# Antibody Seropositivity And Potential Risk Factors For SARS-Cov-2 Among Healthcare Workers (HCW) In A Private Healthcare Group In Malaysia

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## Abstract

**Background:** Healthcare workers (HCW) are at increased risk of infection to Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) due to occupational exposure to confirmed or suspected COVID-19 patient. Various potential risk factors for SARS-CoV-2 infection among HCWs as well as asymptomatic infections; are well documented. This study was conducted to investigate the antibody seropositivity and potential risk factors for SARS-CoV-2 infection among healthcare workers (HCW) in a private healthcare group in Malaysia. This study also sought to identify symptomatic and asymptomatic COVID-19 infection among the HCWs and to determine the relationship between effective prevention & control (IPC) measures and occupational risk with the SARS-CoV-2 antibody status.

**Materials and Method:** This is a cross-sectional study of all identified health care workers (HCW) working in a Malaysia-based private healthcare hospitals group, in which a patient with a confirmed/suspected COVID-19 infection was receiving care. The study had two components, the first is the filling up of a questionnaire (descriptive), the second is the blood test for SARS-CoV-2 antibody (investigative). Data were collected between the period of 1st February 2020 until 1st March 2021 and 1120 HWCs were recruited.

**Results:** SARS-CoV-2 antibody results for all 1120 respondents was positive in 38 respondents (3.4%) and negative in 1082 respondents (96.6%). The study population comprised of 65% HCWs who had direct care to patient and 35% did not give direct care to patient. Low prevalence (3.4%) among the HCWs suggests that there was a low rate of undetected COVID-19 infection in this private healthcare group. 47.4% of the seropositive HCWs had never experienced any symptoms of COVID-19 while 52.6% were symptomatic. 60.7% respondents had their IPC training within the last 3-12 months with 60.3% acquiring more than 2 hours training. More than 95% of the respondents always and most of the time adhered to the WHO recommended hand hygiene practises. According to the risk assessment, 94.6% always or most of the time

wore personal protective equipment (PPE) 91.8% of the respondents agreed that PPE was available in sufficient quantity in the health care facility while 8.2% disagreed.

**Conclusion:** The overall low prevalence of SARS-CoV-2 antibody among the HCWs in this study may be due to effective IPC measures and COVID-19 management in the healthcare facilities. However, the higher prevalence seen among certain group of HCWs indicates the need of more stringent implementation and monitoring of IPC measures as well risk assessment among these groups. HCW's health symptoms should not be used solely to rule out the COVID-19 infection in HCWs. If deemed necessary upon risk assessment, prompt screening or diagnostic testing should be conducted. The enforcement of routine screening testing programs for all HCW, regardless of the presence of symptoms, is highly recommended in healthcare settings to reduce the risk of hospital-acquired SARS-CoV-2 infections.

**Keywords:** Healthcare workers, seroprevalence, risk factor, Infection prevention and control (IPC) measures

### Introduction:

In 2019, a novel coronavirus was identified and first appeared in Wuhan City of Hubei province, China [1].   Globally, as of 9 August 2021, there have   been 202,608,306 confirmed   cases of COVID-19,   inclusive   of 4,293,591 deaths, reported   to   WHO.   A   total of 4,033,274,676 vaccine   doses have   been administered as of 8 August 2021[2].

As the main routes of transmission is via person to person, HCWs who are involved in the provision of care or frequently exposed to Covid-19 patients are the most vulnerable component of the workforce [3]. Many HCWs are in the frontlines at healthcare facilities; putting themselves at high risk from SARS-CoV-2 infection since they are exposed to the virus both from within and outside the healthcare facilities. Based on a report by A.K.Kambhampati, among 6,760 adults hospitalized in 13 states in the United States during March 1 – May 31, 2020; 5 .9% were HCWs and 36% were in nursing-related occupations [3].

In Malaysia, the deputy general of Health stated that as of 16th February 2022, 5,711 HCW were absent from work after they tested positive for COVID-19 while 3,119 missed work after being identified as close contacts and they formed 3.1% of Health Ministry workforce [4]    This was an increase compared to data from the beginning of the pandemic to 18th December 2020,   when 1,771 HCWs had contracted COVID-19 (1.2% of HCWs in Malaysia) and 76.7% of this total infected cases were recorded during the 3rd wave. In terms of the possible source of infection; 31% of the infections were due to community exposure, 31% of the transmission occurred at the workplace and 9% of the HCWs contracted the infection from patients [5].

A cross-sectional study conducted in Oman between February and June 2020, found that out of the 126 HCWs with confirmed COVID-19 infection; 29.4% had never received IPC training, and majority of them followed recommended hand hygiene practice, social distancing protocols and wearing of face mask during routine patient care. This study concluded that even though majority of the HCWs followed the IPC measures, one-third never had specific IPC training, therefore the recommendation was for HCWs to undergo rigorous IPC training to increase confidence in making risk assessments. The   health   facilities   also   needed   to   be

restructured for better adherence to IPC standards[6].

Antibody testing can be used as sero-surveillance studies and to support the investigation of an ongoing outbreak or retrospective assessment of an outbreak and can also be used to estimate infection rates and monitor the progression of the epidemic [7].

The rationale for doing this study is to contribute to research on SARS-CoV-2 antibody seroprevalence and risk factors among HCW in Malaysia in order to integrate theoretical and practical reasoning in the prevention measures undertaken.

This objectives of this study were to determine the antibody seropositivity and the extent of COVID-19 infection among HCW in a private healthcare group in Malaysia. Additionally this study sought to determine the relationship between effective prevention measures and occupational risk with SARS-CoV-2 antibody status.

## Methodology

This cross-sectional study used universal sampling of all 1500 consenting health care workers (HCW) working in a private healthcare hospital group, in which a patient with a confirmed COVID-19 infection was receiving care and consisted of two components, filling up of a questionnaire (descriptive) and blood test for SARS-CoV-2 antibody (investigative).

The inclusion criteria was all HCWs with possible exposure to COVID-19 in the private healthcare hospitals; in which a patient with confirmed COVID-19 infection was receiving care, including exposure to the patient's blood and body fluids, and to contaminated materials or devices and equipment linked to the patient. The exclusion criteria were HCWs who have a

confirmed COVID-19 case among their household or close contacts outside their workplace as well as refusal to give informed consent. The data were collected between the period of 1 February 2020 until 1 March 2021.

Prior the commencement of the study, each healthcare facility administrators and laboratory managers were briefed on the objectives and methodology of the study. A memo accompanied by a flyer on regards to the study was also distributed to all HCWs to ensure better understanding of the study as well as to encourage more participation. Reminders via email and phone call were also done to increase response rate.

A serum sample was collected from the HCWs to screen for the presence of COVID-19 virus specific antibodies using serological testing. Antibody detection was carried out with the Siemens Healthineers SARS-CoV-2 Total (COV2T) assay for in-vitro diagnostic use for the qualitative detection of total antibodies to SARS-CoV-2 in human serum and plasma using the Atellica IM Analyzer. The assay was designed as an aid in the diagnosis of patients with suspected SARS-CoV-2 infection, and as an aid in the determination of immune response (IgG and IgM) of patients who may have been exposed to SARS-CoV-2 virus, when used in conjunction with clinical signs and symptoms and results of other laboratory tests. The presence of antibodies to SARS-CoV-2 indicates that the patient, whether symptomatic or asymptomatic, had an immune response to the virus. Total antibody tests detects both IgG and IgM in the blood to provide a clearer disease-state picture.

All HCWs who completed the SARS-CoV-2 Antibody test were asked to complete a survey questionnaire. The questionnaire was distributed via Zoho; an online survey and questionnaire software. Combining the questionnaire with the

seropositivity status of the HCW would demonstrate the effectiveness of the of the hospital's infection prevention and control measures.

Respiratory specimen collection (e.g. nasopharyngeal) and other specimens for RT-PCR was collected from HCW with positive COVID-19 Total Antibody to determine acute COVID-19 infection. (Please refer to the data collection process flow chart)

Flow Chart of Data Collection Process
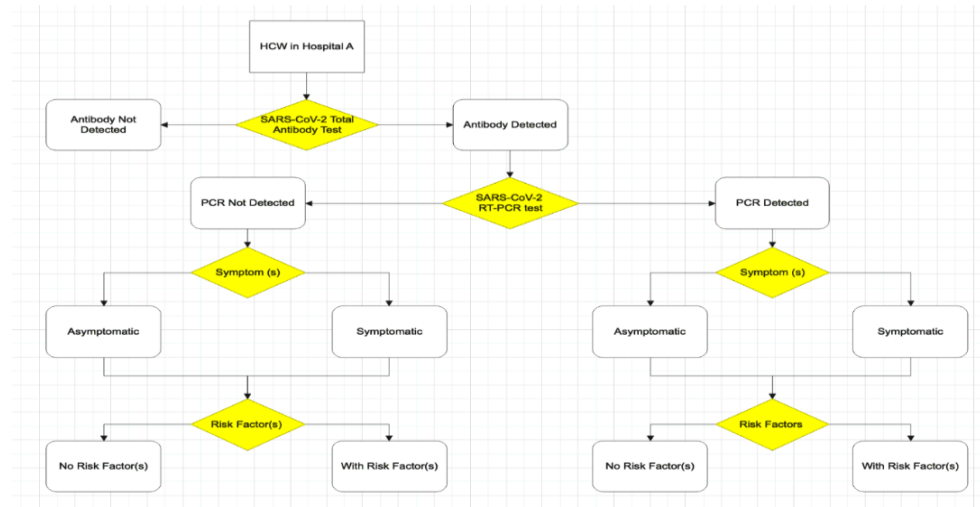


The questionnaire was adopted from the WHO COVID-19 surveillance, case investigation and epidemiological protocols [8] and consisted of 6 sections; Section 1 is the informed consent for the SARS-CoV-2 Antibody blood test. Section 2 is the participants' basic information and demographics. Section 3 is to explore the participants adherence to infection prevention and control (IPC) measures. Section 4 is to investigate the participants' exposure to COVID-19 patients and the nature or extent of the contact. Section 5 is to understand the HCWs health symptoms. The last section of the questionnaire, section 6 is to further explore the HCWs co-morbidities and pre-existing health conditions.

The research design is non-experimental and correlational because the variables were identified and the relationships among the variables were also explored but without

manipulating the variables. Data are gathered from the study population on two or more variables and then correlations between variables are determined.

Data analysis was carried out using the Statistical Package for the Social Sciences or SPSS version 25. The use of SPSS is suitable for this study because it tackles both comparison and correlational statistical tests for univariate, bivariate and multivariate analysis [9].

Ethics approval was obtained from the International Medical University Joint Committee on Research on 2 February 2021 given the Project Approval Number MBAHM I/2021(01).

**Results and Discussion**

For the response rate, a total of 1684 HCWs participated in the research. All 1684 HCWs blood samples were collected for the SARS-Cov-2 Antibody test. However, from this total, only 1120 responded to the questionnaires. Those who refused to answer the questionnaires were excluded from the study.

The overall HCWs seropositivity of 3.4% (38 out of 1120 respondents) in this study was in line with the majority of the published studies; which range from less than 2% to up to 13% [10], [11],[12][13]1[14][15] The low seroprevalence rate in this study suggests that there is a low rate of undetected COVID-19 infection among the HCWs in this private healthcare group. The implementation of effective IPC measures, adequate supply of PPE, effective management of

symptomatic HCW along with efficient contact tracing and quarantine procedures might have contributed to the low seroprevalence among HCWs in this study. This private healthcare group has been adhering closely to their Group COVID-19 Management Guidelines which was also adopted from the Malaysia Ministry of Health COVID-19 Management Guidelines [16], since the beginning of the pandemic. Based on this, we hypothesized that the HCWs from these healthcare facilities would have a better understanding and awareness of the potential risk of infection which would lead to better adherence to IPC measures.

The socio demographic data of the 1120 respondents who participated in this study is tabulated in Table 1.

Table 1: Socio-demography Frequency Distribution

| Demographic | Categories | Frequency (No) | Percentage (%) |
|---|---|---|---|
| Gender | Male | 220 | 19.6 |
| | Female | 900 | 80.4 |
| Age | 20-29 | 360 | 32.1 |
| | 30-39 | 461 | 41.2 |
| | 40-49 | 184 | 16.4 |
| | 50-59 | 78 | 7.0 |
| | 60 and above | 37 | 3.3 |
| Ethnicity | Malay | 592 | 52.9 |
| | Chinese | 225 | 20.1 |
| | Indian | 216 | 19.3 |
| | Others | 87 | 7.8 |
| Occupation | HCW providing direct care to patients | 729 | 65.1 |
| | HCW not providing direct care but have contact with the patient's body fluid, potentially contaminated items or environmental surfaces | 391 | 34.9 |

It was found that 80.4% of the respondents are female and 19.6% are male. Most of the respondents are from the age group of 30- 39

years (41.2%) followed by 20-29 years (32.1%). As for ethnicity, 52.9% are Malays, 20.1% Chinese, 19.3% Indian and 7.8% 41 are other

ethnicities from the Borneo indigenous groups as well as foreigners. Most of the respondents were from the hospital group (55%). Most of the respondents were from healthcare facilities located in the Greater Klang Valley (50.4%) comprising of Selangor, Kuala Lumpur and Putrajaya. 27.1% from the Northern region (Perak, Perlis, Penang, Kedah), 16.1% from the Southern region (Negeri Sembilan, Malacca, Johor), 3.9% from East Cost Malaysia (Sabah, Sarawak) and 2.5% from East Coast Peninsular Malaysia (Pahang, Kelantan, Terengganu).

65.1% are HCWs providing direct care to patients which include the medical doctors, registered nurse, assistant nurse, nurse technician or equivalent, radiology technician, oncology or radiotherapy, phlebotomist, physiotherapist, nutritionist or dietitian, admission or reception clerks, customer service or patient liaison, patient transporter, pharmacist or pharmacy staff and clinic or ward assistant. 34.9% of the respondents were not providing direct care but have contact with the patient's body fluid, potentially contaminated items or environmental surfaces which include the laboratory personnel, catering staff/food service, cleaners/housekeeping/laundry, management/administration, security, laboratory dispatch and support services (Purchasing/Medical Record/Account/IT). From the total respondents, 72.6% of the HCWs job scopes require them to handle patients directly

Table 2 analyses the respondents adherence to infection prevention and control (IPC) measures.

Table 2 Frequency Distribution of Infection Prevention and Control Measures

| Variables | Categories | Response | |
|---|---|---|---|
| | | Frequency (No) | Percentage (%) |
| When your most recent infection control (IPC) measures training within the health care facility? | Last 3 months | 366 | 32.7 |
| | Last 6 months | 202 | 18.0 |
| | Last 12 months | 112 | 10.0 |
| | Unknown | 440 | 39.3 |
| How many hours you have attended the IPC Training (standard precautions, additional precaution) at your respective branches? | Less than 2 hours | 445 | 39.7 |
| | More than 2 hours | 675 | 60.3 |
| Do you follow recommended hand hygiene practices? | Always, as recommended | 858 | 76.6 |
| | Most of the time | 249 | 22.2 |
| | Occasionally | 6 | 0.5 |
| | Rarely | 7 | 0.6 |
| Do you use an alcohol-based hand rub or soap and water before touching a patient? | Always, as recommended | 842 | 75.2 |
| | Most of the time | 244 | 21.8 |
| | Occasionally | 14 | 1.3 |
| | Rarely | 20 | 1.8 |
| Do you use alcohol-based hand rub or soap and water before cleaning/aseptic procedures? | Always, as recommended | 838 | 74.8 |
| | Most of the time | 240 | 21.4 |
| | Occasionally | 19 | 1.7 |
| | Rarely | 23 | 2.1 |

| | | | |
|---|---|---|---|
| Do you use alcohol-based hand rub or soap and water after (risk of) body fluid exposure? | Always, as recommended | 903 | 80.6 |
| | Most of the time | 190 | 17.0 |
| | Occasionally | 12 | 1.1 |
| | Rarely | 15 | 1.3 |
| Do you use alcohol-based hand rub or soap and water after touching a patient? | Always, as recommended | 871 | 77.8 |
| | Most of the time | 217 | 19.4 |
| | Occasionally | 13 | 1.2 |
| | Rarely | 19 | 1.7 |
| Do you use alcohol-based hand rub or soap and water after touching a patient's surroundings? | Always, as recommended | 810 | 72.3 |
| | Most of the time | 268 | 23.9 |
| | Occasionally | 22 | 2.0 |
| | Rarely | 20 | 1.8 |
| Do you follow IPC standard precautions when in contact with any patient? | Always, as recommended | 802 | 71.6 |
| | Most of the time | 266 | 23.8 |
| | Occasionally | 9 | 0.8 |
| | Rarely | 10 | 0.9 |
| | I don't know what IPC standard precautions are | 33 | 2.9 |
| Do you wear PPE when indicated? | Always, according to the risk assessment | 787 | 70.3 |
| | Most of the time, according to the risk assessment | 272 | 24.3 |
| | Occasionally | | |
| | Rarely | 17 | 1.5 |
| | | 44 | 3.9 |
| PPE available in sufficient quantity in the health care facility? | Yes | 1028 | 91.8 |
| | No | 92 | 8.2 |

60.7% respondents had their IPC training within the last 3-12 months and 60.3% had more than 2 hours training while 39.7% had less than 2 hours of training. More than 95% of the respondents always and most of the time adhered to the WHO recommended hand hygiene practises. Unfortunately, 2.9% of the respondents did not know what IPC standard precautions are. As for personal protective equipment (PPE) usage, 70.3% of the respondents always wore PPE according to the risk assessment, 24.3% most of the time, 1.5% occasionally and 3.9% rarely. 91.8% of the respondents agreed that PPE is available in sufficient quantity in the health care facility while 8.2% disagreed.

Table 3 shows analyses the association of HCW occupational risk exposure with SARS-Cov-2 Antibody result. Even though there was no significant relationship between the HCWs occupation and SARS-CoV-2 antibody status, it was noted that seropositivity was significantly higher (63%) in high risk category of staff that is HCW providing direct care to the patients (medical doctors, nurses, radiology, phlebotomist, physiotherapist, dietitian, pharmacist, patient transporter, front desk staff and clinic or ward assistant). This might be attributable to higher frequency and duration of exposure to confirmed or suspected COVID-19

patients. This result confirms the findings in the report by Anita K. Kambhampati [17]. where among 6,760 adults hospitalised in 13 states in the United States during March 1 – May 31, 2020; 5.9% were HCWs and 36% were in nursing-related occupations. Another retrospective study [18] conducted among HCWs in Massachusetts also confirmed this where in terms of occupational risk, there was modest evidence of higher infection rates among 77 frontline HCWs in comparison to those non-frontline HCWs. A study in Terengganu Malaysia found that COVID-19 commonly involved personnel related to clinical work (nurses and doctors) and that early screening and diagnosis of COVID-19 among HCW averted progression to severe COVID-19[19].

A report from Malaysia [20] where 9% of the HCWs possible source of infection were from patients. This was also reflected in the findings of our study (refer Table 3) where there is a significant relationship between HCWs SARSCoV-2 antibody status and their prolonged face-to-face and close contact exposure with positive COVID-19 patients. These frontline HCWs were also at higher occupational risk since they were in contact with the patient and the patient materials. This was clearly evident in our study where there was a significant relationship between the SARS-CoV-2 antibody status and the HCW hand hygiene practises before or after contact with COVID-19 patient's materials.

Table 3 Bivariate analysis of HCW occupational risk exposure associated with SARS-CoV-2 Antibody result

| | Variables | Categories | Antibody Positive | | Antibody Negative | | Total | | Pearson Chi-Square |
|---|---|---|---|---|---|---|---|---|---|
| | | | n | % | n | % | n | % | |
| | Have you had close contact with a confirmed COVID-19 patient (within 1 metre) since their admission? | Yes | 3 | 7.9 | 52 | 4.8 | 55 | 4.9 | .015 |
| | | No | 21 | 55.3 | 821 | 75.9 | 842 | 75.2 | |
| | | I don't know | 14 | 36.8 | 209 | 19.3 | 223 | 19.9 | |
| 1.1 | If yes, how long each time? | <5 minutes | 1 | 33.3 | 16 | 30.7 | 17 | 30.9 | .838 |
| | | 5-15 minutes | 1 | 33.3 | 21 | 40.4 | 22 | 40.0 | |
| | | >15 minutes | 1 | 33.3 | 15 | 28.9 | 16 | 29.1 | |
| 1.2 | Did you have prolonged face-to-face exposure (>15 minutes)? | Yes | 3 | 100.0 | 14 | 26.9 | 17 | 30.9 | .003 |
| | | No | 0 | 0.0 | 38 | 73.1 | 38 | 69.1 | |
| 1.2.1 | If yes, did you wear PPE? | Yes | 2 | 66.7 | 10 | 71.4 | 12 | 70.6 | .004 |
| | | No | 1 | 33.3 | 4 | 28.6 | 5 | 29.4 | |
| 1.3 | If you were wearing a medical mask, what type: | Surgical mask or disposable face mask | 3 | 100.0 | 32 | 61.5 | 35 | 63.6 | .165 |
| | | Cloth mask | 0 | 0.0 | 0 | 0.0 | 0 | 0.9 | |
| | | NIOSH-approved N95 respirators | 0 | 0.0 | 20 | 38.5 | 20 | 36.4 | |
| 1.4 | If you were wearing a respirator, was it test fitted? | Yes | 1 | 33.3 | 24 | 46.2 | 25 | 45.5 | .593 |
| | | No | 2 | 66.7 | 28 | 53.8 | 30 | 54.5 | |
| 1.5 | If you were wearing gloves, did you remove them after contact with the patient? | Yes | 3 | 100.0 | 49 | 94.2 | 52 | 94.5 | .595 |
| | | No | 0 | 0.0 | 3 | 5.8 | 3 | 5.5 | |
| 1.6 | Did you perform hand hygiene before contact with the patient? | Always, as recommended | 3 | 100.0 | 40 | 76.9 | 43 | 78.2 | .543 |

|  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  |  | Most of the time | 0 | 0.0 | 11 | 21.2 | 11 | 20.0 |  |
|  |  | Occasionally | 0 | 0.0 | 1 | 1.9 | 1 | 1.8 |  |
|  |  | Rarely | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |  |
| 1.6.1 | What are you using to perform hand hygiene? | Alcohol-based hand rub | 3 | 100.0 | 38 | 73.1 | 41 | 74.5 | .293 |
|  |  | Soap & water | 0 | 0.0 | 14 | 26.9 | 14 | 25.5 |  |
|  |  | Water | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |  |

Adherence to Infection Prevention and Control (IPC) measures By virtue of their role in patient care, HCWs are considered a vulnerable group for acquiring infection. Encouragingly in this study, most of the HCWs participating in the study have attended IPC measures training, followed the recommended hand hygiene practices and wearing PPE when indicated (refer Table 2).

The CDC found that the detection of SARS-CoV-2 antibodies was less common among those HCWs who reported using PPE [21]. Another study conducted among HCWs working in a COVID-19 ward in Taiwan also concluded that their current IPC measures and PPE regulation is adequate to protect their HCWs against the SARS-CoV-2 [22]. Even though in our study there is no significant relation between adherence to IPC measures and SARS-CoV-2 antibody status, we still believe that the low seropositivity among the HCW was attributable to the infection control policy and practice in the healthcare facilities.

The healthcare facilities have been adhering closely to their internal Group COVID-19 Management Guidelines which was also [20] adopted from the Malaysia Ministry of Health COVID-19 Management Guidelines, since the beginning of the pandemic. The low HCWs seroprevalence together with the high adherence to IPC measures shown in this study suggested that strict infection control, usage of PPE and good hand hygiene practices may reduce the risk of SARS-CoV-2 infection within the healthcare facilities.

## Limitations

This study was limited to a selected healthcare facility hence its findings may not be representative to HCW in other healthcare facilities. There is also a possibility of selection bias because the participation in this study was voluntary and participants were sampled by a non-probability sampling method. Some HCW who did not participate in this study might be seropositive for SARS-CoV-2 antibody. The sample size could also be bigger because a small sample size may underestimate the magnitude of undiagnosed SARS-CoV-2 infection among the HCW. The sensitivity of the serological test also depends on the test time from disease onset or detectable amount of the SARS-CoV-2 antibody. All these could produce false negative results and therefore the observed seroprevalence in this study could potentially underestimate the true prevalence rate. The information on occupational risk exposure and adherence to IPC measures were obtained via self-administered questionnaires. However, this study was conducted shortly after the pandemic thus minimising the potential of recall bias.

## Conclusion and Recommendations

This study is a medium scale study conducted in multisite hospitals. This study can help healthcare policy makers in Malaysia particularly, in coming out with better strategies to protect HCWs from the SARS-CoV-2 infection. Out of 1120 HCW participated in this study, 3.4% were positive for SARSCoV-2 antibody. 47.4% of the seropositive HCWs had never experienced any symptoms of COVID-19 while 52.6% were symptomatic; indicating a slightly higher number of symptomatic cases against asymptomatic cases. The risk factors described in this study were infection prevention and control (IPC) measures and occupational risk. There is significant association of HCWs antibody status with close contact exposure with positive COVID-19 patient, prolonged face-to-face exposure, usage of PPE during this prolonged face-to-face exposure, and whether the HCW perform hand hygiene before or after contact with the COVID-19 patient's materials

Even though there is no significant relationship in this study between the HCW adherence to IPC measures and the antibody status, HCW adherence to IPC measures is still considered an important element towards minimising the risk of getting infected by SARS-CoV-2 [23],[24],[25]. In conclusion, the overall low prevalence of SARS-CoV-2 antibody among the HCWs in this study may be due to effective IPC measures and COVID-19 management in the healthcare facilities. However, the higher prevalence seen among certain groups of HCWs and the location of their place of work indicates the need for more stringent implementation and monitoring of IPC measures as well risk assessment among these groups. As part of the occupational risk exposure assessment, it is also important to identify those HCWs that had close contact with a confirmed COVID-19 patient. Proper PPE should be used according to the setting, target personnel, risk of exposure, type of activity and the mode of transmission of the pathogen (contact, droplet or aerosol). Provision of adequate and regular supply of PPE and appropriate training for HCWs should also be emphasised. Also based on the findings of our study, it is recommended for HCWs to adhere closely to the 5 moments of hand hygiene; hand hygiene before touching a patient, before any clean or aseptic procedure, after body fluid exposure risk, after touching a patient and after touching a patient's surroundings, including contaminated items or surfaces.. The study managed to validate and support certain theoretical understanding of COVID-19 infection and risk factors especially among HCW. Ultimately, it is hoped that by having better understanding of the COVID-19 infection, transmission and as well as the risk factors; healthcare facilities will be able to minimise or mitigate the risk of operational and business disruption related to the COVID-19 infection. Man-days lost or closure of healthcare facilities due to COVID-19 infection among the HCWs

and within the healthcare facilities can be minimised or averted. Practically, this study has offered additional and beneficial information to healthcare policy makers in Malaysia particularly, in coming out with better strategies to protect HCWs from the SARS-CoV-2 infection. The study also provides better oversight into the effectiveness of infection prevention and control measures in healthcare facilities. Therefore from the business perspective, this will help avoid or minimise business disruption as well as enhancing the public image of the healthcare facility as a safe facility

## Author Contributions,

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## Conflicts of Interest,

We, the author(s) declare that we have no conflict of interests.

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