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ABSTRACT

INTRODUCTION: Coronavirus disease (COVID-19) is caused by the severe acute respiratory syndrome coronavirus 2 (SARS-COV2). COVID-19 is highly contagious, potentially fatal, and a global public health concern. Combining optimized personal protective equipment (PPE) use and hand hygiene is the best strategy for preventing COVID-19 in health care workers (HCWs).

METHODS: We conducted a national cross-sectional web-based survey of HCWs in the infection control program (IPC) in Thailand between May 5, 2020 and May 15, 2020. The primary objective was the prevalence of optimized PPE use amongst HCWs. The secondary objective was identification of the independent predictors of optimized PPE use.

RESULTS: We received a response from 46% of HCWs (756/1650), and all those who responded were nurse or HCWs who were registered in the IPC network. Five HCWs were excluded because of missing data, and 751 were included in the final analysis. The prevalences of PPE use were 22% (168/751) for optimized PPE use, 78% (583/751) for non-optimized PPE use, 35% (263/751) for PPE overuse, and 43% (320/751) for PPE underused. In univariate analysis, optimized PPE use was significantly associated with age, education level, knowledge of appropriate negative pressure room selection, and knowledge of apparently milder symptom severity in children than adults. In multivariate analysis, independent predictors of optimized PPE use were knowledge of appropriate negative pressure room selection (aOR = 1.95, 95% CI = 1.18-3.22), the difference in symptom severity between children and adults (aOR = 0.55, 95% CI = 0.37-0.81), and education level (aOR = 1.54, 95% CI = 1.04-2.27).

CONCLUSION: The prevalence of optimized PPE use amongst HCWs was 22%. Independent predictors of optimized PPE use were COVID-19 knowledge-based factors and education level. Therefore, the continued education training program should be implemented to ensure maintenance of appropriate practices during the COVID-19 pandemic.

KEYWORDS: Optimized personal protective equipment, COVID-19 pandemic, knowledge, degree

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Introduction

Coronavirus disease 2019(COVID-19) is caused by the severe acute respiratory syndrome coronavirus 2 (SARS-COV2), and COVID-19 is a potentially fatal disease of great global public health concern.[1] SARS-COV2 is transmitted by respiratory droplets by direct close contact of the exposed mucous membranes including the mouth, the nose, possibly the conjunctiva, indirect contact by fomites in the immediate environment of the infected person, and by the fecal-oral route.[2-4] It is thought that airborne transmission is unlikely. The basic reproduction number (R0) is the expected number of cases generated by one case when the entire population is susceptible, and the estimates of the R0 of COVID-19 have varied widely.[5,6] The symptoms of COVID-19 are similar in children and adults but appear to be milder in children.[7]

Health care workers (HCWs) are a population at high risk of SARS-COV2 infection. As of 3 April 2020, around 10 000 HCWs in Italy were infected, of whom 74 died, and many other HCWs have formed large clusters of infections with many deaths in countries globally.[8-10] The COVID-19 pandemic has led to shortages of personal protective equipment (PPE) or the unintentional use of counterfeit filtering facepiece respirators for general populations, patients, and especially HCWs because SARS-COV2 can be transmitted even by COVID-19 infected individuals who are not yet showing signs of infection.[11-13] On 7 February 2020, the World Health Organization (WHO) estimated that the demand for PPE had increased by 100-fold, and prices had increased by up to 20-fold since the start of the outbreak.[14] Several previous studies and national regulatory bodies have recommended gloves, a

gown, a surgical mask, and goggles or a face shield as optimized PPE for HCWs in close contact with COVID-19 patients.[15-18] At present, the transmission of disease through the conjunctiva is not certain. Animal models demonstrated this mode of transmission; thus, eye protection should be considered as a part of PPE.[19,20]

The WHO recommendations for PPE for HCWs working in patient rooms or wards in the absence of aerosol-generating procedures are according to the setting, personnel, and type of activity. They include medical masks, gown, glove, and eye protection (ie, goggles or face shields) accompanied by hand hygiene. Coveralls, double gloves, or head covers (hoods) that cover the head and neck used in the context of filovirus disease outbreaks (eg, Ebola virus) are not required when managing COVID-19 patients.[21] Overall, optimized PPE and hand hygiene using alcohol-based hand rub (ABHR) or washing with soap and water can reduce rates of disease transmission and protect HCWs. However, the overuse or misuse of standard PPE have detrimental effects, including supply shortages of hoods, mask types, and limiting the potential re-use of equipment.[22-24] It is equally important that HCWs use it appropriately to preserve what may be limited stocks to ensure there is sufficient supply for necessary use throughout an epidemic surge. For at risk HCWs, there are many strategies to control COVID-19 during the COVID-19 pandemic, such as social distancing or physical distancing[25] and 14-day quarantine.[26] Although influenza vaccine is not effective against the SARS-COV2 virus,[27] this vaccine is advisable for the public and HCWs to reduce influenza incidence, allowing for more capacity in health care systems to be devoted to manage COVID-19. Disinfectant regimens that are effective against COVID-19 include a hypochlorite-based regimen (0.1%-0.5%), 70% ethyl alcohol, povidone-iodine (1% iodine), chloroxylenol (0.24%), 50% isopropanol, 0.05% benzalkonium chloride, 1% cresol soap, or hydrogen peroxide (0.5%-7.0%).[28] The disinfectant regimen chosen should be performed 3 times a day and be repeated each time there is contamination.[29] The WHO has stated that spraying individuals with disinfectants is not recommended under any circumstances because of physically and psychologically harmful effects without reducing an infected person's ability to spread the virus through droplets or contact.[30] However, the successful control of a pandemic depends on several factors, including the skills, adequate knowledge, preparedness for COVID-19, level of education, and the resources allocated to hospitals.[31-33]

The Department of Disease Control of Thailand assigned the Bamrasnaradura Infectious Diseases Institute (BIDI) to the infection prevention control program (IPC) and network. BIDI has several programs, such as infection control surveillance and point prevalence survey,[34] including the use of PPE in HCWs. To date, the data on optimized PPE use for COVID-19 in HCWs in Thailand have been sparse. Therefore, we aimed to estimate the prevalence of HCWs who used optimized PPE and also to identify the independent predictors of optimized PPE use.

Materials and Methods

Study design

We conducted the national cross-sectional web-based survey of HCWs in the IPC network in Thailand between May 5, 2020 and May 15, 2020. There are 1650 registered HCWs in IPC network. The study protocol was reviewed and approved by Institutional Review Board of BIDI, Ministry of Public Health, Thailand. The reference approval letter number is SO42h/63_ExPD. Informed consent was waived as participant data were de-identified. The primary objective was to estimate the prevalence of HCW who used optimized PPE. The secondary objective was identification of the independent predictors of optimized PPE use and non-optimized PPE use.

Optimized PPE use was defined as HCWs using PPE including medical masks, gowns, gloves, eye protection (ie, goggles or face shields), performing appropriate hand hygiene along with not using coveralls, double gloves, or head covers (ie, hoods).[21] Non-optimized PPE was defined as HCWs using incomplete appropriate PPE or PPE overuse.

Survey instrument

A self-administered questionnaire designed after reviewing previously validated questionnaires from the several previous studies[32,35-38] and online surveys was developed as an instrument for gathering the data. A pilot study among 10 HCWs was used to assess the clarity, relevance, and explanation of informed consent in the instrument, followed by any revision to it based on the assessment. These responses were excluded from the final analysis. The survey composed of 25 questions that were divided into 3 sections: (1) demographic and characteristics of healthcare worker, (2) practices regarding COVID-19, (3) knowledge of COVID-19, and (4) attitudes toward COVID-19.

Survey administration

The survey was conducted using a Google-based online platform between May 5, 2020 and May 15, 2020. Subject were invited to participate through the IPC network and social media.

Data management

We extracted demographic, work experience and setting, knowledge, attitudes and practices data, including established sex, age, education (bachelor degree or postgraduate degree), experience in hospital work (<1, 1-5, 6-10, 11-20, and ⩾20 year), experience in IPC (<1, 1-5, 6-10, 11-20, and ⩾20 year), hospital type (primary, secondary, tertiary, university,

private, army, or other), care type (adult only, child only, as well as both adult and child), experience with COVID-19 (yes or no), droplet and contact precaution(yes or no), ABHR practice (yes or no), wash with soap and water (yes or no), appropriate disinfectant regimen use (ie, 70% ethyl alcohol, sodium hypochlorite-based, or both alcohol and sodium hypochlorite), appropriate negative pressure room selection (negative pressure rooms for all situation or not), selecting N95 respirator for routine care (yes or no), single room (using air conditioning constantly or not), knowledge that symptom severity in children is apparently milder than in adults (yes or no), spraying disinfectant (yes or no), advising influenza vaccine (yes or no), visit strategy (yes or no), discharge plan for patients including social distancing, hand hygiene(HH), and mask (yes or no), discharge plan for family including social distancing, HH, and mask (yes or no), advising people to wear masks (yes: advise cloth mask wearing or no: did not advise cloth mask wearing), fear of COVID-19 infection (yes: afraid or no: not afraid), and fear of sickness and 14-day quarantine (yes: afraid or no: not afraid).

The definitions for appropriate hand hygiene, social and physical distancing, as well as 14-day quarantine for items used in the questionnaire survey are listed below. All HCWs should use droplet and contact precautions in routine practice for care of patients with suspected or confirmed COVID-19.[15-18,21] For our questionnaire survey, appropriate hand hygiene practice by HCWs was defined as an ABHR that contained at least 60% alcohol for a minimum of 20 seconds or washing with soap and water at the beginning of the workday, before and after touching patients, after using the toilet, before and after preparing food, and before eating.[23,24] We defined social distancing or physical distancing according to the definition of the Centers of Disease Control and Prevention of the United States of maintaining a physical distance of 2 m or more from other people.[25] We defined appropriate 14-day quarantine as 14-day quarantine of close contacts of a HCW infected with COVID-19.[26] Influenza vaccination was advised for the public including HCWs during the COVID-19 pandemic.[27] All HCWs should be checked twice a day for acute respiratory infections symptoms, and body temperature to increase the chances of early diagnosis. If a member of the team is infected with COVID-19, all close contacts should take quarantine measures.[26]

Statistical analysis

Descriptive statistics are presented as mean (SD) for normally distributed continuous variables, median (interquartile range) for non-normally distributed continuous variables, and frequency (%) for categorical variables. All continuous data were compared with the Student's *t*-test or the Mann-Whitney *U* test as appropriate. Categorical data were compared with the chi-square test. A *P*-value of $<.05$ was considered statistically significant. Multivariable logistic regression was used to identify independent predictors of optimized PPE use. All variables with *P*-value $<.05$ in univariate analyses were selected for multivariate analysis. Factors considered were sex, age, education level, experience in hospital work, experience in IPC work, hospital type, care type, experience in COVID-19, droplet and contact precaution, ABHR practice, hand hygiene by washing with soap and water, disinfectant, knowledge of appropriate negative pressure room selection, selecting N95 respirator in all situations, single room, knowledge of apparently milder symptoms in children than adults, spray disinfectant, advising influenza vaccination, visit strategy, discharge plan for patient, discharge plan for family, advising people to wear mask, fear of COVID-19 infection, and fear of sickness and 14-day quarantine. Sample size calculation used the formula of Taro Yamane,[39] assuming a sample size of 1650 registered HCWs in ICN network and the minimum sample size to maintain nominal 95% confidence interval coverage was 322 HCWs.

Result

Figure 1 shows a flow chart of the study population. Seven hundred fifty-six of 1650 registered HCWs (46%) were respondents. Five HCWs were excluded because of missing data. Therefore, 751 HCWs were included in the final analysis. Of these, the prevalence of optimized PPE use for COVID-19 was 22% (168/751). Seventy-eight percent (583/751) did not use optimized PPE for COVID-19, 35% (263/751) of HCWs over-used PPE, and 43% (320/751) of HCWs (43%) under-used PPE.

Table 1 displays the demographics and characteristics of the HCWs responding to the survey. The majority were female, and the mean age of those with optimized PPE use and non-optimized PPE use were 46.1 (SD 6.5) and 44.6 (SD 8.2) years ($P=.015$), respectively. Education level was also significantly different ($P<.05$). Sex, number of beds in health care facility, experience in hospital work, experience in IPC work, hospital type, care type, and experience in COVID-19 of both groups were not significantly different ($P<.05$).

Table 2 displays the knowledge, attitudes and practices of HCW toward COVID-19 comparing those with optimized PPE use and those without optimized PPE use. Knowledge about appropriate negative pressure room selection and the fact that COVID-19 symptoms appear to be milder in children than in adults were significantly different ($P<.05$). Droplet and contact precaution, ABHR practice, hand hygiene by washing with soap and water, disinfectant, selection of N95 respirator for all situations, single room, spraying disinfectant, advising about influenza vaccine, visit strategy, discharge plan for patient, discharge plan for family, advising people to wear a mask, fear of COVID-19 infection, fear of sickness and 14-day quarantine were not significantly different ($P<.05$).

Table 3 displays factors associated with optimized PPE use. In multivariate analysis, independent predictors of optimized PPE were knowledge about the appropriate negative pressure room selection for COVID-19 (aOR = 1.95, 95% CI = 1.18-3.22), knowledge of apparently milder symptom severity in children compared to adults (aOR = 0.55, 95% CI = 0.37-0.81),

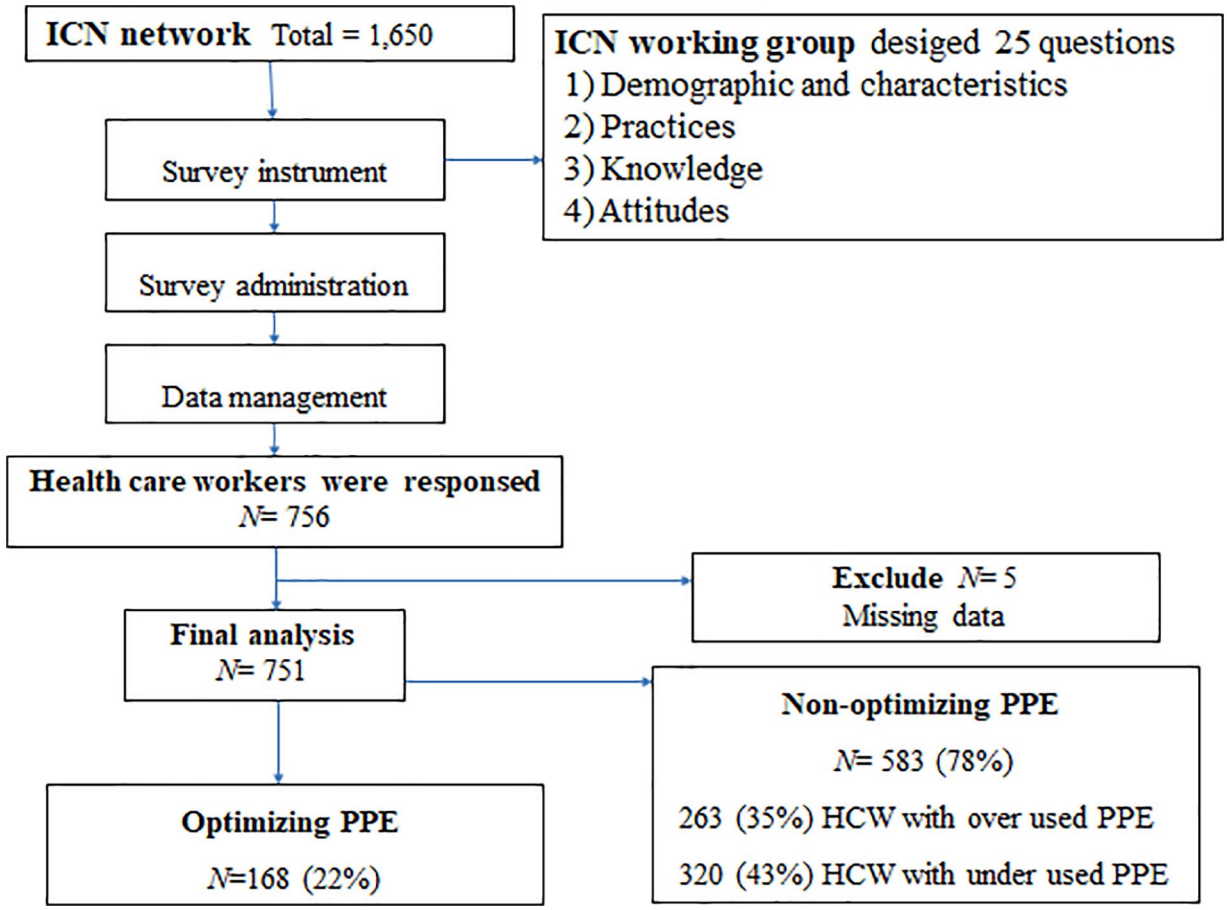

Figure 1. Flow chart of study design.

and an education level of postgraduate degree (OR = 1.54, 95% CI = 1.04-2.27).

Discussion

This survey provides a snapshot of the self-reported prevalence of HCWs who used optimized PPE by HCWs in the IPC network and identifies the independent predictors of optimized PPE use and non-optimized PPE use the network. This study demonstrates that the prevalence of optimized PPE use was 22%. The prevalences of overusing PPE and underusing PPE were 35% and 43%, respectively. The low prevalence of optimized PPE use could have been because of several reasons. Firstly, COVID-19 is an emerging infectious disease that was first isolated and identified in patients who were exposed at a seafood market in Wuhan City, Hubei Province, China on December 2019,[40] so data on appropriate PPE for this disease is variable. Secondly, there may have been a shortage of supplies for Thai health care facilities of appropriate PPE compared to the demand because the COVID-19 pandemic is spreading rapidly across countries and regions. The WHO estimates that industry must increase manufacturing by 40% to supply adequate quantities of PPE.[41] A previous study showed counterfeit filtering facepiece respirators are posing an additional risk to HCWs during COVID-19 pandemic because of panic buying (and shortage) of filtering facepiece respirators in the general population.[11] However, the majority of the counterfeit filtering facepiece respirators were used among general population in Thailand. Thirdly, lockdown policy for social distancing may have adversely affected PPE training. One study demonstrated that 53% of healthcare workers reported that they did not receive proper PPE training.[42] Moreover, a previous study in India showed that the majority surgical trainees felt that the COVID-19 lockdown had adversely affected their learning.[43]

In the present study, the low proportion of optimized PPE use was associated with knowledge about disease such as appropriate negative pressure room selection and knowledge of apparently milder symptoms in children than adults because COVID-19 is an emerging infectious disease,[40] the mode of transmission mode is variable, and the early phase of the COVID-19 pandemic was characterized by uncertainty about the nature of transmission of the disease.[2-4] In the present study, optimized PPE use was associated with HCWs with a postgraduate degree. Similarly, a previous Ugandan study demonstrated that good HCW practice regarding COVID-19 was associated with holding a diploma (aOR 18.4; 95% CI 1-322.9; $P = .046$).[33]

Limitations of the Study

Our study had several limitations. Firstly, the study was a point prevalence cross-sectional survey, and some data are

Table 1. Demographics and characteristics of health care workers (N = 751).

CHARACTERISTICS	OPTIMIZED PPE USE (N = 168)	NON- OPTIMIZED PPE USE (N = 583)	*P*-VALUE
Sex, n (%)			
Female	166 (98.8)	559 (95.9)	.091
Male	2 (1.2)	24 (4.1)	
Age, mean (SD), y	46.1 (6.5)	44.6 (8.2)	.015*
No. beds in health care facility, mean (SD)	220 (367)	172 (229)	.106
Education level, n (%)			
Bachelor degree	114 (67.9)	453 (77.7)	.011*
Postgraduate degree	54 (32.1)	130 (22.3)	
Experience in hospitalized work, n (%)			
<1 y	1 (0.6)	5 (0.9)	.080
1-5 y	3 (1.8)	24 (4.1)	
6-10 y	4 (2.4)	41 (7.0)	
11-20 y	46 (27.4)	159 (27.3)	
⩾20 y	114 (67.9)	354 (60.7)	
Experience in IPC work, n (%)			
<1 y	9 (5.4)	56 (9.6)	.382
1-5 y	48 (28.6)	156 (26.8)	
6-10 y	45 (26.8)	134 (23.0)	
11-20 y	48 (28.6)	181 (31.0)	
⩾20 y	18 (10.7)	56 (9.6)	
Hospital type, n (%)			
Primary	99 (58.9)	365 (62.6)	.788
Secondary	34 (20.2)	115 (19.7)	
Tertiary	21 (12.5)	55 (9.4)	
University	3 (1.8)	11 (1.9)	
Private	8 (4.8)	31 (5.3)	
Army	2 (1.2)	3 (0.5)	
Other	1 (0.6)	3 (0.5)	
Care type, n (%)			
Adult only	20 (11.9)	80 (13.7)	.781
Child only	2 (1.2)	11 (1.9)	
Both adult and child	146 (86.9)	492 (84.4)	
Experience in COVID-19, n (%)			
Yes	83 (49.4)	238 (40.8)	.052
No	85 (50.6)	345 (59.2)	

Abbreviations: COVID-19, coronavirus disease 2019; IPC, infection control program; PPE, personal protective equipment.
*Statistically significant result at the P < .05 level.

Table 2. Practices, knowledge and attitudes of HCW toward COVID-19 (N = 751).

CHARACTERISTIC	OPTIMIZED PPE USE (N = 168)	NON- OPTIMIZED PPE USE (N = 583)	*P*-VALUE
Practices			
Droplet and contact precaution			
Yes	162 (96.4)	571 (97.9)	.258
No	6 (3.6)	12 (2.1)	
ABHR practice			
Yes	161 (95.8)	561 (96.2)	.821
No	7 (4.2)	22 (3.8)	
Washing with soap and water			
Yes	160 (95.2)	551 (94.5)	.738
No	8 (4.8)	32 (5.5)	
Disinfectant			
Using 70% ethyl alcohol	23 (13.7)	90 (15.4)	.383
Using sodium hypochlorite-based	5 (3.0)	31 (5.3)	
Using both alcohol and sodium hypochlorite-based	140 (83.3)	462 (79.2)	
Knowledge			
Negative pressure room			
Appropriate negative pressure room selection	21 (12.5)	130 (22.3)	.004*
No	147 (87.5)	453 (77.7)	
Selecting N95 respirator for routine care			
Yes	5 (3.0)	29 (5.0)	.533
No	163 (97.0)	554 (95.0)	
Single room			
Using air conditioning constantly	17 (10.1)	44 (7.5)	.335
No	151 (89.9)	539 (92.5)	
COVID-19 symptoms appear to be milder in children than in adults			
Yes	127 (75.6)	361 (61.9)	.001*
No	41 (24.4)	222 (38.1)	
Spraying disinfectant			
Yes	3 (1.8)	6 (1.0)	.427
No	165 (98.2)	577 (99.0)	
Advising influenza vaccine			
Yes: advising	16 (9.5)	88 (15.1)	.076
No	152 (90.5)	495 (84.9)	
Visit strategy			
No	126 (75.0)	422 (72.4)	.555
Yes, stop go to room	42 (25.0)	161 (27.6)	

(Continued)

Table 2. (Continued)

CHARACTERISTIC	OPTIMIZED PPE USE (N = 168)	NON- OPTIMIZED PPE USE (N = 583)	*P*-VALUE
Discharge plan for patient (distancing/HH/mask)			
Yes	163 (97.0)	566 (97.1)	1.000
No	5 (3.0)	17 (2.9)	
Discharge plan for family (distancing/HH/mask)			
Yes	86 (51.2)	347 (59.5)	.063
No	82 (48.8)	236 (40.5)	
Advise people mask			
Advising to wear cloth mask	165 (98.2)	563 (96.6)	.444
Not advising to wear cloth mask	3 (1.8)	20 (3.4)	
Attitudes			
Fear of COVID-19 infection			
Yes, afraid	132 (78.6)	478 (82.0)	.315
No	36 (21.4)	105 (18.0)	
Fear of sick and 14-day quarantine			
Yes, afraid	128 (76.2)	451 (77.4)	.755
No	40 (23.8)	132 (22.6)	

Abbreviation: COVID-19, coronavirus disease 2019.
All data are presented as n (%).
*Statistically significant result at the P < .05 level.

Table 3. Associations of optimized PPE use in HCW by multivariable multinomial logistic regression.

VARIABLE	aOR	*P-value*	95% CI
Knowledge			
Appropriate negative pressure room selection	1.95	.009*	1.18-3.22
COVID-19 symptoms appear to be milder in children than in adults	0.55	.003*	0.37-0.81
Education level: postgraduate degree	1.54	.031*	1.04-2.27
Age	0.98	.122	0.96-1.01

Abbreviations: 95% CI, 95% confidence interval; aOR, adjusted odds ratio; COVID-19, coronavirus disease 2019; PPE, personal protective equipment.
*Statistically significant result at the P < .05 level.

missing. In addition, it was a voluntary survey, and there was a short time frame and rapid changes associated to this pandemic. Thus, the results of respondents reflect opinions and perceptions only. Secondly, we did not use a systematic sampling strategy. Hence, the majority of responder were nurses and the sample size was small. Thus, It is possibly unrepresentative of the population of HCWs or IPC teams in Thailand. Finally, this study was an online survey conducted through a web survey service. As the data were self-reported, there is no guarantee that participants provided accurate demographic or characteristics data. Moreover, online surveys with closed-ended questions may have a lower validity rate than other question types and the *low response rate*.

Conclusion

The prevalence of optimized PPE use among HCW was 22%. Optimized PPE use was significantly associated with knowledge about appropriate negative pressure room selection, knowledge of apparently milder symptoms in children than adults, and a HCW with a postgraduate degree.

Author's Note

The study protocol was reviewed and approved by Institutional Review Board of BIDI, Ministry of Public Health, Thailand. The reference approval letter number is SO42h/63_ExPD. Manuscript demonstrate optimized personal protective equipment, COVID-19 pandemic, the several factors, it is suitable for publication. Preprint in PMC Europe.

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Author Contributions

V.M., V.T., and S.C. participated in the study design, wrote the protocol, and collected the data. V.M. and U.J. performed the statistical analyses. V.M. wrote this study. V.M., S.C., and P.P. coordinated, reviewed, and supervised the study. W.M. reviewed the data and revised the text. All authors have read and agreed to the published version of the manuscript.

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