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WORKERS CONFORMITY TOWARD PERSONAL PROTECTIVE EQUIPMENT USE IN VARIOUS HEALTHCARE SETTING DURING THE COVID-19 PANDEMIC: A SYSTEMATIC REVIEW

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ABSTRACT

Background: The COVID-19 disease has nearly entered its second year of pandemicity and as its definitive cure remains indecisive, the use of PPE remains paramount as part of preventive and control measures **Objective:** This study aimed to determine associated factors towards adherence of PPE usage in various healthcare settings. **Methods:** A systematic review was conducted from January until May 2021. Based on multiple online databases (PubMed, Medline, Science Direct), 3 independent researchers evaluated the searches to identify relevant literature in line with selection criteria relating to study design, participants, and the intended outcome. **Results:** The review yielded 13 studies; all were cross-sectional where the adherence among healthcare workers ranged from 51.7% to 96.3%. The adherence during the COVID-19 pandemic were influenced by timeline, situational factor, donning and doffing practices. Barriers to conform were due to shortage of PPE supply, lack of knowledge, long duty hours, high patient workload. **Conclusion:** Multiple factors influences the adherence to PPE usage, and this remains a crucial area to be monitored in the current pandemic that has not shown sign that it's going to end. The result may help with the strategies for maximizing the adherence and ultimately improving the safe work practices of healthcare workers.

Keywords: *PPE; personal protective equipment; coverall; COVID-19; adherence; compliance; barrier.*

1. Introduction

In current situation, the 'Severe Acute Respiratory Syndrome Coronavirus 2' (SARS-CoV-2) has been recognised as one of the biological workplace hazards among healthcare workers (HCWs), especially among those who attends Coronavirus Disease-2019 (COVID-19) patients. As of June 20th, 2021, the total number of people infected was 177,108,695 cases, with over 3.8 million (3,840,223) deaths (WHO, 2021[a]). However, the number of HCW infections and deaths due to COVID-19 is unclear because the World Health Organization (WHO) does not currently make the data publicly available. A systematic review revealed that the pooled prevalence of COVID-19 infection and mortality among HCWs was 10.1% (95% CI: 5.3,14.9) and 0.3% (95% CI:0.2,0.4), respectively (Sahu et al. 2020). Based on evidence based updates, the

transmissibility of COVID-19 virus is apparently by means of respiratory droplets; by direct contact with infected persons or via contaminated objects and surfaces, as well as through airborne transmission (Ahmad et al. 2020, Gallagher et al. 2020, Iwu et al. 2020).

Despite the mounting evidence of the vaccine's efficacy, new variants circulating in the population raise concerns about breakthrough infection, particularly among the fully vaccinated population (WHO, 2021[b]). Therefore, HCWs need to adhere to a strict protocol of Infection Prevention and Control (IPC) measures through standard precautions such as hand and respiratory hygiene, appropriate usage of personal protective equipment (PPE), environmental cleaning through disinfectant and waste management disposal to ensure the resilience of the health system facing a major pandemic like COVID-19 (WHO, 2021[c]).

According to the hierarchy of controls in general, PPE is the least effective measure in reducing the risk of transmission in healthcare settings. However, in times like the prolonged current pandemic, full PPE usage has been recommended by the WHO in curbing the exposure toward the COVID-19 virus among HCWs which includes equipment or specific clothing such as face shields, goggles, masks, gloves, coverall/gowns, headcovers, and shoe covers (WHO, 2020).

At the same time, previous study also highlighted that knowledge of PPE usage among HCWs during the COVID-19 pandemic was relatively good; however, their attitudes and practices against COVID-19 infection were low (Michel-Kabamba et al. 2021, Ojha et al. 2021). Several studies have linked that the spreading of communicable diseases such as SARS and COVID-19 were associated with the low adherence and inappropriate use of PPE among HCWs (Lau et al. 2004, Suzuki et al. 2020).

Therefore, this study aimed to perform a systematic review and describe the adherence toward PPE used in various healthcare settings during the COVID-19 pandemic and associated factors with non-adherence to PPE usage among HCWs.

2. Materials and Method

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols (PRIS-MA-P) recommendations were followed for this study's procedure. The reporting was guided by the PRISMA checklist. PubMed, Medline, and ScienceDirect were chosen as the databases to retrieve the articles from January 1st, 2020 to April 7th, 2021.

The search keywords used were: "Personal Protective Equipment" OR "Face Mask" OR "Face Shield" OR "Sterile Glove" OR "Surgical Glove" OR "Respirator" OR "Gown" OR "Coverall" AND "Compliance" OR "Non-compliance" OR "Compliance" OR "Non–Compliance" OR "Barrier" AND "COVID–19" OR "Coronavirus" OR "SARS-CoV-2". The flow diagram of the review is shown in Figure 1.

Three independent researchers completed selecting the studies and any differences were tended by few discussions held among authors leading to a consensus. The discussion was done in accordance where initially, the title and abstract of the articles were screened before proceeding with the full text. Articles that examined the associating factors to non-adherence of PPE among HCW were included while those not in English or an English translation were unavailable, articles with incomprehensive data, comments, or viewpoints towards HCWs were excluded from this analysis.

The study quality was assessed using the AXIS tool (Downes et al. 2016). The AXIS tool is a 20-item critical appraisal measure developed in 2016 that tackles study design and reporting quality, as well as the possibility of bias in cross-sectional studies. This tool basically addressed few key areas which are study design, sample size justification, target population, sampling frame, sample selection, measurement validity & reliability, and overall methods.

3. Results

We identified 13 articles from the search database and cross-reference, which fulfilled the inclusion criteria. Eleven articles were studied in a single country such as the United States (Darwish et al. 2021, Estrich et al. 2021), India (Prakash et al. 2020, Agarwal et al. 2021), Kuwait (Shehab et

al. 2021), Hungary (Bor et al. 2021); Qatar (Alajmi et al. 2020); Germany (Neuwirth et al. 2020), Ghana (Ashinyo et al. 2021); and Bangladesh (Hossain et al. 2021) while two articles include multiple countries in their studies (Panayi et al. 2020, Gullapalli et al. 2021).

On further description, eight articles were conducted in developing countries, while three articles were done in developed countries. The data collection period was carried out in 2020 that ranged between two weeks to fourteen weeks with an average period of eight weeks. The included articles were published in 2020 onwards, with five studies published in 2020 and eight studies published in 2021.

All articles were cross-sectional studies and the total numbers of participants in the included articles were 10,371; however, the study participants for each article ranged between 122 to 4,776 participants. The results of the review articles are presented in Table 1. Separate quality assessments based on the 20 question of AXIS tool were performed by two authors, and any disagreements were resolved by consensus in the presence of a third reviewer.

The overall quality scores of the articles range from 15 to 20. The mean score for all articles was 17.8. One study had a quality score of 20 (Estrich et al. 2021), four studies had a quality score of 19 (Agarwal et al. 2021, Bor et al. 2021, Ashinyo et al. 2021, Hossain et al. 2021), three studies had a quality score of 18 (Michel-Kabamba et al 2021, Prakash et al. 2020, Gulapalli et al. 2021), three studies had a quality score of 17 (Darwish et al. 2021, Shehab et al. 2021, Neuwirth et al. 2020), one study had a quality score of 16 (Alajmi et al. 2020) and one study had a quality score of 15 [Panayi et al. 2020).

4. Discussion

It was found that the adherence among HCWs toward PPE ranged between 51.7% to 96.3% and these wide differences in adherence to PPE among studies may be attributable to several reasons such as different populations, different data collection methods, different data collection periods, or possible cultural differences between the studies. It was worth noted that PPE preparedness, such as training of HCWs, maintaining PPE stocks, and proper IPC guidelines in developed countries, may lead to higher PPE adherence (Rajamani et al. 2021).

Having said that, PPE preparedness needs strong budgets, but this is not a problem for developed country since they account for about 80% of global spending on healthcare as compared to developing countries [(WHO 2019). Evidence from one of the developing countries such as India suggested that PPE shortage during the pandemic has affected the morale of the health care workers, leading to challenges on proper PPE usage (Sharma et al. 2020).

Adherence to PPE is considered sufficient if the percentage value is equal or greater to 80% and vice versa [Neuwirth et al. 2020). Thus, those with a PPE adherence of 80% and above were categorized as sufficient adherence, while those with a PPE adherence below 80% were considered as insufficient adherence. The result is presented in a map as illustrated in Figure 2.

The in-depth discussion regarding the adherence of PPE during the COVID-19 pandemic can be further divided into three subsections: timeline factors, situation-al factors, and donning and doffing practices.

4.1 Timeline Factors

PPE adherence among the healthcare workers in response to COVID-19 in the study reviewed might be related to timeline factors. We categorized the studies into an earlier or later category, based on the duration of those studies that had been initiated and con-ducted. The cut-off point that is being used is based on the date of Interim Guidance of rational use of PPE for coronavirus disease (COVID-19) issued by the WHO which was on the March 19th, 2020.

The publication provides WHO's guidance for the prudent use of PPE in healthcare and community contexts, as well as during cargo handling. Gloves, medical masks, goggles or a face shield, gowns, as well as respirators (N95 or FFP2 standard or similar) and aprons for specific jobs in handling COVID-19, are all examples of PPE. It is intended to serve as guidance for those involved in the distribution and management of PPE, as well as public health authorities and those working in health care and community settings, and it provides guidance on when PPE should be used (WHO 2020).

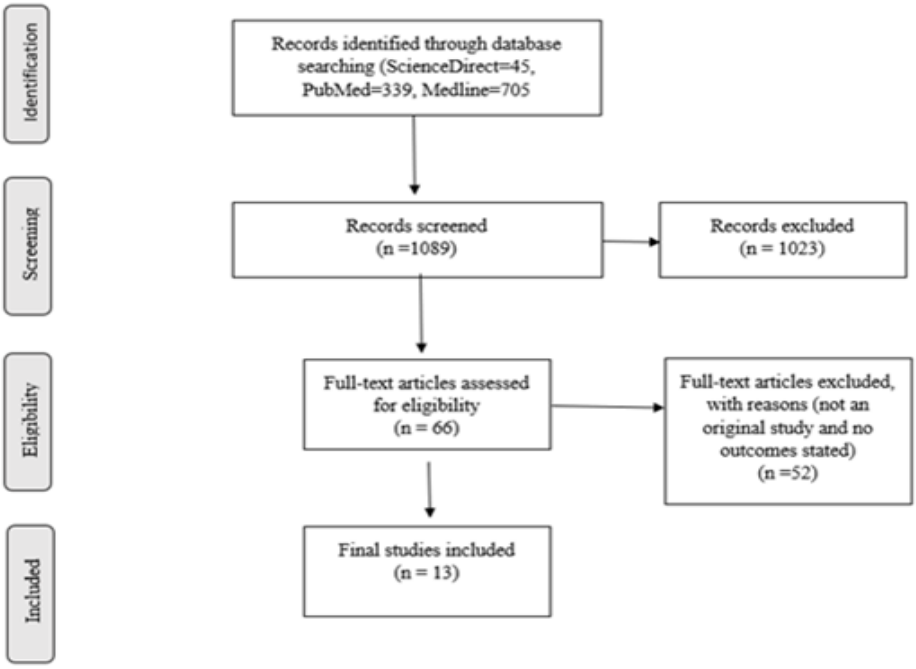

Figure 1. Outcomes of the Literature's Systematic Review as per PRISMA Statement Flow Diagram

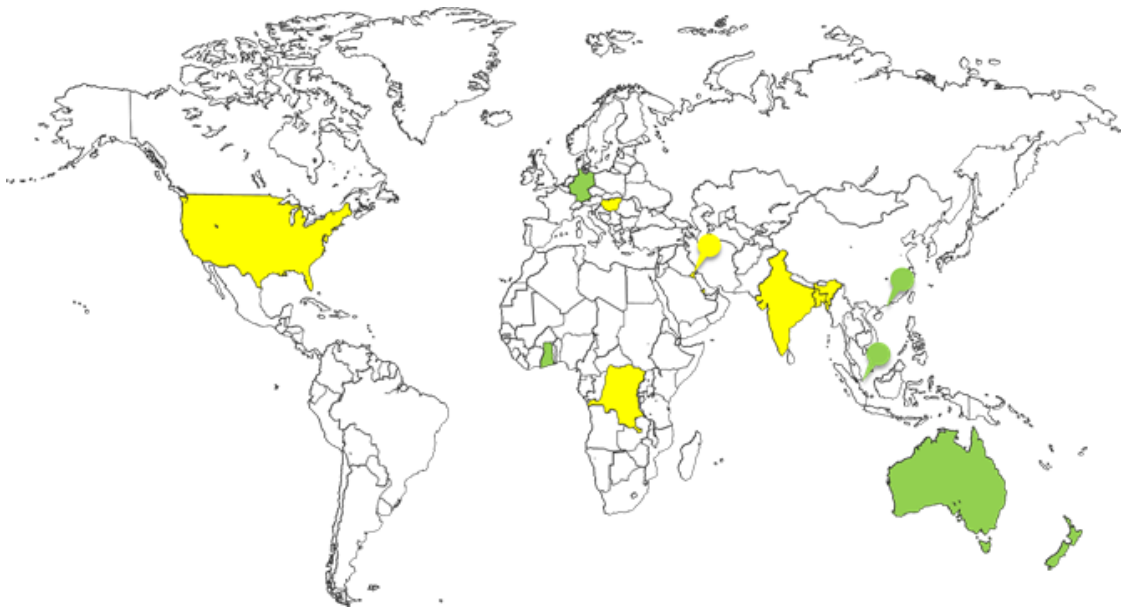

Figure 2. Mapping of PPE Adherence; the green colour is categorized as sufficient adherence (80% and above) while the yellow is categorised as insufficient adherence (< 80%)

Hence, those studies which had been conducted prior to the date were categorized as early study, meanwhile those studies which had been conducted after the date were grouped as later study. In the early study category, there were two studies that indicated sufficient adherence to PPE. The sufficient adherence to PPE usage in the early stage of COVID-19 pandemic was probably due to higher awareness in handling PPE, strict PPE use and clear guidelines of infection control measures regardless of workplace environment and whether any patients or HCWs were known to be COVID-19 positive in countries with advance healthcare system (Alajmi et al. 2020, Neuwirth et al. 2020).

In contrast, one research found insufficient adherence to PPE usage among the HCWs, and this was due to the shortage of PPE supply and unexpected workload in the early period of time of the pandemic. Obviously, the lack of PPE is concerning, as it puts HCWs in less developed nations at a significant risk of developing COVID-19 infection. (Michel-Kabamba et al. 2021). For the later study category, there were four respective studies that support sufficient and another four with insufficient adherence to PPE usage among the HCWs.

On one hand, increased uptake in PPE practices due to increased awareness regarding PPE stocks and necessity for wearing a particular PPE coupled with HCWs' perceptions of safety may have improved as a result of more regulated visitation procedures. This is most likely due to increased transparency from hospitals and government agencies, which is critical for lowering fear and anxiety among HCWs (Prakash et al. 2020, Gulapalli et al. 2021).

Besides, the initiation of a PPE inspectors' teams as per the WHO's interim guideline is an effective quality improvement method to increase HCWs' adherence with PPE usage and was associated with reduced incidence of newly infected HCWs with COVID-19 (Shehab et al. 2021). At the other end, shortage of PPE supply, lack of knowledge, extended duty hours, a high patient caseload, and a cavalier attitude toward one's own safety have all been recognised as major roadblocks and act as important barriers in achieving high PPE use uptake among HCWs (Agarwal et al. 2021).

Although government agencies have recently assured an appropriate supply of PPE, a lack of additional safeguards and the uncertain quality of the equipment may have an impact on HCWs' confidence and practice of PPE in health institutions. Low PPE adherence among HCWs may also be due to a lack of administrative oversight and monitoring of protective measures. (Hossain et al. 2021). In brief, we identified the shortage of PPE supply to the healthcare facilities and high-risk HCWs as the main driver in explaining the low adherence of PPE use among HCWs in either earlier or later study categories. Further shortages of PPE will occur worldwide, driven not only by the number of COVID-19 cases, but also by disinformation, panic buying, and stockpiling. This vicious cycle will continue when additionally, the capacity to expand PPE production is limited, especially if widespread inappropriate use of PPE continues (WHO 2020).

4.2 Situational Factors

This review found that PPE adherence may differ in different clinical settings. PPE adherence at communal hospital areas such as entrances, corridors and lifts, public toilets and cafeteria was high especially in Japan (100%) and the United States (76.8%) (Darwish et al. 2021, Panayi et al. 2020). Based on official guidelines by WHO on different settings, PPE requirements at communal hospital space were only using facemask; patient contact when COVID-19 not suspected– facemask/respirator, gloves, apron; patient contact when COVID-19 suspected or con-firmed-respirator, gloves, eye protection, apron/isolation gown; and for those carrying out aerosol generating procedures (AGPs) and high-risk areas – respirator, gloves, eye protection, isolation gown/apron, boots and hairnet (WHO 2020).

Therefore, it was easier for healthcare workers to adhere to PPE according to the guidelines while in hospital communal places as compared to other settings. Besides that, in Japan, face mask wearing has been developed into a routine practice among the public against a range of health threats [Burgess & Horii 2012). Those working at the emergency departments or intensive care units may have a higher adherence than those working in non-emergency units (Piché-Renaud et al 2020).

This finding can be explained by the lack of perceived susceptibility and lack of perceived severity towards COVID-19 infection at the early stages of the pandemic. In addition, those working at the emergency departments were more likely to have contact with suspected or confirmed cases of COVID-19 patients, which could improve

adherence (Brooks et al. 2021). Surprisingly, adherence to PPE was lower in situation with those who performed AGPs (Darwish et al. 2021, Panayi et al. 2020).

Concern has been raised due to the conflicting guidelines from the World Health Organization and national guidelines on PPE recommendation for AGPs (Rajamani et al. 2021). For example, WHO recommends using PPE based on the risk of aerosol generation, while national guidelines such as The Australian and New Zealand Intensive Care Society (ANZICS) recommend using PPE with airborne precautions for healthcare workers irrespective of AGPs risk. Besides that, low PPE adherence while performing AGPs may be attributed to the perceived negative impact on patient care and the need to attend emergency cases (Moore et al. 2005).

According to WHO, when per-forming AGPs, e.g., tracheal intubation, non-invasive ventilation, tracheostomy, cardio-pulmonary resuscitation, manual ventilation before intubation, and bronchoscopy, HCWs is recommended to wear full PPE as the AGP environments increased risk of transmission. An international survey-based study involving nine geographic regions showed that East Asia showed the highest adherence when carrying out AGPs (76.6%), and the lowest adherence was the Indian Subcontinent with 26.9%. Also, according to this survey, the highest adherence according to the country in carrying out AGPs was Argentina, with 83.3% [Panayi et al. 2020).

In addition, four reviewed articles discussing PPE practice at different specialised units which practice AGPs, namely the operation theatre (OT), intensive care unit (ICU), endoscopy unit, and dental practice. The mean adherence to PPE usage among HCWs at these four subunits was 75.6% (Estrich et al. 2021, Prakash et al. 2020, Bor et al. 2021, Gulapalli al. 2021). The adherence among HCWs working in the operation theatre and ICU were high; 96.3% and 80%, respectively (Gullapalli et al. 2021; Prakash et al. 2020).

Meanwhile, surprisingly the PPE adherence among endoscopists and dental hygienists was 67.5% and 55.7%, respectively (Estrich et al. 2021, Bor et al. 2021). This finding was parallel with the high AGPs done in these two subunits (OT and ICU) compared to others that required higher precaution to prevent transmission (Setlur, Jaiswal & Jahan 2020).

Among the specific AGPs done in the operation theatre and ICU are endotracheal intubation, bronchoscopy, open suctioning, nebulized treatment administration, manual ventilation before intubation, frequent changes of patient lying position, disconnecting the patient from the ventilator, non-invasive positive-pressure ventilation, tracheostomy, and cardiopulmonary resuscitation (CPR) which likely evident to increase the risk of transmission.

Another study done in 6 Asia Pacific countries showed that the adherence of PPE in the ICU improves remarkably due to sufficient PPE stock, increased awareness regarding PPE among HCWs, and confidence in their training on PPE (Gullapalli et al. 2021). These findings were parallel in response to the findings during the early pandemic whereby 5% of HCWs being affected with COVID-19 worked in the ICU.

On the contrary, the administrative approach implemented in dental unit and endoscopy unit such as doing patients' risk stratification, reducing office hours, temporarily suspending clinical services, and conducting COVID-19 screening, might contribute to low adherence to PPE as HCWs feel reassurance and neglect the importance of wearing PPE (Estrich et al. 2021, Bor et al. 2021, Rossato et al. 2021).

4.3 Donning and Doffing Practices

A correct doffing and donning procedure for PPE is very important. The incorrect method of donning and doffing leads to biosafety measures breaches and potentially exposes the HCWs to the virus. In this review, three articles were found assessing the step of donning and doffing of HCWs with mean adherence to PPE of 68.4%. From these, it was observed that an average of 48.6% of donning and doffing steps was incorrect. This finding was supported by another study, which found that 50% and 35% of donning and doffing respectively during the pandemic COVID-19 were incorrect. It was postulated that lack of training received by HCWs (mean of 31.7%) might contribute to this situation (Piché-Renaud et al 2020, Bor et al. 2021).

Additionally, it was observed that mask-fit testing among HCWs was still inadequate, with only an average of 26.8% practicing it (Neuwirth et al. 2020, Hossain et al. 2021). This is troubling since mask-fit testing should ideally be done, as the proper face mask and size are required to establish a proper seal, reducing the number of infected HCWs caring for COVID-19 patients. The

one-size-fits-all equipment designed primarily for Caucasian men's body templates, which ignores the impact of biological features such as facial geometry, could be one explanation for this poor adherence (Chakladar & Scott 2021).

In brief, the shape and size of a person al-so determine whether a person fits a PPE, and thus PPE may be less likely to fit HCWs of certain ethnicities or regions if only one size fits all available. Interestingly, even though the adherence to PPE among HCWs in the operation theatre was high, the most common violation occurred when the surgeon did not wear a face shield ($p<0.001$). Among the reasons for non-adherence with wearing a face shield were discomfort, poor visibility due to thickness, and frequent fogging [Prakash et al. 2020]. From the above findings, it is crucial to overcome the barriers to increase the adherence of PPE among HCWs.

4.4 Associated Factors

There is insufficient quantitative evidence among the reviewed articles on associated factors towards PPE adherence among HCWs during the COVID-19 pandemic. However, based on the findings from the reviewed articles, associated factors with lower adherence to PPE were those who were younger age, male, single marital status (including separated or widowed), fewer years of experience, lower education level, lack of concern about the risk of COVID-19 infection, lack of perceived availability on PPE supplies and government HCWs. Qualitative findings were cited in a few articles that mentioned the reason for PPE non-adherence are due to long working hours, lack of institutional guideline, discomfort issues, poor visibility, and frequent fogging (Michel-Kabamba et al., 2020, Prakash et al., 2020, Agarwal et al., 2021).

A high adherence towards PPE may be related to the sufficient knowledge among HCWs regarding the disease's transmission and risk factor for severe COVID-19 infection. Media can play a role in disseminating information regarding COVID-19 infection, which has proven as an effective way to mitigate the spread of the disease (Zhou et al. 2020). However, it is essential to acknowledge that the use of social media as a source of information may induce anxiety among users regarding COVID-19 (Depoux et al. 2020). Also, being female and married are found to increase adherence to PPE. Hence, from this articles review, our evidence convincingly points that being a female and married are significantly associated with better adherence to PPE.

Women are more likely than men to practice self-care behaviours and to agree to comply with restraining measures implemented, which could be due to factors such as women's greater responsibility or a greater concern about the disease and its transmission to family members (Galasso et al. 2020, Mohammadpour et al. 2020). Also, as previously stated, the PPE is primarily designed for Caucasian men's body templates and not for women.

This made us realize that even the height according to continents differs, i.e. European male average height is 1.8m while for Asian females the average height ranges between 1.55m to 1.6m according to location (World data 2019). This clearly demonstrated the critical importance of having appropriate PPE, particularly for women, because PPE only works effectively when it is properly fitted. Therefore, this might contribute to high perceived susceptibility among women which eventually increases the adherence to PPE. In addition, being married possibly turns an individual to have high perceived susceptibility and is more likely to engage in behaviours to decrease their risk of developing COVID-19 as well as to protect against the transmission of the virus to family members (Mohammadpour et al. 2020).

4.5 Recommendations

Based on the published articles and the findings of this review, we recommend that few areas need improvement to increase the adherence of PPE usage among HCWs. According to the concept of hierarchy of control that has elimination and substitution as the most desirable methods, this approach is deem impossible we are dealing with a new biological hazard.

As the pandemic is still an ongoing issue, engineering control was only able to be use in certain healthcare facilities for example in the hospital setting that care for more severe COVID-19 patients. Elsewhere where more public health services are being implemented for example in mass screening, the role of administrative and PPE usage became the prime agenda for the overall prevention and control approach.

The global shortage of the PPE at the beginning of the pandemic has led to high reuse of the equipment, and improper use of PPE worn

by the HCWs may eventually lead to a reduction in the adherence of PPE usage. To respond to this shortage, engineering control could be implemented by more development in terms of production of reusable PPE rather than disposable PPE. For instance, the effort of producing reusable half-face respirator should be appraised as this is the way forward in the future to overcome the supply chain disruption especially during pandemic. Besides that, the reusable N95 respirator during a pan-demic is feasible and more cost-effective (Anwari et al. 2021).

More research should be done on this matter as the device might require further evaluation in fulfilling the standard requirements be-fore clinical deployment. With regards to the administrative measures, the most important thing is to ensure that the shortage of the equipment should be addressed quickly and tackled efficiently, ensuring the safety of HCWs at the optimum level. For example, the initiative taken by England and Wales to set up an emergency working group called Sustainable Hub for Innovation, Execution, Launch and Distribution (SHIELD) and The South Wales Additive & Rapid Manufacturing Consortium (SWARM) to overcome the shortage of PPE (Jessop et al. 2020).

Furthermore, in times of crisis the PPE should be managed wisely according to the level of needs as highlighted (according to the setting, personnel, and type of activity) by WHO to ensure the supply chain continues and utilization of PPE can be maximized. It is crucial to conduct training regarding PPE to improve knowledge, attitude, and practice. The PPE training should be part of compulsory preparedness and response in every hospital, especially when handling emergencies like the COVID-19 pandemic (Darwish et al.,2021; Michel-Kabamba et al., 2020). The training should not be limited to certain professionals but should involve all HCWs. The modality of training that has been suggested was online training like video training and simulations, which is more interactive compared to the traditional methods.

In comparison to in-person training, the online module made it easier to reach all HCWs, provide addition-al reinforcement, learning opportunities and rapidly evolving recommendations given by the Centers for Disease Control and Prevention (CDC) can be dispersed effectively. In addition, designated authorities should implement regular monitoring and reinforcement to ensure better practice. It has been proposed that PPE inspectors conduct the enforcement, which may result in positive attributes (Shehab et al. 2021). Also, the buddy system to check the donning and doffing should be optimised to obtain better adherence on PPE usage among HCWs.

To overcome the PPE discomfort issue, it was advised for healthcare to collaborate with other industries to do further research on PPE innovation, such as developing ergonomic masks and PPE. Ergonomic PPE will increase user comfort and reduce user fatigue, ultimately increasing adherence to PPE usage. Also, perhaps it is time to create PPE that is tailored to both men and women. The standard must address the distinct needs of men and women. Most importantly women need resources and tools to do their jobs effectively and safely. Apart from size and height, anthropometric measurements such as body proportion and movement, which can be affected by gender, can also have an impact, and must be considered (Mark 2020).

Therefore, seeing the world through the lens of gender and sex will help to advance new product de-signs for women, to fit all environments. Currently, under the auspices of the United Nations Economic Commission for Europe (UNECE), "Gender-responsive Standards Declaration" involving 65 standard bodies have already formally signed the Declaration, taking concrete commitments for action in making gender responsive PPE.

5. Conclusion

In conclusion, adherence of HCWs towards the use of PPE should not be taken lightly. Apart from using PPE, other administrative and engineering controls should be incorporated to reduce COVID-19 infection among HCWs especially in critical areas. Also, further study needed to identify other factors that may be associated with adherence to PPE usage among HCWs as limited data was available. The result may help with the strategies for maximizing the adherence to PPE and improving the safety of HCWs.

Conflicts of Interest

The author declares no conflict of interest.

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Table 1. Characteristics and findings of PPE adherence and associated factors toward PPE usage of the reviewed articles

No.	Author	Setting	Sample Size	Study Design	Study Objective	Study Duration	Findings	
							Adherence (%)	Associated Factors
1.	Agarwal et al. (2021)	HCW working at private and public hospital in India	956	Cross-sectional	To evaluate the preventive practices being followed by HCWs and identify reasons for suboptimal adherence	30th July -30th August 2020	60%	Better adherence of PPE usage was reported among: • Female had better adherence compared to male (p-value <0.001) • Being married had better adherence compared to being single (p-value <0.001) Lower adherence of PPE usage was reported among: • HCWs aged 18 - 30 years old had lower adherence compared to more than 31 years old (p-value < 0.001) • Resident doctors and other paramedical staff (like ward boys, sweepers, OT and lab technicians, optometrists, etc) had lower adherence to preventive practices compared to nurses and senior doctors (p-value <0.001)
2.	Alajmi et al. (2020)	HCW at Hamad Medical Corporation (HMC) in Qatar	393	Cross-sectional	To determine the prevalence of COVID-19 infection in healthcare workers (HCWs) in a national healthcare system and to understand the risk factors for infection	10th March - 24th June 2020	82% (COVID facilities) 68% (non-COVID-19 facilities)	Lower adherence of PPE usage was assumed due to: • complacency with strict infection prevention precautions, • unrecognized infection among patients and coworkers
3.	Ashinyo et al. (2021)	COVID- 19 treatment centre in Ghana	328	Cross-sectional	To assess IPC adherence among healthcare workers in Ghana's COVID-19 treatment centres	May - August 2020	90.6%	Lower adherence of PPE usage was reported among: • Separated/divorced/widowed (OR: 0.08; 95% CI: 0.01–0.43) • Secondary level qualifications (OR 0.08; 95% CI 0.01–0.43) • Non-clinical staff (OR 0.16 95% CI 0.07–0.35) • Cleaners (OR: 0.16; 95% CI: 0.05–0.52) • Pharmacists (OR: 0.07; 95% CI: 0.01–0.49) • Among HCWs who reported insufficiency of PPEs (OR: 0.33; 95% CI: 0.14–0.77).
4.	Bor et al. (2021)	Gastroenterologist from 83 institutes	120	Cross-sectional	To determine the adherence of Hungarian	April 2020	67.5%	• 33.3% of the participants had undergone COVID-19 prevention infection training in their workplace

No.	Author	Setting	Sample Size	Study Design	Study Objective	Study Duration	Findings	
							Adherence (%)	Associated Factors
					endoscopists to national and international recommendations in real-life settings based on the applied PPE			• 60.8% availability of appropriate amount and quality of PPE
5.	Estrich et al. (2021)	A web-based survey among dental hygienists from the US and Puerto Rico	4776	Cross-sectional	To estimate the prevalence infection prevention and control procedures and any associated trends in mental health	29th September-8th October 2020	55.7%	Factors affecting PPE adherence: • Years of experience as a dental hygienist • Level of concern about COVID-19 • Level of PPE supplies available
6.	Gullapalli et al. (2021)	ICUs from all the six countries (Australia, NZ, Singapore, HK, Philippines, and India)	132	Cross-sectional	To determine changes in PPE-preparedness over time	10th August - 1st Sept 2020	80%	• Improved of PPE stock adequacy from 51.9% to 85.6% • Increased in the reported use: o Powered air-purifying respirators: 6.1% to 42.9% o Double gloving: 42.9% to 87.9% o N95 use at all time: 53.7% to 86.4% • Reduction in HCW training for donning and doffing from 60.2% to 44.3%
7.	(Hossain et al., 2021)	HCW working at five different districts of Bangladesh	393	Cross-sectional	To assess the knowledge, attitude, and practice (KAP) regarding personal protective equipment (PPE) among healthcare workers	June - July 2020	51.7%	● Better adherence of PPE usage was reported among: o Reading guidelines (OR 1.736, 95% CI 1.1-2.8, p-value< 0.05) o Workstation ICU (OR 3.821,95%CI 1.4-3.2, p-value< 0.05) o Work hours per week>36 hours (OR 2.1, 95%CI 1.4-3.2, p-value< 0.05) o Used office transport (OR 4.4, 95%CI 2.6-8., p-value<0.05) ● Lower adherence of PPE usage was reported among: o Bachelor/above (OR 0.252, 95% CI 0.15-0.42, p-value<0.05) o Government-employed HCWs (OR 0.125,95%CI 0.08-0.2, p-value<0.05) o Male (OR 0.643,95% CI 0.4-0.9, p-value< 0.05) o Physician (OR 0.310, 95%CI 0.19-0.50, p-value< 0.05)

No.	Author	Setting	Sample Size	Study Design	Study Objective	Study Duration	Findings	
							Adherence (%)	Associated Factors
8.	Michel-Kabamba et al. (2020)	HCW at 23 referral hospitals in the Democratic Republic of Congo	613	Cross-sectional	To assess the knowledge, attitudes, and practices (KAPs) of healthcare workers (HCWs) in the Democratic Republic of the Congo (DRC)	March -April 2020	54.9%	● Better adherence of PPE usage was reported among: ○ Use of social media (aOR: 1.43; 95% CI: 1.01–2.02; p < 0.05) ○ Information from family & friends (aOR 1.71; 95% CI: 1.22–238; p < 0.01) ○ Category of residence (town without/with COVID-19 cases) (aOR: 2.79; 95% CI: 1.93–4.06); p < 0.01)
9.	Neuwirth et al. (2020)	8 wards at the University Hospital in Cologne, Germany	127	Cross-sectional	To investigate the adherence to PPE use in COVID-19 and non-COVID-19 wards during the first epidemic phase	27th Feb – 21st April 2020	85% (COVID wards) 76% (non-COVID-19 wards)	Total adherence between the COVID and non-COVID wards: • Hand hygiene- 82% versus 65% • Donning – 79% versus 73% • Doffing – 85% versus 76%
10.	Prakash et al. (2020)	Surgical Oncology Department in India	122	Cross-sectional	To establish adherence of PPE among HCW involved in surgery of COVID – 19 negative cancer patients	May - June 2020	96.3%	Poor compliance with the usage of face shield due to • discomfort (33%), • poor visibility due to thickness (36%), and • repeated fogging (33%).
11.	Shehab et al. (2021)	Tertiary care hospital in Kuwait	720	Cross-sectional	To reduce the incidence of COVID-19 infection among HCWs by assessing and reinforcing adherence to PPE use and adherence to infection control methods	10th May – 31st August 2020	56% (beginning of the study) 89% (end of study)	Overtime, the were improvement in PPE use with only: • 11% missing/inadequate PPE use • 18% of unnecessary usage of PPE
12.	Darwish et al. (2021)	Healthcare professional in the United States	436	Cross-sectional	To determine adherence to CDC PPE guidelines among healthcare professional	15th June – 17th July 2020		Adherence to PPE varies in different situation: ● Contact with suspected COVID - 19 patient (86.7%) ● Communal hospital space (76.88%) ● Contact with the suspected patient (51.71%) ● Contact with confirmed COVID - 19 patient (55.82%) ● Carrying out aerosol-generating procedures (42.47%)
13.	Panayi et al. (2020)	Multi-country Hospital	1255	Cross-sectional	International survey-based study to ascertain PPE adherence across regions and countries	17th April – 17th June 2020		According to the region, the adherence was as follow: ● East Asia ○ Communal hospital spaces (96·1%)

No.	Author	Setting	Sample Size	Study Design	Study Objective	Study Duration	Findings	
							Adherence (%)	Associated Factors
								○ Patient contact when COVID-19 suspected (69·5%) or confirmed (72·3%), carrying out AGPs (76·6%) ○ High-risk areas (67·5%) ● Australasia ○ Communal hospital spaces (21·7%) ○ Patient contact when COVID-19 suspected (21·7%) ○ High-risk areas (26·1%) ● Indian Subcontinent ○ Patient contact with confirmed cases (30·8%) ○ Carrying out AGPs (26·9%) ● North America ○ Patient contact when COVID-19 not suspected (16.1%) According to country, the highest adherence was as follow: ● Communal hospital space (Japan - 100%) ○ Patient contact when COVID - 19 not suspected (UK - 85%) ○ Patient contact when COVID - 19 suspected (Spain - 81.3%) ○ Patient contact with confirmed cases (Portugal - 81.5%) ○ Carrying out AGPs (Argentina - 83.3%) ○ High-risk areas (China - 71.5%)