Jurnal Aisyah: Jurnal Ilmu Kesehatan

Volume 7, Issue S2, 2022, p. 263–272
ISSN 2502-4825 (print), ISSN 2502-9495 (online)

Risk Factors for Exposure to Laboratory-Confirmed Covid-19 Patients as Early Detection of Workers Groups

Sherly Usman[1], Titiek Hidayati[2*], Akrom[3,4,5]Aida Ainun Nisa[6]

[1] Histology and cell biology, Medicine and Health Science Faculty, Universitas Muhammadiyah Yogyakarta, Indonesia
[2] Public Health and Family medicine Department, Medicine and Health Science Faculty, Universitas Muhammadiyah Yogyakarta, Indonesia
[3] Department of Pharmacology and Clinical Pharmacy, Universitas Ahmad Dahlan, Indonesia
[4] Ahmad Dahlan Drug Information and Crisis Center
[5] Department of Scientific Studies and Publications of Prokami DIY, Yogyakarta, Indonesia
[6] Student of Medicine and Health Science Faculty, Universitas Muhammadiyah Yogyakarta, Indonesia

ARTICLE INFO

Article history:

Received 15 July 2021
Accepted 29 October 2022
Published 10 November 2022

Keyword:

COVID-19 exposure
PPE Health care worker
SARS COV-2
Personal Workload hygiene

A B S T R A C T

The COVID-19 pandemic spreads very quickly this will undoubtedly impact health care workers (HCW) for COVID-19 transmission. A safety-oriented co-sufferer service system for all becomes urgent to be realized. The risk factors for COVID exposure to HCW have not been identified to date. The study aims to identify risk factors for COVID-19 exposure in HCW. This study performed a systematic review of selected journals following the study's objectives. Search journals by keywords by the Problem (HCW co-19 infection), intervention (PPE, shift duration, job), Comparison (physical distance, workload, placebo), and Outcome (odds ratio, risk ratio) (PICO) conducted at Pubmed and Google Scholar. The selection criteria include all types of literature published by peer-reviewed journals, original articles, or short communication published in 2019-2020. Researchers extract journal identity, authors, methods, Results, and conclusions. The data extraction is analyzed and presented descriptively. This study reviewed six articles. Undergraduate education, clinician job, and age increase the risk of COVID-19 exposure. Workload factors and types of services related to an increased risk of COVID-19 exposure are working on the night shift, working longer than 8 hours, intubation services, and working in the emergency department (ER). The incomplete personal protective equipment (PPE) and poor-quality hand washing and hygiene increase the risk of COVID-19 exposure. HCW felt working under pressure also increased the risk of exposure. A work period of more than ten years and attending training can reduce the risk of COVID exposure. Conclusion is There are several factors related to the risk of COVID exposure, including demographic factors, work schedule factors, work stressors, contact history, types of specialized services, PPE, and hygiene behaviors.

Kata kunci:

Paparan Covid-19
personal protective equipment (PPE)
health care workers (HCW)
Personal Workload hygiene

**) corresponding author*

Titiek Hidayati

Department Epidemiology, Family Medicine and Public Health, Medical

A B S T R A K

Penyebaran pandemi COVID-19 yang sangat cepat akan berdampak pada tenaga kesehatan health care workers (HCW) untuk penularan COVID-19. A safety-oriented co-sufferer service system yang berorientasi pada keselamatan menjadi urgen diwujudkan. Faktor risiko pajanan COVID pada petugas kesehatan belum teridentifikasi hingga saat ini. Penelitian ini bertujuan untuk mengidentifikasi faktor risiko pajanan COVID-19 di petugas kesehatan. Penelitian ini melakukan tinjauan sistematis terhadap jurnal-jurnal terpilih sesuai dengan tujuan penelitian. pencarian jurnal dengan kata kunci berdasarkan Masalah (HCW infeksi co-19), intervensi (personal protective equipment (PPE), durasi shift, pekerjaan), Perbandingan (jarak fisik, beban

and Health Science Faculty
Universitas Muhammadiyah Yogyakarta
Kapten Tendean no 59 Kotamadya
Yogyakarta, Indonesia 55252

Email: hidayatifkumy@yahoo.co.id

DOI: 10.30604/jika.v7iS2.1438

kerja, plasebo), dan Hasil (rasio peluang, rasio risiko) (PICO) dilakukan di Pubmed dan Google Cendekia.Kriteria seleksi mencakup semua jenis literatur yang diterbitkan oleh jurnal peer-review, artikel asli, atau komunikasi singkat yang diterbitkan pada tahun 2019–2020. Peneliti mengekstrak identitas jurnal, penulis, metode, Hasil, dan kesimpulan. ekstraksi data dianalisis dan disajikan secara deskriptif. Penelitian ini mengulas enam artikel. Pendidikan sarjana, pekerjaan dokter, dan usia meningkatkan risiko paparan COVID-19. Faktor beban kerja dan jenis pelayanan yang berhubungan dengan peningkatan risiko terpapar COVID-19 adalah bekerja pada shift malam, bekerja lebih dari 8 jam, pelayanan intubasi, dan bekerja di Instalasi Gawat Darurat (IGD). alat pelindung diri (APD) yang tidak lengkap dan kualitas cuci tangan dan kebersihan. Petugas kesehatan bekerja di bawah tekanan juga meningkatkan risiko pajanan. Masa kerja lebih dari sepuluh tahun dan mengikuti pelatihan dapat mengurangi risiko terpapar COVID.

INTRODUCTION

Since the first group of coronavirus cases of coronavirus 2019 (COVID-19) cases was reported in Wuhan (W. Guan *et al, 2020)*, China, at the end of December 2019, case reporting has spread widely worldwide. A rapid increase in the number of deaths affects almost every country in the world. As of May 12, 2020, 4,272,729 cases had been reported globally, with 287,615 deaths. These numbers will increase more quickly when no genuinely useful pandemic management system exists. Apart from the risk of direct infection arising from close contact with patients and coworkers who have the potential to transmit during the COVID-19 pandemic, health care workers are at the forefront of handling COVID-19 in hospitals and primary health care services (WHO, 2019). The lack of staff and infrastructure for infected and terminally ill health workers makes under excessive workload pressure and stress. When cases escalate and require health care, health workers are recognized as a high-risk group for getting this infection. For patients to be helped and control transmission of germs and health workers, survivors needed a COVID pandemic management system oriented to safety for all parties (M. Barati *et al, 2020)*.

Coronavirus Disease (Covid-19), which spreads rapidly, has an impact on health workers (health workers) from various fields (medical, paramedic, and non-medical) (A. Heinzerling *et al,2020)*. As more and more cases of Covid-19 and the speed of transmission cause health workers to be vulnerable to exposure to Covid-19. In a series of cases of 138 patients treated in Wuhan hospital, 40 patients (29% of cases) were health workers. Among the affected health workers, 31 (77.5%) worked in the general ward, 7 (17.5%) in the emergency department, and 2 (5%) in the intensive care unit (ICU). It seems that there are super-spread patients found in hospitals who have gastrointestinal symptoms and are treated in the surgical department. This patient transmits germs to> 10 health workers in the surgical department (W. Guan *et al, 2020)*. The Chinese Deputy Minister at the National Health Commission said that 1716 health workers had been infected in the country on Tuesday, February 11, 2020, of which six people had died (V. C. C. Cheng *et al.2020).* The case in the United States on February 26, 2020, stated that among 121 HCW who were exposed to patients, 43 (35.5%) had symptoms for 14 days after exposure and tested for SARS-CoV-2; three people had positive test results and were known cases of SARS-CoV-2 transmission to Nakes in the United States (J. D. Forrester *et al*, 2020).

Personal safety is first and foremost before giving help is a fundamental principle of services in the health sector, including the COVID-19 pandemic conditions. HCWs are recommended to wear personal protective equipment (PPE) as needed during contact with patients to care for patients with COVID-19 (WHO, 2019). The limited availability of PPE causes medical personnel difficulties in protecting themselves from the risk of contracting Covid-19 (D. Douglas and R. Douglas, 2020). The unavailability of PPE is sufficient to cause anxiety and will have an impact on the attitude of refusal to provide services to health workers. The rejection of services from HCW in a pandemic condition such as this naturally causes the uncontrolled outbreak of Covid-19 (A. S. Fauci *et al*, 2020). An outbreak management system needs to have endeavored which ensures the comfort and safety of working on all health workers, so that outbreak handling is more effective and efficient. It is necessary to identify factors related to the incidence of COVID-19 infection in health workers.

Specific risk factors known to be related to SARS-CoV-2 transmission in health workers are still limited. Based on testing of 43 health workers exposed to COVID-19 patients, risk factors were the presence of close contact and not using PPE according to service standards (A. Heinzerling *et al* , 2020). To protect health workers when treating patients with suspected or confirmed COVID-19, health care facilities must continue to follow WHO guidelines and control local infections. Early recognition and immediate isolation, including control of the source of transmission, for patients with the possibility of infection can help minimize exposure to unprotected and high-risk HCW (A. Remuzzi and G. Remuzzi, 2020). More studies are needed on the health risk factors of COVID-19 among health workers at high risk for infection. This study aims to identify factors that are associated with the incidence of COVID-19 exposure to health workers.

METHOD

Design and Selection Criteria

We systematically reviewed various scientific articles that reported the incidence of COVID infections in healthcare workers. The main objective of the study was to identify factors related to the extent of COVID exposure to health workers. Search Strategy We searched the Pubmed database

and google scholar without language or time restrictions for articles that met the selection criteria. Inclusion Criteria are systematic review, RCT, or observational reports published by peer-reviewed journals; Population: health workers or health workers; Intervention: All types of PPE, workload, education, type of profession, contact history, duration of contact, department or section, hygiene behavior; Results: The effectiveness of PPE in reducing the risk of COVID infection in confirmed health workers. The exclusion criteria are the guideline text and the theoretical model or narrative review.

Searching Procedures

We conducted literature searches in March, April, and early May 2020. Libraries are searched using a combination of search terms: high-risk department, longer duty hours, suboptimal hand hygiene after contact with patients, the effectiveness of Personal Protective Equipment, older clinicians, and interaction time for each encounter with a suspected COVID-19 Patient. The Journal of searching results is screened from the title and abstract and then classified in the original journal article, systematic review, guideline, short communication, and letter to the editor.

Selection Procedure

The author takes selected journals from original articles and short communication. From the selected title, the selection is based on established criteria. Two authors independently selected journals based on predetermined criteria, and then discussed to determine the selected journals.

Data Extraction and Analysis

From selected journals, we extract OR, RR data or mathematical or engineering models from all included studies, authors, year of publication, journals, and location; details of the study population and interventions; study designs and methods, including randomization procedures (RCT) and statistical analysis; results, conclusions, and limitations. Data extraction results are then presented descriptively and narrated in the results section.

RESULTS AND DISCUSSION

Search results and study characteristics

This literature review aims to determine the risk factors for health workers exposed to COVID-19. Library search results using selected keywords in three database centers (google scholar and PubMed) obtained information on the number of impacts and chosen titles based on the classification of article types, as presented in Table 1. We have been searching for the latest literature, namely literature, since 2019. The list of screening titles in the database and then classified according to the type of article. Searching for items in the PubMed data center obtained 24 titles netted. One of them with the title according to the selection criteria, "Transmission of COVID-19 to Health Care Personnel During Exposures to a Hospitalized Patient - Solano County, California, February 2020)" (A. Heinzerling *et al*, 2020). This section explains the results of the research and gives a comprehensive discussion. Results can be presented in figures, graphs, tables, and others that make the reader understand easily. The discussion can be made in several sub-chapters.

Table 1. The number of hits, the type of article, and the title are chosen according to the selection criteria.

No	Database address	Number of hits	Selected title
1	Pubmed	24	1
	Systematic review meta-analisis2	4	0
	Narrative Review and guidance	4	0
	Original articles	16	1
2	Google Scholar	1350	
	Systematic review/ a meta-analysis	35	0
	Original articles	30	5
	Case report/short communication	164	2
	Letter to editor	1156	0

A literature search on Google Scholar received 1350 titles (hits). After screening the title and selecting six journal chosen titles, one of the titles obtained on Google Scholar is the same as that derived from Pubmed. A description of the article title chosen and articles involved in this study, as presented in Table 2.

Risk Factors Due to COVID Exposure from the observational analytic study

The results of data extraction are known to be identified as several factors related to the incidence of COVID- 19 infections in HCW. From the analytic observational research article with cohort design, sectional cross, and case reports, Six groups of COVID exposure risk factors were identified in HCW, as presented in Table 3.

From Table 3, it is known that there are several risk factors associated with COVID-19 exposure to health workers, namely:

Demographic risk factors (L. Ran *et al*, 2020), (Y. Bai *et al* , 2020).

Health status and type of profession (clinician / non-clinician), namely the educational status, not the university. And the clinical job has a higher risk of exposure to COVID. HCW with education does not reach university having a chance of 4.3 x exposure to COVID compared to HCW with university education. Health professionals with a group of clinicians have a higher risk of exposure to COVID (2.78x).

The COVID- 19 pandemic is the work of SARS COV-2 with more varied clinical manifestations making it difficult to detect clinically and without investigations (G. Correia *et al*, 2020), (W. H. Gan *et al*,, 2020). SARS COV-2 has different characteristics from its parent virus, which is a faster mutation and rapid spread with an increased virulence rate in victims with comorbid and older age. Covid-19 case fatality rate (CFR) without comorbid is 0.9%, whereas COVID-19 CFR with hypertension comorbid is 6.0%, Diabetes Mellitus is 7.3%, cardiovascular disease is 10.5%, chronic lung disease is 6.3% and cancer is 6.3% by 5.6% (R. Soetikno *et al* , 2020), (G. Li *et al* , 2020).

The average age of HCW was 36.6 years and above, which is significantly higher compared to health workers who were not infected at 30.5 years (Y. Bai *et al*., 2020), (S. Tian *et al, 2020)*. The results of previous studies stated that NK cells (Natural Killer), cytotoxic cells that play an essential role as

effectors in the defense of anti-viral hosts (Y. Shi *et al, 2020).* The number of partial effector cells will increase with aging, but their toxicity decreases. Besides that, HCV cells (natural killer T cells) are found to decrease in number as a person ages (X. Dong *et al.*, 2020).

Risk factors related to work schedule and stressors (L. Ran *et al*, 2020), (Y. Bai *et al* , 2020).

The night shift and work schedule with stressors have a higher risk (4.4 x and 4.23x) for COVID exposure to health workers. The majority of COVID 19 positive health professionals are those who work the night shift and have poor sleep quality. Night work will result in decreased sleep quality and reduced concentration and fitness. In the analysis of the study of Bai et al. 2020, it can be explained that health workers infected with COVID 19 have significantly higher PSQI (Pittsburgh sleep quality index) scores compared to uninfected health care workers. PSQI tests assess five aspects, namely, sleep quality, nap time, sleep efficiency, sleep disturbance, and dysfunction during the day. Those who have low sleep quality, the risk of COVID infection increases to 2.99 times (CI 1.87-4.78). Sleep quality is related to the quality of life, immunity, and concentration (L. Besedovsky *et al*, 2019).

Table 2. Overview of several articles with titles and abstracts according to selection criteria

Author (year)	Title	Goal	Methode	Results
Kangqi Ng, et al. 2020	COVID-19 and the Risk to Health Care Workers: A Case Report	Assess how adequate PPE used by health care workers caring for positive patients can protect themselves from infection with the virus.	A case report on the use of PPE is complete and its relation to COVID incidences in HCW	The research found that the use of N95 masks was no more effective than surgical masks in protecting health workers exposed to COVID 19. The swab results were 41 health workers all negative (6 people using N95 and 35 people using surgical masks)
Li Ran, et al. (2020)	Risk Factors of Healthcare Workers with Corona Virus Disease 2019: A Retrospective Cohort Study in a Designated Hospital of Wuhan in China	Determine risk factors for health workers with acute respiratory disorders who are COVID- 19 infection at the University of WuhanSS	The cohort retrospective 72 HCW in Wuhan Hospital	HCW who perform medical intervention or surgery, health workers who work in the respiratory department, the department of infection, ICU, and actions that affect aerosols from the airway of patients have a high risk of contracting COVID 19. (Those who work in the department above have a chance of 2.13 times being infected COVID 19, CI: 1.45-3.95). Another risk factor is less optimal health workers in washing hands after contact with COVID 19. Patients (the risk of COVID infection increases 2.64 times in those who are less than optimal washing hands, CI = 1.04-6.71). Besides, health workers who work more than 10 hours per day also have a high risk of COVID infection.
Bai et al (2020)	SARS-CoV-2 Infection in Health Care Workers: A Retrospective Analysis and Model Simulations of a Nosocomial Outbreak	look for risk factors for susceptibility to the COVID 19 virus in health workers who come into direct contact with COVID infected 19 patients	A combination of a retrospective cohort and simulation models on 118 health workers (including, three positive health co-19s) outbreaks	This study revealed that health workers infected with COVID 19 were HCW with an average age of 36.6 years and above. HCW who carried out night shifts felt them were working under pressure, using incomplete PPE - (complete PPE including N95 masks, face, and eye shield, gloves, biohazard suites), and have low sleep quality (a high Pittsburgh score have a 2.99 times risk of COVID exposure 19, CI: 1.87, 4.78).
Heinzerling, A., et al., 2020	Transmission of COVID-19 to Health Care Personnel During Exposures to a Hospitalized Patient — Solano County, California, February 2020	Dentifying risk factors for COVID exposure to health workers	A case report on 148 potential health workers infected with COVID in a hospital in the USA	No risk factors were identified related to the incidence of COVID infection in HCW. At the hospital treating COVID patients. From the results of the search for positive HCW COVID occurred in 3 HCW

Zhou et al. 2020	Knowledge, attitude and practice regarding COVID-19 among health care workers in Henan, China	Identify knowledge, Attitude and professional behavior factors as the risk of Covid-19 exposure to HCW	Cross sectional at HCW in Wuhan at 180,402 doctors, 263,100 nurses and 103,306 Paramedics.	Several factors were identified that were related to the risk of COVID exposure to health workers, including working hours (> 8 hours, not attending training, less than five years of work).
Florendo and Jomar (2020)	A COVID-19 Infection Risk Model for Frontline Health Care Workers	theoretical models were formulated to calculate the risk of COVID 19 infection in health care facilities	Case report and mathematical simulation method using cases in the Philippines	Risk factors found were health workers who experienced more than Ten meetings with patients in 1 hour (the risk will increase every ten times; for example, if there are ten meetings, the number of people experiencing COVID exposure is 1, then if there are 20 meetings the number of exposure are two people, etc.), the duration of work shifts are more than 8 hours per day (the risk will increase 1.5 times if the health worker has a work shift duration of 12 hours per day), the the density of people in one room that has a distance of fewer than 2 meters Between people. Also, it is known from research that frequent cleaning of workspaces, and segregation of patient rooms in open spaces can reduce the risk of infection not only for health workers but also for other patients who are negative COVID-19

Table 3. Demographic factors, family exposure, type of health workers, type of work, workload, health skills, and specialized services related to the incidence of Covid-19 exposure to health workers.

No	Type of Risk factor	OR/RR (CI 95%)	p	Ref
1	**Demographic risk factors**			
a	Education grade (university/non university)	4.3 (1.23-14.74)	0.035	Y. Bai *et al* 2020
b	Clinical job (doctor/nurse)	2.78 (1.03 – 7.49)	0.04	L. Ran *et al*, 2020
2	**Job stressor and schedule Risk factor**			
	Night shift (yes/no)	4.4 (1.13 – 17.17)	0.022	Y. Bai *et al* 2020
	Job stressor (yes/no)	4.23 (1.19 – 15.04)	0.017	Y. Bai *et al* 2020
3	**Contact with unexpected or positive COVID factors**			
	History Contact with covid or suspected covid patients (yes / no)	1.4 (1.16 – 1.69)*	0.00	Y. Bai *et al* 2020
	COVID positive family member (yes / no)	2.76 (2.02-3.77)	0.03	L. Ran *et al,* 2020
4	**Risk factors for special service delivery (high risk)**			
a	History of serving nebulization patients (yes / no)	20.67 (1.42-30.5)	0.01	A. Heinzerling *et al*, 2020
	High Risk Department/General Department	3.48 (1.29 – 9.39)	0.01	L. Ran *et al,* 2020
	diagnosis of upright covid patients (yes / no)	0.12 (0.03-0.41)	0.00	L. Ran *et al,* 2020
	Suspected covid patients	0.30 (0.11-0.81	0.01	L. Ran *et al,* 2020
5	**Risk factors for professional hygiene behavior**			
	Not qualified handwashing status (yes/no)	4.15(1.23 – 14.03)	0.02	L. Ran *et al,* 2020
	Before patient contact, Suboptimal hand hygiene	5.82 (1.96-17.28)	0.00	L. Ran *et al,* 2020
	After contacting the patient, hand hygiene is suboptimal	4.63(1.67-12.86)	0.00	L. Ran *et al,* 2020
6	**Risk factors Professional behavior, PPE and workload**			
	No overload (<8 hours) and handwashing habits	0.71 (0.51-0.97)	<0.05	M. Zhou *et al.* 2020
	Not serving in the frontline and following the training	0.55 (0.43-0.69)	<0.01	M. Zhou *et al.* 2020
	The work period is more than ten years and attended training	0.68 (0.518 – 0.91)	<0.01	M. Zhou *et al.* 2020
	The working period of 5-9 years and always removing PPE properly	0.72(054-093)	<0.05	M. Zhou *et al.* 2020
	The working period is 5-9 years, and is quarantined independently at home	1.52 (1.16-2.05)	<0.01	M. Zhou *et al.* 2020

1. Risk factors are related to the contact history of COVID-positive patients (L. Ran *et al*, 2020), (Y. Bai *et al* , 2020).

A history of contact with patients and family members positive for COVID has a higher risk (1.4 and 2.76x) for exposure to COVID. Originally coronavirus was a type of RNA virus spread by animals or zoonoses (H. A. Rothan and S. N. Byrareddy, 2020). The first time SARS COV-2 was allegedly spread by bats (I. Chakraborty and P. Maity, 2020). Based on the final epidemiological investigation, The world health organization (WHO) stated that SARS COV-2 was spread through droplets. A patient with COVID-19 can spread SARS COV-2 to more than 30 new sufferers. Droplets containing SARS COV-2 can survive outside the body for up to 8 hours. Therefore, contact with COVID-19 sufferers or SARS COV-2 carriers increases the risk of contracting this virus (V. C. C. Cheng *et al* ,2019), (S. W. X. Ong *et al* , 2020).

2. Risk factors for types of specialized services (high risk) (A. Heinzerling et al., 2020), (L. Ran, et al, 2020)

The history of performing nebulization services and assignments in high-risk rooms (ICU, emergency, operating room) has a higher risk of exposure to COVID (20.67x and 3.48x). The diagnosis of upright COVID and suspicious status was identified from reducing the risk of exposure to COVID (0.12x and 0.3x). HCW that work related to remedial actions that have aerosol effects (intubation, anesthesia) are found to have a higher risk of COVID infection 19 compared to health workers who work in emergency department triage (emergency department) (J. D. Forrester *et al*, 2020), (G. Correia *et al,* 2020), (B. Givi *et al, 2020)*. The main route for the spread of COVID-19 is estimated through aerosol droplets released during coughing, sneezing, or breathing. Still, there are also concerns about the possibility of airborne transmission (V. C. C. Cheng *et al*., 2020), (W. H. Gan *et al*, 2020) For this reason; it is an essential consideration for health workers to use the personal device protection (PPE) during duty. Several journals reviewed discussed the use of personal protective equipment (PPE), which has an essential role in protecting health workers from COVID 19. Health workers who use complete personal protective equipment (PPE) can reduce their risk of COVID infection 19 (G. Correia et al, 2020), (W. Chen and Y. Huang, 2020).

3. Risk factors for PPE, hygiene behavior and health professionalism (L. Ran *et al*, 2020).

Poor quality hand washing and suboptimal hygiene before and after contact with a COVID patient increase the risk of exposure to COVID (4.15x, 5.82x, and 4.63x). Complete PPEs include N95 masks, face, and eye shields, gloves, biohazard suites (WHO, 2020). N95 masks block at least 95 percent of microscopic test particles (0.1 - 0.3 microns) (S. Baharoon and Z. A. Memish, 2019). If properly installed, the filtration ability of the N95 respirator exceeds that of the face mask (J. J. Bartoszko *et al,* 2020). Previous studies suggested that the N95 cover had a Relative Risk (RR) value of 0.46 for viral infections (CI 0.23-0.91) and 0.26 (CI 0.16-0.42) for diseases transmitted through droplets. COVID 19 virus is known to have a round or elliptical shape and is often pleomorphic, with a diameter of about 60-140 nm. Although medical workers use N95 masks, it is possible to be exposed to COVID-19, because N95 masks can only protect against microorganisms with size (0.1 - 0, 3 microns). In contrast, the COVID-19 virus size is around 60-140 nm or smaller than the N95 mask protection ability. Based on the above conditions, Face Shield will reduce the risk of COVID-19 virus exposure (WHO, 2020), (V. Offeddu *et al,* 2017), (S. Kalantary et al, 2020). But on the other side, Ng K et al.,2020, in the case report article, suggested that N95 masks were no more effective than surgical masks in protecting health workers from co-19. From the results of a study of 41 health workers who were exposed while treating co- positive 19 patients, all were declared negative COVID-19. In contrast, during treatment, 85% (35 people) of health workers only used surgical masks, and the remaining 15% (6 people) used N95 masks when performing medical procedures that affected aerosols such as intubation, extubation, and non-invasive ventilation (NIV) (B. Givi *et al, 2020)*. PPE that is used more than once will cause the risk of contracting Covid-19 to be higher. PPE that is used more than once will prompt the user to take off and reuse, which risks touching the infected area. Knowledge of proper and correct use of PPE is needed by health workers to reduce the risk of contracting Covid-19 (I. Chakraborty and P. Maity, 2020), (W. Chen and Y. Huang , 2020), (Saqlain, 2020).

4. Cumulative risk factors Professional behavior and workload HCW (M. Zhou *et al*, 2020).

Risk factors for cumulation, not overload (<8 hours) and handwashing habits, not working in the frontline and following the training, work period of more than ten years and attending training and working period of 5-9 years and always releasing PPE properly reduce the risk of COVID exposure to HCW(0.71x, 0.55x, 0.68x and 72x). They have complicated risk factors between 5-9 years of service, and self-quarantine at home increase the risk of exposure to COVID (1.52x).

Environmental factors and frequency of contact with Covid-19 sufferers are associated with the risk of COVID exposure to HCW. The large number of health workers meeting with patients in an hour is one of the causes of health workers infected with COVID 19. From Floredo F's research, J et al.2020, it is obtained data that in 20x meetings of health workers with patients in 1 hour, will increase the risk of infection COVID 2x as much, this will give the chance of super spreaders. In the Philippines, the risk of a person contracting COVID-19 disease is considerable because of the large number of patients who come to the hospital. The average number of patients coming to the hospital is 120 people per hour, or there is an increased risk of 12x. Also, the duration of the work shift affects the risk of co-19 exposure. The recommended period of work shifts from this study is around 8 hours/shift (L. F. Dy and J. F. Rabajante, 2020), (W. H. Gan *et al*, 2020). Crowd density (density of the number of people in one room) is high, causing the risk of contracting COVID 19 higher (Bai *et al*, 2020) state that the minimum distance between people who are in one room is 2 meters. If the distance is less than 2 meters will increase the risk of COVID 19. Giving a length for each patient treated (at least 2 meters), providing curtains or dividing between patients, can reduce the risk of COVID infection in health workers who interact with COVID patients. Also, it is known from research that frequent cleaning of workspaces, and segregation of patient rooms in open spaces, can reduce the risk of infection, not only for healthcare workers but also for other patients who are COVID-19 negative (L. F. Dy and J. F. Rabajante), (I. Chakraborty and P. Maity, 2020), (M. Ferioli *et al*, 2020).

Risk Factors Due to COVID Exposure on HCW from modeling research

From the articles with a case report and modeling method, the candidates for Covid-19 exposure risk factors were identified, as shown in Table 4.

Table 4. Demographic factors, family exposure, type of health worker, kind of work, workload, health skills and specific services related to the incidence of COVID-19 exposure to health workers (L. F. Dy and J. F. Rabajante , 2020)

No	Types of risk factors for modeling results	OR/RR	Ref
1	An HCW who only wears a surgical mask, in the emergency room the COVID-19 referral center is overwhelmed with patients in a 12-hour shift	**7.2**	(L. F. Dy and J. F. Rabajante , 2020)
2	A patient who only wears an ugly surgical mask in a very tight emergency room along with many other patients in a queue for 8 hours	**6.0**	(L. F. Dy and J. F. Rabajante , 2020)
3	A pulmonologist equipped with PPE or an infectious disease specialist performs a rapid round of 16 patients who are placed in each room twice for 8 hours on duty)	0.045	(L. F. Dy and J. F. Rabajante , 2020)
4	An emergency officer equipped with PPE in a tiny emergency room with a COVID-19 centers who is overwhelmed with patients who have shifted for 12 hours)	0.8	(L. F. Dy and J. F. Rabajante , 2020)
5	An anesthesiologist equipped with PPE who intubated two cough patients using video laryngoscopy (performed at close range, lasting for 30 seconds); patients who do not use PPE	1.125	(L. F. Dy and J. F. Rabajante , 2020)
6	An anesthesiologist equipped with PPE who intubated one cough patient using video laryngoscopy (performed at close range, lasting for 30 seconds); patients do not use PPE	**0.675**	(L. F. Dy and J. F. Rabajante , 2020)
7	A triage nurse equipped with PPE in a spacious emergency room from a COVID-19 referral center with an 8-hour shift	**0.0625**	(L. F. Dy and J. F. Rabajante , 2020)

From Table 4, it is known that there are several risk factors for modeling results related to COVID exposure to health workers. Some risk factors of the modeling results are following the results of analytical observational studies and need to be proven immediately about this model with both experimental and observational analytic studies. Based on Table 4, it is known that by modeling, the cumulative factors related to the risk of COVID exposure to HCW can be predicted. From this modeling, it is known that work shift of more than 8 hours, coupled with incomplete PPE that is only using surgical masks and working in the emergency room, increases the risk of exposure to COVID up to 7.2x. This modeling results follow WHO directives and other analytic observational studies [7]. From this modeling, the importance of completeness of PPE is understood for HCW (G. Correia *et al,* 2020), (J. J. Bartoszko *et al*, 2020), (M. Ferioli*, et al*, 2020).

LIMITATION OF THE STUDY

Need further research to identify risk factors for COVID exposure in health workers with an experimental design or cohort with larger sample size.

CONCLUSIONS AND SUGGESTIONS

The number of articles on risk factors related to Covid-19 exposure to HCW is still limited. Most publications are in the form of letters to editors and short communication. Based on data from selected articles, several factors can be identified related to the risk of COVID exposure to health workers, including demographic factors, work schedule factors, and work stressors, contact history, types of specialized services, behavioral behaviors of PPE and communicative behavioral factors.

ETHICAL CONSIDERATION

The Health Research Ethics Committee of the PKU Muhammadyah Gamping No. 077/KEP-PKU/II/2022 approved this study.

Acknowledgment

The author gives his appreciation and thanks to the Head of the Faculty of Medicine and Health Sciences, Universitas Muhammadiyah Yogyakarta and Head of research, development and community service institutions, Universitas Ahmad Dahlan, who provided financial assistance grants for the preparation of review articles. The author also thanks all students who were involved in the initial literature search and screening.

Funding Statement

The Research and Innovation Office of Universitas Muhammadiyah Yogyakarta funded this study.

Conflict of Interest Statement

There are no competing interests in this study.

REFERENCES

Heinzerling, A., Stuckey, M. J., Scheuer T., Xu, K., Perkins, K. M., Resseger H., Magill, S., Verani, J.R., Jain, S., Acosta,M., Epson, E., (2020). Transmission of COVID-19 to health care personnel during exposures to a hospitalized patient–Solano County, California, February 2020, *Morbidity and Mortality Weekly Report*, **69**(15), 472-476. Retrieve from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7755059/

Fauci, A.S., Lane, H.C., Redfield, R.R. (2020). Covid-19 - Navigating the Uncharted, *England Journal of Medicine*, *382(13), 1268-1269*. Retrieve from: https://www.nejm.org/doi/full/10.1056/nejme2002387

Remuzzi, A and Remuzzi, G. (2020). COVID-19 and Italy: what next?, *Lancet*, (2), 10–13. Retrieve from: https://www.sciencedirect.com/science/article/pii/S0140673620306279

Givi B. Schiff, B. A., Chinn, S. B., Clayburgh, D., Iyer, N. G., Jalisi, S., et al. (2020). Safety Recommendations for Evaluation and Surgery of the Head and Neck during the COVID- 19 Pandemic, *JAMA otolaryngology–head & neck surgery*. 146(6), 579-584. Retrieve from: https://jamanetwork.com/journals/jamaotolaryngology/article-abstract/2764032

Douglas, D., Douglas, R., (2020). Addressing the corona virus outbreak: will a novel filtered eye mask help?, *International Journal of Infectious Diseases*. 95, 340–344. Retrieve from: https://www.sciencedirect.com/science/article/pii/S1201971220302551

Correia, G., Rodrigues, L., Gameiro da Silva, M., Gonçalves, T. (2020). Airborne route and bad use of ventilation systems as non-negligible factors in SARS-CoV-2 transmission, *Medical Hypotheses*. 141, 109781. Retrieve from: https://www.sciencedirect.com/science/article/pii/S030698772030801X

Li, G., Fan, Y., Lai Y., Han, T., Li, Z., Zhou, P., et al. (2020). Coronavirus infections and immune responses, *Journal of medical virology*. 92(4), 424–432. Retrieve from: https://onlinelibrary.wiley.com/doi/full/10.1002/jmv.25685

Rothan, H. A., Byrareddy, S. N. (2020). The epidemiology and pathogenesis of coronavirus disease (COVID-19) outbreak, *Journal of autoimmunity*. *109,* 102433. Retrieve from: https://www.sciencedirect.com/science/article/pii/S0896841120300469

Chakraborty, I., Maity, P.(2020). COVID-19 outbreak: Migration, effects on society, global environment and prevention, *Sci. Total Environ.* 728,138882. Retrieve from: https://www.sciencedirect.com/science/article/pii/S0048969720323998

Forrester, J. D., Nassar, A. K.,. Maggio, P. M and. Hawn, M. T. (2020). Precautions for Operating Room Team Members During the COVID-19 Pandemic, *Journal of the American College of Surgeons.* 230(6), 1098-1101. Retrieve from: https://www.sciencedirect.com/science/article/abs/pii/S1072751520303033

Bartoszko, J. J.,. Farooqi, M. A. M., Alhazzani, W., and Loeb, M. (2020). Medical masks vs N95 respirators for preventing COVID-19 in healthcare workers: A systematic review and meta-analysis of randomized trials, *Influenza and other respiratory viruses*. 14(4), 365-373. Retrieve from: https://onlinelibrary.wiley.com/doi/full/10.1111/irv.12745

Ng, K., Poon, B. H., Kiat Puar, T. H., Shan Quah, J. L., Loh, W. J.,. Wong, Y. J.,et al. (2020). COVID-19 and the Risk to Health Care Workers: A Case Report, *Annals of internal medicine*.172(11), 766-767. Retrieve from: https://www.acpjournals.org/doi/full/10.7326/L20-0175

Ran, L., Chen, X., Wang, Y., Wu, W., Zhang, L., and Tan, X. (2019). Risk Factors of Healthcare Workers with Corona Virus Disease: A Retrospective Cohort Study in a Designated Hospital of Wuhan in China, *Clinical Infectious Diseases*. Retrieve from: *https://covid19.tabipacademy.com/wp-content/uploads/2020/04/14.Risk-Factors-of-Healthcare-Workers-with-Corona-Virus-Disease-2019-1.pdf*

Dy L. F., and Rabajante, J. F. (2020). A COVID-19 Infection Risk Model for Frontline Health Care Workers, *Network Modeling Analysis in Health Informatics and Bioinformatics*. 9(1), 1-13. Retrieve from: https://link.springer.com/article/10.1007/s13721-020-00258-3

Besedovsky, L., Lange, T., and Haack, M. (2019). The sleep-immune crosstalk in health and disease, *Physiological reviews*. 99(3), 1325–1380. Retrieve from: https://journals.physiology.org/doi/full/10.1152/physrev.00010.2018?rfr_dat=cr_pub%3D

Bashirian, S., Jenabi, E., Khazaei, S., Barati, M., Karimi-Shahanjarini, A., Zareian, S., et al. (2020). Factors Associated with Preventive Behaviours of COVID-19 among Hospital Staff in Iran in 2020: An Application of the Protection Motivation Theory, *Journal of Hospital Infection.* 105(3), 430-433. Retrieve from: https://www.sciencedirect.com/science/article/pii/S0195670120302103

Zhang, M., Zhou, M., Tang, F., Wang, Y., Nie, H., Zhang, L., et al. (2020). Knowledge, attitude and practice regarding COVID-19 among health care workers in Henan, China, *Journal of Hospital Infection*. 105(2), 183-187. Retrieve from: https://www.sciencedirect.com/science/article/pii/S0195670120301870

Ferioli, M., Cisternino, C., Leo, V., Pisani, L., Palange, P., and Nava, S. (2020). Protecting healthcare workers from sars- cov-2 infection: Practical indications. *European Respiratory Review*, 29(155), 1–10. Retrieve from: https://err.ersjournals.com/content/29/155/200068.short

Soetikno, R., Teoh, A. Y., Kaltenbach, T., Lau, J. Y., Asokkumar, R., Cabral-Prodigalidad, P., et al.(2020). Considerations in performing endoscopy during the COVID-19 pandemic, *Gastrointestinal Endoscopy, 92(1), 176-183.* Retrieve from: https://www.giejournal.org/article/S0016-5107(20)34033-5/fulltext

Tian, S., Hu, N., Lou, J., Chen, K. , Kang, X., Xiang, Z., et al. *(2020).* Characteristics of COVID-19 infection in Beijing. Journal of infection, 80(4), 401-406. Retrieve from: https://www.sciencedirect.com/science/article/pii/S0163445320301018

Ong, S. W. X., Tan, Y. K., Chia, P. Y., Lee, T. H., Ng, O. T., Wong, M. S. Y., et al. (2020). Air, Surface Environmental, and Personal Protective Equipment Contamination by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) from a Symptomatic Patient. *JAMA - J. Am. Med. Assoc,* 323(16), 1610-1612. Retrieve from: https://jamanetwork.com/journals/jama/article-abstract/2762692

Kalantary, S., Khadem, M., and Golbabaei, F.(2020). Personal Protective Equipment for Protecting Healthcare Staff during COVID-19 Outbreak : A Narrative Review. *Frontiers in Emergency Medicine*, 4(2), 1–8. Retrieve from: https://fem.tums.ac.ir/index.php/fem/article/view/409

M. Saqlain, M. M. Munir, S. U. Rehman, A. Gulzar, S. Naz, Z. Ahmed, et al. (2020). Knowledge, attitude, practice and perceived barriers among healthcare professionals regarding COVID-19: A Cross-sectional survey from Pakistan. *Journal of hospital infection,105(3), 419-423*. Retrieve from: *https://www.sciencedirect.com/science/article/pii/S0195670120302383*

Baharoon, S., and. Memish. Z. A. (2019). MERS-CoV as an emerging respiratory illness: A review of prevention methods. *Travel medicine and infectious disease*, 32, pp 101520. Retrieve from:

https://www.sciencedirect.com/science/article/abs/pii/S1477893919302236

Cheng, V. C., Wong, S.-C., Chen, J. H., Yip, C. C., Chuang, V. W., Tsang, O. T., et al. (2020). Escalating infection control response to the rapidly evolving epidemiology of the Coronavirus disease 2019 (COVID-19) due to SARS-CoV-2 in Hong Kong. *Infection Control & Hospital Epidemiology*. 41(5), 493–498. Retrieve from: https://www.cambridge.org/core/journals/infection-control-and-hospital-epidemiology/article/escalating-infection-control-response-to-the-rapidly-evolving-epidemiology-of-the-coronavirus-disease-2019-covid19-due-to-sarscov2-in-hong-kong/52513ACC56587859F9C601DC747EB6EC

Offeddu, V., Yung, C. F. Low, ., M. S. F., and Tam. C. C.(2017). Effectiveness of Masks and Respirators Against Respiratory Infections in Healthcare Workers: A Systematic Review and Meta-Analysis. *Clinical Infectious Diseases*. 65(11), 1934–1942. Retrieve from: https://academic.oup.com/cid/article/65/11/1934/4068747

Guan, W.-j., Ni, Z.-y., Hu, Y.,. Liang, W.-h., Ou, C.-q., He, J.-x., et al. (2020). Clinical Characteristics of Coronavirus Disease 2019 in China. *New England journal of medicine*, 382(18), 1708-1720. Retrieve from: https://www.nejm.org/doi/full/10.1056/neJMoa2002032

World Health Organization (WHO). (2020). Situation Report 82, *Coronavirus Dis. 2019*.WHO, pp 2633. Diunduh dari: https://www.who.int/indonesia/news/novel-coronavirus/situation-reports

World Health Organization (WHO). (2020). Rational use of personal protective equipment for coronavirus disease 2019 (COVID-19) and considerations during severe shortages. *WHO*, pp. 1–28, 2020. Diunduh dari: https://www.who.int/publications/i/item/rational-use-of-personal-protective-equipment-for-coronavirus-disease-(covid-19)-and-considerations-during-severe-shortages

Gan, W. H., Lim, J. W., and Koh. D.(2020). Preventing Intra-hospital Infection and Transmission of Coronavirus Disease 2019 in Health-care Workers. *Safety and health at work*, *11(2), 241-243.* Retrieve from: https://www.sciencedirect.com/science/article/pii/S209379112030161X

Chen W and Huang, Y. (2020). To Protect Healthcare Workers Better, To Save More Lives," *Anesthesia and. Analgesia.* XXX, pp. 1–5. Retrieve from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7172566/

Dong, X., Wang, M., Liu, S., Zhu, J., Xu, Y., Cao, H., et al. (2020). Immune Characteristics of Patients with Coronavirus Disease 2019 (COVID-19). *Aging & Disease*, 11(3), 642–648. Diunduh dari: https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=X.+Dong+et+al.%2C+%E2%80%9CImmune+Characteristics+of+Patients+with+Coronavirus+Disease+2019+%28+COVID-19+%29%2C%E2%80%9D+vol.+11%2C+no.+3%2C+pp.+642%E2%80%93648%2C+2020&btnG=

Y. Bai, X. Wang, Q. Huang, H. Wang, D. Gurarie, M. Ndeffo-Mbah, et al. (2020). SARS-CoV-2 infection in health care workers: a retrospective analysis and a model study. *MedRxiv*, 2020.03.29.20047159. Retrieve from: https://www.medrxiv.org/content/10.1101/2020.03.29.20047159v1

Shi, Y., Tan, M., Chen, X., Liu, Y., Huang, J., Ou, J., et al. (2020). mmunopathological characteristics of coronavirus disease 2019 cases in Guangzhou, China. *MedRxiv*, 2019, p. 2020.03.12.20034736. Retrieve from: https://pesquisa.bvsalud.org/global-literature-on-novel-coronavirus-2019-ncov/resource/fr/ppmedrxiv-20034736

 ISSN 2502-4825 (print), ISSN 2502-9495 (online)