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## Short Communication

## Laboratory biosafety emergency management for SARS-CoV-2

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## ABSTRACT

A biosafety laboratory is a prerequisite for studying emerging infectious diseases. Safe and effective operation in laboratories and the handling of pathogens determine the safety of the personnel, pathogens, and the environment in the laboratory, which are among the key factors for successful experimentation. In this article, we aimed to provide ideas for the emergency management of biosafety laboratories, including a discussion on the urgency of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) related experimental activities, tracking clinical information, taking emergency measures, revision of the risk assessment process, and standardization of personal protective equipment and personnel behavior standards.

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The coronavirus disease 2019 (COVID-19) outbreak started in China in December 2019, and the disease is now a global pandemic. As a basic and guaranteed platform for the research of emerging infectious diseases, a biosafety level 3 (BSL-3) laboratory provides the hardware support for humans to recognize severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and study the COVID-19 prevention and treatment methods. With the existing hardware facilities, safe and effective operations in biosafety laboratories depend on taking the appropriate emergency management measures to protect the personnel, pathogens, and laboratory environment.

## 1. Biosafety level 3 laboratory

BSL-3 laboratories are the most numerous and frequently used laboratories among the high-level biosafety laboratories. The animal biosafety level 3 (ABSL-3) laboratory consists of primary barriers, such as biological safety cabinets, animal isolation equipment, and personal protective equipment (PPE), and secondary barriers, such as architectural structures and electrical and control systems.<sup>1</sup> Through the appropriate hardware facilities and management measures, a BSL-3 laboratory protects the staff, the environment, and the general public from the hazards of pathogenic microorganisms. These laboratories are mainly used for experiments with highly pathogenic microorganisms, such as SARS-CoV, MERS-CoV, HIV, among others.<sup>2</sup>

## 2. Emergency management of SARS-CoV-2

Considering the bounded cognition in the case of SARS-CoV-2, the laboratory PPE often has either excessive or insufficient defense, which may cause extreme panic and wastage of the protective equipment, thus increasing the risk of infection for the staff. In order to ensure personnel and environmental safety while considering the comfort factor and reducing the harmful effects of disinfectants on personnel and facilities, the potential risks were identified and the risk assessment process guidelines and statements were constantly revised based on our knowledge of COVID-19 and SARS-CoV-2, which changed from “not pathogenic” to “highly pathogenic”, and from “cannot be transmitted from person to person” to “does not exclude person to person” to “affirmed person to person”.

## 2.1. Risk assessment management

Risk assessment is a key step toward taking the appropriate emergency management measures to protect the people, pathogens, and the environment. At the beginning of the COVID-19 outbreak, the highest level of PPE was required, since the cause and route of transmission were unknown. At present, there are four known routes of infection of this disease: the respiratory tract, digestive tract, blood, and skin contact, among which the aerosol transmission from the respiratory tract requires the highest level of protection. Therefore, people involved in experimental activities need to wear disposable N95 masks, two layers of protective clothing, and two layers of disposable gloves. Considering the comfort of the personnel and the convenience of operation, and according to

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the criterion “cannot be transmitted from person to person”, it was not recommended to wear positive pressure protective clothing or head cover.

The pathogen was then successfully isolated and suggested to be a new type of coronavirus,<sup>3</sup> which was classified as “SARS-related” or “SARS-like” coronavirus. The clinical diagnosis results showed that the patients had white blood cell counts and chest radiograph symptoms similar to those observed in the cases of SARS coronavirus infections.<sup>4</sup> Therefore, the risk assessment process was revised for the first time to take into account the biological and epidemiological characteristics, potential consequences of exposure, and precautionary measures against the SARS coronavirus. Although no obvious evidence of human-to-human transmission existed at that time, the staff was still required to take strict respiratory protection measures.

In mid-January, the “Guidelines for Biosafety of New Coronavirus Laboratories” clarified the severity of the virus and temporarily managed it according to the category of highly pathogenic microorganisms. However, the guidelines stated that non-propagative diagnostic laboratory work in biosafety level 2 (BSL-2) laboratories should use the PPE of BSL-3 laboratories.<sup>5,6</sup> BSL-3 protection levels ensure a higher level of safety than that needed for handling SARS-CoV, which suggested that SARS-CoV-2 may be more harmful than SARS-CoV; thus, the risk assessment guidelines were revised once again. Based on the existing levels of safety provided by the currently available PPE, the basic management principles of “reduction of procedures and peak-to-peak deviations” were proposed. The entry time was staggered and the amount time of time spent by the personnel in the laboratories was reduced by controlling the number of single pathogenic operations, increasing the number of staff, and formulating experimental plans in advance. In addition, personnel in different containment areas of the laboratories were required to stagger their departure time by more than half an hour in order to fully clean the public area.

With subsequent progression of the COVID-19 epidemic, the new coronavirus was confirmed to be transmitted by person-to-person contact and showed a possibility of causing conjunctival infection.<sup>7</sup> As a result, an immediate third revision in the risk assessment process guidelines was made. Goggles or disposable protective masks were added to the respiratory protection equipment for protection against aerosols to prevent potential conjunctival infection. As more advanced research, clinical diagnoses, and autopsy of the new coronavirus patients were conducted, the biological characteristics of the virus were better defined. By closely following the continuously updated “Guidelines for the Diagnosis and Treatment of Novel Coronavirus (2019-nCoV) Infection” of the National Health Commission and the openly published scientific papers and clinical diagnosis results in China and abroad, the risk assessment process was continuously improved and the staff members were guided to make the transition from “top level protection” at the initial stage to “reasonable protection” with pertinence.<sup>8,9</sup> The laboratory technicians were now required to wear a disposable N95 mask, two layers of protective clothing, two layers of disposable gloves, and disposable protective face shields. In the process of cultivating viruses or in animal anatomy experiments, there may be a risk of infection from aerosols or fluid splashes. The experimental personnel can wear a positive-pressure-powered air-filter hood and a one-time reverse operating suit, which can be replaced conveniently after being contaminated.

## 2.2. Personnel management

Personnel management involves the problems of formulating standard operating procedures according to the risk assessment, conducting special training for laboratory personnel, guiding the

staff on how and why to follow certain protocols and procedures, and sensitizing them regarding the necessity of these actions. Personnel safety does not only include selecting the appropriate PPE but also developing and maintaining the standards for the donning and doffing of PPE. In personnel management, the administrators should actively communicate with the laboratory personnel and pay attention to their requirements and other details to build trust, discover the loopholes in the processes in time, and urge them to comply with the regulations. Providing laboratory personnel with the highest level of convenience and care can significantly improve their compliance and performance. It is beneficial for the administrators to comprehend the mental health of the laboratory personnel and perform good psychological counseling in time.

## 2.3. Disinfection management

Disinfection management is an important aspect of environmental safety in laboratories. Selecting a suitable disinfectant not only ensures effective and efficient disinfection but also minimizes damage to the personnel, facilities, and equipment. When dealing with an unknown pathogen, the most serious pathogen is set as the standard for disinfection. Considering the disinfection effect and safety, the disinfectant containing 0.55% effective chlorine was selected to disinfect the experimental table and samples, while hydrogen peroxide or peracetic acid was selected to disinfect the laboratory environment.<sup>6,10</sup> Although formaldehyde can kill all pathogenic microorganisms and their spores, its use is not recommended because of its carcinogenicity and the damage it causes to the facilities.<sup>10</sup> It is well known that 75% alcohol is a common disinfectant in biosafety laboratories, but it cannot kill all the non-lipid viruses.<sup>10</sup> Seventy-five percent alcohol was not chosen at the early stage of the epidemic because its disinfection effect cannot be verified when the pathogen is unknown. However, when the pathogen was identified as a new type of coronavirus, the disinfection effect of 75% alcohol was verified and it was proved that it could be effective against coronavirus.<sup>9,10</sup> Thus, considering the safety of the disinfectant for the laboratory personnel, 75% alcohol was added as an effective disinfectant.

## 2.4. Management of experimental activities

The management of SARS-CoV-2 experimental activities is crucial to ensure normal operation of the laboratories and to avoid accidents. Since virus cultivation should strictly control the number of single operations, we suggest not operating for prolonged periods of time but operating frequently and shortening the operation time. The designated areas of the items placed in the biosafety cabinet from left to right are the clean area, work area, and dirt area, and the items should be placed such that they do not block the air outlet so as to avoid affecting the air flow or causing an equipment alarm. The number of staff members entering the laboratory can be increased according to the number of the animals that are infected every single time during the animal infection experiments. For example, two persons are allowed to operate for approximately 3 h at ordinary times, and 3–4 persons can enter simultaneously during the emergency period. To reduce the probability of accidents due to personnel fatigue, each entry time is strictly controlled within 4 h. For this reason, sufficient experimental preparations should be done, and a complete scheme should be formulated before the experiment, including the administered dosage, infection dose, route of administration, and other important factors. During the experiment, except for the experimental progress that must be completed on-site, such as the pathological anatomy and observation of animal symptoms, the equipment and infectious material records can be supplemented after leaving the laboratory.

### 3. Conclusion

In this period of the global pandemic of COVID-19, BSL-3 laboratories provide the hardware support to study the biological characteristics, prevention, and treatment of SARS-CoV-2. By closely tracking the clinical information and taking appropriate emergency management measures to standardize the use of PPE and personnel behaviors, the risk assessment process guidelines have been constantly revised to ensure the safety of the personnel, pathogens, and environment and the effective operation of such laboratories.

### 4. Author's contribution

1. Professor Gao Hong is the corresponding author of this article, who provided the ideas for the article and guided the writing.
2. Lin Kaili is the first author and responsible for writing this article.
3. Other authors participated in the drafting of this article.

### CRedit authorship contribution statement

**Kaili Lin:** Conceptualization, Writing - Original Draft. **Meixuan Liu:** Conceptualization. **Haoran Ma:** Conceptualization. **Sidan Pan:** Conceptualization. **Hongwei Qiao:** Conceptualization. **Hong Gao:** Conceptualization, Formal Analysis, Fund Acquisition, Writing - Review and Editing Resources, Supervision.

### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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