Brief Communication

An application to support COVID-19 occupational health and patient tracking at a Veterans Affairs medical center

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ABSTRACT

Objective: Reducing risk of coronavirus disease 2019 (COVID-19) infection among healthcare personnel requires a robust occupational health response involving multiple disciplines. We describe a flexible informatics solution to enable such coordination, and we make it available as open-source software.

Materials and Methods: We developed a stand-alone application that integrates data from several sources, including electronic health record data and data captured outside the electronic health record.

Results: The application facilitates workflows from different hospital departments, including Occupational Health and Infection Control, and has been used extensively. As of June 2020, 4629 employees and 7768 patients have been added for tracking by the application, and the application has been accessed over 46 000 times.

Discussion: Data captured by the application provides both a historical and real-time view into the operational impact of COVID-19 within the hospital, enabling aggregate and patient-level reporting to support identification of new cases, contact tracing, outbreak investigations, and employee workforce management.

Conclusions: We have developed an open-source application that facilitates communication and workflow across multiple disciplines to manage hospital employees impacted by the COVID-19 pandemic.

Key words: coronavirus infections, workflow, systems integration, occupational health

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INTRODUCTION

Background and significance

The incidence of coronavirus disease 2019 (COVID-19) in healthcare personnel has been reported to vary between 3.8% and 38.9%. Multiple strategies have been proposed to manage and protect these critical individuals during the pandemic. Risk reduction strategies involve using policies, processes, and technologies to address screening, testing, monitoring, and quarantining. Characterizing the workforce by occupation, location, symptoms, exposures, and test results is critical to formulate and implement risk reduction strategies, and these data vary over time. The fragmentation of information challenges occupational health staff, infection prevention nurses, and clinical providers to effectively understand the pandemic’s impact on the workforce of an institution in real time. There is a growing number of technology platforms and applications to augment the workflow of screening the patient population, tracking infections, monitoring supplies, and self-triage to support clinical operations. There is also an increasing number of applications that focus on categories such as “diagnosis, prevention, treatment, adherence, lifestyle, and patient engagement.” Although these technologies tackle many important public health concerns, they have not provided adequate support for a comprehensive healthcare system’s occupational health response to the pandemic.

From March through May of 2020, Boston was among the most significantly affected metropolitan areas in the United States with new COVID-19 cases. Several organizations such as The New York Times and Johns Hopkins University report data on COVID-19 cases and related deaths, facilitating understanding of the epidemic at a national and state level. Dashboards such as the COVID-19 Watcher have been created to quickly ascertain information such as the number of cases in Boston and how the city compares to other cities as regards to prevalence of COVID-19. However, it is extremely difficult to quickly determine how many patients and employees are diagnosed with or potentially to COVID-19 infections on a daily basis at an institutional level. Applications have been developed that use information and configurable tools from the electronic health record (EHR) to track persons under investigation and infected patients in hospitals, but questions related to potential exposures and testing of employees are often difficult to answer quickly because complete employee health records are not routinely found in the hospital’s EHR.

OBJECTIVE

We describe our COVID-19 Data Management Platform (COVIDDMP), a flexible informatics solution to facilitate communication and workflow across multiple disciplines in response to the rising occupational exposure to COVID-19. We discuss how our application can quickly adapt to the evolving policies and procedures for protecting healthcare workers as the pandemic progresses. The application is available as open-source software for use by other healthcare systems (https://github.com/bostoninformatics/CovidDMP). The open-source approach allows us to create a flexible framework that can be adapted to integrate data from different sources and interoperable with a range of EHR platforms.

MATERIALS AND METHODS

The Veterans Affairs Boston Healthcare System (VABHS) comprises 3 campuses and 5 Community-Based Outpatient Clinics, providing a comprehensive range of services including primary and specialty care, surgical and emergency services, and short-term and long-term community living centers. Like other healthcare centers throughout the Department of Veterans Affairs (VA), VABHS uses the Veterans Health Information Systems and Technology Architecture (VistA) as the EHR. Real-time access to VistA data by third-party applications is tightly controlled, but VistA data from all VA medical centers are collated in a large data warehouse, the Corporate Data Warehouse (CDW), and updated nightly. Given the rapid development cycle and the need for real-time data, instead of seeking changes to VistA, we chose to develop a stand-alone, open-source platform that integrates data captured outside of the EHR and data exported from the EHR. This added the capability of a 3 times per day VistA extract, utilizing FileMan, the database management system of VistA, to extract near real-time reports, and user-entered data, to the nightly data extract from CDW. Clinical stakeholders determined a 3 times per day frequency of FileMan reports as being adequate for their workflow. Our approach combines a Python-based engine and graphical user interface in the form of a dashboard. The application is enhanced with access controls and security and integrates with an underlying pipeline that accomplishes data source harmonization and integration using R (version 3.6.3, R Foundation for Statistical Computing, Vienna, Austria) and SQL pipelines (Figure 1).

In order to develop and deploy COVIDDMP while policies and procedures are evolving, a rapid and dynamic development structure was put in place. This involved early morning 30-minute scrums with the development team and late afternoon 30-minute check-ins with our stakeholders to update on progress and clarify outstanding requirements. The development team consisted of data scientists, front-end and database engineers, report and quality assurance specialists, and system administrators led by technical architects and project managers. The stakeholders were clinicians, nurses and technical support staff from VABHS, primarily from occupational health, but other teams such as primary care and infectious disease were involved as well. To track requirements, implement a software development life cycle, and facilitate version control, the VA’s GitHub platform was utilized. This allowed technical architects and project managers to create issues describing and prioritizing the requirements and bugs, while developers check in their code and branch out to build features. When features passed quality assurance the code was merged back in after careful review in a pull request by one of the technical architects. During the initial phases of deployment, daily deployment occurred, which stabilized over time to a weekly deployment cycle.

RESULTS

Application components

The resulting COVIDDMP consists of 4 main parts: the data extraction pipeline, the database, the GUI application, and the integrated authentication. The data extraction pipeline has been written in R and SQL. It runs overnight to extract new CDW data and every 15 minutes between 7 AM and 7 PM to verify if new FileMan data are available to be integrated into the COVID-19 database. The data extracted from CDW and the FileMan report include new tests, test results, and persons under investigation. In addition to this, the pipeline pulls data on the patient or employee including contact information, hospitalization status, ward location, and the Patient Aligned Care Team. The Microsoft SQL Server (version 11.0.7001, Micro-
The COVIDDMP database maintains this extract, assigns unique person identifiers to maintain data integrity, and stores a history of all data entered manually by the user. Users are able to add new persons to the database and update or correct information on existing persons. The COVIDDMP assumes that data entered or corrected by the user takes precedence. If more recent data are available from the extract, this is shown separately. This allows users to update the data in real time and not have to wait until the next data pull. This increases efficiency and improves clinical decision making for the healthcare personnel accessing the database. To support rapid development and changing requirements, the COVIDDMP’s database table structure follows a relatively flat, non-normalized model, relying on view structures to provide the most recent data.

The Python-based GUI application contains Search, Add/Edit, and Reporting tabs. The Search tab allows users to search for their person(s) of interest based on dropdown variables such as type (e.g., patient or employee) or ward location and personally identifiable information. Frequently used settings are prepopulated and available as options under the Search tab. Additionally, the Search tab allows the user to track when persons were contacted, drill down to more detailed data or edit specific data. The Add/Edit tab allows the user to add new persons into the application. Any data that is already available in the CDW is preloaded in the application, including contact information, demographic details, tests, symptoms, and other related areas. The Reporting tab displays reports described in more detail subsequently.

### Primary care and occupational health workflows

The platform was designed to facilitate multiple workflows from various hospital departments. We started with a results tracking workflow for primary care then expanded functionality for Occupational Health (OH). OH has 3 primary workflows currently supported by the platform: (1) ensure that employees with positive COVID test results are not at work; (2) return to work those who have been out on quarantine for more than 14 days; and (3) advance those on restricted duties to full duty when clinically appropriate based on guidelines from the United States Centers for Disease Control and Prevention. Using the information captured about the
employees such as symptoms, test results, work location, and occupation, a quarantine plan can be conveyed to the employee and supervisor as well as managed on the platform. An algorithm was created to expedite the assignment of a COVID status for an employee based on the results of testing such as “COVID Positive Retest Pending” or “COVID Positive 2nd Negative.” A report can be generated by the OH team to show which employees have been out longer than 14 days and have not yet returned to work after 2 negative tests. Employees with restricted duties are captured in the application along with notes from the OH team. Discussions are ongoing about developing workflow features to manage duty restrictions. These features allow the OH team to efficiently allocate which employees need reassessment.

Outbreak investigations report
Our Infection Control staff requested a patient level report that would support them in identifying potential outbreaks at the hospital over a designated time frame. This requires the ability to identify on which day and in which ward location of the hospital a patient first tested positive and any subsequent locations to which the patient was transferred. We configured the report to start 48 hours before illness onset per Centers for Disease Control and Prevention guideline. Because COVIDDMP integrates data from multiple VA facilities within the same interface, it allows for tracking of patients who move across different VA facilities.

Director’s daily briefing report
The VABHS leadership requested a daily briefing classified by clinical staff, patients, and the unique category of employees who are also veteran patients. This report is used to monitor healthcare system capacity, adjust staffing needs, and provide published reports to the healthcare system staff (Table 1). Data are provided in aggregate counts of every 24-hour period, as well as cumulatively since March 1, 2020.

Application usage
Since initial deployment the week of March 16, 2020, the application has been used extensively by staff from OH, Infection Control, Primary Care, and other departments. In total, 4629 employees and 7768 patients and have been added for tracking by the application, with 44-759 employees and 128-871 patients newly added each week between March 16 and June 8, 2020 (Figure 2). On average, there are 95 ± 192 updates per day to symptoms, tracking, contact, or other information. Altogether, between April 2 and June 20, 2020, the application was accessed over 46,000 times. In addition to direct usage of the application, data produced by the application are broadly distributed; for example, counts from the Director’s Daily Briefing Report (see previous) are distributed to all VABHS employees and affiliates every weekday by email.

DISCUSSION
Protecting healthcare personnel during the COVID-19 pandemic is critical both for individual employee health and to enable continuity of operations. This is crucially important in cities with high prevalence of the disease.

The data captured by our platform offer an opportunity to create patient-level reports in an effort to support VABHS hospital staff and leadership with COVID-19 monitoring and screening protocols. Integrating data entered by users into the dashboard application with automated data captured by the VA electronic medical record has provided both a historical and real-time view into the operational impact of COVID-19 at the Boston VA. It has informed our mitigation efforts, and policy decisions on the necessary infrastructure for providing detailed reports for various stakeholders with quick turnaround. Our database contains essential COVID-19 information on patients and employees such as clinical symptoms, known exposures, testing history, testing locations, hospitalizations and death, current patient locations, and quarantined employees. We have begun to use this data to develop aggregate and patient-level reports to support the VA’s efforts in identifying new cases, contact tracing, outbreak investigations, and employee workforce management.

On the one hand, the primary limitation of the platform is lack of full integration with the EHR, which necessitates a workaround to address data latency. On the other hand, this lack of integration substantially increases the generalizability of the system to other healthcare
systems, as COVIDDMP can be used in any healthcare system after an appropriate script is written to provide input data in the expected format. Further development in FileMan to automate the frequency of data extract will allow additional latency reduction.

CONCLUSION

We have developed an informatics solution that facilitates communication and workflow across multiple disciplines to manage hospital employees possibly impacted by the COVID-19 pandemic. Our solution is adaptable to evolving policies and procedures for protecting healthcare personnel as the pandemic progresses, and it is available as open-source software for use by other healthcare systems.

AUTHOR CONTRIBUTIONS

NRF, DCE, and NVD led application development. NRF, DCE, JL, TCF, F-CS, VN, NL, RZ, SD, SJM, AA, SDG, PC, and SBJ implemented the application and supporting infrastructure. RBH, MAP, RSS, DJT, JAD, JMS, SE, BC, MTB, and NVD provided requirements. NRF, DCE, JL, TCF, F-CS, RBH, VN, NL, RZ, SD, SJM, SDG, and NVD drafted the manuscript, and all authors critically reviewed the manuscript.

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CONFLICT OF INTEREST STATEMENT

None declared.

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