

# The Effect of Training on Knowledge, Perception, and Practice of Healthcare Personnel on the Use of Respiratory Protective Equipment during COVID-19 Pandemic at a Private Hospital in the Northern part of Thailand.

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## Abstract

**OBJECTIVES:** To determine the effect of the respiratory protective training program of healthcare personnel (HCP) during the Coronavirus Disease 2019 (COVID-19) pandemic at a private hospital in the northern part of Thailand.

**MATERIALS AND METHODS:** This cross-sectional study was conducted with 89 healthcare personnel (HCP) of Bangkok Hospital Phitsanulok, who required wearing a tight-fitting respirator during their duties and attended respiratory protective equipment (RPE) video-based training program regarding the general principles of respirator usage and guidelines on safely re-using RPE. A questionnaire-based assessment of participants' 3-month retention of knowledge and perception was conducted in April 2021. A qualitative fit test (QLFT) was used in terms of practice on RPE. The proportion of correct responses in the 3-month knowledge and perception score were compared with a pre-training test and an immediate post-training test using paired *t*-test. The same analysis was conducted with QLFT using McNemar's test.

**RESULT:** Various types of RPE were used in each test depending on the supply. The most commonly used RPE was N95 (58.4%), the majority of N95 was 3MVLFX 9105. Compared with the pretraining test, the proportion of correct responses in the immediate post-training test increased by 11% ( $p < 0.001$ ; 95% CI 1.07-2.23). Similarly, in 3-month post-training, the percentage of correct response also increased from pre-training by 10.4% ( $p < 0.001$ ; 95% CI 0.08-2.28). HCP had an excellent level of perception on using RPE during COVID-19. No significant change in perception was found between pretraining and both immediate and 3-months after training ( $p = 0.536$  and  $p = 0.384$  respectively). The pass rate significantly raised to 96.6% for an immediate post-training test ( $p < 0.001$ ) and to 98.8% after 3-month ( $p < 0.001$ ).

**CONCLUSION:** Training has played an important role to help HCP improve their knowledge and practice regarding the usage of RPE, but has no significant effect on perception. The assessment of knowledge, perception and practice retention of RPE usage after 3-month showed the positive impacts of video-based training groups on participants' knowledge and practice. Further evaluations are needed on the interventions that enhance HCP perceptions and attitudes on safety behavior. Pre- and in-service training programs for frontline HCP during a Coronavirus 19 disease pandemic need to be considered by Thai Ministry of Public Health.

**Keywords:** knowledge, perception, practice, respiratory protection equipment, SARS-CoV-2, Coronavirus Disease 2019 Pandemic, healthcare personnel, N95, qualitative fit testing

COVID-19 is a respiratory disease caused by the SARS-CoV-2 virus. It has spread from China to many other countries around the world, including Thailand. The virus is thought to spread primarily from person to person, including between people in close contact and through respiratory droplets produced when an infected person coughs or sneezes. These droplets can land in the mouths or noses of people nearby or can be possibly inhaled into the lungs.

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Healthcare personnel (HCP) are at the front line of the COVID-19 outbreak response and as such are at a very high occupational exposure risk, especially when performing any aerosol-generating procedures (e.g., intubation, dental procedure, cough induction procedures).<sup>1</sup> Over 150,000 infections and 1,413 deaths among HCP worldwide were reported on May 8, 2020.<sup>2</sup> Given their often extensive and close contact with vulnerable individuals in healthcare settings, control measures must be enforced in the workplace.

While engineering and administrative controls are considered more effective in minimizing exposure to SARS-CoV-2, personal protective equipment (PPE) e.g. gloves, goggles, face masks, and RPE may also be needed to prevent certain exposures. The types of PPE required during a COVID-19 pandemic were based on the risk of being infected while working.<sup>3</sup>

RPE, such as N95 or better, is recommended for HCP who work at high risk exposure of SARS-CoV-2.<sup>1</sup> The National Institute for Occupational Safety and Health (NIOSH) approved N95 filtering facepiece respirators or better must be used in the context of a comprehensive, written respiratory protection program that includes fit-testing, training, and medical exams according to OSHA's Respiratory Protection standard, 29 of the code of federal regulations (CFR) 1910.134. The Centers for Disease Control and Prevention (CDC)<sup>4</sup> also suggests training on indications for the use of N95 respirators<sup>5</sup>, currently there is no Thai regulation on using RPE yet.

However, lack of knowledge or improper use of RPE was found to be one of the most major occupational risks for COVID-19 infection among HCP.<sup>2</sup> The factors that influence RPE practices were individual's perceptions and knowledge.<sup>6</sup> Although, there is no study about the use of RPE among HCP in Thailand yet, the current study is an attempt to determine the level of knowledge, perceptions, and practice and the effect of training on using RPE among HCP at private hospitals in the northern part of Thailand.

## **Materials and Methods**

This cross-sectional study was conducted on a worker from Bangkok Hospital Phitsanulok who was enrolled in the study. Inclusion criteria comprised being a HCP, aged 18-60 years old, requiring a N95, equivalent or better while working or performing job tasks. Exclusion criteria comprised being unable to use RPE (failed medical-clearance), unable to taste sweet (failed the taste threshold test indicated individual unable to perform saccharin QLFT) and currently having acute upper respiratory tract infection which could affect taste ability.

Written informed consent was obtained and the study was approved by the Institutional Review Board (IRB) with COA number 2020-63 dated November 11, 2020.

## *Sample size*

The study was conducted in HCP at Bangkok Hospital Phitsanulok on HCP who required N95 or equivalent or better while working at an acute respiratory infection (ARI) clinic and ARI ward, emergency department, dental clinic, operating room/anesthesiology department, otolaryngology clinic, eye clinic, radiology department, intensive care unit (ICU), occupational medicine department, etc. In each department, there was a written hospital policy for specific procedures that require RPE.

A total of 122 workers have been recruited from such criteria. The correct responses of knowledge and the key parameters, were used to determine the power of this study. We assumed that each participant would have at least 20% of correct responses after training. At least 60% of 122 workers (74 subjects), would have 81% of power (calculated with the G\*power program, setting the effect size at the intermediate level).

## *Study Procedures*

Participants received a questionnaire (pre-training) to assess knowledge and perception of using RPE. Then, the first QLFT was tested as a baseline. Each participant was asked to use their own RPE (practically used in their jobs), which could be different due to supply shortages during the COVID-19 pandemic.

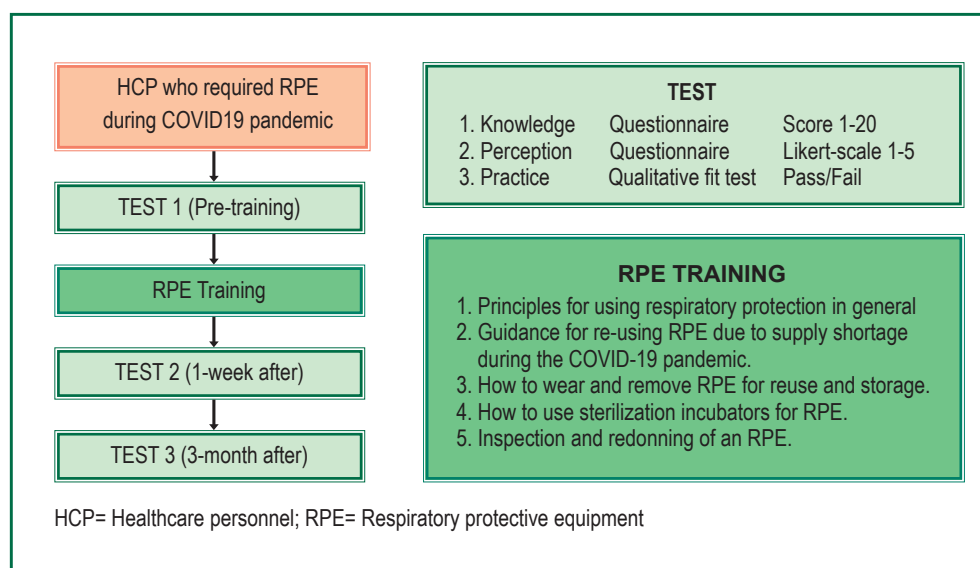
Afterwards, the researchers provided standard respiratory protective training using media. Later, the participants were tested with the same questionnaire (Post-test) and QLFT twice at 1-week and at 3-months to evaluate the results of the training at different times.

## *Investigation design*

The researchers inquired about the list of those who need a respirator with N95 or equivalent or better from relevant department directors. Then, the researcher sent a letter of invitation and explained the research process to that employee. A person could participate in this research voluntarily. Written informed consent was obtained. All subjects answered a respirator medical evaluation questionnaire<sup>7,8</sup> before participating in this study. The questionnaire was reviewed by occupational medicine physicians.

## *Questionnaire design*

A questionnaire based on the Occupational Safety and Health Administration (OSHA) Respiratory protection program standard requirements<sup>9,10</sup> and CDC/NIOSH guidance for optimizing respirator supplies (during COVID-19 pandemic)<sup>5</sup> was developed regarding HCP RPE knowledge and perception. Five occupational health and infection control experts (an infection control nurse, occupational medicine physicians, and nurses) assessed the validity of the



**Figure 1:** Study Procedure

questionnaires. The reliability of the questionnaires was checked by Cronbach's alpha (Cronbarh's alpha = 0.764).

The questionnaire, written in Thai, consisted of three components including demographic, knowledge (20 items), and perceptions (8 items). Knowledge items were categorized as true, false, or unknown. The perception was scored using a Likert scale, which ranged from 1 (completely disagree) to 5 (completely agree), all negative worded responses were scored reversely.

#### *Qualitative fit test (QLFT)*

QLFT is a pass/fail test to assess the adequacy of respirator fit that relies on the individual's sensory detection of a test agent. With the global impact of COVID-19, QLFT is the preferred method<sup>11</sup> to help slow the depletion of N95 respirators' inventory because the respirator used can be worn again after the test. The QLFT was performed by occupational medicine physicians according to OSHA Fit Testing Procedures (Mandatory)<sup>12</sup> using saccharin. Subjects who failed a taste threshold test were indicated unable to perform the fit test. The pass criterion for QLFT is inability to taste sweet in seven exercises (normal breathing, deep breathing, turning the head side to side, moving the head up and down, talking, bending over, and normal breathing).<sup>12</sup>

#### *RPE training*

According to the physical distancing policy during the outbreak, researchers were unable to organize training for all participants at once. Thus, we organized a sub-group training of no more than 20 people. The seating was arranged at a distance of at least 1 meter in a well-ventilated room. To provide the same standardized training for all sub-groups, the researcher designed training in the form of video media. It was divided into 5 videos which were

1. Principles for using respiratory protection in general.<sup>9,10</sup>
2. Guidance for re-using RPE due to supply shortage during the COVID-19 pandemic.<sup>5</sup>
3. How to wear and remove RPE for reuse and storage.
4. How to use sterilization incubators for RPE.
5. Inspection and redonning of an RPE.

The first two contents were no longer than 15 minutes, as it took the most attention,<sup>13,14</sup> the other three contents were only two minutes long. Two volunteers were invited to demonstrate how to put on and remove their RPE, to increase the effectiveness of the training through participation.<sup>15</sup> Participants were free to ask questions throughout the training. These training videos were published via the Bangkok Hospital Phitsanulok application for all employees to access training or to review their knowledge.

Of the 89-HCP completing the training and pre-training test and immediately after-training test, 81 (91%) participated in the 3-month test. Eight participants could not be included in the 3-month test, of these three had resigned from the hospital and five refused to participate when contacted (Figure 2).

#### **Results**

A total of 89-HCP found 77 (86.5%) females and 12 (13.5%) males. Participants were between 21 and 52 years old shown in Table 1. More than a half (57.3%) of participants were nurses, 20.2% were practical nurses, only 5.6% were doctors/dentists. The majority (41%) of the study participants were working at the acute-respiratory-infection unit (both outpatient and inpatient department). Average job experience was 9.5 years and experience of using RPE was 4.5 years (Table 1).

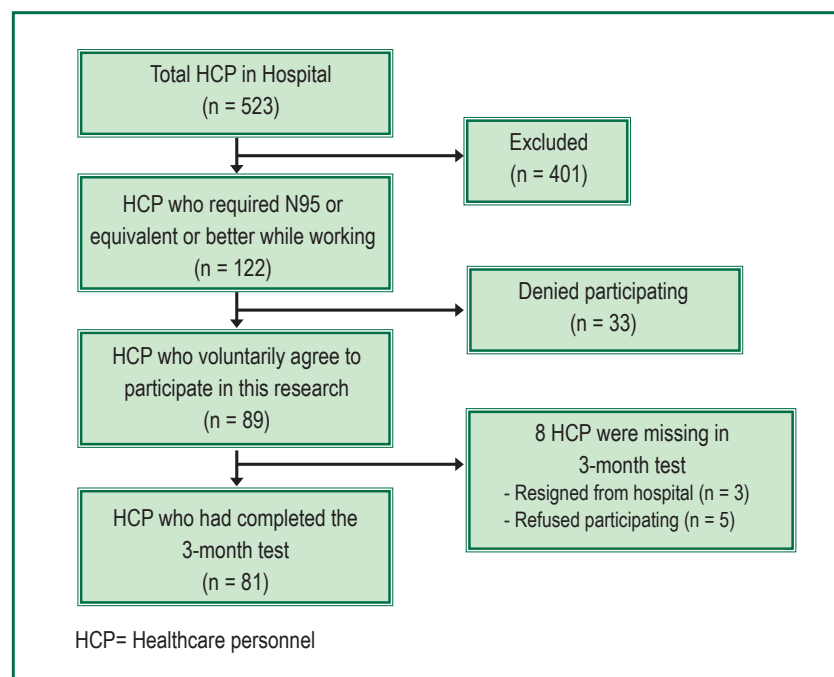


Figure 2: Study inclusion flow diagram

## Results

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Various types of RPE were used in each test depending on the supply. The most commonly used RPE was N95(58.4%), the majority of N95 was 3MVLFX 9105. Numbers of KN95 were used in the first test then the number decreased (24.7%, 6.7%, and 0% respectively) due to its fitting issue. (Appendix: Table C)

*Comparison between pre-training, immediately after training, and three months after training.*

## Knowledge

Results of knowledge assessment of the participants regarding the use of respiratory protection in general and guidance for re-using RPE due to supply shortage during the COVID-19 pandemic in the pre-training, immediate post-training, and 3-month are shown in Table 2. We observed a significant improvement of knowledge after training relative to pre-training. Compared with the pre-training test, the proportion of correct responses in the immediate post-training test increased by 11% ( $p < 0.001$ ; 95% CI 1.07-2.23). Similarly, in the 3-month post-training, the percentage of correct responses also increased from pre-training by 10.4% ( $p < 0.001$ ; 95%CI 0.08-2.28). We found no significant change in knowledge between immediate post-training and 3-month post-training ( $p = 0.314$ ). (Figure 3)

Table 1: Demographics of participants (n = 89)

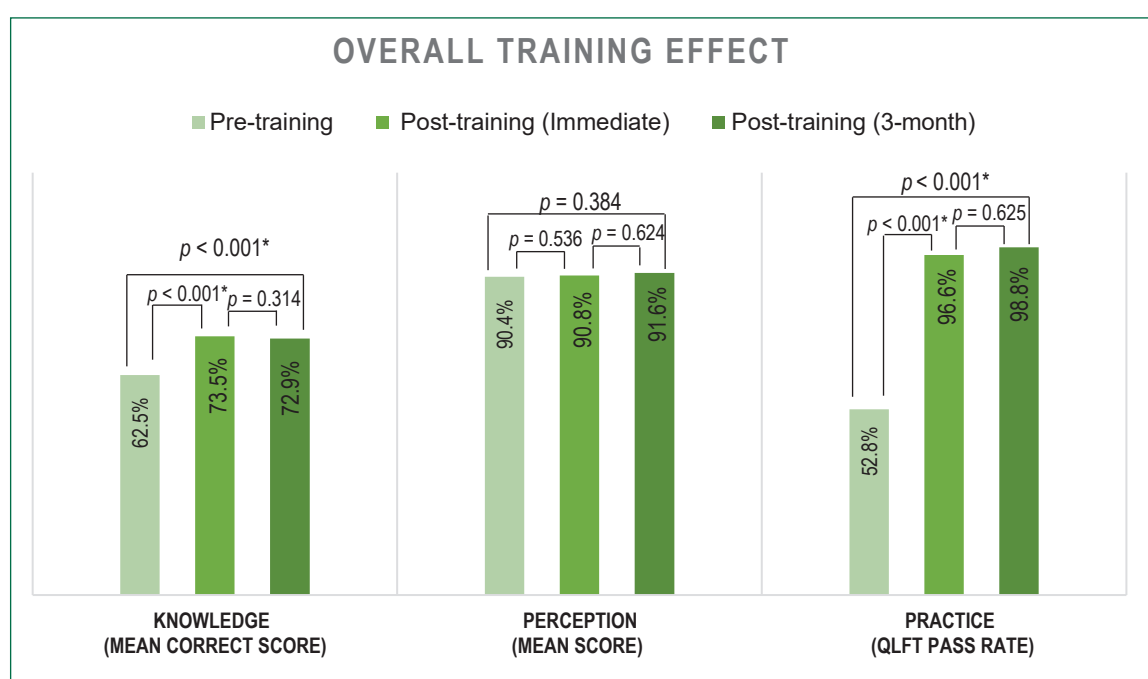
Demographic	n (%)
Gender	
Male	12 (13.5)
Female	77 (86.5)
Age group (years)	
21-30	39 (43.8)
31-40	30 (33.7)
41-50	18 (20.2)
>50	2 (2.2)
Job	
Physician/Dentist	5 (5.6)
Nurse	51 (57.3)
Practical nurse	18 (20.2)
Technician/Escort	9 (10.2)
Janitor	6 (6.7)
Department	
ARI Clinic	19 (21.3)
ARI Ward	22 (24.7)
Emergency department	11 (12.4)
Dental Clinic	4 (4.5)
ICU	5 (5.6)
Operating Room/anesthesiology department	8 (9.0)
Otolaryngology/Eye Clinic	3 (3.4)
Radiology Department	6 (6.7)
Other	11 (12.4)
Job experience (years)	
Mean $\pm$ SD	9.52 $\pm$ 7.10
Range	1 - 28
History of using RPE (years)	
Mean $\pm$ SD	4.50 $\pm$ 4.20
Range	1 - 20

ARI=acute respiratory infection  
ICU=intensive care unit  
RPE=respiratory protective equipment

**Table 2:** The knowledge, perception and practice before and after training, and their retained knowledge after 3-months.

	TEST1 Pre-training	TEST2 Post-training (immediately)	TEST3 Post-training (3-month)	TEST2 VS TEST1		TEST3 VS TEST1	
	n = 89	n = 89	n = 81	p	95% CI	p	95% CI
Knowledge (Mean ± SD)	13.04 ± 2.24	14.70 ± 2.40	14.58 ± 2.70	< 0.001 <sup>a</sup>	1.07 - 2.23	< 0.001 <sup>a</sup>	0.08 - 2.28
Perception (Mean ± SD)	36.15 ± 3.11	36.33 ± 2.35	36.62 ± 2.64	0.536 <sup>a</sup>	-0.34 - 0.76	0.384 <sup>a</sup>	-0.43 - 1.09
Practice (QLFT) (Pass rate)	52.8%	96.6%	98.8%	< 0.001 <sup>b</sup>		< 0.001 <sup>b</sup>	

\* Significant, <sup>a</sup> Paired T-test, <sup>b</sup> McNemar test, QLFT; Qualitative fit test  
 Knowledge score range 1-20, Perception score range 5-40, QLFT Pass/Fail

**Figure 3:** Comparison of proportions of the mean score and QLFT pass rate to each aspect (knowledge, perception, and practice) between three tests.

Conducting the comparison of knowledge separately for each job revealed an improvement among all groups. (Figure 4) Physicians/dentists and nurses had the highest pre-training knowledge correct response (69%, 66.9% respectively), while the lowest were technicians/escort staff and janitors (53.8% and 61.8% respectively). Surprisingly, after training, the janitors had the second-highest correct responses inferior to physicians/dentists (78.4% and 79% respectively). Although, after training, practical nurses became the lowest knowledge score group (68.8%).

When compared to the pre-training test, the percentage of correct responses increased significantly among nurses, technician/escort staff, and janitors ( $p < 0.001$ ,  $p = 0.002$ , and  $p = 0.004$  respectively). For physicians/dentists and practical nurses had an increasing correct percentage of 10% and 3.6% respectively. (Figure 4) The detail of knowledge questions has been shown in Appendix 1 (Table B).

### Perception

No significant change in perception on RPE usage was found between pre-training and both immediate and 3-month after training ( $p = 0.536$  and  $p = 0.384$  respectively) (Table 2). For the pre-training test, the overall mean percentage of mean perception was 90.4%, then slightly increased by 0.8% and 1.15% for immediately and 3-month after training.

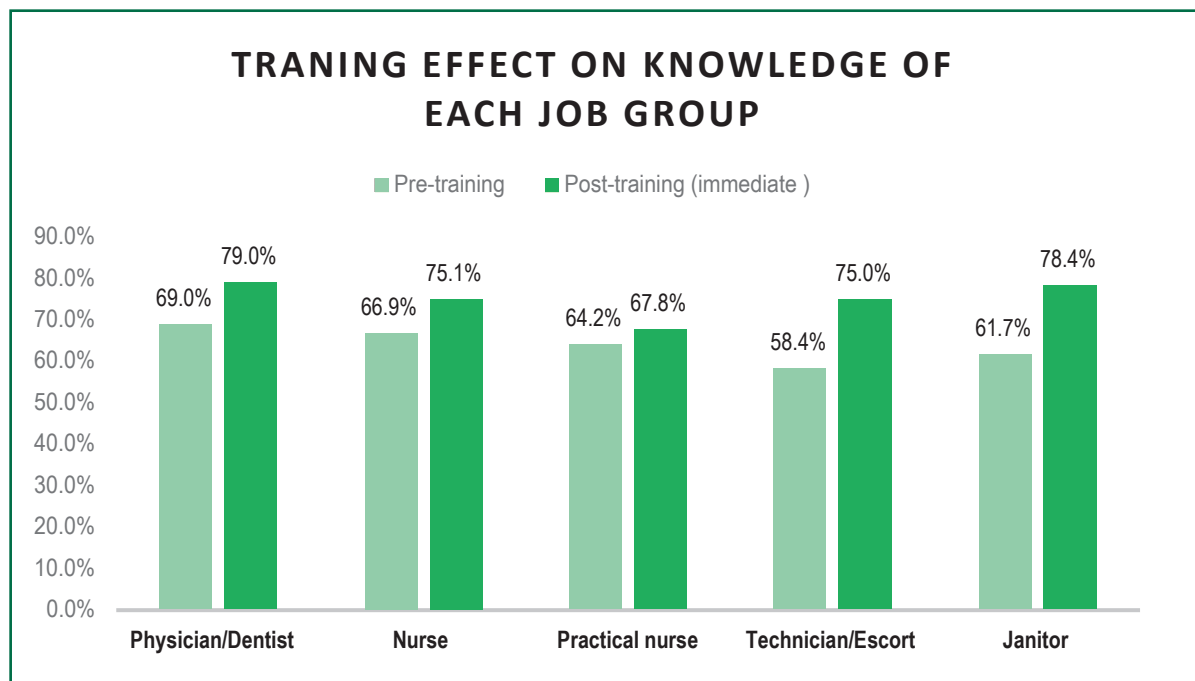
### Practice

When performing a pre-training QLFT, only 52.8% of participants had passed the test. As shown in Figure 3, the pass rate significantly rose to 96.6% for an immediate post-training test ( $p < 0.001$ ). In the 3-month follow-up test, the percentage of the pass rate still significantly increased ( $p < 0.001$ ) to 98.8% compared to pre-training.



Results from the pre-training participant's performance in each RPE type are shown in Table 3. Among all RPE, we observed that KN95 had the lowest pass rate 4.5%, while the 3M 1800 series (1860 and 1870) had the best performance

with a 100% pass rate. (Table 3) After training, 42-HCP, who had failed the pre-training fit test, had all passed the second fit test using three different interventions shown in Figure 5.

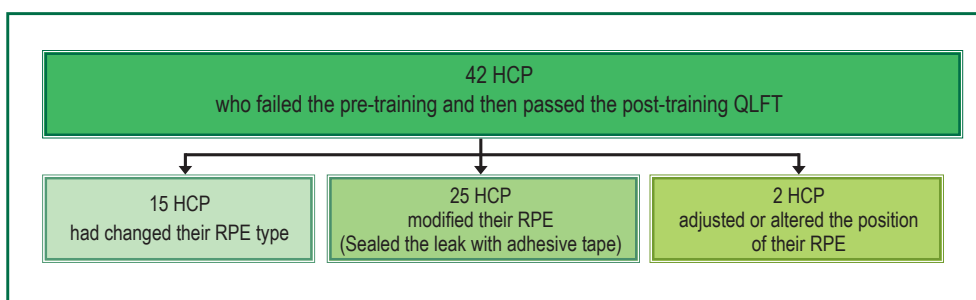


**Figure 4:** The comparison of proportions of a correct response on knowledge of each job group. (EMT/Escort staff; help transfer patient)

**Table 3:** The relationship between respiratory protection equipment (RPE) type with the qualitative fit test (QLFT) on pre-training practice (n=89)

RPE type	Pre-training Practice of QLFT		p
	Fail (n (%))	Pass (n(%))	
KN95	21 (95.5)	1 (4.5)	< 0.001 <sup>a</sup>
N95			
3M 1860	0 (0)	3 (100)	
3M 1870	0 (0)	15 (100)	
3M VFlex 9105	17 (53)	15 (47)	
3M 8210	1 (50)	1 (50)	
GIKO 1200H	0 (0)	1 (100)	
Half-face piece elastomeric respirators	3 (21.4)	11 (78.6)	

\*significant, <sup>a</sup>Fisher's exact test



**Figure 5:** Interventions for healthcare personnel (HCP) who failed the pre-training qualitative fit test (RPE; Respiratory protective equipment)

## Discussion

The rapidly spreading COVID-19 has become a challenge for health systems over the world, and frontline HCP have faced a major crisis because of a limited supply of RPE. N95 respirators are the commonly used PPE to control exposure to infectious pathogens transmitted via the airborne route. N95 respirators are intended to be used once. However, given the supply shortage, many hospitals have no option but to optimize or re-using disposable RPE such as N95. Related to a study of knowledge of HCP among COVID-19 pandemic, Ahmed N. et al., also found that most of the HCP have adequate knowledge about the disease, but they also require additional training on disinfection protocols and the re-use of N95 masks<sup>17</sup>. Thus, video-based training on the principle of general practice on using RPE, CDC's guidance for safely re-using RPE, how to wear and remove RPE for reuse and storage, how to use sterilization incubators for RPE, and inspection and redonning of an RPE were provided in this study with the intention of assisting HCP in working safely during the pandemic.

The aims of this study were first to assess the effect of training on knowledge, perception, and practice of HCP regarding the use of RPE during the COVID-19 pandemic, and it revealed obvious findings with important policy implications. Clearly, training is important as it helps HCP improve their knowledge and practice of using RPE against SARS-CoV-2 and other respiratory hazards, but the training has no significant effect on perception. Overall, when compared to the pre-training test, participants' knowledge of the use of RPE increased significantly immediately after training and 3-months later. As well as the practice, both immediately after-training fit test and 3-month after, the pass percentage of QLFT significantly increased. Even though the training had a slight impact on the perception, the results indicated that most of the studied HCP had an excellent level of perception on using RPE during COVID-19. Similarly, to Hughes et al.,<sup>18</sup> knowledge could be improved by training, while perceptions are influenced by individuals' beliefs and social norms.<sup>19</sup>

The second aim of this study was to investigate the retention of 3-month knowledge, perception, and practice after training. The results indicated, the same as many studies<sup>20,21</sup> that knowledge, perception and practice were good and revealed no significant decline after 3-month months. Since HCP tend to have long-term knowledge<sup>22,23</sup>, authors suggest that RPE training should be provided annually and QLFT should be performed at least once a year or whenever the type of RPE is changed or individual's major facial structure is transformed.<sup>4-6,12,13</sup>

To address the impact of training on RPE usage, we found that janitors had been trained by the employers, regarding how to wear and remove their respirators before participating in the study. As a result, all janitors passed their first QLFT. On the other hand, without information on general practice on RPE usage and guidelines on re-using respirators provided, their pre-training knowledge scores were low. After video-

based training, their knowledge was significantly improved. In conclusion, the RPE training is fundamental for all allied health care workers.

The performance of tight-fitting respirators relies on achieving a good seal between the facepiece of the respirator and the wearer's face. Besides the type, size and shape of respirator has a significant impact on the fit test result. Similar to Ekprechakul et al.,<sup>24</sup> we observed that the K95 gave the poorest performance. An ear-loops K95 provided less seal on the wearer's face compared to other headband-designed respirators in this study. On the other hand, the 3M 1800 series, the three-panel foldable design gave the best performance. We also discovered that the 3M 1800 series was the most preferred respirator in the study because it is easier to store and can be fitted to a wider range of face shapes and sizes than traditional cup shape respirators.

This study was conducted in the middle of COVID-19 pandemic, many types of RPE had a shortage of supply. Interestingly, we observed that 25 of 42 HCP, who previously failed a fit test, could have passed the second and third fit test after the respirator was modified with adhesive tape. Two of 42-HCP have passed the second test after they re-adjusted the facepiece and the straps along the sides of their head until a proper seal was achieved. Several studies during the COVID-19 pandemic have recently confirmed that an adhesive modification enhances respirator's fit and improves its efficacy.<sup>24,25</sup> Therefore, we strongly recommend a modified adhesive respirator in an event of future RPE supply shortages.

## Strengths and limitations

The strength of this study lies in the benefit of the immediate positive impact of training on using RPE for both oneself and the hospital. The HCPs who failed the pre-training QLFT were guided and instructed on how to properly wear and fit their RPE. Also, the training brings good attention to the correct use of RPE during the COVID-19 pandemic. In a situation where large group training was not possible, using video-based training helped standardize the trainings between each group. However, the study has some limitations. First, the subjects who were recruited and met the inclusion criteria were free to agree or disagree to participate in the study which may cause selection bias. And second, since there is a shortage of supply of RPE during COVID-19, the type of RPE used in each test may be different which could influence pre-post training practice results. (Appendix: Table C)

## Conclusions

Training is essential for HCP to improve their knowledge and practice regarding the usage of RPE but has no significant effect on perception. The assessment of knowledge, perception and practice retention of RPE usage after three months showed the positive impacts of video-based training groups on participants' knowledge and practice. Further evaluations are needed on the interventions that enhance HCP perceptions and

attitudes on safety behavior. In conclusion, we would like to emphasize the importance of RPE training. In the context of the COVID-19 pandemic, there is a worldwide shortage of respirators, the re-using and decontamination of respirators are novel concepts for HPC all over the world.

### Conflict of Interest

The authors declare that there was no conflict of interest.

### References

1. Occupational Safety and Health Administration. Guidance on preparing for workplaces for COVID-19. 2020 (Accessed May 27, 2020, at <https://www.osha.gov/sites/default/files/publications/OSHA3990.pdf>.)
2. World Health Organization. WHO calls for healthy, safe and decent working conditions for all health workers, amidst COVID-19 pandemic. 2020. (Accessed May 27, 2020, at <https://www.who.int/news-room/detail/28-04-2020-who-calls-for-healthy-safe-and-decent-working-conditions-for-all-health-workers-amidst-COVID-19-pandemic>)
3. The Centre for Evidence-Based Medicine (CEBM). COVID-19 How many Healthcare workers are infected?. 2020. (Accessed May 27, 2020 at <https://www.cebm.net/COVID-19/COVID-19-how-many-healthcare-workers-are-infected/>)
4. United States Department of Labor. 1910.134 - Respiratory Protection. | Occupational Safety and Health Administration. 2011. (Accessed May 27, 2020, at <https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.134>)
5. United States Department of Labor. Hospital respiratory protection program toolkit: Resources for respirator program administrators. 2015. (Accessed May 27, 2020, at <https://www.osha.gov/sites/default/files/publications/OSHA3767.pdf>)
6. Centers for Disease Control and Prevention (CDC). Strategies for Optimizing the Supply of N95 Respirators: COVID-19. 2020. (Accessed May 27, 2020, <https://www.cdc.gov/coronavirus/2019-ncov/hcp/respirators-strategy/index.html>)
7. Degesys NF, Wang RC, Kwan E, et al. Correlation Between N95 Extended Use and Reuse and Fit Failure in an Emergency Department. *JAMA* 2020;324(1):94-6.
8. Honarbakhsh M, Jahangiri M, Ghaem H. Knowledge, perceptions and practices of healthcare workers regarding the use of respiratory protection equipment at Iran hospitals. *J Infect Prev* 2018;19(1):29-36.
9. United States Department of Labor. 1910.134 App C - OSHA Respirator Medical Evaluation Questionnaire (Mandatory). Occupational Safety and Health Administration. (Accessed May 27, 2020, at <https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.134AppC>)
10. Summacheeva Foundation. Respirator Medical Evaluation Questionnaire [in Thai]. 2018:1-12. (Accessed May 27, 2020, at <https://drive.google.com/file/d/1FTaGZLkKUI1QZ30oeaEuyuJwMikup8yc/view>)
11. United States Department of Labor. Safety and Health Topics | Respiratory Protection - General Guidance | Occupational Safety and Health Administration. (Accessed May 27, 2020, at <https://www.osha.gov/SLTC/respiratoryprotection/guidance.html>)
12. Centers for Disease Control and Prevention (CDC). The Need for Fit Testing During Emerging Infectious Disease Outbreaks. 2020. (Accessed May 27, 2020, at <https://blogs.cdc.gov/niosh-science-blog/2020/04/01/fit-testing-during-outbreaks/>)
13. United States Department of Labor. 1910.134 App A - Fit Testing Procedures (Mandatory). Occupational Safety and Health Administration. (Accessed May 27, 2020, <https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.134AppA>)
14. Burke LA, Ray R. Re-setting the concentration levels of students in higher education: an exploratory study. *Teach High Educ* 2008;13(5):571-82.
15. Stuart J, Rutherford RJ. Medical student concentration during lectures. *Lancet* 1978;2(8088):514-6.
16. Martin BO, Kolomitro K, Lam TCM. Training Methods: A review and analysis. *Hum Resour Dev Rev* 2014;13(1):11-35.
17. Ahmed N, Shakoor M, Vohra F, et al. Knowledge, Awareness and Practice of Health care Professionals amid SARS-CoV-2, Corona Virus Disease Outbreak. *Pak J Med Sci* 2020;36(COVID-19-S4):S49-S56.
18. Hughes P, Ferrett E. Introduction to health and safety in construction: for the NEBOSH national certificate in construction health and safety. 5<sup>th</sup> Edition by Routledge, Taylor & Francis Group. London and New York. 2016.
19. Eccles M, Grimshaw J, Walker A, et al. Changing the behavior of healthcare professionals: the use of theory in promoting the uptake of research findings. *J Clin Epidemiol* 2005;58(2):107-12.
20. Govender K, Rangiah C, Ross A, et al. Retention of knowledge of and skills in cardiopulmonary resuscitation among healthcare providers after training. *SA Fam Pract* 2010;52(5):459-62.
21. Sankar J, Vijayakanthi N, Sankar MJ, et al. Knowledge and skill retention of in-service versus preservice nursing professionals following an informal training program in pediatric cardiopulmonary resuscitation: A repeated-measures quasiexperimental study. *Biomed Res Int* 2013;2013:1-7.
22. Osei-Ampofo M, Tafoya MJ, Tafoya CA, et al. Skill and knowledge retention after training in cardiopulmonary ultrasound in Ghana: an impact assessment of bedside ultrasound training in a resource-limited setting. *Emerg Med J* 2018;35(11):704-7.

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23. Wu S, Li R, Su W, et al. Is knowledge retained by healthcare providers after training? A pragmatic evaluation of drug-resistant tuberculosis management in China. *BMJ Open*. 2019;9(3):e024196.
24. Ekprechakul T, Saiphironthong W, Chaiwong W, et al. Quantitative fit tests of selected respirators for health care workers caring for patients with confirmed or suspected COVID-19. *BKK Med J* 2020;16(2):196-9.
25. Wardhan R, Brennan MM, Brown HL, et al. Does a Modified Adhesive Respirator Improve the Face Seal for Health Care Workers Who Previously Failed a Fit Test?: A Pilot Study During the Coronavirus Disease 2019 Pandemic. *A Pract* 2020;14(8):e01264.

## Appendix

**Table A:** Test questions in the knowledge about RPE usage in general and guidance of reusing during COVID-19 pandemic.

Question
1. To deal with patients with chickenpox, airborne precautions must be taken and N95 must be used.
2. Surgical masks can be used as a protection from airborne particles.
3. N95 are suitable protection against gases and vapours from chemicals.
4. Each person should wear a respirator that fits his or her face.
5. Surgical masks are just as effective against biological agents as N95.
6. Surgical masks with a seal tape on the edge can be used against PM2.5 instead of N95.
7. RPE must be cleaned with alcohol.
8. Each time RPE is worn, a seal check should be performed.
9. After decontaminated, RPE must be left to dry before storing.
10. Face Shield can be used against droplets instead of surgical masks.
11. Preliminary data from CDC guidance suggests limiting the number of reuses to no more than ten uses per device to ensure an adequate safety margin.
12. In case of emergency, another person's N95 can be used if it has been decontaminated.
13. FFP2 is as effective as N95 against airborne particles.
14. When performing procedures that are at high risk of exposure to blood or secretions, a surgical (waterproof) N95 must be used or a surgical mask must be worn over a non-waterproof N95 to prevent water spray.
15. The most significant risk from reusing N95 is aerosol transmission.
16. Discard any respirator that is obviously damaged or becomes hard to breathe through or an elastic band becomes loose.
17. Consider use of a cleanable face shield over an N95 respirator, when feasible to reduce surface contamination of the respirator.
18. After ETT suction of the COVID-19 patient, N95 must be decontaminated immediately before putting it back.
19. Avoid touching the inside of the respirator. If inadvertent contact is made with the inside of the respirator, discard the respirator and perform hand hygiene.
20. Decontaminated N95 must be stored in a ziplock bag to prevent air and moisture.

PM2.5; Particulate matter 2.5, RPE; Respiratory protection equipment, COVID-19; coronavirus disease 2019, ETT; Endotracheal tube, CDC; Centers for Disease Control and Prevention

**Table B:** Perception on RPE usage in general and during COVID-19 pandemic.

Question
1. I believe that HCP are mindful of the respiratory risks associated with their work.
2. I believe that hospital employees should have their respiratory systems checked at least once a year.
3. Hospital personnel should be trained on how to use and safely reuse RPE, such as N95.
4. I think the staff should not have contact with COVID-19 suspected patients without using RPE.
5. I think using N95 alone is not enough to protect against COVID-19.
6. I believe that the respirator's fit on the user's face is critical to its performance.
7. I believe that respiratory pathogens in hospitals are not so dangerous that RPE is required.
8. I think short contact with COVID-19 suspected patients using surgical mask is not dangerous.

HCP; Healthcare personnel, RPE; Respiratory protection equipment, COVID-19; coronavirus disease 2019

**Table C:** Respiratory protection equipment (RPE) type used in each test

	TEST 1 Pre-training (n = 89)	TEST 2 Post-training (immediately) (n = 89)	TEST 3 Post-training (3-month) (n = 81)
N95			
3M 1860	3 (3.4)	4 (4.5)	5 (5.6)
3M 1870	14 (15.7)	13 (14.6)	5 (5.6)
3M 8210	2 (2.2)	3 (3.4)	13 (14.6)
3M VFlex 9105	32 (36)	40 (44.9)	30 (33.7)
GIKO 1200H	1 (1.1)	1 (1.1)	0 (0)
KN95	22 (24.7)	6 (6.7)	0 (0)
Half-face piece elastomeric respirators	14 (15.7)	22 (24.7)	28 (31.5)