

**FACTORS ASSOCIATED WITH COVID-19
WORKPLACE TRANSMISSION AMONG
GOVERNMENT HEALTHCARE WORKERS IN
KELANTAN, 2020-2021**

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KELANTAN, 2020-2021**

by

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LIST OF SYMBOLS

$>$	More than
$<$	Less than
$=$	Equal to
α	Alpha
β	Beta
$\%$	Percentage
n	Frequency

LIST OF ABBREVIATIONS

ROC	Receiver Operating Characteristics
OR	Odd Ratio
CI	Confidence Interval
df	Degrees of freedom
JKN	Jabatan Kesihatan Negeri
HCWs	Healthcare Workers
KPAS	Kesihatan Pekerjaan dan Alam Sekitar
UKP	Unit Kesihatan Pekerjaan
CKP	Cawangan Kawalan Penyakit
MOH	Ministry of Health
SD	Standard Deviation
SPSS	Statistical Package for Social Science
OSHA	Occupational Safety and Health Act
OSH	Occupational Safety and Health
PM	Particulate Matter
NOX	Nitrogen Oxides
PPE	Personal Protective Equipment
IAQ	Indoor Air Quality
IPC	Infection Prevention Control
USM	Universiti Sains Malaysia
USA	United States Of America
UK	United Kingdom
ILO	International Labour Organization
WHO	World Health Organization

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ABSTRAK

Kajian ini bertujuan untuk mengenal pasti peratusan COVID-19 dan faktor berkaitan transmisi tempat kerja di kalangan pekerja kesihatan (HCW) kerajaan. Satu kajian keratan rentas, menggunakan data sekunder kes HCW COVID-19 daripada rekod pendaftaran oleh Unit Kesihatan Pekerjaan dan Alam Sekitar (KPAS) di Jabatan Kesihatan Negeri Kelantan, Malaysia, telah dianalisis menggunakan Excel dan SPSS versi 26. Analisis deskriptif dan regresi logistik berganda dilakukan untuk mengenal pasti faktor-faktor yang berkaitan dengan transmisi tempat kerja COVID-19. Sejumlah 660 HCW didiagnosis sebagai positif COVID-19 antara 1 Mac 2020 dan 31 Disember 2021. Kajian ini menemui transmisi kebanyakan kes bukan dari tempat kerja (77.1%), dengan kes transmisi dari tempat kerja hanya menyumbang 22.9% kes. Faktor-faktor penting yang berkaitan dengan transmisi tempat kerja adalah seperti berikut: kumpulan Profesional Kesihatan Bersekutu (aOR = 1.66; 95% CI = 1.11, 2.63), fasiliti hospital (aOR = 1.63; 95% CI = 1.08, 2.48), fasiliti pejabat kesihatan (aOR = 2.19; 95% CI = 1.12, 4.26), dan HCW yang tidak divaksin (aOR = 1.91; 95% CI = 1.01, 3.62). Kajian lanjut diperlukan untuk menyiasat faktor-faktor persekitaran dan tingkah laku, kerana kesan mereka terhadap transmisi COVID-19 di tempat kerja belum dikaji dengan mendalam. Mengenal pasti faktor-faktor ini akan membantu dalam pembangunan perancangan dan langkah kawalan yang berkesan untuk mencegah penyebaran virus di tempat kerja, terutamanya di persekitaran yang berisiko tinggi.

**FACTORS ASSOCIATED WITH COVID-19 WORKPLACE
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IN KELANTAN, 2020-2021**

ABSTRACT

This study aimed to identify proportion of COVID-19 and associated factors of workplace transmission among government HCWs. A cross-sectional study, using secondary data of COVID-19 HCW case from a registry by Unit *Kesihatan Pekerja dan Alam Sekitar* (KPAS) in Jabatan Kesihatan Negeri Kelantan, Malaysia, was analysed using Excel and SPSS version 26. Descriptive analysis and multiple logistic regression were performed to identify factors associated with COVID-19 workplace transmission. A total of 660 HCWs diagnosed as positive for COVID-19 between 1 March 2020 and 31 December 2021. The cases was mainly non workplace transmission (77.1%), with workplace transmission cases contributing only 22.9% of the case. The significant factors associated with workplace transmission were the following: Health Associate Professional group (aOR = 1.66; 95% CI = 1.11, 2.63), hospital facility (aOR = 1.63; 95% CI = 1.08, 2.48), health office facility (aOR = 2.19; 95% CI = 1.12, 4.26), and not vaccinated HCWs (aOR = 1.91; 95% CI = 1.01, 3.62). Further investigation is needed to examine environmental and behavioral factors, as their impact on COVID-19 transmission in the workplace has not been adequately explored. Identifying these factors would aid in the development of effective planning and control measures to prevent the spread of the virus in work settings, particularly in high-risk environments.

CHAPTER 1

INTRODUCTION

1.1 Introduction

1.1.1 COVID-19 Transmission at The Workplace

The COVID-19 pandemic has had a profound impact on multiple aspects of both employers' and employees' lives, and the workplace has not been exempted from these effects. As individuals gradually return to their offices, factories, and other work settings, it becomes crucial to have a comprehensive understanding of the transmission risks associated with COVID-19. According to Takala et al. (2021), 1.7 billion employees from multiple sectors were at risk of getting COVID-19, especially in the sector that involved person-to-person interaction. Workers are regularly exposed to various dangers at work, including physical, biological, chemical, and organizational risk factors (Teodoro and Giambò, 2022).

Due to the nature of COVID-19 transmission, the workplace has become a risk to the workers getting infected. During the pandemic, COVID-19, HCWs were exposed to biological hazards contributing to the physiological and psychological impact of adapting to a new norm. Many organizations adapted from the COVID-19 pandemic from physical interaction to online communication, and the term work from home is widely used (Bussin and Swart-Opperman, 2021). COVID-19 spreads through human-to-human contact; infection happens when a worker inhales an air droplet from another infected worker. Like other biological hazards, the control measure needs to be from evidence-based scientific measures (Jahangiri *et al.*, 2020). In a healthcare setting, while doing the task, it was almost impossible to avoid human interaction to prevent infection. A study in Thailand has found HCWs' most reliable information on COVID-19 was from fellow HCWs colleagues, health administrators, the WHO

website, and medical publications (Maude *et al.*, 2021). Social interaction in the workplace can be the most difficult way to prevent the further spread of transmission.

1.1.2 Healthcare Workers and COVID-19 Infection

A study in Qatar found that an industry that dealt with public interaction, such as supermarkets considered a high-risk group for getting COVID-19 in the workplace. Meanwhile, in a healthcare provider setting, even though it was considered a high-risk occupational group, with an application of strict infection and control measures, the possibility of getting infected was much lower compared to other industries (Al-Kuwari *et al.*, 2021).

In Malaysia, a study found that the higher transmission of COVID-19 involved HCWs, patient, and community cases led to stricter infection and control measures in the hospital setting (Chong *et al.*, 2021). The finding was consistent with a study done in Italy where they found that medical interventions such as intubation and manipulation of the oxygen mask have put HCWs at a greater risk of being infected from the patient (Colaneri *et al.*, 2021).

In Japan, the largest cluster of COVID-19 occurred at health facilities, contributing up to 30% of various sectors and events. It was also found that the biggest cluster was reported in a hospital where the case reported was > 100 (Furuse *et al.*, 2020). Undoubtedly the healthcare setting posed the greatest threat to HCWs getting COVID-19 infection.

1.1.3 COVID-19 and HCWs

The Health Care Sector was the most affected as the pandemic increased the burden of the workload already overwhelmed before the pandemic. Some countries reported healthcare workers enduring stress and burnout managing patients during the

pandemic (Matsuo *et al.*, 2020; Teo *et al.*, 2021). Furthermore, a study showed that some of the COVID-19 mortality was associated with work (Agius *et al.*, 2020).

The psychological stress from managing severely ill COVID-19 patients also contributes to significant mental health disorders among HCWs (Mehta *et al.*, 2021). Researchers from Malaysia have found the prevalence of occupational burnout among HCWs was 39.1%, and the biggest group was among health inspectors and lab personnel (Roslan *et al.*, 2021). The finding was supported by a study done in Australia, which mentioned that a confirmed case needs to be thoroughly investigated and needs to find close contact in the workplace (Stuart *et al.*, 2021). Increased workplace and community cases will lead to more mental breakdowns in HCWs.

During the pandemic, HCWs faced stress from physical and psychological aspects due to wearing full PPE while they were at work. The situation worsens by extra hours working conditions in order to be present in the health setting (Gan *et al.*, 2020). Some reported that taxis refused to take HCWs wearing a uniform, and private vehicles cancelled bringing HCWs to health facilities (Koh, 2020). The situation created social stigmatization of HCWs and led to further deterioration of morale to provide the best care to the patient.

The infected worker who was not getting serious complications needed to undergo home isolation, while the more severe ones were hospitalized (Barry *et al.*, 2021). This situation will increase the burden of work on his colleague who was not infected at the workplace. According to the Occupational Safety and Health Act (OSHA) 1994 (Act 154), it is the employer's responsibility to ensure that safety and health at the workplace have never been compromised. Some employer has implemented physical barrier to control the transmission at the workplace (Carlsten *et*

al., 2021). However, this engineering control measure was hardly implemented in the health care setting, especially during administering treatment.

Undoubtedly, the health and care industry was the most severely affected by the pandemic since employees who work in healthcare settings were exposed to several risks that impact their physical, emotional, and social well-being. HCWs have demonstrated a greater risk of SARS-CoV-2 infection than the general population ((WHO), 2021).

1.2 Rationale of The Study

Healthcare workers have been at the forefront of the COVID-19 pandemic since its inception. Ensuring the well-being of HCWs has been closely linked to maintaining a safe and healthy workplace environment. Within the workplace, HCWs have faced various hazards, including biological, chemical, physical, ergonomic, and psychosocial hazards. It is essential to continually assess the needs of the workplace during the pandemic to prevent outbreaks and mitigate the risk of burnout among HCWs.

There has reportedly been a need for more data on specific COVID-19 Infection Prevention Control (IPC) regimes to make workplaces safe, even though several national and international health authorities offer recommendations for workplace health and safety (Ingram *et al.*, 2021). Study in Mozambique revealed that to improve the effectiveness of the national COVID-19 emergency plan, further studies on knowledge among healthcare workers on infection control procedures were required (Feldman *et al.*, 2021).

A study found that the employer representatives were unsure of how to identify the hazards. The study suggests that further assistance was required for the employer to confidently carry out the hazard identification process (Eliasson *et al.*, 2021). This study will help the employer identify biological hazards in the workplace so that prevention and control will be more effective. Some of the department in the healthcare setting was recognized as high-risk workplace for COVID-19; however, there were some units where the facility was not well explored regarding the risk for transmission (Bandyopadhyay *et al.*, 2020). There is also a gap in knowledge between workplace transmission and its associated factors in the health facility.

The study aims to provide a better understanding of COVID-19 workplace transmission, enabling the implementation of effective control measures based on the associated factors. By identifying the factors related to COVID-19 transmission in the workplace, the study will assist health practitioners in effectively managing and mitigating the spread of the virus in these settings. The findings are expected to contribute to a holistic approach to workplace safety and transmission prevention.

1.3 Research Questions, Hypothesis, and Objectives

1.3.1 Research Questions

1. What is the proportion of COVID-19 workplace transmission among positive COVID-19 government healthcare workers in Kelantan from 2020 to 2021?
2. What are the factors associated with COVID-19 workplace transmission among positive COVID-19 government healthcare workers in Kelantan from 2020 to 2021?

1.3.2 Hypothesis

There are associations between sociodemographic, occupational-related factors, work classification, job category, vaccination status, and workplace transmission of COVID-19 among positive COVID-19 government healthcare workers in Kelantan.

1.3.3 General Objective

To study the proportion of COVID-19 workplace transmission and its associated factors among positive COVID-19 government healthcare workers in Kelantan from 2020 to 2021.

1.3.4 Specific Objectives

1. To determine the proportion of COVID-19 workplace transmission among positive COVID-19 government healthcare workers in Kelantan from 2020 until 2021.
2. To determine associations between sociodemographic, occupational-related factors, work classification, job category, vaccination status, and workplace transmission of COVID-19 among positive COVID-19 government healthcare workers in Kelantan.

CHAPTER 2

LITERATURE REVIEW

2.1 COVID-19 Workplace Transmission

HCWs were always exposed to various hazards in the workplace. However, during the COVID-19 pandemic, the biological hazard of COVID-19 transmission has emerged as a significant threat. Compared to other work settings, the healthcare environment poses a higher risk of infection due to frequent exposure to infected patients and colleagues. It is worth noting that some HCWs who contracted the virus remained asymptomatic or experienced mild symptoms. However, there have been cases where HCWs became severely ill or even lost their lives due to COVID-19. The transmission of the virus has necessitated isolation measures for infected HCWs and close contacts in the workplace to minimize further spread.

According to a study conducted in Canada, more than three COVID-19 outbreaks were identified across nine industry sectors. The manufacturing sector accounted for the majority of these outbreaks, comprising 45% of the total. The agriculture, forestry, fishing, and hunting sector accounted for 12% of the outbreaks, while the transportation and warehousing sector reported 11% of workplace-associated outbreaks. These findings highlight the varying levels of risk and potential transmission within different industries during the pandemic (Murti *et al.*, 2021).

A study conducted in Italy revealed evidence of workplace transmission in an office setting (Sarti *et al.*, 2021). One worker who was infected with COVID-19 subsequently transmitted the virus to four of their colleagues. It is worth noting that this study did not specifically involve healthcare settings. However, the studies did not involve healthcare settings. Karpowicz J. (2021) conducted a study in the USA from the industry sectors, and he found that out of 30696 workplace-associated cases, 14953

(48.7%) were associated with a workplace cluster. However, healthcare industry workers were excluded from the study.

2.1.1 Prevalence of the Transmission Among Healthcare Workers

In Malaysia, there were few studies conducted on COVID-19 transmission among healthcare workers. (Harith *et al.*, 2022) found that the prevalence of COVID-19 transmission among government hospital staff was 1.03% of all hospital staff which was 155578. Meanwhile, another study conducted on primary care staff in Cheras District Health Office found among 690 total staff, 17.4% had been infected (Nur Suhada Ramli, 2022). A systematic review found the transmission of COVID-19 among HCWs ranged from 0.4% in Spain to 57.06% in New York (Gomez-Ochoa *et al.*, 2021). A study in the west part of peninsular Malaysia by Omar *et al.*, 2022 found that out of the total COVID-19 cases, the majority, 1125 (67.0%), were non-healthcare-associated infections, while only 554 (33%) were classified as healthcare-associated cases. Research from a university hospital in Malaysia has found 0.3% of 5826 HCWs diagnosed positive, of which 12 HCWs had work-related exposure and 5 HCWs had non-work-related exposure (Wan *et al.*, 2021).

Gholami *et al.* (2021) conducted a study where they found that out of a total of 119,883 healthcare workers infected with COVID-19, 15.1% required hospitalization. However, the study did not specify whether the acquisition of COVID-19 was related to workplace transmission or community transmission. In a study conducted in Singapore, it was reported that 1.7% of healthcare workers had been infected out of a total of 5,050 cases in the general population (Wong *et al.*, 2021). This suggests that healthcare workers had a slightly higher infection rate compared to the general population. A study among healthcare workers in Western Australia, reported that out of 25 cases, seven (26.9%) cases involved direct transmission between healthcare

workers, while five (20%) transmissions occurred in close contact outside the workplace (Hogan and McEvoy, 2021).

2.2 Risk Factors for COVID-19 Workplace Transmission Among HCWs

2.2.1 Sociodemographic Factors

Sociodemographic factors include age distribution, sex difference, and different ethnicity.

2.2.1(a) Age Distribution

A study conducted in Ontario, Canada, revealed that in an industrial COVID-19 outbreak, individuals in the age group of 40 to 49 years old had a higher likelihood of getting infected, accounting for 21.5% of the cases ($n = 268$, $p\text{-value} < 0.001$) (Murti *et al.*, 2021). This suggests that individuals in this age range were more susceptible to contracting COVID-19 during the outbreak. Similarly, Gholami *et al.* (2021) found that among healthcare workers (HCWs), the mean age was 38.73, and this age was significantly associated with the transmission of COVID-19 ($p\text{-value} < 0.001$). This suggests that the age of HCWs played a role in their vulnerability to acquiring and transmitting the virus.

2.2.1(b) Sex

In Kuala Lumpur, a study conducted by Nur Suhada Ramli *et al.* (2022) discovered that being male was associated with a threefold increased likelihood of testing positive for COVID-19 from health-acquired infections (odds ratio [OR] 3.22, 95% confidence interval [CI] = 1.43 - 7.29, $p < 0.05$). This suggests that males had a higher risk of contracting the virus through healthcare-associated transmission in that particular setting. Furthermore, a systematic review found that males had a higher

likelihood of getting infected with COVID-19, with a prevalence of 21.4% (95% CI: 12.4-34.2) and a statistically significant p-value of < 0.001 (Gholami *et al.*, 2021). This indicates that across various settings, males had a higher prevalence of COVID-19 infection compared to females.

2.2.1(c) Ethnicity

A study conducted in New Jersey, USA, revealed that race was associated with the transmission of COVID-19 among healthcare workers (HCWs). Non-white clinicians had a higher likelihood of being infected with COVID-19 compared to White clinicians, with infection rates of 10.9% among non-white clinicians and 6.2% among White clinicians ($P = 0.03$). This suggests that non-white HCWs faced a greater risk of contracting COVID-19 in that particular setting (Videon *et al.*, 2022). Additionally, a local study by Nur Suhada Ramli *et al.* (2022) found that the majority of infected HCWs belonged to the Malay ethnicity. This indicates that within the specific healthcare setting examined, HCWs of Malay ethnicity had a higher proportion of COVID-19 infections.

2.2.2 Occupational Factors

A study in Australia has found that job category was associated with infection of COVID-19 among HCWs. The odds ratio of infection among medical practitioners (OR: 0.36; 95% CI: 0.28 – 0.47) was lower compared to the odd ratio among nurse/midwives (OR: 1.61; 95% CI: 1.32 – 2.00) and not much different from other HCW (OR: 1.07; 95% CI: 0.87 – 1.32) (Rafferty *et al.*, 2021). Meanwhile, a study in Saudi Arabia found being nurses (79.7%), doctors (9.5%), and both therapists and technicians (22.9%) were more likely to be tested positive for COVID-19 (Barry *et al.*, 2021). A study conducted in the UK revealed that individuals in non-clinical roles,

such as cleaners and porters, faced a higher risk of acquiring COVID-19 compared to physicians (Eyre *et al.*, 2020).

A study in Malaysia involving all government hospital staff showed a prevalence of 1.03% of staff being infected. The most prevalent was from nursing-related departments, which affected 40.5%, followed by medical professionals, including medical officers and specialists, at 24.1%. At the same time, the lowest transmission occurs among dietitians and nutritionists, support service personnel, and administrative personnel, which were 0.28%, 0.32%, and 0.62%, respectively (Harith *et al.*, 2022). Comparatively, doctors had 1.433 times higher odds of contracting a healthcare-associated COVID-19 infection when compared to administrative staff (Omar *et al.*, 2022).

Research from Mexico has found out of 542 381 HCWs, pulmonology therapists (19%) had the highest risk of getting infected, followed by health attendants (17.5%) and nurses (17.1%). Meanwhile, older HCWs with comorbidity are more prone to mortality (Robles-Perez *et al.*, 2021). A study by International Labour Organization (ILO) has found in Finland, exceptional nursing staff and midwifery had a higher risk of 3.6 times compared to the jobless population getting infected with COVID-19 (Takala *et al.*, 2021). The majority of cases were nurses 48% (95% CI 0.41,0.56 p-value < 0.001), followed by physicians 25% (95% CI 0.16,0.35) (Gomez-Ochoa *et al.*, 2021).

2.2.3 Location of Work

Research in Japan has found that most cases occurred in closed premises such as gyms, restaurants, and crowded events like music festivals (Azuma *et al.*, 2020). Rafferty *et al.* (2021) have found that the odds of infection was increased in hospital and other health facilities (OR; 1.76; 95% CI: 1.28 – 2.41). A UK study found that

working in close proximity to other workers was at higher risk of COVID-19 positive adj. OR 1.14 (95% CI 1.05–1.24) (Yanik *et al.*, 2022). The crowded and small working areas in health facilities will lead to workplace transmission was likely to occur. A study in Switzerland conclude, preliminary evidence indicates that in a lower COVID-19 endemic setting, such as in primary care compared to a hospital setting, brief contact with an infectious COVID-19 case pose only a small risk of COVID-19 transmission (Canova *et al.*, 2020).

A study at a Hospital in East Malaysia found that the prevalence of COVID-19 cases among HCWs is 52 over 2104 screened workers (2.5%); 24 of them were symptomatic, while 29 stated they were working in non-clinical units and low-risk wards (Foo *et al.*, 2021). Ran *et al.*, 2020 conducted a study among HCWs and found that high-risk departments dealing with high-risk procedures and managing positive cases had a 2.13 higher risk of getting COVID-19 compared to low-risk departments (crude RR = 2.13, 95% CI: 1.45–3.95, $P < 0.05$).

Another study in Malaysia discovered working in a hospital setting increased the likelihood of acquiring a healthcare-associated COVID-19 infection by 1.439 times compared to working in a non-hospital setting, the adjusted odds ratio (AoR) was 1.439, with a 95% confidence interval (CI) ranging from 1.080 to 1.917 (Omar *et al.*, 2022). The most common transmission occurred in hospitals wards 43% (95% CI 0.25,.059 p-value < 0.001), followed by the operation theatre and surgical department at 24% (95% CI 0.17,0.31 p-value 0.05) (Gomez-Ochoa *et al.*, 2021).

2.2.4 Nature of Work

One of the strategies adopted to prevent transmission between HCWs and confirmed cases was that the job needs to be divided into two groups, 1 group

managing confirmed cases and another group managing suspected cases (Gan *et al.*, 2020).

Mhango *et al.*, (2020) reported that HCWs managing a positive case with inadequate PPE, long working hours, suboptimal infection control, and comorbidities were a higher chance of getting infected. Nur Suhada *et al.* (2022) have found that those who were directly managing COVID-19 cases were two times more likely to be tested positive for COVID-19 from health-acquired infection (OR 2.28, 95% CI = 1.02 - 5.09, $p < 0.05$). 12. A Study in a teaching hospital in Malaysia found that 3 % were diagnosed as positive for COVID-19 from 571 HCWs, with 28.8% of them exposed to a patient with positive COVID-19 (Muhammad Azami *et al.*, 2021).

2.2.5 Behavioural Factors

Rapid review and meta-analysis have shown compliance to PPE was linked with reducing in the transmission rate (-50% ; p value = 0.004; -23% ; p value = 0.0379) and increased odds of a zero-infection rate ([OR] = 3.0; p value = .0076; OR = 2.16; p value value= 0.003 (Ingram *et al.*, 2021). Jiee *et al.* (2021) conducted a study regarding the determinants of preventive control among 167 participants who were healthcare workers in Sabah and found that female HCWs have slightly better preventive control compared to male ($P = 0.045$). Gomez-Ochoa *et al.* (2021) found that the risk of infection from the positive patients was reduced OR 0.127 (95% 0.017,0.968) with proper PPE use.

Meanwhile, in China, HCW with unqualified hand hygiene, RR= 2.64, 1.04–6.71(95% CI), P value < 0.05 , and suboptimal hand hygiene before and after contact with patients RR= 3.10, 1.43–6.73(95% CI), P value < 0.01 , were more likely to get infected from COVID-19 (Ran *et al.*, 2020). Nur Suhada *et al.* (2022) also found smoking was likely to get test positive for COVID-19 eleven times in health acquired

Infection (OR 10.84, 95% CI = 1.17 - 100.77, $p < 0.05$). Strict adherence to personal protective equipment (PPE) and appropriate attire is crucial for all healthcare job categories in order to prevent transmission of COVID-19 at the workplace (Villani *et al.*, 2020).

2.2.6 Presence of Comorbidity

Gholami *et al.* (2021) and Murti *et al.* (2021) found that HCWs with comorbidity were more likely to get infected. A study about associated factors of hospitalizations among HCWs has found 67.4% of admission have a history of direct patient contact, while 36.4% of them was in the nursing profession group, and 90% of the hospitalized HCWs having at least one comorbidity, which 72.5% of them being obese (Kambhampati *et al.*, 2020). According to a local study, it was found that asymptomatic healthcare workers (HCWs) are more likely to transmit COVID-19 to their coworkers (Omar *et al.*, 2022).

2.2.7 Presence of Symptom

A study in the US has found that to reduce transmission in the workplace, workers who develop symptoms need to urgently notify, isolated, and tested for COVID-19 (Plantes *et al.*, 2021). Gomez-Ochoa *et al.* (2021) found the majority cases of HCWs had symptoms 19% (95% CI 0.12,0.28% p -value < 0.001) while asymptomatic workers 8% (95% CI 0.03,0.16 p -value < 0.001). A screening process was conducted for 2104 staff members in a hospital in Sarawak, revealing that 52 individuals tested positive for COVID-19. Among them, 24 were symptomatic HCWs (Foo *et al.*, 2021).

Furthermore, the odds of acquiring an asymptomatic healthcare-associated COVID-19 infection were 1.848 times higher compared to acquiring a symptomatic infection (Omar *et al.*, 2022). A study in a tertiary hospital in Italy found among

asymptomatic HCWs, the prevalence of getting COVID-19 infection is 3.4% in the same a period of surveillance, they found 5% had mild symptoms, and 1.7% were noted to have a sore throat and rhinitis who all the case initially asymptomatic (Fusco *et al.*, 2020). Symptomatic patients generally have a higher viral load compared to asymptomatic patients, which contributes to their increased infectivity (Kawasuji *et al.*, 2020).

2.2.8 Vaccination Factors

HCWs who get injected with two doses of the COVID-19 vaccine with a period between them will decrease of getting transmitted over the initial six months that, peaked at the initial two months, showing the effectiveness ranging from 0.72 to 0.92 (Hall *et al.*, 2022). A study in the US showed complete vaccination was 80% effective and protective in preventing COVID-19 infection among HCWs (Fowlkes *et al.*, 2021). A study in Kedah discovered, Incomplete or non-vaccination was found to be associated with a 1.400 times higher likelihood of acquiring a healthcare-associated COVID-19 infection, in comparison to the vaccinated group. The adjusted odds ratio (AoR) was 1.400, with a 95% confidence interval (CI) ranging from 1.050 to 1.866 (Omar *et al.*, 2022).

2.2.9 Environmental Factors

Indoor Air Quality (IAQ) plays an important role in the transmission of respiratory infection. A study has shown that improved ventilation was closely linked with the spread of infectious diseases (Abouleish, 2021). Several researchers have shown PM_{2.5} and NO_X would aggravate transmission of COVID-19; it also mentioned that working in confined spaces for longer periods would increase indoor pollution 4-5 times compared to outdoor air quality (Agarwal *et al.*, 2021).

2.3 Conceptual Framework

Based on the literature review, several associated factors were linked with COVID-19 workplace transmission among HCWs. These factors were presented in this conceptual framework. Figure 2.2 shows the conceptual framework of the study. We studied the associated factors, namely sociodemographic factors, occupation, location of work, nature of work factors, comorbidity of HCWs, and vaccination factors with defaulted follow-up.

The sociodemographic factors were age, sex, and ethnicity. Occupational factors included the job category in JKN Kelantan, which involved clinical and non-clinical personnel. The work location included a hospital, health clinic, dental clinic, district, and state health office. Meanwhile, the nature of work included managing patients directly and indirectly. Comorbidity included HCWs having a non-communicable disease. Lastly, vaccination included complete vaccination, incomplete, and not vaccinated.

Variables not being studied included environmental factors, including workspace and Indoor Air Quality (IAQ), and behavioural factors, which included compliance with PPE, smoking status, and hand hygiene practice during working. Even though all factors were significant in COVID-19 workplace transmission, given the limitation of secondary data, those variables were not studied in this research. No Non-Malay group was in this study, so the ethnicity variable was not in the current study.

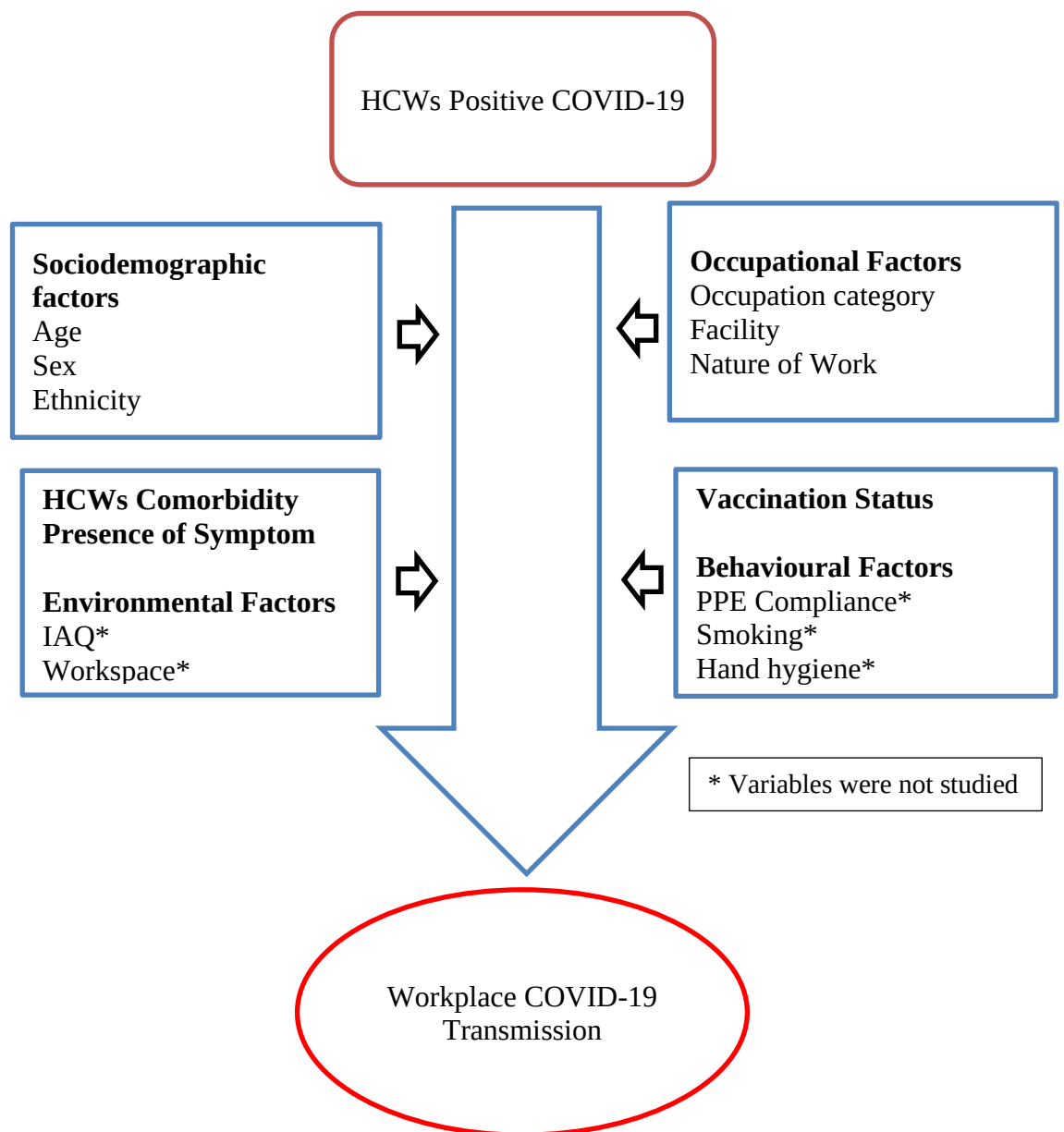


Figure 2.3.1 Conceptual Framework

CHAPTER 3

METHODOLOGY

3.1 Study Design

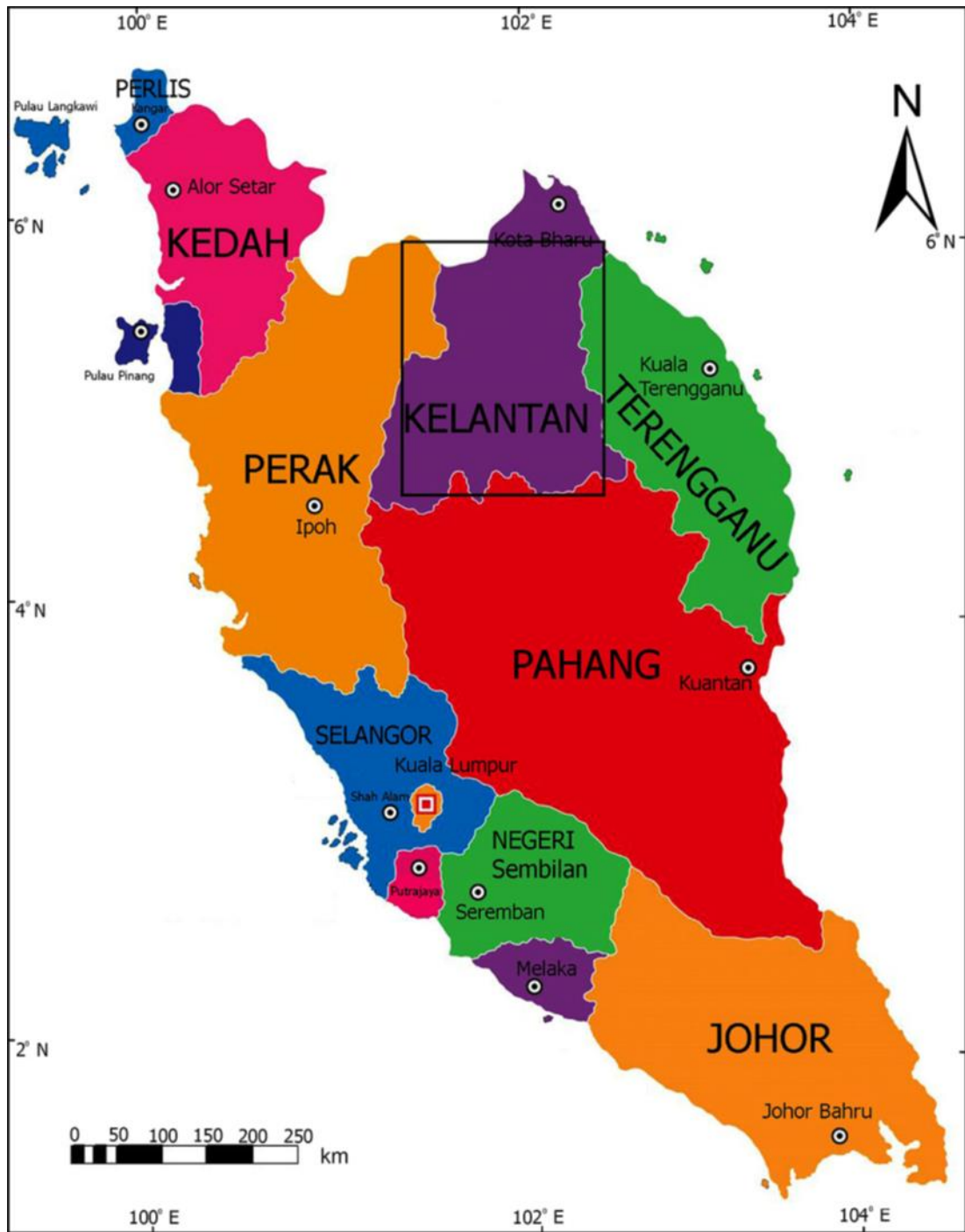
In the current study, a cross-sectional study design was utilized. After HCWs were diagnosed with COVID-19, they needed to notify the *Unit Kesihatan Pekerjaan* (UKP) officer at their facility. After conducting the investigation, the UKP officer needed to notify *Unit Kesihatan Pekerjaan dan Alam Sekitar* (KPAS) JKN Kelantan using the Registry of HCW Positive COVID-19 JKN Kelantan.

3.2 Study Duration

The study was conducted within six months, from December 2022 to May 2023.

3.3 Study Area

This study was carried out in Unit KPAS JKN Kelantan located at Cawangan Kawalan Penyakit (CKP) Jabatan Kesihatan Negeri Kelantan situated in the middle of Kota Bharu City Center, district Kota Bharu, Kelantan. Kelantan is located in the northeastern part of Peninsular Malaysia, shares its borders with Terengganu to the south, Perak to the west, Pahang to the south, and Narathiwat of Thailand to the north (see Figure 3.1). Kelantan itself is situated on the northeastern tip of the Peninsula. Serving as the capital of Kelantan, Kota Bharu is home to a population of approximately 555,757 residents. (Department of Statistics, 2021).



(Source: Pour and Hashim (2017))

Figure 3.3.1 Location of the Kelantan state

3.4 Reference Population

Positive COVID-19 government HCW involving hospitals, health clinics, and health department units (state and district) in Kelantan from 2020 to 2021.

3.5 Source Population

HCWs registered at Kelantan Health Department with COVID-19 infection, registered in Registry of Positive COVID-19 HCW Kelantan, Unit KPAS JKN Kelantan from 2020 to 2021.

3.6 Sampling Frame

Government HCWs diagnosed with COVID-19.

3.7 Subject Criteria

In this study, the criteria for sample selection were as the following:

3.7.1 Inclusion Criteria

Government HCWs employed by the Malaysia Ministry of Health who registered as positive for COVID-19 and notified the *Unit Kesihatan Pekerjaan dan Alam Sekitar* (KPAS) Jabatan Kesihatan Negeri Kelantan between the period of 1 March 2020 to 31 December 2021.

3.7.2 Exclusion Criteria

HCWs who work at a teaching hospital in Kelantan and data with more than 20% incomplete data of the required variables.

3.8 Sample Size Calculation

For **Objective 1**, the sample size calculation using single proportion formula based on the study done by Karpowicz J et al. (2021).

Using single proportion formula:

$$n = \left(\frac{Z}{\Delta} \right)^2 p (1 - p)$$
$$= (1.96/0.04)^2 \times [0.487(1-0.487)]$$
$$= 600$$

*P was based on the prevalence of workplace clusters among workplace-associated cases reported by Karpowicz J et al. (2021) as 48.7%.

After considering 10% non-response rate (missing/incomplete data), the required sample size was 660.

For **Objective 2**, the sample size calculation using PS Software, table 3.1 below briefly explains the sample size calculation:

Table 3.8.1: Summary of sample size calculation

Variables	α	Power	P_0	P_1	m	n	2n + 10%	References
Sex (Male)	0.05	0.80	0.27	0.40	1	206	433	Nur Suhada Ramli <i>et al.</i> , 2022
Age group (40-49 years old)	0.05	0.80	0.16	0.30	1	141	295	Murti <i>et al.</i> , 2021
One or more comorbidities	0.05	0.80	0.33	0.45	1	258	542	Murti <i>et al.</i> , 2021

P_0 = Proportion of factor (male, age group, and comorbidity, respectively) among non-workplace transmission of positive COVID-19 HCW based on literature review.

P_1 = Estimated proportion of factor (male, age group, and comorbidity, respectively) among workplace transmission of positive Covid-19 HCW.

α = Value of standard normal distribution cutting off probability α (1.96 for α = 0.05 (two-tailed))

m = Ratio between non-exposed to exposed

The largest and most feasible sample size was based on one or more comorbidities variables which required 542 subjects after considering the 10% possibility of data entry error.

After comparing the calculation between **Objective 1** and **Objective 2**, the biggest sample size was from Objective 1; hence, n = 660 was used for the study.

3.9 Sampling Method and Subject Recruitment

Proportionate Stratified Random Sampling was used for the study. Firstly, the number of all positive COVID-19 HCWs based on facility obtained from *Unit Kesihatan Pekerja dan Alam Sekitar* (KPAS) Jabatan Kesihatan Negeri Kelantan.

Each facility case was divided using this formula $n = [(Cases\ positive\ in\ each\ facility / Total\ Cases\ in\ Kelantan\ Health\ Department) \times 100] \times 660$. Subsequently, n was obtained from simple random sampling in each facility.

The calculation of Proportionate Stratified Random Sampling was briefly explained in Table 3.2 below:

Table 3.9.1 : Summary of subject recruitment

Facility	Number of Positive Cases (N)	Number of Samples (n)	Percentage (%)
Hospitals	1751	343	52
Health Clinics	951	185	28
<i>Jabatan Kesihatan Negeri (JKN) and Pejabat Kesihatan Daerah (PKD)</i>	396	79	12
Dental Clinics	255	53	8
Total	3353	660	100