

## Coronavirus Pandemic

# Ward renovation and PPE use procedures to protect medical staff from COVID-19 infection

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### Abstract

In the early stages of the coronavirus disease 2019 (COVID-19) outbreak in Wuhan, many cross-infections occurred due to the limited number of wards and insufficient medical staff, which could not cope with the large number of patients visiting the hospital. A series of new infection control measures were implemented in our institution and a Wuhan hospital supported by our medical team, mainly including temporarily transforming the general ward into a passage for the staff to enter the infectious ward and standardizing the procedure for the wearing and removal of personal protection equipment (PPE). These measures significantly improved the situation, and no member of our medical staff was infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) during the middle and late stages of the disease epidemic. We hope that these experiences can provide references for medical institutions that may face an outbreak of COVID-19, especially those in underdeveloped countries and regions.

**Key words:** COVID-19; personal protective equipment; ward reconstruction; nosocomial infection.

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### Introduction

Coronavirus disease 2019 (COVID-19) is a new acute infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which is transmitted mainly through respiratory droplets and direct contact [1-3]. Since December 2019, several patients with COVID-19 have been identified in Wuhan City, Hubei Province, China. Because of the highly infectious nature of the virus, a large number of patients were hospitalized over a short period of time. As of February 24, 2020, more than 3000 medical workers in China were confirmed to be infected with COVID-19, 40% of whom had nosocomial infections that mainly occurred in the early stage of the epidemic [4]. The specific reasons for the high infection numbers included a large number of patients visiting the hospital, no differentiation between clean regions and contaminated regions, insufficient medical supplies, and improper wearing and removal of personal protective equipment (PPE). Based on the relevant

Chinese hospital infection guidelines and clinical experience, this paper summarizes the basic methods of transforming the general ward into a staff passage to the infectious ward and outlines the procedures and guidelines for the wearing and removal of PPE for medical personnel to reduce cross-infections caused by improper protection to ensure the safety of medical personnel treating COVID-19 patients [5].

### Methodology

#### *Ward transformation*

COVID-19 has features of rapid onset and spread and has caused a large number of suspected and confirmed patients to visit the hospital, resulting in infection wards being unable to keep up with demand. Therefore, non-infectious disease hospitals may need to temporarily transform general wards in accordance with the standards of infectious disease wards. This paper reveals how to transform an ordinary ward into a staff passage and divide the staff passage into a “clean

region”, “potentially contaminated region” and “contaminated region” according to the standards of infectious disease wards. The floor of each region was marked with a colour, with green representing a clean region, yellow representing a potentially contaminated region and red representing a contaminated region. According to the schematic diagram, we sealed the original doors from room 4 to room 9, temporarily built new doors in the ward, and aligned two doors in the same room diagonally to reduce air flow in different areas. The isolation ward and staff passage area were equipped with a negative pressure system and air sterilizer according to the conditions of the hospital (Figure 1). In addition, the environment and surfaces of each room were strictly disinfected daily.

*Procedure for donning PPE*

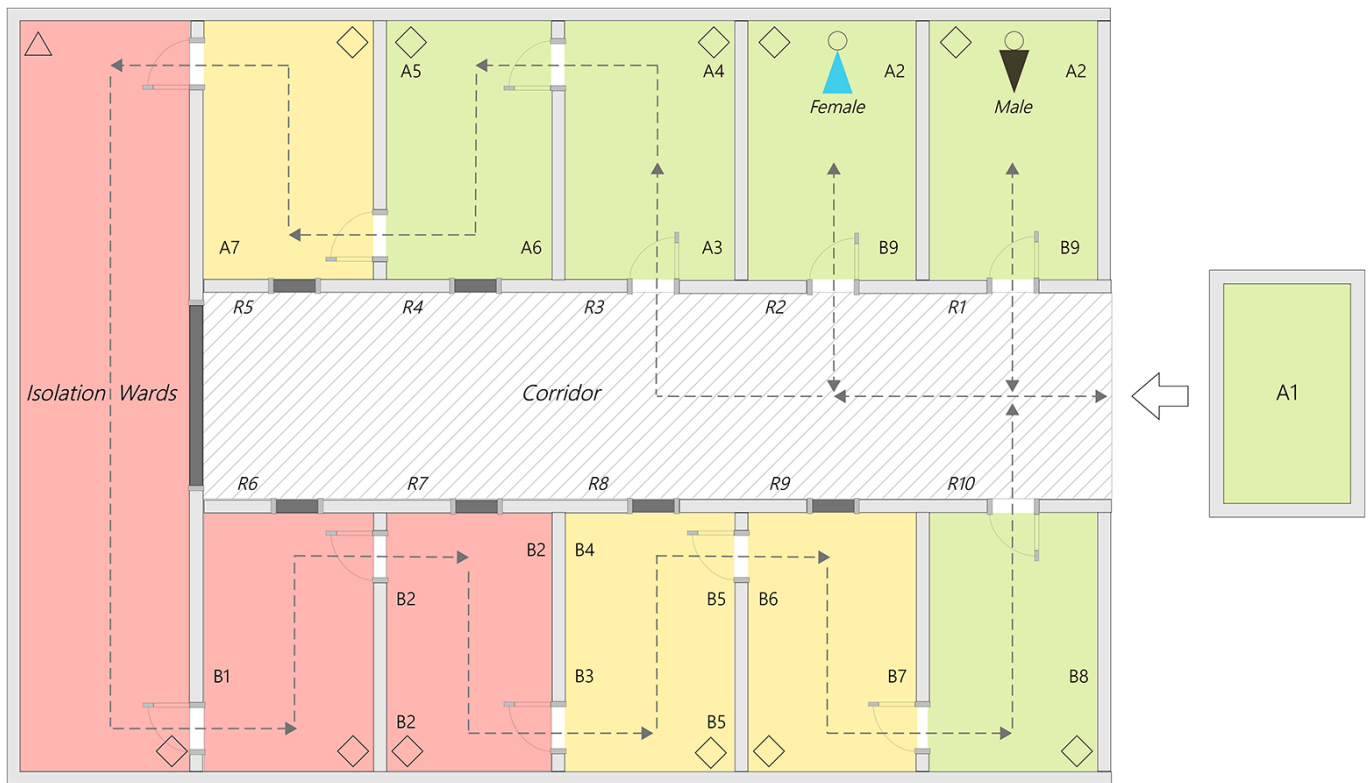
- A1. Monitor the temperature of medical staff at the entrance of the staff passage.
- A2. Enter room 1 or 2, perform hand hygiene procedures, change into work shoes, and change from routine clothes into scrubs if possible.
- A3. Enter room 3, perform hand hygiene procedures, put on a protective medical mask (with a particulate filtration efficiency (PFE) ≥ 95%) and work cap.
- A4. Don work clothes and inner gloves.
- A5. Enter room 4, put on short inner shoe covers (to avoid contaminating the inner surface of the protective clothing), and then put on protective medical clothing, tall outer waterproof shoe covers, and outer gloves.
- A6. Put on goggles and a protective face shield.
- A7. Enter room 5; infection control personnel will confirm the correct use of PPE before the ward can be entered.

- A3. Enter room 3, perform hand hygiene procedures, put on a protective medical mask (with a particulate filtration efficiency (PFE) ≥ 95%) and work cap.
- A4. Don work clothes and inner gloves.
- A5. Enter room 4, put on short inner shoe covers (to avoid contaminating the inner surface of the protective clothing), and then put on protective medical clothing, tall outer waterproof shoe covers, and outer gloves.
- A6. Put on goggles and a protective face shield.
- A7. Enter room 5; infection control personnel will confirm the correct use of PPE before the ward can be entered.

*Key points and precautions for putting on PPE*  
Wearing a protective medical mask (A3)

The mask should be changed quickly, and conversation should be forbidden to avoid cross-infection. To prevent facial pressure injuries, hydrocolloid dressing can be placed under the metal strip of the upper edge of the mask before donning the mask. The metal strip should be fitted closely to the

**Figure 1.** Schematic diagram of the ward transformation and where to put on and remove personal protective equipment (PPE).



R1-R10, rooms 1-10; A1, body temperature measurement area; A2, scrubs and work shoes changing area; A3-A6, PPE dressing areas; A7, infection control personnel confirms whether PPE is acceptable; B1-B7, PPE removal areas; B8, personal cleaning, disinfection and shower areas; B9, daily clothes changing area.

bridge of the nose. A tightness test should be performed to assess whether there is air leakage into and out of the mask (Figure 2A).

**Wearing protective medical clothing (A5)**

Protective clothing of the proper size should be available, and the valid period and integrity of the protective clothing should be checked. Protective clothing should be put on in front of a full-length mirror. The zipper of the protective clothing should be pulled to the top and locked to prevent it from sliding down, and the rubber strip of the neckline should fit tightly. It should be noted that the protective cap covers the inner working cap (Figure 2B).

**Wearing medical gloves (A4 and A5)**

When wearing inner gloves, the gloves should completely cover the cuffs of the work clothes. When wearing outer gloves, the gloves should completely cover the cuffs of the protective medical clothing and be wrapped and fixed with tape to avoid inner clothing or skin contamination caused by glove shifting during work (Figure 2C).

**Wearing goggles (A6)**

It is recommended to use encapsulated goggles. Goggles without an anti-fog function can be coated with an anti-fog agent on the inner layer of the goggles. The upper edge of the goggles should tightly cover the lower edge of the protective cap, and the lower edge of the goggles should cover the upper edge of the mask to avoid eye contamination by aerosols (Figure 2D).

**Procedure for removing PPE**

B1. Enter room 6 from the isolation ward, perform hand hygiene procedures, and remove protective screens and goggles.

B2. Enter room 7, perform hand hygiene procedures, take off protective clothing and tall waterproof outer shoe covers as well as outer gloves. Multiple areas for removing protective clothing should be provided, and spacing between individuals should be maintained to avoid cross-infection.

B3. Enter room 8, perform hand hygiene procedures, and take off short inner shoe covers.

B4. Perform hand hygiene procedures and remove the inner gloves.

B5. Perform hand hygiene procedures and take off the work clothes.

B6. Enter room 9, perform hand hygiene procedures and remove the protective medical mask and work cap.

B7. Perform hand hygiene procedures and remove the surgical mask.

B8. Enter room 10, wash hands with flowing water in line with the 7-step handwashing procedure, and clean the external auditory canal and nose cavity with 75% alcohol.

B9. Enter room 1 or 2 again, take a shower, and replace the scrubs with routine clothes.

**Key points in removing PPE**

**Remove the goggles (B1)**

To prevent the water droplets attached to the inner surface of the goggles from splashing into the eyes, one hand should be used to grasp the outer edge of the goggles, and the other hand should be used to remove

**Figure 2.** Key points in putting on and taking off personal protective equipment (PPE).



2A. Press the metal strip to the bridge of the nose when wearing the mask; 2B. Stick the glue strip on the neckline; 2C. Fix the gloves with adhesive tape; 2D. Cover the lower edge of the protective cap and the upper edge of the mask with the goggles; 2E. Grasp the outer edge of the goggles and then remove the goggles; 2F. Start to remove the protective clothing; 2G. Remove the protective clothing, keeping the clean inner side of the clothing outward; 2H. Take off the mask in a way that avoids touching the outer surface of the mask.

the elastic band from the back of the head and slowly remove the goggles (Figure 2E).

#### Remove protective clothing (B2)

Protective clothing should be removed in front of a full-length mirror. Employees should lean forward, pull the zipper of the protective clothing down to the bottom, and lift and pull off the protective cap, turning it inside out with both hands. The protective clothing should slowly be removed starting in the back with both hands, with the clean inner surface facing outward; clothing should be rolled down, avoiding detachment of the outer gloves from the protective clothing during this process. Contamination of inner clothing or skin should be observed in a mirror during this process. After protective clothing is rolled under the thighs, the tall waterproof shoe covers should be rolled down together with the protective pants. When they are rolled to the heel, one foot is removed, and then the other foot is removed. Finally, the outer gloves are removed and put into a medical waste can, together with the protective clothing and tall waterproof shoe covers (Figures 2F and 2G).

#### Remove the protective medical mask (B6)

When removing the protective medical mask, the head should be bowed. First, the lower elastic string of the mask should be adjusted to the position of the upper elastic string with both hands. Then, the two strings should be lifted together, and the mask should be gently removed. To prevent contamination of both hands, the hands should not touch the surface of the mask. Discard the mask by the elastic strings. The eyes should be closed tightly during the whole process to prevent the mask from flipping and contaminating the eyes. If someone's eyes are contaminated in the process, they should be immediately washed with saline. Other contaminated areas of the skin or mucous membranes can be disinfected with alcohol (Figure 2H).

## Results and Discussion

The transformation of wards should be based on the requirements of infectious ward construction and the actual situation of the hospital. After the transformation, the partition should be reasonable, and the behaviour of medical personnel should be standardized to achieve a good isolation effect [6]. In addition to the body fluids of patients, contact with aerosols is the main source of contamination. In the intensive care unit, the concentration of virus-containing aerosols is very high, and they may spread to other relatively clean working regions [7]. Therefore,

it is necessary to install air sterilization and negative pressure equipment to ensure the air quality in clean regions. However, reconstruction and sufficient equipment installation cannot be achieved in a short period of time, so it is necessary to complete these preparations before a COVID-19 outbreak. The negative pressure region should cover the contaminated area and potentially contaminated area, and the pressure should be set between -15 Pa and -30 Pa.

For staff entering the isolation region, wearing too many clothes may affect comfort. Generally, wearing long-sleeved work clothes plus outer protective medical clothing is sufficient. If conditions permit, the inner layer of clothing can be replaced by scrubs. Inner clothing can be adjusted according to the specific conditions and environments of each hospital.

The protective medical mask is designed to protect medical staff from airborne diseases during the diagnosis and treatment processes. It can filter pathogens and prevent blood and body fluids from contacting the face. The nonmedical N95 respirator is designed to prevent dust inhalation, but its filtration rate is the same as that of a medical respirator, though it lacks the function of preventing fluid contact. In the case of medical respirator shortage, a nonmedical N95 respirator (inner) plus a surgical mask (outside) can make up for its inability to prevent fluid contact [8].

According to the recommendations of the *Technical guidelines on the prevention and control of novel coronavirus infection in medical institutions (First edition)*, those with or suspected to have hand skin damage should wear double-layered gloves [8]; however, long-term work in the isolation ward easily damages single-layer gloves, increasing the risk of occupational exposure, so it is recommended that medical personnel wear double-layered gloves routinely.

Goggles and face shields are protective equipment that protect the eyes or face of medical personnel from splashing liquid. For routine operations, only one of them needs to be worn. For operations that may produce aerosols, such as tracheal intubation, tracheotomy, sputum suctioning, pharyngeal swabbing, etc., a comprehensive respiratory protective device or positive pressure head cover should be worn.

## Conclusion

COVID-19 is highly infectious. To cope with the rapid increase in COVID-19 cases, all medical institutions should complete ward reconstruction before an outbreak so that the building layout meets the requirements of an infectious ward. At the same time,



hospitals should train medical personnel on the processes and precautions of wearing and removing PPE to minimize cross-infection caused by inadequate protection and to ensure the safety of medical staff in the process of diagnosing and treating COVID-19.

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### Authors' Contributions

Zhengze Lin and Hongmei Shu were responsible for the conception and writing of the manuscript, Dongping Jiang was responsible for technical guidance in nosocomial infection control, and Yanlan He, Hongtao Xia, Yong Liu and Nan Xie were responsible for quality control. All authors agree to the final version of the manuscript and publication.

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