JIDC | THE JOURNAL OF INFECTION IN DEVELOPING COUNTRIES

Coronavirus Pandemic

COVID-19 in Malaysia: exposure assessment and prevention practices among healthcare workers at a teaching hospital

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Abstract

Introduction: During the second wave of the coronavirus disease 19 (COVID-19) pandemic, Malaysia reported several COVID-19 clusters related to healthcare workers. Thus, addressing and understanding the risk of exposure in healthcare workers is important to prevent future infection and reduce secondary COVID-19 transmission within the healthcare settings. In this study, we aim to assess exposure and prevention practices against COVID-19 among healthcare workers at the Hospital Canselor Tuanku Muhriz, a university teaching hospital based in Kuala Lumpur, Malaysia.

Methodology: A total of 571 healthcare workers at COVID-19 and non-COVID-19 wards as well as the emergency department and laboratory staff at COVID-19 testing labs were recruited. The presence of novel human coronavirus (SARS-CoV-2) and IgM/IgG antibodies were confirmed in all healthcare workers. The healthcare workers responded to an online Google Forms questionnaire that evaluates demographic information and comorbidities, exposure and adherence to infection prevention and control measures against COVID-19. Descriptive analysis was performed using Statistical Package for the Social Sciences 24.0.

Results: Three healthcare workers (0.5%) tested positive for SAR-CoV-2, while the remaining 568 (99.5%) were negative. All were negative for IgM and IgG antibodies during recruitment (day 1) and follow-up (day 15). More than 90% of the healthcare workers followed infection prevention and control practices recommendations regardless of whether they have been exposed to occupational risk for COVID-19.

Conclusions: The healthcare workers' high level of adherence to infection prevention practices at this hospital helped reduce and minimize their occupational exposure to COVID-19.

Key words: Infection control; COVID-19; healthcare workers; teaching hospital; SARS-CoV-2; exposure assessment.

J Infect Dev Ctries 2021; 15(12):1816-1824. doi:10.3855/jidc.15277

(Received 06 May 2021 – Accepted 24 July 2021)

Introduction

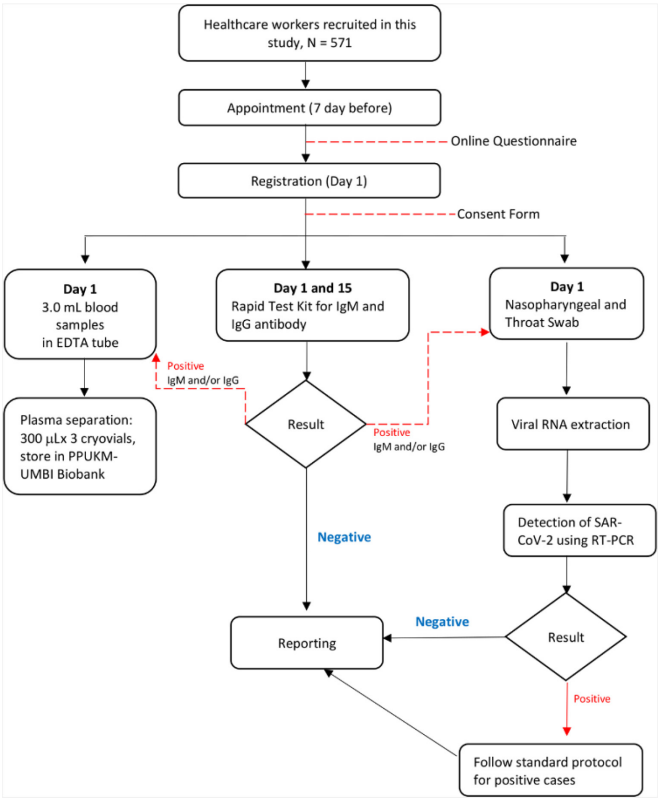
In March 2020, the World Health Organization (WHO) declared the coronavirus disease 2019 (COVID-19) as a pandemic, which became a public health emergency and an international concern [1]. As of December 2020, there have been 65.1 million COVID-19 cases worldwide with 1.5 million deaths and a case fatality rate of 2.30% [2]. COVID-19 is caused by the novel human coronavirus (SARS-CoV-2), a β-coronavirus with an enveloped non-segmented positive-sense RNA virus [1,3]. COVID-19 can be transmitted via bodily fluids through direct contact, aerosol droplets and the faecal–oral route [4-6]. The incubation period of COVID-19 is from 0 to 24 days, with a median incubation period of about 3 to 5 days [7-9]. COVID-19 infection can be either asymptomatic or symptomatic. In symptomatic patients, clinical manifestations usually occur within 7 to 12 days of exposure [7]. Symptoms include fever (99%); dry cough (59%); dyspnoea (31%); fatigue (70%); lethargy, arthralgia and myalgia (35%), and respiratory and multiorgan failure (11-29%) [10-12]. In Malaysia, the

first case of COVID-19 was a Chinese tourist who arrived via Singapore in January 2020 [13]. Malaysia experienced its first wave of COVID-19 on 25 January 2021, lasting three weeks; the second wave began on 27 February, and the third wave in October 2020 [14]. As of December 2020, there has been a total of 67,173 COVID-19 cases with 363 deaths giving a 0.54% case fatality rate [13].

Healthcare workers (HCWs) play an important role in delivering care and services for the clinical management of COVID-19 patients. These HCWs are frontline workers who are either directly or indirectly involved in the healthcare systems and include doctors and nurses as well as health assistants, medical laboratory technicians and medical waste handlers, among others. Employees in the healthcare industry are exposed to various health and safety hazards in their routine work, such as biological (*e.g.* HIV and COVID-19) and chemical exposure. Thus, HCWs must adhere to infection control guidelines including the use of proper personal protective equipment (PPE) to protect themselves from direct contact with COVID-19 patients. Such direct contact, particularly during aerosol-gathering procedures such as endotracheal intubation, extubation, non-invasive ventilation and exposure to open-circuit aerosols, leads to serious occupational health risks to HCWs [6,15]. Hence, the WHO and the Centre for Disease Control (CDC) in the USA have issued several guidelines to protect HCWs during the COVID-19 pandemic, including listing them under priority level 3 for COVID-19 testing [16,17].

As of April 2020, a total of 224 HCWs in Malaysia have been diagnosed with COVID-19, and several HCW-related clusters have been identified [18,19]. During the second wave of COVID-19, two HCW-related clusters from the hospital in Sabah dan Selangor were reported [19]. Thus, reducing secondary COVID-19 transmission requires addressing and understanding the risk of exposure among HCWs during the COVID-19 pandemic to prevent future infections within healthcare settings. This study aims to examine exposure and infection prevention practices against COVID-19 among HCWs at Hospital Canselor Tuanku Muhriz (HCTM), a teaching hospital of Universiti Kebangsaan Malaysia (UKM) in Kuala Lumpur, Malaysia.

Figure 1. The study workflow.



During the recruitment phase (day 1), nasopharyngeal and throat swabs were collected from all participants. The presence of IgM and IgG antibodies were measured during recruitment (day 1) and follow-up (day 15).

Methodology

Study type, design and population

This is a cross-sectional study of 571 HCTM staff members working at the COVID-19 and non-COVID-19 wards as well as emergency department and laboratory workers at the COVID-19 testing labs during the second wave of the COVID-19 outbreak. The sample size was calculated via Raosoft. This study required a total of 352 samples assuming a response rate of 50%, a Z value of 1.96, a margin error of 5% and a 95% confidence interval. However, considering a 20% dropout rate, the optimum sample size required was 422. Figure 1 shows the study workflow and data collection procedures. The inclusion criteria were (1) medical staff working at HCTM (doctors, nurses and laboratory staff); (2) those with no symptoms, which will require them to be tested and (3) those who gave consent to participate in this study. The exclusion criteria were (1) nonmedical staff including administrative workers with no history of direct contact with positive cases; (2) those with symptoms, which will require them to be tested according to existing protocol and (3) those who did not consent to participation. Before sample collection, all participants filled out the online study questionnaire. Biosafety procedures were administrated and adhered to by all staff performing the swabs as well as laboratory

workers, including the use of PPE, masks, and face shields.

Ethics

This study was approved by the Research Ethics Committee UKM (RECUKM) (Ethics document no. UKM PPI/111/8/JEP-2020-284) on 22 April 2020, in accordance with the Declaration of Helsinki. Participants in this study were voluntary and participants received no financial incentive. All participants provided written consent before being recruited in this study.

Swab sample collection

On day 1 of recruitment, trained medical personnel took two swab samples (nasopharyngeal and throat) from the respondents. The swabs were placed into special tubes containing the viral transport medium, triple-sealed and transported to the testing laboratory. The transport swab buffer was heat-inactivated at 56 °C for 30 minutes before use.

Viral RNA isolation

SARS-CoV-2 viral RNA was extracted from 200 µL of the transport swab buffer using the Geneaid Viral Nucleic Acid Extraction Kit II (Catalog No: VR300, Geneaid Biotech Ltd, New Taipei City, Taiwan) according to the manufacturer's protocols. The RNA samples were eluted using 40 µL of the elution buffer. As quality control of RNA isolation, internal RNA extraction controls were extracted from the Liferiver Novel Coronavirus (2019 n-CoV) Real-time Multiplex RT-PCR kit (Liferiver Bio-tech, Shanghai, China) together with the specimens.

Determination of COVID-19 IgM and IgG antibodies

The presence of COVID-19 IgM and IgG antibodies on day 1 (recruitment) and day 15 (follow-up) were determined using Healgen COVID-19 IgG/IgM Rapid Test Cassette (Healgen Scientific LLC, Texas, USA). Briefly, 5 µL of blood was placed onto the sample chamber, and 2 drops of sample buffer were added. The presence of the control band and IgM and IgG antibodies were detected within 15 minutes, and the results were interpreted following the manufacturer's instructions.

Real-time polymerase chain reaction (RT-PCR) for COVID-19 detection

RT-PCR was performed using the Liferiver Novel Coronavirus (2019-nCoV) Real-time Multiplex RT-PCR kit (Liferiver Bio-Tech, Shanghai, China). This RT-PCR kit targets three genes–E, N, and ORF1ab–in a single tube. Briefly, 19 µL of master mix and 1 µL of enzyme were combined, and 5 µL of RNA sample was added. Internal, negative and positive controls were run together with the specimens. PCR was performed in a 96-well plate using the Bio-Rad CFX96 (Bio-Rad Laboratories, Hercules, USA); the PCR reactions were set up and the results were interpreted following manufacturer instructions. Those with inconclusive and positive results were repeated for further confirmation.

Questionnaire

An online questionnaire was developed via Google Forms and shared with all participants through WhatsApp. The questionnaire consisted of items that assess demographic information, comorbidities with diseases such as diabetes and cardiovascular diseases as well as exposure and adherence to infection prevention and control (IPC) measures against COVID-19 either in the hospital or laboratory environment. Baseline demographic data include gender, age, ethnicity, profession, education level, lifestyle (i.e.: smoker or alcohol drinker) and history of medical illness. The questionnaire on adherence to IPC measures was based on the WHO assessment protocol for potential COVID-19 risk factors among HCWs in a healthcare setting [20]. At this stage, the responses were recorded on a four-point Likert scale (1 = rarely; 2 = occasionally; 3 = most of the time; 4 = always) as recommended. Each dependent variable had two possible values: good (most of the time/always have this practice) or poor (rarely/occasionally have this practice).

Occupational exposure to COVID-19

COVID-19 exposure was evaluated using a risk assessment tool. Participants with occupational exposure to COVID-19 were identified as HCWs directly involved in managing and treating confirmed or suspected COVID-19 patients [21].

Data analysis

Data from Google Forms were exported to Statistical Package for Social Science software (version 24.0, IBM, Chicago, IL, USA) and analysed. Descriptive statistics were performed by calculating frequencies and proportions. Data were analysed using Pearson's χ^2 test and p-value < 0.05 were considered statistically significant.

Results

Table 1 shows the baseline characteristics of the 571 HCTM participants. Swab (nasopharyngeal and

throat) and blood samples were collected during the recruitment phase (day 1). Of the 571 HCWs, 556 answered the online questionnaire (97.4% response rate) while 521 returned for the follow-up at day 15 (91.2% follow-up rate). Their mean age was 34.7 ± 6.4 years and ranged from 22 to 57 years. The majority of HCWs were female (71.85%), of Malay ethnicity (81.6%), bachelor's degree holders (39.8%), medical doctors (35.25%), those with no history of medical illness (76.9%), non-smokers (94.9%), those who did not consume alcohol (93.3%), and those with normal body mass index (59.0%). Occupational exposure to COVID-19 among the HCWs had a prevalence rate of 28.8%. All 571 HCWs were negative for IgM and IgG antibodies on day 1 and 15 of recruitment. However, only 3 HCWs at HCTM (0.5%) tested positive for COVID-19, while the remaining 568 (99.5%) were negative.

We conducted an exposure assessment to COVID-19 among HCWs based on their occupational exposure to COVID-19 (Table 2). About 52.5% of HCWs with direct occupational exposure had received IPC training for more than 2 hours. About 32.4% of them have had more than 8 hours of occupational exposure to COVID-19 in one day. Of the 160 HCWs, about 73.8% used PPE consisting of masks (*e.g* N95), gloves, gowns, aprons and shoe covers as needed. The majority of them (81.2%) reported having adequate PPE supplies in their facilities. About 14.4% (n = 24) had experienced COVID-19-like symptoms, including fever (1.9%), cough (6.3%), runny nose (4.4%), muscle and body aches (6.3%), sore throat (3.2%) and diarrhoea (3.2%).

Table 1. Participants' baseline characteristics (N = 571).

Characteristics	Total, N (%)
Gender	
Male	161 (28.2)
Female	410 (71.8)
Age, years	
20-29	121 (21.2)
30-39	318 (55.7)
40-49	116 (20.3)
50-59	16 (2.8)
Ethnicity	
Malay	466 (81.6)
Chinese	64 (11.2)
Indian	31 (5.4)
Others	10 (1.8)
Education level	
Secondary school	51 (8.9)
Vocational certificate	2 (0.3)
Diploma	182 (31.9)
Bachelor's degree	227 (39.8)
Master's degree	85 (14.9)
Doctorate degree	9 (1.6)
Not available	15 (2.6)

Of these HCWs, 5.1% experienced more than 2 symptoms. Of those HCWs who had no occupational exposure to COVID-19, about 42.7% had received IPC training for more than 2 hours. Of the 396 HCWs, about 45.5% used PPE consisting of masks, gloves, gowns,

Table 1 (continued). Participants' baseline characteristics (N = 571).

Characteristics	Total, N (%)
Type of health professional	
Doctor	201 (35.2)
Nurse	192 (33.6)
Pharmacist	8 (1.4)
Laboratory personnel	112 (19.6)
Medical assistant	35 (6.1)
Medical student	2 (0.4)
Assistant pharmacist	6 (1.1)
Not available	15 (2.6)
Occupational exposure to COVID-19	
No	396 (71.2)
Yes	160 (28.8)
Medical History	
None	439 (76.9)
Allergic rhinitis/eczema	8 (1.4)
Asthma/bronchial asthma	33 (5.8)
Diabetes mellitus	8 (1.4)
Hypertension	20 (3.5)
Heart problem	2 (0.3)
Systematic lupus erythematosus	2 (0.3)
Diabetes mellitus and hypertension	11 (1.9)
Diabetes mellitus, hypertension and heart problem	3 (0.5)
Others	30 (5.3)
Not available	15 (2.6)
Smoking status	
Non-smoker	542 (94.9)
Smoker	14 (2.5)
Not available	15 (2.6)
Alcohol drinker	
No	533 (93.4)
Yes	23 (4.0)
Not available	15 (2.6)
Body Mass Index (BMI)	
< 25	337 (59.0)
≥ 25	219 (38.4)
Not available	15 (2.6)
With recent travel history	
No	547 (95.8)
Yes	9 (1.6)
Not available	15 (2.6)
SARS-CoV-2 swab test result	
Negative	565 (98.96)
Positive (E, N, ORF1ab)	3 (0.52)
Inconclusive (E gene)	3 (0.52)
SARS-CoV-2 IgM/IgG antibody test (Day 1)	
Negative	571 (100.00)
Positive	0 (0.00)
SARS-CoV-2 IgM/IgG antibody test (Day 15)	
Negative	519 (90.9)
Positive	0 (0.00)
Not available	52 (9.1)

aprons and shoe covers as needed. Interestingly, about 11.9% of them had experienced COVID-19-like symptoms, including fever (1.5%), cough (5.1%), runny nose (3.3%), muscle and body aches (2.5%), sore throat (4.3%) and diarrhoea (1.3%).

We classified the HCWs based on their occupational exposure to COVID-19 and their adherence to IPC practices (Figure 2). Of those with occupational exposure to COVID-19 (n = 160), 99.4% followed hand hygiene recommendations (most of the time, n = 38 (23.8%); always, n = 121 (75.6%)). Majority (92.5%–100%) followed the recommendation to use alcohol-based hand rubs or soap with water in all procedures including before aseptic procedures, before and after touching patients, after exposure to bodily fluids and after touching patients' surroundings. About 5.7% of the HCWs in this group did not wear PPE as needed (rarely, n = 3 (1.9%); occasionally, n = 6 (3.8%)). Of those HCWs who had no occupational exposure to COVID-19 (n = 396), about 98.2% followed hand hygiene recommendation (most of the time = 81 (20.5%); always = 308 (77.8%). These HCWs followed recommendations to use alcohol-based hand rubs or soap with water in all procedures including before aseptic procedures (97.5%), before touching patients (97.2%), after touching patients (98.5%), after exposure to bodily fluids (94.2%) and after touching patients' surrounding (98.5%). About 8.9% of these HCWs did not wear PPE as needed (rarely, n = 11 (2.8%), occasionally, n = 23 (5.8%)).

Table 2. COVID-19 exposure assessment among healthcare workers (N = 556).

Variables	Occupational exposure to COVID-19		
	Yes, N (%)	No, N (%)	*p*-value
Total	160 (28.8)	396 (71.2)	
IPC training duration			
< 2 hours	76 (47.5)	227 (57.3)	0.035*
≥ 2 hours	84 (52.5)	169 (42.7)	
Duration of occupational exposure to COVID-19			
< 1 hour	46 (28.8)	NA	
1-4 hours	40 (25.0)	NA	NA
5-8 hours	22 (13.8)	NA	
> 8 hours	52 (32.4)	NA	
Adequate PPE in the facilities			
No	30 (18.8)	88 (22.2)	0.365
Yes	130 (81.2)	308 (77.8)	
Type of PPE used			
None	1 (0.6)	4 (1.0)	
Mask/N95	11 (6.9)	42 (10.6)	
Mask/N95 and apron	2 (1.3)	11 (2.8)	
Mask/N95 and gloves	10 (6.3)	13 (3.3)	
Mask/N95 and gown	0 (0.0)	1 (0.3)	
Gloves and apron	0 (0.0)	1 (0.3)	
Mask/N95, gloves and apron	8 (5.0)	62 (15.7)	NA
Mask/N95, gloves and gown	0 (0.0)	5 (1.3)	
Mask/N95, gloves and shoe covers	0 (0.0)	2 (0.5)	
Mask/N95, gloves, apron and gown	8 (5.0)	65 (16.4)	
Mask/N95, gloves, apron and shoe covers	0 (0.0)	3 (0.8)	
Mask/N95, gloves, gown and shoe covers	2 (1.3)	7 (1.8)	
Mask/N95, gloves, apron, gown and shoe covers	118 (73.8)	180 (45.5)	
Have you experienced COVID-19-like symptoms?			
No	137 (85.6)	349 (88.1)	0.480
Yes	23 (14.4)	47 (11.9)	
Type of COVID-19-like symptoms (n = 70)			
Fever	3 (1.9)	6 (1.5)	
Cough	10 (6.3)	20 (5.1)	
Congestion/runny nose	7 (4.4)	13 (3.3)	NA
Sore throat	5 (3.2)	17 (4.3)	
Diarrhoea	5 (3.2)	5 (1.3)	
Muscle and body aches	10 (6.3)	10 (2.5)	
How many COVID-19-like symptoms (n = 70)?			
1 symptom	15 (9.4)	30 (7.6)	
2 symptoms	5 (3.2)	15 (3.9)	0.383
3 and more symptoms	3 (1.9)	2 (0.5)	

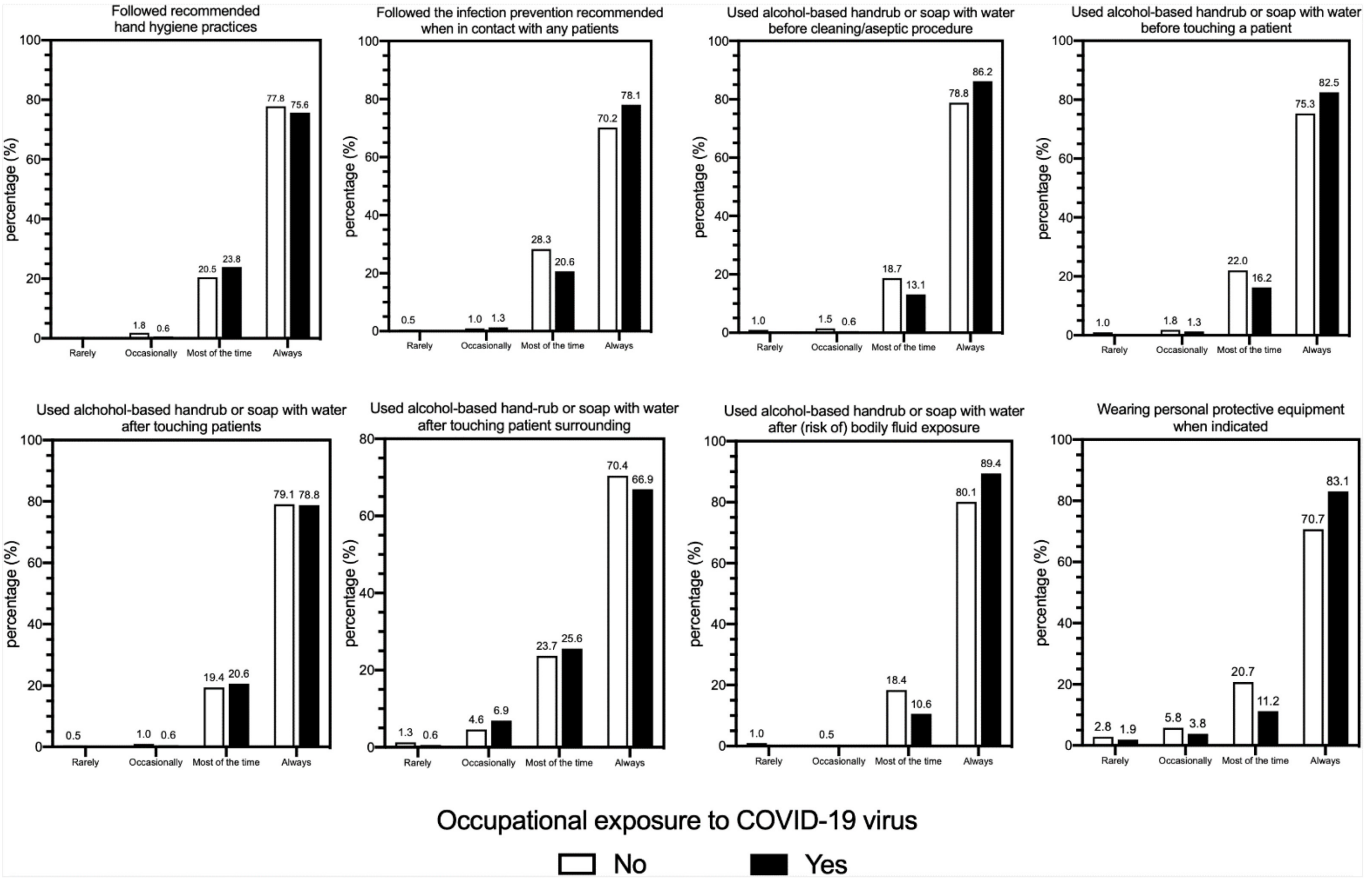
* Significant differences, $p < 0.05$; NA: not available.

Discussion

In this study, three HCWs (0.5%) tested positive for COVID-19 but were asymptomatic at the time of detection. They were referred to the HCTM Infection Control Unit and were admitted to the COVID-19 ward for quarantine and treatment. All their close contacts were referred for swab tests and risk assessments were conducted to curb the virus transmission in the hospital. Although the percentage of asymptomatic cases in this study was lower compared with that studies conducted in the UK (3%) and Indonesia (1.3%), this situation still raises concerns regarding asymptomatic COVID-19 transmission particularly in the healthcare facility setting [22,23]. In December 2020, the Malaysia Ministry of Health reported 1,771 COVID-19 cases among HCWs, of which 76.7% were reported during the third wave of COVID-19 in the country [24]. Out of these COVID-19 cases among HCWs, 33.2% (587) were community-acquired, 31.9% (565) were infected by their colleagues, 8.6% (152) were infected by patients, 3.3% (58) were infected by unknown sources and 23.1% (409) have yet to determine the source of infection [24]. These observations address the need to conduct continuous IPC training to all HCWs to ensure all the HCWs continuously followed the universal prevention recommendation. In addition to that, routine screening, developing and implementing strict policies are essential to prevent HCWs from becoming silent vectors for this virus.

IgM and IgG antibody detection using the rapid test kit revealed that all the HCWs were negative during blood sampling (day 0), including those who tested positive for COVID-19. These positive individuals may have been at an early phase of infection; hence, IgM and IgG antibodies have not developed yet, yielding negative results. Despite reports that the rapid test kit used in this study has a low sensitivity (below 90%), antibody levels in those positive for COVID-19 may have been below detection levels [25,26]. This showed the importance of using gold-standard techniques when

Figure 2. Assessment of adherence to infection prevention and control practices by healthcare workers with and without occupational exposure to COVID-19 (N = 556).



The open bar indicates those who had no occupational exposure to COVID-19, which the closed bar refers to those who had occupational exposure to COVID-19.

conducting a massive and routine screening of COVID-19 outbreak among HCWs. However, for those symptomatic HCWs, an antigen rapid test kit can be used as early containment to prevent the outbreak.

More than 90% of the HCWs participants followed IPC practices recommendations whether or not they were exposed to occupational risk for COVID-19. Interestingly, we did not find any significant differences in the level of IPC adherence between the two groups. The IPC compliance among HCWs in this hospital (IPC adherence level more than 90%) was higher than those in studies conducted in the neighboring countries including in the Indonesia, Thailand and Vietnam (IPC adherence level less than 90%) [27-29]. In addition to that, the IPC compliance among HCWs in this hospital was higher than those in studies conducted in other developing countries including in the Ethiopia, Pakistan, Libya and Uganda [30-33]; nonetheless, the percentage of COVID-19-positive HCWs in this study was lower than in studies in the United States, Italy and China [16,21,34-36].

Based on this study, it was suggested that most of these HCWs in this study were at a low risk of occupational exposure to COVID-19 because of their high levels of adherence to IPC practices. Although less than 5% of HCWs with occupational risk for COVID-19 did not wear adequate PPE when needed, a high risk of infection and transmission remains because HCWs who wear inadequate PPE are at a higher risk of infection than those who use adequate PPE particularly when they were in direct contact with COVID-19 patient and their surrounding environment [37]. Thus, hospitals that provide COVID-19 care need to have proper plans and strategies to minimise the risk of infection among HCWs. These include continuous IPC training to the HCWs regardless of their occupational exposure to COVID-19, protecting HCWs by ensuring sufficient PPE supply, updating the working guidelines on the infection and prevention practices according to the current situation, routine screening to enable early detection and isolation of infected personnel.

This study has several limitations. The online questionnaire was not validated, and responses depended much on honesty and were affected by the recall and thus may have been subjected to recall bias. In addition, this study was limited to one hospital only and cannot be used to extrapolate IPC adherence in all hospital and COVID-19 treatment centres in Malaysia. Further study needs to be conducted to determine the impact of the COVID-19 pandemic on the HCWs' mental health as the number of COVID-19 cases continues to increase.

Conclusions

In conclusion, the high level of adherence to infection prevention practices among HCWs at HCTM had helped reduce and minimise occupational exposure to COVID-19. To maintain a high level of adherence to IPC, continuous IPC training must be compulsory for all HCWs and policies to protect HCWs' safety must be continuously developed and strictly implemented. Also, massive and routine screening for HCWs, particularly those working in COVID-19 wards and experiencing COVID-19-like symptoms is needed to prevent COVID-19 from spreading in the healthcare facility.

Acknowledgements

The authors would like to thank the members of the Malaysian Cohort Project for providing support in participant recruitment. This work was supported by internal grants from the Hospital Canselor Tuanku Muhriz and the UKM Medical Molecular Biology Institute.

References

1. Sohrabi C, Alsafi Z, O'Neill N, Khan M, Kerwan A, Al-Jabir A, Iosifidis C, Agha R (2020) World Health Organization declares global emergency: A review of the 2019 novel coronavirus (COVID-19). Int J Surg 76: 71–76.
2. Worldometers (2021) Worldometer Malaysia COVID-19 coronavirus pandemic update. Available: https://www.worldometers.info/coronavirus/country/malaysia. Accessed 20 January 2021.
3. Guo YR, Cao QD, Hong ZS, Tan YY, Chen SD, Jin HJ, Tan KS, Wang DY, Yan Y (2020) The origin, transmission and clinical therapies on coronavirus disease 2019 (COVID-19) outbreak - an update on the status. Mil Med Res 7: 11.
4. Zhou P, Yang XL, Wang XG, Hu B, Zhang L, Zhang W, Si HR, Zhu Y, Li B, Huang CL, Chen HD, Chen J, Luo Y, Guo H, Jiang RD, Liu MQ, Chen Y, Shen XR, Wang X, Zheng XS, Zhao K, Chen QJ, Deng F, Liu LL, Yan B, Zhan FX, Wang YY, Xiao GF, Shi ZL (2020) A pneumonia outbreak associated with a new coronavirus of probable bat origin. Nature 579: 270-273.
5. Li JY, You Z, Wang Q, Zhou ZJ, Qiu Y, Luo R, Ge XY (2020) The epidemic of 2019-novel-coronavirus (2019-nCoV) pneumonia and insights for emerging infectious diseases in the future. Microbes Infect 22: 80-85.
6. Ng K, Poon BH, Kiat Puar TH, Shan Quah JL, Loh WJ, Wong YJ, Tan TY, Raghuram J (2020) COVID-19 and the risk to health care workers: A case report. Ann Intern Med 172: 766-767.
7. Velavan TP, Meyer CG (2020) The COVID-19 epidemic. Trop Med Int Health 25: 278-280.
8. Li Q, Guan X, Wu P, Wang X, Zhou L, Tong Y, Ren R, Leung KSM, Lau EHY, Wong JY, Xing X, Xiang N, Wu Y, Li C, Chen Q, Li D, Liu T, Zhao J, Liu M, Tu W, Chen C, Jin L, Yang R, Wang Q, Zhou S, Wang R, Liu H, Luo Y, Liu Y, Shao G, Li H, Tao Z, Yang Y, Deng Z, Liu B, Ma Z, Zhang Y, Shi G, Lam TTY, Wu JT, Gao GF, Cowling BJ, Yang B, Leung GM, Feng Z (2020) Early transmission dynamics in Wuhan,

China, of novel Coronavirus-infected pneumonia. N Engl J Med 382: 1199-1207.
9. Guan W, Ni Z, Hu Y, Liang W, Ou C, He J, Liu L, Shan H, Lei C, Hui D, Du B, Li L, Zeng G, Yuen KY, Chen R, Tang C, Wang T, Chen P, Xiang J, Li S, Wang J, Liang Z, Peng Y, Wei L, Liu Y, Hu Y, Peng P, Wang J, Liu J, Chen Z, Li G, Zheng Z, Qiu S, Luo J, Ye C, Zhu S, Zhong N (2020) Clinical characteristics of 2019 novel coronavirus infection in China. Preprint. medRxiv 2020.02.06.20020974.
10. Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, Wang B, Xiang H, Cheng Z, Xiong Y, Zhao Y, Li Y, Wang X, Peng Z (2020) Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. Jama 323: 1061-1069.
11. Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, Zhang L, Fan G, Xu J, Gu X, Cheng Z, Yu T, Xia J, Wei Y, Wu W, Xie X, Yin W, Li H, Liu M, Xiao Y, Gao H, Guo L, Xie J, Wang G, Jiang R, Gao Z, Jin Q, Wang J, Cao B (2020) Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet 395: 497-506.
12. Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, Qiu Y, Wang J, Liu Y, Wei Y, Xia J, Yu T, Zhang X, Zhang L (2020) Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: A descriptive study. Lancet 395: 507-513.
13. Director-General of Health Malaysia (2020) KPK press statement 11 December 2020 – current situation of coronavirus disease 2019 (COVID-19) in Malaysia. Available: https://kpkesihatan.com/2020/12/11/kenyataan-akhbar-kpk-11-disember-2020-situasi-semasa-jangkitan-penyakit-coronavirus-2019-covid-19-di-malaysia/. Assessed 12 December 2020. [Available in Malaysian]
14. Ng CFS, Seposo XT, Moi ML, Tajudin MABA, Madaniyazi L, Sahani M (2020) Characteristics of COVID-19 epidemic and control measures to curb transmission in Malaysia. Int J Infect Dis 101: 409-411.
15. Centers for Disease Control and Prevention (2020) Interim US guidance for assessment and public health management of healthcare personnel with potential exposure in a healthcare setting to patients with coronavirus disease (COVID-19). Available: https://www.cdc.gov/coronavirus/2019-ncov/hcp/guidance-risk-assesment-hcp.html. Accessed 30 January 2021.
16. CDC COVID-19 Response Team (2020) Characteristics of health care personnel with COVID-19 - United States, February 12-April 9, 2020. MMWR Morb Mortal Wkly Rep 69: 477-481.
17. World Health Organization (2020) Coronavirus disease (COVID-19) outbreak: rights, roles and responsibilities of health workers, including key considerations for occupational safety and health: interim guidance. Available: https://apps.who.int/iris/handle/10665/331510. Accessed 19 March 2020.
18. Nienhaus A, Hod R (2020) COVID-19 among health workers in Germany and Malaysia. Int J Environ Res Public Health 17: 4881.
19. Director-General of Health Malaysia (2020) KPK press statement 18 April 2020 – current situation of coronavirus disease 2019 (COVID-19) in Malaysia. Available: https://kpkesihatan.com/2020/04/18/kenyataan-akhbar-kpk-18-april-2020-situasi-semasa-jangkitan-penyakit-coronavirus-2019-covid-19-di-malaysia/. Assessed 12 December 2020. [Available in Malaysian]
20. World Health Organization (2020) Protocol for assessment of potential risk factors for coronavirus disease 2019 (COVID-19) among health workers in a health care setting. Available: https://apps.who.int/iris/handle/10665/332071. Assessed 23 March 2020.
21. Nguyen LH, Drew DA, Graham MS, Joshi AD, Guo CG, Ma W, Mehta RS, Warner ET, Sikavi DR, Lo CH, Kwon S, Song M, Mucci LA, Stampfer MJ, Willett WC, Eliassen AH, Hart JE, Chavarro JE, Rich-Edwards JW, Davies R, Capdevila J, Lee KA, Lochlainn MN, Varsavsky T, Sudre CH, Cardoso MJ, Wolf J, Spector TD, Ourselin S, Steves CJ, Chan AT Coronavirus Pandemic Epidemiology Consortium (2020) Risk of COVID-19 among front-line health-care workers and the general community: A prospective cohort study. Lancet Public Health 5: e475-e483.
22. Rivett L, Sridhar S, Sparkes D, Routledge M, Jones NK, Forrest S, Young J, Pereira-Dias J, Hamilton WL, Ferris M, Torok ME, Meredith L, CITIID-NIHR COVID-19 BioResource Collaboration, Curran MD, Fuller S, Chaudhry A, Shaw A, Samworth RJ, Bradley JR, Dougan G, Smith KG, Lehner PJ, Matheson NJ, Wright G, Goodfellow IG, Baker S, Weekes MP (2020) Screening of healthcare workers for SARS-CoV-2 highlights the role of asymptomatic carriage in COVID-19 transmission. Elife 9: e58728.
23. Bella A, Akbar MT, Kusnadi G, Herlinda O, Regita PA, Kusuma D (2021) Socioeconomic and behavioral correlates of COVID-19 infections among hospital workers in the Greater Jakarta Area, Indonesia: a cross-sectional study. Int J Environ Res Public Health 18: 5048.
24. Director-General of Health Malaysia (2020) KPK press statement 18 December 2020 – current situation of coronavirus disease 2019 (COVID-19) in Malaysia. Available: https://kpkesihatan.com/2020/12/18/kenyataan-akhbar-kpk-18-disember-2020-situasi-semasa-jangkitan-penyakit-coronavirus-2019-covid-19-di-malaysia/. Assessed 1 February 2021. [Available in Malaysian]
25. Zainol Rashid Z, Othman SN, Abdul Samat MN, Ali UK, Wong KK (2020) Diagnostic performance of COVID-19 serology assays. Malays J Pathol 42: 13-21.
26. Ghaffari A, Meurant R, Ardakani A (2020) COVID-19 Serological Tests: How well do they actually perform? Diagnostics (Basel) 10: 453.
27. Rizki SA, Kurniawan J, Budimulia P, Sylvanus P, Alexandra A, Sinaga TD, Kurniawan A, Lugito NPH (2021) Knowledge, Attitude, and Practice in Indonesian Health Care Workers Regarding COVID-19. Asia Pacific J Public Health 33: 662-664
28. Maude RR, Jongdeepaisal M, Skuntaniyom S, Muntajit T, Blacksell SD, Khuenpetch W, Pan-Ngum W, Taleangkaphan K, Malathum K, Maude RJ (2021) Improving knowledge, attitudes and practice to prevent COVID-19 transmission in healthcare workers and the public in Thailand. BMC Public Health 21: 749.
29. Tien TQ, Tuyet-Hanh TT, Linh TNQ, Hai Phuc H, Van Nhu H (2021) Knowledge, attitudes, and practices regarding COVID-19 prevention among Vietnamese healthcare workers in 2020. Health Serv Insights 14: 11786329211019225.
30. Asemahagn MA (2020) Factors determining the knowledge and prevention practice of healthcare workers towards COVID-19 in Amhara region, Ethiopia: a cross-sectional survey. Trop Med Health 48: 72.
31. Saqlain M, Munir MM, Rehman SU, Gulzar A, Naz S, Ahmed Z, Tahir AH, Mashhood M (2020) Knowledge, attitude,

practice and perceived barriers among healthcare workers regarding COVID-19: A cross-sectional survey from Pakistan. J Hosp Infect 105: 419-423.
32. Olum R, Chekwech G, Wekha G, Nassozi DR, Bongomin F (2020) Coronavirus disease-2019: Knowledge, attitude, and practices of health care workers at Makerere University Teaching Hospitals, Uganda. Front Public Health 8: 181.
33. Hweissa NAB, Shawesh FA, Krema SO, Mansour AA (2020) Knowledge, attitude and practice (KAP) for preventing the coronavirus (COVID19) pandemic among libyan health care workers. Libyan J Med Sci 4: 109.
34. Garzaro G, Clari M, Ciocan C, Grillo E, Mansour I, Godono A, Borgna LG, Sciannameo V, Costa G, Raciti IM, Bert F, Berchialla P, Coggiola M, Pira E (2020) COVID-19 infection and diffusion among the healthcare workforce in a large university-hospital in northwest Italy. Med Lav 111: 184-194.
35. Zhan M, Qin Y, Xue X, Zhu S (2020) Death from Covid-19 of 23 health care workers in China. N Engl J Med. 382: 2267.
36. Sikkema RS, Pas SD, Nieuwenhuijse DF, O'Toole Á, Verweij J, van der Linden A, Chestakova I, Schapendonk C, Pronk M, Lexmond P, Bestebroer T, Overmars RJ, van Nieuwkoop S, van den Bijllaardt W, Bentvelsen RG, van Rijen MML, Buiting AGM, van Oudheusden AJG, Diederen BM, Bergmans AMC, van der Eijk A, Molenkamp R, Rambaut A, Timen A, Kluytmans JAJW, Oude Munnink BB, Kluytmans van den Bergh MFQ, Koopmans MPG (2020) COVID-19 in health-care workers in three hospitals in the south of the Netherlands: a cross-sectional study. Lancet Infect Dis 20: 1273-1280.
37. Ashinyo ME, Dubik SD, Duti V, Amegah KE, Ashinyo A, Larsen-Reindorf R, Kaba Akoriyea S, Kuma-Aboagye P (2020) Healthcare workers exposure risk assessment: A survey among frontline workers in designated COVID-19 treatment centers in Ghana. J Prim Care Community Health 11: 2150132720969483.

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Conflict of interests: No conflict of interests is declared.