

# Assessment of Risk Factors for Coronavirus Disease-2019 in Healthcare Workers: A Case–Control Study

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## ABSTRACT

**Background and aims:** With the rise of coronavirus disease-2019 (COVID-19) cases globally, the infection among frontline healthcare workers (HCWs) escalates many folds. There is, however, limited literature from low middle-income countries regarding risk factors for COVID-19 infection in HCWs. We conducted a case–control study to evaluate the risk factors of COVID-19 infection to HCWs.

**Materials and methods:** This case–control study was conducted in a designated COVID-19 hospital. Eighty-one HCWs involved in direct care of COVID-19 patients, identified as cases, and 266 were recruited as controls. Telephonic interviews with participants were conducted, and information regarding demographic variables, chemoprophylaxis, exposure to infected patients, and adherence to infection prevention and control (IPC) measures was collected.

**Results:** We observed a statistically significant difference in the number of times training session for IPC measures attended by HCWs ( $p = 0.02$ ), performance of aerosol-generating medical procedures (AGMPs) ( $p < 0.001$ ), practices of donning and doffing of personal protective equipment (PPE) ( $p < 0.001$ ), hand hygiene ( $p < 0.001$ ), and decontamination of highly touched surfaces ( $p < 0.001$ ). Logistic regression analysis revealed if the decontamination of highly touched surfaces is decreased by one unit, the odds of getting COVID-19 infection is multiplied by a factor of 0.41 and AGMPs decrease the risk of being a case by 0.76.

**Conclusion:** This study highlighted that inadequate observation of IPC methods increases the risk of COVID-19 infection to frontline HCWs, whereas performance of AGMPs does not enhance the risk. In this study, HCWs undertaking an AGMP, because of concern of acquiring infection, were more diligent during procedures and hence had lesser infection.

**Keywords:** COVID-19, Healthcare workers, Risk factors.

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## INTRODUCTION

Since its advent, severe acute respiratory syndrome Coronavirus 2 (SARS CoV2) has incurred tremendous burden on global health facilities. Healthcare workers (HCWs) are the frontline of the current coronavirus disease-2019 (COVID-19) pandemic response and as such are exposed to hazards that put them at risk of acquiring infection. Compared with general community, frontline HCWs have a threefold increase in risk of positive test for COVID-19.<sup>1</sup> Detection of risk factors for COVID-19 infection in HCWs is crucial for maintaining sustainable workforce against the pandemic and to prevent risk of infection transmission to colleagues, patients, and family. Identification of risk factors is also important for amendment and tailoring local hospital infection control policies.

There are a limited number of studies from India, which identified the risk factors for COVID-19 infection among HCWs. Chatterjee et al. conducted a case–control study to identify the risk factors associated with COVID-19 infection in HCWs. They found that HCWs performing endotracheal intubation had higher odd of acquiring infection, while the consumption of hydroxychloroquine (HCQ) and use of personal protective equipment (PPE) were reported to independently reduce the risk of infection.<sup>2</sup> Another study using online questionnaires reported the inutility of HCQ prophylaxis in the prevention of infection to HCWs and advantage of PPE in mitigating risk of infection even in high-risk zones of hospital.<sup>3</sup>

A recent systematic review on infection and mortality of HCWs worldwide due to COVID-19 suggested disparities between regions of world with the highest number of infections and deaths in Europe, whereas Indian subcontinent and Africa reported a

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relatively low number.<sup>4</sup> Reporting and testing bias have been attributed as one of the factors for the disparity in infection and death rates of HCWs.

As there is paucity of data regarding the risk factors of COVID-19 infections in HCWs from low middle-income countries, we conducted a case–control study to assess the risk factors for SARS-CoV-2 infection in HCWs working in a dedicated COVID-19 health facility in India.

## MATERIALS AND METHODS

A single-center retrospective case–control study on the assessment of risk factors for COVID-19 infection was conducted in HCWs employed with a tertiary care-dedicated COVID-19 hospital from September 7, to October 15, 2020. Ethical clearance from institutional ethical committee was obtained, and the study was

registered with Clinical Trial Registry of India. Healthcare workers with laboratory-confirmed COVID-19 infection were recruited as cases, and other HCWs in the same healthcare setting without any evidence of infection were recruited as controls.

### Participants

For the identification of cases and controls, records of HCWs presenting between April 2020 and July 31, 2020, to screen outpatient department (OPD), which is dedicated for screening and testing of HCWs suspected to be infected with COVID-19, were obtained.

In our center, HCWs are deployed for care of COVID-19 patients for a duration of 14 days in different hospital locations, and they got themselves tested on the 5th day of last exposure through reverse transcriptase polymerase chain reaction (RT-PCR) assay. HCWs who had exposure to COVID-19 patients and whose RT-PCR test was reported as positive were included as cases. For the selection of controls, HCWs who had tested negative on RT-PCR assay for COVID-19 were identified. Based on the start and end date of exposure of a case, HCWs working in the same hospital location were recruited as "controls" according to their respective duty roster at that period of time. The controls were recruited in the minimum ratio of 1:3 for cases.

Interviews with cases and controls were carried out using a questionnaire telephonically by two investigators. At the start of interview, a brief verbal consent was taken and each participant was explained that the questions are being asked for research purpose. Information collected included demographic data, coexisting comorbidities, place of posting of HCW, duration of daily work hours, average number of patients encountered daily, information on training in infection prevention and control (IPC) measures, adherence to IPC, any chemoprophylaxis taken, signs and symptoms of COVID-19 infection, and treatment received (Annexure 1). The part of questionnaire that includes the assessment of exposure to COVID-19 and adherence to IPC during healthcare interactions and during aerosol-generating medical procedures (AGMPs) is based on World Health Organization (WHO) interim guidance on HCW risk assessment (Request ID:350305, permission request granted on June 24, 2020, for WHO copyrighted material).<sup>5</sup>

As the questionnaire was administered telephonically, the assessment of adherence to IPC measures, including hand hygiene (HH), donning, and doffing of PPEs, was limited to HCW's perception of their own behavior. However, to promote honest response of participants, we took precautions that included assurance of full confidentiality to participants, variation of wording of question (use of forgiving words, e.g., with so much work there is no time for HH during COVID times/HH is not required when you are wearing gloves/It is not possible to doff PPE properly after exhaustion from work) or embedded the question about HH in permissive context (e.g., HH requires so much hand rub solutions).<sup>6,7</sup>

### Definition of Variables

For the purpose of this study, we defined HCW as a person who is serving in a healthcare setting and who has the potential for direct or indirect exposure to patients or their infectious secretions and materials (e.g., doctors, nurses, housekeeping, technical staff, general duty workers).

Close contact within 1 m with a suspected or confirmed COVID-19 patients for more than 15 minutes or indirect contacts with their fomites was defined as "exposure."

A HCW exposed to a COVID-19 patient in the 14 days prior to the health worker's confirmation positive test, irrespective of clinical signs and symptoms, was termed as a "case." HCWs identified with a positive test result but those who were not deployed for care COVID-19 patients or who had reported having confirmed COVID-19 case among their close contacts, within previous 14 days, were excluded.

A HCW working in the same hospital location at the same time period, who was asymptomatic and tested negative for COVID-19 infection, was defined as a "control."

Personal protective equipment is referred to specialized clothing used by a HCW to minimize hazards of exposure during contact to COVID-19 patients. It includes protective hooded coverall disposable suit with shoe covers, gloves, face shield, facemask, and/or respirators.

Aerosol-generating medical procedures are the procedures carried out by HCWs in COVID-19 patients that aggrandize the generation of aerosols. These procedures include endotracheal intubation, cardiopulmonary resuscitation, nebulization, open airway suctioning, tracheostomy, and bronchoscopy.

Infection prevention and control measures are practices adopted to prevent the spread of infection among HCWs and patients.

Hand hygiene means cleaning hands by using either handwashing with soap or alcohol-based hand sanitizer or spray.

Decontamination of highly touched surfaces is referred to cleaning of surfaces that sustains more than three contacts per interaction with 70% alcohol solutions.<sup>8</sup>

Hydroxychloroquine chemoprophylaxis is defined as HCQ dosage of 400 mg twice a day on day 1 followed by 400 mg once weekly for 7 weeks.<sup>9</sup>

### Statistical Analysis

The statistical software SPSS version 24.0 was used in the analysis of data. Categorical variables are presented in number and percentage (%), and continuous variables are presented as mean  $\pm$  standard deviation (SD). Demographic variables, HCQ prophylaxis, training for IPC measures, AGMPs, and adherence of HCWs to IPC measures were compared between the cases and controls. Qualitative variables were compared using Chi-square test/Fisher's exact test. Comparison between cases and control was conducted; odds ratio (OR), their 95% confidence intervals (CIs), and *p*-values were calculated. *p*-value less than 0.05 was considered as significant at 95% confidence level. As the dependent variable (COVID-19 infection in HCWs) can be predicted from more than one independent variable, a stepwise forward logistic regression analysis was carried out.

### RESULTS

A total of 133 HCWs (3.6%) infected with COVID-19, including two deaths, were identified till the end of July 2020. Out of 131 HCWs, 11 could not be contacted and 39 were excluded as they reported COVID-19 infection from their colleagues/family members.

On comparison of cases to controls, no significant difference in demographic characteristics was observed (Table 1). There was no significant difference in the number of weeks HCQ prophylaxis taken by cases or controls. A significant difference in the number of times training session for IPC measures attended (*p* = 0.02) and performance of AGMPs (OR 0.36, 95% CI 0.21–0.60, *p* < 0.001) by the cases versus controls was seen. No significant difference in different types of AGMPs carried out was found (Table 2).

**Table 1:** Demographic variables

Demographic parameters	Groups		p
	Case	Control	
Age (mean ± SD) in years	31.9 ± 7.1	31.6 ± 6.4	0.696
Age group (n)	21–30 years	44 (54.3%)	140 (52.6%)
	31–40 years	30 (37%)	99 (37.2%)
	>40 years	7 (8.6%)	27 (10.1%)
Gender (n)	Male	61 (75.3%)	182 (68.4%)
	Female	20 (24.6%)	84 (31.5%)
Marital status (n)	Unmarried	36 (44.4%)	106 (39.8%)
	Married	45 (55.5%)	160 (60.1%)
Education level (n)	Below matriculation	5 (6.1%)	12 (4.51%)
	Matriculation	6 (7.4%)	20 (7.51%)
	Intermediate	20 (24.6%)	81 (30.45%)
	Graduation	34 (41.9%)	85 (31.95%)
	Postgraduation	16 (19.7%)	68 (25.56%)
Job designation (n)	Doctor	31 (38.27%)	103 (38.72%)
	Nurses	25 (30.86%)	75 (28.19%)
	Technician	4 (4.93%)	11 (4.13%)
	Nursing orderlies	12 (14.81%)	51 (19.17%)
	Housekeeping	9 (11.11%)	26 (9.77%)
Working department (n)	Emergency department	11 (13.58%)	37 (13.90%)
	Isolation wards	38 (46.91%)	125 (46.99%)
	Intensive care unit	26 (32.09%)	85 (31.95%)
	Operation theater	6 (7.40%)	19 (7.14%)
Work experience (in years)	7.1 ± 5.5	6.9 ± 5.3	0.829
Average working hours per day	9.7 ± 2.3	9.6 ± 2.2	0.729
Average number of patients seen per day	26.8 ± 17.9	25.8 ± 15.6	0.63

Analysis of practices regarding adherence of HCWs to IPC measures revealed no difference in usage of PPEs (Table 3). There was, however, statistically significant difference observed in practices of donning and doffing of PPEs ( $p < 0.001$ ), HH ( $p < 0.001$ ), and decontamination of highly touched surfaces ( $p < 0.001$ ).

On the assessment of exposure of COVID-19 infection to cases, 16% (13/81) were uncertain about their source of exposure from either patients or colleagues. About 7.4% admitted transmission of infection to colleagues or family members. Sixty-one percent of HCWs who tested positive for COVID-19 required hospitalization. None of the cases required intensive care unit (ICU) admission. The most common symptoms reported were body ache (37%), sore-throat (32%), fever (23.5%), cough (19.8%) followed by alteration in taste or smell, diarrhea, or others. Only 2.5% of cases reported difficulty in breathing.

To assess the risk factors for COVID-19 infections, a stepwise forward logistic regression analysis was carried out with COVID-19 infection in HCW as a dependent variable (coding; case = 0, control = 1). Only two independent variables decontamination of highly touched surfaces (coding; always = 1, most of the times = 2, sometime = 3, rarely = 4) and performance of AGMPs (coding; yes = 1, no = 2) were found as significant predictors that in combination contributed significantly to the risk of COVID-19 infection in HCWs. Adjusted OR and 95% CI from this model are presented in Table 4.

We found that if decontamination of highly touched surfaces is decreased by one unit, the odds of getting COVID-19 infection

are multiplied by a factor of 0.41. Performance of AGMPs decreased the risk of being a case by 0.76.

## DISCUSSION

The analysis of risk factors for COVID-19 infection in HCWs could provide a framework for preventing further spread among HCWs. A previous case-control study from India by Chatterjee et al. found that the performance of endotracheal intubation had higher odds of infection transmission, whereas the consumption of HCQ and the use of PPE were associated with a reduced risk of COVID-19 infection.<sup>2</sup> However, the study did not include the assessment of many other variables influencing the risk of COVID-19 transmission such as duration of working hours, comorbid conditions in HCWs, HH, and practice of decontamination of environmental surfaces.<sup>10,11</sup>

In the present study, participants acknowledged that the lack of adherence to IPC measures is a significant risk factor for HCWs to acquire COVID-19 infections. The risk of infection is increased by a factor of 0.41 if highly touched surfaces are inadequately decontaminated. COVID-19 has been shown to remain viable in aerosols for hours and detected up to 72 hours on plastic and stainless-steel surfaces.<sup>12</sup> Studies have shown that rigorous decontamination procedures are effective in reducing potential risk of infection to HCWs.<sup>13,14</sup> In the present study, although sampling of environmental surfaces was not done, inadequate decontamination

**Table 2:** Comparison of comorbidities, HCQ prophylaxis, IPC training, and AGMPs between cases and controls

		Cases	Controls	<i>p</i>	Odd ratio	95% CI
Comorbidities	No	73 (90.12%)	250 (93.98%)	0.23	0.584	0.24–1.419
	Yes	8 (9.87%)	16 (6.01%)			
HCQ prophylaxis	Yes	48 (59.25%)	141 (53%)	0.32	1.289	0.77–2.13
	No	33 (40.74%)	125 (46.99%)			
IPC training	Yes	49 (60.49%)	166 (62.40%)	0.75	0.922	0.55–1.53
	No	32 (39.50%)	100 (37.59%)			
Number of sessions of IPC training attended	1	46	118	0.021	—	—
	2	1	32			
	≥3	2	16			
AGMPs	Yes	26 (32.09%)	151 (56.76%)	<0.001	0.36	0.21–0.60
	No	55 (67.90%)	115 (43.23%)			
Nebulization	Yes	14 (17.28%)	69 (25.93%)	0.11	0.597	0.31–1.12
	No	67 (82.71%)	197 (74.06%)			
Intubation	Yes	12 (14.81%)	52 (19.54%)	0.10	0.48	0.36–1.41
	No	69 (85.18%)	214 (80.45%)			
Collection of sputum	Yes	1 (1.23%)	19 (7.14%)	0.04	0.16	0.02–1.23
	No	80 (98.76%)	247 (92.85%)			
Suctioning	Yes	6 (7.40%)	38 (14.28%)	0.10	0.48	0.19–1.18
	No	75 (92.59%)	228 (85.71%)			
Tracheostomy	Yes	0	7 (2.63%)	0.14	1.31	1.23–1.39
	No	81 (100%)	259 (97.36%)			
CPR	Yes	2 (2.46%)	15 (5.63%)	0.24	0.42	0.09–1.89
	No	79 (97.53%)	251 (94.36%)			

HCQ, hydroxychloroquine; IPC, infection prevention and control; AGMPs, aerosol-generating medical procedures; CPR, cardiopulmonary resuscitation

of surfaces has been perceived as a strong factor by participants for transmission of infection.

Poor infection control measures by HCWs have previously been shown to be responsible for COVID-19 infection.<sup>15</sup> Houghton et al., in a recent systematic review, described several factors as a barrier for adherence to IPC measures such as lack of training and education for all grades of frontline workers, voluntary nature of attendance to available training, long working hours, lack of logistics such as PPE, poor workplace culture.<sup>16</sup>

In the present study, no difference was observed in the reported training in IPC measures between the cases and controls ( $p = 0.75$ ), whereas there was a significant difference in the number of times the training sessions ( $p = 0.02$ ) were attended. Studies have indicated that training achieves only short-term change in behavior, and to sustain adherence ongoing feedback using an audio or audio-visual performance feedback, automatic contact monitoring or stationing a dedicated person to guide HCW through each step of PPE removal or HH regardless of their previous experience can be utilized.<sup>17–19</sup> Attending more sessions of IPC training by controls as observed in the present study could have possibly sensitized them to their importance and hence improved compliance with IPC measures.

A retrospective cohort study by Ran et al. found the ascending risk of COVID-19 infection with an increase in daily work hours.<sup>10</sup> They reported that working 15 hours per day would lead to infection of all the staff in high-risk department. As the average working hours in cases and controls in our study was 9.5 hours, we did not find average working hours of HCWs to be a significant risk factor.

Working in high-risk departments such as ICUs has been speculated to carry higher risk of acquiring SARS infection as these departments have critically sick patients having higher viral load and there is higher probability of AGMPs in these locations. A recent analysis of 106 HCWs deaths from UK found that none were anesthesiologists or intensive care staff.<sup>20</sup> Similarly, an early retrospective analysis from Wuhan, China, reported that 77.5% of infected HCWs worked in general wards followed by emergency departments (17.5%) and critical care (5%).<sup>21</sup> It has been postulated that HCWs working in the high-risk departments may have systematically prepared at protecting themselves and meticulously used IPC measures.

We observed that out of 81 infected HCWs directly involved in patient care, 47% worked in isolation wards, 32% in ICUs, and 13% in emergency department. On stepwise logistic regression, however, working in high-risk departments is not found to be a significant risk factor for COVID-19 infection.

An antimalarial drug HCQ has been suggested for prophylaxis of SARS CoV2 infection for high-risk population by Indian Council of Medical Research.<sup>9</sup> There is, however, a lack of scientific evidence to support the role of HCQ in prophylaxis against COVID-19 infection. We found no difference in the HCQ intake between cases and controls. A recent study by Albella et al. also found no clinical benefit of daily administration of HCQ as pre-exposure prophylaxis.<sup>22</sup>

Worldwide, older age, and presence of comorbidities remain strong risk factors of mortality from COVID-19.<sup>23</sup> The presence of comorbidities and age of HCWs are not observed to be significant risk factors for acquiring infection in our study. In our center,

**Table 3:** Comparison of adherence to infection prevention control (IPC) measures between cases and controls

IPC measures		Case	Control	p
PPE during patient interaction	Yes	81 (100%)	265 (99.62%)	0.58
	No	00	01 (0.37%)	
Gloves	Always	80 (98.76%)	266 (100%)	0.07
	Mostly	01 (1.23%)	00	
	Sometimes	00	00	
	Rarely	00	00	
Mask	Always	80 (98.76%)	264 (99.24%)	0.68
	Mostly	1 (1.23%)	02 (0.75%)	
	Sometimes			
	Rarely			
Face shield	Always	76 (93.82%)	246 (92.48%)	0.60
	Mostly	04 (4.93%)	16 (6.01%)	
	Sometimes	00	03 (1.12%)	
	Rarely	01 (1.23%)	01 (0.37%)	
Gown	Always	78 (96.29%)	266 (100%)	0.002
	Mostly	03 (3.70%)	00	
	Sometimes	00	00	
	Rarely	00	00	
Donning and doffing of PPE as per protocol	Always	56 (69.13%)	231 (86.84%)	<0.001
	Mostly	21 (25.92%)	34 (12.78%)	
	Sometimes	03 (3.70%)	00	
	Rarely	01 (1.23%)	00	
HH after touching patients	Always	45 (55.55%)	220 (82.70%)	<0.001
	Mostly	28 (34.56%)	37 (13.90%)	
	Sometimes	08 (9.87%)	04 (1.50%)	
	Rarely	00	04 (1.50%)	
HH after doing procedures	Always	43 (53.08%)	224 (84.21%)	<0.001
	Mostly	28 (34.56%)	33 (12.40%)	
	Sometimes	09 (11.11%)	7 (2.63%)	
	Rarely	00	1 (0.37%)	
HH after exposure to body fluids of patients	Always	45 (55.55%)	231 (86.84%)	<0.001
	Mostly	29 (35.80%)	31 (11.65%)	
	Sometimes	07 (8.64%)	2 (0.75%)	
	Rarely	00	1 (0.37%)	
HH after touching surroundings of patient	Always	27 (33.33%)	127 (47.74%)	0.07
	Mostly	34 (41.97%)	89 (33.45%)	
	Sometimes	9 (11.11%)	15 (5.63%)	
	Rarely	11 (13.58%)	34 (12.78%)	
Decontamination of highly touched surfaces	Always	14 (17.28%)	110 (41.35%)	<0.001
	Mostly	44 (54.32%)	99 (37.21%)	
	Sometimes	13 (16.04%)	54 (20.30%)	
	Rarely	10 (12.34%)	2 (0.75%)	

PPE, personal protective equipment; HH, hand hygiene

**Table 4:** Stepwise forward logistic regression of risk factors

Independent variables	B	SE	Wald	df	Sig.	Exp (B)	95% CI for Exp (B)
AGMPs	-1.421	0.503	7.998	1	0.005	0.09	0.09-0.64
Decontamination of highly touched surfaces	-0.89	0.323	7.591	1	0.006	0.218	0.21-0.77

AGMP, aerosol-generating medical procedures

many older HCWs and those with significant comorbidities have been excluded from direct care for patients with COVID-19. This vulnerable section of HCWs has been entrusted with policy decisions, management protocols, and periodic revision-based day-to-day feedback, and administrative management as per guidelines from hospital infection control division of our center.

We found that the performance of AGMPs reduces COVID-19 infection to HCW. This is in contrast to the results observed by previous studies.<sup>2,11</sup> Based on data from 2003 SARS epidemic, during initial phases of ongoing pandemic, it was believed that AGMPs substantially increase the risk of transmission.<sup>24</sup> There is, however, limited evidence to imply that AGMPs directly increase the risk of infection transmission to HCWs. A recent study showed that very less amount of aerosolization was detected during tracheal intubation with face mask ventilation. On the other hand, volitional cough by patient and tracheal extubation, respectively, produced 35 times and 15 times greater aerosolized particles.<sup>25</sup> Retrospective analysis of data from a series of 202 COVID-19 patients requiring emergency tracheal intubation showed that none of the operators became infected.<sup>26</sup> There are numerous complex dynamic variables affecting droplet-airborne spread of infection during AGMPs. Environmental factors increasing the risk of infection transmission during an AGMP include small crowded room with inadequate ventilation rate, temperature, and humidity. The physical proximity and time spent during AGMP by HCWs in critical patients are important operator factors. The risk of incurring infection is increased when during AGMPs patient is coughing, sneezing, or talking and he/she is not wearing a surgical mask.<sup>27</sup>

Our observation that AGMPs reduces the risk of infection can be attributed to the fact that the HCWs performing AGMPs were more concerned about the procedure and infection risk; hence, they were more vigilant and they diligently observed IPC measures.

In the present study, we included all grades of HCWs in a ratio of 1:3 for cases to controls for the assessment of risk factors, and 91.6% of them participated. There are, however, certain limitations to our study. As it was a telephonic survey, there is a concern for recall bias. We used a negative RT-PCR test for choosing controls; serological assay was not included for defining them. Although RT-PCR assay is the gold standard for the diagnosis of COVID-19, it has limitations such as false-negative results, and over the course of illness, there is potential for change in accuracy of diagnosis. Another limitation of the study is that telephonic survey was used to assess the adherence of HCWs to HH behavior and donning and doffing of PPEs. Self-reporting of HH is known to overestimate compliance and tends to be invalid if precautions are not observed.<sup>7</sup> As our survey was anonymous and full confidentiality to participants was assured, it should have limited the biases. Additionally, to encourage honest response and to mitigate socially desirable responses during interview, we employed few strategies, such as the use of forgiving words, and embedded the question about HH in permissive context. Direct or remote observation of HH is considered as the gold standard method for assessing compliance but they are costly and time-consuming.<sup>28</sup> Hence, self-reported compliance is an accepted surrogate. Moreover, as our study was aimed at comprehensive assessment of risk factors, including demographic and work-related characteristics, HCQ prophylaxis, AGMPs, and adherence to IPC in transmission of COVID-19 infection to HCWs, it was practically not possible to employ observation methods to measure adherence to practices of HH, and donning and doffing PPEs.

## CONCLUSION

Performing an AGMP and lack of adherence to IPC measures are the main factors responsible for the transmission of COVID-19 infection to HCWs in our setup. The role of AGMPs as a risk factor should be interpreted in the context of other dynamic variables during performance of procedures such as environmental factors, patient factors, and operator-related factors such as level of PPE used and time spent in proximity to patient.

Poor adherence to infection control methods is the leading cause of infection to HCWs all over the world. In addition to the formulation of local guidelines, compliance of HCWs for practicing proper IPC measures can be improved by institutional support and periodic feedback-based training.

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## ANNEXURE 1: QUESTIONNAIRE

### A. Demographic profile

1. Name:
2. Age:
3. Gender:  
Male  
Female
4. Marital status:  
Single  
Married
5. Education:  
Post Graduation  
Graduation  
Intermediate  
Matriculation  
Below matriculation
6. Job category:  
Doctor  
Nursing staff  
Technician  
Nursing orderly  
Housekeeping staff  
Others
7. Department:  
Emergency ward  
Intensive Care Unit  
Isolation ward  
Operation theatre  
Others (Please specify):
8. Any comorbidity:
9. Work experience (number of years):
10. Average working hours per day:
11. Average number of contacts with COVID-19 patients per day
12. Have you taken hydroxychloroquine prophylaxis?  
Yes..... No.....
13. Have you received training on infection prevention and control measures?  
Yes..... No.....  
If yes, please indicate how many times IPC training sessions have been attended.....
14. Have you tested positive on RT-PCR test for COVID-19?  
Yes..... No.....

### B. Assessment of exposure to COVID-19

15. Identified exposure to confirmed cases:  
Patients  
Family or friends  
Colleagues  
Unknown
  16. Transmitted to family or friends: Yes..... No.....
  17. Signs and symptoms (please tick on one or more as applicable):  
No symptoms  
Fever  
Malaise/body ache  
Sore-throat  
Cough  
Diarrhea  
Breathing difficulty  
Others (please specify)
  18. Whether hospitalized: Yes..... No.....
  19. Treatment facility: Isolation ward..... ICU.....
- ### C. Activities performed on COVID-19 patients
20. Did you provide direct care to a confirmed COVID-19 patient?  
Yes..... No.....Unknown
  21. Did you have face-to-face contact (within 1 meter) with a confirmed COVID-19 patient in a health care facility?  
Yes..... No.....Unknown
  22. A. Were you present when any aerosol-generating procedures (AGP) were performed on the patient?  
Yes..... No.....Unknown  
B. If yes, what type of AGP procedure?  
Tracheal intubation  
Nebulizer treatment  
Open airway suctioning  
Collection of sputum  
Tracheostomy  
Bronchoscopy  
Cardiopulmonary resuscitation  
Other, specify
  23. Did you have direct contact with the environment where the environment where the confirmed COVID-19 patients was cared for? E.g., bed, linen, bathroom, medical equipment  
Yes..... No.....Unknown

## QUESTIONNAIRE

### D. Adherence to infection prevention and control (IPC) during healthcare interactions

(For the following questions, please quantify the frequency you wore PPE, as recommended: "Always, as recommended" should be considered wearing the PPE when indicated more than 95% of the time; "Most of the time" should be considered 50% or more but not 100%; "occasionally" should be considered 20% to under 50%; and "Rarely" should be considered less than 20%.)

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1. During the period of a healthcare interaction with a COVID-19 patient, did you wear personal protective equipment (PPE)?	<input type="checkbox"/> Yes <input type="checkbox"/> No
- If yes, for each item of PPE below, indicate how often you used it:	
1. Single gloves	<input type="checkbox"/> Always, as recommended <input type="checkbox"/> Most of the time (50% or more but not 100%) <input type="checkbox"/> Occasionally 20% to under 50% <input type="checkbox"/> Rarely (less than 20% of the time)
2. Medical mask	<input type="checkbox"/> Always, as recommended <input type="checkbox"/> Most of the time <input type="checkbox"/> Occasionally <input type="checkbox"/> Rarely
3. Face shield or goggles/protective glasses	<input type="checkbox"/> Always, as recommended <input type="checkbox"/> Most of the time <input type="checkbox"/> Occasionally <input type="checkbox"/> Rarely
4. Disposable gown	<input type="checkbox"/> Always, as recommended <input type="checkbox"/> Most of the time <input type="checkbox"/> Occasionally <input type="checkbox"/> Rarely
5. Waterproof apron	<input type="checkbox"/> Always, as recommended <input type="checkbox"/> Most of the time <input type="checkbox"/> Occasionally <input type="checkbox"/> Rarely
2. During the period of healthcare interaction with the COVID-19 patient, did you remove and replace your PPE according to protocol (e.g., when medical mask became wet, disposed the wet PPE in the waste bin, performed hand hygiene, etc)?	<input type="checkbox"/> Always, as recommended <input type="checkbox"/> Most of the time <input type="checkbox"/> Occasionally <input type="checkbox"/> Rarely
3. During the period of healthcare interaction with the COVID-19 case, did you perform hand hygiene before and after touching the COVID-19 patient? NB: Irrespective of wearing gloves	<input type="checkbox"/> Always, as recommended <input type="checkbox"/> Most of the time <input type="checkbox"/> Occasionally <input type="checkbox"/> Rarely
4. During the period of healthcare interaction with the COVID-19 case, did you perform hand hygiene before and after any clean or aseptic procedure was performed (e.g., inserting: peripheral vascular catheter, urinary catheter, intubation, etc.)?	<input type="checkbox"/> Always, as recommended <input type="checkbox"/> Most of the time <input type="checkbox"/> Occasionally <input type="checkbox"/> Rarely
5. During the period of healthcare interaction with the COVID-19 case, did you perform hand hygiene after exposure to body fluid	<input type="checkbox"/> Always, as recommended <input type="checkbox"/> Most of the time <input type="checkbox"/> Occasionally <input type="checkbox"/> Rarely
6. During the period of healthcare interaction with the COVID-19 case, did you perform hand hygiene after touching the COVID-19 patient's surroundings (bed, door handle, etc)? Note: this is irrespective of wearing gloves	<input type="checkbox"/> Always, as recommended <input type="checkbox"/> Most of the time <input type="checkbox"/> Occasionally <input type="checkbox"/> Rarely
7. During the period of healthcare interaction with the COVID-19 case, were high touch surfaces decontaminated frequently (at least three times daily)?	<input type="checkbox"/> Always, as recommended <input type="checkbox"/> Most of the time <input type="checkbox"/> Occasionally <input type="checkbox"/> Rarely

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### D. Adherence to infection prevention and control (IPC) when performing aerosol-generating procedures

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1. During aerosol-generating procedures on a COVID-19 patient, did you wear personal protective equipment (PPE)?	<input type="checkbox"/> Yes <input type="checkbox"/> No
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