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Concise Communication

Healthcare personnel interactive pathogen exposure response system

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Abstract

Exposure investigations are labor intensive and vulnerable to recall bias. We developed an algorithm to identify healthcare personnel (HCP) interactions from the electronic health record (EHR), and we evaluated its accuracy against conventional exposure investigations. The EHR algorithm identified every known transmission and used ranking to produce a manageable contact list.

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Exposure investigations are regularly conducted in the hospital setting for many diseases, including tuberculosis and more recently severe acute respiratory coronavirus virus 2 (SARS-CoV-2). However, conventional exposure investigations are time-consuming, prone to recall bias, and labor intensive for the infection prevention and control (IPC) team tasked with ascertaining patient and healthcare personnel interactions.[1]

Timely and effective exposure investigations and notification of possible exposures are essential to prevent onward transmission. The electronic health record (EHR) serves as a chronicle of healthcare personnel (HCP) and patient interactions and can aid more effective exposure investigations.[2–5] Using methods to analyze clinical EHR data that previously demonstrated the importance of HCP–patient contacts in transmission of vancomycin-resistant *Enterococcus*,[6] we developed an algorithm to both identify index patient–HCP interactions and rank those interactions based on the likelihood of exposure. We retrospectively applied this EHR algorithm to findings from real-world coronavirus disease 2019 (COVID-19) exposure investigations conducted in our hospital to evaluate the potential of integrating these algorithms into IPC practice.

Methods

We compared EHR-based findings to 7 conventional exposure investigations conducted between November 1, 2020, and February 1, 2022, at The Johns Hopkins Hospital (JHH), a 1,095–bed, academic, tertiary-care center in Baltimore, Maryland. Exposure investigations were conducted on all hospitalized patients who tested positive for SARS-CoV-2 and who were not already appropriately isolated.[7] All admitted patients were tested on admission for SARS-CoV-2 and every 7 days while hospitalized or through provider discretion.[8] To identify potentially exposed HCP, information on the index patient, including the infectious period and exposure definition, was sent by e-mail to the managers of HCP who may have interacted with the patient. The exposure time frame was defined as 48 hours before symptom onset or positive test if asymptomatic. Managers were responsible for identifying potentially exposed HCP within their team. HCP were defined as exposed if their interaction with the index patient included the following: (1) performing an airborne-generating procedure without respirator and eye protection, (2) being within 2 m (6 feet) of an unmasked patient for >15 minutes without a respirator, or (3) being within 2 m (6 feet) of a patient for >15 minutes without a mask or eye protection. If an HCP tested positive after an exposure, genomic sequencing was performed, if samples were available, to confirm transmission.

The JHH uses the Epic EHR system (Epic Systems, Verona, WI), and the algorithm uses data from the clinical reporting database. Potentially exposed HCP were detected based on both time-stamped data that are highly likely to be associated with an actual physical interaction between a patient and an HCP (eg, medication administration or laboratory specimen collection[6]) and non–time-stamped EHR records (eg, care team assignment). For time-stamped data, events close in time (<15 minutes) were concatenated to estimate time spent with patients with increasing time given a higher "contact score." For non–time-stamped events, each was mapped to a contact

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Table 1. Comparison of Exposure Investigation Methods

Exposure Investigation	No. of Exposed HCP Identified by Traditional Investigations	No. of Exposed HCP Identified by the EHR	% of HCP Identified Through Traditional Methods also Identified by the EHR	No. of Exposed HCP with Subsequent Positive Tests	Comments/Findings
1	12	74	91.6	0	Lead clinical RN not identified through the EHR
2	6	82	16	0	All HCP not identified through the EHR were EVS staff
3	10	82	80	0	Student, RN not identified through the EHR
4	15	55	73	0	Unit associate, PA resident, Customer service representative not identified through the EHR
5	23	98	65	7	Unit associate, RN, nutrition, medical coordinator, and transport not identified through the EHR
6	9	119	100	3	All HCP identified
7	4	50	100	0	All HCP identified

Note. HCP, healthcare personnel; EHR, electronic health record; RN, nurse; EVS, environmental services; PA, physician assistant.

type and assigned a point if the contact type was more likely to be associated with a physical interaction (eg, transport) than ones less likely (eg, care team assignment). The sum of each events contact score was used to rank the potential HCP exposure, with higher scores suggesting increased likelihood of exposure (see Supplementary Material online for full algorithm description).

Statistical analysis

To compare findings from conventional and EHR-based exposure investigations, we used descriptive statistics including total, median, and range of HCP identified through traditional and EHR-based methods. Percentage agreement was calculated by determining the number of exposed employees identified through traditional methods who were also identified through the EHR algorithm.

Results

In total, 7 conventional exposure investigations that occurred between November 1, 2020, and February 1, 2022, were included in this study. The investigations were all COVID-19 exposures in patients initially negative at admission who were later found to be positive. Through conventional exposure investigation methods, a median of 10 exposed HCP (range, 4–23) were identified, whereas the EHR-based method identified a median of 82 HCP (range, 50–119) possibly at risk (Table 1). The EHR-based contact scores had high specificity for identifying HCP at risk. The median contact score for all HCP was 1 (range, 0–58), and the median contact score for HCP also identified through conventional exposure investigation was 7 (range, 0–58). Additionally, every known HCP identified through conventional methods who tested positive after a patient exposure was identified in the EHR-based list. In total, 20 HCP were identified through conventional methods who were not identified through use of clinical EHR data; however, none of the individuals tested positive for SARS-CoV-2.

Of the 7 infection clusters, 2 were confirmed by genomic sequencing, and all positive HCP were identified by the algorithm as at risk of exposure (Fig. 1). The median contact score of HCP with a confirmed transmission was 14 (range, 3–33), and they all appeared above the median contact score. In contrast, HCP who were identified as potentially at risk of exposure but did not have a documented COVID-19 infection in these clusters had a median contact score of 4 (range, 0–47).

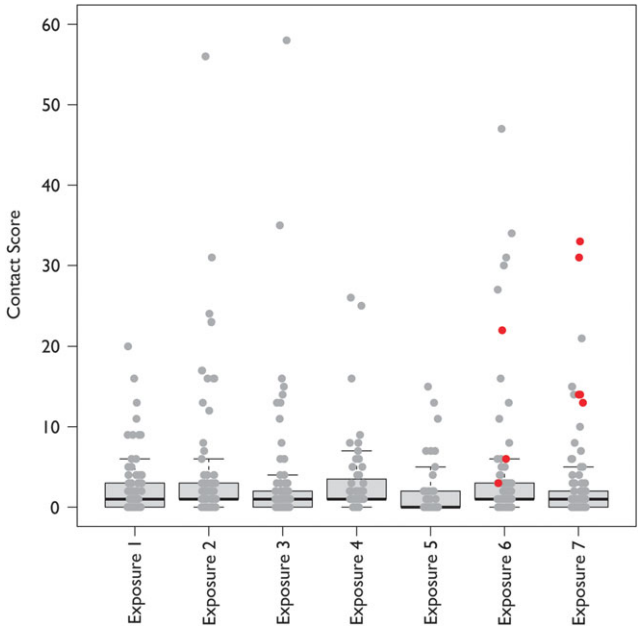

Fig. 1. HCP contact scores in exposure investigations. These boxplots show the spread of contact scores for each exposure investigation that was performed. Only exposed HCP identified through the EHR are included. The red dots represent HCP who tested positive for SARS-CoV-2 and all appear above the median contact score for these exposure investigations. The grey dots represent exposed HCP who did not have a recorded positive test.

Discussion

Clinical EHR data are comprehensive and, for certain events, highly time specific, making them ideal for conducting IPC exposure investigations. In our study, EHR data were highly sensitive and specific in identifying HCP that were at high risk of exposure.

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All HCP–patient COVID-19 transmissions confirmed through conventional methods were identified by the EHR algorithm, and HCP with a documented transmission had higher contact scores than those who tested negative.

The use of clinical data reduces the need for HCP to remember at-risk interactions but does not assess adherence to PPE. As a result, the median list length of HCP identified through clinical data was significantly larger than conventional processes (82 vs 10). To combat the potential problem of overnotification, which has been noted in other EHR-based exposure investigations,[9] we created a "contact score" that estimated the risk of exposure based on time and type of activity. Our comparison to conventional exposure investigations showed that all HCP who tested positive were above the median of contact scores (Fig. 1). Thus, depending upon the infections, cutoffs can be set for notifiying HCP to ensure that only those at greatest risk are contacted.

EHR-based algorithms have limitations. Although 100% of HCP who could reasonably be expected to have charted information about a patient were captured, overall, only 75% of all HCP identified through conventional measures were identified. Most of those missed by the EHR algorithm were HCP who were unlikely to enter data into the EHR, such as food and environmental service staff and students. None of the missed individuals tested positive for SARS-COV-2. Thus, although EHR-based methods are not a direct substitute for traditional exposure investigations, they can augment traditional methods by more rapidly and accurately identifying HCP at highest risk of exposure. This technique of identifying HCW–patient interactions through EHR can be generalized to other transmissible infectious diseases in healthcare settings.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/ice.2022.261

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

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