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## Brief Report

## A systems approach to understanding SARS-CoV-2 transmission among healthcare workers in a cluster

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## A B S T R A C T

Preventing transmission of COVID-19 between healthcare workers is essential to optimize patient, employee, and organizational outcomes. We used a systems engineering approach to analyze contact tracing interviews from a cluster of COVID-19 at our healthcare institution and identified modifiable and non-modifiable causes of transmission. Similar work system analyses may be useful to institutions in identifying multiple factors contributing to infection clusters among healthcare workers, and in developing layered infection prevention methods to further reduce transmission.

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## INTRODUCTION

Healthcare institutions have undertaken structural and behavioral interventions to mitigate SARS-CoV-2 transmission between patients and healthcare workers (HCW) and among HCW, including screening for symptoms of COVID-19 or recent exposures, requiring personal protective equipment including in office spaces, physical distancing, and setting up efficient contact tracing measures.<sup>1</sup> These recommendations rely on proper institutional implementation and training as well as individual compliance.

On October 3, 2020, the Infection Control team at our healthcare institution was notified of two lab-confirmed cases of COVID-19 with an epidemiological link to an ancillary department (Department A) of our 505-bed hospital. Staff in Department A had contact with patients and visitors but did not provide direct patient care. Ultimately, Department A had the highest attack rate of all departments within our institution to date. During this cluster, the community prevalence of COVID-19 in [BLINDED] County was 120 cases per 100,000 (high activity level). Vaccines against SARS-CoV-2 were not yet available.

We used the Systems Engineering Initiative for Patient Safety (SEIPS) model to evaluate contact tracing interviews with HCW in

Department A who tested positive for COVID-19. This model evaluates multiple facets of the complex healthcare work system to identify factors contributing to an outcome.<sup>2</sup>

The [BLINDED] Institutional Review Board deemed this study to be quality improvement and exempt from review.

## METHODS

## Case definition

We defined a case as a HCW with a confirmatory SARS-CoV-2 PCR laboratory result, irrespective of clinical signs or symptoms, and an epidemiological link with a confirmed case in Department A.

## Contact tracing and data collection

HCW self-monitored for signs and symptoms of COVID-19 twice daily. If a HCW became symptomatic, they were instructed to call Employee Health Services (EHS). An EHS nurse discussed their symptoms and scheduled an appointment for a free, off-site COVID-19 test. The HCW was instructed to remain home from work while waiting for test results.

Immediately upon receiving a positive COVID-19 test result, an EHS nurse informed the HCW and conducted an interview based on public health contact tracing questions. Questions involved the HCW's role, location, work shift, symptoms, symptom onset date,

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positive test date, potential exposures in the last 14 days, and any known exposure to a coworker including 48 hours prior to symptom onset. The Infection Control team reviewed interviews and sent de-identified specimens for sequencing at an affiliated campus research lab.

#### Laboratory methods

Specimens were obtained using nasopharyngeal swabs and diagnostic COVID-19 testing was completed by our institution's hospital lab using molecular methods.

## RESULTS

#### Cases and contacts

Between October 2 and November 24, 2020, eight of 16 (50%) HCW from Department A and one HCW with an epidemiological link to Department A tested positive for COVID-19 (Fig 1). Two HCW from Department A tested negative. Six HCW did not report COVID-19 symptoms, exposure, or testing to EHS.

#### Clinical characteristics

The most reported symptoms were cough (77.8%), runny nose (66.7%), and muscle pain (66.7%). One HCW reported no symptoms. There were no deaths or hospitalizations from COVID-19 in any cases. Six cases (66.7%) worked while symptomatic and nine (100%) worked while potentially infectious (Fig 1).

#### Relationship between cases

Cases 1 and 2 were household contacts. Case 6 was neighbors with Cases 1 and 2, with frequent unmasked contact outside of work. Cases 4 and 5 were also household contacts. Five cases reported contact with a colleague with known COVID-19. Two cases had contact with a family or community member with known COVID-19. Two HCW in Department A had contact with a colleague with known COVID-19 and tested negative.

#### Virological findings

Cases 1–4 had identical or nearly identical sequencing results. Cases 5 and 6 had distinct strains unrelated to others in the cluster. Cases 8 and 9 had identical sequencing results to one another, but distinct from cases 1–4. Case 7 tested positive at a clinic outside of our institution and their specimen was unable to be sequenced. These findings have been published.<sup>3</sup>

#### The SEIPS model

We analyzed results from contact tracing interviews using the SEIPS model to identify work system elements that may have contributed to this cluster (Fig 2).

Following discovery of the cluster, department leadership limited office capacity to four people and prohibited eating and removing masks in the office. However, transmission between HCW continued after these changes (ie, transmission pair occurring in November).

## DISCUSSION

While many HCW cases are likely brought into the workplace due to community transmission, this SEIPS-based approach was valuable in systematically identifying possible factors leading to workplace transmission (Fig 2).<sup>3</sup> Factors contributing to transmission in this cluster (eg, HCW working while symptomatic, personal relationships between HCW outside of work, and lapses in PPE and physical distancing due to small shared spaces) are consistent with other studies.<sup>4,5</sup> Many factors such as personal relationships between HCW are not modifiable, thus institutions should be cognizant of non-workplace spread causing and enhancing workplace clusters. Other factors are modifiable, but require more significant cultural changes (eg, HCW working while sick). Our institution provided paid sick leave for symptomatic staff, however multiple motivations contribute to presenteeism and organizations should encourage compliance through policies addressing these motivations.<sup>6</sup> Ultimately, additional transmission occurred despite changes at our institution to address modifiable factors (eg, limiting office capacity). Because SARS-CoV-2 transmission dynamics (eg, via aerosols) and the limits of non-pharmaceutical interventions (eg, personal protective

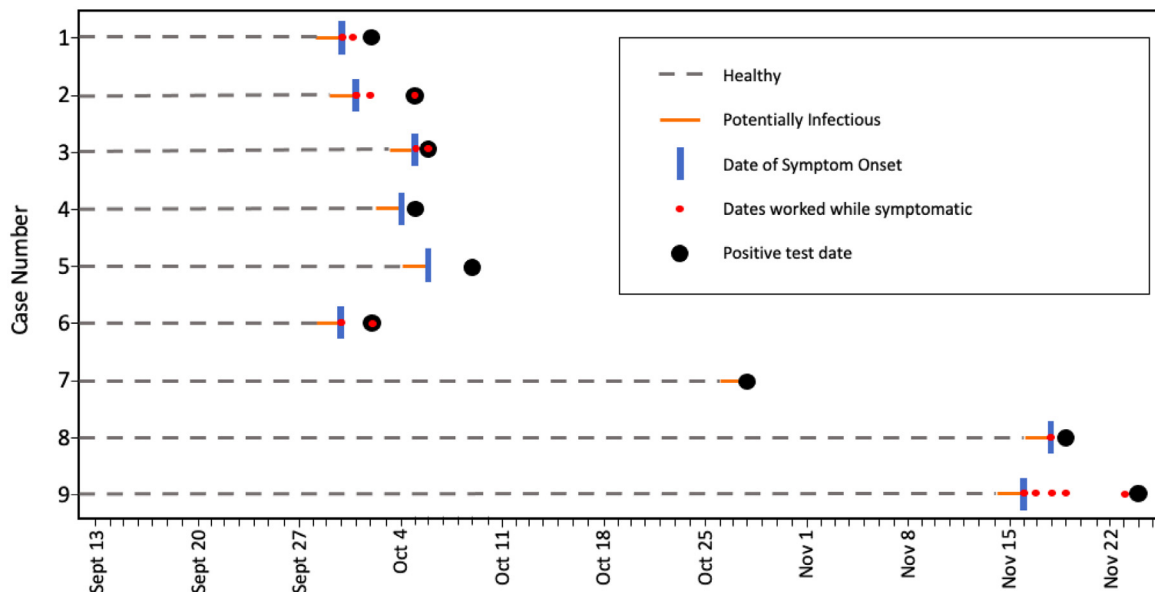
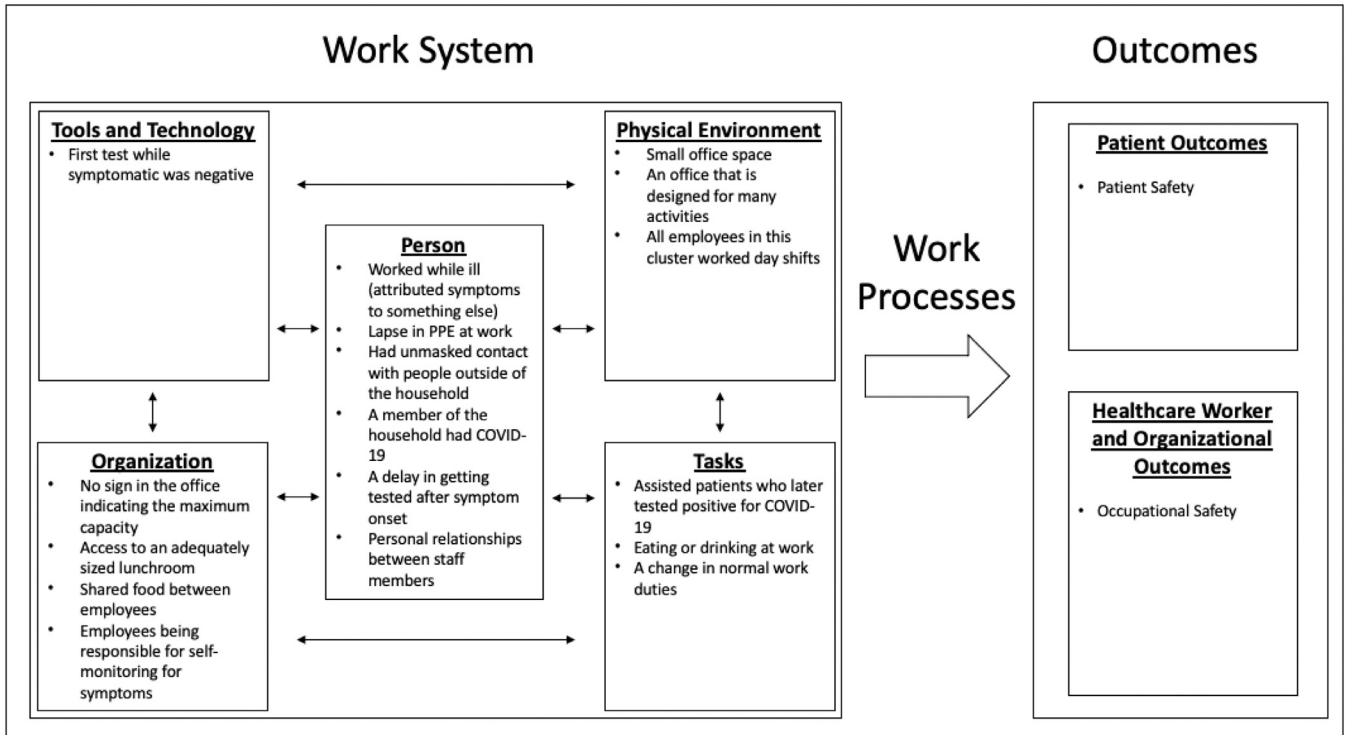


Fig 1. Timeline of symptom onset and positive test result of HCW, Madison, Wisconsin, USA, 2020.



**Fig 2.** Themes identified in contact tracing interviews in the framework of the Systems Engineering Initiative for Patient Safety model, Madison, Wisconsin, USA, 2020.

equipment as necessary but not sufficient to eliminate transmission) can drive transmission among HCWs in addition to the work system factors identified here, layered infection prevention steps are necessary for effective infection control planning.<sup>7,8</sup>

One limitation of this analysis is that we did not directly interview cases. Interview data were limited to HCW disclosures. This cluster occurred before the arrival of the highly contagious delta variant.

**CONCLUSIONS**

Both modifiable and non-modifiable elements of the work system contributed to this infection cluster. Work systems analyses can be used to identify both types of factors, and both should be considered in designing infection control plans to prevent transmission among HCW in the workplace.

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