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Original Article

Rapid Detection Test for COVID-19 among Healthcare Workers and the Role of Personal Protective Equipment

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Abstract

Background: In this study, we assessed the prevalence of positive rapid detection test (RDT) among healthcare workers (HCWs) and evaluated the role of personal protective equipment (PPE) and knowledge of the pandemic.

Methods: In a cross-sectional study conducted between August 2020 and October 2020 in a tertiary referral center (Tehran, Iran), we enrolled 117 physicians, nurses, and other HCWs (OHCWs)—aides, helpers, and medical waste handlers—regularly working in coronavirus disease 2019 (COVID-19) wards. The RDT kit was utilized to reveal recent infection; data on demographics, PPE use and availability, and knowledge of the pandemic was collected through pre-defined questionnaires.

Results: Overall, 24.8% (95% CI: 16.8–32.7%) of HCWs had positive RDTs. The more PPE was available and used, the less the chance of positive RDT was (OR: 0.63 [0.44–0.91], $P = 0.014$ and 0.63 [0.41–0.96], $P = 0.030$). The same was true for the knowledge of prevention and adhering to preventive rules (OR: 0.44 [0.24–0.81], $P = 0.008$ and 0.47 [0.25–0.89], $P = 0.020$). OHCWs had the highest prevalence of positive RDT, while they had more shifts per month, less accessibility to PPE, and less knowledge of the pandemic than physicians.

Conclusion: The findings of this study suggest that HCWs should have a thorough knowledge of the pandemic along with using PPE properly and rationally. Furthermore, adhering to preventive regulations plays a crucial role in HCWs' safety. It is also noteworthy that shifts should be arranged logically to manage exposures, with a special attention being paid to OHCWs.

Keywords: COVID-19, COVID-19 testing, Healthcare workers, Personal protective equipment

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Introduction

The novel coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was first isolated from patients with pneumonia of unknown origin in Wuhan, China. The coronavirus disease 2019 (COVID-19) spread throughout the world within a short period and became a pandemic.[1] It is mostly transmitted by respiratory droplets, even before the symptoms appear, and it seems that each patient can spread the disease to an average of 2.2 other people (reproductive number [R0] = 2.2).[2,3]

Being on the front line of the battle against the COVID-19, healthcare workers (HCWs) are at a significantly higher risk of infection. The chance of becoming infected with SARS-CoV-2 for HCWs seems to be more than three times compared to the general population.[4] Evidence gained from previous studies revealed that the use of personal protective equipment (PPE) might reduce the disease transmission rate and protect HCWs.[5] However, scarcity caused by the pandemic can remarkably limit access to adequate PPE, leading to HCWs' anxiety and confusion over their protection. Although using PPE could be a critical measure to ensure HCWs' safety, other factors may also put HCWs at a higher risk of infection, which must be resolved.

Serological tests for SARS-CoV-2 are believed to be able to identify a recent infection. The median time for the detection of antibodies by serological tests has been reported as 5 days for IgM and 14 days for IgG after the initial infection.[6] Rapid detection tests (RDTs) are among the most popular tests detecting IgM and IgG antibodies

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in the blood within 10 to 30 minutes. Several studies have reported a sensitivity and specificity of almost 100% for RDTs in the mid- and late-stage of the disease (8–14 days and >14 days, respectively).[7] In this study, we aimed to (1) evaluate the prevalence of positive RDTs among HCWs, indicative of their recent infection, (2) assess their access to PPE and their adherence to preventive regulations, and (3) evaluate the correlation between PPE usage and knowledge of the pandemic and having a positive RDT.

Materials and Methods

Study Population and Recruitment of Participants

A cross-sectional study was conducted between August 2020 and October 2020 in a vast tertiary and referral academic medical center (Imam Khomeini Hospital Complex, Tehran University of Medical Sciences, Tehran, Iran), enrolling a group of volunteered frontline HCWs. They were eligible for this study if they were regularly working at COVID-19 wards, intensive care units (ICUs), triage, and clinics during the month preceding the study, comprising physicians, nurses, and other HCWs (OHCWs)— aides, helpers, and medical waste handlers. The exclusion criteria were defined as chronic underlying diseases, immunocompromised individuals, or a history of taking immunosuppressive medications.

Based on the previous studies conducted on HCWs, in the case of serological assessment of COVID-19, the sample size needed for this study was calculated as 107 participants.[8] In the initial stage, we informed HCWs dealing with COVID-19 patients and wards with the study protocol and design and provided them with the opportunity to fill a request form if they were willing to participate in this study. During the submission period, 127 HCWs requested to join the study. After interviews and applying the inclusion and exclusion criteria, we eventually enrolled 117 HCWs in the study. The result of RDT (positive/negative) was defined as the outcome measure, and the correlation between variables and the outcome measure (positive/negative RDT) was assessed utilizing appropriate statistics.

Study Protocol

Pre-defined questionnaires, designed based on the experience gained from previous pandemics[9] and the current COVID-19 outbreak, were used to collect data regarding age, sex, job, type of transportation, number of shifts during the preceding month, shift hours, number of patients that each individual was in close contact with during shifts, and history of experiencing COVID-19-related symptoms. Having access to PPE (including face shields, gowns, gloves, and surgical masks, based on the pre-defined protection protocols of the center), using it, and adherence to PPE during their shifts were inquired. Participants were also asked to rank their access to PPE and its usage from 0 (never) to 5 (always). Besides, the knowledge of the pandemic (symptoms, routes of transmission, and protective measures) and applying protective regulations were assessed using a scale ranging from 0 (knowing nothing) to 5 (fully aware of the situation). Respondents were asked to complete the forms based on their status over the preceding month (questionnaires used in this study would be available on demand). Recent COVID-19 infection was assessed utilizing the VivaDiag™ IgM/IgG RDT kit (VivaChek Biotech [Hangzhou] Co., Ltd., China). We repeated the test for a sample chosen randomly out of the study population (n = 20) and we found a reliability of 95% (95% CI: 92–96%) for the test.

Data Analysis

Logistic regression analyses were performed to evaluate the association between different factors, including sex, job, ward, number of shifts and patients, PPE availability, PPE use, and knowledge of the pandemic, as independent variables (separately) and the RDT result as the dependent variable. PPE availability, use and knowledge levels were compared between different job groups based on medians using nonparametric k independent samples median test. Numeric and ordinal variables are presented as mean ± SD, and median and interquartile range, respectively. Frequencies were reported based on the percentage. Analyses were performed using the Statistical Package for Social Science (SPSS® version 24 for macOS, SPSS Inc. headquarter, Chicago, USA). Odds ratio (OR) and 95% confidence intervals (CIs) were calculated for all factors. *P* values of 0.05 or less were regarded as statistically significant.

Results

In this study, 117 HCWs (80.3% female) were included after applying inclusion and exclusion criteria with the mean age of 40.7 ± 8.0 years (ranging from 23 to 65 years). Regarding jobs, 30.7% (n = 36) were physicians, 48.7% (n = 57) were nurses, and the remaining were OHCWs. Among the study population, 29 HCWs (24.8%, 95% CI: 16.8–32.7%) had a positive RDT—27.3% among HCWs working in COVID-19 wards and ICUs (24 out of 88 HCWs), and 25.0% and 11.8% among HCWs working at clinics and the triage department, respectively. In almost all HCWs with a positive RDT, both IgM and IgG were positive, except for one HCW testing positive for IgG only. We found a significant association between having a positive test and jobs and having symptoms as well as duration of the symptoms; most HCWs with a positive RDT experienced COVID-19-related symptoms (89.7%, $P = 0.009$), with a longer duration than individuals with a negative RDT (13.9 ± 10.7 and 6.2 ± 5.4 days, respectively, $P = 0.002$). Moreover, we found that PPE availability and usage had a significant association with RDT ($P = 0.050$ and 0.030, respectively). Knowledge of the prevention and adherence to preventive rules were also inversely associated with having a positive RDT ($P = 0.030$ and 0.049, respectively). All participants' characteristics are presented in Table 1, and based on jobs in Table 2 and Table 3.

Table 1. General Characteristics of the Study Population, Prevalence of Positive Rapid Detection Test, and Evaluation of Different Factors among Healthcare Workers

Characteristics	Total No. (%) or Mean ± SD	Positive RDT[a] No. (%) or Mean ± SD	Negative RDT[a] No. (%) or Mean ± SD	*P* Value
Gender				
Female	94 (80.3)	20 (69.0)	74 (84.1)	0.105
Male	23 (19.7)	9 (31.0)	14 (15.9)	
Age	40.7 ± 8.0	39.9 ± 9.1	41.0 ± 7.7	0.580
Job				
Physicians	36 (30.7)	4 (13.8)	32 (36.4)	0.002[b]
Nurses	57 (48.7)	13 (44.8)	44 (50.0)	
OHCWs	24 (20.6)	12 (41.4)	12 (13.6)	
Working Site				
COVID-19 wards and ICUs	88 (75.2)	24 (82.8)	64 (72.7)	0.405
Triage	17 (14.5)	2 (6.9)	15 (17.1)	
Clinics	12 (9.4)	3 (10.3)	9 (10.2)	
Way of transportation				
Personal vehicle	60 (51.3)	13 (44.8)	47 (53.4)	0.230
Public transport	46 (39.3)	15 (51.7)	31 (35.2)	
Walking	11 (9.4)	1 (3.4)	10 (11.4)	
Distance from the hospital (km)				
<10	41(35.1)	8 (27.6)	33 (37.5)	
10–15	40 (34.2)	13 (44.8)	27 (30.7)	0.605
>20	19 (16.2)	4 (13.8)	15 (17.0)	
15–20	17 (14.5)	4 (13.8)	13 (14.8)	
Number of shifts	18.7 ± 8.4	18.9 ± 8.2	18.6 ± 8.5	0.881
Symptoms				
Yes	82 (70.1)	26 (89.7)	56 (63.6)	0.009[b]
No	35 (29.9)	3 (10.3)	32 (36.4)	
Duration of symptoms	8.7 ± 8.3	13.9 ± 10.7	6.2 ± 5.4	0.002[b]

RDT, rapid detection test; OHCWs, other healthcare workers (aides, helpers, and medical waste handlers); PPE, personal protective equipment.
[a] As almost all HCWs with a positive RDT were tested positive for IgM and IgG, they were not reported separately; [b] *P* value ≤ 0.01.

Table 2. Characteristics and Various Factors among Healthcare Workers Based on Jobs

Characteristics	Physicians	Nurses	OHCWs
Gender			
Female	25 (69.4)	53 (93)	16 (69.6)
Male	11 (30.6)	4 (7.0)	7 (30.4)
Age	42.0 ± 9.9	39.2 ± 6.3	42.0 ± 8.1
Working site			
COVID-19 wards and ICUs	19 (52.8)	48 (84.2)	21 (87.5)
Triage	11 (30.6)	6 (10.5)	1 (4.2)
Clinics	6 (16.7)	3 (5.3)	2 (8.3)
Number of shifts	10.9 ± 7.1	22.8 ± 6.4[b]	20.4 ± 6.3[b]
Symptoms duration	6.2 ± 4.5	8.6 ± 8.9	13.7 ± 10.7[a]

OHCWs, other healthcare workers (aides, helpers, and medical waste handlers);
[a] *P* value ≤ 0.05 and [b] *P* value ≤ 0.001 compared to physicians.

Regarding PPE availability, OHCWs reported having significantly less access to PPE than physicians ($P = 0.034$). Besides, regarding the number of shifts, physicians had a mean of 10.9 ± 7.1 shifts per month, which was significantly lower than nurses and OHCWs (22.8 ± 6.4 and 20.4 ± 6.3, respectively) ($P < 0.001$). OHCWs also had remarkably lower knowledge levels of prevention against COVID-19 infection than physicians ($P = 0.013$).

Logistic regression tests also revealed that the chance of having a positive RDT was significantly associated with jobs, PPE availability, PPE use, experiencing symptoms, symptoms' duration, knowledge of the symptoms, transmission routes, and protective measures, as well as adherence to preventive regulations. The more PPE was available and used, the less the risk of having a positive RDT was, and the same was true for the knowledge of symptoms and transmission routes and adherence to preventive rules. Regarding jobs, OHCWs had the highest risk, and nurses also had a higher risk of positive RDT than physicians (Table 4).

Discussion

Overview of the Main Results

Overall, we found a prevalence of 24.8%, 95% CI: 16.8%–32.7%, regarding positive RDT among HCWs. We found

Table 3. Personal Protective Equipment Availability and Use as well as Different Parameters of Knowledge of the Pandemic among Different Job Categories and Positive or Negative Rapid Detection Test

	Total	Positive RDT	Negative RDT	Physicians	Nurses	OHCWs
PPE availability						
Median (IQR)	4 (3–5)	4 (2.5–5)	4 (4–5)[a]	5 (3.25–5)	4 (4–5)	4 (2–5)[b]
<4, No. (%)	31 (26.7)	12 (41.4)	19 (21.8)	9 (25.0)	11 (19.3)	11 (47.8)
≥4, No. (%)	85 (73.3)	17 (58.6)	68 (78.2)	27 (75)	46 (80.7)	12 (52.2)
PPE usage						
Median (IQR)	4 (4–5)	4 (3.5–5)	5 (4–5)[a]	5 (4–5)	5 (4–5)	4 (3–5)
<4, No. (%)	19 (16.4)	7 (24.1)	12 (13.8)	4 (11.1)	9 (15.8)	6 (26.1)
≥4, No. (%)	97 (83.6)	22 (75.9)	75 (86.2)	32 (88.9)	48 (84.2)	17 (73.9)
Knowledge of the symptoms						
Median (IQR)	4 (4–5)	4 (3.5–5)	4 (4–5)	5 (4–5)	4 (4–5)	4 (3–5)
<4, No. (%)	15 (12.9)	7 (24.1)	8 (9.2)	2 (5.6)	6 (10.5)	7 (30.4)
≥4, No. (%)	101 (87.1)	22 (75.9)	79 (90.8)	34 (94.4)	51 (89.5)	16 (69.6)
Knowledge of the transmission						
Median (IQR)	5 (4–5)	5 (4–5)	5 (4–5)	5 (4–5)	5 (4–5)	4 (4–5)
<4, No. (%)	8 (6.9)	4 (13.8)	4 (4.6)	1 (2.8)	3 (5.3)	4 (17.4)
≥4, No. (%)	108 (93.1)	26 (86.2)	83 (95.4)	35 (97.2)	54 (94.7)	19 (82.2)
Knowledge of the prevention						
Median (IQR)	5 (4–5)	4 (3.5–5)	5 (4–5)[a]	5 (4.25–5)	5 (4–5)	4 (4–5)[b]
<4, No. (%)	10 (8.6)	7 (24.1)	3 (3.4)	3 (8.3)	3 (5.3)	4 (17.4)
≥4, No. (%)	106 (91.4)	22 (75.9)	86 (96.6)	33 (91.7)	54 (94.7)	19 (82.6)
Sticking to prevention regulations						
Median (IQR)	4 (4–5)	4 (4–5)	5 (4–5)[a]	5 (4–5)	5 (4–5)	4 (4–5)
<4, No. (%)	10 (8.6)	6 (20.7)	4 (4.6)	3 (8.3)	3 (5.3)	4 (17.4)
≥4, No. (%)	106 (91.4)	23 (79.3)	83 (95.4)	33 (91.7)	54 (94.7)	19 (82.6)

RDT, rapid detection test; IQR, interquartile range; OHCWs, other healthcare workers (aides, helpers, and medical waste handlers); PPE, personal protective equipment.
[a] *P* value ≤0.05 compared to positive RDTs and [b] *P* value ≤ 0.05 compared to physicians.

a significant association between having a positive test and jobs and having symptoms as well as duration of the symptoms; most positive cases experienced COVID-19-related symptoms with a longer duration than individuals with a negative RDT. PPE availability and usage had a strong association with RDT, and knowledge of the prevention and adherence to preventive rules were also inversely associated with having a positive RDT. OHCWs had the highest prevalence of positive RDT, while they had more shifts per month, less access to PPE, and less knowledge of the pandemic than physicians.

Rapid Serological Tests

There is still much controversy regarding how to diagnose COVID-19 patients. No doubt, validated and accurate laboratory testing for SARS-CoV-2 is a crucial part of the timely management of the COVID-19.[10] Recently, RDTs have gained much attention among the scientific community, and many studies have evaluated the sensitivity and specificity of these tests.

A review by Zainol Rashid et al concerning the diagnostic performance of COVID-19 serological assessments of nine available RDT kits showed that the sensitivity for both IgM and IgG tests ranges between 72.7% and 100%, while specificity ranges between 98.7% to 100%.[11] Based on these experiences, we utilized RDT to elucidate recent SARS-CoV-2 infection among HCWs working at COVID-19 wards, having regular close contacts with COVID-19 patients.

HCWs and RDT

The front line caring for COVID-19 patients in hospitals comprises the medical staff, which puts them at a remarkably higher risk of infection than the general population. In Italy, 20% of responding medical staff were infected, and some died.[12] COVID-19 infection of only one HCW can have a drastic effect on the healthcare system itself.[4] In our study, 24.8% of HCWs tested positive, most of whom worked at COVID-19 wards and ICUs. Still, many HCWs working in other sites had positive RDTs, which raises the importance of protecting HCWs in other sites the same as COVID-19 wards against the virus, especially HCWs working in clinics. Regarding jobs, physicians had a lower risk of a positive RDT than nurses and OHCWs. We found that physicians in our study had significantly fewer shifts per month than the other two groups, which could be one of the potential factors associated with the lower risk of positive RDT in this group of HCWs.

Table 4. Binary Logistic Regression Analyses Assessing the Association between Different Factors and the Risk of a Positive Rapid Detection Test

Variables	OR	95% CI	*P* Value
Gender (male[a])			0.081
Female	0.42	0.16, 1.11	
Age	0.98	0.93, 1.04	0.542
Job (physiocian[a])			
Nurse/Physician	2.36	0.70, 7.92	0.003**
OHCWs/Physicians	8.72	2.32, 32.76	
Working Site (COVID ward[a])			0.270
Other sites (Clinic/Triage)	0.55	0.19, 1.60	
Ways of transportation (walking[a])			
Personal vehicle	2.77	0.32, 23.64	0.218
Public transportation	4.84	0.57, 41.38	
Distance from the hospital (< 10 km[a])			
10–15 km	1.99	0.72, 5.49	0.570
15–20 km	1.27	0.32, 4.95	
>20 km	1.10	0.29, 4.23	
Number of shifts	1.00	0.95, 1.06	0.880
Symptoms (No[a])			0.014*
Yes	4.95	1.39, 17.66	
Symptoms duration	1.14	1.05, 1.24	0.002**
PPE availability	0.63	0.44, 0.91	0.014*
PPE usage	0.63	0.41, 0.96	0.030*
Knowledge of the symptoms	0.59	0.37, 0.96	0.030*
Knowledge of the transmission	0.60	0.36, 0.99	0.046*
Knowledge of the prevention	0.44	0.24, 0.81	0.008**
Sticking to preventive regulations	0.47	0.25, 0.89	0.020*

OR, odds ratio; CI, confidence interval; OHCWs, other healthcare workers (aides, helpers, and medical waste handlers); PPE, personal protective equipment.
[a] Reference; **P* value ≤ 0.05, ***P* value ≤ 0.01; P-values have been reported based on binary logistic regression analysis for each factor.

PPE Utilization

The most significant share of HCWs' protection consists of using PPE while interacting with patients. A body of evidence reveals that using PPE reduces the rate of disease transmission and protects HCWs.[5] Concordantly, we found that using PPE was significantly associated with a lower risk of positive RDT among HCWs; the more PPE was used during the shifts, the less likely the RDT was positive. The standard PPE guidance from Public Health England for medical staff involved in the direct care (within 1 m) of patients with confirmed or suspected COVID-19 includes a disposable apron, gloves, a fluid-repellent surgical mask, and eye protection comprising either goggles or a face shield.[13] When working in high-risk units (where aerosol-generating procedures are undertaken), a respirator (N99 or FFP3 equivalent) is recommended instead of a surgical mask, along with a fluid-repellent long gown and full-face shield or visor.[14]

PPE Availability

In addition to using PPE, having adequate access to it is also crucial. As we found in this study, better access to PPE vastly reduced the risk of positive RDT; recent studies in China and Italy also confirmed this finding.[15-17] According to estimates provided by the WHO for the PPE needed by HCWs, 89 million medical masks, 76 million gloves, 1.6 million goggles, and 30 million gowns are required globally to confront the COVID-19 each month.[14] Following the study by Delgado et al in Latin America, many of the medical staff did not have the required PPE recommended by the WHO, incredibly in the case of surgical or N95 masks and face shields.[18] In another study by Tabah et al in Australia, at least one piece of standard PPE was unavailable for 52% of the participants, and 30% reported reusing single-use PPE.[19] In our study, OHCWs complained of having less access to PPE compared to physicians, which could be another reason for OHCWs to have a higher chance of positive RDT. The shortage of PPE, combined with unclear and changing guidance, would result in anxiety and confusion for the medical staff.[14]

Using PPE Properly

In addition to using and accessing PPE, using them properly and rationally can be even much more essential.[20] PPE should be simple to remove after use without contaminating the user, and complex PPE is likely to increase the risk of contamination during removal. Medical staff must understand the role of using PPE to reduce disease transmission from patients to staff and other patients. It is equally important that staff use it appropriately to maintain a limited quota and ensure enough resources for essential use.[12] There is little evidence that training proper donning and doffing (removing) PPE, simulation, and face-to-face instructions are likely beneficial.[21] It is worth noting that PPE's adverse effects could be associated with longer shift durations, including heat, thirst, pressure areas, skin reactions, headaches, inability to use the bathroom, and extreme exhaustion.[19,22] Having longer shifts, HCWs have to tolerate longer on PPE, so they are more prone to PPE adverse effects, reducing their desire to use the equipment. The WHO has also published a document recently related to the conservation of PPE stocks globally that focuses on the appropriate use of PPE, avoiding PPE overuse, and maintaining supply chains.[12]

It is widely believed that SARS-CoV-2 is transmitted mostly via droplets from infected patients' respiratory systems; however, the virus could also be found in the blood and other body fluids.[23,24] OHCWs have more direct contact with these fluids, especially while handling hospital waste. If they do not use PPE correctly and manage the waste appropriately, they can be infected and spread the disease easily.

Knowledge of the Pandemic

We found that the most associated factors with the chance of having a positive RDT were HCWs' knowledge of the

disease's symptoms, routes of transmission, methods of prevention, and adherence to preventive regulations. Better awareness led to a significantly lower chance of a positive test. In our study, OHCWs' knowledge of the prevention against the infection was found to be significantly lower than physicians, which could probably reduce their insight on the importance of PPE use in high-risk situations as well as being able to recognize suspicious patients, especially in non-COVID-19 wards, and this could also explain why they were more likely to have a positive RDT than the others.

Limitations

This study indeed had some limitations, as it was a single-center observational study with a limited number of RDT kits available at the time of the study, which limited the applicability of multiple regression analyses to evaluate the effect of combination of factors in the RDT positivity. So, the findings of the present study should be applied and referenced with caution. Multi-center studies with larger sample sizes in the future are highly recommended to better elucidate the role of each factor concerning HCWs' becoming infected by the virus and the role of preventive measures in their well-being and safety.

Implications for Health Practice

According to our findings, not only is it enough to use the PPE, but also learning the correct and rational use along with the full knowledge over common symptoms of the disease, routes of transmission, the basic principles of prevention, and adherence to these principles play a critical role. Besides, having adequate access to PPE for all HCWs, including physicians, nurses and OHCWs (aides, helpers, and medical waste handlers) according to their needs, could protect medical staff and patients against SARS-CoV-2. Learning to apply PPE properly would prevent waste of resources during the pandemic, as well. In addition, we found that OHCWs had significantly more shifts per month than physicians, which might be another factor associated with the increased risk of positive RDT among this group. Thus, it is crucial to pay special attention to OHCWs, as they play an essential role in the healthcare system, and protecting them against the virus is as important as physicians and nurses.

In conclusion, the findings of this study suggest that HCWs should have thorough knowledge of the pandemic along with using PPE properly and rationally. Furthermore, adhering to preventive regulations plays a crucial role in HCWs' safety. It is also noteworthy that the shifts should be arranged logically to manage exposures, with special attention being paid to OHCWs.

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Authors' Contribution

MH and AA: Designing questionnaires, data gathering, statistical analysis, drafting the large proportion of the manuscript. MT, PF, and AAb: data gathering, drafting a proportion of the manuscript. SG, MA, EK, AR, MM, MH, and EM: data gathering, conducting RDTs. MS, FG, MH, FA, BM, AS: Designing the study protocol, checking and approving final questionnaires, and editing and approving the final manuscript.

Conflict of Interest Disclosures

The authors have no conflicts of interest to declare.

Ethical Statement

The ethics in medical research committee of Tehran University of Medical Sciences, Tehran, Iran, approved the study protocol (Ethics Approval Code. IR.TUMS.VCR.REC.1399.180), and each participant was provided with a written informed consent form prior to the study.

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References

1. World Health Organization. Situation Reports. Available from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports/. Accessed August 7, 2020.
2. Singhal T. A review of coronavirus disease-2019 (COVID-19). Indian J Pediatr. 2020;87(4):281-6. doi: 10.1007/s12098-020-03263-6.
3. Velavan TP, Meyer CG. The COVID-19 epidemic. Trop Med Int Health. 2020;25(3):278-80. doi: 10.1111/tmi.13383.
4. Hirschmann MT, Hart A, Henckel J, Sadoghi P, Seil R, Mouton C. COVID-19 coronavirus: recommended personal protective equipment for the orthopaedic and trauma surgeon. Knee Surg Sports Traumatol Arthrosc. 2020;28(6):1690-8. doi: 10.1007/s00167-020-06022-4.
5. Cook TM. Personal protective equipment during the coronavirus disease (COVID) 2019 pandemic - a narrative review. Anaesthesia. 2020;75(7):920-7. doi: 10.1111/anae.15071.
6. Guo L, Ren L, Yang S, Xiao M, Chang D, Yang F, et al. Profiling early humoral response to diagnose novel coronavirus disease (COVID-19). Clin Infect Dis. 2020;71(15):778-85. doi: 10.1093/cid/ciaa310.
7. Ghaffari A, Meurant R, Ardakani A. COVID-19 serological tests: how well do they actually perform? Diagnostics (Basel). 2020;10(7):453. doi: 10.3390/diagnostics10070453.
8. Stubblefield WB, Talbot HK, Feldstein LR, Tenforde MW, Ur Rasheed MA, Mills L, et al. Seroprevalence of SARS-CoV-2 among frontline healthcare personnel during the first month of caring for patients with COVID-19-Nashville, Tennessee. Clin Infect Dis. 2021;72(9):1645-8. doi: 10.1093/cid/ciaa936.
9. Naghavi SH, Shabestari O, Roudsari AV, Harrison J. Design and validation of a questionnaire to measure the attitudes of hospital staff concerning pandemic influenza. J Infect Public Health. 2012;5(1):89-101. doi: 10.1016/j.jiph.2011.11.002.
10. Kubina R, Dziedzic A. Molecular and serological tests for COVID-19 a comparative review of SARS-CoV-2 coronavirus laboratory and point-of-care diagnostics. Diagnostics (Basel). 2020;10(6):434. doi: 10.3390/diagnostics10060434.
11. Zainol Rashid Z, Othman SN, Abdul Samat MN, Ali UK, Wong KK. Diagnostic performance of COVID-19 serology assays. Malays J Pathol. 2020;42(1):13-21.
12. The Lancet. COVID-19: protecting health-care workers. Lancet. 2020;395(10228):922. doi: 10.1016/s0140-6736(20)30644-9.
13. Poller B, Lynch C, Ramsden R, Jessop K, Evans C, Tweed K, et al. Laundering single-use gowns in the event of critical shortage: experience of a UK acute trust. J Hosp Infect.

2020;106(3):629-30. doi: 10.1016/j.jhin.2020.08.017.
14. Jessop ZM, Dobbs TD, Ali SR, Combellack E, Clancy R, Ibrahim N, et al. Personal protective equipment for surgeons during COVID-19 pandemic: systematic review of availability, usage and rationing. Br J Surg. 2020;107(10):1262-80. doi: 10.1002/bjs.11750.
15. Liu M, Cheng SZ, Xu KW, Yang Y, Zhu QT, Zhang H, et al. Use of personal protective equipment against coronavirus disease 2019 by healthcare professionals in Wuhan, China: cross sectional study. BMJ. 2020;369:m2195. doi: 10.1136/bmj.m2195.
16. Zhao Y, Liang W, Luo Y, Chen Y, Liang P, Zhong R, et al. Personal protective equipment protecting healthcare workers in the Chinese epicentre of COVID-19. Clin Microbiol Infect. 2020;26(12):1716-8. doi: 10.1016/j.cmi.2020.07.029.
17. Felice C, Di Tanna GL, Zanus G, Grossi U. Impact of COVID-19 outbreak on healthcare workers in Italy: results from a national e-survey. J Community Health. 2020;45(4):675-83. doi: 10.1007/s10900-020-00845-5.
18. Delgado D, Wyss Quintana F, Perez G, Sosa Liprandi A, Ponte-Negretti C, Mendoza I, et al. Personal safety during the COVID-19 pandemic: realities and perspectives of healthcare workers in Latin America. Int J Environ Res Public Health. 2020;17(8):2798. doi: 10.3390/ijerph17082798.
19. Tabah A, Ramanan M, Laupland KB, Buetti N, Cortegiani A, Mellinghoff J, et al. Personal protective equipment and intensive care unit healthcare worker safety in the COVID-19 era (PPE-SAFE): an international survey. J Crit Care. 2020;59:70-5. doi: 10.1016/j.jcrc.2020.06.005.
20. World Health Organization (WHO). Rational Use of Personal Protective Equipment for Coronavirus Disease (COVID-19): Interim Guidance, 27 February 2020. WHO; 2020.
21. Verbeek JH, Rajamaki B, Ijaz S, Sauni R, Toomey E, Blackwood B, et al. Personal protective equipment for preventing highly infectious diseases due to exposure to contaminated body fluids in healthcare staff. Cochrane Database Syst Rev. 2020;4(4):CD011621. doi: 10.1002/14651858.CD011621.pub4.
22. Gheisari M, Araghi F, Moravvej H, Tabary M, Dadkhahfar S. Skin reactions to non-glove personal protective equipment: an emerging issue in the COVID-19 pandemic. J Eur Acad Dermatol Venereol. 2020;34(7):e297-e8. doi: 10.1111/jdv.16492.
23. Sun J, Xiao J, Sun R, Tang X, Liang C, Lin H, et al. Prolonged persistence of SARS-CoV-2 RNA in body fluids. Emerg Infect Dis. 2020;26(8):1834-8. doi: 10.3201/eid2608.201097.
24. Peng L, Liu J, Xu W, Luo Q, Chen D, Lei Z, et al. SARS-CoV-2 can be detected in urine, blood, anal swabs, and oropharyngeal swabs specimens. J Med Virol. 2020;92(9):1676-80. doi: 10.1002/jmv.25936.