

ORIGINAL ARTICLE

The Prevalence of Covid-19 Positivity Among Healthcare Workers Managing Covid-19, Its Associated Factors and Adherence to Personal Protective Equipment in Terengganu

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ABSTRACT

Introduction: COVID-19 is highly contagious and spread rapidly affecting almost the whole world. Many healthcare workers (HCWs) who served as frontliners were infected and some even died due to the illness. The COVID-19 pandemic has negatively impacted the mental health and overall well-being of HCWs, leading to burnout, anxiety, depression and stress. Therefore, this study aims to determine both the prevalence and risk factors associated with COVID-19 infection and compliance with Personal Protective Equipment (PPE) among HCWs in Terengganu. **Methods:** This retrospective record review study included all HCWs at Hospital Sultanah Nurzahirah and Hospital Hulu Terengganu who were exposed to or worked with COVID-19 patients from June 2020 to June 2021. PPE compliance was evaluated through questionnaires. **Results:** A total of 260 HCW are included in this study. However, none of them were tested to be positive for COVID-19 PCR. Overall, 187 workers (71.9%) reported full compliance to PPE guidelines, with facemasks having the highest compliance rate (96.2%). However, risk of inadequate PPE usage was found to be higher among healthcare assistant and shorter duration of exposure. **Conclusion:** The study found no COVID-19 cases among the healthcare workers, highlighting the effectiveness of strict PPE adherence particularly facemask. PPE compliance is crucial in preventing virus transmission within healthcare settings and indicates specific factors affecting PPE use, assisting in targeted improvements for frontline workers' safety. However, retrospective design of this study and reliance on self-reported data may cause bias and eventually affect the generalizability of the findings.

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INTRODUCTION

Coronavirus Disease 2019 or otherwise known as COVID-19 is the latest threat to global health and humanity. The pathogen that is responsible for COVID-19 is SARS-CoV-2 (severe acute respiratory syndrome coronavirus-2). COVID-19 was first discovered in Wuhan, China in December 2019 and had been spreading rapidly to various countries. Therefore, on March 11 2020, the World Health Organization (WHO)

recognized it as a pandemic considering its significant ongoing spread in multiple countries across the world (1). The transmission of the virus can occur through direct physical contact with the Covid-19 patients or through contaminated objects or surface areas (2). The COVID-19 pandemic has negatively impacted the mental health and overall wellness of HCW, leading to burnout, anxiety, depression and stress (3,4). A major reason for this is their concern that they might be infected with the disease and potentially transmitting the virus to their loved ones (3).

Globally, the prevalence of HCW getting infected with COVID-19 at Spain, China, France, Italy and United States are ranging from 15% to 20% (5). Meanwhile,

the prevalence of positive COVID-19 cases among HCW caring for COVID-19 patients in USA and UK was 2.7% (6), in Spanish was 4% (7), and in Southern Italy was 3.4% (8). The National Health Commission of the People's Republic of China had reported that as of February 24, 2020, a total of 3387 out of 77,262 patients with COVID-19 (4.4%) in China were health care workers or others who worked in medical facilities (9). Meanwhile, a press statement from the Director General Ministry of Health Malaysia on 23 April 2020 titled "Current Situation of Coronavirus Disease 2019 (COVID-19) in Malaysia" reported that 325 out of 5603 healthcare workers (5.8%) had tested positive for COVID-19. The prevalence of positive Covid-19 among HCW at University Malaya Medical Centre (UMMC) which is one of the Covid-19 designated hospitals was 0.3% (17 out of 5826) (10). Notably, Terengganu recorded the lowest prevalence of COVID-19 cases among HCW with only 0.03% between January 2020 to December 2020, when compared to other states in Malaysia (11).

Generally, healthcare workers (HCW) are more likely to be infected with COVID-19 compared to the general community (3). This is because they act as frontliners responsible in treating, managing and caring for COVID-19 patients, which in turn caused them to be in close contact with the patients. Healthcare workers who had close contact and were exposed to the Covid-19 patients in healthcare settings had higher risk to be infected with Covid-19 compared with those not directly involved with the patients (6,12,13). As such, nurses and medical doctors are the HCW that mostly being infected with Covid-19 as they had frequent, close contact with the patients and spend more time at their bedside (14). Previous study had reported that frequent close contact with the COVID-19 patients increased the risk of being infected, particularly when HCW not wearing appropriate PPE (15). However, HCW in non-Covid-19 wards are at higher risk to be infected with Covid-19 than HCW in the Covid-19 wards because they are not wearing appropriate PPE while caring for not-yet-diagnosed Covid-19 patients, while HCW in Covid-19 wards wearing appropriate PPE upon contact with the infected patients (7).

Meanwhile, in Malaysia, HCW are mainly infected in the healthcare settings when they are caring patients that are not suspected of having COVID-19 causing them to not wear appropriate PPE (16). As the pandemic accelerates, compliance to the Personal Protective Equipment (PPE) is deemed as effective in protecting HCW against COVID-19 infections by reducing the transmission and spread of the virus (17). Therefore, the World Health Organization (WHO) has recommended the use of PPE to all healthcare workers involved in the COVID-19 cases (18). Full compliance (100%) in PPE during COVID-19 pandemic referred to when HCW wear all 5 PPE including N95 respirators, face shield/

goggles, gown, gloves and hair cover, while other than that or fail to wear one of the PPE were considered as not comply with the PPE.

Previous study in Jordan revealed that only 39.3% of them wearing full PPE when caring for COVID-19 patients, with the most frequently used PPE was gloves (44.9%), and only 24.6% of them wearing eye protection (19). Similarly, previous studies in Iran and Ghana also reported masks and gloves as the most commonly used PPE by HCW (17,20). The Ghana study also reported high compliance (90.6%) with the PPE usage during healthcare interactions with the COVID-19 patients, and higher while performing aerosol-generating procedure (AGP) with 97.5% of them wearing full PPE (20).

Though there are many studies focusing on COVID-19 among healthcare workers in Malaysia, there are limited published studies on healthcare workers caring for COVID-19 positive patients or work in COVID-19 related areas in Terengganu. One such study reported that a total of 919 HCW in Terengganu were infected with COVID-19 between March 2020 to September 2021 (21). However, the study did not investigate the HCW compliance to PPE. To the authors' knowledge, no published studies have investigated PPE compliance among health care workers in Terengganu.

Therefore, this study objectives is to determine the prevalence and factors associated with COVID-19 positive among HCW who care for COVID-19 patients and work in COVID-19 related areas in Terengganu as well as to determine the prevalence and risk-factors associated with their compliance to full PPE. By identifying all these factors, we can improve our compliance to PPE and eventually further reduce risk of COVID-19 infection among HCW.

METHODS

Study design

This is a retrospective record review study. Demographic data, PPE assessment, and PCR COVID-19 swab samples were collected from eligible participants who had consented to participate this study. Since this is a retrospective record view study, all the demographic data, PPE assessment and PCR COVID-19 swab samples has already been collected from Hospital Sultanah Nurzahirah (HSNZ) and Hospital Hulu Terengganu (HHT). Both HSNZ and HHT are public hospitals located in Terengganu. While HSNZ is the main tertiary referral hospital and served as a key hospital in managing and treating COVID-19 patients, including severe cases that required intensive care and advanced medical support, HHT served as a supporting facility managing mild to moderate COVID-19 cases and handling non-critical patients to reduce the burden on HSNZ. The study was conducted in accordance with the principles outlined in the Declaration of Helsinki. Research approval was

obtained from the Terengganu State Health Department and HSNZ, while ethical approval was granted from the Human Research and Ethics Committee, Universiti Sains Malaysia.

Participants

All the participants that fulfilled the inclusion criteria i.e. HCW who work in HSNZ and HHT in COVID-19 related areas and exposed to COVID-19 positive patients during the period of June 2020 to June 2021. HCW under quarantined and had incomplete form for PPE surveillance is excluded from this study.

Study Protocol

This study involve secondary data review following directive order from HSNZ and Terengganu State Health Department (reference number: HSNZ. KT.600/1/1/12(48)) for all HCW who provide care to COVID-19 patients to screen for swab sample PCR COVID and PPE assessment prior to return to non-covid ward routine. For COVID-19 screening and diagnosis, both oropharyngeal and nasopharyngeal samples are collected using specialized swabs designed to effectively obtain cells from mucosal surfaces including from the back of the nose and throat. These samples are placed into Viral Transport Media (VTM) to preserve the virus's viability until testing. According to the Ministry of Health Malaysia's SOP circular dated August 13, 2020, all swab samples should be stored at 2-8 degrees Celsius before processing. The personnel collecting these samples must be registered medical practitioners who have completed specific training and hold a certificate of attendance for sample collection and handling, including training in the appropriate use of personal protective equipment (PPE). (PPE), including gloves, gowns, masks (such as N95 respirators), and face shields, is essential for safeguarding healthcare workers during the collection process. Sterile collection tubes are used to hold the swabs after sampling, accompanied by labels and requisition forms for proper identification and tracking. Additionally, specialized bags and specimen transport containers are employed to ensure the safe and secure transportation of samples to the testing facility, all of which contribute to accurate COVID-19 testing.

The samples were sent to lab for COVID-19 PCR test as per guidelines. The test is a gold standard laboratory diagnosis and widely used method for detecting RNA, including the SARS-CoV-2 virus responsible for COVID-19. In our clinical setting, we employ qualitative COVID-19 PCR testing, where results are reported as either positive or negative. This approach ensures clarity and consistency by focusing on detecting the presence or absence of viral RNA, rather than quantifying the viral load. Ct values are integral to this qualitative assay; the presence of a Ct value indicates the presence of the target pathogen, while the absence of a Ct value implies that the target was not present in the reaction. For our in-house COVID-19 PCR testing, six different extraction

kits were utilized to ensure efficient viral RNA isolation and high-quality results. These kits include the QIAamp Viral RNA Mini Kit, Ribospin vRD, MagCore Viral Nucleic Acid Extraction Kit, MAGMAX Viral/Pathogen Kit, GENTiTM 32 Advanced DNA/RNA Extraction Kit, and the Liferiver Viral RNA Isolation Kit. These extraction kits are designed to efficiently isolate viral RNA and generally known for high sensitivity and specificity, typically over 95%, when proper protocols are followed including manufacturer's recommendations, and the quality of the sample collected. In addition to these extraction kits, we employ five different PCR reagents to conduct the testing: GenoAmp, Biosewon, Lytestar, Allplex, and Integrated DNA Technology. This combination of extraction kits and PCR reagents allows for robust and reliable detection of the virus.

Additionally, the laboratory handling these samples must be supervised by a clinical microbiologist and accredited under ISO 15189 for medical testing, specifically in microbiology molecular testing, to ensure adherence to high standards for accurate SARS-CoV-2 detection through PCR testing. This stringent oversight and personnel training help maintain the highest safety and accuracy standards in the testing process.

Besides that, HCWs were also given a set of questionnaires as part of continuous improvement for assessment of compliance to PPE in managing COVID-19. The questionnaire consists of four sections. Firstly, demographic data including age, gender, job designation and years of service. Secondly, attendance at a briefing session on donning/ doffing procedures prior to managing COVID-19 patients (yes or no). Thirdly, an assessment of the risk of exposures, focusing on type of working experience, duration of exposure and activities posing a risk of COVID-19 transmission. Finally, an evaluation of PPE usage, using a 6-point Likert scale ranging from "never" (0%) to "always" (100%). This section covers practices such hand hygiene before donning, mask, fit check mask, head cover, face shield, gown, shoe cover, gloves, and hands hygiene each step of doffing. Data will be kept anonymous, and no further disciplinary action will be taken following the PPE surveillance if the participants revealed to not fully comply with the PPE regulations. All the PCR COVID-19 samples have been taken and PPE survey has been done (data already collected). All the data were kept in Infectious Disease Unit HSNZ as hardcopy. Data then were reviewed and extracted into an excel sheet. Only HCW that fulfil both inclusion and exclusion criteria were included in this study.

Statistical Analysis

All statistical analyses were performed using IBM SPSS statistic software package version 26.0. Descriptive analysis was used to analyse the socio-demographic characteristic of subjects. Numerical data were presented as mean and standard deviation (SD) while categorical

data were presented as frequency (n) and percentage (%). Meanwhile, risk factors for compliance to PPE was analyzed using simple logistic regression analysis followed by multiple logistic regressions. Variable selection was performed using forward and backward selection. Then, the most parsimonious model was chosen to finalize the results. A p-value < 0.05 was used as the level of significance.

RESULTS

Baseline Information

Table I showed descriptive statistics for baseline characteristics of the respondents. Initially, a total of 300 HCW were screened under the Surveillance Screening programme. However, 40 of them provided incomplete questionnaire, and therefore were excluded in this study. Hence, a total of 260 healthcare workers at Hospital Sultanah Nurzahirah (HSNZ) and Hospital Hulu Terengganu (HHT) had completely answered the questionnaire and underwent PCR COVID-19 swab screening test. From 260 HCW, 153 of them are from HSNZ, while the rest 107 are from HHT. None of them was found to be positive. The overall mean age among healthcare workers who provide care to COVID-19 positive patients was 36.75 years old. From that, 219 (84.2%) of the healthcare workers were female, 188 (72.3%) were staff nurse/ community nurse, 23 (13.5%) were medical officer, 26 (10.0%) were medical assistant and 11 (4.2%) were healthcare assistant. Overall, 187 workers (71.9%) had a self-reported 100% compliance towards personal protective equipment (PPE).

Table I: Baseline characteristics of the respondents (n=260)

Variables	n (%)
Age in years ^a	36.75 (7.68)
Gender	
Male	41 (15.8)
Female	219 (84.2)
Designation	
Medical Assistant	26 (10.0)
Medical Officer	35 (13.5)
Healthcare assistant	11 (4.2)
Staff nurse/ community nurse	188 (72.3)
Working experience in years ^a	12.65 (7.55)
Type of working experience	
Ward	219 (84.2)
Tent screening	34 (13.1)
Laboratory	7 (2.7)
Duration of exposure	
More than 6 weeks	160 (61.5)
4 – 6 weeks	21 (8.1)
2 – 4 weeks	18 (6.9)
Less than 2 weeks	61 (23.5)
Activity that involved in patient's care	
Examine patients	132 (50.8)
Taking sample swab	48 (18.5)
Taking vital sign	190 (73.1)
Aerosolized generating procedure	16 (6.2)
Blood taking	49 (18.8)
Serve patients (diet / medication / medications prescribe)	162 (62.3)
Handling sample	71 (27.3)
Cleaning patient's room / toilet / lift/ patient's flow	58 (22.3)
Radiology procedure	2 (0.8)
100% compliance to PPE	
Hand hygiene before donning	241 (92.7)
Wearing mask	250 (96.2)
Fit check mask	228 (87.7)
Headcover	228 (87.7)
Face shield	227 (87.3)
Wearing gown	235 (90.4)
Shoe cover	217 (83.5)
Gloves	245 (94.2)
Hands hygiene each step of doffing	245 (94.2)

^aData presented in mean (SD)

PPE Compliance according to Subgroups

Table II shows the descriptive statistics for each subgroup based on the PPE compliance status. The mean age was higher in those with full PPE (Mean=37.03, SD=7.73). According to the gender, 161 female healthcare workers (86.1%) and 26 male healthcare workers (13.9%) complied with PPE. The mean working experiences were higher in those with full PPE (Mean=13.23, SD=7.76). Otherwise, a total of 124 healthcare workers (66.3%) and 145 healthcare workers (77.5%) had a duration of exposure of more than 6 weeks and designation as staff nurse/ community nurse, respectively.

Table II: The descriptive statistics of factors associated with PPE compliance (n=260).

Variables	n (%)		Total (n=260)
	HCW with full PPE (n=187)	HCW with inadequate PPE (n=73)	
Age in years ^a	37.03 (7.73)	35.81 (7.31)	36.75 (7.68)
Gender			
Male	26 (13.9)	15 (20.5)	41 (15.8)
Female	161 (86.1)	58 (79.5)	219 (84.2)
Attended donning and doffing briefing/ training session			
Yes	181 (96.8)	68 (93.2)	249 (95.8)
No	6 (3.2)	5 (6.8)	11 (4.2)
Working experience in years ^a	13.23 (7.76)	11.14 (6.78)	12.65 (7.55)
Designation			
Medical Assistant	20 (10.7)	6 (8.2)	26 (10.0)
Medical Officer	20 (10.7)	15 (20.5)	35 (13.5)
Healthcare assis- tant	2 (1.1)	9 (12.3)	11 (4.2)
Staff nurse/ com- munity nurse	145 (77.5)	43 (58.9)	188 (72.3)
Type of working ex- perience			
Ward	161 (86.1)	58 (79.5)	219 (84.2)
Tent screening	22 (11.8)	12 (16.4)	34 (13.1)
Laboratory	4 (2.1)	3 (4.1)	7 (2.7)
Duration of expo- sure			
More than 6 weeks	124 (66.3)	36 (49.3)	160 (61.5)
4 – 6 weeks	11 (5.9)	10 (13.7)	21 (8.1)
2 – 4 weeks	9 (4.8)	9 (12.3)	18 (6.9)
Less than 2 weeks	43 (23.0)	18 (24.7)	61 (23.5)

^aData presented in mean (SD)

Factors Associated with PPE Compliance

Table III showed the application of simple and multiple logistic regression in predicting the factors associated with full personal protective equipment (PPE) compliance. All variables with p-value <0.25 and biologically or clinically important from simple logistic regression were included in multiple logistic regression. The variables that were included in the multiple logistic regression were gender, attended doffing and donning briefing/ training sessions, working experience (years), designation, type of working experience and duration of exposure. Variable selection was performed using forward and backward selection. Then, the most parsimonious model was chosen to finalize the results. Based on the forward selection, the results indicated that designation and duration of exposure showed a statistically significant association with adherence to the personal protective equipment (PPE) in multiple logistic regression.

Table III: Associated factors of adherence to personal protective equipment (PPE) using simple and multiple logistic regression (n=260)

Variables	Simple logistic regression		Multiple logistic regression	
	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Gender				
Female	0	0.189		
Male	1.601 (0.793, 3.234)			
Attended donning and doffing briefing/training session				
Yes	0	0.200		
No	2.218 (0.655, 7.507)			
Working experience in years	0.963 (0.928, 0.999)	0.047		
Designation				
Medical Assistant	0		0	
Medical Officer	2.500 (0.806, 7.751)	0.112	2.882 (0.892, 9.315)	0.077
Healthcare assistant	15.000 (2.521, 89.235)	0.003	16.684 (2.671, 104.196)	0.003
Staff nurse/ community nurse	0.989 (0.373, 2.617)	0.981	1.248 (0.453, 3.439)	0.668
Type of working experience				
Inside ward	0			
Outside ward	1.601 (0.793, 3.234)	0.189		
Duration of exposure				
More 6 weeks	0		0	0
4 – 6 weeks	1.442 (0.743, 2.800)	0.280	1.404 (0.691, 2.851)	0.348
2 – 4 weeks	3.444 (1.273, 9.322)	0.015	3.913 (1.410, 10.854)	0.009
Less than 2 weeks	3.131 (1.231, 7.963)	0.017	2.624 (0.961, 7.166)	0.060

OR=odd ratio; CI= confidence Interval
 LR multiple logistic regression model applied

Forward

The final model of associated factors of full PPE compliance among healthcare workers who provide care to COVID-19 positive patients in Hospital Sultanah Nurzahirah and Hospital Hulu Terengganu using multiple logistic regression could be interpretable as:

1. Healthcare assistant workers increased the risk of inadequate PPE by 16.68 compared to medical assistant workers (Adjusted OR=16.684; 95% CI: 2.671, 104.196; p=0.003).
2. Healthcare workers with a duration of exposure of 2 – 4 weeks increased the risk of inadequate PPE by 3.913 compared to healthcare workers with longer than six weeks (Adjusted OR=3.913; 95% CI: 1.410, 10.854; p=0.009)

Comparison of the Adherence Rates between Inside and Outside COVID-19 Wards

The comparison of adherence rates according to the workplace type is shown in Table IV. From the results, 161 healthcare workers (73.5%) working at inside ward and 26 healthcare workers (63.4%) working at outside ward had 100% compliance to PPE. Statistically, there was no significant association between the overall adherence rate to PPE and the type of workplace inside or outside the ward (p>0.05). According to each item in compliance with PPE, there was a statistically significant association of items (head cover, face shield, shoe cover, and hands hygiene each step of doffing) and the working place (p<0.05).

Table IV: Comparison of adherence rates based on the working place (n=260).

Variable	n (%)			p-value
	Inside ward	Outside ward	Total	
100% compliance to PPE				
Yes	161 (73.5)	26 (63.4)	187 (71.9)	0.255 ^a
No	58 (26.5)	15 (36.6)	73 (28.1)	
Hand hygiene before donning				
<50% compliance rate	1 (0.5)	1 (2.4)	2 (0.8)	0.429 ^b
>50% compliance rate	1 (0.5)	0 (0.0)	1 (0.4)	
Almost 80% compliance rate	13 (5.9)	3 (7.3)	16 (6.2)	
100% compliance rate	204 (93.2)	37 (90.2)	241 (92.7)	
Wearing mask				
Almost 80% compliance rate	7 (3.2)	3 (7.3)	10 (3.8)	0.197 ^b
100% compliance rate	212 (96.8)	38 (92.7)	250 (96.2)	
Fit check mask				
0% compliance rate	4 (1.8)	0 (0.0)	4 (1.5)	0.267 ^b
<50% compliance rate	3 (1.4)	0 (0.0)	3 (1.2)	
>50% compliance rate	1 (0.5)	1 (2.4)	2 (0.8)	
Almost 80% compliance rate	17 (7.8)	6 (14.6)	23 (8.8)	
100% compliance rate	194 (88.6)	34 (82.9)	228 (87.8)	
Head cover				
0% compliance rate	4 (1.8)	1 (2.4)	5 (1.9)	<0.001 ^b
Around 20% compliance rate	1 (0.5)	0 (0.0)	1 (0.4)	
<50% compliance rate	6 (2.7)	0 (0.0)	6 (2.3)	
>50% compliance rate	0 (0.0)	4 (9.8)	4 (1.5)	
Almost 80% compliance rate	10 (4.6)	6 (14.6)	16 (6.2)	
100% compliance rate	198 (90.4)	30 (73.2)	228 (87.7)	
Face shield				
0% compliance rate	4 (1.8)	0 (0.0)	4 (1.5)	0.001 ^b
Around 20% compliance rate	1 (0.5)	0 (0.0)	1 (0.4)	
<50% compliance rate	5 (2.3)	0 (0.0)	5 (1.9)	
>50% compliance rate	1 (0.5)	3 (7.3)	4 (1.5)	
Almost 80% compliance rate	11 (5.0)	8 (19.5)	19 (7.3)	
100% compliance rate	197 (90.0)	30 (73.2)	227 (87.3)	

CONTINUE

Variable	n (%)			p-value
	Inside ward	Outside ward	Total	
Wearing gown				
0% compliance rate	4 (1.8)	0 (0.0)	4 (1.5)	0.112 ^b
<50% compliance rate	3 (1.4)	1 (2.4)	4 (1.5)	
>50% compliance rate	2 (0.9)	1 (2.4)	3 (1.2)	
Almost 80% compliance rate	9 (4.1)	5 (12.2)	14 (5.4)	
100% compliance rate	201 (91.8)	34 (82.9)	235 (90.4)	
Shoe cover				
0% compliance rate	8 (3.7)	0 (0.0)	8 (3.1)	0.038 ^b
Around 20% compliance rate	2 (0.9)	0 (0.0)	2 (0.8)	
<50% compliance rate	5 (2.3)	1 (2.4)	6 (2.3)	
>50% compliance rate	5 (2.3)	2 (4.9)	7 (2.7)	
Almost 80% compliance rate	12 (5.5)	8 (19.5)	20 (7.7)	
100% compliance rate	187 (85.4)	30 (73.2)	217 (83.5)	
Gloves				
0% compliance rate	1 (0.5)	0 (0.0)	1 (0.4)	0.333 ^b
>50% compliance rate	2 (0.9)	0 (0.0)	2 (0.8)	
Almost 80% compliance rate	8 (3.7)	4 (9.8)	12 (4.6)	
100% compliance rate	208 (95.0)	37 (90.2)	245 (94.2)	
Hands hygiene each step of doffing				
0% compliance rate	3 (1.4)	0 (0.0)	3 (1.2)	0.041 ^b
>50% compliance rate	1 (0.5)	0 (0.0)	1 (0.4)	
Almost 80% compliance rate	6 (2.7)	5 (12.2)	11 (4.2)	
100% compliance rate	209 (95.4)	36 (87.8)	245 (94.2)	

^a pearson chi-square test, ^b fisher exact test.

DISCUSSION

Despite the high-risk exposure environment, the prevalence of healthcare workers (HCWs) at Hospital Sultanah Nurzahirah (HSNZ) and Hospital Hulu Terengganu (HHT) infected with COVID-19 were 0%, with majority of them (71.9%) self-reporting full compliance with the PPE protocol. Similarly, no positive COVID-19 was reported among HCW working at the designated COVID-19 hospitals (General Hospital Kuala Lumpur and Hospital Sungai Buloh, Selangor) as those HCW strictly followed the standard operating procedures (SOP) and had properly worn the PPE (16). The Ministry of Health Malaysia strictly instructed that all HCW treating COVID-19 patients must wear proper and adequate PPE, must follow SOP, maintain social distancing and practice good hand hygiene (16). There are different types of PPE recommended for different settings and for different activity/ job descriptions (22).

The most basic PPE that must be worn when treating any patients are the surgical mask and frequent hand hygiene (22).

Similarly, the prevalence of positive COVID-19 among HCW in Jordan, Japan and China caring for the coronavirus patients was 0% (23–25). This might be due to the hospitals' strict policy and preventive measures taken to minimize the exposure of the coronavirus to their HCW such as wearing N95 respirators and surgical masks at the same time, well trained in putting and removing PPE as well as good hand hygiene habits (24,25). As a precaution, the HCW in China also stayed at the designated hotels, followed social distancing and wore masks outside the hospital settings which further protected them from any contamination outside the hospital/ healthcare settings (25).

Moreover, another study conducted in British Columbia

also reported 0% prevalence of positive COVID-19 among their HCW working at the high-risk departments (intensive care unit (ICU) and emergency department) (26). This is because their compliance with the use of personal protective equipment (PPE) was 100% (26). Since there are no COVID-19 cases among our respondents, further analysis to identify the risk factors for positive COVID-19 cannot be performed. Thus, we can only assume that high compliance with PPE usage reported by our respondents is the reason why our HCWs were not infected with COVID-19, as previous studies have shown that positive COVID-19 infections among HCWs are often the result of inadequate or inappropriate PPE usage (27,28). Another possible explanation for this is that the supply and usage of PPE had improved leading to the reduction in COVID-19 infections among HCW in Malaysia (16).

Out of 260 HCW at HSNZ and HHT, 187 (71.9%) of them always used full PPE when caring for the COVID-19 patients and 95.8% of them had attended a training session on donning (putting on) and doffing (removing) of PPE, which is much higher than the Jordan study as only 39.3% and 34.7% of them use full PPE and had training in PPE, respectively (19). The most frequently used PPE in our study were masks and gloves with 96.2% and 94.2%, respectively. Similarly, previous studies in Iran and Ghana also reported masks and gloves as the most commonly used PPE by HCW (17,20). The three main routes for the SARS-CoV-2 transmission including inhalation, droplets and contacts had the probability of infection at 57.0%, 35.0% and 8.2%, respectively (18), which further highlighted the importance of wearing a mask or using respiratory protection when HCW are near the COVID-19 patients (29).

PPE compliance is highest during patient contact when COVID-19 is not suspected and lowest when carrying out aerosol-generating procedure leading to the assumption that PPE compliance varied based on different types of PPE required (30). It was highest when only masks or respirators are required and lowest when full PPE are required including gown, glove, mask, and eye protection (30). Previous studies had demonstrated that adequate or sufficient stock of PPE as well as proper training on PPE usage can lower the infection rates amongst healthcare workers (15,31). Thus, healthcare organizations are advised to provide proper training to their HCW on how to wear and remove PPE properly (25), as it reduced the risk of COVID-19 infections to the HCW (20). A combination of video display and live demonstration are selected as the most suitable training for PPE (32).

The present study found that designation or occupation of the HCW significantly associated with their compliance to the PPE in which healthcare assistant were more likely to not comply with the full PPE than medical assistant, whereas PPE full compliance between

nurse and medical assistant are similar. Meanwhile, a study in the United States (US) reported that doctors and nurses demonstrated the highest compliance with the use of PPE compared to other healthcare workers (33). Moreover, studies in Ghana and Qatar reported that pharmacists had lower compliance with the PPE usage compared to medical doctors (20,34). These findings supported the hypothesis that frequent close contact or direct contact with patients affects their compliance to the PPE. However, contradict to the present study, Badran et al. (2021) reported no significant association between compliance and the designation of the HCW.

In regards to the duration of exposure, the present study found that the duration of exposure of less than 2 weeks (< 2 weeks) and 2-4 weeks increased the risk of non-compliance by 2.624 and 3.913, respectively compared to more than 6 weeks (> 6 weeks) duration of exposure meaning that longer duration of exposure increased the compliance of PPE which is consistent with the United States study (35). The US study found a significant association between duration of exposure and PPE compliance as shorter duration of exposure increased the risk of inadequate/ non-compliance of PPE while longer duration increased the PPE compliance (35). Further analysis based on the type of PPE revealed that the compliance to glove and gown usage increased when the duration of exposure increased (35).

Furthermore, the present study found no significant association between compliance with gender, PPE training session, working experience (year) and type of working experience (inside or outside ward). Similar results were also obtained from the previous study (34). On the contrary, a study conducted in Egypt had demonstrated that gender, PPE training, exposure to COVID-19 patients as well as high-risk exposure to SARS-CoV-2 are the significant factors for HCW compliance to the PPE usage (36). Although the present study found no significant association between training and PPE compliance, it is crucial for HCW to receive training on donning and doffing PPE as training can improve HCW knowledge and ability to correctly putting and removing PPE (37).

Strength and Limitations of the Study.

The strength of the present study is that this is the first study in Malaysia particularly in Terengganu state that reported the PPE compliance among healthcare workers caring for COVID-19 patients. The results obtained from this study can be used as a guideline for healthcare organizations to strengthen and increase the safety of HCW against COVID-19 infections. Although this study only covered two public hospitals in Terengganu, which limits the generalizability of the findings to all HCWs in the state, these hospitals offers contrasting perspectives as HHT provides insights into the rural setting, while HSNZ provides insights into the urban setting. Together, these hospitals serve both urban and rural

populations, covering a variety of healthcare settings in Terengganu. Consequently, while the data from the HSNZ and HHT may not be comprehensive, it can provide valuable insights into the experiences of HCWs in Terengganu during COVID-19 pandemic. However, it is acknowledged that including more healthcare facilities in future studies would further strengthen the generalizability of the findings.

The limitation of the present study is that it use self-reported questionnaires to determine whether the HCW are compliant with the use of PPE or not. The weakness of the questionnaire is that the HCW may under-report or over-report their compliance with the PPE leading to bias in their reports. Under-reported non-compliance can lead to policymakers to assume and believe that the existing PPE guidelines and training are adequate, even when there are gaps in knowledge or compliance. Future studies should also include the direct observation by trained professionals as done in the German study (38), because it is more accurate, non-bias and reliable. Another limitation of this study is a relatively small sample size focusing only on two public hospitals located at Terengganu, Malaysia, and thus limits the generalizability of the results. Future studies should include a larger sample size of HCW caring for COVID-19 patients working at various hospitals in Malaysia.

CONCLUSION

Overall, the prevalence of positive COVID-19 PCR among HCW in our study is 0% and they demonstrated high compliance in PPE usage. The risk factors for PPE compliance were the designation of HCW and duration of exposure. No significant association was found between gender, duration of working experience, PPE training and type of working place (inside or outside ward) with compliance to PPE. The findings of this study highlighted the importance of wearing proper and adequate PPE to ensure the safety of HCW during COVID-19 pandemic. Besides, this study also emphasized the critical need for healthcare organization and policymakers to ensure that healthcare workers are provided with adequate PPE and receive comprehensive training. This is essential to ensure their safety, reduce the risk of infections and consequently improve their ability to manage and care for patients, particularly during pandemics like COVID-19. However, retrospective design of this study and reliance on self-reported data may causes bias and eventually affect the generalizability of the findings. Hence, for future research, a prospective study design with a larger sample size, and direct observation are strongly recommended.

ETHICS OF STUDY

This study was approved by the Human Research Ethics Committee of University Sains Malaysia (USM/

JEPeM/21120777) and Medical Review & Ethic Committee (MREC), Ministry of Health Malaysia NMRR-20-909-54858.

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