

# SARS-COV-2 Seroprevalence among Health Care Workers in Private and Public Hospitals in Tehran, Iran

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# Abstract

## Background

Estimating the prevalence of SARS-COV-2 antibody seropositivity among health care workers (HCWs) is crucial. In this study the seroprevalence of anti-SARS-COV-2 antibodies among HCWs of five hospitals of Tehran-Iran with high COVID-9 patient's referrals was assessed.

## Methods

HCWs from public and private hospitals were included and were asked questions on their demographic characteristics, medical history, hospital role and usage of personal protective equipment (PPE). Seroprevalence was estimated on the basis of ELISA test results (IgG and IgM antibodies in blood samples) and adjusted for test performance.

## Results

Among the 2065 participants, 88.4% and 11.6% HCWs were recruited from the public and private hospitals, respectively. The overall test-performance adjusted seroprevalence estimate among HCWs was 22.6 (95% CI 20.2-25.1) and it was higher in private hospitals (37.0%; 95% CI 28.6-46.2) than public hospitals (20.7%; 95% CI 18.2-23.3). PPE usage was significantly higher among HCWs of public versus private hospitals (66.5% vs. 20.0%). Test-adjusted seroprevalence estimates were highest among assistant nurses and nurses, and lowest among janitor/superintendent categories.

## Conclusions

Seroprevalence of SARS-COV-2 among HCWs depends on hospital type, hospital department, and hospital role. The PPE usage was especially suboptimal among HCWs in private hospitals. Continued effort in access to adequate PPE is warranted.

## Introduction

As the severe acute respiratory syndrome coronavirus 2 (SARS-COV-2) reached a pandemic level, with more than 132 million cases globally by April 2021, the risk of virus transmission among health-care workers (HCWs) with close contact to patients with coronavirus disease (COVID-19) has increased (1, 2). Hence, to reduce the risk of virus transmission and to assess safety precautions in hospitals, estimating the prevalence of antibody seropositivity among HCWs is crucial (3). Nevertheless, factors such as surge in COVID-19-related hospital admissions and limited access to diagnosis test could partly restrict the efforts in conducting seroprevalence surveys among HCWs (4, 5).

Overall, a higher prevalence of SARS-COV-2 antibodies among HCWs compared to non-HCWs were reported in studies conducted in different countries, including the USA and Sweden (2, 4, 6). Iran was among the first countries that reported widespread outbreaks of SARS-COV-2 in several provinces (7). In a

recently conducted study in 18 cities across 17 provinces in Iran, the difference in prevalence of antibody seropositivity among front-line and non-front-line HCWs was low (21.6% vs.18.0%) (7). Similarly, in a study conducted among staff of Mofid children's hospital in Tehran, Iran, no difference was observed in risk of seropositivity among HCWs versus individuals working in administrative departments (8). The similar seroprevalence estimates among HCWs versus non-HCWs in these studies could partly be due to lack of compliance to safety protocols and/or limited access to personal protective equipment (PPE) in some hospitals (8, 9).

Although these studies provide some insight into the prevalence of SARS-COV-2 antibodies among HCWs in Iran, their data did not include information on the potential variation in antibody seropositivity by HCW's hospital role, type of hospital (e.g., public vs. private), and hospital departments. Furthermore, although use of PPE for reducing the risk of transmission in departments treating COVID-19 patients has been recommended, it has been shown that by April 2020, 1,710 COVID-19 infections and 116 deaths among HCWs in Iran were related to insufficient access to PPE (9, 10). Hence, additional data on PPE protection against prevalence of SARS-COV-2 antibodies among HCWs in hospitals is required for work-safety policy decision-making.

To address the current knowledge gaps, in this study we assessed the seroprevalence of anti-SARS-COV-2 antibodies among HCWs in the five hospitals of Tehran-Iran that had the most COVID-9 patients in the first few months of the pandemic.

## Methods

### Study design and population

In this cross-sectional study, we used serological testing to assess the prevalence of SARS-CoV-2 antibodies among HCWs, in five hospitals in Tehran, Iran. We included both government-based (i.e., public) teaching hospitals as well as private hospitals. The three public hospitals were selected as they had major COVID-19 patient's referral in Tehran. Two private hospitals were randomly selected from the listed private hospitals in Tehran.

Compared to the public hospitals, private hospitals are smaller and have lower number of HCWs. Hence, all HCWs who were working within two assigned days in the selected private hospitals were invited to participate in our study and samples from those who agreed to participate were collected in public hospitals, due to the higher number of HCWs, more time was required for sample collection (i.e., total duration of data collection from public hospitals: three weeks and 3 days).

### Test characteristics

Detailed information on test characteristics were reported previously (7). In summary, Pishtaz Teb SARS-CoV-2 ELISA kits (catalogue numbers PT-SARS-COV-2.IgM-96 and PT-SARS-COV-2.IgG-96) approved by Iran's Food and Drug Administration were used and validated to assess the presence of SARS-CoV-2-

specific IgG and IgM antibodies in serum samples (7). The accuracy of the ELISA kits was validated by using serum samples (collected within 2–4 weeks of symptom onset) from 154 patients with RT-PCR confirmed COVID-19 and 110 serum samples collected and stored in the Digestive Diseases Research Institute (DDRI) biobank, 2 years before the pandemic (7). Overall, 103/154 samples tested positive for either IgG (94 (61%)) or IgM (79 (51%)) with the ELISA kits, resulted in sensitivity of 66.9% (95% CI 58.9–74.2%) (7). Besides, 108/110 pre-pandemic samples tested negative for both IgG and IgM SARS-CoV-2-specific antibodies, resulted in specificity of 98.2% (95% CI 93.6–99.8) (7).

## Sample and data collection

This study is in accordance with Helsinki declaration and approved by ethical committee of Digestive Diseases Research Institute under ethical code of IR.TUMS.DDRI.REC.1399.005. After informed consent was obtained the HCWs underwent serology testing and their following information was collected: age, sex, and Body Mass Index (BMI), presence of comorbidity (i.e., presence of at least one of the following conditions namely diabetes, heart disease, hypertension, lung disease, kidney disease, asthma, fatty liver disease, cirrhosis, hepatitis B, hepatitis C, HIV, autoimmune hepatitis, thalassaemia, haemophilia, dementia, multiple sclerosis, malignancy, inflammatory bowel disease, and history of organ transplantation), hospital type, contact with COVID-19 patient, personal protective equipment (PPE) usage, categorized as mask only or mask and other equipment including gowns, shield and/or goggles, HCW's hospital role, and working department. Furthermore, data on COVID-19-related symptoms were collected and participants were categorized based on the experienced number of COVID-19-related symptoms into asymptomatic, paucisymptomatic (1-3 symptoms), or symptomatic ( $\geq 4$  symptoms). History of the COVID-19-related symptoms such as anosmia, sore throat, headache, shortness of breath, diarrhoea, conjunctivitis, weakness, myalgia, arthralgia, altered level of consciousness, and chest pain in the preceding 12 weeks were also requested. (7).

A laboratory technician then collected 5 mL of venous blood into an EDTA-coated microtainer which later were couriered to DDRI laboratory and stored at stored at  $-80^{\circ}\text{C}$  (7). Detailed information on sample collection and ELISA kits has already been published elsewhere (7).

## Statistical analysis

Baseline characteristics of participants among seronegative vs. IgG or IgM positive individuals were reported. Two-sided  $\chi^2$  test was used to compare PPE usage among hospital types, HCW's hospital roles, and hospital departments, and to compare the antibody seropositivity among different roles. To assess the seroprevalence of SARS-CoV-2-specific antibodies among HCWs, the overall crude frequencies of positive tests and test performance adjusted estimates, stratified by age categories, sex, BMI, presence of comorbidity, HCWs job type, department of work, hospital type, diagnosed COVID-19, contact with infected patients, and symptom categories were estimated. The 95% confidence intervals (CIs) for crude seroprevalence were estimated using exact binomial models and a bootstrap method was used to construct the 95% CIs for the adjusted estimates (7, 11). All statistical analyses were conducted by STATA

software, version 12. The statistical approach used for the test performance adjustment and the bootstrap method is provided in detail elsewhere (7).

## Results

In total among the 2065 participants, 1825 (88.4%) and 240 (11.6%) HCWs were recruited from the public and private hospitals, respectively (Table 1). Overall, 66.0% of participants were male, 41.4% aged 30–39 years, 52.1% had BMI  $\leq$  25, 24.3% had at least one comorbid condition, and 19.6% were working in Covid-19 patients ward (Table 1). Nurses and assistant nurses were the most and least frequent hospital roles (32.5% vs. 8.9%) among participants.

Table 1  
Baseline characteristics

	<b>Total (n = 2065)</b>	<b>Seronegative (n = 1725)</b>	<b>IgG or IgM positive (n = 340)</b>
Age (years), mean (SD)	37.49 (9.2)	37.29 (9.1)	38.46 (9.2)
Age categories, n (%)			
• < 30	439 (21.7)	378 (22.4)	61 (18.3)
• 30–39	839 (41.5)	704 (41.7)	135 (40.5)
• 40–49	496 (24.5)	404 (23.9)	92 (27.6)
• 50–59	222 (11)	184 (10.9)	38 (11.4)
• ≥ 60	27 (1.3)	20 (1.2)	7 (2.1)
Sex, n (%)			
• Female	702 (34)	576 (33.4)	126 (37.1)
• Male	1363 (66)	1149 (66.6)	214 (62.9)
BMI, mean (SD)	25.17 (4.1)	25.09 (4.1)	25.55 (3.9)
BMI categories			
• ≤ 25	1058 (52.1)	909 (53.5)	149 (44.7)
• 25.1–30	757 (37.3)	610 (35.9)	147 (44.1)
• > 30	217 (10.7)	180 (10.6)	37 (11.1)
Comorbidity, n (%)			
• No	1557 (75.7)	1303 (75.8)	254 (74.9)
• Yes	500 (24.3)	415 (24.2)	85 (25.1)
Hospital type, n (%)			
• Public	1825 (88.4)	1547 (89.7)	278 (81.8)
• Private	240 (11.6)	178 (10.3)	62 (18.2)
Diagnosed COVID-19, n (%)			
• No	313 (74.4)	267 (84.8)	46 (43.4)
• Yes	108 (25.7)	48 (15.2)	60 (56.6)
Contact with COVID-19 patients, n (%)			
• No	433 (21)	380 (22)	53 (15.6)

	Total (n = 2065)	Seronegative (n = 1725)	IgG or IgM positive (n = 340)
• Yes	1632 (79)	1345 (78)	287 (84.4)
Symptoms, n (%)			
• Asymptomatic (0)	629 (30.6)	569 (33.1)	60 (17.9)
• Paucisymptomatic (1–3)	716 (34.9)	625 (36.4)	91 (27.2)
• Symptomatic ( $\geq 4$ )	708 (34.5)	524 (30.5)	184 (54.9)
Health worker positions			
• Physicians	365 (17.7)	306 (17.8)	59 (17.4)
• Nurses	670 (32.5)	539 (31.3)	131 (38.5)
• Assistant nurses	184 (8.9)	145 (8.4)	39 (11.5)
• Janitor/building superintendents	349 (16.9)	316 (18.4)	33 (9.7)
• Hospital technicians	207 (10)	169 (9.8)	38 (11.2)
• Administration staff	286 (13.9)	246 (14.3)	40 (11.8)
Health worker department			
• COVID-19 patients ward	303 (19.6)	224 (17.2)	79 (32.5)
• ICU or surgery ward	264 (17.1)	233 (17.9)	31 (12.8)
• Other wards	980 (63.4)	847 (65)	133 (54.7)

In total, 340 HCWs were tested positive for SARS-COV-2-specific IgG or IgM antibodies, 81.8% were employed at the public hospitals and 18.2% at the private hospitals. Overall, 17.9% of seropositive individuals were asymptomatic (Table 1).

In the analyses comparing PPE usage by hospital type, HCW's hospital role, and hospital department, combined usage of mask and any other type of PPE was significantly higher among HCWs of public hospitals than private hospitals (66.5% vs. 20.0%,  $\chi^2 = 192.61$ ,  $P \leq 0.001$ ). Similarly, the usage of other PPE types including gowns (46.9% vs. 20.4%,  $\chi^2 = 39.24$ ,  $P \leq 0.001$ ), and shield and/or goggles (37.2% vs. 16.7%,  $\chi^2 = 39.24$ ,  $P \leq 0.001$ ), were significantly higher in the public hospitals. Furthermore, combined usage of mask and any other type of PPE significantly varied among the HCW's hospital role, with the highest usage was observed among nurses and the lowest among administrative staff (67.5% vs. 42.0%,  $\chi^2 = 62.25$ ,  $P \leq 0.001$ ). Similarly, the frequency of combined mask and any other type of PPE usage significantly differed among hospital departments (ICU or surgery ward vs. COVID-19 patients ward vs. other wards: 75.4% vs. 72.6% vs. 62.9%, respectively,  $\chi^2 = 20.26$ ,  $P \leq 0.001$ ) (Table 2).

Table 2  
PPE usage among HCWs and hospitals

	Mask only	Mask and other type of PPE	P-value
Health worker positions			≤ 0.001
• Physicians	139 (38.1)	226 (61.9)	
• Nurses	218 (32.5)	452 (67.5)	
• Assistant nurses	61 (33.2)	123 (66.8)	
• Janitor/building superintendents	120 (35.8)	215 (64.2)	
• Hospital technicians	98 (44.3)	123 (55.7)	
• Administration staff	166 (58.0)	120 (42.0)	
Hospital type			≤ 0.001
• Public	612 (33.5)	1213 (66.5)	
• Private	192 (80.0)	48 (20.0)	
Health worker department			≤ 0.001
• COVID-19 patients ward	83 (27.4)	220 (72.6)	
• ICU or surgery ward	65 (24.6)	199 (75.4)	
• Other wards	364 (37.1)	616 (62.9)	

Combined usage of mask and any other type of PPE versus mask only showed significantly lower antibody seropositivity among nurses (17.0% vs. 24.8%,  $\chi^2 = 5.59$ ,  $P = 0.018$ ) but not any other job categories.

The overall test-performance adjusted seroprevalence estimate among HCWs was 22.6 (95% CI 20.2–25.1). Among hospital roles, the test-adjusted seroprevalence estimates were highest among assistant nurses (29.8; 95% CI 21.1–40.0) and nurses (27.3; 95% CI 22.8–32.2), and lowest among janitor/superintendent categories (11.8; 95% CI 7.4–17.3) (Table 3).

Table 3

Frequencies and prevalence of seropositive tests stratified according to health worker hospital role

	<b>Frequencies</b>	<b>Prevalence (95%CI)</b>	<b>Test performance adjusted prevalence (95%CI)</b>
Physicians	59/365	16.2 (12.5–20.3)	22.1 (16.5–28.5)
Nurses	131/670	19.6 (16.6–22.8)	27.3 (22.8–32.2)
Assistant nurses	39/184	21.2 (15.5–27.8)	29.8 (21.1–40)
Janitor/building superintendents	33/349	9.5 (6.6–13.0)	11.8 (7.4–17.3)
Hospital technicians	38/207	18.4 (13.3–24.3)	25.5 (17.7–34.6)
Administration staff	40/286	14.0 (10.2–18.6)	18.8 (12.9–25.8)
Overall	340/2065	16.5 (14.9–18.1)	22.6 (20.2–25.1)

In the stratified analysis by hospital type, the seroprevalence of SARS-COV-2 was higher in private hospitals (37.0%; 95% CI 28.6–46.2) compared to the public hospitals (20.7%; 95% CI 18.2–23.3) (Table 4). Furthermore, in the stratified analysis by hospital's department seroprevalence estimate was higher in the COVID-19 patients ward (37.3; 95% CI 29.9–45.5) (Table 4). Finally, the highest age-stratified test-performance adjusted seroprevalence was observed among HCWs aged  $\geq 60$  years (37.1; 95% CI 14.3–68.4), with BMI 25.1–30.0 (27.1; 95% CI 22.9–31.7), those in close contact with infected patients (24.3; 95% CI 21.5–27.3), and symptomatic individuals (37.2; 95% CI 32.3–42.4) (Table 5).

Table 4

Frequencies and prevalence of seropositive tests stratified according to hospital type and health worker department

	<b>Frequencies</b>	<b>Prevalence (95%CI)</b>	<b>Test performance adjusted prevalence (95%CI)</b>
<b>Hospital type</b>			
• Public	278/1825	15.23(13.6–17)	20.67(18.2–23.3)
• Private	62/240	25.83(20.4–31.9)	36.97(28.6–46.2)
<b>Hospital department</b>			
• COVID-19 patients ward	79/303	26.07(21.2–31.4)	37.34(29.9–45.5)
• ICU or surgery ward	31/264	11.74(8.1–16.3)	15.30(9.7–22.2)
• Other wards	133/80	13.57(11.5–15.9)	18.11(14.9–21.7)

Table 5  
Frequencies and prevalence of seropositive tests stratified according to baseline characteristics

	Frequencies	Prevalence (95%CI)	Test performance adjusted prevalence (95%CI)
Sex			
• Female	126/702	17.95(15.2–21)	24.84(20.6–29.5)
• Male	214/1363	15.7(13.8–17.7)	21.39(18.5–24.5)
Age categories			
• < 30	61/439	13.9(10.8–17.5)	18.61(13.8–24.1)
• 30–39	135/839	16.09(13.7–18.8)	21.99(18.3–26.1)
• 40–49	92/496	18.55(15.2–22.3)	25.77(20.7–31.5)
• 50–59	38/222	17.12(12.4–22.7)	23.56(16.3–32.2)
• ≥ 60	7/27	25.93(11.1–46.3)	37.12(14.3–68.4)
BMI categories			
• ≤ 25	149/1058	14.08(12-16.3)	18.9(15.8–22.3)
• 25.1–30	147/757	19.42(16.7–22.4)	27.11(22.9–31.7)
• > 30	37/217	17.05(12.3–22.7)	23.46(16.2–32.2)
Comorbidity			
• No	254/1557	16.31(14.5–18.2)	22.33(19.6–25.3)
• Yes	85/500	17.0(13.8–20.6)	23.38(18.5–28.9)
Diagnosed COVID-19			
• No	46/313	14.7(11-19.1)	19.84(14.1–26.6)
• Yes	60/108	55.56(45.7–65.1)	82.7(67.5–97.4)
Contact with COVID-19 patients			

	Frequencies	Prevalence (95%CI)	Test performance adjusted prevalence (95%CI)
• No	53/433	12.24(9.3–15.7)	16.06(11.5–21.4)
• Yes	287/1632	17.59(15.8–19.5)	24.29(21.5–27.3)
Symptoms			
• Asymptomatic (0)	60/629	9.54(7.4–12.1)	11.91(8.6–15.9)
• Paucisymptomatic (1–3)	91/716	12.71(10.4–15.4)	16.78(13.2–20.9)
• Symptomatic ( $\geq 4$ )	184/708	25.99(22.8–29.4)	37.21(32.3–42.4)

## Discussion

In this cross-sectional study among HCWs, the frequency of PPE usage as well as seroprevalence of SARS-COV-2 varied considerably by hospital type, hospital department, and HCW's hospital role. Overall, the highest prevalence of seropositivity was observed in the private hospitals, COVID-19 patient's ward department, and individuals aged 60 years and older. Furthermore, concurrent use of mask and any other type of PPE was significantly higher among HCWs of public hospitals, ICU or surgery ward, and nurses. Finally, 17.6% (60/340) of participants who had positive test results for SARS-COV-2 antibodies did not report experiencing any symptoms.

In general, our overall test-adjusted SARS-COV-2 seroprevalence estimate of 22.5% among HCWs in Private and Public Hospitals was similar to the reported seroprevalence estimates in conducted cross-sectional studies of HCWs in the UK (24.4%) (Shields, 2020) and New York City (27.0%) (2, 12). Consistent with other studies, we also observed variation in SARS-COV-2 seropositivity by HCWs hospital role and department (4, 12). The highest seroprevalence was observed among nurses and assistant nurses, which could be due to closer contact with COVID-19 infected patients (4). In contrast, antibody positivity in our study was lower among Janitor/building superintendents, who compared to nurses, may follow different hospital policies with respect to SARS-COV-2 safety precautions (4, 13). For instance, according to the World Health Organization (WHO) rational use of PPE, the type of PPE that should be used among hospital cleaners who enter the room of patients with COVID-19 partly differs from what HCWs should use (e.g., using Heavy-duty gloves) (14).

We observed 17.6% positive SARS-COV-2 antibody among HCWs with no history of COVID-19 symptoms. Similarly, several studies reported the same findings, indicating the potential virus transmission among HCWs within hospital departments (12, 15, 16). In a study conducted in multistate hospital network in the USA, 29% of participants with detected antibodies, reported no symptoms of COVID-19 (16). These findings highlight the potential "subclinical nature" of COVID-19 disease spectrum and the importance of

testing HCWs regularly to prevent the virus spread within the hospital environment (15–17). In addition to screening HCWs for SARS-COV-2 seropositivity, assessing viral load among asymptomatic and symptomatic participants could provide some information about the viral transmission and pathogenesis of SARS-COV-2 in hospital setting (2).

In this study we found that overall, the combined usage of mask and any other type of PPE among HCWs of public hospitals was significantly higher than private hospitals. As a result, the seroprevalence of SARS-COV-2 was higher in private hospitals compared to the public hospitals (37% vs. 20.7%). The observed difference in PPE usage could partly be attributed to the fact that the included public hospitals in this study were the major COVID-19 referral centers in Tehran. Hence, limited access to PPE supply in country may have caused unequal distribution of PPE in private versus public hospitals. Furthermore, different policy and health regulations on PPE usage across private and public hospitals may contribute to the observed difference (4). Further investigation on potential impact of PPE shortage on infection transmission in private hospitals is required.

Considering the higher seroprevalence of SARS-COV-2 among HCWs with BMI  $\geq$  25.1 and the fact that about 24% of our study participants had at least one comorbid condition, the risk of COVID-19 and its complications could be elevated among vulnerable hospital staff. On the other hand, since the risk of infection is higher among individuals with comorbidity condition, the viral transmission may also be higher among HCWs with underlying medical diseases (18–20). Hence, sufficient access to PPE as well as assigning HCWs with comorbid conditions to hospital wards with lower risk of infection, may need to be considered as the potential strategies to reduce the risk of infection and mortality among HCWs (3).

To the best of our knowledge, this is the first seroprevalence study in Iran that reports the SARS-COV-2 seropositivity among HCWs by hospital types, department, and participant's role. Additionally, the prevalence of seropositive tests was stratified according to HCW's baseline characteristics and PPE usage. Despite the strengths, this study had some limitations that should be considered. First, since patients were recruited during short period of time in each hospital, the study participants may not be representative of all HCWs working in each centre. Second, data on baseline characteristics, presence of COVID-19 symptoms, and contact with infected patients were collected using a self-reported questionnaire, which may introduce recall and/or misclassification bias in the study. Finally, among seropositive HCWs, it was not possible to differentiate between the community acquired or hospital transmitted infections. Hence, the potential routs of SARS-COV-2 transmission among HCWs remains unknown.

In conclusion, the findings of this study imply that seroprevalence of SARS-COV-2 among HCWs depends on hospital type, hospital department, and hospital role. The PPE usage, as a main strategy in infection prevention, was suboptimal, especially among HCWs in private hospitals. HCWs with close contact to COVID-19 patients and with comorbidity conditions are at higher risk of infection and continued effort in access to adequate PPE, regular screening of hospital staff for detecting asymptomatic personnel, to

reduce transmissions within hospitals, especially during the upcoming wave of infection, are warranted (6).

## Declarations

### Funding

This work was supported by Digestive Diseases Research Institute [grant number: 99-1-97-47932].

### Conflict of Interest

The authors do not have an association that might pose a conflict of interest

### Data Availability

The data that support the findings of this study are available from Tehran university of medical sciences. Restrictions apply to the availability of these data, which were used under licence for this study. Data are available from the authors with the permission of Tehran university of medical sciences.

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