MEDDOCS Open Access Publisher

ISSN: 2639-4391

Annals of Epidemiology & Public Health

Open Access | Research Article

Protective Behavior and Factor Associated with Inappropriate Personal Protective Equipment (PPE) Use among Frontline Disease Control Personnel during the Early Phase of Pandemic

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Received: Sep 26, 2022

Accepted: Oct 19, 2022

Published Online: Oct 21, 2022

Journal: Annals of Epidemiology and Public health

Publisher: MedDocs Publishers LLC

Online edition: http://meddocsonline.org/

Keywords: Protective behavior; Factor; Epidemiology; PPE; COVID-19; Seroprevalence.

Abstract

Background: Disease control personnel have an important role in preventing spreading of COVID-19, such as case screening, outbreak investigation, and contact tracing. This study aims to find out their protective behaviors and other associated factors with inappropriate PPE use, as well as the percentage of seropositivity by natural SARS-CoV2 infection in September 2020 during the period without any COVID-19 vaccine.

Methods: This is a cross-sectional study of 172 Thai Department of Disease Control personnel, which all had done questionnaires regarding demographic data and protective behavior. The blood test was performed to find out Neutralizing antibody titer (Nab) and Enzyme-Linked Immunosorbent Assay (ELISA). Data were analyzed using descriptive statistics and binary logistic regression was conducted for identifying factors associated with inappropriate Personal Protective Equipment (PPE) use.

Results: Of all 172 participants, 38 (22.1%) were Health Care Workers (HCW), 79 (45.9%) were Public Health Personnel (PHP), and 55 (32%) were Non-Health Workers (NHW). Most were female (130; 75.6%). Hand hygiene was the behavior with the highest proportion of being done every time among all participants during work (90.5%), while cleaning high-touch surface and using cashless system were done only a few or sometimes by most participants (55.9% and 56.1%, respectively). Middle age, less experience, and working as Public Health Officers, were associated with appropriate PPE use during work. Participants who had trained for PPE use at least once in the recent year practice inappropriate PPE use less than those who had not been trained, even though there were no significant differences.

Cite this article: Techasuwanna R, Thammawijaya P, Salakij B, Iamsirithaworn S, Praekunatham H, et al. Protective behavior and factor associated with inappropriate Personal Protective Equipment (PPE) use among Frontline Disease Control Personnel during the early phase of pandemic. A Epidemiol Public Health. 2022; 5(2): 1092

Conclusion: Cleaning high-touch surface and using cashless system should be more emphasized. Strengthening PPE use skills among all related personnel should be done, especially among NHW, by teaching, training, and frequently evaluating these skills before confronting the health risk.

Background

Since the outbreak of unknown viral pneumonia in Wuhan city, China, in December 2019, the pandemic of COVID-19 was declared on 11th March 2020. Department of Disease Control (DDC), Ministry of Public Health, Thailand, has been responsible for the control of the outbreak in Thailand. Many personnel were in charge of many risky tasks, which were outbreak investigation, international passenger screening at the point of entry, laboratory testing including nasopharyngeal and throat swabs, and others such as desk job forcing to face the high risk or confirmed COVID-19 patients. Temperature and symptom screening has been set since 3rd January 2020 at Suvarnabhumi and Don Mueang International Airport. People with high body temperature or respiratory tract infection were asked to get tested for respiratory viral panels or other tests regarding suspected disease since no genomic sequencing of SARS-CoV2 at the moment. With the rapid procedure of genomic sequencing of the SARS-CoV2 from China on 11th January 2020 [1], Thailand could diagnose the first case of COVID-19 passenger outside China very soon on 13th January 2020. After that, all passengers with suspected symptoms were asked to be quarantined and got tested in a hospital until the confirmation of a negative result of SARS-CoV2.

After the first case, there were more imported cases, followed by local transmission in the country. The first wave of the COVID-19 epidemic in Thailand occurred in March 2020 and took approximately 2 months from March to April, with the number of the hand total cases from March to August reported at 188 and 3,370, respectively (figure 1). Disease control personnel's tasks were mainly related to the preventive field, but not related to treatment. In previous studies, frontline Health Care Personnel were more likely to be infected with COVID-19 infection [2-5], especially frontline Health Care Workers (HCW) with high exposure to COVID-19 patients. However, there was data scarcity on risk behavior and infection rate among disease control personnel. Since protective behavior is an important tool for these frontline personnel, one crucial protective behavior is the appropriate use of PPE [2-3, 6]. Therefore, this study aims to describe the protective behaviors of these personnel in both daily lives and during work, identify factors associated with inappropriate PPE use, and assess the seroprevalence of SARS-CoV2 antibodies from natural infection among disease control personnel working at DDC after the first wave of the COVID-19 epidemic in Thailand, the period without any COVID-19 vaccines.

Methods

Study design and participants

This is a cross-sectional study aiming to assess protective behaviors and factors associated with inappropriate PPE use, and seroprevalence of SARS-CoV2 antibodies from natural COVID-19 infection in disease control personnel working on the frontline or doing tasks with a high risk of contracting the disease after the first wave of COVID-19 outbreak in Thailand. The data was collected in September 2020. Disease control personnel who were working at 4 study sites of the DDC; 1) Division of Epidemiology (DoE), 2) Institute for Urban Disease Control and Prevention (IUDC), 3) Division of International communicable Disease Ports and Quarantine (DIPQ), 4) Office of Disease Prevention and Control region 12 (ODPC-12) Songkhla, were invited to participate in this study. The Thailand DDC's main task is to prevent people from health threats and, hence, to reduce morbidity and mortality. The work is mainly related to the epidemiological field such as outbreak investigation and response, contact tracing, symptom screening at the point of entry, and collecting nasopharyngeal and throat swabs from risk persons. Some kinds of personnel's tasks may not be directly related to this, such as cleaning staff or the receptionists at the laboratory service for SARS-CoV2 for risk people. In this study, we classified disease control personnel into 3 categories; 1) Health Care Workers (HCW), professionals who provided clinical and health services, mainly doctors and nurses, 2) Public Health Personnel (PHP), mainly the public health technical officers working in operational and technical aspects of disease preventive services, 3) Non-Health Workers (NHW) whose provide non-health services to support HCW and PHP, such as cleaning (at the service area), data entry, public relation, etc.

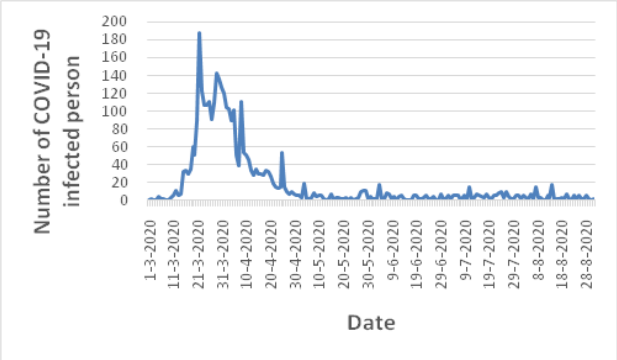

Figure 1: The first wave of the COVID-19 epidemic in Thailand.

The sample size was determined for the four aforementioned study sites under DDC as the target population, with confidence limits as +/- 3% of 100, and 50% anticipated frequency, the estimated sample size was 169, based on the formula from Schaeffer RL [7]. To avoid missed responses or failed blood specimens, we decided to collect 180 participants in case of a 10% loss. Due to a limited number of eligible and available personnel in the 4 study sites, we were finally able to collect 172 participants with blood samples and completed questionnaires. The inclusion criteria for participants are all personnel aged at least 18 years, and working within 2 meters with high-risk contact persons, such as outbreak investigation, collecting secretion from the suspected cases, temperature check and symptom screening at the points of entry and international airports. Exclusion criteria are people with immunodeficiency status, such as primary immunodeficiency, asplenia, taking any immunosuppressive medication, or other immunosuppressive conditions, because this status can cause undetectable immune titer and a false negative result could not be excluded. All eligible participants have been notified of the study's details and asked to sign an informed consent before blood collecting and filling out the questionnaire.

The procedures

All eligible participants have been described in all procedures in details and asked to sign a consent form before participating in the study. All eligible participants' blood was drawn and sent for conventional neutralization assay and enzyme-linked immunosorbent assay (ELISA). After that, they would answer a self-administered questionnaire. The questionnaires were divided into 3 parts. The first part consisted of demographic data

and work characteristics, the second part was the risk history of being infected, and the last part was risk behavior in daily life and during work. For blood tests, similar antibody results were interpreted as final results. For different results, only one positive neutralizing antibody was interpreted as immunity against SARS-CoV2 due to the very high specificity of the test [8-9]. However, the sample with a negative neutralizing antibody with positive ELISA would be further performed with Immuno fluorescent Assay (IFA) due to its lower specificity [10] and if both ELISA and IFA were positive, the result would be concluded as immunity against SARS-CoV2.

Statistical analysis

Risk behaviors were categorized using a 4-point Likert Scale. Four-point is doing that behavior every time (>95%), three-point is often (50-95%), two-point is sometimes (20-50%), and one-point is few (<20%).

Descriptive statistics were used to describe the working place, types of work, and risk behaviors. Chi-square tests were used to describe differences in categorial variables which were participants' demographic data and work characteristics. Independent t-tests were used to compare continuous variables which were age, work duration, and the number of contacts per person per day. We use binary logistic regression to assess the associations between participants' characteristics and inappropriate PPE use. The p-values lower than 0.05 were considered statistically significant. The data were analyzed with IBM SPSS statistics version 25.

Ethical issues

All procedures were performed under the approval of the Ethics Committee for Research in Human Subjects, Department of Disease Control, Thailand. The ethical number is FWA 00013622.

Results

Demographic data

Of all 172 participants, 38 (22.1%) were Health Care Workers (HCW), 79 (45.9%) were Public Health Personnel (PHP), and 55 (32%) were Non-Health Workers (NHW). Overall average age was 38.8 (SD 11.7) years and most were female (130; 75.6%). There were no significant differences in genders and age between HCW, PHP, and NHW. The median work duration was 34.5 (IQR 8-132) months (table 1).

Table 1: Demographic data and characteristics of work.

Data	Total (Percentage)	HCW	PHP	NHW	p-value
Number	172 (100%)	38 (22.1%)	79 (45.9%)	55 (32%)	-
Gender					
Male	42 (24.4%)	13 (34.2%)	13 (16.5%)	16 (29.1%)	0.069[a]
Female	130 (75.6%)	25 (65.8%)	66 (83.5%)	39 (70.9%)	
Average age (SD)	38.8 (11.7)	36.5 (9.8)	39.9 (11.9)	39 (12.5)	0.336[b]
Workplace					
DoE	55 (32%)	22 (57.9%)	30 (38%)	3 (5.5%)	<0.001[a]
IUDC	75 (43.6%)	14 (36.8%)	25 (31.6%)	36 (65.5%)	
DIPQ	30 (17.4%)	1 (2.6%)	14 (17.7%)	15 (27.3%)	
ODCP 12 Songkhla	12 (7%)	1 (2.6%)	10 (12.7%)	1 (1.8%)	
Work duration (months)					
Median (IQR)	34.5 (8-132)	24.5 (7.75-68.25)	50 (27-156)	13 (6-144)	0.108[b]

[a]Chi-square test, [b]Independent t-test

Table 2: Frequency of preventive behaviors among DDC personnel.

Behavior	Few	Sometimes	Often	Always	Median (IQR)	N
1. Behaviors in personaldaily life						
1.1 Cleaning hands with soap or alcohol gel after using the toilet, before having food, or after touching any fomites	2 (1.2%)	9 (5.2%)	74 (43%)	87 (50.6%)	4 (3-4)	172
1.2 Touching face, eyes, nose, mouth, including wound area[‡]	8 (4.8%)	28 (16.9%)	71 (42.8%)	59 (35.5%)	3 (3-4)	166
1.3 Sharing belongings, such as glass, dishes, and bowls[‡]	5 (3.4%)	6 (4.1%)	33 (22.6%)	102 (69.9%)	4 (3-4)	146
1.4 Practice physical distancing	17 (9.9%)	58 (33.9%)	69 (40.4%)	27 (15.8%)	3 (2-3)	171
1.5 Wearing mask while going out	1 (0.6%)	4(2.3%)	32 (18.6%)	135 (78.5%)	4 (4)	172
1.6 Cleaning high-touch surface	24 (14%)	72 (41.9%)	55 (32%)	21 (12.2%)	2 (2-3)	172
1.7 Using cashless system	25 (14.6%)	71 (41.5%)	61 (35.7%)	14 (8.2%)	2 (2-3)	171
2. Behaviors during work						
2.1 Cleaning hands before and after meeting with any persons during work	2 (1.2%)	0	14 (8.3%)	152 (90.5%)	4 (4)	168
2.2 Being careful about hand contamination to the face or other parts of your body	1 (0.6%)	3 (1.8%)	36 (21.3%)	129 (76.3%)	4 (4)	169
2.3 Taking sick leave while being sick	21 (13.1%)	23 (14.4%)	53 (33.1%)	63 (39.4%)	3 (2-4)	160

[†]Median and IQR of the sum score, [‡]Score has been reversed for mean calculation.

Behavior result

When it came to COVID-19 preventive behavior, participants often answered each question based on what they do in their everyday lives and at work. When they were unable to respond to a question, such as whether they used N95 at work and they had never used it, they could respond with not applicable (N/A), which will not be factored into the score. From a median score of risk behaviors, hand hygiene got full marks with the highest proportion of participants practicing good hand hygiene every time while working (152/168, 90.5%). On the other hand, of all behaviors, the lowest behavior's median scores occurred during daily life, which was using a cashless system and cleaning high-touch surface (table 2).

We collect all 9 risk behaviors associated with the inappropriate of using PPE (in supplementary table), including the method of wearing and taking off PPE. Out of 172, there were 142 participants reported these 9 behaviors regarding their frequency and the result could be further analyzed. We defined good behaviors as a sum score for each person more than 90% (at least 33 from 36). There were 40 of 142 participants who were defined as practicing poor behavior or inappropriate PPE use. After doing binary logistic regression, it shows that PHP and HCW used appropriate PPE more than NHW, even though there was a significant difference only between the PHP and NHW groups, that NHW used inappropriate PPE 5.574 times higher than PHP. Surprisingly, participants who had worked for more than 1 year were 2.4 times more likely to use PPE inappropriately than those who had worked for 1 year or less, significantly. Finally, participants age less than 31 years or more than 45 years tended to use PPE inappropriately by 4.954 and 4.425 times respectively higher than the middle age (31-45 years) significantly (table 3).

Table 3: Characteristics associated with inappropriate PPE use.

Characteristic	Inappropriate PPE use†	Crude OR[a] (95.0% CI)	Adjusted[b] OR (95.0% CI)
Gender			
Male	14 (38.9%)	1.958 (0.877-4.371) 1	-
Female	26 (24.5%)		
The main type of work			
HCW (total=34)	7 (20.6%)	0.875 (0.322-2.381)	1.787 (0.580-5.507)
PHP (total=70)	16 (22.9%)	1	1
NHP (total=38)	17 (44.7%)	2.732 (1.169-6.383)	5.574[α] (1.963-15.828)
Work duration			
≤ 1 year (total=46)	8 (17.4%)	1	1
> 1 year (total=96)	32 (33.3%)	2.375 (0.992-5.683)	6.348[α] (2.088-19.295)
Age (years)			
≤ 30 (total=54)	17 (31.5%)	2.625 (0.978-7.046)	4.954[α] (1.600-15.335)
31-45(total=47)	7 (14.9%)	1	1
≥ 46 (total=41)	16 (39%)	3.657 (1.320-10.133)	4.425[α] (1.440-13.599)
Frequency of PPE training within the recent year			
0 (total=11)	4 (36.4%)	1.964 (0.510-7.567)	
1 (total=60)	20 (33.3%)	1.719 (0.793-3.724)	-
≥ 2 (total 71)	16 (22.5%)	1	

[a]OR (95%CI): odds ratio (95.0% confidence interval), [b]Adjusted for all variables in the table, †Percentage by column. [α]with statistical significance (p-value < 0.05).

Supplementary table: Frequency of preventive behaviors during work related to PPE use among DDC personnel.

Behavior	Few	Sometimes	Often	Always	Median (IQR)	N
1 Wearing appropriate Personal Protective Equipment (PPE) during work	6 (3.7%)	10 (6.2%)	23(14.2%)	123 (75.9%)	4 (4)	162
2 Wearing PPE before meeting patients, any risk persons, or international passengers	7 (4.3%)	8 (5%)	21 (13%)	125 (77.6%)	4 (4)	161
3 Mask fit testing on N95 mask before working	8 (5.1%)	8 (5.1%)	33 (20.9%)	109 (69%)	4 (3-4)	158
4 No adjusting mask while meeting any risk persons	13 (7.9%)	10 (6.1%)	44 (26.7%)	98 (59.4%)	4 (3-4)	165
5 Put on PPE correctly (both method and ordering, according to Thailand Department of Disease Control's guideline)	5 (3.2%)	6 (3.9%)	28 (18.2%)	115 (74.7%)	4 (3-4)	154
6 Taking off PPE correctly (both method and ordering, according to Thailand Department of Disease Control's guideline)	5 (3.3%)	6 (3.9%)	25 (16.3%)	117 (76.5%)	4 (4)	153
7 Taking off gloves correctly	4 (2.5%)	2 (1.2%)	16 (9.9%)	139 (86.3%)	4 (4)	161
8 Taking off gown correctly (both method and ordering)	4 (2.6%)	8 (5.3%)	37 (24.3%)	103 (67.8%)	4 (3-4)	152
9 Taking of N95 correctly	3 (1.9%)	5 (3.1%)	39 (24.2%)	114 (70.8%)	4 (3-4)	161

Serological result

Blood results from both the neutralization test and the ELISA were negative in 171 (out of 172) individuals. Because one person had a negative neutralizing antibody but a positive ELISA, IFA was performed, and the outcome was negative. As a result, the seroprevalence of COVID-19 in DDC personnel was nil in September 2020.

Discussion

This study aims to know the risk behaviors and seroprevalence of SARS-CoV2 infection among disease control personnel working at the Department of Disease Control, Thailand. Since there was a scarcity of data in this group, this study revealed a new perception of risk behavior including the factors related to inappropriate PPE use, which could be useful to develop guidelines for their safety while working.

If only cleaning hands was considered, participants tended to be more cautious while working than when continuing their routine activities, which might be due to the awareness of international travelers and the fear of COVID-19 during the early stages of the pandemic. This could lead to a higher risk of getting an infection from daily activities than work, compatible with the result of HCW in the USA that the seropositivity is mainly associated more with community exposure than the causative factor from work or environment [11].

The most frequent improper risk behaviors were the low frequency of using the cashless system and sanitizing high-touch surface. There was no precise data on the risk of contracting the disease via using money papers or coins, but this activity could carry a risk of contact, similar to the risk of failing to clean high-touch surface. Surfaces are key sources of fomites such as SARS-CoV2 RNA, but these aren't a concern unless the viable fomite breakthrough oral and nasal mucosa, and this could carry a risk of indirect SARS-CoV2 transmission [12-17]. Cleaning high-touch surface like doorknobs and attempting to utilize fewer contact methods might be beneficial in this regard, and they may be encouraged more in Thailand.

When it comes to the appropriateness of using PPE among DDC personnel, factors significantly affected the proper use of PPE were types of work, age groups of participants, and duration of work. NHW, compared with HCW and PHP, were likely to use PPE the least appropriately, and this may result from the lower experience of using PPE among NHW before the COVID-19 origination. However, all DDC personnel's PPE practice for using the N95 mask was acceptable, with only 5.1% of all participants having never performed a fit test while using the N95 mask on duty against COVID-19, higher than another study among HCW [18], and most of the participants (69%) performed fit test every time.

Additionally, a higher frequency of training might reduce the risk of inappropriate PPE use, although there was no statistical significance. Regarding the crude OR, the risk of inappropriate PPE use among personnel who had not trained in the recent year was almost as twice of personnel who had trained at least one or more (Table 4). The result was in the same way as the previous studies, in which participants were both HCW and non-healthcare workers, did better not only the appropriate to prevent gaining and spreading infection, but also the optimization of using PPE [19-22]. Therefore, training should be forced in health policy not only in health care settings, but also in related work, such as laboratory and epidemiological settings, and evaluation should be done to find out training's effectiveness and consistency.

Surprisingly, among all participants, those who worked for longer periods (more than a year) used less suitable PPE than those with less experience, which is the opposite of our assumption nor the literature that ones with more work duration and experience had more protective behaviours and better compliance with PPE than another group [21,23],but correlated with another paper that HCW with more experience abided the protective measures lower than those with less experience [24]. We assume that the participants with more working experience maybe negligent and thought that their methods of using PPE were already appropriate without awareness of the current guideline.

For age-related factors, middle-aged participants (between 31 and 45 years) use PPE the most appropriately, and we assume that the middle age may have to bear the family burden or worry of spreading the infection to their old parents or young children at home. This result is similar to the previous study on protective behaviors during COVID-19 [25], which found that anxiety and afraid of death increased the protective behaviors via higher risk perception in the middle-aged group.

The zero outcome of SARS-CoV2 antibody might be due to the outbreak's modest spike, as well as the strong vigilance and dread of COVID-19. The result was also implied as no previous COVID-19 infection in this group since convalescent neutralizing antibodies have usually been detected for at least 6 months after the infection [26], although symptomatic infection usually generates higher IgG and neutralizing titer significantly [27].

Limitations

This study was conducted only on participants working at the Department of Disease Control, which may cause a problem of generalizability. However, the result of this study may be applied and used for personnel who do similar tasks or work in other public health settings. Another limitation was the data on risk behaviors was self-report, thus there might be some kinds of misclassification errors caused by memory or social desirability biases.

Conclusion

In conclusion, cleaning hands was the best protective behavior among disease control personnel, while cashless system and sanitizing high-touch surface were the worst protective behaviors. The factors associated with inappropriate PPE use were age, work duration, and the main type of work. The seroprevalence of SARS-CoV2 antibodies from natural infection was nil, implied that there was no infection among the personnel in the past.

We suggest that related state agencies should promote the awareness of fomite contacts among disease control personnel, even though there was no precise data on the risk of contracting SARS-CoV2 infection via this route, the activity could carry a risk of SARS-CoV2 contact via hands, and SARS-CoV2 at hands might be potential sources of COVID-19 infection by breaking through oral mucosa such as nasal cavities. Keeping the personnel posted via digital platforms may raise awareness and create a better solution to this topic. Finally, public health organizations responsible for disease control activities, as one of health policymakers, should strengthen PPE using skills among disease control personnel, especially among NHW, by teaching, train-

ing, and frequent evaluating these skills before confronting the health risk.

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