Original Article

Characterization and assessment of exposure risks of healthcare personnel during the COVID-19 pandemic

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Abstract

Introduction: Healthcare personnel have the right to decent, healthy, and safe working conditions during COVID-19. Despite our best efforts to safeguard them against SARS-CoV-2 infection, a substantially large number of healthcare personnel fell ill and succumbed to COVID-19. This study aimed to characterize the SARS-CoV-2 exposures among healthcare personnel and determine the risk level of those events, thereby identifying and focusing on the key areas that influence workplace safety. **Materials and Methods:** A pre-tested questionnaire was used to collect data from healthcare personnel on the type of exposure, place, and use of preventive measures, along with demographic and occupational data. Exposure events were categorized into low, moderate, and high-risk by using a risk categorization protocol. **Results:** Doctors were primarily found to be involved in the aerosol-generating procedure, which had 94 times higher odds (95% CI: 43.9926–201.17) for high-risk exposures than other activities. In contrast, nurses were more likely to experience close-contact exposures (OR: 2.77, 95% CI: 1.44–5.33). Both critical care units and operation theaters were identified to have higher odds (OR: 2.34, 95% CI: 1.33–4.23 and OR: 2.31; 95% CI: 0.99–5.42, respectively) than the wards for high-risk exposures. Use of personal protective equipment was poor, with breaches reported in 10.2% of all exposure events. The lacunae in practice were addressed by repeated training and counseling and by ensuring the adequacy of resources in required areas. **Conclusions:** The assessment was beneficial for safeguarding healthcare personnel and assuring a safer workplace during the early phase of the COVID-19 pandemic.

Keywords: COVID-19, exposure, personal protective equipment, risk, SARS-CoV-2

Introduction

The COVID-19 pandemic took everyone by surprise and distressed all individuals across the globe. Standing at the forefront against the virus, healthcare personnel (HCP) were no exception. According to the World Health Organization (WHO) estimates, approximately 115,500 HCP (80,000–180,000) died of COVID-19 between January 2020 and May 2021.[1] In India, as per the Institute for Health Metrics and Evaluation estimates, 2775 HCP succumbed to COVID-19 during the same period.[2] The prevalence of laboratory-confirmed SARS-CoV-2 infections among HCP ranged from 5.7% to 11% across these surveys,[3-5] with 1% mortality reported in one of the published reports.[5] Besides substantial morbidity and mortality, the long-term sequel of COVID-19 among HCP was also a matter of grave concern. Moderate-to-severe fatigue was described as the most disabling symptom in HCP, whereas shortness of breath, sleep disturbances, and anxiety were reported by almost all HCP who were struggling to cope with their symptoms several months after the acute infection.[6] In addition, the neurocognitive symptoms (poor focus during interaction with the patient, forgetting the name of the essential medications, etc.) significantly hampered the productivity of the HCP.[7] Therefore,

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preventing SARS-CoV-2 infection among HCP was deemed necessary not only for the smooth functioning of the hospitals during the crisis hours but also for sustaining uninterrupted patient care services.

Unfortunately, HCP in India were vastly untrained in infection prevention and control (IPC) practices to tackle the virus. The shortage of PPE in India in the earlier months of the pandemic further complicated the situation.[8] Furthermore, understanding the different kinds of exposures could offer insightful information to all HCP, including primary care physicians, empowering them to prioritize appropriate preventive measures against SARS-CoV-2 at their workplaces. Under these circumstances, we had planned this study to characterize the COVID-19 exposures among HCP and to determine the risk level of those exposure events.

Materials and Methods

Study Design and Period: This study retrospectively analyzed the data on exposure events between May 25 and August 15, 2020. Data from the HCP were collected within 24 hours of exposure.

Study Centre: The study center was a 2500-bed tertiary care hospital in Varanasi, a city in Uttar Pradesh, India.

Study Population: The study population included HCP directly involved in patient care or exposed to the immediate patient environment. All HCP were housed in an in-campus accommodation facility during their duty period for caring for COVID-19 patients.

Inclusion, Exclusion Criteria, and Definitions: HCP with either exposure to laboratory-confirmed COVID-19 cases or immediate patient care environment were included in the study. Administrative staff, engineering staff, and other ancillary staff who were not directly involved in patient care were excluded.

Exposure was defined as providing care to a COVID-19 patient, having face-to-face contact with the patient, performing the aerosol-generating procedure (AGP) on the patient, or having direct contact with the patient's environment.[9]

The following activities were included under *aerosol-generating procedures*: positive pressure ventilation (BiPAP and CPAP), endotracheal intubation, airway suction, high-frequency oscillatory ventilation, tracheostomy, thoracic physiotherapy, nebulizer treatment, sputum induction, bronchoscopy, and autopsy.

Close contact for HCP was defined as a) being within approximately 1 meter of a COVID-19 patient or b) having unprotected direct contact with infectious secretions or excretions of the patient (e.g. being coughed on, touching used tissues with a bare hand).

Exposure for more than 15 minutes was termed *prolonged exposure*. Any duration of exposure was considered prolonged if the exposure occurred during the performance of an AGP.

Data collection: A pre-tested questionnaire (Supplementary File 1) in English was used to collect the data. HCP exposed to a laboratory-confirmed COVID-19 patient were encouraged to voluntarily report their exposure to the infection prevention and control (IPC) team. They were asked to fill out the soft copy of the questionnaire and send it to assessors by email or WhatsApp. Contact tracing for all direct contacts of a laboratory-confirmed source patient was also conducted, and data on exposures for additional HCP were recorded.

Exposure risk assessment: The risk assessment based on the information provided by each HCP was done by the members of the IPC team, which was an integral part of the institute's COVID-19 task force.[10] The risk categorization protocol was adopted from the advisory for managing HCP during the COVID-19 pandemic by the Ministry of Health and Family Welfare, Government of India (MoHFW, GoI)[11] and slightly modified to make it (Supplementary File 2) implementable at the local level. Upon assessment, the exposure risk was intimated to the HCP with recommended appropriate advice (Supplementary File 2). All HCP were advised to monitor their health and report for the appearance of any clinical symptoms that may be suggestive of COVID-19 (e.g. cough, shortness of breath, sore throat, anosmia, myalgia, malaise) till 14 days after exposure.

Laboratory testing for COVID-19: Laboratory testing was sought for those with high-risk exposures or developed symptoms during the monitoring period. Oropharyngeal and nasopharyngeal swab specimens were collected in the viral transport medium and tested with real-time reverse transcriptase-polymerase chain reaction (rRT PCR) to detect SARS-CoV-2. If an HCP tested positive, he/she was isolated and treated based on their clinical presentation and according to the clinical management guidelines by the MoHFW, GoI.[11]

Sample size estimation: The sample size for this study was calculated using the following formula: sample size (N) = Z^2 P $(1 - P)/d^2$, where Z is the standard normal variate (1.96 at 95% confidence interval), P is the population proportion (it was assumed to have a maximum value of 0.5), and d is the precision or margin of error (decided to be 0.05). Adding the non-response rate of 20%, the estimated minimum required sample size for the study was 462.

Data analysis: A single exposure event for each HCP was considered. The Chi-square test was used to determine the association between variables. Multivariate logistic regression analysis was performed with variables for which significant association was found in the Chi-square test. Statistical analyses were conducted with SPSS for Windows Version 16 (SPSS Inc., Chicago, IL, USA). The level of significance was set as $P < 0.05$.

Results

The HCP submitted a total of 654 filled questionnaires during the study period. In total, 144 questionnaires were excluded due to missing information or the submission of duplicate responses. Finally, questionnaires filled out by 510 HCP were assessed.

Characterization of COVID-19 exposure events: Exposure events (n = 510) were characterized in terms of AGP-related exposures (68; 13.33%), prolonged (for more than 15 minutes, and including the AGP-related events) exposures (320; 62.75%), close contact (exposure within 1 meter of the COVID-19 patient but not including the AGP-related events) exposures (358; 70.2%), and prolonged closed contact (exposure within 1 meter of the COVID-19 patient for more than 15 minutes but not including the AGP-related events) exposures (217; 42.55%). The characteristics of exposures among different occupational groups and places of exposure within hospital premises are depicted in Table 1.

AGP-related exposures took place mainly in critical care units (50%), followed by wards (25%), operation theaters (14.71%), and emergency triage (10.29%), respectively. Among the non-AGP-related exposure events, both close contact and prolonged close contact exposures were mainly reported from wards (51.96% and 50.23%), followed by critical care units (22.07% and 28.57%), and emergency triage (14.8% and 10.14%), respectively. Location of exposures had a significant association with prolonged exposure (including AGP-related exposures) events ($P < 0.001$), AGP-related exposures ($P < 0.001$), close contact (not including the AGP-related events) exposures ($P = <0.001$), and prolonged closed contact (not including the AGP-related events) exposures ($P = <0.001$).

Adherence to PPE use during occupational COVID-19 exposure events: Figure 1a and b depict comparisons between the use of different combinations of PPE by HCP occupational groups and common locations in the hospitals, respectively.

The use of PPE during the AGP-related exposures is separately depicted in Figure 2. Appropriate use of PPE for AGP was found in only 13 (19.12%) instances.

An accidental breach in the PPE occurred in 52 (10.2%) of the total 510 occupational exposure and 13 (19.12%) of 68 AGP-related exposure events. These were proportionally higher among sanitation staff (2 of 3; 66.67%) than other occupational groups, viz. doctors (17 of 143; 11.89%), nurses (15 of 208; 7.21%), and ward attendants (18 of 151; 11.92%).

The practice of hand hygiene immediately after exposure was almost similar among all occupational groups, with the highest frequency reported by ward attendants (117 of 151; 77.48%), followed by nurses (157 of 208; 75.48%), and doctors (104 of 143; 72.73%), respectively [Figure 1a]. Location-wise, the practice of hand hygiene after exposure was somewhat better in critical care units (104 of 134; 77.6%) and general wards (176 of 228; 77.19%) than in emergency triage (57 of 80; 71.25%) and operation theaters (30 of 42; 71.42%).

Determination of risk level: The exposure events (n = 510) were categorized into low (335; 65.69%), moderate (106; 20.78%), and high-risk (69; 13.53%) exposures. Table 2 depicts the frequency distribution of different variables with the assessed risk categories. A significant association of risk categories was found with occupation ($P = 0.011$) and location of exposures within the hospital ($P < 0.001$).

Multivariate analysis: The results of multivariate analyses of variables such as HCP occupation and location of exposures with dependent variables are depicted in Table 3. Although nurses were 2.77 (95% CI: 1.44–5.33) times more likely to experience non-AGP-related close contact exposures than doctors, they were 59% (OR: 0.41; 95% CI: 0.22–0.77) less likely to be involved in high-risk exposures. Critical care units posed a higher risk for prolonged exposures (OR: 2.56; 95% CI: 1.56–4.19) and AGP-related exposures (OR: 4.22; 95% CI: 2.24–7.91) than the wards. Similarly, operation theaters had higher odds for prolonged

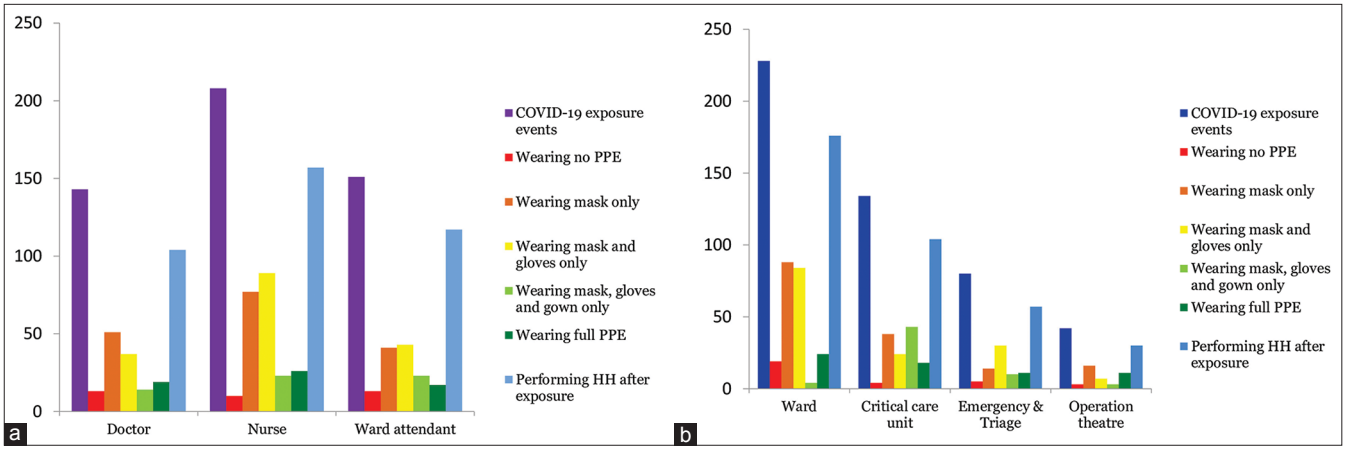

Figure 1: a: Bar diagram depicting different PPE combinations among occupational groups. b: Bar diagram depicting the use of different PPE combinations at various patient care locations

Table 1: Characterization of occupational exposure events with respect to the occupation of HCP and locations within the healthcare facility

Variables	Prolonged exposure (including all AGP-related exposures) *n*=510			AGP-related exposures *n*=510			Close contact exposures (excluding AGP-related exposures) *n'*=442			Prolonged close contact exposures (excluding AGP-related exposures) *n''*=358		
	Yes (%) Total=320	No (%) Total=190	*P*	Yes (%) Total=68	No (%) Total=442	*P*	Yes (%) Total=358	No (%) Total=84	*P*	Yes (%) Total=217	No (%) Total=141	*P*
Occupation												
Doctors	96 (30)	47 (24.74)	0.25	28 (41.18%)	115 (26.02)	0.04	89 (24.86)	26 (30.95)	<0.001	58 (26.73)	31 (21.99)	0.123
Nurses	125 (39.06)	83 (43.68)		19 (27.94%)	189 (42.76)		171 (47.77)	18 (21.43)		102 (47.01)	69 (48.94)	
Ward attendants	92 (28.75)	59 (31.05)		20 (29.41%)	131 (29.64)		92 (25.7)	39 (46.43)		51 (23.5)	41 (29.07)	
Others	07 (2.19)	01 (0.53)		01 (1.47)	07 (1.58)		06 (1.67)	01 (1.19)		06 (2.76)	0**	
Location												
Ward	136 (42.5)	92 (48.42)	<0.001	17 (25)	211 (47.74)	<0.001	186 (51.96)	25 (29.76)	<0.001	109 (50.23)	77 (54.61)	<0.001
Critical care unit	106 (33.13)	28 (14.74)		34 (50)	100 (22.62)		79 (22.07)	21 (25)		62 (28.57)	17 (12.06)	
Emergency and Triage	32 (10)	48 (25.26)		07 (10.29)	73 (16.52)		53 (14.8)	20 (23.81)		22 (10.14)	31 (21.98)	
Operation theater	36 (11.25)	06 (3.16)		10 (14.71)	32 (7.24)		26 (7.26)	06 (7.14)		20 (9.22)	06 (4.26)	
Other areas within hospital premises*	10 (3.12)	16 (8.42)		0	26 (5.88)		14 (3.91)	12 (14.29)		04 (1.84)	10 (7.09)	
Use of full PPE												
Yes	47 (14.69)	17 (8.95)	0.049	15 (22.06)	49 (11.09)	0.01	42 (11.73)	07 (8.33)	0.37	30 (13.82)	19 (13.48)	0.92
No	273 (85.31)	173 (91.05)		53 (77.94)	393 (88.91)		316 (88.27)	77 (91.67)		187 (86.18)	122 (86.52)	

Figures in parentheses denote percentages. Percentages were calculated considering the column total for a single variable. *As AGP-related exposure events occurred only in direct patient care areas but not in other areas (support service areas, Radiology, Blood bank, Clinical laboratory), the latter was not considered in the Chi-square test for AGP-related exposures. **The Chi-square test could not be performed for the concerned variable due to the 'zero' value within a cell. Instead, Fisher's exact test was performed

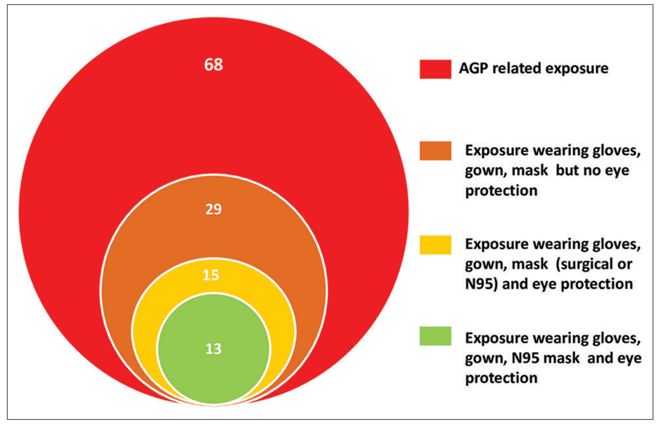

Figure 2: Venn diagram showing the proportion of appropriate PPE use during an aerosol-generating procedure

exposures (OR: 4.05; 95% CI: 1.64–10.02) and AGP-related exposures (OR: 3.87; 95% CI: 1.63–9.21) than the wards. Both critical care units (OR: 2.34; 95% CI: 1.33–4.23) and operation theaters (OR: 2.31; 95% CI: 0.99–5.42) also had higher odds than the wards for high-risk exposures.

AGP-related activities were found to have 94 times higher odds (OR: 94.07; 95% CI: 43.9926–201.17) for high-risk exposures than non-AGP-related activities ($P < 0.001$).

Laboratory diagnosis of COVID-19 among exposed HCP: Among the total 101 HCP (asymptomatic high risk = 64, symptomatic high risk = 5, symptomatic moderate risk = 12, symptomatic low risk = 15), 13 (12.87%) HCP (doctors: 08, nurses: 03, ward attendants: 01, sanitary staff: 01), tested positive. They were also categorized under high or moderate risk levels during exposure risk assessment.

Discussion

In our study, AGP-related exposures were significantly higher among doctors (41.48%) than among other HCP, and half of such exposures (50%) occurred solely in the critical care units. The most frequent reason for a COVID-19 patient being treated in a critical care setting was documented to be the requirement for respiratory support,[12] which involves interventions that are considered high AGPs.[13] In our hospital critical care units, these high-risk AGPs were primarily performed by doctors. This also led to greater proportions of assessed high-risk exposures among doctors (40.58%). WHO recommended using N95 FFP2 or FFP3 respirators, eye protection, and other PPEs for HCP performing AGPs.[14] Interestingly, wearing gowns, masks, and gloves was higher in critical care units during the non-AGP-related exposures [Figure 1b]. Still, our study reported using appropriate PPEs with N95 or equivalent respirators and eye protection only in 18.84% of all AGP-related exposures [Figure 2]. From the above findings, the already existing practice of using PPE in critical care units might explain better use of PPEs in that location. Still, the same might not be enough to prevent AGP-related SARS-CoV-2 viral transmission. Further assessment

Table 2: Assessment of risk level of the occupational exposure events to COVID-19

Variables	Total (%) n=510	Low risk n_1=335	Moderate risk n_2=106	High risk n_3=69	*P*
Age					
18–30 years	287 (56.27)	179 (53.43)	63 (59.43)	45 (65.22)	0.25
31–45 years	181 (35.49)	129 (38.51)	35 (33.02)	17 (24.64)	
>45 years	42 (8.24)	27 (8.06)	8 (7.55)	7 (10.14)	
Gender					
Male	340 (66.67)	222 (66.27)	69 (65.09)	49 (71.01)	0.695
Female	170 (33.33)	113 (33.73)	37 (34.91)	20 (28.99)	
Occupation					
Doctors	143 (28.04)	91 (27.16)	24 (22.64)	28 (40.58)	0.011
Nurses	208 (40.78)	131 (39.11)	58 (54.72)	19 (27.54)	
Ward attendants	151 (29.61)	107 (31.94)	23 (21.7)	21 (30.43)	
Others	08 (1.57)	06 (1.79)	01 (0.94)	01 (1.45)	
Location					
Wards	228 (44.71)	149 (44.48)	55 (51.89)	24 (34.78)	
Critical care units	134 (26.27)	73 (21.79)	32 (30.19)	29 (42.03)	<0.001
Emergency and Triage	80 (15.69)	61 (18.21)	13 (12.26)	06 (8.7)	
Operation Theater	42 (8.24)	28 (8.36)	05 (4.72)	09 (13.04)	
Other areas within the hospital premises	26 (5.09) Radiology=3, Blood bank=2, Clinical Lab=2, Support services locations=19	24 (7.16)	01 (0.94)	01 (1.45)	
Performing or presence during AGP					
Yes	68 (13.3)	13 (3.88)	02 (1.89)	53 (76.81)	<0.001
No	442 (86.7)	322 (96.12)	104 (98.11)	16 (23.19)	

of the risk level also revealed that most exposures categorized under the high-risk group (42.03%) also occurred in critical care units. Accordingly, we advocated using even enhanced respiratory protections for the HCP performing high-risk AGPs in critical care settings.[15]

In this study, both non-AGP-related close contact and prolonged closed contact exposures were more common among the nurses compared to the other occupational groups. It was evident that nurses had to spend far more time than other HCP[16,17] and had a higher frequency of close contact with patients.[18] Our findings indicated that the same was true in the COVID-19 situation. Albaqawi *et al*.[19] from Saudi Arabia also reported that nurses caring for COVID-19 patients had a high exposure rate to SARS-CoV-2. Special attention to nurses' protection during the COVID-19 pandemic was warranted with intense education and training.[20] Along the same lines, we conducted repeated training for all HCP, with particular emphasis on the nurses. Moosavi *et al*.[21] reported that HCP with low age and fewer years of experience were at higher risk of COVID-19 occupational exposures compared to HCP of higher age and with more years of experience. However, our study did not find any association between the age of HCP and the COVID-19 exposure risks.

Our study also revealed that not wearing appropriate PPE was significantly associated with prolonged exposures. Previous studies reported that HCP and frontline workers with adequate PPE had a lower risk of infection than those with inadequate or re-use of PPE.[22,23] Besides long duty shifts, social discrimination and discomfort associated with wearing PPEs were reported as leading distressing factors among HCP during the pandemic.[24] Considering the discomfort of wearing PPEs and our findings, we recommended small duty shifts (≤6 hours duration) for HCP to the hospital authority.

Besides improper use of PPEs and extended duty hours, suboptimal hand hygiene was linked to COVID-19 among HCP.[25] Atnafie *et al*.[26] reported that good hand hygiene practice was adopted in their study in only over half of the HCP (56.7%). A multicentric study conducted in COVID-19 care locations in India found that the total hand hygiene adherence rate was only 59.7%.[27] The overall hand hygiene practice among the HCP in our study seemed better and did not differ much among various occupational groups. On the contrary, a recent meta-analysis also revealed that nurses had the highest hand-hygiene compliance (80%; 95% CI: 74%–87%), and auxiliary workers had the lowest compliance (70%; 95% CI: 62%–77%).[28]

An accidental breach in PPE was reported in 10.2% of occupational exposures in our study. A recent study from India revealed that 15.2% of high-risk exposures related to PPE breaches led to laboratory-confirmed SARS-CoV-2 infections among HCP.[29] Before the pandemic, HCP in India were not well accustomed to using higher-level PPEs, including N95 or equivalent respirators, eye protection (goggles or face shield), and coverall suits. They also encountered significant difficulties arising from excessive sweating, pressure sore on the skin, fogging of goggles and face shields, and even suffocation, which could lead to frequent manipulation of the PPEs, resulting in a breach in those items.[30] We addressed this by instituting the buddy system

Table 3: Multivariate analysis of the independent variables with different types of occupational exposure events and assessed high-risk exposures

Variables	Prolonged exposure (including all AGP-related exposures)		AGP-related exposures		Close contact exposures (excluding AGP-related exposures)		Prolonged close contact exposures (excluding AGP-related exposures)		High-risk exposures	
	OR (95% CI)	***P***	**OR (95% CI)**	***P***	**OR (95% CI)**	***P***	**OR (95% CI)**	***P***	**OR (95% CI)**	***P***
Occupation										
Doctors	-	-	1	-	1	-	-	-	1	-
Nurses	-	-	0.41 (0.22–0.77)	0.005	2.77 (1.44–5.33)	0.002	-	-	0.41 (0.22–0.77)	0.005
Ward attendants	-	-	0.62 (0.33–1.17)	0.14	0.68 (0.38–1.22)	0.20	-	-	0.71 (0.38–1.33)	0.297
Others	-	-	0.58 (0.06–4.96)	0.62	1.75 (0.20–15.22)	0.61	-	-	0.58 (0.06–4.96)	0.62
Location										
Ward	1	-	1	-	1	-	1	-	1	-
Critical care unit	2.56 (1.56–4.19)	<0.001	4.22 (2.24–7.91)	<0.001	0.5 (0.26–0.95)	0.03	1.36 (0.81–2.29)	0.23	2.34 (1.33–4.23)	0.004
Emergency and Triage	0.45 (0.26–0.75)	0.002	1.19 (0.47–2.98)	0.71	0.35 (0.18–0.69)	0.002	0.5 (0.26–0.93)	0.028	0.68 (0.27–1.75)	0.43
Operation theater	4.05 (1.64–10.02)	0.002	3.87 (1.63–9.21)	0.002	0.58 (0.21–1.55)	0.28	2.35 (0.9–6.13)	0.07	2.31 (0.99–5.42)	0.026
Other areas within the hospital premises	0.42 (0.18–0.97)	0.042	-	-	0.15 (0.06–0.37)	<0.001	0.28 (0.008–0.93)	0.03	0.34 (0.04–2.62)	0.3

OR=Odds Ratio; CI=Confidence Interval

for donning and doffing the PPEs and ensuring the quality of PPEs by providing the required inputs for purchasing those items.[31]

Our study categorized only 13.53% of the total exposure events under the high-risk level, and 76.81% of the latter was related to AGP activities. Furthermore, AGP-related activities had 94 times higher odds (OR: 94.07; 95% CI: 43.9926–201.17) for high-risk exposures than other activities. On a similar note, Ashinyo *et al*.[32] also reported that only 14% of all occupational exposures in their study had a high risk of SARS-CoV-2 infection, and HCP performing or present during AGP had a 23.8 times higher chance of COVID-19 exposure than other HCP. In another study from South India, the researchers designated 12.3% of the healthcare-related exposure under the high-risk category.[4]

In the multivariate analysis, it was observed that nurses were more likely (OR: 2.77; 95% CI: 1.44–5.3) to encounter non-AGP-related close contact exposures, but they were 59% less likely to experience (OR: 0.41; 95% CI: 0.22–0.77) high-risk level exposure compared to doctors. Both operation theaters (OR: 4.05; 95% CI: 1.64–10.02) and critical care units (OR: 2.56; 95% CI: 1.56–4.19) had higher odds for prolonged exposures than general wards. The high-risk occupational exposures were more likely to occur in our critical care units (OR: 2.34; 95% CI: 1.33–4.23) and operation theaters (OR: 2.31; 95% CI: 0.99–5.42) than in the general wards. Similarly, a group of investigators from Bangladesh found that HCP working in critical care units and OT complexes had a slightly increased chance of getting the SARS-CoV-2 infection.[33]

Our study highlights the unique obstacles that HCP encountered during the COVID-19 epidemic, making it highly pertinent for primary care clinicians and family physicians. Comprehending the exposure risk patterns is particularly important for care providers in primary care settings as it enables them to design preventative measures efficiently. The results highlight how crucial it is to provide adequate training and resources to all HCP, including family physicians, to ensure adherence to personal preventive measures. In addition, focusing on filling in practice gaps and ongoing quality improvement underscores practical measures all HCP should adopt to maintain a safer workplace.

Our study had several limitations. First, the risk categorization protocol used was based on the early evidence of COVID-19, and the assessment was dependent on self-reporting with possible errors arising from recall bias. Second, following the national policy, not all exposed HCP were tested for SARS-CoV-2. Testing all exposed HCP could provide data better for statistically analyzing the risk assessment protocol's actual strength to predict the probability of infection following any level of exposure.

Nevertheless, our study was conducted against the backdrop of an unprecedented situation to deal with the challenge of hospital workforce management during the first wave of the pandemic. Ensuring the quality of care while safeguarding the HCP by suspension of work posed a unique dilemma. Fortunately, the

interim advisories by WHO and MOHFW, GoI provided relevant guidance to impose working restrictions for high-risk exposures only and advocated a 14-day quarantine for the HCP having such exposures. Thus, an adequate workforce was secured for the smooth functioning of our healthcare system.[9,10] Moreover, the study's findings put forward crucial insight into the situational analysis of the workplace and the pattern of behavioral practice among HCP. Our future endeavors would be directed toward overcoming the perceived hurdles in exposure risk minimization and continuous quality improvements with the training of the HCP and promotion of occupational health.

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Ethical policy and Institutional Review Board statement

Ethical permission for this study was obtained from the Institutional Ethics Committee, Institute of Medical Sciences, BHU, Varanasi (Letter number Dean/EC/3296). Data were analyzed and presented anonymously. Since it was a retrospective review of the available records, the consent from the HCP was waived.

Data availability statement

Data supporting the findings are incorporated within the manuscript. Any additional dataset of this study may be available from the corresponding author, Dr. Tuhina Banerjee (Email: drtuhina@yahoo.com), upon reasonable request.

Key messages

From the beginning of the COVID-19 pandemic, we experienced our healthcare system dwindling. Many healthcare workers fell ill or succumbed to COVID-19. The nationwide shortage of personal protective equipment further complicated the situation. Through this manuscript, we shared our endeavors to assess the risk among our healthcare workers and our subsequent efforts to protect them against the deadly virus. This assessment brought us a unique opportunity to recognize the gap in practice and improve the safety of healthcare workers.

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Conflicts of interest

There are no conflicts of interest.

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Supplementary File 1

COVID-19 Virus Exposure Risk Assessment Form for Health Care Workers (HCW)					
1. Health Care Worker Information					
A. Name:	B. Department				
C. Phone number	D. Age (in completed years)			E. Gender	
F. Current place of stay (Complete address)					
G. Type of HCW (specify), & Designation (Doctor, Nurse, Technician, others)					
2. HCW interactions/activities performed on COVID-19 patient information					
A. Date of exposure to confirmed COVID-19 pt.					
B. Place of Exposure:					
C. COVID-19 Patient details Patient symptomatic since (Date) Test Sample sent on (Date)					
D. Source control (Source/Patient wearing a cloth face covering or facemask)	Yes/No				
E. Approximate min. distance from the patient (in meters)					
F. Duration of contact (minutes)					
G. Aerosol-generating procedure was performed on the patient?	Performed	Present/ Not Present			
G2. If yes, what type of procedure	1. Intubation/2.Nebulisation 3.Airway suctioning, 4. Tracheostomy S. Collection of sputum, 6. Bronchoscopy, 7. CPR 8. Other:				
H. Accidental exposure to body fluids	Yes/	No			
I. Did you have ‹direct contact with the environment where the confirmed COVID-19 patient was cared for? E.g. bed, linen, medical equipment, bathroom etc.	Yes/	No/	Unknown		
J. During the health care interaction with a COVID-19 patient, did you wear PPE	Yes/	No			
J 2. If yes, which of the below items of Protection used:	Yes/	No Yes/	No Yes/	No Yes/	No
1. Surgical triple layer mask	Yes/	No			
2. N95 mask					
3. Single use gloves					
4. Disposable gown					
5. Face shield or goggles/protective glasses					
K. Did you perform hand hygiene after touching the patient's surroundings (bed, door, handle etc.), regardless of whether you were wearing gloves?	Yes/	No/	NA		

Supplementary File 2

INSTITUTIONAL GUIDELINE FOR RISK ASSESSMENT IN HEALTH CARE PERSONNELS HAVING CONTACT WITH COVID 19 CASES.

Objective

- This document is intended to assist in assessment of risk of infection in health care personnel's (HCP) who have been exposed to a patient with COVID-19 in order to decide further appropriate actions including monitoring and work restriction.
- These recommendations are made according to the best available information's and guidelines in respect to COVID-19 and are subject to review as and when new evidence becomes available.

Key considerations

- According to current evidence, the COVID-19 virus is transmitted among people through close contact and droplets, and airborne transmission can occur during aerosol-generating procedures (AGPs) [#].
- Understanding how HCP exposure to COVID 19 virus translates into risk of infection is critical for abiding with the infection prevention and control (IPC) recommendations.
- Contaminated hands (of health workers), surfaces, and fomites play a key role in spread of the disease, as do the AGPs. This chain can be interrupted by following strict infection control practices.
- Transmission of COVID-19 to HCP is associated with handling and caring for patients with COVID-19 and can occur and be amplified by noncompliance with standard precautions, based on transmission mechanisms, especially in healthcare settings. HCP should also ensure that patient is wearing mask, as far as possible in the facility.
- Ensure rational and proper use of personal protective equipment's (PPE). PPE includes gloves, medical/surgical face masks - hereafter referred as "medical masks", goggles, face shield, and gowns, as well as items for specific procedures filtering facepiece respirators (i.e. N95 or FFP2 or FFP3 standard or equivalent) - hereafter referred to as "respirators".
- Although use of PPE is the most visible control used to prevent the spread of infection, it is only one of the IPC measures and should not be relied on as a primary prevention strategy.
- The following precautions are recommended for care of patients with suspected or confirmed COVID-19:
- **Precautions for any suspected or confirmed COVID-19 case: standard + contact + droplet transmission precautions.**
- **Precautions for any suspected or confirmed COVID-19 case and AGPs: standard + contact + airborne transmission (aerosols or droplet nuclei) precautions.**
- All the HCP must report every exposure to COVID-19 to the concerned Head of the Department/In-charge.
- The Head of the Department/In-charge will get the details of the exposure filled by the HCP in the standard assessment form (Annexure I) enclosed herewith at the earliest after the exposure on the same day and will duly inform the Infection control officer (ICO).
- Based on this further risk assessment will be done by ICO (in the presence of HCP), the exposure will be categorized as high/medium/low risk for COVID-19 infection.
- The ICO will decide upon the actions based on the level of exposure and will report to concerned HoD and the MS on the same day.

Glossary

- **Self-monitoring** means HCP should monitor themselves for fever by taking their temperature twice a day and remain alert for symptoms of COVID-19 (e.g., cough, shortness of breath, sore throat, anosmia, myalgia, malaise). Anyone on self-monitoring should contact the Head of department /In-charge of the concerned department immediately, if they develop fever or respiratory symptoms during the self-monitoring period to determine whether medical evaluation is needed.
- **Active monitoring** means that the state or health care authority assumes responsibility for establishing regular communication with potentially exposed people to assess for the presence of fever or symptoms of COVID-19 (e.g., cough, shortness of breath, sore throat, anosmia, myalgia, malaise).
- **Close contact** for healthcare exposures is defined as follows: a) being within approximately 3 feet (1 meters) of a person with COVID-19 for a prolonged period of time i.e. more than 15 minutes (such as caring for or visiting the patient; or sitting within 3 feet of the patient in a healthcare waiting area or room); or b) having unprotected direct contact with infectious secretions or excretions of the patient (e.g., being coughed on, touching used tissues with a bare hand). Any duration of exposure should be considered prolonged if the exposure occurred during performance an aerosol-generating procedure.
- **High risk exposure** close contact with a COVID-19 case in the health care setting who is not wearing a cloth face covering or facemask while HCP was providing direct care to a COVID-19 patient (physical examination, nursing care, carrying out AGPs, airway sampling) or contact with bodily fluids from COVID-19 cases or with a contaminated environment without proper use of recommended personal protective equipment (PPE), or not performing hand hygiene when providing patient

care.

- **Medium-risk exposures** generally include HCP who had prolonged (more than 15 minutes) close contact with patients with COVID-19 who were wearing a cloth face covering or facemask while HCP nose and mouth were exposed to material potentially infectious with the virus causing COVID-19. Some low-risk exposures are considered medium-risk depending on the type of care activity performed. For example, HCP who were wearing a gown, gloves, eye protection and a facemask (instead of a respirator) during an aerosol generating procedure would be considered to have a medium-risk exposure. If an AGP had not been performed, they would have been considered low-risk.
- **Low-risk exposures** generally refer to brief interactions (less than 15 minutes) with COVID-19 case or prolonged (more than 15 minutes) close contact with such case who were wearing a cloth face covering or facemask for source control while HCP were wearing recommended PPE (according to their clinical activities) including medical mask or respirator. Use of eye protection in addition to a facemask or respirator would further lower the risk of exposure.
- Examples of **brief interactions** include: briefly entering the patient room without having direct contact with the patient or their secretions/excretions, brief conversation at a triage desk with a patient who was not wearing a cloth face covering or facemask.
- HCP with no direct patient contact and no entry into active patient management areas who adhere to routine safety precautions do not have a risk of exposure to COVID-19 (i.e., they have no identifiable risk).

Table 1: Epidemiologic Risk Classification for Asymptomatic Healthcare Personnel Following Exposure to Patients with COVID-19 or their Secretions/Excretions in a Healthcare Setting, and their Associated Monitoring and Work Restriction Recommendations

Epidemiologic risk factors	Exposure category	Recommended Monitoring for COVID-19 (until 14 days after last potential exposure)	Work Restrictions for Asymptomatic HCP
Prolonged close contact with a patient with COVID-19 who was wearing a cloth face covering or medical mask (i.e., source control)			
HCP PPE: None	Medium	Active	Exclude from work for 14 days after last exposure
HCP PPE: Not wearing a medical mask or respirator	Medium	Active	Exclude from work for 14 days after last exposure
HCP PPE: Not wearing eye protection	Low	Self-monitoring	None
HCP PPE: Not wearing gown or gloves	Low	Self-monitoring	None
HCP PPE: Wearing all recommended PPE (except wearing a medical mask instead of a respirator)	Low	Self-monitoring	None
Prolonged close contact with a patient with COVID-19 who was not wearing a cloth face covering or medical mask (i.e., no source control)			
HCP PPE: None	High	Active	Exclude from work for 14 days after last exposure
HCP PPE: Not wearing a medical mask or respirator	High	Active	Exclude from work for 14 days after last exposure
HCP PPE: Not wearing eye protection[b]	Medium	Active	Exclude from work for 14 days after last exposure
HCP PPE: Not wearing gown or gloves[a,b]	Low	Self-monitoring	None
HCP PPE: Wearing all recommended PPE (except wearing a medical mask instead of a respirator)[b]	Low	Self-monitoring	None

HCP=healthcare personnel; PPE=personal protective equipment. [a]The risk category for these rows would be elevated by one level if HCP had extensive body contact with the patients (e.g., rolling the patient). [b]The risk category for these rows would be elevated by one level if HCP performed or were present for a procedure likely to generate higher concentrations of respiratory secretions or aerosols. For example, HCP who were wearing a gown, gloves, eye protection and a facemask (instead of a respirator) during an AGP would be considered to have a medium-risk exposure.

*Fever is either measured temperature >100.0°F or subjective fever. Note that fever may be intermittent or may not be present in some patients, such as those who are elderly, immunosuppressed, or taking certain medications (e.g., NSAIDs). Clinical judgement should be used to guide testing of patients in such situations. Respiratory symptoms consistent with COVID-19 are cough, shortness of breath, and sore throat.

While self-monitoring, HCW should observe social/physical distancing, strict compliance to hand hygiene and respiratory etiquettes as per the IPC guidelines for COVID 19.

[#]**Aerosol-generating procedures (AGPs)** include the following: positive pressure ventilation (BiPAP and CPAP), endotracheal

intubation, airway suction, high-frequency oscillatory ventilation, tracheostomy, thoracic physiotherapy, nebulizer treatment, sputum induction, bronchoscopy, and autopsy.

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