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Letter to the Editor

Contamination of personal protective equipment by SARS-CoV-2 during routine care of patients with mild COVID-19



Dear Editor

We have read the article by Ye G, et al.¹ with great interest. The authors found that gloves of healthcare workers (HCWs) who care coronavirus disease 19 (COVID-19) patients were frequently contaminated (15.4%) and eye protection or face shield were less contaminated (1.7%). With regard to personal protective equipment (PPE) the World Health Organization and Centers for Disease Control and Prevention recommend using a face shield or goggles, gloves, isolation gowns, and masks in low-risk situations. Furthermore, when HCWs who care for patients with COVID-19 take part in an aerosol-generating procedure, they should wear an N95 or respirator.^{2,3} Thus, the recommended PPE does not include coveralls, covered boots, or hair coverings. However, some studies have raised concerns about contamination of the neck, ears, feet, or shoes when caring for patients with COVID-19, suggesting that HCWs should also wear a coverall, head cover, and boots.⁴ In this study, we evaluated the contamination of PPE by SARS-CoV-2 during routine care of hospitalized patients with mild COVID-19 to identify contamination in different areas of the body.

The present study was performed at Asan Medical Center, Seoul, South Korea. In our hospital, patients with COVID-19 were placed in the negative pressure isolation room, with an air exchange rate of 10 times per hour. HCWs caring for patients with confirmed COVID-19 routinely wore coveralls, an N95 mask or powered air-purifying respirator, a face shield, double gloves, and boots (Supplemental Fig. 1). Nineteen nurses were invited to participate in the study, all of whom consented to the sampling. Their activities included checking vital signs, administering oral medication, phlebotomy, and bedpan disposal. After approximately 4 h of duty, but before the nurses doffed the PPE, surface swab samples were collected from the outside surface of the PPE at top of the head, neck, wrist, abdomen, back, foot dorsum, and sole by swabbing 15 times using aseptic Dacron swabs that were pre-moistened with viral transport media (3 mL). Detailed patients' characteristics, laboratory procedures and statistical analysis are shown in supplemental material. The ethics committee of our institution waived the need for approval and consent from the patients because the study was considered a quality control project.

A total of 133 surface swab samples were collected from PPE worn by 19 HCWs caring for the two patients (Table 1). Of them, 15 (11%) revealed positive SARS-CoV-2 PCR results in the following areas: top of the head (26%), foot dorsum (26%), sole (16%), wrist (5%), and abdomen (5%). No SARS-CoV-2 RNA was detected on the neck and back. The top of the head, foot dorsum, and sole were

more frequently contaminated than the neck, wrist, abdomen, and back (23% [13/57] vs. 3% [2/76], $P < 0.001$ by Fishers' exact test).

Our data showed contamination of SARS-CoV-2 on the head, foot dorsum, and sole of the HCWs, even when caring for patients with mild COVID-19 who did not undergo aerosol-generating procedures. These data will inform policies regarding PPE and doffing procedures to protect HCWs against SARS-CoV-2 infection.

Ong et al. performed a PPE sampling study by collecting samples from the front of goggles, N95 respirator, and shoes of 30 HCWs. They found that all 90 samples were negative,⁵ perhaps because the HCWs in that study spent a shorter time in the patients' rooms (6 min) than in the present study (4 h). Similarly, Yung et al. reported that three samples from the PPE of HCWs' caring for an infant with COVID-19 (face shield, N95 mask, and gown) were negative for SARS-CoV-2.⁶ Conversely, another study found that the front surface of one shoe was positive, while the gown, N95 mask, and face visor were negative.⁷ Feldman et al. performed a simulation study indicating that the neck, ear, hair, and shoes were frequently contaminated when performing intubation procedures.⁴

In the present study, we systematically performed PPE sampling from the top of the head to the foot dorsum and sole to evaluate SARS-CoV-2 contamination. The top of the head may have been positive because the HCWs habitually touched their heads. Alternatively, it may have become contaminated while bending down to perform routine activities (phlebotomy). Airborne particles may also have settled in this area. The foot may have been positive because gravity and air flow can cause the virus to fall to the ground.⁸ These results are in line with the previous studies reporting positive SARS-CoV-2 PCR results from both air samples⁹ and the foot dorsum of PPE.⁴ Taken together with previous studies, the present findings suggest that coveralls, head covers, and boots are needed to prevent contamination, even in low-risk situations involving routine care of patients with mild COVID-19, without aerosol-generating procedures. Further studies are needed to identify how frequently HCWs touch their head, and larger studies should be carried out to validate our findings.

The present study had several limitations. Firstly, the individual activity of the HCWs was not documented, and therefore, we could not identify any association between activity and SARS-CoV-2 positivity. Secondly, in patient A, we collected samples more than 10 days after symptom onset; therefore, the viable virus may not have shed, as reported in a previous study.¹⁰ That said, we did collect earlier samples from patient B, and similar results were found, showing that the top of the head (1/9), wrist (2/9), abdomen (1/9), foot dorsum (2/9), and sole (2/9) were contaminated. Thirdly, we did not perform any viral culture to demonstrate viable virus, and thus, the SARS-CoV-2 RNA may not have corresponded with a live, infective virus. Further studies are needed to ascertain whether (1) viable virus can be detected on the uncovered body sites of HCWs

Table 1
Results of SARS-CoV-2 PCR from surface swab samples of personal protective equipment.

No.	Patient	Clinical characteristics of the patient			SARS-CoV-2 viral load (log copies/mL)										
		Symptom	Days after symptom onset	SARS-CoV-2 viral load (log copies/ml) from nasopharyngeal swab	Top of the head	Neck	Wrist	Abdomen	Back	Foot dorsum	Sole				
1	A	No	12	3.97	2.98	ND	ND	ND	ND	ND	2.98	ND	ND	ND	ND
2		No	13	N/A	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3		No	13	N/A	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4		No	13	N/A	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5		No	13	N/A	ND	3.34	ND	ND	ND	ND	ND	2.59*	ND	ND	ND
6		No	13	N/A	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7		No	14	3.16	2.92	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8		No	14	3.16	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9		No	15	N/A	ND	2.57*	ND	ND	ND	ND	ND	ND	ND	ND	2.84
10	B	No	15	N/A	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11		Hyposmia	3	5.68	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12		Hyposmia	3	5.68	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13		Hyposmia	3	5.68	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
14		Hyposmia	4	5.48	3.30	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.27
15		Hyposmia	4	5.48	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.30
16		Hyposmia	4	5.48	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
17		Hyposmia	4	5.48	ND	ND	ND	ND	ND	ND	ND	2.3*	ND	ND	2.64
18		Hyposmia	4	5.48	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
19	Hyposmia	5	5.59	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
				Total positive rate, % (positive results/no. of tests)	26 (5/19)	0 (0/19)	5 (1/19)	5 (1/19)	5 (1/19)	0 (0/19)	26 (5/19)	0 (0/19)	16 (3/19)		

ND: not detected, N/A: not available.

* Viral RNA copy number < limit of detection (2.63 log copies/mL).

wearing PPE or on the surface of PPE and (2) such virus can be transmitted to HCWs.

In conclusion, even routine care for patients with mild COVID-19 without aerosol-generating procedures led to frequent contamination by SARS-CoV-2 in multiple areas, including the head and feet. Therefore, our data support the wearing of PPE that fully cover the head and feet, as well as cautious doffing procedures.

Declaration of Competing Interest

None.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jinf.2020.06.021.

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