

# Two Areas and One Passage: A Simplified Protocol for the Transformation of General Hospitals to Infectious Disease Hospitals Upon the Pandemic Outbreak

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## Study Protocol

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# Abstract

Infectious disease hospitals and wards fell far short of demand after the COVID-19 pandemic outbreak. Consequently, it was of urgent importance to transform existing general wards into temporary infectious disease wards for COVID-19 patients. However, due to the limitations of the original structure of public hospitals, general wards could not meet the structural criteria requiring “three areas, two passages, and two hallways” for receiving infectious disease patients. In this article, we present a “Two Areas and One Passage” reconstruction and working protocol, which has been proved to be safe and easy to achieve by medical staff during the epidemic of COVID-19 in 2020. This protocol tremendously helps to save workforce and personal protective equipment compared with standard transformation protocol and thus might be used as an exemplary protocol for the transformation of general hospitals to infectious disease hospitals upon pandemic outbreak. Besides, it also provide a new scope for us to transform the general hospital to military infectious disease hospital if there occur abundant infectious disease suffers in the battlefield.

## Background

In 2020, the medical systems of many countries worldwide have been unexpectedly impacted and overwhelmed by the COVID-19 pandemic<sup>1,2</sup>. Hospitals and wards for infectious diseases fall short of demand<sup>3</sup>. Temporary compartment hospitals were designated for patients with mild symptoms or asymptomatic infection, while numerous severe symptomatic COVID-19 patients, even those with complications, could not be quarantined and treated in infectious disease wards<sup>4</sup>. Therefore, it is of an urgent need to transform the existing general wards into temporary infectious disease wards for COVID-19 patients. However, general wards did not meet the structural criteria requiring “Three areas, Two passages, and Two Hallways” for receiving infectious disease patients<sup>5</sup>, where the Three areas refer to “contaminated,” “potentially contaminated,” and “clean” areas, the Two passages refer to one-way entering and exiting passages, this classic structure has been proved to be safe and effective in Ebola treatment centers<sup>6</sup>. The Two Hallways refer to the patient and staff hallways. General hospitals involved in epidemic control were facing an urgent challenge of finding a simple and fast transformation protocol, which would be compliant with the infection control policy of China.

All authors of the present article are from Tangdu Hospital, which was designated to receive confirmed COVID-19 patients in Shaanxi Province during the COVID-19 outbreak<sup>7</sup>. This hospital also dispatched medical teams to Wuhan to work in temporary COVID-19 hospitals and treat the confirmed COVID-19 patients. Most of the authors of this paper worked in the Maternity and Child Healthcare Hospital of Hubei province since February 17, 2020. Figure 1 shows the original plane graph of the general wards in this hospital, whose design is quite universal for Chinese public hospitals. Three groups of elevators are set in different areas for patients, medical staff, and waste delivery. There are two fire stairs located beside patient and staff elevator rooms. The office area and the ward are generally independent of each

other. Medical staff passes through a simple and independent passage and doors to enter or exit the ward. Patients and their family members cannot freely enter the office area.

## The Standard Reconstruction Protocol And Its Disadvantages

The standard reconstruction (STR) protocol was used trying to set up “Three Areas and Two Passages”, thus transforming this general ward into the infectious disease ward. The “Two Hallways” could not be realized in general public hospitals. The office area was separated into two areas, *i.e.*, the clean area (green area, GA) and potentially contaminated area (yellow area, YA). The whole ward and ward hallway were regarded as the contaminated area or red area (RA). With such a setup, there was no second hallway for medical staff due to the limitation of the original design of general wards. The YA was supposed to be linked with the RA *via* a small buffering room with one-way doors, while the GA was supposed to be connected to the YA *via* another small buffering room with one-way doors as well. According to the STR protocol, medical staff in the GA should wear the Level-1 personal protective equipment (PPE), *i.e.*, an N95 mask and white coat to perform management, command, and coordination work. In contrast, those in the YA should wear the Level-2 PPE, which includes an N95 mask, goggles, and medical protection jumpsuit. Staff would stay in YA to accomplish medical records and nursing management activities, such as order management, drug dispensing, *etc.* Staff could enter the RA through the ward entrance buffering room, wearing the Level-3 PPE, including a face shield, an outer waterproof isolation suit, and protective boots additionally added to the Level-2 PPE. Due to the respiratory transmission feature of COVID-19 and infection control needs, the buffer rooms in YA and route to and out patient’s ward are vitally important in any reconstruction protocol for air precipitation, meanwhile the medical staff equipped with heavy layer of PPE also need multiple rooms and sufficient time to follow critical steps of removing their PPE. Therefore, staff in RA would need to pass at least two undressing rooms and corresponding buffering rooms for disinfection and then undress before entering the GA. If staff from the YA would need to go to the GA, they would also need to enter RA before undressing. The most prominent advantage of the structure of “three areas and two passages” is that such design offers enough space for the disinfection and sedimentation of pathogens when medical staff enters or exits the infectious disease ward. Yet, after on-site investigation, we found that the “three areas and two passages” could not be achieved in general hospitals, because it was impossible to set up so many standard buffering areas in the general ward. Under the circumstances of PPE shortage<sup>8</sup>, the added burden would be placed on PPE supply following such protocol.

As shown in Fig. 2, such reconstruction and working protocol have at least four disadvantages: 1) The initial entering passage only has one buffering room separating the RA and GA, which is not enough to isolate airflow from RA. GA could be contaminated by each entry into RA, which may be extremely dangerous to all medical staff working in GA. 2) Medical waste from the rooms in the undressing passage is delivered to the ward through the waste passage in each room. These waste passages could further increase the contamination possibility of undressing rooms by opening and closing doors, and through any doors accidentally left unclosed. 3) Medical Staff must wear Level-2 PPE in YA dealing with

paperwork and nursing management activities, which tremendously increases the consumption of PPE. 4) Medical staff workload might be too heavy for the doctors and nurses to finish all management and paperwork, as well as treatment activities.

## **“ Two Areas And One Passage” Protocol And Its Advantages**

We hereby carried out a simplified reconstruction (SIR) protocol of “Two Areas and One Passage” to meet the quarantine requirements for respiratory infectious diseases. In our solution, the entrance buffering room and doors would be all shut and sealed, thus turning YA in STR protocol into GA thanks to no direct communication with RA. The unnecessary connecting doors in the ward are to be blocked, as shown in Fig. 3. The “Two Areas” refer to the GA and the RA. The doors and buffering room between GA and YA in STR protocol could be eliminated. Consequently, the whole office area would become a fully independent GA. In this design, the medical staff would only need to wear Level 1 PPE while dealing with paperwork and nursing management activities. The “One Passage” implies that staff would enter and exit the ward through one pathway, *i.e.*, the undressing and corresponding buffering rooms. Medical staff would need to put on Level-3 PPE in GA before entering the undressing passage to enter the ward (Fig. 3). The passage would be kept disinfected by 24-hours ultraviolet lights and static electricity absorptive air sterilizer to minimize the risk of cross-infection between different rooms. Furthermore, we modified our working protocol according to One Passage structure. While entering the ward through the passage, medical staff would be required to finish the following assignments: 1) carrying medical items, medicines, and other necessities into the RA; 2) checking the consumption of sterilizing supplies, including hand sanitizer, moist towelettes and paper towels in the undressing room, and reminding the next shift to replenish the supply in time; 3) collecting waste in each undressing room and carrying it to RA for centralized delivery and processing; 4) supervising the undressing procedures of the off-duty medical staff from RA to prevent opportunistic infection due to inappropriate undressing process after 4-hour work.

Once proposed, this reconstruction and working protocol have been widely accepted by all the experts from the Center for Disease Control of China and infection control staff at our temporary hospital for five main reasons: 1) The reconstruction was simple, executable, and achievable in two days. It saved a lot of time because there was no need to create an entrance buffering room, trash room, additional storage room, and dressing room. During the epidemic, saving the reconstruction time means that the hospital could be immediately put into operation, thus saving more lives, and improving the epidemic control. 2) The office area of the medical staff was greatly expanded. Only one storage room and one dressing room were needed, and there was no need for any buffering room between GA and YA as in the STR protocol. The space these three rooms would occupy was saved, making the work of medical staff much more convenient. 3) At least 50% of PPE were preserved with the SIR protocol compared to the STR protocol, as staff in GA did not need to wear PPE doing paperwork and nursing management work. 4) The labor force was greatly reduced as to the SIR working protocol because there was no need to arrange any shifts to collect waste from undressing rooms or to specially supervise the undressing process. Staff did not need to wear Level-3 PPE while doing paperwork and nursing management, so that their shift lasted up to 8 h,

thus greatly reducing working personnel requirement. 5) This reconstruction and working protocol effectively prevented air in the undressing room and GA from being contaminated by that in RA, because the only passage connecting RA and GA was the undressing passage. The two buffering rooms and two undressing rooms were adequate for disinfection and sedimentation of pathogens in this passage.

During the outbreak of COVID-19, the admission of confirmed patients not only posed higher requirements for epidemic control facilities but also put heavier mental stress to everyone. This was another critical advantage of this reconstruction and working protocol due to a lack of medical staff during that period. The ratio of medical staff to patients was nearly 1:1 for more than 50 days when our temporary hospital received confirmed patients in Wuhan. It is a great challenge to set-up a workforce-saving strategy for all medical staff, especially for nurses in this special circumstances<sup>9</sup>. The infection risk of medical staff was minimized when “Two Areas and One Passage” protocol was applied for the transformation of a general hospital to an infectious disease hospital. The long undressing passage also gave all medical staff enough confidence to protect themselves<sup>10</sup>. This might be an optimal solution for public hospitals to respond to the pandemic receiving infectious patients quickly. It took 50 days from the admission of the first group of patients to leave our temporary hospital in Wuhan, where a total of 1,765 confirmed patients were treated. No hospital-acquired infection of medical staff occurred. After the evacuation, all the medical staff was quarantined for 14 days, and no infection or asymptomatic infection was identified by the two nucleic acid tests and the COVID-19 antibody test, thus fully supporting the rationality of this reconstruction and working protocol under such circumstances.

## Discussion

During the COVID-19 outbreak, there exist so many troubles to transform the original structure of public hospitals to infectious disease hospitals under the criteria “three areas, two passages, and two hallways”. The new protocol “two areas and one passage” we practised in Wuhan proved to be time, PPE and labor force saving. Furthermore, the office area of the medical staff was greatly expanded compared with the standard transformation protocol. Most importantly, no hospital-acquired infection of medical staff occurred during our 50 days of working there. So we think there must be the same problems in other hospitals in the world and the success of this protocol in Wuhan COVID-19 hospital might provide an exemplary transformation protocol for the general hospitals during the pandemic outbreak. At last, it also provide a new scope for us to transform the general hospital to military infectious disease hospital if there occur abundant infectious disease suffers in the battlefield.

## Abbreviations

1. COVID-19☐coronavirus disease 2019
2. STA☐standard reconstruction
3. SIR☐simplified reconstruction
4. PPE☐personal protective equipment

5. GA green area/the clean area
6. YA yellow area/potentially contaminated area
7. RA red area/contaminated area

## Declarations

(1) Ethics approval and consent to participate

Not applicable

(2) Consent for publication

The authors all agree to submit our manuscript to the journal of Military Medical Research.

(3) Availability of data and material

The data and material is available and original that has not been previously published.

(4) Competing interests

We declare no competing interests.

(5) Funding

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(6) Authors' contributions

JY and DL wrote the manuscript. WG and MP designed and mapped the concepts.

(7) Acknowledgements

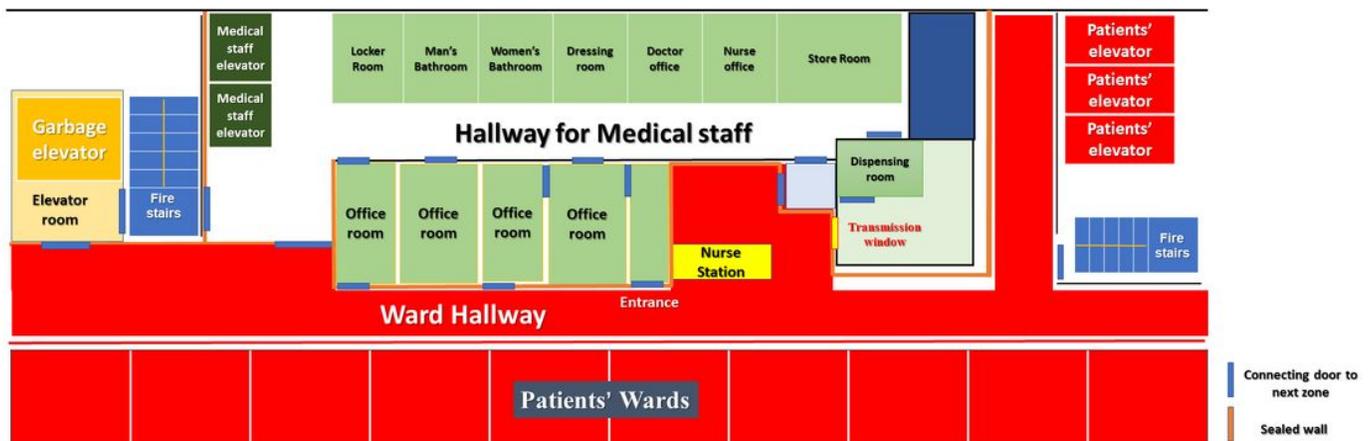
The authors have authorised me to act as corresponding author during the review process. We assure that this manuscript represents original material that has not been previously published and we do think the protocol in this report is of novelty and significance under the current circumstances.

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## Figures



**Figure 1**

The original plane graph of the general wards in the general hospital.

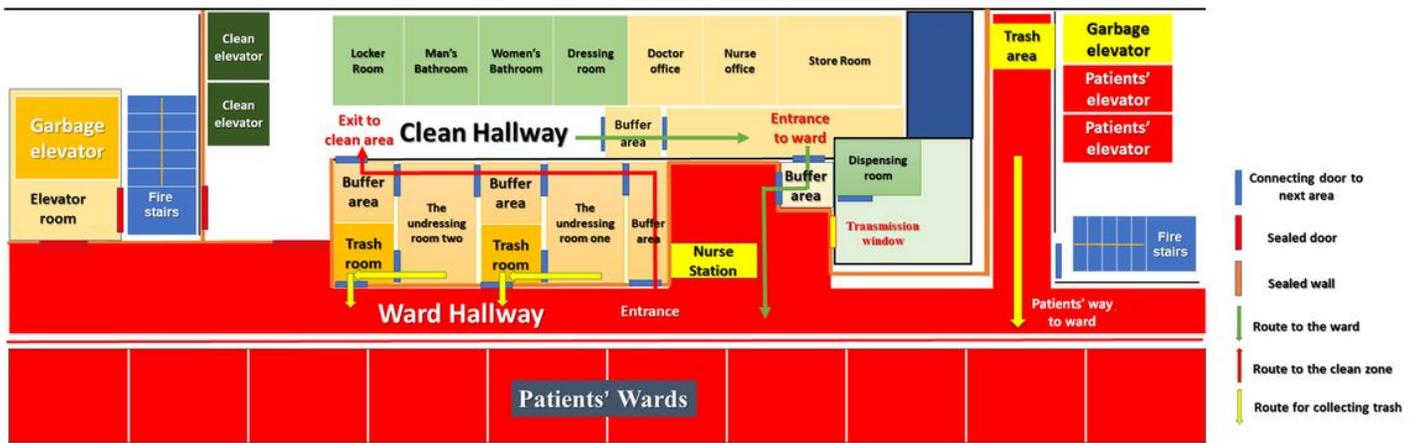


Figure 2

The standard reconstruction (STR) and working protocol of “Three Areas and Two Passages” transforming the general ward into infectious disease ward.

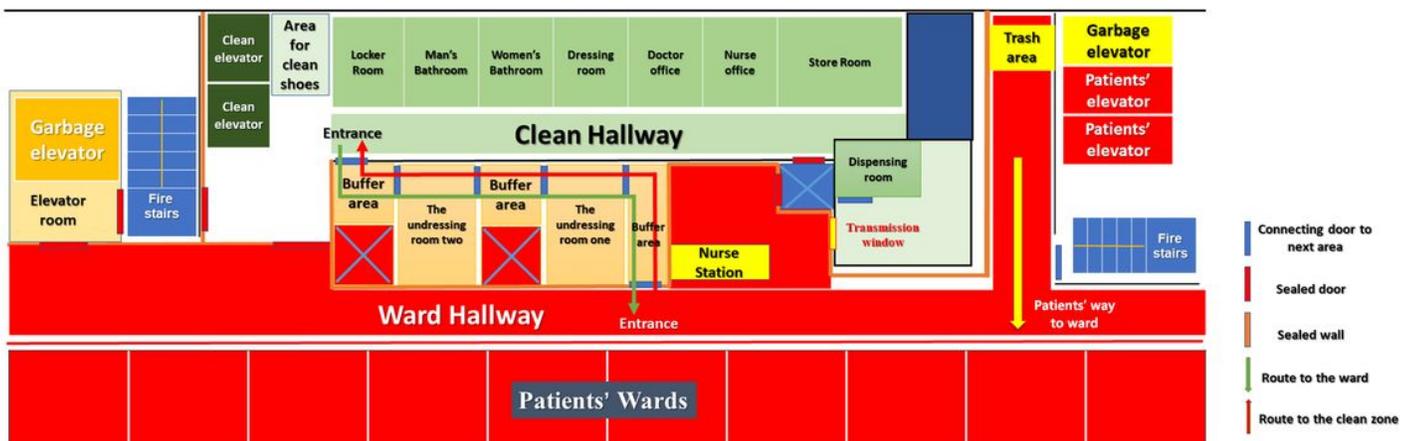


Figure 3

The simplified reconstruction (SIR) and working protocol of “Three Areas and One Passage” transforming the general ward into infectious disease ward.