

Original Research

Cite this article: Mustafa ZU, Majeed HK, Latif S, *et al.* Adherence to infection prevention and control measures among health-care workers serving in COVID-19 treatment centers in Punjab, Pakistan. *Disaster Med Public Health Prep.* 17(e298), 1–8. doi: <https://doi.org/10.1017/dmp.2022.252>.


Keywords:

COVID-19; disease outbreaks; infection control; pandemics; Pakistan

Corresponding authors:

Muhammad Salman,
Email: msk5012@gmail.com;
Tauqeer Hussain Mallhi,
Email: tauqeer.hussain.mallhi@hotmail.com.

Adherence to Infection Prevention and Control Measures Among Health-Care Workers Serving in COVID-19 Treatment Centers in Punjab, Pakistan

Zia Ul Mustafa MPhil^{1,2}, Hafiza Kiran Majeed MBBS³, Shaiza Latif MBBS³, Muhammad Salman PhD⁴ , Khezar Hayat MPhil⁵, Tauqeer Hussain Mallhi PhD⁶, Yusra Habib Khan PhD⁶, Amer Hayat Khan PhD¹, Usman Abubakar PhD¹, Kishwar Sultana PhD⁷ and Brian Godman PhD^{8,9,10}

¹Discipline of Clinical Pharmacy, School of Pharmaceutical Sciences, Universiti Sains Malaysia, Gelugor, Penang, Malaysia; ²Department of Pharmacy Services, District Headquarter (DHQ) Hospital, Pakpattan, Pakistan; ³Department of Medicine, Faisalabad Medical University, Faisalabad, Pakistan; ⁴Institute of Pharmacy, Faculty of Pharmaceutical and Allied Health Sciences, Lahore College for Women University, Lahore, Pakistan; ⁵Institute of Pharmaceutical Sciences, University of Veterinary and Animal Sciences Lahore, Lahore, Pakistan; ⁶Department of Clinical Pharmacy, College of Pharmacy, Jouf University, Sakaka, Al-Jouf, Kingdom of Saudi Arabia; ⁷Faculty of Pharmacy, The University of Lahore, Lahore, Pakistan; ⁸Strathclyde Institute of Pharmacy and Biomedical Sciences, University of Strathclyde Glasgow, United Kingdom; ⁹Division of Public Health Pharmacy and Management, School of Pharmacy, Sefako Makgatho Health Sciences University, Pretoria, South Africa and ¹⁰Centre of Medical and Bio-Allied Health Sciences Research, Ajman University, Ajman United Arab Emirates

Abstract

Objective: Infection prevention and control (IPC) measures are easily adoptable activities to prevent the spread of infection to patients as well as among health-care workers (HCWs).

Methods: This cross-sectional study evaluated the adherence to IPC measures among HCWs working at coronavirus disease 2019 (COVID-19) treatment centers in Punjab, Pakistan. HCWs were recruited by means of convenient sampling through Google Form® using the World Health Organization risk assessment tool. All data were analyzed using SPSS 20.

Results: A total of 414 HCWs completed the survey (response rate = 67.8%), and majority of them were males (56.3%). Most of the HCWs were nurses (39.6%) followed by medical doctors (27.3%). Approximately 53% reported insufficiency of personal protective equipment (PPE), 58.2% did not receive IPC training and 40.8% did not have functional IPC team at their health facilities. The majority of HCWs (90%) used disposable gloves and N95 facemasks while interacting with COVID-19 patients. Nearly 45% used protective face shields and gowns before providing care to their patients. Hand hygiene practices while touching, and performing any aseptic procedure was adopted by 70.5% and 74.1% of HCWs, respectively.

Conclusions: In conclusion, the adherence to IPC measures among Pakistani HCWs working in COVID-19 treatment centers is good despite the limited availability of PPEs. Their practices can be optimized by establishing institutional IPC teams, periodic provision of IPC training, and necessary PPE.

As of October 29, 2021, more than 245 million confirmed cases of coronavirus disease 2019 (COVID-19) have been reported worldwide with 4.9 million deaths.¹ In Pakistan, the first case of COVID-19 was reported on February 26, 2020, and after that a substantial number of positive cases have been reported throughout the country in different phases of the COVID-19 outbreak.^{2–5} To date, more than 1.2 million laboratory confirmed cases of COVID-19 with 28,449 deaths have been reported in Pakistan. The COVID-19 recovery rate in Pakistan is more than 95%, and there are currently approximately 23,000 active cases in the country.⁶ In the Province of Punjab, 440,139 laboratory-confirmed cases of COVID-19 have been reported, with more than 12,000 deaths.⁶ While providing healthcare services, more than 115,000 HCWs have lost their lives around the globe after being infected with COVID-19 up until May 24, 2021.⁷ Local media reports revealed that 14,627 HCWs were infected throughout Pakistan with 143 deaths as of March 22, 2021.⁸

Healthcare workers (HCWs) are considered as highly vulnerable population to experiencing severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) due to their clinical role, particularly in hospital settings.^{9–11} HCWs need to perform their duties in highly critical settings, including emergency units, isolation wards, intensive care units (ICUs), and critical care units (CCUs).^{12–15} Since the emergence of the COVID-19 pandemic, HCWs have shown remarkable

resilience and professional dedication during the routine care processes despite fear of becoming infected and infecting others.¹⁶ However, HCWs possess an appreciably greater risk of being positive for SARS-CoV-2 compared with the population at large.¹⁷ Consequently, the protection of frontline warriors against COVID-19 is of great importance for a country's preparedness against current and future pandemics. In addition, ensuring as far as possible available HCWs to deal with COVID-19 as well as other priority disease areas. Pakistan is currently under the sixth COVID-19 wave, where restrictions on the movement of citizens re-implemented in recent months.¹⁸ The availability of effective vaccines against COVID-19 should help with reducing such activities in the future.

To prevent infection spread among HCWs, and to their patients, many standard precautions have been developed and practiced throughout the world, and HCWs have been advised to follow them strictly while attending to their patients.¹⁹ Many international organizations including the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) have advised HCWs to follow standard infection prevention and control (IPC) principles while providing care to suspected or confirmed cases of COVID-19 in hospitalized settings as well as in the community.^{20,21} All these guidelines stress that HCWs exposed to actual or suspected COVID-19 patients in hospitals should adopt hand hygiene, respiratory hygiene, environmental cleaning, disinfection, and the use of personal protective equipment (PPE) while providing care to patients, in addition to vaccination. The government of Pakistan initiated vaccination campaigns for COVID-19 on February 2, 2021, and in the first phase of the vaccination drive, front-line HCWs received COVID-19 vaccines free of charge from the state.²²

Country guidelines have also been issued to HCWs to follow standard operating procedures. In the case of Pakistan, these include guidelines by The Ministry of National Health Services, Regulation, and Coordination concerning the selection and recommended use of PPE by the HCWs against COVID-19,²³ with correct PPE seen as a physical barrier to prevent the spread of the virus from either a suspected or confirmed case of COVID-19.²⁴ Medical masks, gloves, gowns, and protective face shields/goggles are the recommended PPE that must be worn by HCWs while interacting with COVID-19 patients.²⁵ Hospital settings are considered as sites of infection spread particularly between COVID-19 patients and between patients and HCWs; consequently, effective water sanitation and hygiene (WASH) protocols are necessitated to support IPC activities. However, we are currently unaware of any study that has been reported from Pakistan among exposed HCWs regarding their compliance with IPC in established treatment centers for COVID-19 patients. We are aware that certain health authorities in Pakistan as well as the WHO have advocated such practices, and similar studies have been undertaken in neighboring countries during the ongoing pandemic,^{26–29} however, we did not come across any study conducted in Pakistan. Consequently, the objectives of the current study are to evaluate IPC compliance among exposed HCWs in COVID-19 treatment centers in the Punjab Province, Pakistan. The findings can potentially be used to improve future compliance with IPCs and their directives in this province and wider in Pakistan if there are concerns. In addition, these findings can provide guidance to other low- and middle-income countries (LMICs) during these challenging times. This is important because the Pakistani healthcare system, similar to healthcare systems in other LMICs, has been under considerable strain since the emergence of this pandemic. Initially, this was

due to the non-availability of sufficient medical and testing facilities, lack of trained HCWs to handle such disasters, and insufficient PPEs to treat COVID-19 patients. In addition, in Pakistan and elsewhere, the emergence of the COVID-19 pandemic has imposed an appreciable adverse psychological impact on HCWs.^{24,30–32}

Methods

Study Design

This cross-sectional study was conducted among HCWs working in different COVID-19 treatment centers in both public and private hospitals of the 4 divisions in the Punjab Province of Pakistan (Lahore, Sahiwal, Faisalabad, and Bahawalpur). The health department in the government of Punjab is partitioned into Specialized Healthcare and Medical Education Departments as the administrative body for tertiary/teaching hospitals, while the Primary & Secondary Health Care department controls primary and secondary hospitals established throughout the province of Punjab. Secondary and tertiary care hospitals in the Punjab were equipped with COVID-19 isolation wards for the treatment of hospitalized COVID-19 patients. Moreover, the private sector hospitals also established COVID-19 wards to accommodate suspected or positive COVID-19 patients. All these health facilities were provided with the necessary health personnel and laboratory facilities to treat COVID-19 patients since the start of the pandemic in Pakistan.

Study Population

The study population included HCWs working in COVID-19 treatment centers in both public and private hospitals established in the 4 divisions of Punjab. All HCWs including medical doctors, nurses, pharmacists and laboratory personnel who were willing to participate in the study were included. Those who declined to participate were excluded. All HCWs currently serving in other departments of the hospitals besides COVID-19 wards and HCWs in COVID-19 wards unwilling to participate due to any reason, were excluded from this study. The sample size was calculated using the Raosoft sample size calculator using 50% response rate from the study participants, 95% confidence interval, and 5% margin of error.³³ The calculated sample was 377. A convenient sampling method was used to recruit the study participants.

Study Instrument

The questionnaire used in this study was adapted from the WHO risk assessment and management tool among HCWs specifically designed in the context of COVID-19.²⁵ A pilot study was conducted among 25 HCWs to enhance the utility of study instrument. During this study, all the participants were asked about the clarity, understandability, and relevance of all the questions and response options of the study tool. The final study sample did not include participants of this pilot study. Based on the finding of the pilot study, the content validity reached 1. Moreover, Cronbach's alpha of the questionnaire was found to be 0.77, showing adequate internal consistency. The final version of questionnaire has 4 sections including section 1, which consists of 11 items covering demographic characteristics and the availability of IPC facilities at the hospital. Section 2 collected information on the activities performed by the HCWs on COVID-19 patients and has 4 items. Section 3 has 10 items and assessed the adherence to IPC measures among HCWs during their interactions with COVID-19 patients.

Each item in section 3 has 4 different options, and HCWs were required to select 1 option according to their usual practices of wearing PPE and hand hygiene when they provide care to COVID-19 patients. The 4 options were “always, as recommended” (which means more than 95% of the time they follow this practice), “most of the time” (which means 50% or more but not 100%), “occasionally” (which means 20% to below 50%), and “rarely” (which means less than 20% following these practices). Section 4 comprised 10 items regarding IPC activities during aerosol-generating procedures. All the study participants were classified as either compliant or non-compliant. A compliant category assigned to those HCWs who were following IPC measure “always, as recommended” and “most of the time,” while non-compliant were those HCWs who were adopting IPC measures “occasionally” or “rarely.”

Data Collection Procedure

Due to COVID-19 restrictions, online versions of the data collection tool were developed using Google Forms®. The hyperlink of the questionnaire was sent to all the participants through social media channels, including WhatsApp, Facebook, and Gmail, with the request to provide their responses. All the participants were recruited using convenient sampling technique to complete the questionnaire voluntarily according to their routine practices while providing care to COVID-19 patients. The principal investigator (ZUM) sought the help of medical doctors and pharmacists to provide assistance to the ward servants and cleaners, laboratory personnel, and those who had difficulty filling out the e-questionnaire at their respective centers.

Statistical Analysis

The statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) version 22.0 for Microsoft Windows. The categorical data were presented as frequencies and percentages. Kruskal-Wallis (3 or more groups) and Mann-Whitney (2 groups) tests were used to assess the difference based on demographic characteristics. A $P < 0.05$ was considered statistically significant during the analysis.

Results

Demographic Characteristics of Study Population and Availability of the IPC Facilities

A total of 610 HCWs were invited to participate, with 414 subsequently responding, giving a response rate of 67.8%. The majority of the study participants were male (56.3%) and aged 25-36 years (60.9%). More than two-thirds resided in urban areas (76.8%). Most of the participants (62.4%) had less than 6 years of working experience. More than one-third of the participants were nurses (39.6%), followed by medical doctors (27.3%) and laboratory personnel (13.3%). The majority of the participants (90.3%) were working in public hospitals. Most of the HCWs (52.9%) reported that they did not have sufficient PPE. Fifty-nine percent indicated that their hospitals had functional IPC teams, while 41.8% had attended IPC training. Table 1 summarizes the demographic characteristics of the respondents.

Table 1. Demographics characteristics and availability of IPC facilities

Variables	Frequency (n = 414)	Percentage (%)
Gender		
Male	233	56.3
Female	181	43.7
Age group (in years)		
≤ 25	85	20.5
26-35	252	60.9
36-45	59	14.3
46-55	14	3.4
> 55	4	1.0
Marital status		
Married	168	40.6
Unmarried	246	59.4
Residence		
Rural	96	23.2
Urban	318	76.8
Experience		
< 1 year	76	18.4
1-5 years	182	44.0
6-10 years	105	25.4
> 10 years	51	12.3
Education		
Matriculation	15	3.6
Higher school education	14	3.4
Diploma	196	47.3
Graduation	149	36.0
Masters/specialization	40	9.7
Medical staff		
Medical doctor	113	27.3
Nurse	164	39.6
Pharmacist	22	5.3
Physical/respiratory therapist	26	6.3
Laboratory personnel	55	13.3
Ward servant/cleaner	24	5.8
Others staff	10	2.4
Hospital ownership		
Public	374	90.3
Private	40	9.7
Hospital type		
Tertiary care	258	62.3
Secondary care	156	37.7
City (Division)		
Lahore	155	37.4
Sahiwal	112	27.1
Faisalabad	88	21.3
Bahawalpur	59	14.3
Availability of IPC facilities		
Experienced an interruption in water supply	96	23.2
Had sufficient PPEs	195	47.1
Availability of IPC team	245	59.2
Had attended training on IPC	173	41.8

Table 2. Healthcare worker activities performed on COVID-19 patient in a health care facility

Questions	Yes	No	Unknown
Did you provide direct care to a confirmed COVID-19 patient?	278 (67.1)	92 (22.2)	44 (10.6)
Did you have face-to-face contact (within 1 meter) with a confirmed COVID-19 patient in a health care facility?	267 (64.5)	137 (33.1)	10 (2.4)
Did you have direct contact with the environment where the confirmed COVID-19 patient was cared for bed, linen, medical equipment, bathroom, etc.?	325 (78.5)	87 (21.0)	2 (0.5)
Were you present when any aerosol-generating procedures were performed on the patient?	209 (50.5)	176 (42.5)	28 (6.8)

Table 3. Adherence to IPC procedures during health care interactions

Questions	Compliant	Non-compliant
During a health care interaction with a COVID-19 patient, did you used single-use gloves?	370 (89.4)	44 (10.6)
During a health care interaction with a COVID-19 patient, did you used an N95 mask (or equivalent respirator)?	374 (90.3)	40 (9.7)
During a health care interaction with a COVID-19 patient, did you used a face shield or goggles/protective glasses?	187 (45.1)	227 (54.8)
During a health care interaction with a COVID-19 patient, did you used a disposable gown?	186 (44.9)	228 (55)
During a health care interaction with the COVID-19 patient, did you remove and replace your PPE according to a protocol (e.g., when medical mask became wet, disposed of the wet PPE in the waste bin, performed hand hygiene, etc.)?	292 (70.6)	122 (29.5)
During a health care interaction with the COVID-19 patient, did you perform hand hygiene before and after touching the COVID-19 patient (whether you were wearing gloves)?	292 (70.5)	122 (29.4)
During a health care interaction with the COVID-19 patient, did you perform hand hygiene before and after any clean or aseptic procedure was performed (e.g., while inserting a peripheral vascular catheter, urinary catheter, intubation, etc.)?	307 (74.1)	107 (25.8)
During a health care interaction with the COVID-19 patient, did you perform hand hygiene after exposure to body fluid?	326 (78.8)	88 (21.3)
During a health care interaction with the COVID-19 patient, did you perform hand hygiene after touching the patient's surroundings (bed, door handle, etc.), regardless of whether you were wearing gloves?	339 (81.9)	75 (18.1)
During a health care interaction with the COVID-19 patient, were high-touch surfaces decontaminated frequently (at least three times daily)?	300 (72.5)	114 (27.6)

Health-Care Workers Activities Performed on COVID-19 Patients

The different activities performed by HCWs on COVID-19 patients are shown in Table 2. More than two-thirds (67.1%) were providing direct care to COVID-19 patients, while 64.5% indicated that they had face-to-face contact (within 1 meter) with COVID-19 patients. Approximately 50% of the study participants indicated that they were present around the patients when aerosol-generating procedures were performed.

Adherences to IPC Measures During Health-Care Interactions

The majority of the participants used disposable gloves (89.4%) and N95 masks (90.3%) when they had health interactions with COVID-19 patients. However, less than half of the study participants used protective face shield/goggles (45.1%) and disposable gowns (44.9%) when they had health interactions with COVID-19 patients. Most of the HCWs (70.6%) removed their PPE according to the predefined protocols. More than two-thirds practiced hand hygiene practices before and after touching a patient (70.5%) and before and after performing any aseptic procedure (74.1%). Table 3 shows the adherence to IPC guidance among HCWs during healthcare interactions with COVID-19 patients.

Adherences to IPC Measures During Aerosol-Generating Procedures

During aerosol-generating procedures including tracheal intubation, open airway suctioning, sputum collection, nebulizer treatment, tracheostomy, bronchoscopy, and cardiopulmonary resuscitation, the most compliant IPC measures among HCWs

were hand hygiene before and after any clean or aseptic procedure (89.6%), hand hygiene before and after touching a COVID-19 patient regardless of whether HCWs were wearing gloves (88.9%), wearing single-use gloves (82.1%), and wearing an N95 mask (or equivalent respirator) (79.3%). The least compliant IPC measures were wearing a face shield or goggles/protective glasses (54.8%) and wearing a disposable gown (56.2%). Table 4 describes the adherence to IPC measures when participants were performing aerosol-generating procedures.

Association Between Demographics and IPC Facilities Variables With IPC Adherence

The association between demographic variables including gender, age, marital status, residence, working experience, level of education, medical staff, hospital ownership, hospital type, study areas, and availability of different IPC facilities with IPC adherence is shown in Table 5. Significant ($P < 0.05$) association was observed with the medical staff category, with IPC adherence indicating that the highest adherence manifested by HCWs.

Discussion

To the best of our knowledge, this is the first study undertaken in Pakistan that has assessed adherence to IPC measures among HCWs providing care for COVID-19 patients. In addition, one of the first exploratory studies from a LMIC determining adherence levels to IPC measures among HCWs working in COVID-19 treatment centers providing guidance for others. The current study revealed that more than half of the HCWs indicated that the availability of PPE was insufficient in their health facilities.

Table 4. Adherence to IPC measures when performing aerosol-generating procedures

Questions	Frequency (%)	
	Compliant	Non-compliant
During aerosol-generating procedures on a COVID-19 patient, did you wear single-use gloves?	340 (82.1)	74 (17.8)
During aerosol-generating procedures on a COVID-19 patient, did you wear an N95 mask (or equivalent respirator)?	328 (79.3)	86 (20.7)
During aerosol-generating procedures on a COVID-19 patient, did you wear a face shield or goggles/protective glasses?	227 (54.8)	178 (45.1)
During aerosol-generating procedures on a COVID-19 patient, did you wear a disposable gown?	236 (56.2)	178 (43.7)
During aerosol-generating procedures on the COVID-19 patient, did you remove and replace your PPE according to a protocol (e.g., when medical mask became wet, disposed of the wet PPE in the waste bin, performed hand Hygiene, etc.)?	304 (73.6)	110 (26.6)
During aerosol-generating procedures on the COVID-19 patient, did you perform hand hygiene before and after touching the COVID-19 patient, regardless of whether you were wearing gloves?	368 (88.9)	46 (11.1)
During aerosol-generating procedures on the COVID-19 patient, did you perform hand hygiene before and after any clean or aseptic procedure was performed?	371 (89.6)	43 (10.4)
During aerosol-generating procedures on the COVID-19 patient, did you perform hand hygiene after exposure to body fluid?	321 (77.5)	93 (22.5)
During aerosol-generating procedures on the COVID-19 patient, did you perform hand hygiene after touching the patient's surroundings (bed, door handle, etc.), regardless of whether you were wearing gloves?	358 (86.5)	34 (13.5)
During aerosol-generating procedures on the COVID-19 patient, were high-touch surfaces decontaminated frequently (at least three times daily)?	313 (75.6)	101 (24.4)

Aerosol-generating procedures include tracheal intubation, nebulizer treatment, open airway suctioning, sputum collection, tracheotomy, bronchoscopy, cardiopulmonary resuscitation (CPR), etc.)

However, these findings are higher than the results reported in a multinational study conducted in South America, which reported that only 13% of HCWs had enough PPEs.³⁴ Sarfraz et al. (2020) reported similar findings from LMICs, where there were appreciable differences in the availability of PPE among HCWs across LMICs.³⁵ This is a concern because, as mentioned, the availability and correct use of PPE is essential to help prevent HCWs from getting COVID-19,³⁶ and could be one of the major obstacles to implementing effective IPC measures in many LMICs. Our survey also reported that around one-quarter of the participants experienced an interruption in water supply in the previous week, which is concerning given the necessity of WASH protocols to support IPC activities. This is in contrast with the results of a recent study conducted in Ghana, where the majority of hospitals did not experience any interruption in fresh water supply in their COVID-19 treatment centers. This is a reflection generally of the proactive approach in Ghana during the pandemic.^{36,37} Consequently, interventions to ensure an uninterrupted water supply at COVID-19 treatment facilities are essential to enhance IPC adherence.

The WHO IPC guideline also recommends training and education of HCWs at the health facility level to optimize IPC measures.³⁸ In the current study, the majority of the HCWs were not trained in IPC measures. This observation contrasts with the findings of a Ghanaian study, in which almost all HCWs received training on IPC measures at the health facility level.³⁶ However, other studies conducted among LMICs have shown poor compliance among HCWs with IPC measures.^{29,39,40}

Most of the HCWs in our survey used disposable gloves and masks during their interaction with COVID-19 patients, similar to the findings in Saudi Arabia.^{13,41} Encouragingly, this is higher than a study in Ethiopia, where only a small proportion of HCWs used facemasks in the correct way; however, a higher proportion was wearing PPE correctly before entering the patient area.⁴² Of concern is that approximately half of the HCWs in our study were not using protective face shields/goggles and gowns before interacting with COVID-19 patients and during aerosol-generating procedures, which needs to be addressed going forward.

These results are in contrast to a study conducted in Saudi Arabia, where appreciably greater adherence was reported among HCWs relating to their usage of protective face shield/goggles and gowns.⁴¹ and a study conducted by El-Sokkary et al. (2021) in Egypt with a similar high adherence to correct PPE among HCWs.⁴³

Encouragingly again, most of the HCWs in our study were practicing the doffing of PPE according to the recommendations during interactions with COVID-19 patients or during aerosol-generating procedures. These findings are similar to the findings of a study conducted in India, which reported that the majority of HCWs practice donning and doffing PPE according to the guidelines.⁴⁴ Our findings showed a higher proportion of HCWs adhering to PPE than a study from Nigeria, where only 6-12% of HCWs perform doffing of PPEs as per recommended protocols.⁴⁵

Hand hygiene is another recommended strategy to prevent the spread of infection. Consequently, it is highly recommended that HCWs practice hand hygiene while providing care to COVID-19 patients, especially in LMICs where there can be concerns with the cleanliness of wards. In the current study, encouragingly more than three-quarters of HCWs practiced recommended hand hygiene techniques before and after touching COVID-19 patients, after exposure to patient's body fluid, and when carrying out any aerosol-generating procedures. This contrasts with a study in Sri Lanka, where only one-third of medical students surveyed were performing recommended hand hygiene during care provision for COVID-19 patients.⁴⁶

We are aware that this study has several limitations. These include the inclusion of only 4 divisions of the Punjab Province, which will impact the generalizability of the findings. In addition, a convenience sampling technique was used, which is associated with the risk of biases. The responses were self-reported, making the results vulnerable to social desirability bias. Despite these limitations, this study has described adherence to IPC measures among HCWs in Pakistan and other low-resource settings, giving direction for the future research and policy implementation.

Table 5. Association of demographic variables with IPC adherence

Variables	IPC adherence during health care interactions		IPC adherence to aerosol-generating procedures	
	Mean rank	p-value	Mean rank	p-value
Gender				
Male	213.97	0.211	212.85	0.301
Female	199.17		200.62	
Age (years)				
≤ 25	208.45	0.739	85	0.918
26-35	212.00		252	
36-45	195.25		59	
36-45	183.79		14	
> 55	167.50		410	
Marital status				
Married	209.12	0.819	212.64	0.469
Unmarried	206.39		203.99	
Residence				
Rural	225.36	0.095	196.40	0.299
Urban	202.11		210.85	
Experience				
< 1 year	207.63	0.020	200.57	0.156
1-5 years	226.32		222.09	
6-10 years	185.62		196.95	
> 10 years	185.22		187.48	
Education				
Matriculation	260.93	0.009	261.60	0.004
Higher school education	242.04		249.71	
Diploma	179.58		178.38	
Graduation	185.40		186.19	
Masters/specialization	260.93		261.60	
Medical staff				
Medical doctor	221.15	<0.001	230.80	<0.001
Nurse	228.73		210.58	
Pharmacist	217.95		236.86	
Physical/respiratory therapist	225.10		182.35	
Laboratory personnel	59.17		108.14	
Ward servant/cleaner	312.60		285.94	
Others staff	199.85		252.85	
Hospital ownership				
Public	208.80	0.497	210.46	0.123
Private	195.31		179.81	
Hospital type				
Tertiary care	206.90	0.895	206.21	0.778
Secondary care	208.49		209.63	
City				
Lahore	212.28	0.726	216.97	0.478
Sahiwal	212.36		209.51	
Faisalabad	196.28		193.27	
Bahawalpur	202.46		200.01	
Availability of IPC facilities				
Experienced an interruption in water supply				
Yes	208.22	0.946	216.11	0.420
No	207.28		204.90	
Sufficiency of PPEs				
Yes	198.39	0.143	198.77	0.161
No	215.61		215.27	

(Continued)

Table 5. (Continued)

Variables	IPC adherence during health care inter- actions		IPC adherence to aerosol-generating procedures	
	Mean rank	p-value	Mean rank	p-value
Availability of IPC team				
Yes	216.25	0.073	208.37	0.859
No	194.81		206.24	
Training on IPC				
Yes	209.36	0.789	204.96	0.714
No	206.17		209.32	

Conclusions

Adherence to IPC strategies among Pakistani HCWs is encouraging. However, key areas were identified for improvement to enhance future protection. Institutional IPC teams comprising all stakeholders need to be established to effectively execute all infection prevention activities. Moreover, the provision of necessary PPE, training on proper donning and doffing, and the development and implementation of effective IPC guidelines at the hospital level are critical going forward for the maximum protection of HCWs. We will be monitoring this in the future in Pakistan.

Data availability statement. The data set for this study are available on appropriate request from corresponding author.

Acknowledgments. We thank the administration of the concerned hospitals for their cooperation and support in the completion of this study. Moreover, we acknowledge the services of pharmacy technicians of the participated while completing data collection procedures.

Funding. No funding available for this study.

Conflict of interest. All the authors declared that no conflict of interest is associated with this project.

Ethical considerations. The study protocol was approved by the Research Ethics Committee, Department of Pharmacy Practice, University of Lahore, Lahore (reference no. REC/DPP/FOP/42). Approval was also obtained from the various hospital administrators before data collection. All participants provided an electronic informed consent before their participation in the study. Participation was voluntary and all the participants were assured about the confidentiality of their data.

References

1. World Health Organization. WHO Coronavirus (COVID-19) Dashboard. 2021a. Accessed October 29, 2021. <https://covid19.who.int/>
2. Salman M, Mustafa ZU, Khan TM, et al. How prepared was Pakistan for the COVID-19 outbreak? *Disaster Med Public Health Prep.* 2020;14(3): e44-e45.
3. Abid K, Bari YA, Younas M, et al. Progress of COVID-19 Epidemic in Pakistan. *Asia Pac J Public Health.* 2020;32(4):154-156.
4. Kamran SH, Mustafa ZU, Rao AZ, et al. SARS-CoV-2 infection pattern, transmission and treatment: multicenter study in low to middle-income districts hospitals in Punjab, Pakistan. *Pak J Pharm Sci.* 2021;34(3(Supplementary)):1135-1142
5. Godman B, Haque M, Islam S, et al. Rapid assessment of price instability and paucity of medicines and protection for COVID-19 across Asia: findings and public health implications for the future. *Front Public Health.* 2020;8:585832.
6. Government of Pakistan. Pakistan cases details. 2021. Accessed October 29, 2021. <https://covid.gov.pk/stats/pakistan>
7. World Health Organization. Director-General's opening remarks at the World Health Assembly, 24 May 2021. Accessed October 10, 2021. <https://www.who.int/director-general/speeches/detail/director-general-s-opening-remarks-at-the-world-health-assembly-24-may-2021>
8. Geo News. 143 health workers have lost life to coronavirus in Pakistan so far. 2021. Accessed October 29, 2021. <https://www.geo.tv/latest/340998-143-health-workers-have-lost-life-to-coronavirus-in-pakistan-so-far>
9. Nguyen LH, Drew DA, Graham MS, et al. Risk of COVID-19 among front-line health-care workers and the general community: a prospective cohort study. *Lancet Public Health.* 2020;5(9):e475-e483.
10. Vilibic-Cavlek T, Stevanovic V, Tabain I, et al. Severe acute respiratory syndrome coronavirus 2 seroprevalence among personnel in the healthcare facilities of Croatia, 2020. *Rev Soc Bras Med Trop.* 2020;53:e20200458. doi: 10.1590/0037-8682-0458-2020
11. Razu SR, Yasmin T, Arif TB, et al. Challenges faced by healthcare professionals during the COVID-19 pandemic: a qualitative inquiry from Bangladesh. *Front Public Health.* 2021;9:647315.
12. Deressa W, Worku A, Abebe W, et al. Risk perceptions and preventive practices of COVID-19 among healthcare professionals in public hospitals in Addis Ababa, Ethiopia. *PLoS One.* 2021;16(6):e0242471.
13. Almomammed OA, Aldwihi LA, Alragas AM, et al. Knowledge, attitude, and practices associated with COVID-19 among healthcare workers in hospitals: a cross-sectional study in Saudi Arabia. *Front Public Health.* 2021;9:643053.
14. Chou R, Dana T, Buckley DI, et al. Epidemiology of and risk factors for coronavirus infection in health care workers: a living rapid review. *Ann Intern Med.* 2020;173(2):120-136.
15. Yang JY, Parkins MD, Canakis A, et al. Outcomes of COVID-19 among hospitalized health care workers in North America. *JAMA.* 2021;4(1): e2035699.
16. Liu Q, Luo D, Haase JE, et al. The experiences of health-care providers during the COVID-19 crisis in China: a qualitative study. *Lancet Glob Health.* 2020;8(6):e790-798.
17. Muiry R, Parsons V, Madan I. Risks posed by Covid-19 to healthcare workers. *Occup Med (Lond).* 2021;71(2):56-58.
18. Mirza Z. The sixth wave. 2022. Accessed August 4, 2022. <https://www.dawn.com/news/1697634>
19. Wong EL-Y, Ho K-F, Dong D, et al. Compliance with standard precautions and its relationship with views on infection control and prevention policy among healthcare workers during COVID-19 pandemic. *Int J Environ Res Public Health.* 2021;18(7):3420.
20. World Health Organization. Infection prevention and control during health care when coronavirus disease (COVID-19) is suspected or confirmed. 2021. Accessed October 10, 2021. <https://www.who.int/publications/i/item/WHO-2019-nCoV-IPC-2021.1>
21. Center for Disease Control and Prevention. COVID-19 overview and infection prevention and control priorities in non-US healthcare settings. 2021. Accessed October 29, 2021. <https://www.cdc.gov/coronavirus/2019-ncov/hcp/non-us-settings/overview/index.html>
22. Gul A. Pakistan starts COVID-19 inoculation drive. 2021. Accessed October 29, 2021. <https://www.voanews.com/covid-19-pandemic/pakistan-starts-covid-19-inoculation-drive>

23. **Ministry of National Health Services Regulations and Coordination, (NHSR&C) Government of Pakistan.** National Guidelines COVID-19 & PPEs. 2021. Accessed October 29 2021. https://covid.gov.pk/new_guidelines/01June2020_20200509_Guidance_on_selection_and_use_of_PPE.pdf
24. **Khalid A, Ali S.** COVID-19 and its challenges for the healthcare system in Pakistan. *Asian Bioeth Rev.* 2020;12(4):551-564.
25. **World Health Organization.** Risk assessment and management of exposure of health care workers in the context of COVID-19: interim guidance 19 March 2020. 2021. Accessed October 11, 2021. <https://apps.who.int/iris/handle/10665/331496>
26. **World Health Organization.** WHO Pakistan integrating infection, prevention and control measures for COVID-19 response. 2021. Accessed October 29, 2021. <http://www.emro.who.int/pak/pakistan-news/who-pakistan-integrating-infection-prevention-and-control-measures-for-covid-19-response.html>
27. **El-Sokkary RH, Khater WS, El-Kholy A, et al.** Compliance of healthcare workers to the proper use of personal protective equipment during the first wave of COVID-19 pandemic. *J Infect Public Health.* 2021;14(10):1404-1410.
28. **Ilyas N, Azuine RE, Tamiz A.** COVID-19 pandemic in Pakistan. *Int J Transl Med Res Public Health.* 2020;4(1):37-49.
29. **Etafa W, Gadisa G, Jabessa S, et al.** Healthcare workers' compliance and its potential determinants to prevent COVID-19 in public hospitals in Western Ethiopia. *BMC Infect Dis.* 2021;21(1):454.
30. **Shahbaz S, Ashraf MZ, Zakar R, et al.** Psychosocial, emotional and professional challenges faced by female healthcare professionals during the COVID-19 outbreak in Lahore, Pakistan: a qualitative study. *BMC Womens Health.* 2021;21(1):197.
31. **Salman M, Mustafa ZU, Raza MH, et al.** Psychological effects of COVID-19 among health care workers, and how they are coping: a web-based, cross-sectional study during the first wave of COVID-19 in Pakistan. *Disaster Med Public Health Prep.* 2022:1-13. doi: [10.1017/dmp.2022.4](https://doi.org/10.1017/dmp.2022.4)
32. **Salman M, Mallhi TH, Khan YH, et al.** Suicidal ideation amid COVID-19 pandemic: a cross-sectional study among healthcare workers during the first wave of COVID-19 in Pakistan. *Disaster Med Public Health Prep.* 2022:1-2. doi: [10.1017/dmp.2022.124](https://doi.org/10.1017/dmp.2022.124)
33. **Raosoftware.** Sample size calculator. Accessed December 12, 2022. <http://www.raosoftware.com/samplesize.html>
34. **Martin-Delgado J, Viteri E, Mula A, et al.** Availability of personal protective equipment and diagnostic and treatment facilities for healthcare workers involved in COVID-19 care: a cross-sectional study in Brazil, Colombia, and Ecuador. *PLoS One.* 2020;15(11):e0242185.
35. **Sarfraz A, Sarfraz Z, Anwer A, et al.** Availability, use, and satisfaction of personal protective equipment among healthcare workers: a cross-sectional assessment of low-and middle-income countries. *J Occup Environ Med.* 2020;62(11):e657-e664.
36. **Ashinyo ME, Dubik SD, Duti V, et al.** Infection prevention and control compliance among exposed healthcare workers in COVID-19 treatment centers in Ghana: a descriptive cross-sectional study. *PLoS One.* 2021;16(3):e0248282.
37. **Afriyie DK, Asare GA, Amponsah SK, et al.** COVID-19 pandemic in resource-poor countries: challenges, experiences and opportunities in Ghana. *J Infect Dev Ctries.* 2020;14(8):838-843.
38. **World Health Organization.** Guidelines on core components of infection prevention and control programmes at the national and acute health care facility level. 2021. Accessed October 11, 2021. <https://www.who.int/teams/integrated-health-services/infection-prevention-control/core-components>
39. **Bekele T, Ashenaf T, Ermias A, et al.** Compliance with standard safety precautions and associated factors among health care workers in Hawassa University comprehensive, specialized hospital, Southern Ethiopia. *PLoS One.* 2020;15(10):e0239744.
40. **Ilesanmi OS, Afolabi AA, Akande A, et al.** Infection prevention and control during COVID-19 pandemic: realities from health care workers in a north central state in Nigeria. *Epidemiol Infect.* 2021;149:e15. <https://doi.org/10.1017/S0950268821000017>
41. **Albeladi FI, Alluli MM, Daghiri KA, et al.** Level of adherence to COVID-19 preventive measures among health care workers in Saudi Arabia. *Cureus.* 2021;13(6):e15969.
42. **Tekalegn Y, Sahiledengle B, Bekele K, et al.** Correct use of facemask among health professionals in the context of Coronavirus Disease (COVID-19). *Risk Manag Healthc Policy.* 2020;13:3013-3019.
43. **El-Sokkary RH, El-Kholy A, Mohy Eldin S, et al.** Characteristics and predicting factors of Corona Virus Disease-2019 (COVID-19) among health-care providers in a developing country. *PLoS One.* 2021;16(1):e0245672.
44. **Alao MA, Durodola AO, Ibrahim OR, et al.** Assessment of health workers' knowledge, beliefs, attitudes, and use of personal protective equipment for prevention of COVID-19 infection in low-resource settings. *Adv Public Health.* 2020: Article ID 4619214. doi: [10.1155/2020/4619214](https://doi.org/10.1155/2020/4619214)
45. **Garg K, Grewal A, Mahajan R, et al.** A cross-sectional study on knowledge, attitude, and practices of donning and doffing of personal protective equipment: an institutional survey of health-care staff during the COVID-19 pandemic. *Anesth Essays Res.* 2020;14(3):370-375.
46. **Liyanage G, Dewasurendra M, Athapathu A, et al.** Hand hygiene behavior among Sri Lankan medical students during COVID-19 pandemic. *BMC Med Educ.* 2021;21(1):333.