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Upgrading and Maintenance of Laboratory Animal Facilities in Ordinary Chinese Universities

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Abstract

As the main place for animal rearing and experimentation, laboratory animal facilities have strict limitations on environmental conditions such as temperature, humidity, pressure difference, noise, cleanliness, and air exchange rate, and there are standardized requirements in management for personnel operations, entry and exit of items and animals into and out of the facilities. Through accumulating the construction and management experience of the laboratory animal facilities of Guangdong Medical University where the author is located for nearly 14 years (from 2010 to 2024), the author explores and summarizes from the aspects of upgrading and maintenance of animal facilities, aiming to provide practical and feasible practical references for the construction of laboratory animal facilities in ordinary Chinese universities and research institutes.

Keywords

Laboratory animal; Facility; Ordinary university.

1. Introduction

Laboratory animal facilities are the sum of buildings and supporting equipment used for the production and reproduction of laboratory animals or for scientific research, teaching, biological products and drug development using laboratory animals. According to their different purposes of use, they are divided into laboratory animal production and breeding facilities and animal experiment facilities [1]. The safe operation of facilities and the standardized control of environmental conditions are essential conditions to ensure the quality of laboratory animals and the smooth progress of animal experiments, while scientific and professional upgrading and maintenance are the keys to ensuring the stable operation of facilities throughout the year, ensuring that environmental conditions meet the standards, improving the operating efficiency of equipment, reducing the failure rate of equipment, and prolonging the service life of the system [2]. The area of the laboratory animal facilities of the Laboratory Animal Center in the Dongguan Campus of Guangdong Medical University is 6180 m2. The civil construction was completed in 2010, and the "Laboratory Animal Use License" issued by the Guangdong Provincial Department of Science and Technology was obtained in 2019. It has been put into use for 5 years now, and the overall operation is in good condition, providing more conveniences and platform foundations for the teaching and scientific research of our university.

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2. The Operation Status of Laboratory Animal Barrier Facilities in Chinese Ordinary Universities

2.1. Overall Construction Status of Laboratory Animal Barrier Facilities

Under the guidance of "Technical Code for Laboratory Animal Facility Buildings" (GB 50447-2008) [3], the laboratory animal barrier facilities adopt a double-corridor (clean corridor and dirty corridor) design. There are air shower rooms, storage rooms, quarantine rooms, breeding rooms, and laboratory operation rooms within the barrier system. Outside the barrier facilities, there are also receiving rooms, changing rooms, sterilization rooms, washing and disinfection rooms, storage rooms, and offices. The total construction area is approximately 2400 square meters. The overall walls and ceilings of the barrier facilities are composed of color steel sandwich panels, and the floors use anti-static PVC flooring. The connection between the walls and the floors uses aluminum alloy materials. And it is equipped with an independent air conditioning and ventilation system, first changing room, second changing room, air shower room, quarantine room and supporting receiving room. The breeding rooms are equipped with independent ventilation cages (IVC), small trolleys, and electronic scales; the laboratory operation rooms are equipped with clean benches, refrigerators, super-clean benches, etc.; in addition, there are also equipment and facilities such as high-pressure sterilizers, transfer windows, and pure water systems.

The design parameters of the barrier system include: humidity 40%-70%, temperature: 20°C-26°C, air cleanliness: level 7; air exchange rate: 15-20 times per hour, the minimum static pressure difference with the adjacent rooms: ≥10 Pa, ammonia concentration ≤14 mg/m3, noise ≤60 dB, the lowest working illuminance: 200 lx, and the day-night alternation time is 12 h/12 h.

2.2. Main Problems Existing in the Operation of Facilities

2.2.1. The facility design is outdated and the hardware configuration of the facility is insufficient

The civil construction of our school's barrier facilities was completed in 2010, and the internal space design is relatively traditional. Due to the funding limitations of ordinary universities, the equipment configuration is lagging, and the reserved space is insufficient, resulting in difficulties in subsequent equipment installation and retrofit. With the rapid development of the life sciences and pharmaceutical fields and the standardization of research in related fields, the number of newly installed cages and hardware configurations in 2019 are difficult to meet the current research needs of the construction of high-level medical universities in our school.

2.2.2. Complicated access management and potential safety hazards in the facilities

During the operation of the barrier facilities, the flow of people, animals, and goods is the three key links for the operation of the facilities and also an important link of cross-contamination. With the continuous increase in the number of cages, the entry and exit of personnel, animals and items, especially large-scale facilities, within the facilities have increased sharply, bringing great biosafety hazards to the facilities [4].

2.2.3. Lack of professionals and limited facility upgrade and maintenance

The operation of laboratory animal facilities involves a wide range and is highly professional. Different facilities have different environmental requirements. Relying only on the relevant personnel and technologies of the unit is difficult to support the safe and stable operation of a wide variety of laboratory animal facilities with large areas. The vast majority of the staff in the Laboratory Animal Center of our school have backgrounds in laboratory animal and medical-related majors, and lack professionals with professional knowledge and practice in electromechanical, HVAC, and automatic control, etc., and it is difficult to discover the hidden

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dangers in the operation of facilities and equipment and lack daily maintenance in a timely manner. At the same time, due to the limitations of factors such as the system, the maintenance, equipment and consumables purchase cycle of laboratory animal facilities in universities is long, resulting in a long troubleshooting cycle, poor stability and great potential hazards of the facility environment [5].

3. Facility Operation Management Upgrade and Maintenance

3.1. Introduction of Intelligent Facilities

After many investigations and on-site surveys, and with the permission of the funds, many intelligent systems such as independent ventilation breeding systems, animal laboratory information management systems, water supply and drainage systems, automatic access control and automatic door systems have been successively introduced to upgrade the laboratory animal facilities of our school to the greatest extent.

3.1.1. Independent Ventilation Breeding System

The IVC independent ventilation cage can provide uniform and low-flow clean air for SPF animals. The exhaust gas emitted by the animals enters the main engine exhaust system through the return air duct of the cage rack, and then is discharged outdoors after filtering, thereby maintaining low ammonia level and humidity in the cage box, reducing the frequency of bedding replacement, preventing cross-infection among animals, and ensuring the health of laboratory animal workers, significantly improving the welfare level of laboratory animals [6]. The IVC independent ventilation cage is suitable for the cultivation, reproduction, preservation and various short-term animal experiments of SPF animals, and is especially suitable for raising immunodeficient animals and transgenic animals. The animal laboratory of our school adopts dozens of independent ventilation breeding systems, that is, independent ventilation cage boxes to breed mice and rats, expands 4000 cage positions and improves the laboratory breeding environment, minimizing the potential biosafety hazards caused by the complex entry and exit of personnel, items, animals and equipment as much as possible.

3.1.2. Animal Laboratory Information Management System

All aspects of business such as laboratory animal production and reproduction, preservation and sales, animal experiment management, ethical review, financial settlement, material procurement and inbound and outbound storage, and the issuance of various bills are complex and cumbersome [7]. Under the traditional management mode, these works are all in the charge of special personnel, using manual records, statistics, classification and data storage, etc., there is a large amount of work, requiring multiple repetitive labors, low work efficiency, non-standard manual record materials, and prone to errors or deviations, it is difficult to ensure the integrity and accuracy of records, and makes the work lack continuity, etc. [8]. The school has cooperated with Zhongke Equipment (Guangzhou) Biosafety Technology Co., Ltd. to develop a set of intelligent comprehensive management system for laboratory animals to standardize the processes and network automation of all links, so as to improve the management efficiency and level, so as to comprehensively control the dynamic information of various items from production to experimental services, and finally achieve standardized, scientific, process-based and information-based management [9].

3.1.3. Water Supply and Drainage System

The standards for drinking water of laboratory animals are strict and need to comply with relevant national regulations. For example, as stipulated in GB14925-2023 "Laboratory Animal Environment and Facilities", the drinking water of ordinary-level laboratory animals should meet the domestic drinking water standard of GB5749, while animals at the barrier environment and above levels need to use sterile water [1]. This means that as the level of

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laboratory animals increases, the requirements for water purification treatment also increase to ensure that there are no harmful substances interfering with the experimental results. The whole building of the laboratory animal center of our school prepares ultrapure water and soft water centrally and supplies them uniformly. The drinking water of large animals adopts the automatic drinking water system for large animals. After disinfecting the drinking water, it is directly supplied to the animals for drinking through the automatic drinker. The drinking water of small animals adopts the reverse osmosis sterile filtered water system, and is connected to the filling machine in the barrier through pipelines for water supply [10]. The water supply and drainage system reduces the workload of workers while reducing the pressure of the autoclave, which is more conducive to the stability of the system.

3.1.4. Automatic Access Control and Automatic Door System

The entrance access control system of the animal laboratory adopts face recognition. After the user selects the work name on the computer screen (such as: experiment, animal breeding, cleaning and disinfection, safety inspection, etc.) or fills in the experimental information directly, the system will automatically record the entry and exit of personnel, and unauthorized personnel cannot enter the laboratory, thereby reducing the cumbersomeness of manual registration and preventing unauthorized personnel from entering the controlled area. Automatic doors are set on the main passages and are automatically switched on and off through infrared induction [10].

3.2. Maintenance of Experimental Animal Facilities

3.2.1. Establish a high-level management team and strengthen supervision and communication

The maintenance work of experimental animal facilities involves more than a dozen majors such as water supply and drainage, HVAC, and electrical. In daily operation, professional managers are needed to carry out daily management work [11]. Digital and intelligent management and low-carbon operation are the development directions of experimental animal facility management in the future [5]. Our school has established a high-level maintenance team based on the actual situation. The person in charge is responsible for notifying before and after maintenance, and doing a good job in detail control to avoid the impact of operations on the space environment and equipment that hinders normal work. Professional maintenance personnel need to be able to complete fixed services according to the purpose of employment, such as 24-hour duty, maintenance of clean lamps and ultraviolet lamps, regular replacement of primary, medium and high-efficiency filters, etc. Every quarter, the management team should summarize the maintenance work in the past period, strictly train the maintenance personnel according to the process of the entry and exit of experimenters, comprehensively assess the difficulty of maintenance and optimize the work.

3.2.2. Screen professional outsourcing services and optimize facility management

Although the commercial service of operation and maintenance has been booming in recent years, it is of uneven quality. Our school has made itemized procurement for the maintenance services of highly professional ventilation and air conditioning systems, water supply and drainage, security systems and washing and disinfection equipment. Among them, large equipment is mainly maintained professionally by the original manufacturer, and it is generally agreed that 1 to 2 self-inspections of maintenance are carried out every month, engineers are on duty by phone, and it is promised that they will arrive at the scene to deal with the problem within one day if there is a problem, and simple problems will be solved within a few hours, and big problems will be solved within a few days [12]; others such as purification engineering systems (such as automatic control, air supply and exhaust, HVAC, etc.) are entrusted to

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different professional companies. The entrustment agreement is generally signed once a year to facilitate the timely elimination of maintenance companies with low professionalism.

4. Conclusion

This article takes the Dongguan Experimental Animal Center of Guangdong Medical University as an example to expound the current situation of the construction and operation management of the experimental animal barrier facility, and finds that there are problems such as outdated facility design, insufficient hardware configuration, safety hazards caused by complex entry and exit management, and lack of professionals. In response to the above problems, we have introduced intelligent facilities such as independent ventilation feeding systems, animal laboratory information management systems, water supply and drainage systems and automatic access control systems, which have improved the operating efficiency and safety of the facilities and reduced the potential biosafety hazards, and also achieved comprehensive informatization of experimental animal management. At the same time, we have established a high-level maintenance team and strengthened the internal supervision and communication mechanism to ensure the stable operation of the facilities. In view of the differences in the quality of outsourcing services, we carefully select professional maintenance companies and sign detailed entrustment agreements to optimize facility management and improve service quality. Therefore, for peer units, they should base on their own facility status, carefully consider the intelligent transformation of facility hardware, and continuously improve the professional level of team management. When choosing an outsourcing service, it is necessary to consider the response time and service cycle of the outsourcing service unit according to local conditions, and strive to minimize the operational risk of the facility to ensure the continuous, efficient and safe operation of the experimental animal barrier facility and provide a strong guarantee for the smooth development of scientific research work.

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