Survey and enlightenment on the wearing of protective equipment of nurses working on the front line against COVID-19

Maojie Wu, BS, Lin Zhang, MD, Ning Ning, PhD, Li Liu, BS, Xiaoyan Liu, PhD

Abstract
At present, coronavirus disease 2019 (COVID-19) remains a significant challenge for health workers around the world. This survey aims to highlight the status of the implementation of occupational protection measures for nurses working on the front line against COVID-19, and to analyze the problems in the process of wearing protective equipment.

This cross-sectional study was conducted among 165 nurses who worked in COVID-19-stricken areas in China in March 2020. The questionnaire covered 3 aspects, namely: general information, the current condition of protective equipment wearing, and the wearing experience of protective equipment.

A total of 160 (96.97%) valid questionnaires were collected. The average time of wearing protective equipment for the nurses surveyed was 6.38±3.30 hours per working day. For front-line nurses with low risk of infection, repeated wear of protective equipment was as follows: medical protective mask 30.77%, double latex gloves 8.46%, goggles/protective mask 15.38%, protective suit 15.38%; less wear of protective equipment was as follows: work cap 7.69%, surgical mask 7.69%, single layer latex gloves 30.77%, goggles/protective mask 30.77%, and isolation gown 46.15%. For nurses who were at moderate risk of infection, repeated wear of protective equipment was as follows: surgical mask 62.22%, goggles/protective mask 68.89%, and isolation gown 65.56%; less wear: work cap 5.56%, medical protective mask 15.56%, latency gloves 15.56%, goggles/protective mask 5.56%, and protective suit 16.67%. For front-line nurses with high risk of infection, repeated wear of protective equipment was as follows: surgical mask 64.91%, more than double latex gloves 8.77%, goggles/protective mask 75.44%, isolation gown 75.44%; less wear: work cap 1.75%, medical protective mask 1.75%, latency gloves 26.32%, goggles/protective mask 1.75%, protective suit 1.75%. The main discomforts of wearing protective equipment were poor vision due to fogging (81.88%), stuffiness (79.38%), poor mobility (74.38%), sweating (72.5%), and skin damage (61.25%).

More detailed personal protection standards should be developed, and the work load of nurses should be reduced. Actions should be taken to ensure the scientific implementation of personal protective measures. To solve practical clinical problems, future protective equipment may focus on the research and development of protective equipment applicable for different risk levels, as well as the research on integrated design, fabric innovation, and reusability.

Abbreviation: COVID-19 = 2019-nCoV coronavirus disease 2019.

Keywords: coronavirus disease 2019, front-line nurses, personal protection, survey

1. Introduction
The outbreak of coronavirus disease 2019 (COVID-19) around the world has triggered extraordinary attention. Studies have identified the pathogen of COVID-19 as 2019-nCoV, a highly infectious virus to which people are generally susceptible. It can be transmitted human-to-human through respiratory droplets, close contact, and other routes.[1] Amid the pandemic, the effective control of infection sources, the blocking of routes of infection, and the protection of susceptible populations are 3 keys to the prevention and control of infection.[2] As the main force working on the front line against COVID-19, nurses are at high risk of exposure. While treating patients, it is crucial to effectively implement occupational protection measures to prevent the infection of front-line nurses and ensure their safety. To highlight the current conditions of the implementation of occupational protection measures for nurses working on the front line against COVID-19, and to analyze the problems in the process of wearing protective equipment, the aim of this study is to provide a reference for the management of nosocomial infection prevention and control, and the improvement of medical personal protection technology.
2. Materials and methods

2.1. Respondents

A total of 165 nurses who worked in COVID-19-stricken areas in China were selected through convenience sampling. Inclusion criteria:

1. Working on the front line against COVID-19 as nurses; and
2. Volunteered for this survey.

Exclusion criteria:

1. Not working on the front line against COVID-19; and
2. Working as nurses against COVID-19 in Hong Kong, Macau, and Taiwan.

This study was approved by the Clinical Trials and Biomedical Ethics Committee of our hospital, and written informed consent was obtained from all participants.

2.2. Questionnaire

A questionnaire related to wearing the protective equipment for nurses working on the front line against COVID-19 was designed based on literature review and clinical practice. The questionnaire covered 3 aspects, namely: general information, the current condition of protective equipment wearing, and the wearing experience of protective equipment. It contained 13 items, including 11 choice questions and 2 fill-in-the-blank questions. Two evidence-based nursing and 2 nosocomial infection prevention and control experts were invited to evaluate the contents of the questionnaire, which was revised after trial tests into the final draft.

2.3. Survey

Before conducting the survey, the respondents were informed of the purpose, significance and methods of this survey. The survey was conducted from March 8, 2020 to March 16, 2020 with the consent of the respondents. The questionnaires were distributed to WeChat groups of front-line nurses in each COVID-19-stricken area through wjx.cn (an online questionnaire distributing platform). Valid questionnaires were singled out from those submitted with an unreasonable time, incomplete, with logic problems or submitted from the same WeChat account. A total of 165 questionnaires were distributed and 160 valid questionnaires were collected, with a valid response rate of 96.97%.

2.4. Statistical analysis

SPSS 22 (IBM, Chicago, IL) was used for statistical description. Enumeration data were described by frequency and composition ratio, and measurement data presented by mean ± standard deviation.

3. Results

3.1. General information of respondents

A total of 160 respondents were included in this survey. The basic information of respondents is shown in Table 1.

3.2. Current condition of protective equipment wearing

According to the results of the questionnaire, the average time of wearing protective equipment for the 160 front-line nurses surveyed was 6.38 ± 3.30 hours per working day. Of the nurses surveyed, 54.38% required assistance to put on and take off protective equipment, and it took an average of 23.03 ± 19.35 minutes and 22.69 ± 13.75 minutes, respectively, to put on and take off protective equipment. The current condition of protective equipment wearing of different types of front-line nurses is shown in Table 2.

3.3. Experience of wearing protective equipment

The front-line nurses experienced some discomfort such as stuffiness, dizziness, breathing difficulty, skin damage, poor mobility, et al when they wore the protective equipment. The detailed results are recorded in Table 3.

4. Discussion

4.1. The outbreak of public health events inspires the development of higher levels of personal protection standards

The outbreak of COVID-19 around the world has aroused great concern at home and abroad. China has identified it as a Class B infectious disease and manages it as a Class A infectious disease. According to research and reports, in transmission, its pathogen 2019-nCoV is:

1. concealed, colorless, odorless, difficult to detect;
2. hysteretic, often with a delayed onset and the incubation period can be as long as 24 days;
3. transmissible through multiple channels, mainly through respiratory droplets and close contact, as well as aerosol and digestive tract, which are subject to confirmation in the fifth edition of the Diagnosis and Treatment Protocol for COVID-19 of the National Health Commission of the People’s Republic of China; and
4. unstable and may mutate.

Table 1: General information of respondents (n=160).

| Item                                   | Number | Proportion (%) |
|----------------------------------------|--------|----------------|
| Gender                                 |        |                |
| Male                                    | 20     | 12.50          |
| Female                                 | 140    | 87.50          |
| Age                                     |        |                |
| 18–24                                  | 11     | 6.88           |
| 25–30                                  | 67     | 41.88          |
| 31–40                                  | 61     | 38.13          |
| 41–50                                  | 19     | 11.88          |
| 51 and above                           | 2      | 1.25           |
| Employer before working on the front line |        |                |
| Tertiary hospital                      | 144    | 90.00          |
| Secondary hospital                     | 16     | 10.00          |
| Primary hospital                       | 0      | 0.00           |
| COVID-19 stricken area served          |        |                |
| Wuhan, Hubei                           | 12     | 7.50           |
| Other areas in Hubei                   | 28     | 17.50          |
| Areas outside Hubei                    | 120    | 75.00          |
| Time spent on the front line           |        |                |
| Less than 1 mo                         | 72     | 45.00          |
| 1–2 mo                                 | 80     | 50.00          |
| Over 2 mo                              | 8      | 5.00           |
In addition to the high infectivity of COVID-19 itself, front-line nurses shoulder heavy responsibilities and are at high risk of exposure due to their intensive work. Results of this survey show that the 160 surveyed front-line nurses wore protective equipment for an average of 6.38 ± 3.30 hours during workdays and they were exposed to high-intensity work environments with a high risk of infection for long periods. How to protect medical workers from occupational exposure and infection is an important issue for the current pandemic prevention and control, and the continuous improvement of infectious disease management in the future. By now, the National Health Commission of China has issued Technical Guidelines for COVID-19 Prevention and Control in Medical Institutions (First Edition),[5] and other standards related to personal protection. Some COVID-19-stricken areas and medical institutions have also developed implementation plans for personal protection according to their actual situation.[7] However, problems still exist in protection standards, for example, the contents about graded protection are not detailed enough, and the coverage of job types and work scenarios is limited. To prevent the tragic death of more medical workers from 2019-nCoV infection and better respond to public health outbreaks, higher personal protection standards must be developed.

### 4.2. Scientific infection prevention and control depends on the implementation of reasonable and appropriate personal protective measures

Technical Guidelines for COVID-19 Prevention and Control in Medical Institutions (First Edition) issued by the National Health Commission of the People’s Republic of China clearly requires that medical institutions regulate the protection work to ensure that the personal protection of medical workers is in place.[4] However, due to the mental pressure brought about by the pandemic and the shortage of protective supplies, the contradiction between insufficient and excessive use of protective equipment has emerged on the front line against COVID-19. According to the data of this survey, Type A: less wear: work cap: 7.69%, surgical mask: 7.69%, single layer latex gloves: 30.77%, isolation gown: 46.15%. Wear beyond standard: medical protective mask: 30.77%, facial protective equipment: 15.38%, protective suit: 15.38%. Repeated wear: double layers latex gloves: 38.46%. Type B: Less wear: work cap: 3.3%, medical protective mask: 15.56%, facial protective equipment: 5.56%, protective suit: 16.67%. Wear below standard: single layer latex gloves: 15.56%. Repeated wear: surgical mask: 62.22%, wear more than 2 facial protective equipment: 68.89%, wear an isolation gown over a protective suit: 65.56%. Type C: Less wear: work cap: 1.75%, medical protective mask: 1.75%, latex gloves: 26.32%, facial protective equipment: 1.75%, Protective suit: 1.75%. Not used according to standard: single layer latex gloves: 26.32%. Repeated wear: wear a surgical mask over a medical protective mask: 64.91%, wear more than double layer latex gloves: 8.77%, wear more than 2 facial protective equipment: 75.44%, wear an isolation gown over a protective suit: 75.44%. Data obtained in this survey show that not all of the front-line nurses who are at high risk of infection, such as those who nurse critically ill patients, wear protective suits, medical

### Table 2

| Item                                      | Work suit | Work cap | Medical protective mask | Surgical mask | Single layer latex gloves | Double latex gloves | goggles/ protective mask | Protective suit | Isolation gown |
|-------------------------------------------|-----------|----------|-------------------------|--------------|----------------------------|--------------------|--------------------------|----------------|----------------|
| **A (N = 13)**                            |           |          |                         |              |                            |                    |                           |                |                |
| Protection standards                      | *         |          |                        |              | *                          |                    |                           |                |                |
| Less wear                                 | 0         | 1        |                         |              | 1                          |                    |                           |                |                |
| Repeated wear                             |           |          |                         |              |                            |                    |                           |                |                |
| **B (N = 90)**                            |           |          |                         |              |                            |                    |                           |                |                |
| Protection standards                      | *         |          |                        |              | *                          |                    |                           |                |                |
| Less wear                                 | 0         | 3        |                         |              | 14                         |                    |                           |                |                |
| Repeated wear                             |           |          |                         |              |                            |                    |                           |                |                |
| **C (N = 57)**                            |           |          |                         |              |                            |                    |                           |                |                |
| Protection standards                      | *         |          |                        |              | *                          |                    |                           |                |                |
| Less wear                                 | 0         | 1        |                         |              | 1                          |                    |                           |                |                |
| Repeated wear                             |           |          |                         |              |                            |                    |                           |                |                |

A (low risk of infection): general nursing in COVID-19-stricken areas, such as triage in general outpatient and emergency departments and community consultation; B (moderate risk of infection): general nursing in close contact with confirmed mild or suspected patients, such as in isolation observation rooms and isolation wards; C (high risk of infection): nursing of critical patients, where the spraying or splashing of substances in the respiratory secretions of patients may occur, such as sputum suction, airway nursing and endotracheal intubation nursing. * Standard Wear Items; ☐ Choose one of the items to wear; — Not involved.

### Table 3

| Item                                     | Number of people | Proportion (%) |
|------------------------------------------|------------------|----------------|
| No obvious discomfort                    | 11               | 6.88           |
| Stiffness                                | 127              | 79.38          |
| Dizziness and headache                   | 81               | 50.63          |
| Sweating                                 | 116              | 72.50          |
| Breathing difficulty                     | 94               | 58.75          |
| Poor vision due to fogging               | 131              | 81.88          |
| Poor mobility                            | 119              | 74.38          |
| Skin damage                              | 98               | 61.25          |
| Communication difficulty                 | 89               | 55.63          |
| Psychological discomfort                 | 36               | 22.50          |
| Unattractive appearance                  | 16               | 10.00          |
| High risk of occupational exposure       | 94               | 58.75          |
| Others                                   | 6                | 3.75           |
protective masks and other necessary protective equipment. For those who are at lower risk of infection, including those who practice general nursing, such as triage in general outpatient and emergency departments and community consultation, the coverage of protective suit, medical protective masks and facial protective equipment reached 15.38%, 30.77%, and 15.38% respectively. The incidence of wearing several layers of latex gloves reached 38.46%. For front-line nurses with high risk of infection, the incidence of wearing surgical masks over protective masks, more than double layers of latex gloves, more than 2 kinds of facial protective equipment, and the incidence of wearing isolation gown over protective suit was 64.91%, 8.77%, 75.44%, and 75.44%, respectively. This indicates that some front-line nurses do not wear corresponding protective equipment according to the exposure risk level, and there are problems of insufficient or excessive protection and unreasonable distribution of protective supplies. This could be due to the lack of detailed standards on graded protection, the lack of a classification of medical protective suits, and the use of the same level of protective suits for different risk categories. In addition, the higher the risk level, the higher the incidence of repeated wear. For example, medical protective masks and surgical masks, goggles and protective masks, protective suit, and isolation gown were worn together unnecessarily in this survey. The phenomenon of wearing multiple unnecessary protective equipment may be related to panic on the part of front-line nurses. Due to reports,[2] improperly wearing multiple layers of protective equipment not only fails to increase the protective effect but also tends to increase the risk of infection, resulting in the waste of medical resources. Therefore, scientific prevention and control and efficient use of protective supplies depend on the implementation of reasonable and appropriate personal protective measures.

4.3. The improvement of infection prevention and control quality requires the innovation and optimization of personal protective equipment

With the progress of society and the continuous development of science and technology, modern protective equipment should not only be capable of providing protection but also be comfortable, convenient, and environmentally friendly.[8] Through surveying front-line nurses on their experience of wearing protective equipment, it is found that the main discomforts of wearing protective equipment are poor vision due to fogging (81.88%), stuffiness (79.38%), poor mobility (74.38%), sweating (72.5%), and skin damage (61.25%), probably because of the heavy workload on the front line, the poor air permeability of the materials, and the lack of attention to comfort and convenience in the design. In terms of the wearing and removal of protective equipment, 54.38% of the nurses surveyed required assistance to put on and take off protective equipment, and it takes an average of 23.03 ± 19.35 minutes and 22.69 ± 13.75 minutes, respectively, to put on and take off protective equipment. In general, in addition to disposable medical protective suits, front-line nurses wear goggles, shoe covers, latex gloves, protective masks, and other protective equipment. There are many pieces of equipment and the wearing process is complicated. To prevent contamination in the process, nurses usually need special assistance to smoothly wear or remove a whole set of protective equipment. This not only brings inconvenience to front-line nurses but also causes excessive consumption of supplies and manpower. Therefore, there is still a huge demand to improve the quality of personal protection in infection prevention and control. In the future, the research and development of protective equipment may focus on integrated design, fabric innovation, and reusability to create more light, comfortable, environmentally friendly personal protective equipment with good protection effect.

5. Conclusion

Through surveying nurses working on the front line against COVID-19, this study surveyed problems of not wearing corresponding protective equipment according to the exposure risk level, and improperly wearing multiple layers of protective equipment. Results show that the current discomfort of wearing protective equipment include poor vision due to fogging, stuffiness, poor mobility, sweating, and skin damage. Authorities should develop more detailed personal protection standards and reduce the workload of medical workers to ensure the scientific implementation of personal protection measures. Future protective equipment may focus on the research and development of protective equipment applicable for different risk levels, as well as the research on integrated design, fabric innovation and reusability, to solve practical clinical problems.

Author contributions

Conceptualization: Ning Ning, Xiaoyan Liu.
Data curation: Li Liu.
Investigation: Maojie Wu, Lin Zhang.
Methodology: Xiaoyan Liu.
Resources: Lin Zhang, Ning Ning.
Writing – original draft: Maojie Wu, Lin Zhang.
Writing – review & editing: Xiaoyan Liu.

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