Clinical Infectious Diseases

BRIEF REPORT

Transmission of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) From Asymptomatic and Presymptomatic Individuals in Healthcare Settings Despite Medical Masks and Eye Protection

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We describe 3 instances of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) transmission despite medical masks and eye protection, including transmission despite the source person being masked, transmission despite the exposed person being masked, and transmission despite both parties being masked. Whole genome sequencing confirmed perfect homology between source and exposed persons' viruses in all cases.

Keywords. SARS-CoV-2; viral transmission; masking; infection control

Public health agencies recommend that asymptomatic healthcare workers and patients wear medical masks during all clinical encounters in order to prevent severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) transmission in case either party has asymptomatic or presymptomatic coronavirus disease 2019 (COVID-19). Abundant laboratory, case report, and population data support these policies, but the emerging evidence that SARS-CoV-2 is transmitted by respiratory aerosols begs the question of whether there is residual risk of infection when wearing medical masks alone [1, 2]. Respiratory aerosols can bypass medical masks via gaps between the wearer's face and the mask, allowing potentially infectious aerosols to escape from the infected source and enter the respiratory tract of an exposed person despite both parties being masked [3–5]. There are very little data, however, on whether these theoretical concerns lead to demonstrable infections. We describe 3 cases of SARS-CoV-2 transmission with homologous whole genome sequencing that occurred despite the use of medical masks and eye protection.

METHODS

All patients and employees newly diagnosed with SARS-CoV-2 at Brigham and Women's Hospital in Boston are reviewed daily to identify possible exposures and transmissions. Cases in which transmission may have occurred despite one or both parties being masked were flagged, and specimens were sent to the Massachusetts Department of Public Health for whole genome sequencing (Table 1). Tiled, whole-genome amplicon sequencing was performed using an ARTIC V3 SARS-CoV-2 protocol adapted by state public health laboratories and the Centers for Disease Control and Prevention (CDC) [6–9]. Samples were amplified using multiplex polymerase chain reaction (PCR) primer reactions and sequenced on the Illumina MiSeq sequencer. Genomes with ≥95% coverage were aligned, and single nucleotide polymorphism differences were calculated. The study was approved by the Massachusetts Department of Public Health's Institutional Review Board (genome sequencing) and the Mass General Brigham Institutional Review Board (epidemiologic analysis). The hospital's standard-issue mask for all patients and most employees is an ASTM level 1 mask with ear loops. The cases described in this report occurred between mid-November 2020 and mid-January 2021.

RESULTS

Case 1. Transmission From an Asymptomatic Unmasked Patient to Two Patient Care Assistants Wearing Masks and Face Shields

An 82-year-old woman was admitted to hospital with anorexia, weakness, and urinary retention. A nasopharyngeal PCR specimen was negative for SARS-CoV-2 on the day of admission. The patient was diagnosed with depression, managed on standard precautions, and referred to a chronic care institution. She was retested for SARS-CoV-2 on hospital day 6 prior to discharge per the policy of the receiving institution and found to be positive (cycle threshold 15). She did not have any symptoms suggestive of COVID-19 throughout her hospital course. Two patient care assistants who served as 1:1 observers for the patient in the days before she was diagnosed with SARS-CoV-2 infection developed respiratory viral syndromes 4 days and 5 days after the patient's diagnosis and tested positive for SARS-CoV-2. One patient care assistant had spent 4 hours with the patient on hospital day 3, and the other spent 8 hours with the patient on hospital day 4. Both reported wearing masks and face

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Table 1. Summary of Cases With Whole Genome Sequencing-confirmed SARS-CoV-2 Transmission Despite Use of Masks and Eye Protection

Case	Transmission Direction	Exposure Duration and Circumstance	Patient Consistently Masked?	Healthcare Worker Personal Protective Equipment
1	Asymptomatic hospitalized patient to 2 patient care assistants	4-hour and 8-hour sitter shifts	No	Masks and eye protection
2	Presymptomatic nurse to hospitalized patient	8-hour nursing shifts (non-ICU)	No	Mask and eye protection
3	Presymptomatic patient to physician	45-minute outpatient visit	Yes, except for brief oral exam	Mask and eye protection

Abbreviations: ICU, intensive care unit; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

shields at all times. They spent most of their time sitting with the patient in her room to prevent her from harming herself. The patient was inconsistent in her mask use but did not undergo any aerosol-generating procedures. There were 6 air changes per hour in the patient's room. Whole genome sequencing confirmed 0 single nucleotide polymorphism differences between the patient's isolate and the 2 patient care assistants' viruses.

Case 2. Transmission From a Presymptomatic Masked Nurse to an Unmasked Patient

A 56-year-old man with esophageal cancer was admitted with esophageal perforation and empyema. He underwent esophageal stent placement and pleural washout. The nurse assigned to the patient on hospital days 11–13 developed symptoms of COVID-19 on hospital day 13 following a community contact, left work, and tested positive for SARS-CoV-2 2 days later (cycle threshold 17). The patient was retested on hospital day 19 on account of his exposure to the nurse and was positive (cycle threshold 13). The nurse reported wearing a mask and goggles at all times but noted that the patient did not wear a mask. There were 6 air changes per hour in the patient's room. Whole genome sequencing confirmed 0 single nucleotide polymorphism differences between the nurse and patient's isolates.

Case 3. Transmission From a Presymptomatic Masked Patient to an Ambulatory Provider Wearing a Mask and Goggles

An internist saw a new patient in ambulatory clinic. The patient had no fever, respiratory symptoms, taste or smell alteration, or systemic complaints. The encounter lasted approximately 45 minutes, most of which consisted of face-to-face discussion at a distance of approximately 3 feet. The patient was not tested for SARS-CoV-2 before the encounter. The patient wore a hospital-issued medical mask throughout the visit except when asked to briefly lower her mask so that the provider could examine her oropharynx. The provider wore a medical mask and goggles and washed her hands before, during, and after the encounter. The examination room had 9 air changes per hour. Two days later, the patient developed symptoms of COVID-19 and tested positive for SARS-CoV-2 (cycle threshold 19). The physician developed symptoms of COVID-19 4 days after the encounter and also tested positive for SARS-CoV-2 (cycle threshold 17). Whole genome sequencing confirmed 0 single nucleotide polymorphism differences between the patient and physician's specimens.

The strains associated with these 3 transmission events were different from one another (≥30 single-nucleotide polymorphism [SNP] differences) and were not consistent with any of the current variants of concern from the United Kingdom (B.1.1.7), South Africa (B.1.351), or Brazil (P.1) [10].

DISCUSSION

These 3 case studies demonstrate the possibility that providers can both transmit and be infected by SARS-CoV-2 despite wearing medical masks and eye protection. The theoretical basis for transmission despite medical masks and eye protection is clear: SARS-CoV-2 is primarily transmitted via respiratory particles, some of which are small enough and mobile enough to pass through the gaps between medical masks and patients' and providers' faces [2–5]. The risk is highest with prolonged encounters at short range with patients early in the course of their infection when their viral loads are highest, particularly if one of the parties is unmasked, because respiratory emissions and viral burden are highest immediately adjacent to the respiratory tracts of source individuals and rapidly dissipate with distance [11, 12].

What is unclear from these 3 case studies is how often transmission takes place despite one or both parties wearing medical masks and eye protection. Multiple studies report that cloth masks and medical masks are associated with fewer infections; it is therefore likely that masks lower infectious inoculum and the probability of infection but do not eliminate it [1]. Infection risk occurs along a continuum where risk is moderated by multiple factors including viral burden in the source, quantity and density of respiratory emissions, mask filtration and fit, eye protection, distance between the source and exposed individual, duration of exposure, quality of ventilation, vaccination status, and host immunity [11]. No one factor is perfectly protective (and its absence does not guarantee infection), but each component is likely additive.

These cases raise the question of whether additional measures are needed to enhance respiratory protection and source control in healthcare. Options include improving the fit of medical masks by using ties rather than ear loops, adding mask fitters, or using respirators more widely. N95 respirators are optimized for fit and filtration but require fit testing, can be uncomfortable to wear for long periods, and are sometimes in short supply.

The need for respirators should therefore be calibrated to degree of risk. They likely add the most value when caring for patients with known or suspected COVID-19 and for sustained encounters at close quarters with untested individuals and/or unmasked individuals in communities with high incidence of disease. The marginal value of respirators outside of these circumstances may be less but dedicated studies are needed.

This study highlights the value of whole genome sequencing to explore transmission events. Whole genome sequencing can help clarify whether potentially related infections were indeed related or coincidental, a valuable tool when trying to investigate possible transmissions that may have occurred despite adherence to public health recommendations. Sequencing does not provide definitive evidence of transmission but does provide supportive evidence within a suggestive epidemiologic context. Sequencing can also help detect variants with increased transmission potential [10].

Limitations of our study include the lack of population level data quantifying the frequency of transmissions despite medical masks, the possibility that transmission may have taken place via fomites or self-contamination rather than via mask failure, and the chance that transmission may have taken place via unidentified intermediaries under different circumstances from the ones we describe. In each case, however, the interactions and time sequences we described are plausible, and whole genome sequencing demonstrated perfect homology between source and exposed parties.

In sum, we demonstrate SARS-CoV-2 transmissions between parties wearing medical masks, including cases in which just the source was masked, just the exposed was masked, and in which both parties were masked. These findings teach the importance of not relying upon medical masks and eye protection alone to prevent SARS-CoV-2 transmission and beg the question whether respirators should be used more widely when caring for high-risk patients under high-risk conditions in high incidence communities.

Notes

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