Post-Occupancy Evaluation to Improve the Clinical Laboratory in Tertiary Hospitals in Shaoxing

Wenzhao LIU

StudentID: 201221822

Faculty of Science and Engineering
University of Nottingham, Ningbo, China

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ABSTRACT

Nowadays, medical technology is developing at high speed, and laboratory medicine has been developed. As a hospital clinical laboratory in vital sectors, the laboratory is getting more and more attention from society. It not only needs to meet the work needs of the inspectors, but also considers the psychological needs of the inspectors. An efficient and clean working environment helps improve the efficiency and work comfort of inspectors. In China, most of the laboratory design does not have efficient circulation planning, and there is no clear functional division, which hinders the space of the laboratory from achieving maximum efficiency. Relatively few researchers have investigated the impact of the physical environment on inspectors.

This research concentrates on the effect of the design of the clinical laboratory to develop an efficient and clean environment for inspectors. A method combining practice and theory is proposed to investigate the spatial and social attributes of the laboratory. According to the design before and after the reconstruction of the same hospital's laboratory, the spatial layout of the laboratory is analyzed and studied to understand the work requirements and work of the inspectors. Based on the spatial syntactic theory, the layout of the laboratory is simulated by measuring the spatial properties of the laboratory plan. The comparative analysis of the results reveals the problems that need to be improved in the laboratory, This study also proposes methods for laboratory improvement and behavioral research, which can be used in other studies. In addition to spatial layout design, architects also need to consider other influencing factors, including the location and orientation of the room and users' psychology.

Keywords: Clinical laboratory design, Space Syntax, Spatial design

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CHAPTER 1. INTRODUCTION

1.1 Research Background

1.1.1 The Status Quo of Clinical Laboratory

Today, as the global economy booms and transformation of the medical model and medical technology updates, medical institutions in China has launched a wave of new challenges. Laboratory services in medical systems play a pivotal role in patient diagnosis. Leaven, L. (2015) had shown that the laboratory affects about 65% of the most critical decisions regarding admission, discharge and medication. Laboratory testing costs account for about 10% of hospital bills, so laboratory will directly affect the revenue and expenditure of the hospital. Reducing laboratory costs and improving laboratory performance will help to reduce total medical costs, which is one of the main goals of Chinese hospitals.

As one of the essential medical technology departments that are highly dependent on various technologies, the laboratory has evolved from a simple manual experiment operation to intelligent equipment operations. Along with the tremendous changes in the laboratory, how to create an efficient and clean space for testing medical care has become an important issue that must be solved in the construction of contemporary hospitals.

The layout of the interior room and the design of the circulation will directly affect the efficiency of the laboratory. The functional composition of the laboratory can be seen from Figure 1.1.Orderly and reasonable equipment placement will also help inspectors improve work efficiency, thus further increasing the number of hospital service personnel and reducing patient waiting time.

Clinical laboratory as a medical institution, its equipment update speed is

very rapid, and project tendering is conducted every two years to update or replace the inspection equipment. Therefore, clinical laboratory inevitably needs to expand or rearrange its internal layout to adapt to this unprecedented change. In order to make the laboratory work more efficient and to meet the requirements of the equipment update, the subject of indoor flexible layout and circulation design optimization of the laboratory is particularly essential.

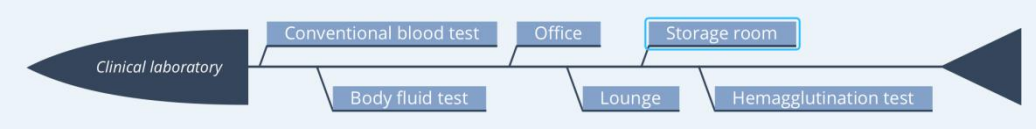


Figure 1.1Function Map of Clinical Laboratory

1.1.2 Research in Laboratory Abroad

Chang, Y.M. (2010)found that the development of foreign laboratory medicine was earlier. In 1590, the manufacture of microscopes laid the foundation for the development of laboratory medicine. In the mid-20th century, the appearance of the first blood cell counter significantly improved the accuracy and precision of the test. In 1959, the establishment of radioimmunoassay opened up a new field of laboratory medicine.

Dong, M.& Hu, C.M. (2003) said that in some developed countries abroad, under the influence of medical technology, economic strength and national medical policies, people have high requirements for the laboratory. Relevant organizations and management also have detailed regulations, such as the US Clinical Laboratory Improvement Act (CLIA), which provides detailed regulations and requirements for the design of the laboratory.

American scholar Mayer, L. (1995) published the book *Design and Planning of Research and Clinical Laboratory Facilities* in 1995, he discussed the planning, planning, mechanical engineering, electrical engineering, pipeline engineering, animal facilities, Department

supporting facilities and laboratory workspace of the laboratory, and mainly discussed the design and planning of the laboratory. In the chapter of the standard plan of the laboratory, the authors summarized the essential and area indicators of the modular design of laboratory standards, as well as list some typical examples of modular design.

International studies on hospital circulation organization and functional space are very systematic, and each stage has similar practical cases to test. The current research on circulation and function of hospital buildings has been highly integrated; in contrast, Sheng, Y.J. (2017) showed that China is still in the system research stage in this aspect of research. This aspect is due to the phenomenon that the theoretical research in China is lagging behind the practice cases, and on the other hand, it is based on the “Chinese general hospital building in the expansion stage of large general hospitals.”. The primary point, the corresponding research needs to explore a development path of its own. Since there is no mega-single stage in foreign countries, the case of hundreds of thousands of square meters has exceeded the scale of international theoretical and practical research. It needs a balanced model with Chinese characteristics to cope with large-scale human circulation. Besides, in large and medium-sized cities, due to the speed of urban expansion is higher than the speed of hospital network coverage, high-profile and high-level well-known general hospital buildings are generally located in the city center but have to take care of patients in the entire area. Therefore, it is urgent to expand and expand within a limited scope, which means efficient circulation. The line can save the hospital more space for treatment and reduce the problem of cross-contamination and confusion caused by crowds. Therefore, the importance of the circulation organization can be imagined. The actual situation of each hospital has also continuously indicated that the circulation organization of the hospital and its related functional space

organization have become an integral part. The two are mutually restrained and affect the current operational efficiency and environmental quality of modern general hospitals will also have an impact on the new stage of hospital building operations shortly. In terms of theoretical research, although there are many related kinds of literature, most of the research methods mainly divide hospitals into emergency department, medical technology building and inpatient department according to their functions, and then analyze and study them. There are too many characteristics to study, and the specificity is more than universal. Moreover, hospitals need to conduct research referring to different systems, such as the transportation system, functional system and space system, is relatively rational and scientific. The research on the transportation system based on this needs to continue to be studied systematically. At the most basic level, architectural research needs to further improve the research framework and lay the foundation for the establishment of hospital building research theory.

1.1.3 The Future Challenges of Clinical Laboratory

1.1.3.1The Rapid Development of Medical Technology Has Brought New Development Opportunities

Laboratory medicine is one of the fastest-growing disciplines in recent decades (Greer, A.L.1988).Laboratory medicine combines the best scientific experimental evidence with clinical practice, making medical decisions and using health resources at the right time and with less expense. All need to rely on laboratory medicine. With the progress of science and technology and the development of clinical medicine, the development of laboratory medicine is also continually evolving. From the original manual test operation to the current state of automation, information, quality control and standardization, the functions of

laboratory medicine are also continually developing. The laboratory has also developed from a simple laboratory to one of the most important medical technology departments in testing, consulting and teaching. It is working mode has changed from manual operation to automatic analysis. For a large number of intelligent equipment pipeline operations, all this makes the inspection department form a modern department integrating high-tech equipment and advanced technology.

So far, there have been three trends in the development of laboratory medical technology. The first is that with the development of essential medicine and the application of high-tech, various types of automated instruments have been introduced one after another, and the technical quality and academic level of the inspection workers will be higher. On the other hand, the experimental technology is developing toward miniaturization, simplification. Each type of test enables the inspector (or medical staff) to conduct tests on the patient's side and immediately obtain the results, which significantly facilitates the patient and the clinic, but how to standardize and enhance control of automated instruments is also a challenge. A new topic has been proposed. The third aspect is that with the gradual maturity of gene cloning technology and the gradual improvement of gene sequencing work, the post-gene era has gradually arrived Holmberg, T. & Ideland, M. (2013) said that at the end of the 20th century, mathematical science was widely infiltrated in the field of biology. Under the circumstance of structural genomics, functional genomics and environmental genomics, molecular diagnostics technology will make breakthroughs. These tasks are gradually entering the clinical practice from experimental basic research, and also bring a new field to laboratory medicine, which provides new opportunities for the development of the discipline, and also makes fundamental changes in the management model and human structure of the laboratory. Standardization, networking, legal management, standardization of

experimental methods and implementation and management of a comprehensive quality assurance system have become the fundamental tasks of the construction of the laboratory.

1.1.3.2The Change of Medical Examination to Laboratory Medicine Has Changed the Position and Concept of the Laboratory

With the application of automated instruments and supporting reagents, as well as standardized management, methodological research is not the focus of the laboratory, but through standardized and networked management of laboratories, timely and accurate reports, more participation in clinical diagnosis and treatment, and cooperation between laboratories and clinicians, the laboratory have become an important tool for experimental diagnosis (Price, C.C.2000). Therefore, new problems have also been encountered in the construction of disciplines. First of all, laboratory work should be tightly integrated with clinical practice, then should continue academic exchanges and information exchanges with clinical laboratory personnel. Limited experimental data should be transformed into practical diagnostic information to participate in clinical practice more and more directly. Secondly, this transformation also requires a corresponding shift in the knowledge structure of the laboratory staff. The fundamental theoretical knowledge of experimental medicine, such as biology, biochemistry and immunology, can no longer meet the needs of the development of the discipline. It must have more theoretical and practical clinical medicine. The concept of continuous development requires us to strengthen continuing education and personnel training to make the inspectors have transformed from simple experimental technology to clinical and technical combination, improving the overall academic quality and level. The third aspect is reflected in the apparent changes in the talent

structure of the laboratory, from the pure inspection technology-based team to the multidisciplinary combination of clinicians, inspectors, information management, and bioengineering personnel.

1.1.3.3 The Transformation of Medical Mode Puts Forward New Requirements for Laboratory

The transformation of the medical model has brought about new changes in the needs of society and patients for medical services, and it has also put forward new requirements for testing the positioning and content of work. Brewster, L. R. (2010) wrote in *Changes in hospital competitive strategy: a new medical arms race?* that transformation of medical mode is required that the existing teaching mode be innovated in the laboratory to cultivate high-quality talents to meet the needs of the clinical laboratory.

1.2 Research Aim and Objectives

This research focuses on the theoretical analysis and data collection towards a specific site, the clinic laboratory, which aims to deal with the temporary issues and introduce the foresight and flexibility to the theoretical framework. Considering its backgrounds, reasonable and practical arrangement of the clinic laboratories could improve the experience of doctors because the circulation design could connect every single part much more tightly and all of these parts would not interact with each other, therefore, working circulations could upgrade the facilities to be more accessible and practical for doctors to use them increasingly more sufficiently. To conclude it, this research could provide the clinic laboratories with more research evidence and reference data to further standardize the logical design to achieve the targeting goals to help the clinic laboratories to be more flexible and adaptable, which

should be regarded as the most significant contributions of this research towards the actual conditions. The research of objective are:

- To investigate the relatively more reasonable and efficient size of these specific sites through evidently comparing the new-built clinic laboratories with old ones.
- To provide research support to take advantages of these sites more scientifically and economically through the circulation simulations.
- To improve doctors' work efficiency and hospitals' more significant economic benefits through the arrangement readjustment of these clinic laboratories.
- To optimize the module partition in these sites through on-site observation and analysis.
- To improve the design through stimulation analysis of laboratory in different development stages.

1.3 Research Questions

According to the research aim, the following questions are explored:

1). What are the main factors affecting the environment of the laboratory?

2). What are the relevant factors that affect the efficiency of the staff of the laboratory?

3).What can physical improvement can be made to enhance the space design to improve staff efficiency in the laboratory? (layout of space/Inspection equipment placement)

4).What is the most critical function that the laboratory needs to add now?

5).What improvements should be made by the laboratory for the development of information technology in the future?

1.4 Research Framework

The study is to improve the spatial layout of the laboratory, the circulation of staff, and the planning of circulation, to help the laboratory has a comfortable rest space, and a suitable placement of the inspection materials, so that the work area and the file area stores have a distinct clean partition, making the work more hygienic and efficient. Through literature review, field research and focus group, the study on laboratory space have revealed the related recommendations to improve overall environmental layout and doctors efficiency (Figure 1.2).The research was divided into four parts:

1). Through two field observations, specific field information for the laboratory can be obtained.

2). Through the focus group discussion, the researcher compare and discuss the situation before and after the laboratory expansion, can give the advantages and disadvantages before and after the laboratory expansion, and can fully understand the staff's suggestions and expectations for the laboratory.

3). Through the simulation design of the laboratory, the researcher can evaluate the space layout of the simulation laboratory, the interaction between each space and each space, and the circulation of the staff after discussing with the staff.

4). After a generalization, a reasonable inspection area can be obtained, which can provide a scientific theoretical basis for the subsequent construction of the laboratory.

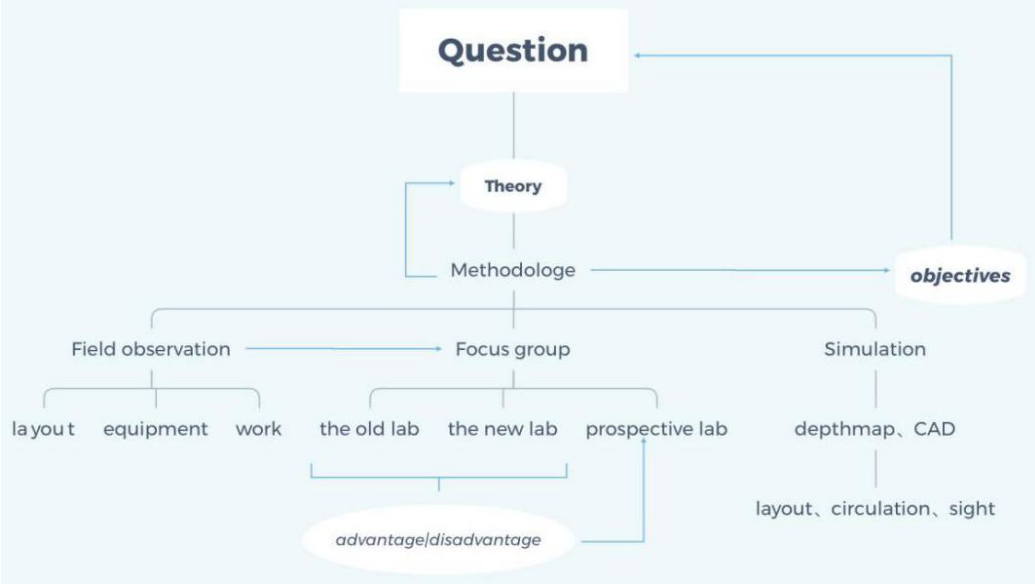


Figure 1.2 Research Framework

1.5Research Gap

This research is mainly aimed at the laboratory after reconstruction and expansion. The expansion of hospitals will bring opportunities for the development of hospitals. Domestic projects on the reconstruction and expansion of medical buildings are increasing. However, there are obvious shortcomings in the standards and relevant reference materials for the reconstruction and expansion of medical buildings. Most of them are based on the analysis of particular cases, which do not have much reference value. Foreign medical reconstruction projects are more mature than those in China and have specific reference value, but they still can not meet the needs of hospitals in China. Many medical renovation and expansion projects in China lack references in literature and perfect design. There are also problems such as waste of land, uncomfortable space utilization and so on. In addition, in the literature of the domestic medical building reconstruction and expansion, there is a lack of information for the laboratory. While in the reform and expansion of the laboratory, there is almost no data for reference. Finally, in the medical

design specifications, the contents of the laboratory are very few, and the writing time is too early to apply to the contemporary laboratory.

CHAPTER2. LITERATURE REVIEW

2.1 Clinical Laboratory Design Overview

2.1.1 Introduction of Laboratory Design

The laboratory is a bridge between clinical medicine and primary medicine, including hematology, body fluids, clinical chemistry of blood transfusion, clinical microbiology and clinical immunology. Every day, we undertake the testing of various human and animal specimens including wards, emergency patients, various medical examinations and scientific research. The clinical laboratory is the place to carry out these jobs and provides office, work and experimentation for the laboratory staff. Division and function of laboratory can be seen in Table 2.1.

Mercer .D, W. (2008) put forward laboratory design should include following seven points:

- site selection
- space programming
- adjacent function block design
- inspection requirements
- workshop design, facilities/building system survey
- conceptual design

Franklin, Ashley, M.B. Walker, and J. Borum. (2010) suggest that people must pay great attention to the following aspects when designing the laboratory to ensure the safety and stability of the laboratory and the health of the experimenters and other personnel.

First of all, the hospital is the place where the virus grows and breeds most densely. Therefore, in order to better carry out experiments in the laboratory and avoid the contamination of microorganisms such as bacteria and viruses, we should consider ventilation when selecting the

laboratory address. The laboratory is isolated from the external environment, but this does not mean that the laboratory is completely out of the hospital. Moreover, Truchaud, Alain, et al (1997) proposed the laboratory within the laboratory should also be divided into different areas according to the type of experiment, and the environmental requirements of different areas are also different.

Secondly, inspections are carried out in the inspection area of the laboratory. In order to ensure that the cultured bacteria will not contaminate other experimental supplies and the experimental environment, we should set up the bacterial culture room of the laboratory, and each area of different experimental types must have obvious boundaries.

Finally, the laboratory must have safety protection measures in the laboratory, so this laboratory should be designed with a disinfection sensor system, such as an automatic hand-washing device. The drainage system of the laboratory should be very fundamental because most of the sewage discharged from the laboratory will contain pathogenic bacteria. If it is not handled well, it will cause a large area of disease.

Area	Functions
Conventional blood collection test	Blood sample collection, routine blood test
Hemagglutination test	Blood coagulation test
Body fluid collection and testing	Body fluid sample collection, body fluid test
Data analysis storage	Analysis and archiving of experimental data
Sample receiving and storage	Reception and registration of foreign samples, storage of internal samples
Temporary blood bank	The registration of blood transfusion applications facilitates the blood transfusion department to prepare blood products, so as to timely supply blood transfusion requirements.
lounge	Rest and dressing inside the laboratory

Table 2.1 Division and Function of Laboratory

2.1.2 Introduction of Laboratory Design in China

In China, the design of the laboratory should be based on humanization, available treatment, resource sharing, reducing repetitive construction, reducing and preventing cross-infection in hospitals, and responding to emergencies. At the same time, the design of modern hospitals should be advanced, the development of the inspection industry has entered a new era of automation and promotion of information technology from the past manual operation. Therefore, designers must pay attention to the rationalization, humanization and security of design concepts when designing inspection department, and at the same time, designers should share resources. In the design of the laboratory, the designer should also pay attention to reduce cross-infection in the hospital, create a pleasant and harmonious working environment, and to improve the level of medical examination. Designers should consider not only the quality of personnel,

equipment and technology, but also other factors in laboratory design. Designers should also pay attention to saving resources, including personnel, equipment, facilities, funds and technology, which is an essential guarantee for a good design. It is also vital to create a clean, bright and harmonious working environment. As can be seen from Figure 2.1, the situation of the laboratory of China.

Figure 2.1 Acupuncture Treatment Process

(Source: https://baike.baidu.com/pic/%E6%A3%80%E9%AA%8C%E7%A7%91/7317565/0/b90e7bec54e736d18d3768a295504fc2d5626970?fr=lemma&ct=single#aid=0&pic=b90e7bec54e736d18d3768a295504fc2d5626970)

In *Architectural Design Data Collection (The Third Edition 2017)*, the design requirements of relevant inspection departments are as follows:

- There should be a direct connection between the sample receiving area and each area of the laboratory. The amount of chemical and hematological analysis is large, so the space layout should be nearest to the sample receiving center, and the microbial laboratory area should be relatively independent at the far end of the work area. The logistics transmission system can effectively improve the transmission efficiency of laboratory samples.
- Each working area of the laboratory department should adopt large

open space, which is convenient to use and has strong adaptability. In the laboratory areas of biology, mycology, parasitology, tuberculosis and virology, ventilation cabinets and other equipment should be equipped, and strict ventilation measures should be adopted to exclude all possible contaminated bacteria and biotoxic substances of chemical reagents, to form separate rooms. There should be a large waiting area in front of the blood sampling center (blood sampling room).

- Most automatic analyzers have special requirements for individual liquid pipes, electric appliance, temperature, humidity and vibration isolation. Most devices need a stable power supply, telephone and Internet transmission equipment. Many laboratory equipment requires pure water supply, usually made by reverse osmosis system.
- Attention should be paid to the use of anticorrosive materials in the decoration design of indoor floor, wall, working table and inspection unit. Bacteriostatic and easy-to-clean decoration treatment should be adopted in the whole inspection area. Bacteria room should be equipped with individual washing facilities, not mixed with other washing facilities.

In *The Code for Architectural Design of General Hospital (2014)*, the design requirements of relevant laboratory departments are as follows:

- The laboratory should be located in its own area. Most of the specimens of the laboratory department are blood, urine, stool and other articles or pathological tissues, which belong to bacteria-carrying substances. Therefore, the laboratory should be an independent area and should not be allowed to cross with other departments in order to ensure safety.
- The laboratory should have ventilation cabinet, instrument room (office), Reagent Room (assembly), anti-vibration platform, and facilities for storing expensive drugs and highly toxic drugs.

- The laboratory should have washing facilities, individual washing and disinfection facilities for bacterial testing, and each laboratory should have a washing pool with non-manual switches. Examination specimens should be equipped with waste disinfection treatment facilities.

2.2 Clinical Space Layout and Circulation Arrangement

2.2.1Definition of Circulation

The study of moving circulation began in 1927, which was written in Survey Method 2 in Planning and Design - Dynamic Line Observation, (Dai, F & Zhang, J.F2008).From Bruno Julius Florian Taot's residential architecture study in 1927, the study of moving circulation has entered into development. Japanese architecture defines the moving circulation as the movement of people or objects in circulation on a plan. Generally speaking, the moving circulation refers to the user's walking route in the building space. Wang, P (2010) wrote that circulation connects the various functional spaces and guides the user's behavior so that the building space meets the needs of the user. On the other hand, it also dominates the user's direction and order of use of the building space and functional structure.

Circulation space (Channel, etc.) is one of the public and active elements of architecture. Moreover Lu, M.M. (2006) thought the circulation space connects the other functional spaces in the building, realizes the continuous network in the building, and forms the “structure” in the building together with the node space. They organize the different functional spaces in the building and bring together the complex phenomena. As a combination of basic units, it also has unlimited

possibilities.

2.2.2 Circulation Division

Building circulations is a concept proposed by Chen, R. (2007).It is often used in architectural design. Circulation refers to the path of people's activities in architecture. In a space, the division of space is achieved by circulation design. Different functional areas are divided by circulation, so that people can move more comfortably in the space within the divided areas.

Today, as the modern building plan becomes more and more complex and perfect, we take the construction circulation out of the architectural plan research for proper research, trying to understand the dialectic between the circulations, functions and spaces in the building through the building circulations analysis. In the relationship between people and architecture, designers need to deeply understand human emotions as the main body of construction, which enables designers to build buildings that are suitable for society in their future design career.

The circulation is the route of human activities. Generally speaking, the circulations in the building are characterized by diversity and complexity. This study will study and analyze different types of building circulations, from simple to complex, summarizing the commonalities and characteristics of building circulations in different buildings. Researcher explore the interaction between human behavior, functional needs, spatial composition, process and architectural circulation in different buildings. Finally, the specific circulation are put forward similar problems, and the circulations are analyzed and studied by using system theory. Through the circulation analysis of large-scale comprehensive public hospitals, we have a thorough understanding of the building circulation system, and try to put forward a new method of building circulation.

The working mode of the laboratory controls its two unique circulation

processes, which is confirmed by Fu.Z.Y & Tan.L.Y.(2018). One is the circulation for the staff: starting from the cleaning area, inspectors need to change shoes, change clothes, reasonably protect, wash hands before they enter the inspection area to work, and return to the original position after the work is over. The other is the circulation of the specimen: the specimen is collected, the specimen handed over or transferred from the window, inspector pretreatment, inspects, disinfects, collects and processes the samples professionally.

2.2.3 Planning for Circulation Organization

Through the analysis and summarization of the moving circulation characteristics and laws of space users, the functional space is rationally organized and arranged, Huang, Y.P (2002) suggested the user's behavior is scientifically organized, and the circulation is reasonable. In this way, the structure and form of circulation can be designed to satisfy both users and functional space, so that the spatial organization and user's behavior needs can be coordinated.

Qi, Q. (2016) considered the location of functional blocks and then links functional blocks with circulation space in general hospital building design firstly, but lacks the impact of circulation on functional distribution.

Secondly, the traditional method of circulation research is to divide the circulation into horizontal and vertical, and then according to the doctor's circulation, the cleansing circulation and other types of resolution, and finally organized according to the type.

The organization of circulations is ultimately determined by the type of circulations, such as dirty circulation, after thinking from a system perspective, we can see that the circulation system is made up of a single circulation. At each level, the nodes are connected in series to form a cycle. The abstract way to connect these nodes in series is to see each node. The functional roles are not significantly different and are used to

control the circulation of people and evacuation.

The most significant difference after circulation nodalization is that: remove the unique factors of the traditional circulation and generalize the issue of circulation. After objective analysis, it can be seen that the characteristics of the node are mainly based on two points, namely the size of the quantity and the direction of the shunt. The circulation systems at all levels are composed of such nodes. Therefore, from a systematic point of view, each circulation system has its own characteristics. It is necessary to abide by the organizational principles of this level and to build a circulation network of this level. The way each circulation operates is determined by the amount of each point, which is the quantitative feature of the circulation. The reasonable judgment of the directionality and circulation type of each node is a meaningful way to judge the circulation level, and the directionality and circulation-type balance of the network composed of multiple circulations in each level is an essential guarantee for the stability of the circulation system. Through the design considerations of the circulation nodes, each function is combined with the requirements as required. This way, the traditional way of setting the function block according to the need and then connecting by circulation should be more targeted.

Besides, traditional transportation often uses a tandem method instead of a parallel method to form a network, which significantly increases the reliability of hospital buildings.

Finally, data collection due to the quantitative assessment of the effectiveness of large general hospitals is carried out at the node level. The traditional method of circulation research cannot directly reflect it. Conversely, the processing method at the circulation level of the evaluation conclusion cannot be directly reflected. Therefore, the analysis of the circulation organization of large general hospitals at the node level is qualitative. A bridge between quantitative and quantitative circulation

efficiency will lay the foundation for future research directions.

2.2.4 Several Factors Affecting the Circulation

People have different behaviors in buildings, and all the actions people do will directly affect how to organize the circulation of buildings, which is said by Chen, R(2017). From the perspective of the discipline of architecture, behavior and architecture are closely related. Human behavior is closely related to the circulation of buildings, and different behavioral requirements of people in buildings lead to different types of circulations. The demand for people's environment for different behaviors leads to a clear functional division and avoiding the intersection of circulations. This is a common requirement in architectural design. The circulation organization must be clear and concise. In general, people want to travel as short as possible in the building, and the demand for circulation is as near as possible， the more convenient it is, the better, It can be said that human behavior is the most critical factor in circulation organization.

In the hospital laboratory, on the one hand, they are required to be independent of each other and do not interfere with other inspection subjects. On the other hand, they must maintain proper contact with each other. Also, these inspection function partitions are generally small in volume but large in number. In terms of functional characteristics, a single-aisle is used to organize circulation on the plan. It is a logical form of spatial organization to connect the various spaces of use with such a narrow space dedicated to transportation. The disadvantages of the high usage rate of the walkway and the compactness of the plan are that the functional space is poorly oriented and the ventilation conditions are poor.

2.2.5 Circulation Organization Existing Problems in Clinical Space

Wang, A.H.(2015) proved that former general hospital department of the public space of our country existing status has many problems:

- The labyrinthine layout.
- The cold space environment.
- The crowded waiting area of humanized space design.

These problems also make people feel bored and depressed? The psychological reaction directly affects people's needs and spatial behavior and the overall evaluation of the hospital, and even lead to a weak health effect. All these conditions are the result of designers and hospitals' abstract space design without paying attention to medical staff from the perspective of managers.

2.3 Clinical Laboratory Functional Space

2.3.1 Several Factors Affecting the Laboratory Space

In the space used by the laboratory, the laboratory does not include patients, so the spatial impact of patient factors can be ruled out. In the *Study on the area of medical function space in large general hospitals*, Luo, H. (2016) wrote that both the factors of the medical model change and the technical factors would have an impact on space.

First of all, we should consider the factors of medical model transformation. In the process of continuous updating of the laboratory, sample transportation has evolved from simple manual transportation to intelligent equipment pipeline operation. Therefore, the transformation of the medical mode has a significant impact on the spatial functional layout, and the medical mode is also one of the essential elements to determine the spatial functional layout. With the change of the medical mode, people pay more and more attention to the people-oriented concept. In the future, the construction of hospitals will be carried out on the basis of guaranteeing people's basic medical needs, and designers will strive to create an excellent medical environment, so the development of new medical modes will bring new changes in the medical space, all of which will be

reflected in the medical space.

Secondly, technical factors is a very active element, the impact on the laboratory mainly includes two aspects: one is the development of construction technology, and the other is the development of science and medical technology. In the last century, the laboratory was limited by science and technology and the economy. The space in the laboratory was mostly inflexible. The space between the frame structure and the steel structure was free, and the layout of the laboratory was free. Due to the initial construction of the laboratory, indoor mechanical ventilation technology is not standard. The designer should pay attention to its ventilation and lighting and use the decentralized space to reduce the depth of the space when designing. At present, the natural ventilation in the laboratory cannot meet the needs of the laboratory very well, but with the popularization of mechanical ventilation technology, the problem of mechanical ventilation can solve the problem of poor ventilation caused by super-large space.

Science and technology have also brought about medical technology innovation. In the laboratory, in the past, when the samples were sent from outpatient hospitals, the manual transmission efficiency was low. The pneumatic transmission technology developed today can transmit samples through pneumatic transmission bottles to improve work efficiency. It is also convenient for management. In the past, the medical records were stored in paper, occupying a large space in the hospital. With the advent of the computer era, the size of the medical record room was significantly reduced, and more space was released as medical space.

2.3.2 Laboratory Space Relevant Suggestion

Tertiary hospital design specifications stipulate that laboratories should be located in outpatient buildings, and should be self-contained. The area of

the inspection department of the Tertiary hospitals should be no less than 1200 ㎡, and the area of the inspection department of the hospital should be no less than 800 ㎡. The area of the inspection department generally accounts for 2% of the total area of the hospital. The layout of the laboratory should be divided into clean areas, semi-soil areas and contaminated areas, and the fields should be separated by partitions. The laboratory should be separated from each other, and personnel and articles should have separate entrances and exits.

2.4Laboratory Function Zoning

The laboratory is the space and place for medical inspection work, and it is one of the research objects of the “inspection construction and management”. The layout of laboratories should facilitate the connection between patients and laboratories, clinical departments and laboratories. Besides, the layout of laboratories should make full use of the efficiency of the use of various equipment, and be conducive to the health and mental health of employees. The laboratory should be located in the center of the hospital. The specialized laboratories such as hematology laboratory, body fluid laboratory, clinical chemistry laboratory, immunology laboratory, microbiology laboratory and molecular biology laboratory should be relatively concentrated. Laboratory equipment should be easy to use, spacious space, bright light, air circulation, avoiding direct sunlight and convenient disinfection. The laboratory and the office are strictly distinguished, and the contaminated area is strictly distinguished from the non-polluted area. Experimental workplace: The laboratory of the hospital laboratory can be divided into the emergency laboratory, outpatient laboratory, ward inspection room and central experimental area (i.e., centralized laboratories). Information exchange is carried out between computers at each experimental site.

Fu, Z.Y. & Tan, L.Y.(2018)believed that the functional division of laboratories should clearly distinguish clean areas, semi-polluted areas and polluted areas. There should be partitions between the areas. The clean area is mainly composed of the dressing room and office. Semi-contaminated areas are mainly used for stacking reagents, and have auxiliary functions such as washing tables. The contaminated area is mainly composed of the blood collection room and testing laboratory.

CHAPTER 3. RESEARCH DESIGN & METHOD

3.1 Research Design

The study was conducted in three phases, enabling the researcher to understand the laboratory's spatial layout, equipment layout better, and physical environment requirements of physicians, facilitating researcher to improve spatial layout design and improve laboratory internal functional cycles. This theory helps inspectors improve the environmental comfort of the laboratory and improve the efficiency of inspectors.

At the beginning of the study, the researcher conducted two field observations to obtain specific information about the laboratory, such as the current space layout of the laboratory and the size and location of the inspection equipment in the laboratory. At the same time, in the process of communicating with the inspector, we know the relevant information of the inspector, such as the specific content of the inspection work, the steps of the inspection project and the frequency of occurrence. The researcher used the computer to read and describe the previous inspectors, and restored the spatial arrangement of the former laboratory. After collecting the information on the laboratory, the researcher organized the information. In the second stage, the researcher conducted a focus group discussion to compare and discuss the information before and after the expansion of the laboratory. The main direction is to draw the advantages and disadvantages of the laboratory before and after the expansion, as well as the inspector's recommendations and expectations for the laboratory. After the second stage, a simulation design for the laboratory will be carried out, and after discussing with the staff, the researcher got a research mode that is relatively more in line with the current inspection requirements. After that, the researcher uses the "Space Syntax" to make more for the in-depth analysis, assess the spatial layout of the simulated

laboratory, the interaction between each space and each space, and the circulation of staff members. Finally, a reasonable summary of the laboratory is obtained, which provides a scientific theoretical basis for the subsequent construction of the clinical laboratory. The ethics consideration was made in relation to the research process.

3.1.1 Research Samples

The research samples were chosen in a laboratory of a tertiary hospital in Shaoxing, China, which is a typical representative, because the hospital meets the requirements of the project. After a new construction and an expansion, the hospital has undergone a medical reform in China. Because of the increasing daily demand and development, the hospital can represent the expansion of hospitals in China at the same time because of demand problems. And this hospital is a tertiary hospital, it is the highest level of hospital in China and can represent the higher medical level of Chinese hospitals, the area of the laboratory is larger than 1500 ㎡, and the layout of the laboratory can clearly distinguish between the office area and the partition area, the height of the ceiling is larger than 2.6m, which is in line with the standard of the tertiary hospital. It is a large hospital, and the hospital has advanced medical equipment and complete hospital departments. It is a hospital integrating medical treatment, teaching, scientific research, health care and rehabilitation. It has a high management level and participation. The research on major national projects and projects has been adopted by relevant government management departments, which is in line with research projects.

Moreover, the hospital was established in 1979 and was newly built in 1996. Since its construction, the Laboratory has been continuously reformed to adapt to the development of contemporary medical care. The Laboratory has witnessed the development of medical care in China. In 2019, the hospital will be rebuilt in another place. Research the subject of

the ever-changing exploration of the Laboratory (Table 3.1).

Site	Code	Construction time	area
Tertiary Hospital in Shaoxing	Old laboratory	1996	38.34
	New laboratory	2017	146.88
	Post-designed laboratory	2019	146.88

Table 3.1 Information of Hospitals Participating in the Study

3.1.2 Ethics Consideration

Ellis & Becker(1982) think that the definition of ethics is correct behavior and principles and does not do any harm to people. Research Ethics Sub-Committee of the University of Nottingham, Ningbo Approved Ethical approval. In the study of the subject, a total of three forms are relevant. The Research Ethics Checklist (Appendix A) was to show the necessary information and situation of the survey. The Participant Information Sheet (Appendix B) provided the survey content for participants, allowing them to consider whether to join the survey and sign the Participant Consent Form(Appendix C). These processes were governed by the University's Code of Research Conduct and Research Ethics.

University's Ethics Committee focuses on ways to gain access to participants and sites.

First and foremost, the researcher contacted the recruited hospitals to explain the research purpose and obtained permission.

Second, the researcher contacted the director of the laboratory to discuss the details of the focus group.

Third, the researcher explained the purpose of the study to the inspectors and asked them to sign the participant's consent and related documents with the consent of the participants. With inspectors' consent, the researcher used their free time to talk with them and conduct a focus group. Participants have the right to choose whether to participate in the

survey.

3.2 Methods

3.2.1 Observations and Measurements

Observation is a way to get feedback in time, and get useful information in the first place (Boughamoura. et al., 2006). At the same time, investigators are bringing their unique background and experience into the situation(Mullings, C. 1984). Therefore, in order to obtain first-hand information, observation is undoubtedly one of the best methods.

Before the observation, the researcher prepared the research plan and observation content through literature reading and querying inspectors, and carried out a literature search on the design of the laboratory, medical environment, humanized design, hospital streamline, and functional division of the laboratory. The researcher found that people attach great importance to medical buildings, and inspectors also attach great importance to research issues. However, there is a lack of research results on the laboratory at home and abroad, and there is also a lack of corresponding research literature references, so this study is critical. Also, Buchmann, M. (1992) thought a series of observations need to visit the field. And the current laboratories can be better understood by field observations., the area and size of each functional block, observe the daily work and inspection items of the laboratory staff, understand the work content and work of the inspectors' surroundings. Finally, to make a list, particular observations and further investigations of the inspection items are required to understand the circulation of the inspection items and the order and frequency of use of the equipment.

The study was conducted in a hospital for seven days. The work of the inspection staff was observed and the spatial layout properties of the laboratory were observed. The researcher arrived at the hospital and then

communicated with the director of the laboratory about the daily work of the laboratory in order to understand the current development of the laboratory. The director of the laboratory led the researcher to visit the laboratory and introduced the equipment and basic situation of the laboratory. The researcher then independently observed and noted that they did not bother the staff. The researcher observes the spatial layout and physical environment of the laboratory, such as lighting, ventilation, color, and the activities of the inspectors. The researcher should pay more attention to functional layout, working mode of inspectors and laboratory environment. Also, the researcher needs to measure the size of the space to map the layout for future analysis.

Field investigation is a method in which control of the research situation is less in the hand of the researcher than other methods (DeWalt, K. and DeWalt, B. 2011). Field surveys include Observations and Measurements in this design.

3.2.2 Focus Group

Focus groups take the form of group interviews, in which the moderator guides the interviews and all participants in a group discuss the topics raised by the moderator. The results discussed by the group members during the discussion are the primary data for subsequent studies. Generally speaking, focus groups invite six to eight participants with similar backgrounds. The moderator is a well-trained professional who works on a predetermined discussion topic(Morgan, D. 1998).

The researcher conducted two rounds of focus groups (Figure 3.1). The focus group is divided into four parts.

First, the researcher determines the project name and content, consults relevant books, determines the topic of discussion, and prepares relevant materials and screening questions.

Second, the researcher needs to determine participation. Those who are

required to participate have the same working background and are representative. The researcher will participate in the work according to the age of work (Table 3.2). The researcher hopes that everyone can be represented at each level of work.

After the researcher has arranged the time and place, the host needs to invite the participants to the laboratory. Before the meeting starts, the host prepares the meeting materials and forms. During the focus group discussion, the researcher will record the information promptly, check the records after the meeting, and confirm the records with the participants.

Finally, the host thanked all the participants. Researcher screened out the useful information after the panel discussion, and compared the results of the discussion among the participants to draw practical conclusions. The researcher conducted a second round of focus group discussions in order to allow participants in the laboratory to support the conclusions reached by the researcher and to supplement previous conclusions for a new round of discussion.

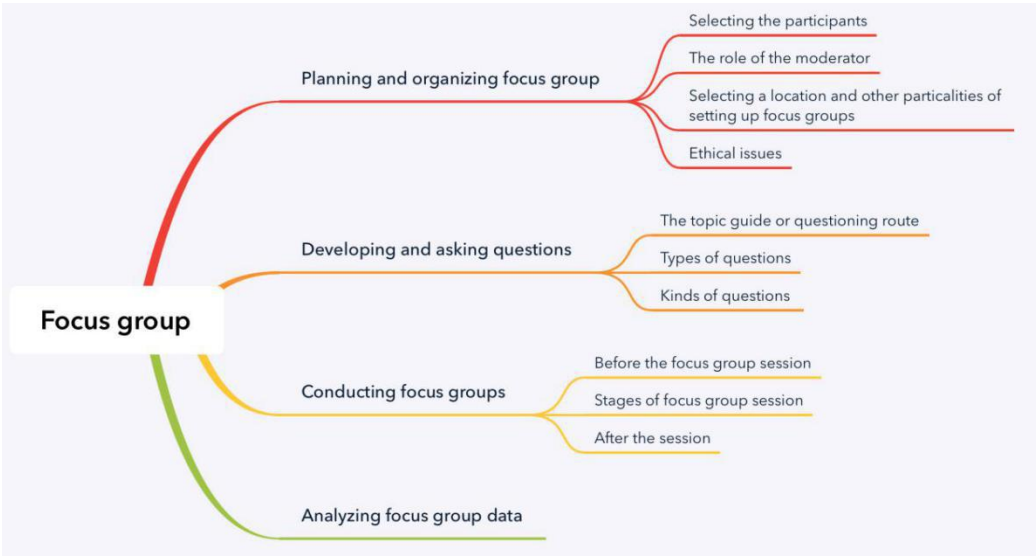


Figure 3.1 Focus Group Frame

The researcher believes that the focus group is well suited to obtain information about the laboratory from the laboratory. Focus groups can

discuss and come up with several different views and record the dynamics of interaction within a group, such as a consensus, divergence and ideological differences among participants; in fact, focus groups can also obtain information about job positions among participants. Unlike many other methods, focus groups are the appropriate way to get information from a different person who has something in common.(Lia, L.2003).

Number	Gender	Working age	Occupation
1	Male	5 years or more	Director of the laboratory
2	Male	5 years or more	Chief technician
3	Female	3-5 years	Deputy chief technician
4	Female	3-5 years	Inspectors
5	Female	1-3 years	Inspectors
6	Female	1-3 years	Inspectors

Table 3.2 Focus Group Participants Information

3.2.3 Space Syntax

Space syntax is a human-centered and scientific-based research method. It mainly studies the relationship between spatial layout and a series of social, economic and environmental phenomena(Hiller, B.1988). Space syntax is a relatively advanced research method, which can accurately analyze the spatial layout and other issues, and can be used for reference:

- Analysis of the spatial distribution of hospital environment
- Observing space usage patterns
- Optimizing the Use Plan of Space Design
- Interactive solutions.

The space syntax is a mathematical method developed by an architect to describe and analyze space (Thaler, U.2005). The space syntax is a set of mathematical methods, which relies on mathematical methods to abstract

and simulate the relationship between space and space. Space syntax also relies on mathematical methods to discover the relationship between space and social activities(Hillier, B. 2008). Because of the limited logical deduction ability of space syntax, the space syntax has not explored the artistry of space. Spatial grammar explores those problems related to mathematics. The software uses spatial syntax. As long as researcher only need to establish accurate mathematical equations according to their requirements and correctly describe the state of the space system in the software, the software can automatically calculate the relationship between spaces.

3.2.3.1 Depthmap Software Simulation

Using simulation software to simulate laboratory layout is research based on spatial syntax theory, combining AutoCAD and Depthmap to analyze laboratory layout (Liu, P. et al.2018). The spatial behavior of the laboratory is an integral part of the laboratory's spatial layout and circulation optimization planning research. Combining user-generated content (UGC) and site survey data, this research overlays the configuration of walking route networks preferred by space syntactic doctors. Based on the spatial syntax, the doctor's walking route is affected by the instrument distribution and the functional structure of the test structure. Through spatial syntactic analysis, it promotes the understanding of the spatial pattern of the behavior of the purpose of the examiner; this knowledge will help optimize the spatial path, improve the efficiency of doctors, and provide practical guidance for the most efficient route for doctors to work.

3.2.3.2 Visibility Graph Analysis (VGA)

In architectural design, Visibility Graph Analysis (VGA) is a method to analyze the visibility of buildings or cities(Park, C.K.2014).Visual graph analysis is based on the theory of spatial syntax architecture, which is used to analyze spatial visibility by Turner. et al. (2001), and the visibility

map is constructed in the grid area of the plan map to realize the application of spatial visibility analysis (Varoudis, T. et al.2013).

Visibility Graph Analysis (VGA) provides information about visibility relationships between spaces in a project. The visibility diagram describes the spatial configuration of the layout and the corresponding relationship between colors. In the visible graph, the setting of the grid depends on the size of the layout plan. The depth map of each grid represents a value. The software divides the highest and lowest values of the whole plan into ten levels and represents them in different colors. Red denotes higher values and blue denotes lower values (Figure 3.2). Each grid is in the analysis space, and each grid displays the color of the area.

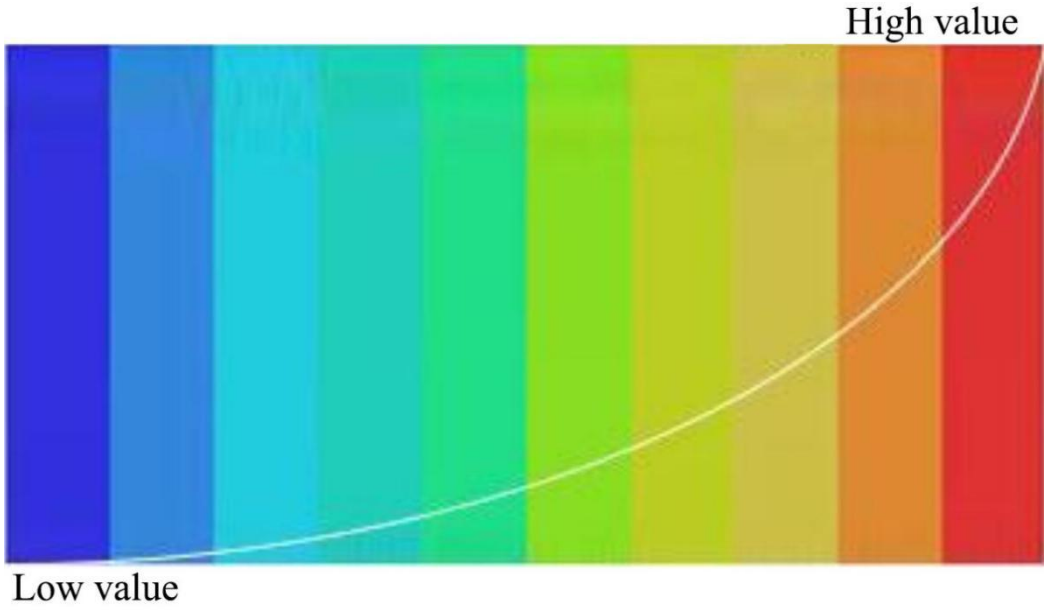


Figure 3.2 Color 10 Levels Distribution

In this study, the researcher used VGA to measure three spatial characteristics of three laboratory plans: connectivity, visual integration (HH) and visual step depth. Because of the size of architectural design, the design size of space is related to the size of human beings and the activity space, and the human perspective is 170 degrees, the human perspective is small, this study uses 0.1m grid spacing to simulate, in

order to meet the human scale. Using Depthmap, the researcher not only analyzed the plans of three laboratories, but also analyzed the depth of visual steps in each functional area of the new laboratory. The results of visual analysis in each region were compared. The researcher uses the three properties of VGA defined by spatial syntax theory to study the layout of the laboratory, improve the efficiency of inspectors and improve connectivity of the internal environment in the laboratory..

Connectivity has set the distance of sight to 5m, because in the laboratory, the field of view is not very wide, you need to see the device of the laboratory, after field test by researcher, you can see the use of the device within 5m, so it is most appropriate to set the distance of the line of sight to 5m.

Connectivity is a measure of the spatial compactness of one space connected to another, which is reflected by numerical values (Hillier, 1988). Visual Integration measures the visual distance from one space to another (Hillier, 1996). Visual Step Depth is to determine a selection set in space and then calculate the minimum visual depth from that selection set to any block in the system (Space Syntax: a concise introduction, 2014).

3.2.3.3 Agent Analysis

The relationship between spatial layout and human mobility mode is a random form. The different behavior habits of each person lead to different areas of human activity in space. This simulation mode determines the behavior mode of people walking in random situations (Hillier. et al., 1987). Turner and Penn (2002) define the agent's behavior in space as putting the agent in space. The agent imitates the human's behavior and moves in space, and records the agent's trajectory. The trajectory of an agent's activity helps to understand human's action and reaction to space. The agent's activity route depends on the visual perception in the surrounding environment, and changes the walking path through the visual equipment.

The model simulates human activities in space; the model emphasizes the importance of visual sense to human movement in space, and simulates spatial connectivity and visibility with space syntax. As shown in (Figure 3.3), the image shows the agent's walking path in space and records the results of the human simulation. Warm area means that people walk more times in this area, red is the most, cold area means that people walk fewer times in this area, blue is the least, gray is the unused area.

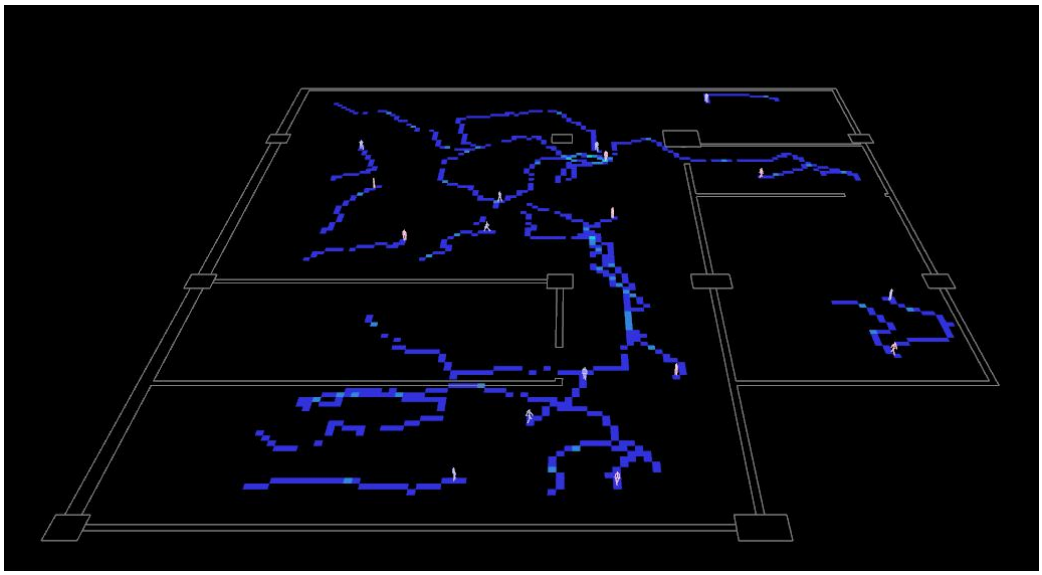


Figure 3.3 Record of Agent's Walking Route

CHAPTER 4. DATA COLLECTION & ANALYSIS

4.1 Introduction

Lampard, R.B.R. (1997)indicates that data collection is a process of collecting and measuring information on target variables in a given system, enabling people to assess relevant issues and to arrive at results. The goal of all data collection is to obtain high-quality data to obtain convincing answers through data analysis.

Data collection refers to collecting information from all relevant sources to obtain credible data, analyzing the answers to research questions, and evaluating the results by testing hypotheses.

This study involves the following factors:

- Analysis of the characteristics of the layout of the laboratory;
- Analysis of the circulation planning of the laboratory;
- Analysis of placement of the laboratory equipment;
- Observation and investigation existing laboratory problems and areas for improvement;
- Understanding the needs of inspectors and satisfaction with departments;
- Analyzing how to improve the working environment of the laboratory and improving the efficiency of doctors;
- How to plan in the laboratory analyze spatial syntactic theory to provide results that improve the environment of the laboratory.

The collection of findings describes and discusses the design of existing laboratory programs in spatial syntax applications and provides informational data collected through panel discussions.

4.2 Observations

The researcher carefully observed the spatial layout and equipment layout of the laboratory under the guidance of the laboratory staff (inspector). During the observation process, the researcher believed that the laboratory was very clean and hygienic, the equipment was placed in an orderly manner, the inspectors were very clear and concise, and the inspectors communicated with ease and pleasure. The researcher observed the inspection work and the work circulation of the inspectors, observed the number of inspection specimens in the laboratory, and the average workload of the laboratory, and the behavior of the inspectors near the operating platform. During researcher observation, the researcher found the following information:

- There is no dressing room or sink in the preparation area of the entrance. If the inspectors need to change clothes or wash their hands, they need to go to the bathroom.
- The area of the liquid detection area is too small to accommodate only one inspector during the experiment.
- The channel of the blood coagulation test area can only accommodate one inspector, and other staff cannot pass through it when experimenting.
- Inspection departments lack storage space, and testing reagents are stored in channels.

4.2.1 Plan Review and Analysis

The researcher drew the floor plans of new and old laboratory based on observation on site. General information of new and old Laboratories are showing in (table 4.1).

Construction time	Area	Function
1996 version	38.34 ㎡	routine blood test
2017 version	146.88 ㎡	Body fluid test, blood coagulation test, routine blood test

Table 4.1 General Information of New and Old Laboratories

In the old laboratory (Figure 4.1):

- The plan is elementary.
- There is only a single room.
- The work items of the inspectors are relatively regular.
- Only the routine blood test department is used.
- The test instruments are relatively few.
- The indoor layout is simple and straight.
- There is no room separation.
- The inspectors are very simplified, only one to five inspectors are accommodated in a department.
- The activity circulation is simple.

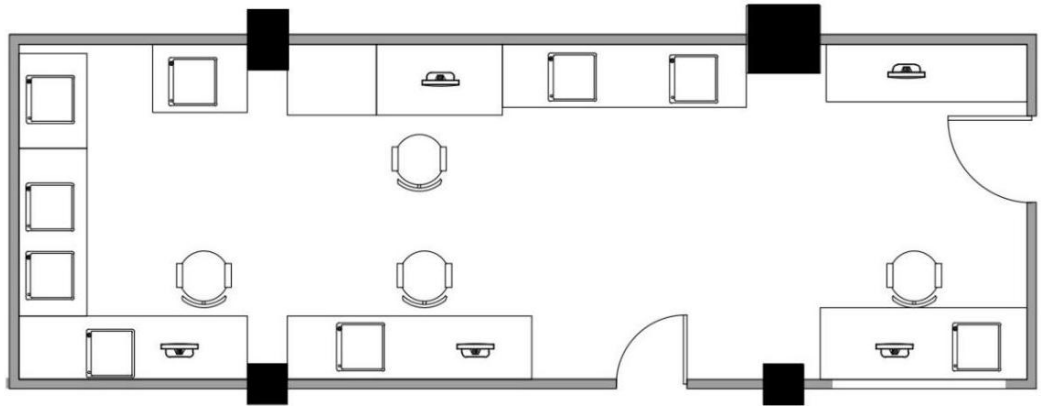


Figure 4.1 Old Laboratory Plan

In the new laboratory (Figure 4.2):

- The position of the test window interacting with the patient has changed and the patient waiting area has changed.
- The circulation is also a lot more complicated.

- Compared with the old inspection department, there are many improvements, but there are not many inspectors in the new laboratory, the staff is relatively simple, and there will still be congestion.
- Due to the late reconstruction and expansion problems in the laboratory, there is a lack of consideration for ventilation and lighting. Although there is an exhaust system, it cannot provide perfect ventilation.
- Due to the vast expansion span, the office of the laboratory must also use lighting during the day.
- In general, compared with the old laboratory, the laboratory environment is more comfortable, but there are still problems such as close walking distance and unsatisfactory inspection area.

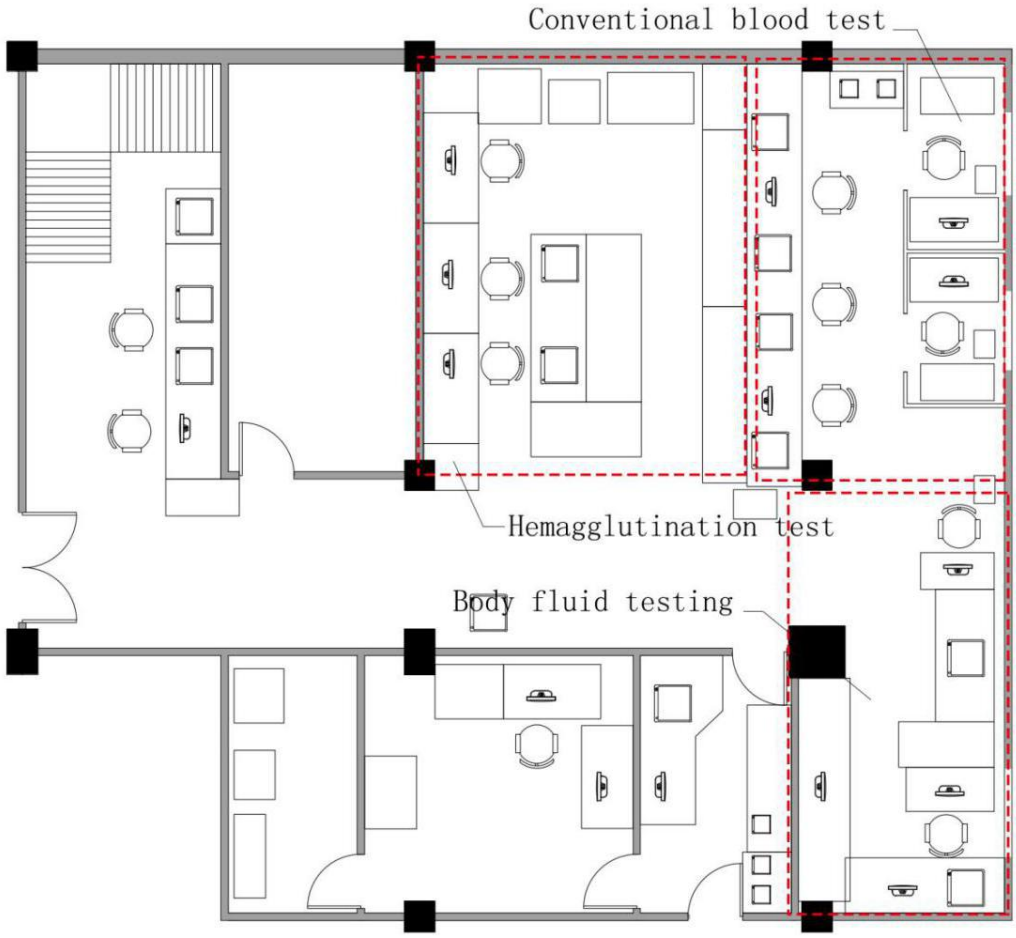


Figure 4.2 New Laboratory Plan

The new laboratory (Figure 4.3) has placed the routine blood test part on the far right side of the room. The planar layout is designed to meet routine blood tests. In the clinical inspection area, the routine blood tests is one of the most regular tests. In the plan, routine blood tests are arranged on the right side, so the researcher also needs to pay attention to the right side of the plan. As a separate waiting hall, there is an ample waiting area, giving the location of two sample collection windows. Secondly, the body fluid collection and detection part is also an essential part of the clinical examination and the frequency of the consultation is relatively high. Compared with the conventional blood test part, the outpatients are not so much, so it is also placed on the right side. In the body fluid detection area, a body fluid collection window is set, which is

placed on the right side of the laboratory, the collection window close to the waiting hall, which does not affect the rest of the hospital, but can operate alone. The time of blood coagulation test is longer than the other two tests, and it should be associated with a blood test, but it is relatively independent, so it is placed in the middle of the laboratory and next to the routine blood test. The office is located near the entrance of the new laboratory, which is close to the corridor side. Different from the inspection area, the inspector also organizes the office and data in the office area. The advantage of being close to the corridor side is to distinguish between the inspectors and the office staff, and the division is distinct. The employee's lounge is placed on the left side, next to the inspection material entrance, wholly separated from the inspection area toseparate the clean and dirty areas. The staircase next to the secondary entrance (equipment and material entry) leads to the second-floor microbiology laboratory, HIV laboratory, etc.

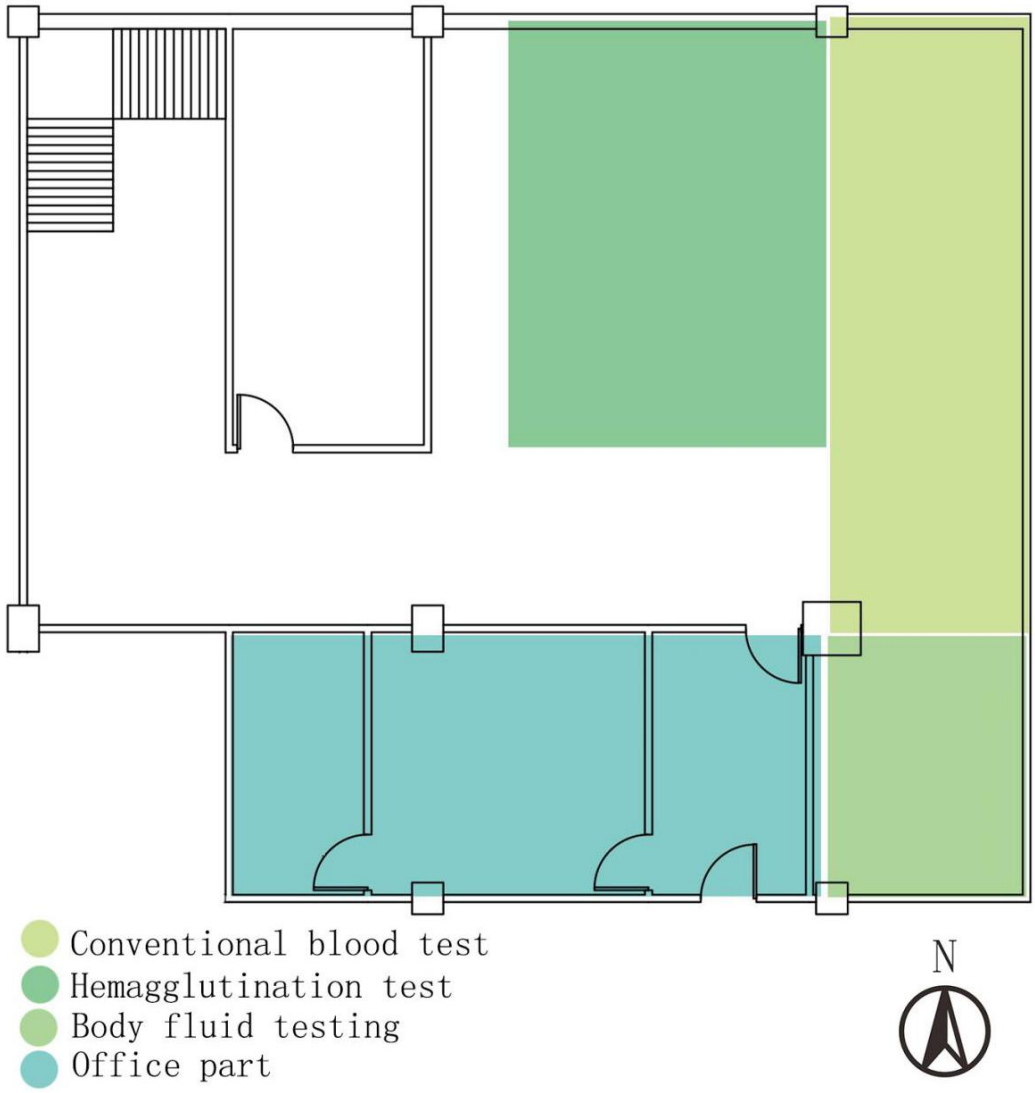


Figure 4.3 New Laboratory Functional Partition

Conventional blood tests, body fluid tests and blood coagulation tests are all close to the entrance of the laboratory, close to the specimen collection room and the washing room. There are many microscopes in the room, and most of them need to be equipped with side tables, most of which are fully automatic inspection instruments and computer equipment. Occupied by space, the inspection department needs a lot of power supply because of the large number of inspection equipment. In some cases, the water supply and drainage are directly connected with the inspection equipment. The inspection department adopts an ample space for the internal use of

the experimental platform and is routinely tested in the laboratory. The number of people is large, and the outpatient doctor needs to wait for the test results to make a diagnosis. Therefore, the inspection department of the test samples are required to be more urgent most of the time; the routine laboratory is located closer to the entrance in the central inspection department because the specimen is mostly human waste. There may be odors in the room, and the researcher needs to consider ventilation and waste disposal (setting up sample disposal space).

Due to the complexity of the inspection project and the hygienic safety requirements, the functional requirements of the functional units are also different. For example, with the introduction of advanced technology, the automation and assembly line work make the inspection space adopt a large open space and has strong adaptability. The sample receiving area is the only area in direct contact with the patient, which should facilitate the patient's access and provide a comfortable and private space for the patient.

4.2.2 Observing Inspector Work

- In the routine blood testing area, the inspectors mainly operate in the specimen collection and inspection area. The general inspectors collect the blood specimens, and then the inspectors perform the inspection and analysis of the extracted blood specimens, and carry out the sample comparison analysis on the computer. The analysis sends the results to the inspection department, and the general division is also the blood sample collection window. The routine blood test of the inspectors is mainly blood routine and C-reactive protein detection. There are automatic blood type analyzers, Micro-gel blood type centrifuge and five-class blood cell analyzer in the routine blood testing area.
- In the blood coagulation test area, there is only one person in the

blood coagulation test area, and the activity area is only limited to the blood coagulation test area. After completing part of the test, the inspectors will go to other test areas to help, or to the office area. Circulation of blood coagulation test is also clear, this work is a blood coagulation analysis. After receiving the specimen, the inspector closely observes the state of the specimen and numbers it. It is placed on the specimen rack that comes with the instrument in order, and the result is detected by using the blood coagulation analyzer. The inspector will analyze the inspection data, report and review the results, and finally send the results to the sub-list. If the doctor has questions and feedback on the patient's results, the blood coagulation staff will find and process them in time to make a reasonable explanation. The main instruments are various types of blood coagulation analyzers.

- In the body fluid test area, there are many testing items for the body fluid testing, and the instruments are used more. There are routine urine test, routine stool test, leucorrhea routine test, routine test of prostatic fluid, routine examination of cerebrospinal fluid. After the inspector receives the sample, it is placed in the corresponding inspection instrument, and the transmitted data is analyzed on the computer. After confirming that the data is correct, the inspection order is issued to the distribution sheet. The main tasks in the office area are collection and data analysis, and inspectors have less work to do in this area.

Clinical examination stuff collection and examination specimen collection circulation are shown below (Figure 4.4,Figure 4.5).

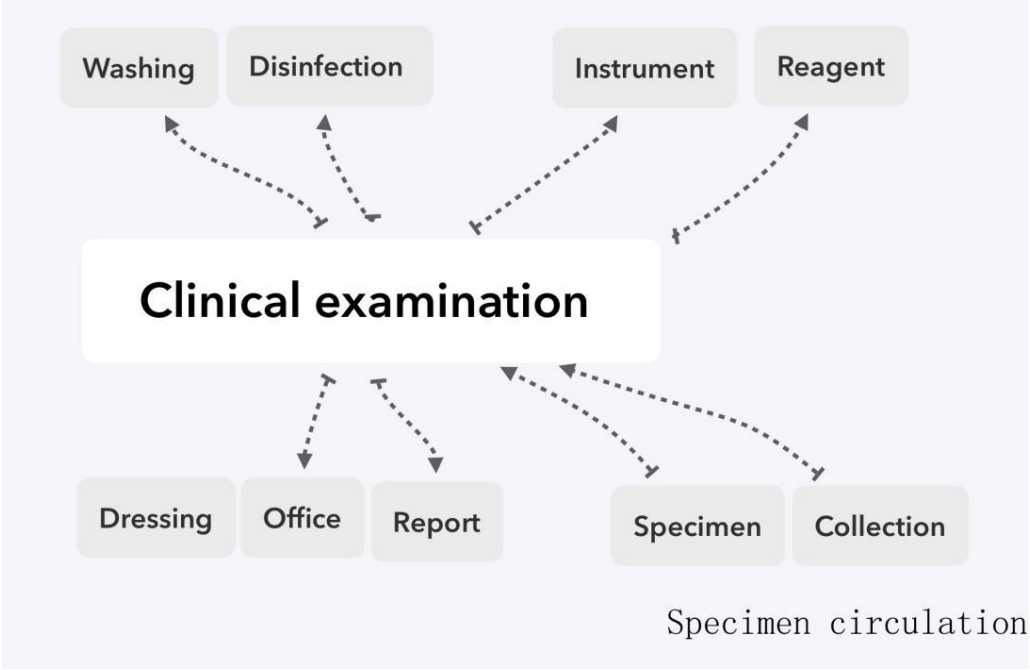


Figure 4.4 Clinical Examination Specimen Collection Circulation

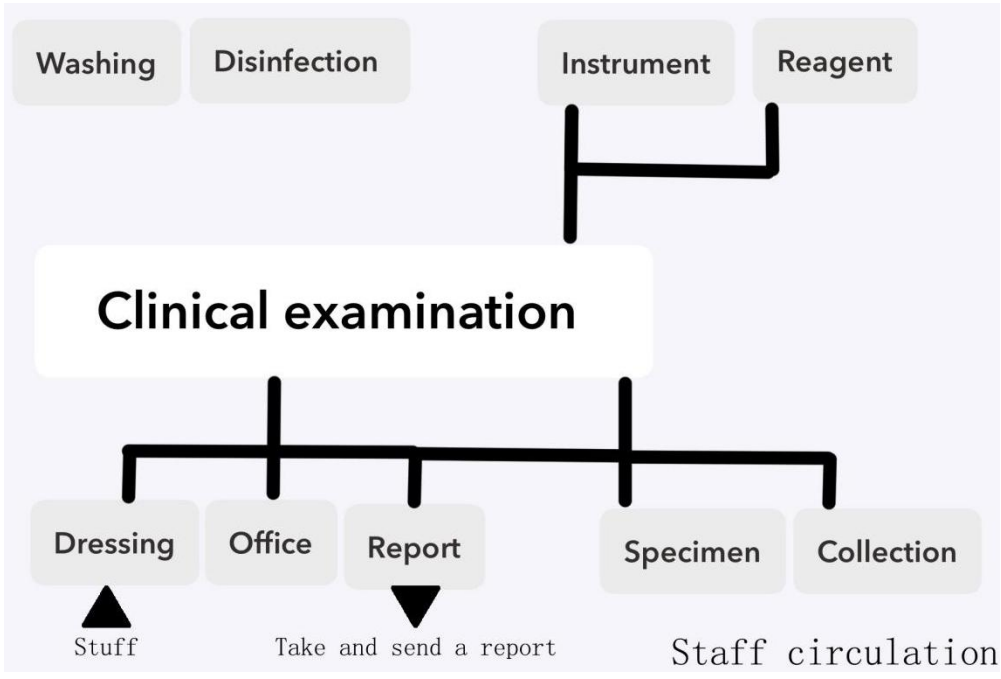


Figure 4.5 Clinical Examination Stuff Collection

4.2.3 Observation and Inspection Equipment

The workload of the laboratory depends on the patient's test demand; that is, the number of tests performed every day. However, with the

development of science and technology, the test speed of the test equipment in the laboratory can be simultaneously performed, and the number of inspections can be performed simultaneously. The workload has a significant impact. That is, the type and quantity of instruments and equipment configured in each inspection unit have a positive influence on the number of inspections that the laboratory may complete in one day and the space required by the laboratory. After observation and informal talks with inspectors, the researcher listed the equipment configured in the laboratory (Figure 4.6,Table 4.2).

Figure 4.6 Equipment Diagram of New Laboratory

Number	Equipment name	Brand	Clinical function	Size（cm）l*w*h
1	Urine automatic analyzer	DIRUI-FUS2000	Test items: Urinary bilirubin (URO), bilirubin (BIL), ketone body (KET), creatinine (CRE), occult blood (BLD), protein (PRO), microalbumin (ALB), nitrite (NIT)), white blood cells (LEU), glucose (GLU), specific gravity (SG), pH, ascorbic acid (VC), calcium (Ca); 12 urine tests	70*74*59
2	Leucorrhea automatic analyzer	HUAJING-HJ500	Using computer graphics processing technology to carry out dynamic analysis and detection of female physiological leucorrhea	103*70*58
3	Automatic blood type analyzer	HAMILT	Testing items include ABO\Rh typing, erythrocyte antibody screening, red blood cell antibody identification, red blood cell cross matching, DAT detection, weak D analysis, platelet antibody screening, and platelet cross-matching.	138*76*88
4	Microgel gel blood	TDA	Centrifugal blood coagulation	32*40*20

	centrifuge			
5	Five-class blood cell analyzer	SYSMEX-XE2100	Blood cell analysis	70*92*71
6	Whole blood C-reactive protein analyzer	Goldsite-Aristo	C-reactive protein assay	62*70*78
7	Serum amyloid assay	Hipro	Serum amylase assay	38*27*34
8	Five-class blood cell analyzer	SYSMEX-XN1000	Blood cell analysis	63*74*86
9	Ultra-low temperature refrigerator	Zhongke Meiling	Inventory inspection reagent	117*70*189
10	Medical refrigerated frozen		Freeze-sealing reagent 4 degrees Celsius refrigerator, lower layer vacuum vacuum calibration bottle	70*60*181

	refrigerator			
11	refrigerator -50 degrees Celsius	SANYO	Ice virus sample	75*86*185
12	Centrifuge	THERMOUl-trac entrifuge	Ultracentrifugation	44*60*34
13	Automatic blood coagulation analyzer	CP2000	Hemagglutination analysis	68*68*119
14	Automatic urine analyzer (2 in 1)	Roche-601701	Urine analysis	178*53*65
15	Haier medical ice storage box	Haier	Freezing test reagent	61*69*195

Table 4.2 Laboratory Equipment List

4.2.4 Observing the Furniture of the Laboratory

A large number of inspections in the laboratory require an inspection surface, the workbench. The selection and arrangement of the workbench should satisfy the use function of the laboratory in the greatest extent, and at the same time ensure that the staff can work safely and comfortably. Workbenches are usually manufactured to standard and are available in fixed and modular combinations. Fixed workspace can be selected for a relatively fixed inspection space, and some test spaces have temporary changes, and a modular workbench can be selected for assembly and handling, or a combination of fixed and modular arrangements can be used. Furnitureof new laboratory can be seen in Figure 4.7.

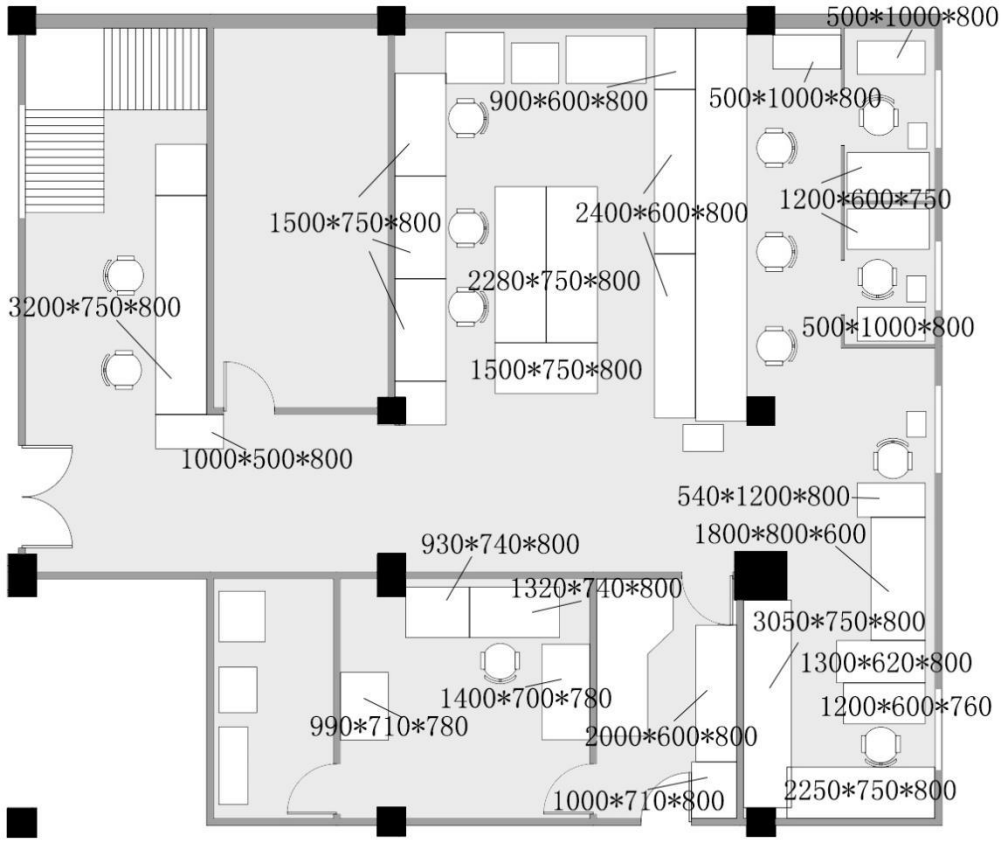


Figure 4.7 Furniture Map of New Laboratory

4.3 Focus Group

After the consent of the six participants, the researcher grouped the six participants according to their working age. Skilled in interpersonal communication and fairness, the host uses the method of exploration to promote interaction, and concentrates on the construction aspect without letting the discussion go to other aspects, resulting in wasted time. The focus group discussion was held in the conference room of the hospital to make the participants more comfortable and ease. After two panel discussions, the researcher's stated goals were successfully achieved. The Participant Consent Forms were signed to indicate that collected data can be analyzed and then the original data was secretly saved.

4.3.1 Old Laboratory

In the first part, the focus group mainly aims to lock in the old laboratory (Table 4.3). In the question-and-answer about the shortcomings of the old laboratory, researcher learned that there were many problems in the old laboratory. The main problem is that the laboratory area is too small. Researcher believes that the old hospitals did not attach importance to laboratories, which led to the lack of resources allocated to laboratory. However, now, with the development of medical technology, the laboratory has become an essential medical technology department of the hospital. The main reason for the reconstruction is that it cannot meet the daily work needs. With the increasing number of patients, the original inspection department has been unable to test too many samples.

Moreover, with the improvement of the people's material living standards, the inspection projects are gradually increasing. The original small space cannot accommodate the inspectors and new instruments. In order to meet the daily teaching and experimentation, the laboratory needs to add corresponding supporting rooms, lead to the reduction of the original experimental part area. The narrow space is more crowded, resulting in circulation chaos and too narrow aisles, and the original lounge is separated from the laboratory, making it very inconvenient to use. The design of the old laboratory is streamlined. In the view of researcher, this kind of design is relatively limited to the era at that time. At that time, there were not so many inspection items in the laboratory and there were not many work-spaces needed. So the old laboratory met the requirements of the laboratory at that time, but the designers did not consider too many future laboratories developments. The advantages of the old laboratory are mainly that the circulation design and functional division of the old laboratory are very concise. The reason for this design before the old inspection department was that:

- The original inspection department was not large.
- The inspection project is not complicated.
- The inspection personnel are relatively small.

So the design is relatively easy. It is easier to test the department. Of course, the advantages of the old laboratory can also be used as a reference for the subsequent revision of the laboratory. When asked about the comparison with the old laboratory, it is not difficult to find that the old laboratory is not convenient for the new laboratory, whether in the course of use or other daily activities. As a result, the inspectors are unable to meet the needs of the work environment, and more and more contradictions are gradually exposed during the work of the inspectors.

Questions and answers about the old laboratory	
Question	**Q1-1: What are the disadvantages of the old laboratory?**
Answer	A1-1-1: Too far from the toilet.
	A1-1-2: It is too far from the rest locker room. The duty room at night will be very noisy because it is too close to the emergency room.
	A1-1-3: After the sample is received, it is easy to mix in the inspection area.
Question	**Q1-2: What are the advantages of using the old laboratory?**
Answer	A1-2-1: The partition is concise and easy to operate.
	A1-2-2: Because the previous work is simple, the operation space is concentrated and the reception is convenient.
	A1-2-3: Clear cleaning partition.
Question	**Q1-3: Compared with the new laboratory, what is the difference, do you think it is more convenient or troublesome to use, and what is it?**

Answer	A1-3-1: The previous inspection equipment was small and the use space was small. This will not be able to enlarge the area where the body fluid collection is detected during the subsequent expansion.
	A1-3-2: The door opening position is different. However, the old inspection department opened the door too close, and only used one door during work.
	A1-3-3: The archives and office areas are relatively small, and the laboratories of the inspection department are scattered, which is not particularly convenient to use.
	A1-3-4: The space of the laboratory is linear. The staff of different inspection projects will interfere with each other, that is, the channel overlaps with the workspace, which affects the work efficiency.
	A1-3-5: Because the conditions are limited, the buffer is not perfect, the lab is the corridor, and there is no good transition.
	A1-3-6: There is no special channel for sample transportation, and one is shared with the inspection window.
	A1-3-7: Because the site is small and there are few inspection items, the inspectors are also very limited. In a narrow space, it cannot accommodate too many inspectors.
	A1-3-8: Office space is limited due to space.

Table 4.3 Focus Group On the Old laboratory Discussion Table

4.3.2 New Laboratory

In the second part, the focus group paid more attention to the discussion of the new laboratory (Table 4.4). The host asked participants about the spatial layout of the laboratory. Researcher learned that the main contradictions were concentrated in three major areas (routine blood test, blood coagulation test, and body fluid test).

The researcher found that:

- The unreasonable arrangement of equipment led to the insufficient workspace, narrow space led to the uncomfortable working environment.
- The reason that individual inspection areas could not accommodate two inspectors at the same time led to inefficient inspection.
- Especially in the body fluid detection area, because of the diversity of detection instruments, the working area is insufficient and the channel distance is narrow. Researcher believe that this is due to a series of problems caused by the insufficient total area of the laboratory. The circulation planning is not precise, the storage area is lacking, and the office space is unreasonable. It formed the unreasonable and unscientific space layout of the laboratory, which not only affected the working environment of the laboratory, but also reduced the efficiency of the inspectors.

The researcher then asked about the placement of the testing instruments in the laboratory and the layout of the tables and chairs. Comfort, table and chair comfort is not a too big problem. Inspectors believe that the height of tables and chairs is appropriate and comfortable, but the problem of the placement of instruments and tables and chairs still needs to be improved. The placement of equipment and desks and chairs needs to change with the circulation plan of the laboratory, especially how to place equipment and desks and chairs adjacent to functional blocks becomes a significant problem. It is a very challenging problem to make the equipment sequential without affecting each other in the process of equipment operation. When discussing the air circulation and lighting of the laboratory, the inspectors put forward a demand for the fresh air system. The original old-fashion ventilation function could not meet the current requirements, but the installation of new equipment will affect the work. Under the installation, this also puts new requirements on the space

layout. It is necessary to place the workspace close to the window as much as possible, and adopt natural ventilation to keep the indoor air fresh.

Questions and answers about the new laboratory	
Question	**Q2-1: Which partition in the new laboratory is messy, which leads to inconvenience, why?**
I	A2-1-1: In the body fluid collection and detection area, because of the relationship of the previous inspection department layout, this piece cannot be made large, with the increase of equipment, the increase of equipment, resulting in a serious shortage of this area.
	A2-1-2: Body fluid collection detection zone: This area cannot be easily moved because of the limited acceptance window of the test sample.
	A2-1-3: In the body fluid collection and detection area, the use of the leucorrhea analyzer is very inconvenient because the equipment is placed too low, and the circulation space is blocked when the inspection is performed.
	A2-1-4: The routine internal blood collection detection part is crowded because the blood collection window is too close to the test bed. Although it is convenient, when the data is analyzed, it is impossible to walk, and when using the centrifuge, it is necessary to suspend other items. This means that blood centrifugation and other items cannot be performed at the same time.
	A2-1-5: Stacking inspection reagents or other cargo in the aisle next to the blood coagulation test, causing congestion in the aisle.
Questio	**Q2-2: Is the area of the new laboratory sufficient? (Crowded**

n	**during use)?**
Answer	A2-2-1: The body fluid collection test is not enough. The routine blood collection and detection area is not enough. The blood coagulation test is not enough, occupying the area of the office area for data analysis and archiving. This results in an unclear sanitization zone, no buffer zone (semi-contaminated zone) and cross-interference in the contaminated zone.
	A2-2-2: The office area is not enough. It is not very comfortable when doing data analysis and archiving.
	A2-2-3: If you can, it is also recommended to make the lounge bigger. In the evening, the shift and changing clothes are still crowded. Especially when changing clothes, it is impossible to change clothes and waste work time.
	A2-2-4: The storage area of several refrigerators and blood banks is also limited.
Question	**Q2-3: At present, there are areas in the laboratory and the frequency of use is small.**
Answer	A2-3-1: The frequency of use in refrigerators and storage cabinets is actually not high, but the area occupied is large.
	A2-3-2: File storage and data analysis are wasted in some areas, such as sinks, but the body fluid detection area is not enough, occupying the office area. I hope these problems can be solved.
Question	**Q2-4: Do you think the isolation between the laboratory and the outside is good? Are the isolation areas clean?**
Answer	A2-4-1: It is not particularly in place. The contaminated area can be close to the door. Because of the limited space, the clean-up zone is quite clear, but some areas have overlapping parts. The

	circulation of people and logistics are not well differentiated.
	A2-4-2: The circulation of people and logistics are not well separated. At the exit of goods, there is no good distinction between them.
	A2-4-3: The detection reagent is placed on the aisle next to the blood coagulation test, which not only affects the experimental test, but also affects the partition.
Question	**Q2-5: Do you think the equipment is highly suitable? (Because it differs from international standards, the international laboratory table height is recommended to be 850mm, but the real 800mm)**
Answer	A2-5-1: The height of the table is very comfortable, but the height of the chair is not very comfortable.
	A2-5-2: The chair height is OK, but I hope I have a backrest.
Question	**Q2-6: How to deal with the placement of updated devices and obsolete devices?**
Answer	A2-6-1: The new equipment is purchased through bidding, replacing the old equipment. When the old equipment is used, it will be eliminated when it takes up too many locations, and it will still be placed when it takes up less area.
Question	**Q2-7: When you are doing the test, which equipment feels the most inconvenient to use, can you solve it by changing the position?**
Answer	A2-7-1: The leucorrhea analyzer, because the instrument is too large, the equipment is placed low.
	A2-7-2: Centrifuge, which affects the use of other equipment during use.

Question	**Q2-8: What new problems existed in the laboratory before the redevelopment, you can start from the perspective of light and air circulation.**
Answer	A2-8-1: Because the ventilation equipment is remodeled, it is not perfect.
	A2-8-2: When performing certain special infection projects, window ventilation is required, and there may be problems with direct exhaust.

Table 4.4 Focus Group On the New Laboratory Discussion Table

4.3.3 Expectation Laboratory

In the third part, the focus group mainly discussed the expectations of the laboratory (Table 4.5).

- In the laboratory, participants hoped that the area of the routine blood test part will be larger. The inspectors mainly consider work, human movement and frequency of use.
- The body fluid detection part is the second largest part of the laboratory staff. Considering the diversity of instruments and the rationality of equipment placement, the researcher hope to expand the area of the body fluid detection area based on convenient sampling.
- In the discussion process of the focus group, the participants most often mention the storage of test reagents, inspection. Storage rooms for inspection supplies and equipment are being phased out, and they hope to increase the size of the area. Secondly, it is desirable to add an ice storage warehouse. The inspectors hope to have a refrigerator that can store samples and reagents. Separate toilets for men and women are also mentioned, and a larger conference room for discussion and discussion is also mentioned.

Question and Answer about the Expectation Laboratory	
Question	**Q3-1: Which piece of the prospective laboratory is more important, which one is most likely to be expanded, or which one is more demanding?**
Answer	A3-1-1: Body fluid collection test area, because it is too crowded. The update of the instrument leads to a smaller working area.
	A3-1-2: The body fluid collection test area, the instrument is increased, but limited to the previous site restrictions, no expansion.
Question	**Q3-2: What updates are there in the new laboratory?**
Answer	A3-2-1: The size of the refrigerator is quite large, but it has to exist. I hope there is a cold storage that can store samples and reagents.
	A3-2-2: I hope to have a room temperature reagent library.
	A3-2-3: I hope there is a warehouse that can stack the instrument and inspection goods.
	A3-2-4: There is a separate toilet for men and women, because it is very inconvenient to go to the toilet in the laboratory.
	A3-2-5: I hope there is a meeting room to have a discussion venue outside the lab.

Table 4.5 Focus Group On the Expectation Laboratory Discussion Table

4.3.4 The First Post-designed Laboratory

The focus group of the second round is mainly for the problems summarized in the first round of discussions (Table 4.6). The researcher seeks solutions in the simulated floor plan, and then discuss with the participants in the first roundabout whether they will be the first. The

problem of the round has been solved reasonably, and a laboratory that is more in line with today's needs has been obtained, and there is a certain plan for future development. In the second round of focus groups, the researcher mainly discussed the ideas of some researcher in the clinical laboratory to improve the working environment (Figure 4.8,Table 4.7).

- First, in the collection window section, the researcher proposed to change the scattered sample collection window to a continuous window, and change the collection to closed, but the researcher still want to stay the same, because they are used to the past form, the benefits of these changes do not balance the increase in laboratory funding.
- Followed by the blood coagulation part, the researcher hopes to widen the aisle of the blood coagulation part, and also increase the blood coagulation test area, but for this purpose, the laboratory needs to add storage room to place the original storage cabinet and freezer in the blood test area.
- The researcher then adjusted the entrance section, moving all the inspection equipment at the entrance section to another place, replacing it with a sink and a dressing room.
- The researcher did not only adjust the cleaning partition, but also allowed the inspection personnel to enter the inspection. The circulation of the department is more concise.
- In the processing of the office part, the researcher integrated the office partly on the plan design and took the first internal partition, but the inspectors said that the significance of doing so is not unusually large.
- Finally, when the researcher and participants explored improvements in design, the voices of the storage rooms and ice storage were still significant, and the improvement of the floor plan did not solve these problems well.

Figure 4.8Functional Zoning Map of New Laboratory

Question and Answer about the First Post-designed Laboratory	
	Window collection part
Question	**Q4-1 Is it necessary to change the collection window to a private seal?**
Answer	A4-1-1 Open type will be better, it will be more convenient to take samples (physical examination, using a table).
	A4-1-2 Closed better, more private, but it is more convenient to use now.
	A4-1-3 The style is very good now, it can meet the daily needs, or it is not recommended to change.
Questi	**Q4-2 Is it reasonable to place the body fluid collection**

on	**window and the blood collection window side by side?**
Answer	A4-2-1 Uniform collection, but did not consider fire pipes.
	A4-2-2 It is more appropriate to place by partition, because the detection content is relatively independent and there is no interference.
	Blood coagulation part
Question	**Q4-3 Is it reasonable to partially withdraw the storage cabinet and widen the hemostasis of the blood coagulation test?**
Answer	A4-3-1 Reasonable, it is recommended to store separately.
	Sample collection storage and sample detection part
Question	**Q4-4 Is it reasonable to move the sample collection area to the lower part of the blood coagulation test?**
Answer	A4-4-1 Sample collection can be combined with sample detection, or it can be separated, because the connection between the two is not so close, but the collection and storage of the sample can be placed in the ice storage area.
	A4-4-2 Those can be combined to make it more convenient to use.
Question	**Q4-5 Is it reasonable to change the original sample collection to the storage area?**
Answer	A4-5-1 There is currently no storage area, and it is important to open reagents and laboratory for debris storage.
	A4-5-2 This location is more reasonable to store.
	Entrance part
Question	**Q4-6 Is it reasonable to adjust the daily entrance position and change the hand washing and changing position? (for the previously proposed cleaning partition problem)**

Answer	A4-6-1 reasonable.
	A4-6-2 The original part of the entrance is too crowded and properly adjusted.
	Office part
Question	**Q4-7 The office blood bank area removes the wall, the area becomes larger, and is the area more flexible and reasonable?**
Answer	A4-7-1 Not particularly suitable, I hope to add a separate ice storage and storage room.
	A4-7-2 The dirty partition is not obvious.
	A4-7-3 Although the office area has become larger, the actual available area is still small.
	other
Question	**Q4-8 Other suggestions for this remodeling plan?**
Answer	A4-8-1 I hope to add an ice store.
	A4-8-2 Storage can be placed separately.
	A4-8-3 Blood bank can have a good treatment.
	A4-8-4 The dirty partition also hopes to rearrange.
	A4-8-5 The height of the collection window is recommended to be moderately reduced.

Table 4.6 Focus Group On the First Post-designed Laboratory Discussion Table

	Test areas	Activity	User's psychological expectation	Space scale design points
Workspace	Conventional blood collection test	Routine examination, various anemia and blood disease screening, health checkups, etc.	Quiet, private and convenient	Suitable for equipment scale and clear working space
	Hemagglutination test	The four coagulation factors include prothrombin time (PT), activated partial thromboplastin time (APTT), thrombin time (TT), and fibrinogen (FIB). The purpose is to understand whether the patient's hemostatic function is defective before surgery. Prepare in advance to prevent intraoperative bleeding and be caught off guard.		

	Body fluid collection test	Identification of the nature of the chest and ascites and assisted diagnosis of meningeal disease. Examination of gastrointestinal diseases and screening of digestive tract tumors. Diagnosis of various acute and chronic nephritis, multiple myeloma, urinary tract infection, nephrotic syndrome, diabetes, etc.		
	Sample receiving and storage	Receive sample, code storage		
	Data archiving and analysis	Perform sample data collection and analysis, and archive		
Waiting space	Clinical examination blood fluid collection queue waiting area		Easy to find and arrive; orderly and convenient	The space is large in scale, the space ratio is appropriate, and there are rest facilities for communication.

Circulation space			Smooth, easy path	Have enough waiting and circulation width, and have a clear orientation
Rest space	lounge	Rest, change clothes	Bright and transparent, easy to change clothes, pleasant environment, quiet	Meet the staff's rest requirements, have temporary rest, storage function
Storage space	Storage area	Equipment storage and inspection tool storage	Dry and tidy	Does not affect circulation, size needs to be larger than what you want to store

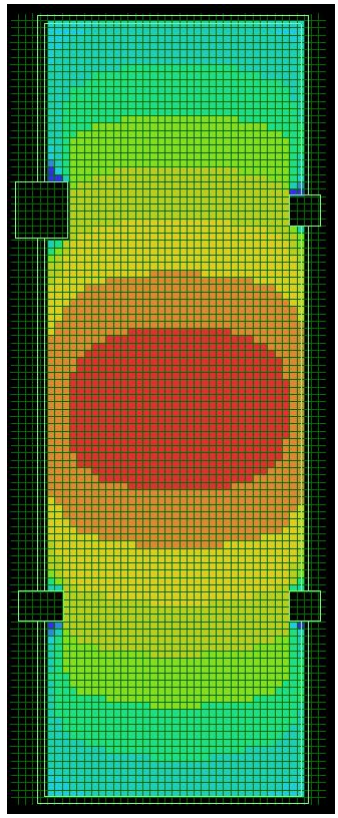
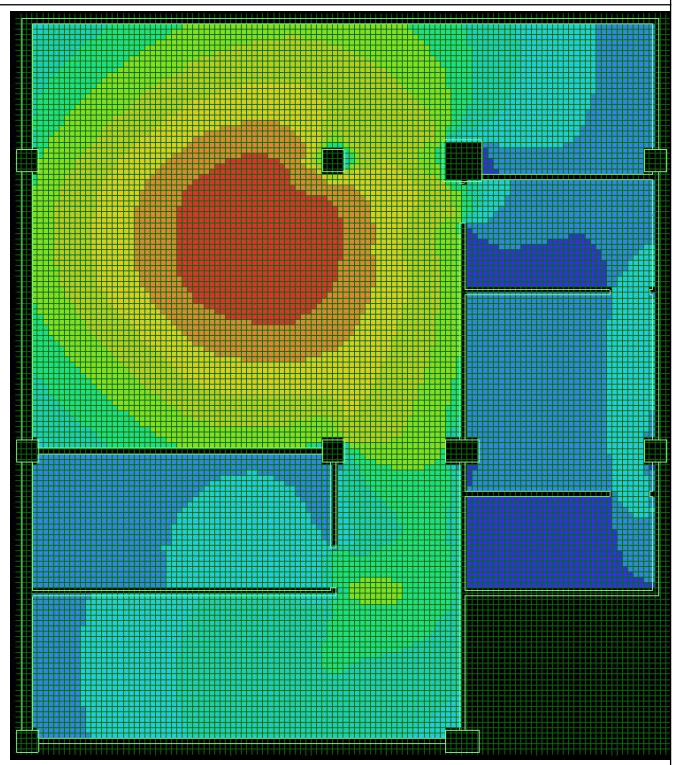
Table 4.7 Laboratory Functional Zoning Table

4.4 Simulation

The plans of the new and old laboratory and post-test laboratory investigated were conducted with software simulation analysis based on space syntax. In this study, the researcher not only analyzed the interior space of the three inspection area (excluding all furniture and doors), but also studied the impact of the layout planning of the three inspection areas of the laboratory on the work efficiency of the inspectors. Through this study, the researcher improved the working environment of the inspectors. Using spatial syntax theory to compare three plans can help to obtain design strategies for future laboratory design to improve tester satisfaction. The study proposes visual features for layouts including VGA and Isovist, as well as proxy analysis for simulating human behavior.

4.4.1Visibility Graph Analysis (VGA)

The VGA presents several properties about visibility relationships between spaces in the research. The researcher draws the plan in CAD, straightening curve, closing plan boundary, and imports the plan into DepthmapX. The plan is divided into several small grids, set according to a distance of 550 mm. Grid spacing, then the researcher can perform a line of sight analysis.

Old laboratory	
New laboratory	

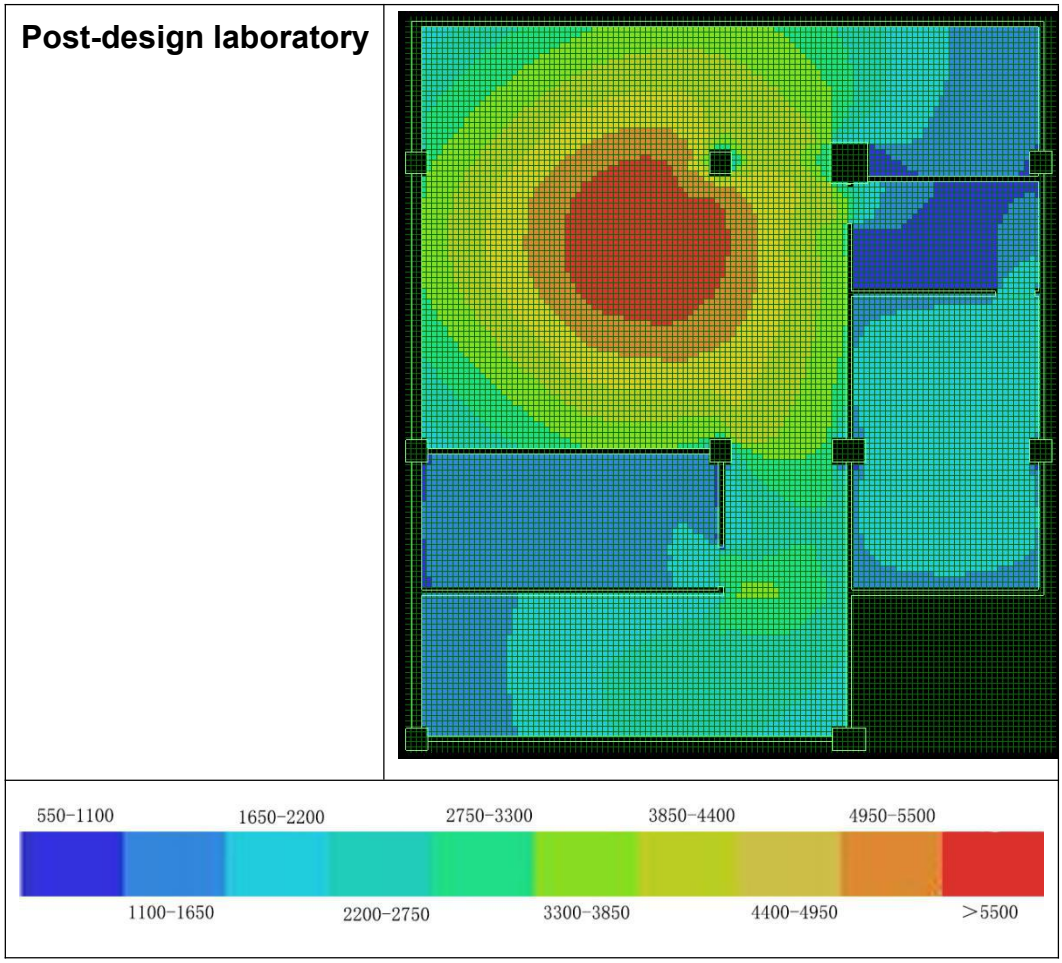


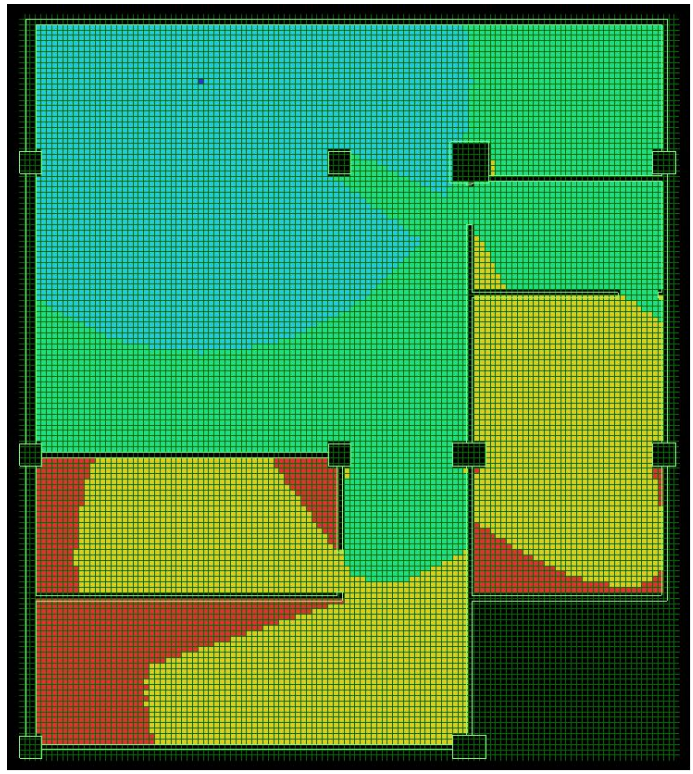
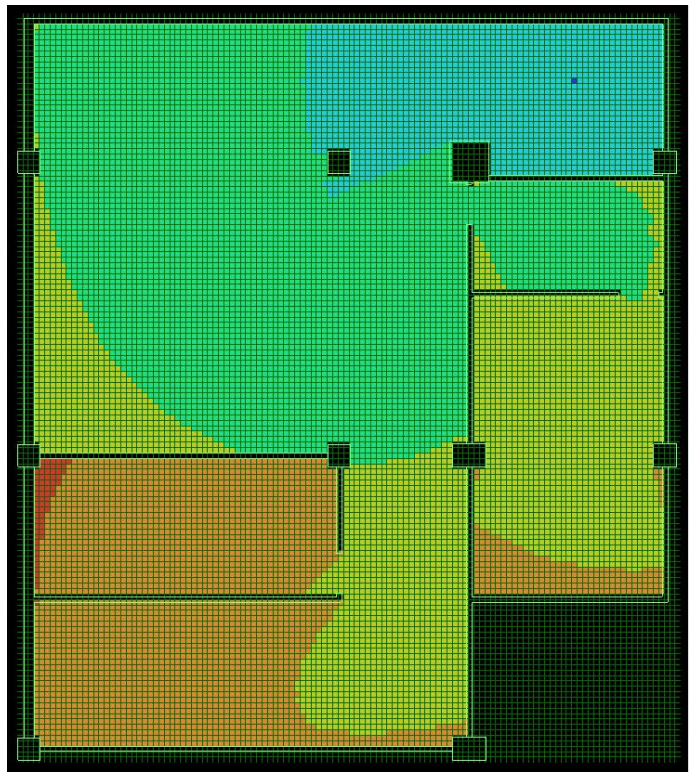
Figure 4.9 Visibility Graphs with Connectivity Values of Three Laboratories

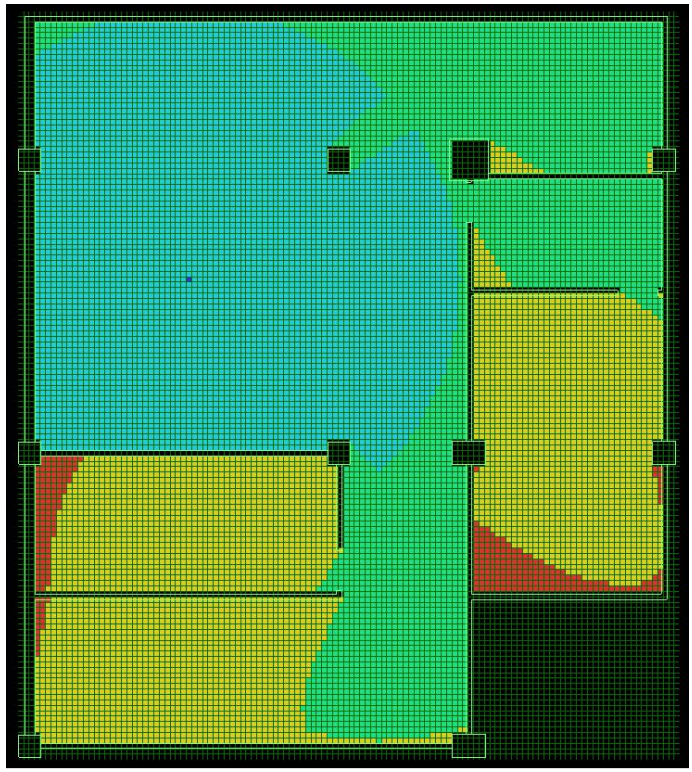
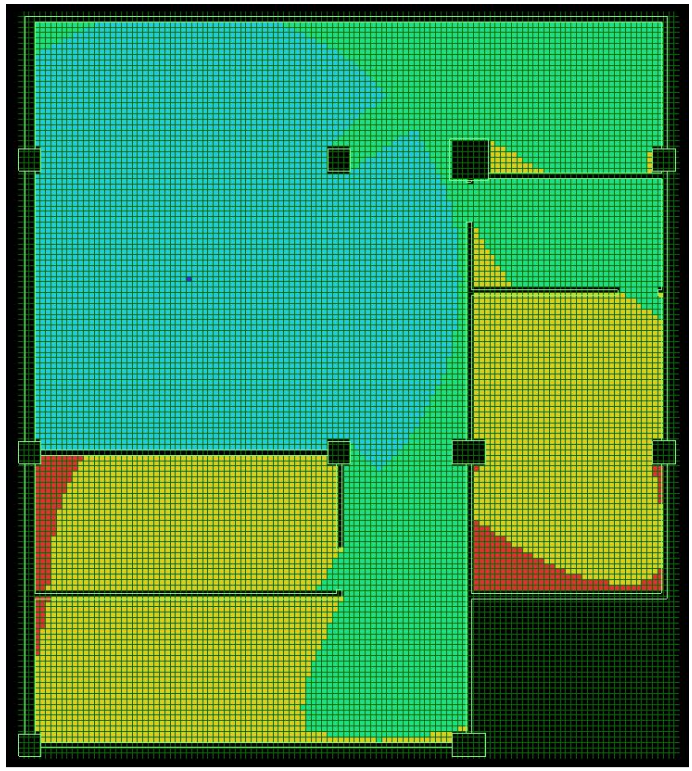
Figure 4.9 shows the connectivity values of the three hospital laboratory plans, in which different connectivity values are expressed in different colors. According to connectivity values, it is divided into ten numerical sections from low to high, and it is corresponding to 10 colors. The higher the numerical value, the closer the corresponding color in the plan is to red, and the lower the numerical value, the closer the corresponding color in the plan is to blue. As can be seen from the figure, the most significant point of connectivity values in the experimental areas of the three laboratories is located in the exam part. In the old laboratory, because of the small area, connectivity values do not differ too much. The more central the area of vision is, the larger the area of vision is. It begins to

decrease on both sides of the room. New laboratory and post-designed laboratory connectivity graphics are not very different. The main reason is that post-designed laboratory is designed on the original basis, so without changing the column network, the changes are not significant. The most difference is the lounge and office parts, because the internal walls have been changed.

In the experimental area of the three laboratories, compared with other locations, the experimental area needs a more spacious vision of the inspectors and more attention of the designers. As the most critical position in the laboratory, the inspection area is the main body of the laboratory, which connects other spaces. The other spaces in the laboratory need to be centered around the inspection area. Not only should they be located in the central position, but also the design of their line of sight is fundamental. The width and length of the inspection space in the laboratory will affect the quality of the line of sight. In the laboratory, the office, lounge and storage room are all auxiliary laboratories to play their functions better and meet the daily needs of the laboratory, so when considering the line of sight, the three spaces can be placed in a secondary position for consideration.

4.4.2Visual Depth Analysis

Viewpoint in the routine blood inspection area	
Viewpoint in the body fluid detection section	

Viewpoint in the blood clot detection section	
Viewpoint in the office area	

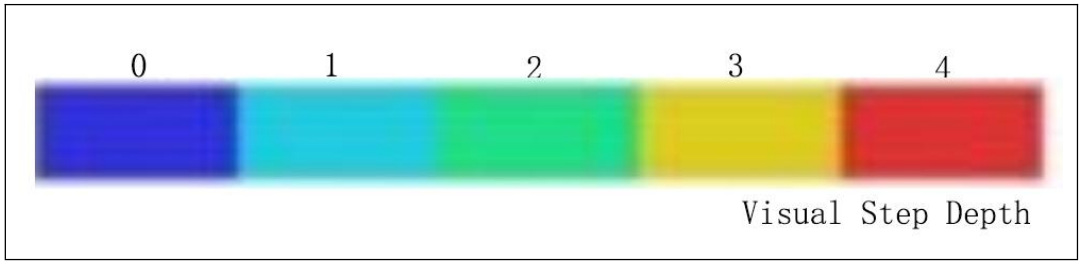
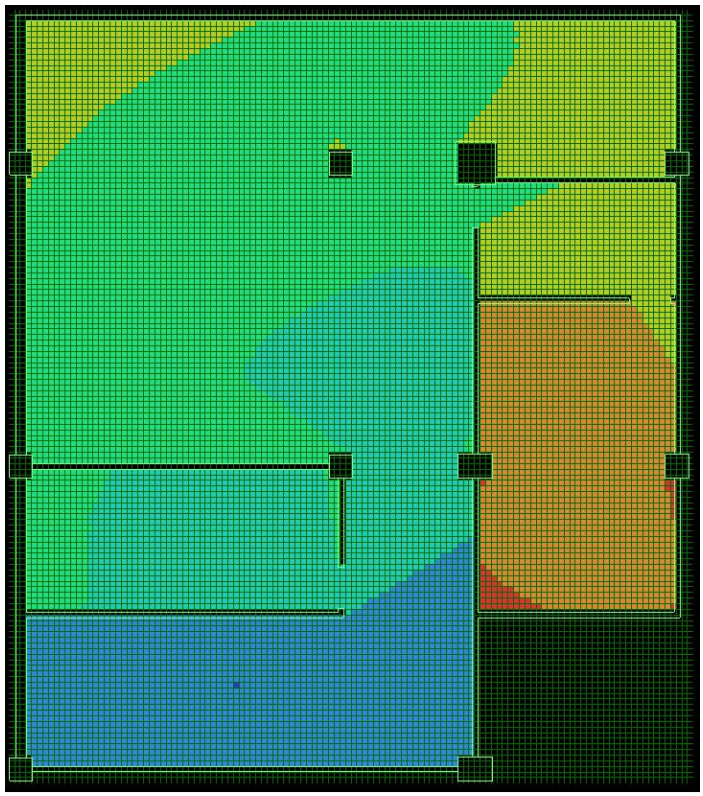
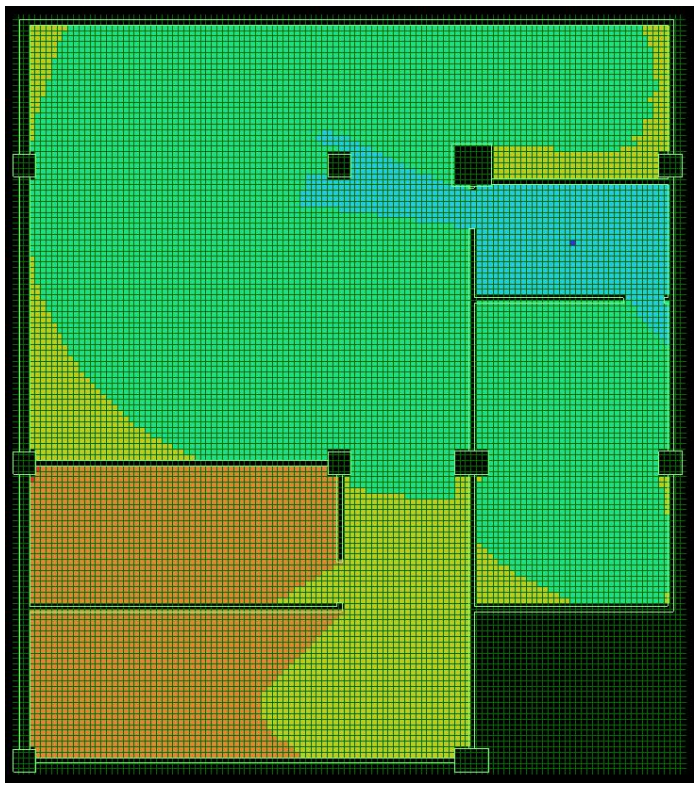


Figure 4.10 Visual Depth in Inspection Area and Rest Area

Figure 4.10 is the visual depth analysis of inspection areas and rest area, that is, in a specific space, from the center of the space to the surrounding, according to 5 m as a visual step, the closer the color is to blue, the fewer visual steps can be seen from that point, and the closer the color is to red, the more visual steps are needed to see. At the same time, it also shows that at a particular location, the red area shows stronger occlusion, the visual limitation of its surrounding space boundary is more obvious, and the color red also represents more privacy in space. On the contrary, close to the blue area means that the mesh is less occluded and the space boundary is less restricted. It can be seen from Figure 4.8 that in the part of the hemagglutination test, the area that a visual step can reach is the largest, indicating that the line of sight here is the most open. At the same time, a line of sight step completely covers the part of the hemagglutination test, indicating that this area and space size is suitable for hemagglutination test. According to Figure 4.8, we can see that in the initial design of the inspection area, the three inspection parts can well cover the whole area and meet the daily space needs. In the office space, the whole office is blue, indicating that a visual depth can be reached, which also shows that the vision in the office is perfect. OK, it can meet the needs of inspectors. However, it can also be seen that in the laboratory, it is relatively difficult to see the office and the lounge, which gives the office area enough privacy, but also has a good connection with the laboratory.

Viewpoint in the storage area	
Viewpoint in the entrance area	

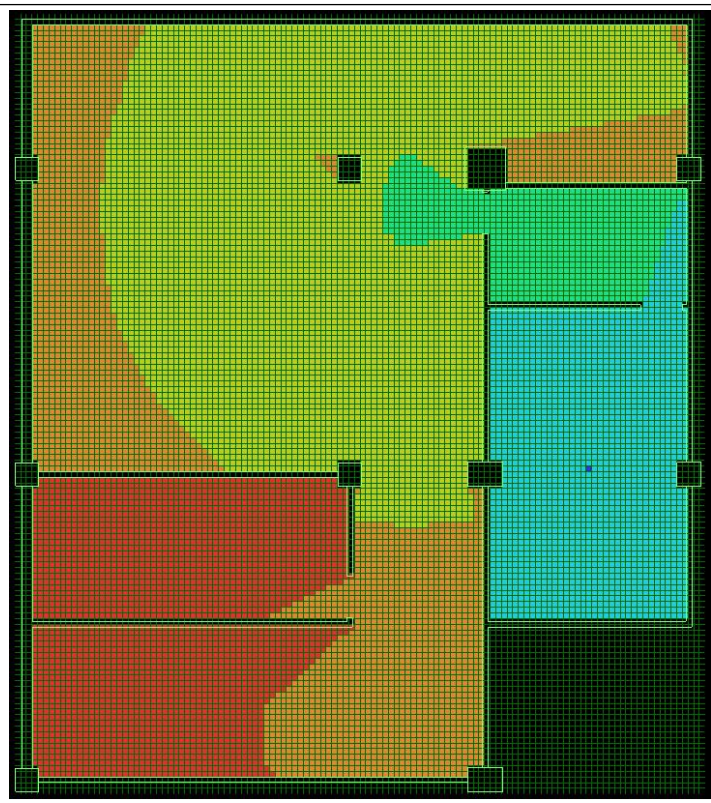
Viewpoint in the rest area	

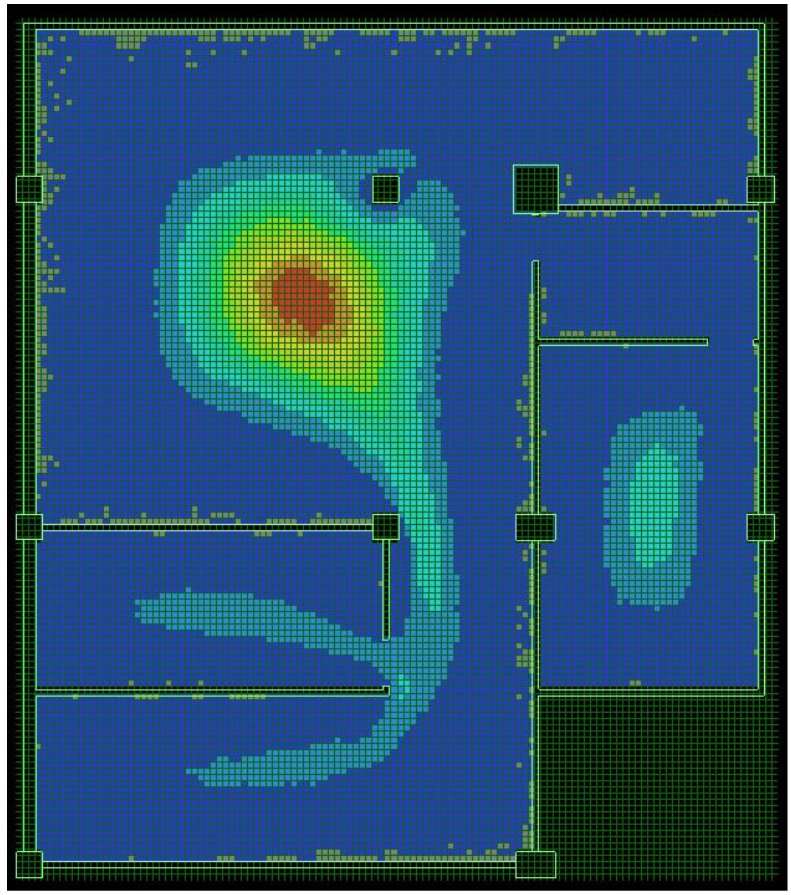
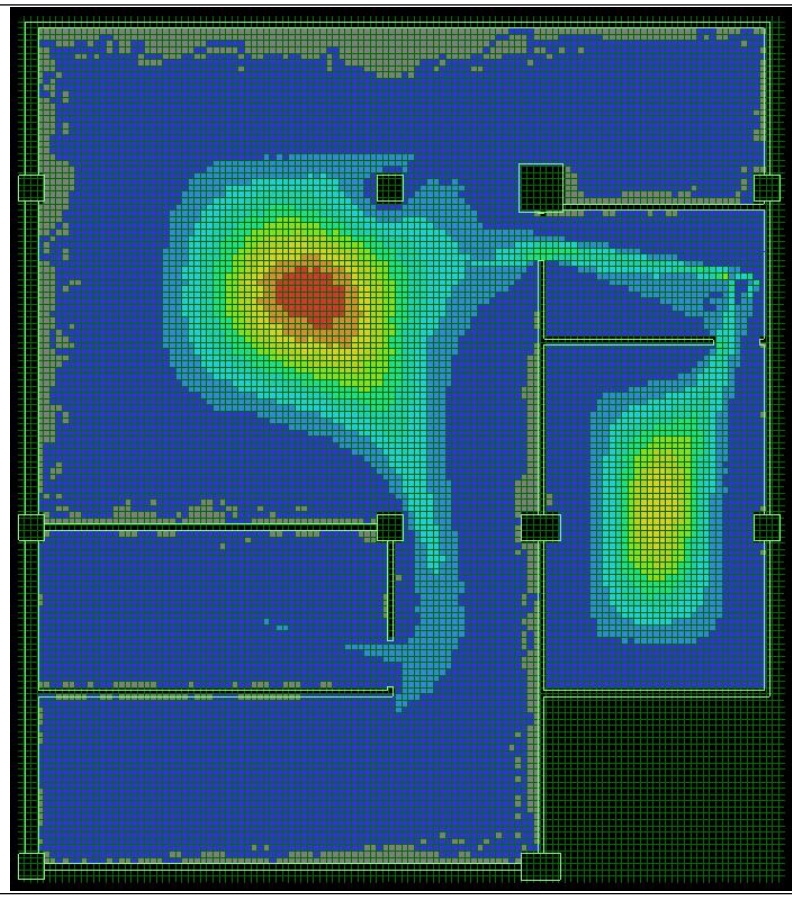
Figure 4.11 Visual Depth in Inspection Areas and Lounge

Figure 4.11 is the visual depth analysis of storage space, entrance space and rest space. From the graph, we can see the visual depth of storage space, entrance space and rest space. The three spaces have functional independence, especially in entrance space. In the narrow space, it will not interfere with other spaces, and will not see the staff of the inspection department. Working conditions, storage space is also very independent, will not affect the inspectors at work, the inspectors in the lounge, also have proper privacy during the rest.

4.4.3 Agent Analysis

The focus of this study is the spatial layout of the laboratory. The researcher hopes that by changing the space layout of the laboratory, the working environment of the laboratory can be improved and the working efficiency of the laboratory staff can be improved. This study pays more

attention to the design of spatial planning, taking into account the impact of human behavior on space. At present, human behavior or social activities are not only affected by the internal environment of buildings, but also by other external factors, so it is difficult to study them. Turner (2002) designed a building model, which uses agents to simulate human's natural activities in a particular scene, and agents automatically select visual features of the environment, to achieve a realistic simulation of human behavior. This simulation can be implemented using proxy analysis tools in Depthmap. The agent model without considering other external factors is helpful to understand the cognitive basis of natural motion better and to standardize individual movement behavior and response to space activities. Researcher made detailed observation of the laboratory, which met the requirements of Depthmap proxy analysis tools. The space use proxy was easier to simulate, and compared with the real world space function and human behavior.

Free circulation agent analysis	
Main portal circulation agent analysis	

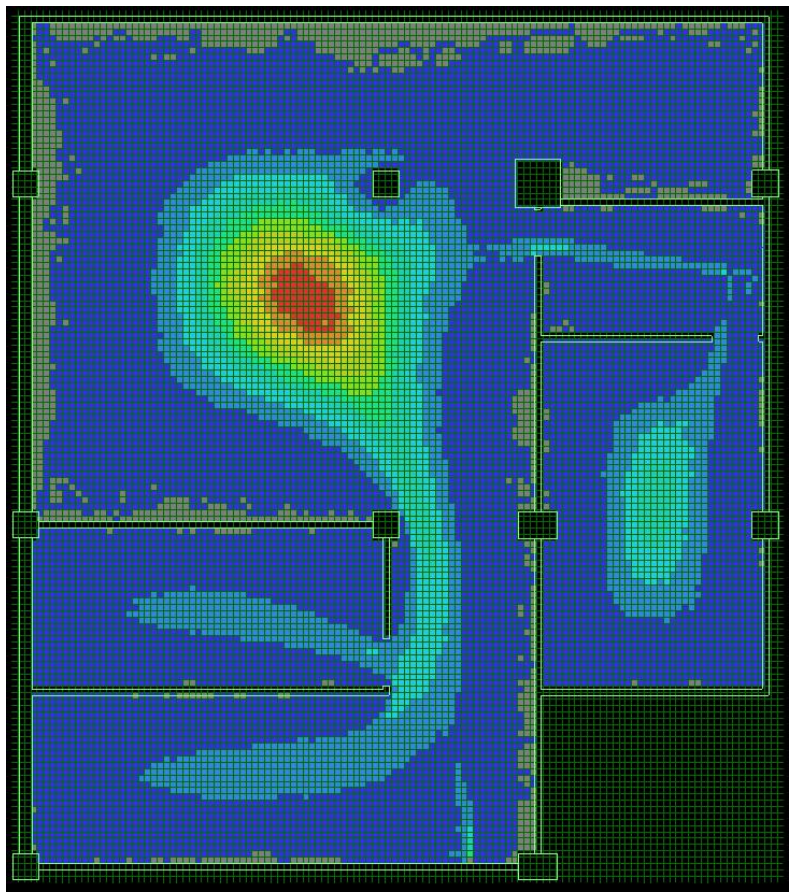
Secondary circulation agent analysis	

Figure 4.13Laboratory agent analysis

This simulation experiment used fifty agents to be active in the laboratory at a fixed period (1000 steps), and randomly placed one agent every ten seconds. Researcher record agent path tracking based on computer data, and synthesize the image of each agent's path. In a fixed period, the path of repeated walking is marked red. The more times different agents repeat walking, the more color in the region is red, and the less-traveled area is marked as red. Blue, the fewer the agents, walk the road, the bluer they are.

From the analysis chart of random agent in Figure 4.13, it can be seen that if the agent is randomly placed in the laboratory, most agents operate in the laboratory area. This simulation reflects the importance of the inspect area in the laboratory, and the designers should pay attention to

making the channels in this area more spacious, which also reflects the importance of this area in the laboratory area. The results show that the test area is the most densely populated, and the test part, which has the most connection with other items in the laboratory should be placed. From the main entrance and sub-entrance (secondary portal) agent analysis chart of Figure 4.10, it can be analyzed whether the entrance is reasonably placed. Inspectors entering the inspection department from the main entrance should first go to the restroom for dressing and disinfection, and then to the experimental area. Therefore, the design is very reasonable. The primary function of the inspection department is to satisfy the inspectors. The experimental function, so the experimental area should be placed in the first place, is the most convenient to reach, and secondly, the main entrance also needs to facilitate access to the lounge. The secondary entrance is mainly equipment and test reagents. In addition to reaching the experimental area, it should also be convenient to reach the storage room and office. The equipment fully meets the requirements.

Depthmap cannot fully simulate the activities of inspectors in the laboratory in the real scene, because the inspection project takes a specific time, and inspectors will be fixed beside a certain equipment in a particular time, but the simulation software can provide more evidence to support the design more accurately, based on these agents. Walking simulation results show that designers can consider space management in the early design process rather than in the construction stage, and can take more account of the specific situation of users, and then make better-humanized design according to the simulation results. Besides, software simulation can help designers to determine the space with the best visual field as the main room, arrange the essential contents of the space in this space, and find out the public and private spaces, which will

need the privacy of the space in a closed space.

CHAPTER Ⅴ. DISCUSSION

5.1 Interpretation of findings

The space design is mainly aimed at improving the environment of the laboratory, thus improving the work comfort and work efficiency of the inspectors. The efficiency and accuracy of the test will directly affect the doctor's diagnosis and patient safety. Evidence shows that spatial layout and environmental factors may lead to increasing staff pressure and increased the risk of error. Based on the analysis of the results of investigation and simulation, some contradictory findings were found.

5.2 Factors Affecting the Laboratory

Researcher have found potential conditions that could lead to environmental differences. The layout of the laboratory is influenced by various factors such as interior design, location, scale, surrounding departments, and culture. Different spatial layouts and environmental characteristics also affect the efficiency of the inspectors. The size of the aisle, the distance between the function block and the function block, the order in which the instrument is placed, the control of the light source, and the indoor ventilation are all important factors that affect the efficiency of the inspector. Inspectors' work efficiency, potential errors, stress levels and job satisfaction are also affected by these design issues. The layout design and transformation of the laboratory is comparative and researched, and it is based on actual conditions. The experience of fully applying a case in different situations is almost impossible. The real-time situation of the new and old hospitals in the study is also different. They are based on the situation at the time, and then the design is completed with specific future predictions. In the prospective laboratory, only the

needs of the past two inspection departments can be analyzed. Plan maps need to meet the current needs and achieve the optimal plan. The improvement of the plan can consider future development to the greatest extent. The number of these studies is insufficient and the scope is narrow, but the results of each study are still valid. Changes in the laboratory that occur over time can also provide a reasonable explanation for the direction of demand for medical facilities and the development goals of the laboratory.

5.2.1 Interior Design

To explore visibility, the researcher simulated the spatial layout within the laboratory, but did not include furniture and equipment. However, furniture and equipment have some impact on visibility. The materials of the furniture, the choice of color and the form of placement may create different spaces to give the inspector a different working experience. The shape of the furniture can also have different effects on the space. For example, researcher can use furniture to create a semi-closed privacy space or control the distribution and occupancy of people by controlling the placement of furniture.

5.2.2 Table and Chair Height Consideration

The tables and chairs of the laboratory have greatly affected the efficiency of the inspectors and the comfort of the work. According to the researcher, the height of the tables and chairs in the inspection room is different from the height of the international laboratory tables and chairs, and other inspection tables are being searched. The height of the chair was found to be different, so the institute felt that the height of the table and chair in the laboratory was also a point of discussion. Researcher feel that Asians' height and posture lead to differences from international standards. In the case of ergonomics, it is easy for people to work, and can consider the

issues of work efficiency, human health, safety and comfort (Chen, F.2006). Ergonomics refers to the working space of the staff before and after, and is a manifestation of humanization (Salvendy, G.2012). The Clinical Laboratory Design Guide gives the laboratory's facility standards, the size of the lab's typical workbench, and the standard between the lab bench and the lab bench. According to international ergonomic standards, a versatile international laboratory standard map has been issued. These standard atlases and data provide potent data support for laboratory space design (Table 5.1).

	Minimum Standards	Recommend Standards
Chair up and down adjustment range	12.7cm	15.2cm
People sit down knee height	68.6cm	71.1cm
Drawer load	20kg	20kg
Channel width between two worktables	1.5 m	1.5 — 1.8m
Workbench and wall distance	1.2m	1.5 m

Table 5.1 Suggestion Form for Furniture and Channel Distance in Laboratory

Wang, Z.G. (2009)

The researcher also consulted laboratory planning and design manual, and described the table and chair standards of the laboratory, and drew the size of the human body of the inspector at work, as well as the various dimensions of the channel in the laboratory specification (Figure 5.1, Figure 5.2, Figure 5.3, Table 5.2).

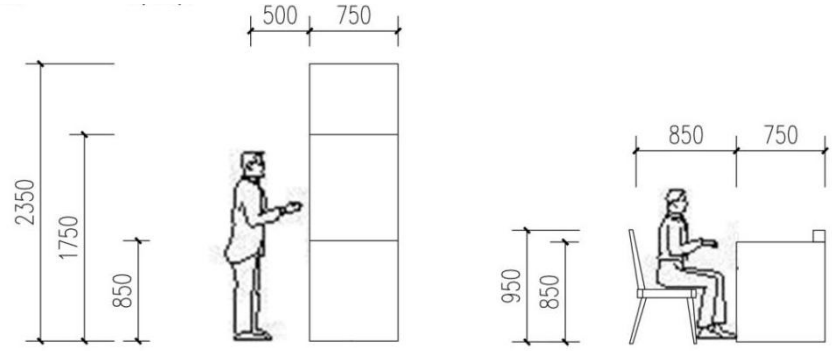


Figure 5.1Inspection Personnel Schematic Diagram

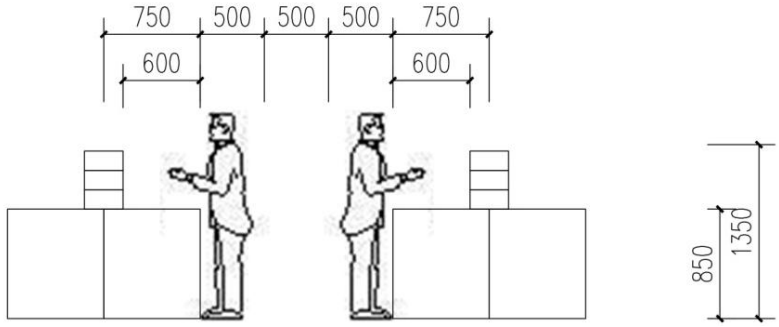


Figure 5.2Laboratory Table Size Diagram

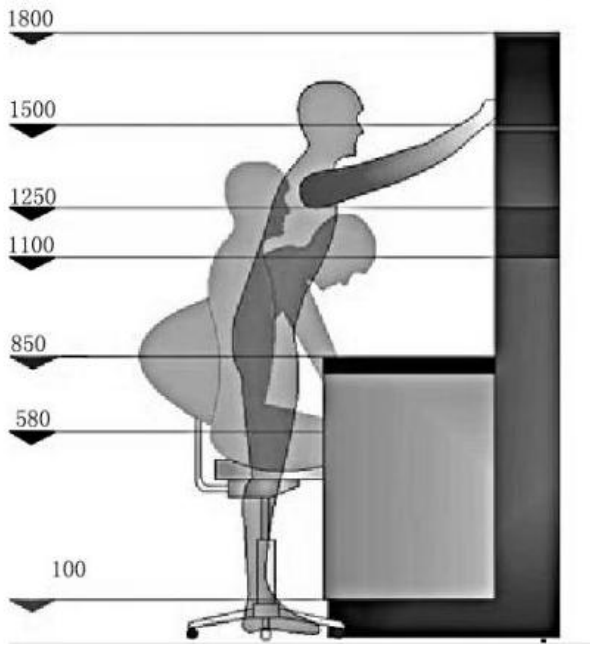


Figure 5.3Inspection Personnel Activity Size Diagram

Graph cite by: Wang, Z. G. (2009).

width		76cm
height	Sitting operation	76.2cm
	Standing operation	91.4cm
	General height	85cm

Table 5.2 Laboratory Inspector Activity Height Recommendation Form

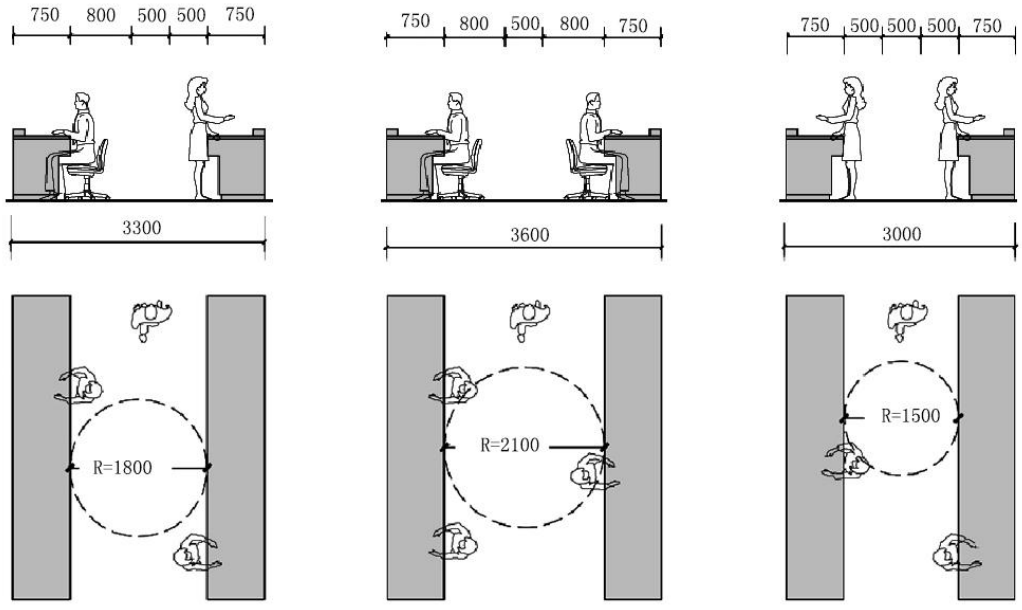
5.2.3 Laboratory Size

If the laboratory module is not well designed, the room is too ample, and the building area ratio does not reach its efficiency and cost-effectiveness, resulting in waste; the room is too narrow, the aisle may be too narrow, and the inspection space is not safe. Alternatively, there can only be a workbench space on one wall. Based on the ergonomics and facilities standards of the laboratory, it can be concluded that a universal inspection unit module has 3300mm, 3600mm, 3900mm, etc.; The size of the 3300mm bay is based on two rows of workbenches and equipment. Inspectors stand on both sides and work can be done in the middle. The 3600mm opening is based on two rows of workbench and equipment, and while standing on one side and sitting on the side, the middle can be a mode of work. The 3900mm opening is based on two rows of workbench and equipment, sitting on both sides, and the working mode can be passed in the middle (Table 5.3, Figure 5.4).

The inspection space of different functional units, such as blood routine test, blood coagulation test, body fluid test section and office, can be expressed as a superposition of multiple basic modules.

Name: Channel 1 of the experimental platform and the experimental platform (the channel spacing is indicated by L)	
L＞500mm	One side can operate
L＞800mm	Sitting on the side
L＞1200mm	While you can sit on the side, you can stand on the side, you can’t pass the middle.
L＞1500mm	Can sit on both sides, in the middle can pass
L＞1800mm	You can sit on both sides, and you can pass the instrument in the middle.

Table 5.3 Test Table and Channel Distance Chart



Sitting on the side, standing on the side, passing in the middle

Sitting on both sides, in the middle

Standing on both sides, in the middle

Figure 5.4Test Table and Channel Distance Diagram

In addition to some large open spaces, the laboratory also needs some small space that requires ventilation, temperature and cleanliness. At the same time, the space of the laboratory is more dependent on artificial environments such as air conditioners, so the size of its modules can't be

too big, otherwise it will cause waste on the area, it is recommended to be 7200mm-12000mm in the length of the room, so that the workbench can be combined in different directions to form a more flexible space to utilize the worktable arrangement for different lengths.

5.3 Laboratory Position

The relationship between the position of the laboratory and other functional units of the hospital will also have a positive impact on the efficiency and health of the laboratory. The following two aspects should be considered to consider the location of the laboratory.

The first is time efficiency. Since the patient does not need to enter the private inspection area of the laboratory, most of the inspection work in the laboratory can be done in areas away from other departments of the hospital. However, the results of the test are significant for the diagnosis and treatment of the disease. Therefore, the location of the laboratory should be set in consideration of the time of collection and delivery of the test sample. The sampling unit of the laboratory should be convenient for the arrival of the outpatient, or at the doctor's office. Samples of general blood, urine, etc. are collected for specific sampling. Outside the central laboratory, some micro-test rooms can be placed close to the emergency and intensive care unit to meet the time requirements of these departments for test results.

The second is the prevention of pollution. When setting up the position of the laboratory, it is also considered that the laboratory of the laboratory is a polluting department.

The specimens examined are mostly blood, body fluids, excretions (urine, stool, sputum) and the human body. The body organization, these are not only the source of pollution, but also the source of bacteria. At the same time, the inspection work requires stricter scientificity, so it should be an

independent unit to form a closed space and avoid crossing with others. Researcher have thought about this problem in the design process. One layer is convenient for patients to find and convenient to pay, but the inspection queue will interfere with other patients, which will lead to congestion. The second-level separate laboratory is suitable for dispersing people, but it will cause inconvenient problems such as payment detours. Inspection Departments on the 1st or 2nd floor are still to be discussed.

CHAPTER 6. SUMMARY AND RECOMMENDATIONS

6.1 Recommendations for Improving Design

This study investigated the functional layout of the hospital laboratory, the circulation organization, the physical environment, the work circulation of the inspectors, the needs of the comprehensive inspectors on the ward, compared the situation of the new and old laboratory, analyzed the shortcomings of the space design, and proposed the improvement strategy of the laboratory. The purpose of this research is to develop the space layout of the laboratory by comparing the situation of the old and new laboratory, to improve the work efficiency and work environment satisfaction of the inspectors.

This paper proposes a method combining practice and theory to study the old and new laboratory cases, and then use the space syntax theory to simulate the plan. This method shows the relationship between the spatial layout and humanization between the functional blocks of the laboratory. The comparative analysis found that some of the results are consistent with the theory and some are contradictory. The study showed common problems in the laboratory, and also partially revealed the problems and solutions after the hospital was rebuilt. In addition to spatial layout design, architects need to consider several other influencing factors, including the location and size of the building, financial budget, interior design and user psychology. The results will eventually be applied to the practice of laboratory design (Table 6.1).

Recommendations
1. The laboratory should be located at the entrance of the near-inspection department; for the clinical examination of the outpatient service, there should be a room for the specimen and a waiting area.
2. It is better to have a storage room in the laboratory. The room should face north, dry and well ventilated. The roof should be sheltered and insulated, the doors and windows should be reliable, the windows should be high, and the doors and windows should be equipped with sunshade.
3. The laboratory is separated from the external environment.
4. The light pollution area inside the inspection department should be separated from the substantial pollution area and the clean area.
5. There is at least one medical biochemical trash can in each area of the laboratory.
6. In order to facilitate the work circulation, there must be a direct link from the sample receiving center to each area of the laboratory.
7. The water mill floor is used in the laboratory and the design is easy to clean.
8. There is a sink in each area of the Laboratory.
9. Natural ventilation and lighting.
10. If there is free space, it is best to be a preparatory laboratory for future expansion of new projects or research.

Table 6.1 Design Recommendation Table

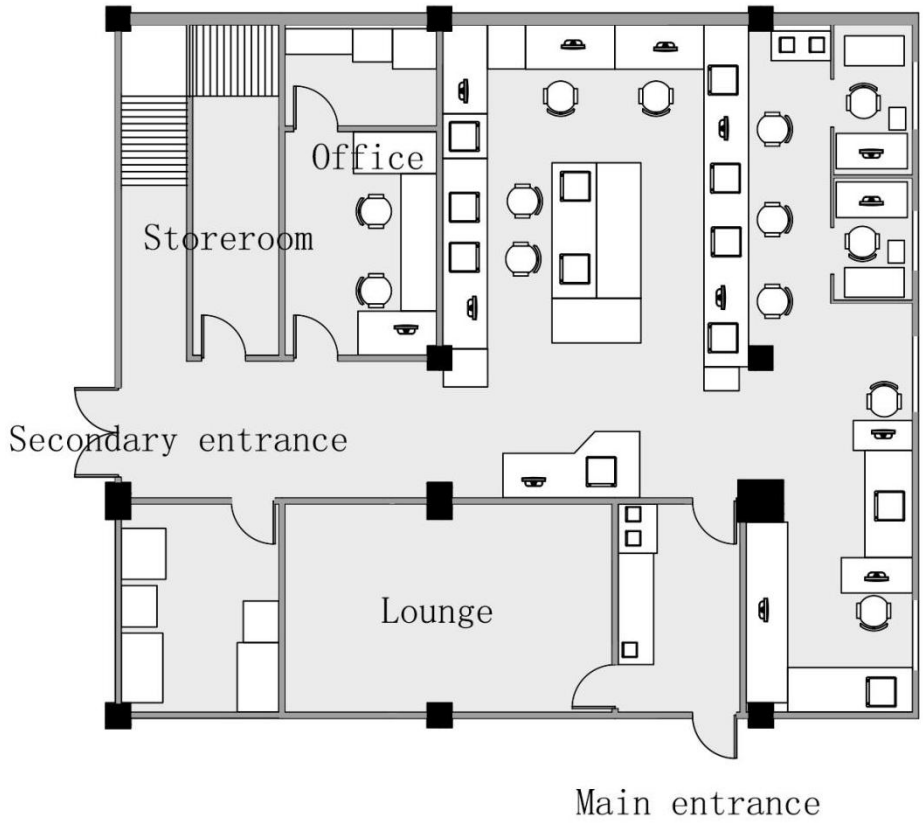


Figure 6.1 Second Post-designed Laboratory

Figure 6.1 is the final version drawn according to the characteristics of Shaoxing Hospital after a series of focus group discussions and analysis of simulation results. The design scheme covers the needs of inspectors, and has a certain plan for the future development of the laboratory. It can help inspectors to improve their work efficiency, and also improve the working environment of the laboratory. The improvement of other laboratory departments can obtain design ideas and suggestions from this design.

6.2 Significance of Improving the Clinical Laboratory

At present, the inspection department has introduced a large number of internationally advanced medical models and medical facilities, but its relatively backward design has also made it impossible for the laboratory

to exert its maximum benefits. Besides, some of the hospitals have been unable to meet the hospital departments after the reconstruction and expansion because of the reconstruction and expansion of the hospital, which has led to a series of problems. By investigating the situation of the laboratory and the needs of the inspectors, combined with a large number of relevant literature, the researcher proposed the recommendations for the humanized design of the modern laboratory and the targeted recommendations for the specialized laboratory.

The researcher simulated the laboratory and focused on the psychological impact of the inspectors to improve the laboratory environment. In this study, the spatial syntactic theory was used to test the rationality of the spatial environment. The space syntax theory uses spatial characteristics such as connectivity, integration, visual step depth, and visibility to analyze the three plans and create predictions. Using agent analysis simulates human activities behavior to understand space accessibility. After importing the project, the simulation analysis can be carried out through software, which is both cost-saving and scientific.

When designing the laboratory, one of the problems is the balancing of the various functional blocks in the laboratory, such as routine blood tests and blood coagulation tests, which need to be interrelated, but for different testing items, there are still differences between the two. The design usually needs to meet a variety of requirements and limit each other. With the development of the era, the requirements of the laboratory are continually changing. The initial design cannot meet the current needs, but the design and inspection department cannot over-consider the development and development. There is uncertainty, no one can clarify the road to its development, and if the future development is over-considered, it will easily cause the space to be idle and the resources to be wasted. Therefore, how to integrate the subsequent development

into the current design also puts new demands on the researcher, and the researcher need to balance the advantages and disadvantages.

6.3 Limitation of This Study

With the continuous advancement of science and technology, technology, information and digitalization are the inevitable trends in the development of the hospital laboratory. New developments put new demands on the development of laboratory building. With the change of medical model, the requirements of the engineering design of the laboratory are also towards complexity and change, the design of the laboratory should be continuously enriched and improved. At the same time, there are also deficiencies in this article, mainly in the following three aspects.

First，most of the working parameters and spatial, technical parameters in the article are from national and local standards, and these statistical compilations are a systematic project. One year's study does not collect all the information very well. At the same time, due to the health and safety requirements of the laboratory, hospitals require confidentiality of some relevant data, which brings some difficulties to the field research of this paper, and also the inadequacy of this paper.

The second limitation is the limited number of samples. Since the study time is limited to one year, this research is aimed at the reconstruction and expansion of a hospital, and each hospital has a certain degree of particularity. This study investigated a representative hospital for research and analyzed it using spatial syntactic theory. The analysis plan comes from the development of a hospital laboratory, based on the design of the original laboratory, which may result in a more targeted outcome. The layout of the inspection departments in different regions is different, and this design cannot give specific solutions. Future research will require

more time and place to optimize, and more samples may be more convincing. The small collection of interviews and focus group discussion data were also limiting factors in this study. A small amount of data may be because the inspectors are very busy; there are a large number of inspection samples that need to be inspected every day, so the data collected is relatively small. Communication between researcher and users is an essential part of understanding the needs of users (inspectors).

In addition, In this study, natural ventilation and indoor air quality were mentioned in both observations and focus group discussions. Optimal space height, window types and locations do affect effective natural ventilation and sufficient indoor air quality, but this research only mentions that these may affect natural ventilation and sufficient indoor air quality. It is also the preliminary stage of laboratory research, and there is not enough time to study these variable contents. In future research, researchers will study the specific effects of these variable factors on natural ventilation and indoor air quality on this basis.

The last point is that the type of plan discussed in the simulation design is also applicable to the inspection departments of different categories and levels, but the disadvantage is that the control at the height of the modular space has not been studied.

6.4Further Recommendations for Future Research

China is entering a period of rapid development in the construction of laboratory medicine, and the laboratory is also flourishing under the leadership of laboratory medicine. How to provide a pleasant working environment for the inspectors under the premise of satisfying the functional conditions, and providing a pleasant office atmosphere for the inspectors is the focus of the designers. However, many medical

institutions are currently facing the challenge of testing talent shortages. A large number of inspection talents go to first-tier cities, which leads to a shortage of inspection personnel in other cities. The main reason is that the work and research environment of the laboratory is not enough to meet the requirements. By improving the medical environment, inspections can be reduced. The work pressure of personnel, improve social satisfaction, lay the foundation for winning the talents of the laboratory, and at the same time create a healthy working environment. Architects need to analyze changes in the physical environment and use a theoretical framework to design a sound laboratory. They should also consider scale and cost constraints and carefully analyze the space to meet user goals and requirements.

Architects need to design the laboratory from a rational and human perspective. Because the personnel in the laboratory are relatively single, the architect should focus on the efficiency, safety and health of the inspectors, and should also meet the psychological needs of the inspectors. The medical environment was studied using the design theory of comparison between the front and the back. Based on spatial syntactic theory, the design of human behavior was verified and improved. Although the purpose of this study is to improve the laboratory environment by changing the space layout of laboratory, improving the efficiency of inspectors, how to improve the problems brought about by laboratory renovation is one of the objectives to be explored. The researcher speculated that in the future, the laboratory would use information technology, and the transportation of samples to the laboratory will be completed automatically. The medical staff will collect the test samples and use the automated transmission system. The electronic equipment will automatically analyze the samples according to the sample conditions so that the results will be exported. Architects should also seek

development and design in the direction of the Intelligent Inspection Division.

Appendix A： Research Ethics Checklist

University of Nottingham Ningbo

Research Ethics Checklist for

Undergraduate and Taught Masters Students

[strongly informed by the ESRC (2012) *Framework for Research Ethics*]

A checklist should be completed for **every** research project or thesis where the research involves the **participation of people**, **the use of secondary datasets or archives relating to people and/or access to field sites or animals**. It will be used to identify whether a full application for ethics approval needs to be submitted.

You must not begin data collection or approach potential research participants until you have completed this form, received ethical clearance, and submitted this form for retention with the appropriate administrative staff.

Completing the form includes providing brief details about yourself and the research in Sections 1 and 2 and ticking some boxes in Sections 3 and/or 4, 5, 6. **Ticking a shaded box in Sections 3, 4, 5 or 6 requires further action by the researcher**. Two things need to be stressed:

- Ticking one or more shaded boxes does **not** mean that you cannot conduct your research as currently anticipated; however, it does mean that further questions will need to be asked and addressed, further discussions will need to take place, and alternatives may need to be considered or additional actions undertaken.
- Avoiding the shaded boxes does **not** mean that ethical considerations can subsequently be 'forgotten'; on the contrary, research ethics - for everyone and in every project – should involve an ongoing process of reflection and debate.

The following checklist is a starting point for an ongoing process of reflection about the ethical issues concerning your study.

SECTION 1: THE RESEARCHER(S)

1.1: Name of principal researcher (in CAPITALS):LIU WENZHAO

1.2: Status: ☐ Undergraduate student

☒ Postgraduate taught student

1.3: School/Division: Faculty of Science and Engineering

1.4: Student ID number: 20122182

1.5: Degree programme: MRes program

1.6: Module name/number:

1.7: Email address: saxwl2@nottingham.edu.cn

1.8: Names of other project members (if applicable):

1.9: Name of supervisor for dissertations; module convenor or staff member for other research projects: Dr Jun Lu

	Yes	No
1.10: I have read the University of Nottingham Ningbo *Code of Research Conduct and Research Ethics*: http://www.nottingham.edu.cn/en/research/researchethics/unnc-research-code-of-conduct.aspx	☒	☐
1.11: (If applicable)I have read the University of Nottingham's *e-Ethics@Nottingham: Ethical Issues in Digitally Based Research* (2012) and agree to abide by it http://www.nottingham.edu.cn/en/research/documents/e-ethics-at-the-university-of-nottingham.pdf	☒	☐
1.12: When conducting research on people (Section 5) I will prepare both a *participant consent form* as well as an *information sheet*. I am aware that the following templates are available on the Ethics webpage: http://www.nottingham.edu.cn/en/research/researchethics/ethics-approval-process.aspx - Participant consent form 1 - Participant Information Sheet English and Chinese	☒	☐

SECTION 2: THE RESEARCH

2.1: Title of project:

Post-Occupancy Evaluation to Improve the Clinical Laboratory in a Tertiary Hospital in Shaoxing

Please provide brief details (50-150 words) about your proposed research, as indicated in each section

This study mainly aims at the hospital laboratory. Through this comparative study before and after the expansion of the laboratory of a tertiary hospitals in the city, it can help the clinical laboratory be designed with an optimised layout and size to accommodate medical staff activities safely and efficiently. This study can be better achieved by exploring the following questions:

1. What does a doctor do in the laboratory?

2. What is the order of operation when a doctor taking a blood test?

3. How are samples placed before sample processing?

4. How is the sample processed after the operation is completed?

5. What do doctors pay most attention to at work?

2.2: Research question(s) or aim(s)

1. Through space optimization to improve the spatial layout of the clinical laboratory, the circulation of work and the planning of traffic circulation
2. Through spatial re-planning to help the laboratory have a safe and efficient working environment.

2.3: Summary of Method(s) of data collection

1. Field observation: To be a marginal participant observation in clinical laboratory, to collect the date such as doctor's activities, the circulation of work and laboratory room layouts.

2. Focus groups: To discuss the advantages and disadvantages of the new and old laboratory with doctors and discuss the development direction of the future laboratory.

2.4: Proposed site(s) of data collection

Chinese Medicine Hospital Shangyu Shaoxing.

2.5: How will access to participants and/or sites be gained?

Get in touch with the department in advance, and get permission from doctors in the department.

SECTION 3: RESEARCH INVOLVING USE OF SECONDARY DATASETS OR ARCHIVES RELATING TO PEOPLE

If your research involves use of secondary datasets or archives relating to people all questions in Section 3 **must** be answered. If it does not, please tick the 'not relevant' box and go to Section 4.

NOT RELEVANT	☒

Please answer each question by ticking the appropriate box.

	Yes	No
3.1: Is the risk of disclosure of the identity of individuals low or non-existent in the use of this secondary data or archive?	☐	☐

3.2: Have you complied with the data access requirements of the supplier (where relevant), including any provisions relating to presumed consent and potential risk of disclosure of sensitive information?	☐	☐

SECTION 4: RESEARCH INVOLVING ACCESS TO FIELD SITES AND ANIMALS

If your research involves access to field sites and/or animals all questions in Section 4 **must** be answered. If it does not, please tick the 'not relevant' box and go to Section 5.

NOT RELEVANT	☐

Please answer each question by ticking the appropriate box.

	Yes	No
4.1: Has access been granted to the site?	☒	☐
4.2: Does the site have an official protective designation of any kind?	☐	☒
If yes, have the user guidelines of the body managing the site a) been accessed?	☒	☐
b) been integrated into the research methodology?	☒	☐
4.3: Will this research place the site, its associated wildlife and other people using the site at any greater physical risks than are experienced during normal site usage?	☐	☒
4.4: Will this research involve the collection of any materials from the site?	☐	☒
4.5: Will this research expose the researcher(s) to any significant risk of physical or emotional harm?	☐	☒
4.6: Will the research involve vertebrate animals (fish, birds, reptiles, amphibians, mammals) or the common octopus (*Octopus vulgaris*) in any capacity?	☐	☒
If yes, will the research with vertebrates or octopi involve handling or interfering with the animal in any way or involve any activity that may cause pain, suffering, distress or lasting harm to the animal?	☐	☒

SECTION 5: RESEARCH ON PEOPLE

If your research involves the participation of people all questions in Section 5 **must** be answered.

Please answer each question by ticking the appropriate box.

	Yes	No

5.1: Does the study involve participants age 16 or over who are unable to give informed consent? (e.g. people with cognitive impairment, learning disabilities, mental health conditions, physical or sensory impairments?	☐	☒
5.2: Does the research involve other vulnerable groups such as children (**aged under 16**) or those in unequal relationships with the researcher? (e.g. your own students)	☐	☒
5.3: Will this research require the cooperation of a gatekeeper* for initial access to the groups or individuals to be recruited?	☒	☐
5.4: Will this research involve discussion of sensitive topics (e.g. sexual activity, drug use, physical or mental health)?	☐	☒
5.5: Could the study induce psychological stress or anxiety or cause harm or negative consequences beyond the risks encountered in normal life?	☐	☒
5.6: Are drugs, placebos or other substances (e.g. food substances, vitamins) to be administered to the study participants or will the study involve invasive, intrusive or potentially harmful procedures of any kind?	☐	☒
5.7: Will this research involve people taking part in the study without their knowledge and consent at the time?	☐	☒
5.8: Does this research involve the internet or other visual/vocal methods where people may be identified?	☐	☒
5.9: Will this research involve access to personal information about identifiable individuals without their knowledge or consent?	☐	☒
5.10: Does the research involve recruiting members of the public as researchers (participant research)?	☐	☒
5.11: Will the research involve administrative or secure data that requires permission from the appropriate authorities before use?	☐	☒
5.12: Is there a possibility that the safety of **the researcher** may be in question?	☐	☒
5.13: Will financial inducements (other than reasonable expenses and compensation for time) be offered to participants?	☐	☒

**Gatekeeper- a person who controls or facilitates access to the participants*

B. Before starting data collection

	Yes	**No**
6.12: My full identity will be revealed to all research participants.	☒	☐
6.13: All participants will be given accurate information about the nature of the research and the purposes to which the data will be put. (*An example of a Participant Information Sheet is available for you to amend and use* at xxxxx) *http://www.nottingham.edu.cn/en/research/documents/participant-information-sheet-in-english-and-chinese.doc*	☒	☐

6.14: All participants will freely consent to take part, and, where appropriate, this will be confirmed by use of a consent form. (An example of a Consent Form is available for you to amend and use at: http://www.nottingham.edu.cn/en/research/researchethics/ethics-approval-process.aspx)	☒	☐
6.15: All participants will freely consent to take part, but due to the qualitative nature of the research a formal consent form is either not feasible or is undesirable and alternative means of recording consent are proposed.	☐	☒
6.16: A signed copy of the consent form or (where appropriate) an alternative record of evidence of consent will be held by the researcher.	☒	☐
6.17: It will be made clear that declining to participate will have no negative consequences for the individual.	☒	☐
6.18: Participants will be asked for permission for quotations (from data) to be used in research outputs where this is intended.	☒	☐
6.19: I will inform participants how long the data collected from them will be kept.	☒	☐
6.20: Incentives (other than basic expenses) will be offered to potential participants as an inducement to participate in the research. (Here any incentives include cash payments and non-cash items such as vouchers and book tokens.)	☐	☒
6.21: For research conducted within, or concerning, organisations (e.g. universities, schools, hospitals, care homes, etc) I will gain authorisation in advance from an appropriate committee or individual.	☒	☐

C. During the process of data collection

	Yes	No
6.25: I will provide participants with my University contact details, and those of my supervisor, so that they may get in touch about any aspect of the research if they wish to do so.	☒	☐
6.26: Participants will be guaranteed anonymity only insofar as they do not disclose any illegal activities.	☒	☐
6.27: Anonymity will not be guaranteed where there is disclosure or evidence of significant harm, abuse, neglect or danger to participants or to others.	☒	☐
6.28: All participants will be free to withdraw from the study at any time, including withdrawing data following its collection.	☒	☐
6.29: Data collection will take place only in public and/or professional spaces (e.g. in a work setting	☒	☐
6.30: Research participants will be informed when observations and/or recording is taking place.	☒	☐
6.31: Participants will be treated with dignity and respect at all times.	☒	☐

D. After collection of data

	Yes	No
6.32: Where anonymity has been agreed with the participant, data will be anonymised as soon as possible after collection.	☒	☐

6.33: All data collected will be stored in accordance with the requirements of the University's Code of Research Conduct	☒	☐
6.34: Data will only be used for the purposes outlined within the participant information sheet and the agreed terms of consent.	☒	☐
6.35: Details which could identify individual participants will not be disclosed to anyone other than the researcher, their supervisor and (if necessary) the Research Ethics Panel and external examiners without participants' explicit consent.	☒	☐

E. After completion of research

	Yes	No
6.37: Participants will be given the opportunity to know about the overall research findings.	☒	☐
6.38: All hard copies of data collection tools and data which enable the identification of individual participants will be destroyed.	☒	☐

SECTION 7: ETHICAL APPROVAL

(Complete either Part A or part B)

Part A

Student's declaration of ethical research

If you did NOT tick any of the shaded boxes *in Sections 3, 4, 5 and 6 of this form*, please sign and date below **and** get the checklist countersigned (see below).

Students must submit the authorised checklist along with their assessed work to the Module Convenor or Supervisor.

*Dissertation students **must** include the checklist, previously signed and authorised by their supervisor, as an appendix when they submit their dissertation proposal. Please keep one copy of this form for your personal records.*

By signing this form you are agreeing to work within the protocol which you have outlined and to abide by the University of Nottingham Ningbo's Code of Research Conduct and Research Ethics. If you make changes to your research protocol (such as changes to methods of data collection, the proposed sites of data collection, the means by which participants are accessed) which in turn would change your answers to any of the above questions then you **must** complete a new form and submit a copy to your supervisor/tutor. Once approved this should be lodged with the School Office.

Signed 刘文剑 Date .....8th March 2019.....

Staff Authorisation (by supervisor for dissertations; module convenor or staff member for other research projects)

Having reviewed the ethical issues arising from the proposed research:

- ☒ I consider this to be a minimum-risk study and confirm the research can go ahead as planned.
- ☐ I have requested that changes be made to the research protocol. (The researcher must complete and submit a revised form which integrates these changes.)
- ☐ This project must be referred on to the Research Ethics Panel for more detailed ethical scrutiny. (Please forward a hard copy to the School's Research Ethics Officer.)

Signed .... Date .....19/03/2019.....

Designation .....Jun Lu (supervisor).....

Please note: **any** research protocols lodged with the School Office may be subject to review by the School's Research Ethics Panel.

Part B

If you ticked any of the shaded boxes in sections 3, 4, 5 or 6 of this form, then you must complete SECTION 7b (below). You must then discuss all ethical issues arising, record the outcome and have this form countersigned by a member of staff (see below).

SECTION 7b: FURTHER INFORMATION & JUSTIFICATION OF METHODOLOGY

One box should be completed for **each** shaded box ticked in sections 3, 4, 5 or 6 of this form.

Ethical issue:

5.3: This research will require the cooperation of a gatekeeper for initial access to the participating groups.

Rationale for chosen methodology and/or how ethical issue is to be addressed:

The project will use the observation method to look at the complex activities of the doctors, the equipment used and the environment in Clinical laboratory department. The benefits of the study to the doctors will be realised through the provision of more efficient and safe clinical environments which will be designed with up-to-date research based on current clinical practice.

The project will also use the focus group method to compare and discuss the situation before and after the expansion of the laboratory. The main direction is to draw the advantages and disadvantages of the laboratory before and after the expansion, as well as the staff's recommendations and expectations for the laboratory.

The primary subjects for the study are the doctors at the Clinical laboratory department in hospital in Shaoxing. Preliminary discussions about the recruitment will be held with Dr Feng Xu (who is in charge of the department, as the gatekeeper at Shaoxing Shangyu Chinese Medicine Hospital.) The researcher will then approach the doctors and invite them to participate in the project. All the doctors will be given an information sheet and asked to sign a consent form. If they decline, they will be excluded from the study.

Supervisor's/staff member's response (including whether ethical issue has been satisfactorily addressed):

I have discussed with the researcher on the issues carefully. I believe the justification and arrangements will be able to satisfactorily address the issue.

Jun Lu (supervisor)

Student's declaration of ethical research

If you ticked any of the shaded boxes *in Sections 3, 4, 5 and 6 of this form*, you should have completed Section 7b after discussion of the ethical issues with your module convenor or supervisor. Then please sign and date below **and** get the checklist countersigned by your module convenor or supervisor (see below).

Students must submit the authorised checklist, along with their work to be assessed, to the Faculty Office.

Dissertation students **must** include the checklist, previously signed and authorised by their supervisor, as an appendix when they submit their dissertation proposal. Please keep one copy of this form for your personal records.

By signing this form you are agreeing to work within the protocol which you have outlined and to abide by the University of Nottingham's Code of Research Conduct and Research Ethics. If you make changes to your research protocol (such as changes to methods of data collection, the proposed sites of data collection, the means by which participants are accessed) which in turn would change your answers to any of the above questions then you **must** complete a new form and submit a copy to your supervisor/tutor. Once approved this should be lodged with the School Office.

Signed ..... Date .....

Staff Authorisation (by supervisor for dissertations; module convenor or staff member for other research projects)

This section **must** be completed in **all** cases where additional information has been provided in Section 7b. It is also helpful for the project supervisor to comment on the further information provided by the student in Section 7b.

Please note that **all projects involving vulnerable groups or the study of illegal activities** should be referred on to the School Research Ethics Panel.

Having reviewed the ethical issues arising from the proposed research:

- ☒ I consider this to be a minimum risk study and confirm the research can go ahead as planned.
- ☐ I have requested that changes be made to the research protocol. (The researcher must complete and submit a revised form which integrates these changes.)
- ☐ This project must be referred on to the Research Ethics Panel for more detailed ethical scrutiny. (Please forward a hard copy to the School's Research Ethics Officer.)

Signed ..... Date .....19/03/2019.....

Designation .....Jun Lu (supervisor).....

Please note: **any** research protocols lodged with the School Office may be subject to review by the School's Research Ethics Panel.

The School Research Ethics Panel

- ☒ agrees that the research can go ahead as planned
- ☐ requests further information on the research protocol (see details below)
- ☐ requests amendments to the research protocol (see details below)

School REC ..... Date 4/4/2019

4/4/2019

Appendix B：Participant Information Sheet

Participant Information Sheet

Post-Occupancy Evaluation to Improve the Clinical Laboratory in a Tertiary Hospital in Shaoxing

Dear Participant,

Thank you for agreeing to participate in this field observation survey in connection with my Master degree at the University of Nottingham Ningbo. The project is a study of Post-Occupancy Evaluation to Improve the Clinical Laboratory in a Tertiary Hospital in Shaoxing.

Your participation in the survey is voluntary. You are able to withdraw from the survey at any time and to request that the information you have provided is not used in the project. Any information provided will be confidential. Your identity will not be disclosed in any use of the information you have supplied during the survey.

The research project has been reviewed according to the ethical review processes in place in the University of Nottingham Ningbo. These processes are governed by the University's Code of Research Conduct and Research Ethics. Should you have any question now or in the future, please contact me or my supervisor. Should you have concerns related to my conduct of the survey or research ethics, please contact my supervisor or the University's Ethics Committee.

Yours truly,

<insert name>

Contact details:

Student Researcher: Wenzhao Liu（wenzhao.liu@nottingham.edu.cn)
Supervisor: Jun Lu (jun.lu@nottingham.edu.cn)

University Research Ethics Committee Coordinator, Ms Joanna Huang

(Joanna.Huang@nottingham.edu.cn)

声明

论文题目：绍兴某医院检验科空间功能使用前后综合评估

尊敬的参与者：

谢谢您参与这次实地观测调查。这次调查是我在宁波英国诺丁汉大学研究生论文相联系的。研究题目是绍兴某医院临床检验科空间功能使用后综合评估。

您是自愿参与此次实地观测调查的。您可以在任何时候选择放弃这次的实地观测调查，并要求您提供的信息不被使用在此次调查中。您提供的所有信息都是保密的。在使用您提供的信息时不会涉及您的身份以及个人信息。

宁波诺丁汉大学已根据研究道德检查程序对这项研究项目进行检查。这一程序是在学校关于研究行为和研究道德的行为标准的指导下进行的。如果您现在或将来有任何疑问，请联系本人或我的导师。如果您对我在问卷中的研究行为或研究道德有任何质疑，请联系我的导师或者英国诺丁汉大学的道德委员会。

联系方式：
研究员：刘文钊（wenzhao.liu@nottingham.edu.cn)
导师： Jun Lu (jun.lu@nottingham.edu.cn)

诺丁汉大学研究道德委员会秘书：Ms Joanna Huang
(Joanna.Huang@nottingham.edu.cn)

Appendix C： Participant consent form

PARTICIPANT CONSENT FORM

Project title Post-Occupancy Evaluation to Improve the Clinical Laboratory in a Tertiary Hospital in Shaoxing

Researcher's name Wenzhao Liu

Supervisor's name Jun Lu

- I have read the Participant Information Sheet and the nature and purpose of the research project has been explained to me. I understand and agree to take part.
- I understand the purpose of the research project and my involvement in it.
- I understand that I may withdraw from the research project at any stage and that this will not affect my status now or in the future.
- I understand that while information gained during the study may be published, I will not be identified and my personal results will remain confidential.
- I understand that the data collection will be recorded.
- I understand that data will be stored in accordance with data protection laws.
- I understand that I may contact the researcher or supervisor if I require more information about the research, and that I may contact the Research Ethics Sub-Committee of the University of Nottingham, Ningbo if I wish to make a complaint related to my involvement in the research.

Signed …… (participant)

Print name ……**Date** ……

Contact details

Researcher: Wenzhao Liu（wenzhao.liu@nottingham.edu.cn)

Supervisor: Jun Lu(jun.lu@nottingham.edu.cn)

UNNC Research Ethics Sub-Committee Coordinator:

Joanna.Huang@nottingham.edu.cn

参与者同意书

项目标题　绍兴某医院检验科空间功能使用前后综合评估

研究者姓名　刘文钊

导师姓名　Jun Lu

- 本人已阅读声明，项目组织者已经我解释了研究项目的性质和宗旨。本人理解并同意参与。
- 本人理解项目的和在项目中的参与作用。
- 本人明白可以在研究项目的任何阶段退出，不会因此影响现在以及将来的状况
- 本人明白研究过程中信息可能会被公开，但本人身份不会被确认，个人的调查结果始终是被保密。
- 本人知道面谈/数据采集将会被录音
- 本人了解数据会根据数据保护相关法律进行存储
- 本人知道，如果需要进一步有关研究的信息可以联系研究者或者导师，如果需要对参与研究提出投诉则可以联系宁波诺丁汉大学科研伦理小组委员会。

参与者签名.....

日期.....

联系方式

研究者：刘文钊（wenzhao.liu@nottingham.edu.cn)
导师：　Jun Lu(jun.lu@nottingham.edu.cn)
诺丁汉大学研究道德委员会秘书：　MsJoanna　Huang (Joanna.Huang@nottingham.edu.cn)

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