Case Report

Innovative use of health informatics to augment contact tracing during the COVID-19 pandemic in an acute hospital

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ABSTRACT

This case report describes the innovative design and build of an algorithm that integrates available data from separate hospital-based informatics systems, which perform different daily functions to augment the contact-tracing process of COVID-19 patients by identifying exposed neighboring patients and healthcare workers and assessing their risk. Prior to the establishment of the algorithm, contact-tracing teams comprising 6 members would spend up to 10 hours each to complete contact tracing for 5 new COVID-19 patients. With the augmentation by the algorithm, we observed ≥60% savings in overall man-hours needed for contact tracing when there were 5 or more daily new cases through a time–motion study and Monte Carlo simulation.

This improvement to the hospital’s contact-tracing process supported more expeditious and comprehensive downstream contact-tracing activities as well as improved manpower utilization in contact tracing.

Key words: COVID-19, contact tracing, informatics system, data mining algorithm, improved manpower utilization

INTRODUCTION

Contact tracing is the process of identifying, assessing, and managing people who have been exposed to a virus to prevent onward transmission.¹ As Singapore is a densely populated city–state, timely identification and isolation of people exposed to the virus to reduce further spread through efficient and effective contact tracing is a key national strategy in the management of the COVID-19 pandemic.² Government agencies and healthcare institutions carry out contact tracing in an integrated manner for all COVID-19 patients.

The contact-tracing process in our hospital and how it interfaced with the Ministry of Health’s community-level contact tracing is illustrated in Figure 1. The process was initiated at the hospital upon the diagnosis of a COVID-19 patient. As only 1% of cases have an incubation period longer than 14 days,³ the activity map—which comprised minute-to-minute details on the COVID-19 patient’s activities for the period starting from 14 days before the onset of symptoms to the point the patient was admitted to the designated COVID-19 facilities in the hospital—was obtained through a phone interview. The activity map included specifying the time and areas the patient had been to, the people he/she had encountered, and their contact information. In order to identify the healthcare workers (HCWs) and other patients who were in contact with the index case during this period, the clinical notes, patient movement charts, other patients’ locations, and staff rosters were reviewed and cross-referenced by the contact-tracing team.

Subsequently, these preliminarily identified HCWs were interviewed via telephone to verify their contact with the COVID-19 patient, the nature of their exposure, and the personal protective
equipment they were attired in to assess their risk of contracting the virus. This was a time-consuming and labor-intensive investigative process. Healthcare workers and other patients assessed to be at a higher risk of infections based on the prevailing infection control guidelines were isolated at home or in the wards and monitored for symptoms.

The hospital’s contact-tracing process must be expeditious and comprehensive to support downstream activities in the community as well as the hospital itself. The information from the activity mapping and contact tracing of other patients and HCW was shared with Ministry of Health within 24 hours, so that follow-up actions of community-level contact tracing and isolation of the at-risk groups would be timely. This benchmark was in line with the US Center for Disease Control and Prevention Interim US Guidance for Risk Assessment and Management of Healthcare Personnel with Potential Exposure to COVID-19 which states that the care team contact-tracing process should be completed within 24 hours of each case’s identification. Data scientists, operations managers, and clinical staff worked closely to integrate data available in the informatics systems with human-based interviews to improve the timeliness, comprehensiveness, and efficiency of the contact-tracing process.

**MATERIALS AND METHODS**

A data-mining algorithm was developed to integrate the available data from hospital-based informatics systems that perform various day-to-day functions to augment the contact-tracing process of COVID-19 patients in identifying exposed HCWs and neighboring patients.

Data from 5 separate informatics systems used by our hospital in its day-to-day operations were utilized in this algorithm. These systems were designed to serve different functions and were not primarily contact-tracing tools. The systems were: (1) the clinical electronic medical records system, Sunrise Clinical Manager, that captured all relevant clinical information including orders and results of diagnostic tests; (2) the Systems, Applications, and Products inpatient module that recorded patient movements from registration at the hospital’s Accident and Emergency Department (A&E) to inpatient admission and subsequent discharge; (3) the real-time locating system that tracked the movement of every patient upon admission through a radio-frequency identification tag; (4) the outpatient appointment system that captured specialists outpatient clinic (SOC) operational data; and (5) the radiology information system that captured radiological, operational, and diagnostic data.

The SingHealth-IHiS Electronic Health Intelligence System (eHINTS) is an enterprise analytic platform that serves both analysis and reporting needs. It features a single enterprise data repository that is refreshed daily through integrating data from multiple healthcare transactional systems, including the aforementioned 5 informatics systems. Data integration into the repository starts daily at midnight and is completed at about 6 am every morning.

The algorithm was scripted to extract the information required in a sequential manner from the eHINTS repository data derived from these 5 source systems to meet the contact-tracing requirement. The algorithm schema was segmented in 4 stages (See Figure 2): the first stage identified all A&E visits, inpatient episodes, and SOC visits of the patient in the past month; the second stage mapped the real-time locating system data and generated a navigation table of the patient’s journey as an inpatient; the third stage captured all other A&E, Inpatient, and SOC patients within the premises during the same duration of the COVID-19 patient’s visit; finally, the fourth stage identified all healthcare staff who could have come into contact with the COVID-19 patient using clinical documentation entries and orders placed in the EMR, and these systems, as a proxy.

The algorithm would run and generate a customized contact-tracing report for each COVID-19 patient providing the following information for the period the patient was in the hospital: the patient’s presence in the various areas and the time period, patients at the same area during the same time period, and HCWs who attended to
the patient at the various areas. The contact-tracing team then scoped the contacts to be interviewed based on this comprehensive report. HCWs who attend to more than 1 COVID-19 patient will be reflected as a contact in each of their reports.

The algorithm and contact-tracing reports were piloted and fine-tuned for the first 50 COVID-19 positive patients admitted to our hospital. It was evaluated for its accuracy and effectiveness in improving the contact-tracing process.

A time-motion study was conducted comparing the time and manpower needed for the nonalgorithm-augmented contact-tracing workflow versus the algorithm-augmented workflow for a few days that have the equivalent number of newly diagnosed COVID-19 patients for up to 5 patients per day. Utilizing the base data from the time-motion study, a Monte Carlo simulation with MS-Excel Solver tool for various scenarios of multiple new COVID-19 patients on a day was conducted.

RESULTS AND ANALYSIS

We observed significant time savings for our staff performing the detailed activity mapping and the report gave a reliable validation reference for the final contact-racing reports. (Table 1) The model demonstrated significant time and manpower savings to complete the contact-tracing process, especially for days with higher volume of new COVID-19 patients detected. Effectively, we observed ≥60% savings in overall man-hours needed to complete contact tracing when there are 5 or more new daily COVID-19 patients. This algorithm was subsequently applied for all COVID-19 patients to augment the contact-tracing team.

DISCUSSION

In the COVID-19 pandemic, expedient identification of individuals with significant exposure to COVID-19 patients is a key strategy in breaking the chain of transmission and flattening the epidemiological curve. A literature review of the databases of PUBMED, Cochrane, and Embase, with the search terms of “contact tracing” and “COVID-19” did not return any studies that described an integrated use of hospital informatics systems to augment contact tracing.

With the increasing number of new cases diagnosed daily, the capacity for timely contact tracing would have to be met by increasing staff numbers to perform interviews of the COVID-19 patient and their contacts. The algorithm’s value-add was the rapid and comprehensive identification of the COVID-19 patient’s activity as well as other individuals at risk (eg, HCWs and other patients). The contact-tracing staff could then focus on the interviews and risk assessment of the contacts. As a result of better efficiency in manpower utilization, we are also able to maintain a lean contact-tracing team despite the hospital experiencing an increasing number of COVID-19 patients.

Limitations

The algorithm was limited in real-time data content because of its dependency on the eHINTS data repository, which is designed as a midnight snapshot server with daily data uploads scheduled at 23:59 hours. Hence, for patients who presented at A&E and admitted on the same day, the contact-tracing reports were supplemented with screenshots from the live EMR system. The time needed for this manual sequence was negligible and can be automated in future.
CONCLUSION

Close interaction between the data scientist, operations managers, and clinical staff were essential in the design, improvement, and operationalization of the aforementioned contact-tracing model that integrated the use of data from informatics systems with interview-based contact tracing by the contact-tracing teams. This model delivered faster contact tracing in the hospital, hence supporting more expeditious and comprehensive downstream contact-tracing activities, as well as improved manpower utilization in contact tracing.

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AUTHOR CONTRIBUTIONS

All 3 authors meet the 4 criteria of authorship in accordance with ICMJE guidelines. VN designed the algorithm in collaboration with the clinical lead and contact-tracing teams. PBH was the clinical lead of the contact-tracing teams and guided the design of the algorithm in collaboration with the data scientists. SC oversaw the integration of the data, contact-tracing process, and operational activities of the contact-tracing teams. All 3 authors drafted the manuscript, approved the final version to be published, and agreed to be accountable for all aspects of the work.

CONFLICT OF INTEREST STATEMENT

None declared.

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