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Short Report

Transmission of infection from non-isolated patients with COVID-19 to healthcare workers

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SUMMARY

Insufficiently protected healthcare workers (HCWs), defined as high-risk contacts of patients with coronavirus disease 2019 (COVID-19), are routinely quarantined. This study evaluated the transmission of infection from a symptomatic patient with COVID-19 to 60 HCWs exposed at ≤2 m for ≥15 min or during aerosol-generating procedures. Following ≥106 unique high-risk contacts, none of the HCWs tested positive for severe acute respiratory syndrome coronavirus-2 RNA or developed antibodies. The HCWs reported adherence to basic infection control procedures. These results are in accordance with other reports, and should reassure HCWs and further stimulate broader evaluation of the foundation for the current practice of home quarantining non-symptomatic HCWs.

Introduction

During the coronavirus disease 2019 (COVID-19) pandemic, the proportion of healthcare workers (HCWs) amongst verified, infected individuals has been reported to be between 10% and 20% [1,2]. A considerable proportion of HCWs with COVID-19 self-report that they were infected at work [1,3]. An objective evaluation of the risk of HCWs contracting severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) compared with the general population is difficult as the test criteria for HCWs differ from those of the general population.

An increasing number of reports indicate low rates of SARS-CoV-2 transmission from non-isolated patients to HCWs [4–9]. It is interesting that the incidence of asymptomatic cases amongst HCWs in a hospital showed the same trend of viral transmission as the general community, and decreased following social distancing despite the hospital remaining full of patients with COVID-19 [10].

A level 1 trauma centre received transfer of a middle-aged patient with a pelvic injury from a hospital in a region with a low prevalence of COVID-19. The patient had mild hypoxia ($satO_2$ 96% on 3 L O_2) but no obvious airway symptoms. The patient was placed in a single-bed room on a regular ward. The

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patient was not isolated, but social distancing measures were enforced due to the ongoing pandemic. As such, mixing with other patients, such as during meals, was prohibited. The room had fresh-air ventilation with three air changes per hour, a hand sink with soap and disinfectants on both sides of the door, and received once-daily cleaning including disinfection of all contact surfaces. The hospital provides clothing for all HCWs which is changed at least once per day. HCWs and patients in the study hospital did not (and, at the time of writing, still do not) wear masks on a general basis.

From the day of admission, the patient experienced intermittent fever and diarrhoea in addition to mild hypoxia (Table I). On day 4, the fever increased and the patient developed a cough with purulent sputum. The patient was isolated the following morning, and two consecutive tests showed high viral loads (Ct=27.3 and 23.3) of SARS-CoV-2. By then, the patient had undergone two operations under combined general and epidural anaesthesia in an operating theatre with laminar air flow and 50 air changes per hour. Sixty HCWs were quarantined for 2 weeks due to participation in aerosol-generating procedures (AGPs) with insufficient personal protective equipment (PPE), or close contact viral exposure (defined as ≤2 m for ≥15 min).

The risk of transmission of SARS-CoV-2 from patients to HCWs is a highly relevant issue. It affects not only HCWs, but also how hospitals plan healthcare services during this pandemic. The aim of this study was to evaluate the extent of SARS-CoV-2 transmission from a symptomatic, non-isolated patient to HCWs in a hospital with adequate capacity.

Methods

This study was approved by the Regional Committee for Medical and Health Research Ethics in Mid-Norway (REK 2020/6073). Quarantined HCWs were invited to participate under informed written consent.

The participants were tested for SARS-CoV-2 RNA approximately 2 weeks after viral exposure. Samples were taken from the retrotonsillar pharynx according to the procedure used in a specialized COVID-19 outpatient clinic for hospital employees. RNA was extracted from the samples using an easyMag extractor (bioMérieux, Marcy l'Etoile, France), and analysed with an in-house real-time reverse transcriptase polymerase chain reaction (PCR) assay targeting the E-gene of SARS-CoV-2 [11].

To evaluate if any of the exposed HCWs had COVID-19, sera were collected approximately 3 weeks following exposure for the detection of antibodies against SARS-CoV-2. EDI Novel Coronavirus COVID-19 IgG and IgM ELISA (Epitope Diagnostics, Inc., San Diego, CA, USA) were used for initial testing, and supplemented with tests from DiaSorin (LIAISON SARS-CoV-2 S1/S2 IgG test), Abbott (Alinity i SARS-CoV-2 IgG), Roche (Elecsys Anti-SARS-CoV-2) and Wantai (WANTAI SARS-CoV-2 Ab ELISA).

All participants completed a questionnaire to map the type and extent of viral exposure, symptoms while in quarantine, and self-evaluation of adherence to hand hygiene procedures. This included handwashing with soap and water or disinfectant, prior to and following procedures in a patient room, and direct or indirect contact with a patient.

Table II
Antibody test results: discrepant test results from five of 57 healthcare workers (HCWs) using anti-SARS-CoV-2 assays from five different manufacturers

	EDI IgM	EDI IgG	DiaSorin IgG	Abbott IgG	Roche Total Ab	Wantai Total Ab
	S/CO	S/CO	S/CO	S/CO	S/CO	S/CO
HCW 1	0.38	0.99[a]	<0.25	0.04	0.10	0.23
HCW 5	0.43	**1.43**	<0.25	0.01	0.10	0.05
HCW 37	0.38	0.37	**4.64**	0.01	0.11	0.00
HCW 41	0.43	0.47	**2.13**	0.02	0.11	0.00
HCW 50	0.38	0.93[a]	<0.25	0.14	0.10	0.02

SARS-CoV-2, severe acute respiratory syndrome coronavirus-2; S/CO, signal-to-cut-off ratio.
S/CO ratio ≥1 is positive.
[a] Borderline.

Results

Fifty-eight of 60 quarantined HCWs agreed to participate in the study. Two HCWs could not be reached in time for testing. One HCW withdrew from the study following the throat swab and all data were excluded, leaving 57 participants for analysis. Fifty-seven HCWs completed an RNA test, antibody testing and answered the questionnaire.

All participants tested negative for SARS-CoV-2 RNA and SARS-CoV-2 IgM. In addition, all participants tested negative for IgG and total antibodies with tests from three of five manufacturers. Discrepant test results are presented in Table II. These

Table I
Timeline with clinical parameters and aerosol-generating procedures (AGPs)

	Admission	Day 1	Day 2	Day 3	Day 4	Day 5
Temperature (°C)	37.2–38.8	37.3–37.9	37.7–38	37.3–38	38.3–39.9	Positive SARS-CoV-2 test
O_2 saturation (%)	91 room air 96 w/3 L O_2	96 room air	96 room air 100 ventilated	95–98 room air	89 room air 92 w/1.5 L O_2	#
AGPs	-	-	Intubation Extubation Open surgery 3 h 50 min	-	Intubation Extubation Open surgery 1 h 45 min	O_2 sat at discharge: 98–100

SARS-CoV-2, severe acute respiratory syndrome coronavirus-2.

Table III
Disease transmission from non-isolated patients with coronavirus disease 2019 to healthcare workers (HCWs) not wearing recommended personal protective equipment

	Ref	HCWs (*N*) exposed ≥15 (10) min or during AGPs	HCWs (*N*) exposed during AGPs	HCWs (*N*) with positive SARS-CoV-2 RNA	HCWs (*N*) with positive SARS-CoV-2 IgG
Hong Kong	[7]	11	Not known	0	Not measured
Singapore	[8]	35	35	0	Not measured
Switzerland	[4]	10	0	0	Not measured
California	[5]	121	17	3 (2 AGPs + one 2-h exposure)	Not measured
Illinois	[6]	53 (32 symptomatic + 21 asymptomatic)	Not known	0	Not measured
Boston	[9]	43	Not known	2 (> 60 min exposure)	Not measured
Present study (Norway)		57	12	0	0
Total		330	64	5	

AGPs, aerosol-generating procedures; SARS-CoV-2, severe acute respiratory syndrome coronavirus-2.

discrepant, positive, results were reproducible. Twenty-two HCWs (39 %) experienced some airway symptoms during quarantine, of which a sore throat was most common (*N*=12). None of the responders experienced loss of taste and smell. Fifteen HCWs had already been tested during their quarantine period because of symptoms, and all tested negative at both test points.

There were ≥106 unique contacts of ≥15 min at ≤2 m, or during AGPs, between HCWs and the non-isolated COVID-19 patient. Nineteen nurses on the ward had ≥46 unique close contacts that also included oral hygiene. Twelve HCWs had been exposed during AGPs: seven during in- and/or extubation at ≤2 m from the patient's head, and another five at >2 m. Eleven HCWs were present during open surgery involving power drilling, electrocautery and pulsed lavage.

Half of the affected HCWs (*N*=30) had not used any form of PPE while exposed. Surgical masks were used by 16 of 57 HCWs, and by none of 19 nurses on the ward. Disposable gloves were used by 35 of 57 HCWs and visor/glasses were used by five of 57 HCWs. One HCW reported close contact with the patient during extubation without wearing a surgical mask. The majority (*N*=40, 70%) of HCWs were certain that they had adhered to hand hygiene procedures, and 16 were quite certain (total 98%). One HCW reported that it was unlikely that he/she had performed proper hand hygiene.

Discussion

This study found that ≥106 unique close contact exposures, including 12 contacts during AGPs, with a non-isolated patient with COVID-19 resulted in no cases of SARS-CoV-2 transmission from the patient to HCWs. With one exception, all included HCWs were certain or quite certain that they had adhered to hand hygiene procedures at the time of exposure.

Ideally, and according to common practice, samples for PCR testing should have been collected on day 7 and repeated on day 14 following exposure. However, as this study required ethical approval and written consent, it was not possible to organize the study in time for testing during the first week. Nevertheless, this study is, to the authors' knowledge, the first to complement throat swabs with antibody testing in a prospective study of symptomatic and non-symptomatic HCWs. It must be stressed, however, that even antibody tests do not seem to reveal all individuals who have been infected previously with COVID-19. The test results illustrate that antibody tests may give false-positive results in a low-prevalence setting, and retesting with alternative assays may be necessary to draw a conclusion.

To the authors' knowledge, six other reports on disease transmission from non-isolated COVID-19 patients to HCWs have been published (Table III). Of 330 HCWs, five HCWs tested positive for SARS-CoV-2 RNA. Two of 64 HCWs (3%) that had been exposed during AGPs without wearing a particulate respirator contracted COVID-19. All seven positive cases were reported from hospitals with seemingly good infection prevention practices.

COVID-19 screening of the study patient, both before transfer and upon admission, was suboptimal. The procedure for patient transfer between hospitals was consequently changed from oral clarification on the telephone to strict documentation by written questionnaires. The affected ward normally serves as a unit for revision arthroplasties and spinal surgery. At the time of the incident, elective surgeries had been reduced to a minimum, and the ward then hosted a broad range of orthopaedic patients. Abrupt changes in established means of organizing care of patients must be considered a risk factor for impaired patient safety. It is likely that the re-organization due to the COVID-19 pandemic contributed to the delay in diagnosing this very disease and sending 60 HCWs into quarantine.

In conclusion, there appears to be a low risk of virus transmission from non-isolated COVID-19 patients to HCWs in hospitals with adequate capacity, and in HCWs who adhere to basic measures to prevent the transmission of infectious diseases. The results should reassure HCWs, and further stimulate a broader evaluation of the foundation for the current practice of home quarantining non-symptomatic HCWs.

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Conflict of interest statement
None declared.

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