey was implemented. Therefore, not all employees were required to complete the full 21 days. HCP who continued to provide care to the patient were required to perform symptom monitoring for 21 days after their last contact with the patient. HCP caring for a patient with monkeypox in the absence of any identified breaches in PPE were considered to be in the low or uncertain category according to public health authorities.

Integrating clinical follow-up into design

REDCap provided technical support for the core project needs. However, due to the need for rapid assessment to deploy PEP and the complexity of exposure assessment, establishment of a call center was needed. This workflow addressed HCP with limited technical proficiency, language barriers, or both, as well as focused review of HCP reporting high- or intermediate-risk exposures who may qualified for PEP.

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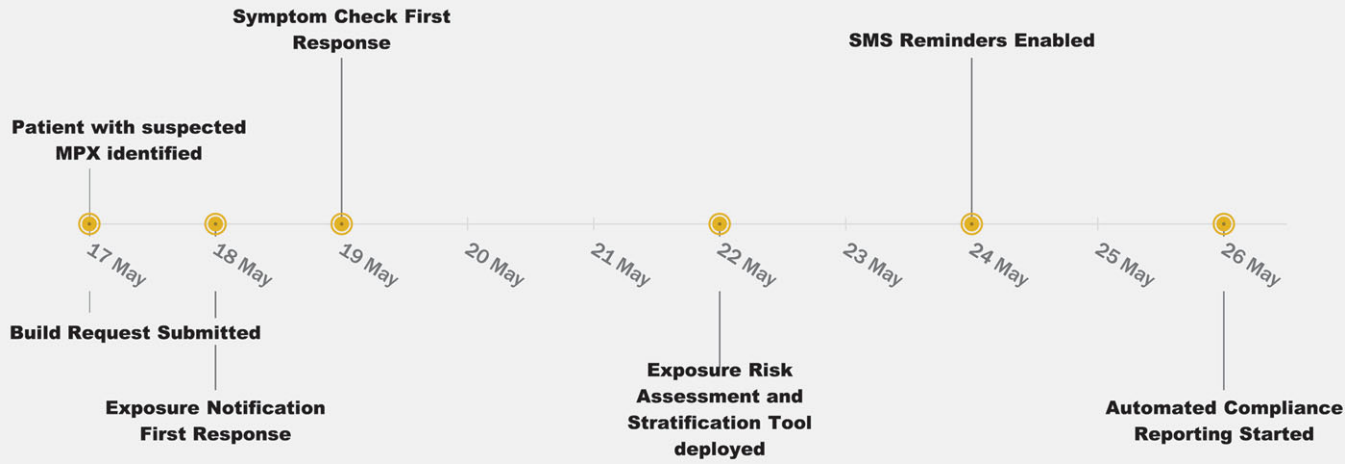

Fig. 2. Timeline of implementation for MGH Monkeypox REDCap tool kit. Within hours of identification of a suspect monkeypox case at Massachusetts General Hospital, a request for REDCap build was submitted. The Notification of Possible Exposure tool was deployed within 24 hours of preliminary diagnosis of monkeypox, and the symptom-check tool shortly thereafter, with first responses received within 24 hours of confirmation of monkeypox diagnosis. The Exposure Risk Assessment and Stratification tool was deployed on May 22, 2022, followed by symptom-check reminders via SMS text on May 24 and automated compliance reporting on May 26, 2022. MPX, Monkeypox; SMS, short message service.

Timeline of implementation and updating in real time

The initial identification of a possible case of monkeypox occurred on May 17, 2022, with confirmation by the CDC on May 18, 2022. The first notification of possible exposure was sent that evening, on May 18, 2022, and initial symptom checks began the evening of May 19, 2022. Upon confirmation of risk-exposure categorization and stratification with Massachusetts Department of Public Health on May 20, 2022, the first exposure-risk assessments and risk stratifications were deployed via telephone call on May 22, 2022 (Fig. 2).

Updating and maintaining a change history of assessments was included as part of the strategy to maintain data integrity and reporting consistency. The symptom check was reduced from twice daily to once daily during the study period, and additional functionality was added to support HCP, including SMS (short message service, or text message) reminders and expansion of the call center's scope. Among individuals enrolled in Symptom Check, approximately 25% chose to receive notifications by short message service (SMS text) in addition to e-mail. Adding in the SMS option for daily reminders resulted in an increase in compliance. HCP who enrolled in SMS text messaging had an average daily compliance rate of 94.9%, and those only receiving e-mail reminders had a compliance rate of 88.4%.

Support for HCP with limited technical proficiency or language barriers

To identify HCP who were anticipated to require assistance with symptom monitoring and risk assessment, managers were asked to proactively identify HCP on the list of exposed individuals with any of the following: limited technical proficiency, minimal use of work or home e-mail, or limited language proficiency. HCP identified through this approach were prioritized for call-center outreach.

Support for HCP with reported high- and intermediate-risk exposures

HCP reporting high- and intermediate-risk exposures received a prompt upon survey completion indicating that they would receive follow-up by call-center clinicians to assist in exposure verification and categorization and to provide PEP counseling, when indicated.

Integrated dashboard for tracking

For symptom-check compliance, the call center utilized an Excel file that was updated daily with HCP data exported from REDCap via an application programmable interface (API). Survey data collected in REDCap was loaded into an Excel file via a Power Query accessing the REDCap API. A transformation of the data was preprogrammed to produce a final data set of noncompliant HCP and their associated contact information. Call-center staff were trained to easily perform the extractions, which required no knowledge of coding, advanced Excel knowledge, or authentication in REDCap. Call-center staff were trained to document whether a phone call was made and to add any notes that may improve on future outreach efforts (ie, if HCP was working night shifts, the best time to reach them during the day or if the HCP had requested changing the e-mail to which notifications were being sent).

Additionally, many reports were created within REDCap that allowed stakeholders and technical staff the ability to monitor the actual symptom data being generated. For example, a report was created to identify any HCP who had reported being symptomatic at their latest assessment; this generated a work queue for call-center staff to prioritize outreach to HCP who required immediate follow-up.

Discussion

Timely and comprehensive evaluation of exposures, including risk assessment and ongoing symptom monitoring, is necessary and can present logistical challenges, especially in the setting of an emerging outbreak with evolving definitions of exposures and urgency to offer and administer PEP to a subset of exposed individuals. We report on rapid development of monkeypox-specific solutions using REDCap and early experience in deployment.

Utilizing REDCap as the base technology facilitated flexibility in design and approach, and integration of targeted clinical support enhanced the functionality of the tools developed. The technology

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used by the clinical team supporting HCP had to be intuitive, accessible in real time by multiple remote staff. It had to include search abilities for HCP records and a data-entry interface. Using another, previously developed, custom MGB REDCap external module, assigned team members were able to access a user-friendly interface to search for HCP records within the REDCap project. Proactive identification of HCP who may benefit from clinical support, either based on technical proficiency (including both access to email and comfort with survey completion) or language barriers, or for whom counseling for PEP is indicated, was a critical component of the approach. As the tools continue to be deployed, workflows including clinical support can continue to be optimized for efficiency.

The MGH Monkeypox REDCap tool kit and any custom external modules code are available to other organizations to use (Supplementary Material online). Customization may be indicated if an organization or entity is adapting local public health definitions of exposure or follow-up based on responses. The overall strategy of the solution design and development was collaborative, with different developers creating components of the solution simultaneously by focusing on specific areas: survey question formats, automated notifications, authorized access, and reporting. Given the increase in compliance observed with the SMS option that became available partially through the deployment, it is recommended that such features be made available at initiation to support HCP.

In summary, there was an immediate need to operationalize exposure notification, risk assessment and stratification, and symptom-monitoring technology within days of identification of a monkeypox case. This was possible due to the modularized nature of REDCap, the concise communications from the teams involved, including OHS and the infection control team on their system needs, and the experience of the development team in creating similar tools prior to and during the COVID-19 pandemic to support operations and research efforts. We anticipate that sharing this approach and the tools employed may assist others in similar circumstances, and lead to advancements and improvements. These tools also have broad applicability outside healthcare settings, where many of the same needs have been identified in the response to community spread of monkeypox.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/ice.2022.167

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Conflicts of interest. All authors report no conflicts of interest relevant to this article.

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