ABSTRACT

Background: The appropriate use of personal protective equipment (PPE) can significantly reduce the risk of infection associated with caring for patients. This study aimed to investigate the knowledge, awareness, and behaviors related to the PPE usage among frontline nurses in a nationally designated coronavirus disease 2019 (COVID-19) hospital during the COVID-19 pandemic.

Materials and Methods: The study was performed in two phases: (1) a questionnaire survey to assess the knowledge, awareness, and behaviors related to PPE use, and (2) in-depth personal interviews to elaborate the survey findings. The questionnaires were distributed to all 121 registered nurses in three isolation wards and an intensive care unit which dedicated for patients with COVID-19 and 102 nurses completed survey (84.3% response rate). In-depth interviews were conducted with a total of 7 nurses.

Results: Among the survey participant, 100% stated that they knew how to protect themselves while providing nursing care and 93.1% stated that they knew the recommended PPE by task. Most survey participant mainly wore gloves, face shield, N95 or equivalent respirator, and a long-sleeved gown, but one-third of the participants sometimes used coveralls instead of long-sleeved gown. In-depth interviews, the importance of timely updated and specific guidelines for selecting the appropriate type of PPE was highlighted. The adequate supply of PPE, convenience at work, and the role of responsible leadership mainly determined behaviors related to the PPE.

Conclusion: As new information on COVID-19 continues to emerge, the up-to-date and specific PPE guideline with evidence should be prepared. The spread of accurate information, the role of accountable leadership, and the active communication under positive organizational culture are important for the proper use of PPE.

Keywords: COVID-19; Personal protective equipment; Healthcare personnel; Prevention and control
INTRODUCTION

With the spread of the coronavirus disease 2019 (COVID-19) pandemic, healthcare workers (HCWs) are at a greater risk of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) infection due to the nature of their work. In a meta-analysis conducted early in the pandemic, HCWs comprised 10% of all confirmed COVID-19 cases [1]. Although there is limited evidence on the type of personal protective equipment (PPE) that offers the best protection, the appropriate use of PPE can significantly reduce the infection risk associated with caring for patients with COVID-19 [2].

In January 2020, the first case of COVID-19 in Korea was reported [3]. Initially, following the example of the Middle East Respiratory Syndrome (MERS) outbreak, the Korea Disease Control and Prevention Agency (KDCA) guidelines recommended coveralls with foot covering, gloves, goggles or face shield, and N95 or equivalent respirator in any situations involving any contact with suspected or confirmed patients, and powered air purifying respirator (PAPR) for aerosol generating procedures (AGPs) [4]. However, these recommendations differed from those of the World Health Organization (WHO) or other regions and even raised the issue of PPE shortage [4-7]. The subsequently revised guidelines allowed HCWs to choose between coveralls with foot covering and a long-sleeved gown for contact precautions and stated that PAPR was not necessarily required when performing AGPs [8, 9]. Nevertheless, this change may have caused misunderstanding and confusion among HCWs [4].

In the context of the pandemic, HCWs play a critical role in providing care for patients with COVID-19. Frontline HCWs such as nurses and physicians in the intensive care unit or isolation wards should ensure the appropriate use of PPE to protect themselves and prevent nosocomial spread. Simultaneously, there are hurdles in using PPE optimally, including higher patient volumes, unavailability of equipment, increased anxiety and fear, dearth of information, and ambiguity in recommendations. However, few studies have examined the current status of PPE usage and related factors among HCWs during the COVID-19 pandemic [10]. Thus, this study aimed to evaluate the knowledge, awareness, and behaviors related to PPE usage among frontline nurses in a nationally designated COVID-19 hospital in Korea during the COVID-19 pandemic.

MATERIALS AND METHODS

1. Study setting
This study was conducted at the National Medical Center (NMC), a 480-bed public hospital in Seoul, Korea. The hospital was designated by the Korean government as a national center for emerging infectious diseases since the MERS outbreak in 2015 and as the initial receiving center for critical patients with COVID-19 during the first wave of pandemic admissions. During the study period, the NMC operated 3 cohort isolation wards with a total of 44 beds for patients with moderate illness, and an intensive care unit (ICU) with 16 beds for patients with critical illness. According to the KDCA guidelines, the initial NMC PPE recommendation for COVID-19 patient care was coveralls with foot covering for contact precautions, goggles or face shields for eye protection, N95 or equivalent respirators for respiratory protection, and PAPRs for AGPs. From the August 2020, “four-item sets” including gloves, goggles or face shield, N95 or equivalent respirator, and long-sleeved gowns were added to the NMC recommendations. Thereafter, HCWs have been able to choose...
between the four-item set and a previously recommended set that included coveralls with foot covering at their own discretion. Figure 1 presents the timeline for the change of PPE recommendations, the hospital setting, and the study period.

2. Study design, participants, and data collection

We performed the study in two distinct phases: a questionnaire survey and in-depth face-to-face interview between May 11 and May 21, 2021 [11, 12]. The questionnaire survey was conducted to assess the knowledge, awareness, and behaviors related to PPE usage among nurses providing care to patients with COVID-19. The in-depth interview further elaborated the survey findings by exploring participants' views, experiences, and reasons of behavior [13, 14].

For the quantitative phase, we developed a self-administered questionnaire based on previous studies related to the 2009 H1N1 influenza pandemic [15-17]. The survey questionnaire was broadly divided into four sections (Supplementary Survey File). The first section comprised questions associated with participants' demographic characteristics. The second section was designed to examine participants’ knowledge and information sources regarding PPEs. The third section was designed to investigate participants’ awareness of PPE. The participants were asked to report how helpful they thought each PPE item was to prevent COVID-19 infection. The listed PPEs were as follows: N95 or equivalent respirator, gloves, goggles, face shields, long-sleeved gowns, coveralls with foot covering, and PAPRs. The final section was made up of questions to assess the participant’s behavior and inconvenience experienced for each listed PPE. A 5-point Likert scale with the options of “strongly agree”, “agree”, “I do not know”, “disagree”, and “strongly disagree” was used to rate questionnaire statements, except the questions concerning sources of information, specific PPE item, and demographic characteristics. The questionnaires, including the informed consent forms, were distributed to all registered nurses working in the isolation wards and ICU designated for patients with COVID-19.

In-depth interviews were conducted with a total of 7 participants, who provided consent. The interview candidates were obtained through purposive sampling and snowball sampling among nurses working in isolation wards or the ICU for patients with COVID-19 during the study period [18]. A semi-structured questionnaire was developed focusing on the
relevant factors of knowledge, awareness, and behaviors to be explored in the interview (Supplementary Table 1). As the interview progressed, questions and answers were added freely in order to be able to elucidate the context of wearing PPE during the current COVID-19 pandemic.

### 3. Data analysis

The quantitative data were analyzed using descriptive statistical methods. All Likert-scale responses were dichotomized as “agree” if the response was “strongly agree” or “agree,” and “do not agree” if the response was “I do not know,” “disagree,” and “strongly disagree.” Participants’ characteristics were summarized as frequencies and proportions or medians and interquartile ranges (IQRs).

For qualitative analysis, the transcription of the interviews was initially divided into units of a total of 425 semantic paragraphs. Then, divided paragraphs were subsequently coded by a single researcher using a coding framework. The coding framework included themes of influencing knowledge, awareness, and behaviors, and subthemes derived from the content through the framework analysis method [19]. The subthemes and their content items were developed through constant comparison throughout the coding process. Additional three researchers independently coded a random sample of 36 paragraphs (10% of all paragraphs), followed by an iterative process of discussing classification of paragraphs and reaching consensus. Finally, inter-coder agreement calculated by Cohen’s Kappa statistic was more than 0.80, which indicated very good agreement [20].

### 4. Ethics statement

The present study protocol, questionnaires, and consent statement were reviewed and approved by the Institutional Review Board of the National Medical Center (Reference number NMC-2021-03-023). Informed written consent was obtained from all participants in this study.

### RESULTS

The questionnaires were distributed to 121 registered nurses, with 84.3% (n = 102) completing the survey. The median age of the participants was 27 years (IQR: 25 - 31), and 52.9% of participants (n = 54) had at least four years of clinical experience. Among the participants, 35.3% (n = 36) worked in the ICU and 64.7% (n = 66) worked in the isolation wards. Table 1 and Supplementary Table 2 describes the detailed demographic characteristics of participants. All interview participants were registered nurses working in isolation wards or the ICU for patients with COVID-19, with clinical experience ranging from 4 to 18 years.

#### 1. Knowledge

For the questions on self-assessed level of knowledge, most survey participants stated that they had adequate knowledge (Table 2, Supplementary Table 3). In particular, 100% (n = 102) stated that they knew how to protect themselves while providing nursing care and 93.1% (n = 95) stated that they knew the recommended PPE by task. On the other hand, there was a difference between the proportion of correct answers to questions based on the KDCA guidelines. Only 14.7% (n = 15) of survey participants correctly identified that PAPR was not necessarily recommended when performing AGPs according to the KDCA guidelines. Most survey participants relied on the hospital education program (78.4%) and informal practical
learning in the ward (41.2%) to get information about the recommended PPE and usage. About a quarter of the participants (23.5%) replied that the guideline document issued by a health authority was their source of information.

In qualitative analysis, 5 themes related knowledge were identified (Table 3): provision of adequate guideline, leadership, information other than official guidelines, previous experience, and education and communication. The most frequently raised issue was necessity of guidelines to select the appropriate type of PPE, highlighting it as an important relevant factor of knowledge provision (n = 95). In particular, it was very important to present objective and scientific evidence for wearing long-sleeved gowns instead of coveralls. Moreover, the existence of responsible leadership, such as physicians and senior nurses, also played a significant role in providing up-to-date guidance (n = 31) (Table 3). The selected remarks are as follows:

“Because it was the first time that we had experienced (COVID-19). So, we agreed that 'let's go as high level as possible for PPE use’... and after getting used to it, we should start taking them off one by one... It was said that 'yes, it seems to be okay to level down,' but we had no accurate information, actually.”

“What is the most important factor when 'leveling down PPE', the most important thing for members to accept? I think it’s just information. I keep thinking that there is not enough information. I had been still wearing a coverall... but as he (the leader of the nursing team) explained so well... so I changed my mind.”
2. Awareness

Most survey participants believed that the use of appropriate PPE could prevent SARS-CoV-2 infection to themselves (98.0%) and their families (94.0%) (Table 2, Supplementary Table 3). All participants were confident about the donning and doffing of PPE. Regarding individual items of PPE, all participants trusted N95 or equivalent respirators (100.0%) as the best preventive measure to control the transmission of SARS-CoV-2, followed by gloves (96.1%), face shield (92.2%) and long-sleeved gowns (92.2%) when providing nursing care (Table 4).

On questions about inconvenience, 86.3% (n = 88) complained of inconvenience from wearing PPE (Table 4). At the same time, 98.0% (n = 100) stated that they could withstand the inconvenience for their patients. The most inconvenient PPE item was identified as coveralls with foot covering (77.5%), followed by PAPR (75.5%), goggles (67.7%), and N95 or equivalent respirator (62.8%).

In qualitative analysis, 6 themes related awareness were identified (Table 3): acceptability of guideline, previous experience, individual specificity, leadership, communication, and...
others. The experience from PPE shortage in the early days of the COVID-19 pandemic, past negative experiences from the MERS outbreak, interaction with leadership, personal psychological barriers, and increased anxiety were mentioned as influencing factors of the current PPE use (n = 25). To reduce the negative awareness of PPE, it was essential for the

Table 3. The themes and subthemes extracted from the in-depth interview

| Theme                          | Subtheme                                      | Frequency of mentioned |
|--------------------------------|-----------------------------------------------|------------------------|
| Knowledge                      | Provision of adequate guideline               | 175                    |
|                                |      Presentation of objective evidence        | 95                     |
|                                |      Clarity of the content                   |                        |
|                                |      Timely update                            |                        |
|                                |      Information about the disease            |                        |
|                                |      Uniform guidelines                       |                        |
|                                |      Sufficiently specific guideline          |                        |
| Leadership                     | Responsible leadership                        | 31                     |
|                                | Competent leadership                          |                        |
|                                | New leadership                                |                        |
| Information other than official guidelines | From other wards or hospitals                 | 19                     |
|                                | Personally obtained                           |                        |
|                                | Provided by colleagues                        |                        |
| Previous experience            | Experiences from the MERS outbreak response   | 16                     |
| Education and communication    | Active communication for the content          | 14                     |
|                                | Formal educational programs                   |                        |
| Awareness                      | Acceptability of guideline (for each individual) | 124          |
|                                | Accumulation of positive experience after following the latest guidelines | 27                     |
|                                | Practical applicability                       |                        |
|                                | Sufficient level of protection                |                        |
|                                | Reliability of the evidence                   |                        |
|                                | Experience during MERS epidemic               | 25                     |
|                                | Negative experiences (past use of PPE)        |                        |
|                                | Experience caring for critically ill patients |                        |
| Individual specificity         | Psychological barriers or fears               | 25                     |
|                                | Concerns about spreading to family            |                        |
|                                | Difference in sensitivity to risk             |                        |
| Leadership                     | Responsible leadership                        | 25                     |
|                                | Authoritative leadership                      |                        |
|                                | Competent leadership                          |                        |
|                                | Showing example by leadership                 |                        |
|                                | New leadership                                |                        |
| Communication                  | Active communication for guideline            | 21                     |
|                                | Empathy and persuasion                        |                        |
|                                | Respect for personal choices                 |                        |
| Others                         | New facility                                  | 1                      |
| Behaviors                      | Conditions for use                            | 126                    |
|                                | Adequate supply                               | 57                     |
|                                | Convenience at work                           |                        |
|                                | Convenience of donning and doffing            |                        |
|                                | Provision of suitable facilities              |                        |
|                                | Quality of PPE                                |                        |
| Leadership                     | Responsible leadership                        | 26                     |
|                                | Showing example by leadership                 |                        |
| Communication and cooperation  | Active communication for PPE use              | 14                     |
|                                | Cooperation with administrative service       |                        |
| Previous experience            | Experiences from the MERS outbreak response   | 12                     |
| Others                         | Respect for personal choices                 | 17                     |
|                                | PPE selection of colleagues                   |                        |
|                                | Vaccinated or not                             |                        |
|                                | Excessive waste production                    |                        |
|                                | New facility                                  |                        |

MERS, Middle East respiratory syndrome; PPE, personal protective equipment.
leadership to explain, to communicate with, and persuade nurses based on empathy and trust (n = 25). Through the communication, participants could ask questions, resolve doubts, and reduce their anxiety. The selected remarks are as follows:

“I think there should be a leading person in the hospital who tells me like this... 'Now you reviewed all the references...I trust that you can do it well'. If something went wrong, the leader asked why it happened and listened...When a leader runs away, the people under him (or her) also back off.”

3. Behavior

All survey participants responded that they wore N95 or equivalent respirator, gloves, and face shield at work during the study period (Table 4, Supplementary Table 4). The proportion of participants who chose the long-sleeved gowns (98.0%) was much higher than the coveralls with foot covering (33.3%) in the questions that allowed multiple answers. Only a small proportion of participants used goggles (4.7%) and PAPR (3.9%) while proving nursing care.

In qualitative analysis, 5 themes related awareness were identified (Table 3): conditions for use, leadership, communication, previous experience, and others. The adequate supply of PPE, convenience at work, provision of suitable facilities, and quality of PPE were frequently mentioned as influencing factors of the behaviors related to the PPE use (n = 25) (Table 3). Some nurses still selected and wore PPE based on their past experience from the MERS outbreak, but behaviors related PPE have changed through the examples of physicians or senior nurses. The selected remarks are as follows:

“After four-item sets were introduced, it was really, really comfortable and easy to work... and we kept watching the leader follow the new recommendations himself (herself)... it led to a change in our PPE use.”

DISCUSSION

To our knowledge, this study represents the first effort in Korea to investigate knowledge, awareness, behaviors, and influencing factors related to the usage of PPE during the current COVID-19 pandemic. In our study, most frontline nurses usually wore four-item sets, including gloves, face shield, N95 or equivalent respirator, and a long-sleeved gown, but one-third of the participants sometimes used coveralls with foot covering instead of long-sleeved gown. These results potentially suggest the differences between changes in PPE guidelines and changes in the field behavior.

Table 4. Responses to questions about each PPE item*  

| PPE                  | Wearing PPE helps prevent infection | Wearing PPE brings discomfort | Currently wearing PPE |
|----------------------|-------------------------------------|-----------------------------|------------------------|
| N95 or equivalent respirator | 102 (100.0)                     | 64 (62.8)                   | 102 (100.0)            |
| Powered air purifying respirator | 83 (81.4)                       | 77 (75.5)                   | 4 (3.9)                |
| Gloves               | 98 (96.1)                          | 54 (52.9)                   | 102 (100.0)            |
| Goggles              | 47 (46.1)                          | 69 (67.7)                   | 2 (4.7)                |
| Face shield          | 94 (92.2)                          | 37 (36.3)                   | 102 (100)              |
| Long-sleeved gown    | 94 (92.2)                          | 32 (31.4)                   | 100 (98.0)             |
| Coverall with foot covering | 82 (80.4)                        | 79 (77.5)                   | 34 (33.3)              |

*Multiple answers were allowed.
PPE, personal protective equipment.
With the spread of the pandemic, knowledge about clinical characteristics and transmission modes of COVID-19 progressed rapidly. Therefore, PPE recommendations to protect HCWs providing face-to-face care had to be changed accordingly. In addition, the recommended PPE for HCW protection should be determined to minimize not only the risk of infection, but the adverse effects of wearing PPE, such as exhaustion, irritant dermatitis, heat stress, or dehydration [21, 22]. Overuse of PPE is a form of misuse, and it leads to avoidable PPE shortages and subsequently increases risk of infection to HCW [23]. The WHO guidelines have been consistent with these principles by recommending gowns, gloves, medical masks, or N95 equivalent respirators and eyeglasses for HCWs directly caring for patients with COVID-19 and not recommending double layering of gloves or gowns, shoe protection, and hoods [7]. These recommendations are the same in the United States and Europe [5, 24]. While PPE recommendations from international organizations are largely consistent, PPE use in field was not. In Italy, the first European region heavily affected by COVID-19, 73% (264/360) of HCWs wore hazmat suits, and 6% (24/379) used PAPR in ICU in the early COVID-19 pandemic [25]. However, 17% (352/2,072) of HCWs in hospitals from 89 countries outside Italy wore hazmat suits, and 7% (160/2,300) used PAPR in the same study; meanwhile, no HCW wore full body suits in both community and hospital settings in Canada [10]. Compared to reports from other regions, our findings show a higher utilization of coveralls, as some nurses still used them until May 2021 in Korea.

Nevertheless, it would be challenging to optimize the recommended PPE set to protect all transmission modes in the early stages of the pandemic, as evidence has not been built up for best practices for infection prevention and control. Our in-depth interview results suggested that PPE guidelines can be easily accepted by HCWs when they are specific, clear, consistent, and present objective evidences. Similar results have been reported in studies conducted in other areas; about 75% Italian physicians (n = 516) were unsatisfied with the PPE guideline during the COVID-19 pandemic, and it significantly influenced their risk perception about contracting the infection [26]. As for HCWs in South America, up to 51.4% participants complained of insufficient knowledge about using PPE, which made the participants perceive themselves to be less prepared and trained [27]. As pointed out in prior studies, the inconsistent or outdated policies on PPE use against COVID-19 are common problems among many countries [23, 28]. In addition to the recommendations from the government or the public health authority, some institutional policies and guidelines should be prepared to take into account the hospital facilities and the supply of PPE [27].

Preparing clear PPE guidelines does not guarantee consensus or immediate use among HCWs. In particular, the role of leadership was critical across all domains of knowledge, awareness and behaviors of PPE use for the participants, as highlighted in prior studies [29]. The role of leaders including collaboration, communication, proactivity, and ownership of infection prevention measures have been known as facilitators for the adoption of guidelines among HCWs [30-32]. Our interview results presented that the significance of showing the example of wearing four-item sets by leaders. It is important for leaders to establish close contact with HCWs and build trust in the field, beyond a limited role in providing and managing guidelines.

Our study is limited as it is a self-report voluntary survey in a single institution; the results may show potentially selected responses and over-represent a small proportion of the overall situation. However, since the NMC has treated patients with emerging infectious diseases at the forefront in Korea, these results can provide insight to the effective management of PPE.
among HCWs despite some limitations of a single-institution study. Second, it is likely that the results presented biased opinions by considering only nurses in isolation wards and the ICU as study participants among various HCWs. Although these nurses are the representative front-line HCWs in close contact with COVID-19 patients, it is necessary to examine the views for physicians, infection control team, and other medical technicians for the future. In addition, a survey on HCWs working in places with a high risk of exposure to COVID-19 such as emergency rooms and hemodialysis rooms is also needed. Given that the infection control team in hospitals plays a key role in preventing nosocomial infection, how new measures can be incorporated into their existing role should be considered for coping with pandemics brought about by emerging infectious diseases.

In conclusion, while the PPE guidelines for COVID-19 in the field needed to be up-to-date and specific, the adoption of the latest guideline was not straightforward due to various structural and individual factors. Nevertheless, as new information of COVID-19 continues to emerge, the latest specific guidelines for PPE use should be effectively communicated to all HCWs in a more reliable manner. It is highly desirable that HCWs are encouraged to rationalize PPE use based on the latest scientific literature, as well as by being aware of international guidelines and best practices. To use the appropriate PPE in the field, it is important to support the role of accountable leadership who work together and set an example of PPE use among HCWs.

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SUPPLEMENTARY MATERIALS

Supplementary Survey File

The use of personal protective equipment among frontline nurses in a nationally designated COVID-19 hospital during the pandemic Survey Questionnaire (English)

Click here to view

Supplementary Table 1

The categories of the semi-structured questionnaire for in-depth interview

Click here to view

Supplementary Table 2

Demographic characteristics of the survey participants according to working place

Click here to view
**Supplementary Table 3**
Responses to questions about knowledge, sources of information, and awareness according to working place

Click here to view

**Supplementary Table 4**
Responses to questions about each PPE item according to working place

Click here to view

**REFERENCES**

1. Sahu AK, Amrithanand VT, Mathew R, Aggarwal P, Nayer J, Rhoi S. COVID-19 in health care workers - A systematic review and meta-analysis. Am J Emerg Med 2020;38:1727-31.

2. Alhazzani W, Møller MH, Arabi YM, Loeb M, Gong MN, Fan E, Oczkowski S, Levy MM, Derde L, Dzierba A, Du B, Abboodi M, Wunsch H, Cecconi M, Koh Y, Chertow DS, Maitland K, Alshamsi F, Kelley-Cote E, Greco M, Laudyn M, Morgan JS, Kesecioglu J, McGeer A, Mermel L, Mammen MJ, Alexander PE, Arrington A, Centofanti JE, Citerio G, Baw B, Memish ZA, Hammond N, Hayden FG, Evans L, Rhodes A. Surviving sepsis campaign: guidelines on the management of critically ill adults with coronavirus disease 2019 (COVID-19). Crit Care Med 2020;48:e440-69.

3. Kim JY, Choe PG, Oh Y, Oh KJ, Kim J, Park SJ, Park JH, Na HK, Oh MD. The first case of 2019 novel coronavirus pneumonia imported into Korea from Wuhan, China: implication for infection prevention and control measures. J Korean Med Sci 2020;35:e61.

4. Park SH. Personal Protective Equipment for Healthcare Workers during the COVID-19 Pandemic. Infect Chemother 2020;52:165-82.

5. Centers for Disease Control and Prevention (CDC). Interim Infection Prevention and Control Recommendations for Healthcare Personnel During the Coronavirus Disease 2019 (COVID-19) Pandemic. Updated September 10 2021. Available at: https://www.cdc.gov/coronavirus/2019-ncov/hcp/infection-control-recommendations.html. Accessed 15 July 2021.

6. Kang J, Jang YY, Kim J, Han SH, Lee KR, Kim M, Eom JS. South Korea’s responses to stop the COVID-19 pandemic. Am J Infect Control 2020;48:1080-6.

7. World Health Organization (WHO). Rational use of personal protective equipment for COVID-19 and considerations during severe shortages: interim guidance, 23 December 2020. Available at: https://apps.who.int/iris/handle/10665/338033. Accessed 15 July 2021.

8. Korea Disease Control and Prevention Agency (KDCA). Guidance on hospitals’ responses to COVID-19. 1-2nd ed. Updated 2021. Available at: http://ncov.mohw.go.kr/shBoardView.do?brdId=2&brdGubun=24&ncvContSeq=4545. Accessed 15 July 2021.

9. Korea Disease Control and Prevention Agency (KDCA). Infection prevention and control for COVID-19 in healthcare facilities (March 10, 2020). Updated 2020. Available at: http://ncov.mohw.go.kr/shBoardView.do?brdId=2&brdGubun=24&ncvContSeq=1277. Accessed 15 July 2021.

10. Silverberg SL, Puchalski Ritchie LM, Gobat N, Murthy S. COVID-19 infection prevention and control procedures and institutional trust: Perceptions of Canadian intensive care and emergency department nurses. Can J Anaesth 2021;68:1165-75.

11. Ivankova NV, Creswell JW, Stick SL. Using mixed-methods sequential explanatory design: From theory to practice. Field Methods 2006;18:3-20.

12. Tariq S, Woodman J. Using mixed methods in health research. JRSM Short Rep 2013;4:204253313479197.
13. Fuchs A, Abeglen S, Berger-Estilita J, Greif R, Eigenmann H. Distress and resilience of healthcare professionals during the COVID-19 pandemic (DARVID): study protocol for a mixed-methods research project. BMJ Open 2020;10:e039832.

14. Rossman GB, Wilson BL. Numbers and words: Combining quantitative and qualitative methods in a single large-scale evaluation study. Eval Rev 1985;9:627-43.

15. Hu X, Zhang Z, Li N, Liu D, Zhang L, He W, Zhang W, Li Y, Zhu C, Zhu G, Zhang L, Xu F, Wang S, Cao X, Zhao H, Li Q, Zhang X, Lin J, Zhao S, Li C, Du B; China critical care clinical trial group. Self-reported use of personal protective equipment among Chinese critical care clinicians during 2009 H1N1 influenza pandemic. PLoS One 2012;7:e44723.

16. Ma X, He Z, Wang Y, Jiang L, Xu Y, Qian C, Sun R, Chen E, Hu Z, Zhou L, Zhou F, Qin T, Cao X, An Y, Sun R, Zhang X, Lin J, Ai Y, Wu D, Du B; China critical care clinical trial group (CCCCTG). Knowledge and attitudes of healthcare workers in Chinese intensive care units regarding 2009 H1N1 influenza pandemic. BMC Infect Dis 2011;11:24.

17. Daugherty EL, Perl TM, Needham DM, Rubinson L, Bilderback A, Rand CS. The use of personal protective equipment for control of influenza among critical care clinicians: A survey study. Crit Care Med 2009;37:1210-6.

18. Valerio MA, Rodriguez N, Winkler P, Lopez J, Dennison M, Liang Y, Turner BJ. Comparing two sampling methods to engage hard-to-reach communities in research priority setting. BMC Med Res Methodol 2016;16:146.

19. Gale NK, Heath G, Cameron E, Rashid S, Redwood S. Using the framework method for the analysis of qualitative data in multi-disciplinary health research. BMC Med Res Methodol 2013;13:117.

20. Feuerman M, Miller AR. Relationships between statistical measures of agreement: sensitivity, specificity and kappa. J Eval Clin Pract 2008;14:930-3.

21. Davey SL, Lee BJ, Robbins T, Randeva H, Thake CD. Heat stress and PPE during COVID-19: impact on healthcare workers’ performance, safety and well-being in NHS settings. J Hosp Infect 2021;108:185-8.

22. Kiely LF, Moloney E, O’Sullivan G, Eustace JA, Gallagher J, Bourke JF. Irritant contact dermatitis in healthcare workers as a result of the COVID-19 pandemic: a cross-sectional study. Clin Exp Dermatol 2021;46:142-4.

23. Chuighati AA, Khan W. Use of personal protective equipment to protect against respiratory infections in Pakistan: A systematic review. J Infect Public Health 2020;13:385-90.

24. European Centre for Disease Prevention and Control (ECDC). Infection prevention and control and preparedness for COVID-19 in healthcare settings - Sixth update. Updated 2021. Available at: https://www.ecdc.europa.eu/en/publications-data/infection-prevention-and-control-and-preparedness-covid-19-healthcare-settings. Accessed 15 July 2021.

25. Ippolito M, Ramanan M, Bellina D, Catalisano G, Iozzo P, Di Guardo A, Moscarelli A, Grasselli G, Giarratano A, Bassetti M, Tabah A, Cortegiani A. Personal protective equipment use by healthcare workers in intensive care unit during the early phase of COVID-19 pandemic in Italy: a secondary analysis of the PPE-SAFE survey. Ther Adv Infect Dis 2021;8:2049936121998562.

26. Savoia E, Argentini G, Gori D, Neri E, Pillch-Loeb R, Fantini MP. Factors associated with access and use of PPE during COVID-19: A cross-sectional study of Italian physicians. PLoS One 2020;15:e0239024.

27. Martin-Delgado J, Viteri E, Mula A, Serpa P, Pacheco G, Prada D, Campos de Andrade Lourenço D, Campos Pavan Baptista P, Ramírez G, Mira JJ. Availability of personal protective equipment and diagnostic and treatment facilities for healthcare workers involved in COVID-19 care: A cross-sectional study in Brazil, Colombia, and Ecuador. PLoS One 2020;15:e0242185.

28. Angrup A, Kanaujia R, Ray P, Biswal M. Healthcare facilities in low- and middle-income countries affected by COVID-19: Time to upgrade basic infection control and prevention practices. Indian J Med Microbiol 2020;38:139-43.
29. Houghton C, Meskell P, Delaney H, Smalle M, Glenton C, Booth A, Chan XHS, Devane D, Biesty LM. Barriers and facilitators to healthcare workers’ adherence with infection prevention and control (IPC) guidelines for respiratory infectious diseases: a rapid qualitative evidence synthesis. Cochrane Database Syst Rev 2020;4:CD013582.

30. Dubé E, Lorcy A, Audy N, Desmarais N, Savard P, Soucy C, Bassetto S, Rajon M, Brunet F, Barbir C, Quach C. Adoption of infection prevention and control practices by healthcare workers in Québec: A qualitative study. Infect Control Hosp Epidemiol 2019;40:1361-6.

31. Rangachari P, L Woods J. Preserving organizational resilience, patient safety, and staff retention during COVID-19 requires a holistic consideration of the psychological safety of healthcare workers. Int J Environ Res Public Health 2020;17:4267.

32. Tomer Y, Ng Gong M, Keller MJ, Southern W, Kitsis EA, Kajita GR, Shapiro LI, Jariwala SP, Epstein EJ. Teamwork and leadership under fire at the epicenter of the COVID-19 epidemic in the Bronx. Front Med (Lausanne) 2021;8:610100.