Evidence-Based Spatial Design to Improve Clinical Staff Efficiency in Obstetrical Nursing Units: Three Case Studies in Anhui Province, China

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Submitted in September 2018, in partial fulfillment of the
conditions of the award of the degree MRes
in Sustainable Building Technology

ACKNOWLEDGEMENTS

I benefited from UNNC's one-year postgraduate study. I would like to thank the graduate school for training. Not only did I get professional guidance in academic research, but I also got help on other skills. This paper was successfully completed under the guidance and support of different people. I take this opportunity to acknowledge these contributions and express my appreciation.

I would like to extend my gratitude to my supervisor, Dr. Jun LU. From the beginning of the thesis topic, draw up proposal, research methods, questionnaire design, data collection and analysis, until the final revision of the final draft, the supervisor was to guide and help me seriously. She was deeply touched by her academic rigorous attitude and her serious and responsible work. She taught me to learn to manage my own time and independent learning ability. Thanks to the supervisor for dialing many times and even painstakingly modifying the paper for me.

I would also like to acknowledge the contributions of clinical staff of all three hospitals surveyed for their support. Because their help that I was able to successfully observe and collect available data and valuable opinions from staff. Finally, I would also like to thank my family for all their encouragement and support throughout my entire graduate career. Thanks to the enthusiasm of my classmates. I thank their all for joining me in a life of graduate students full of happiness and passion.

At the end of the paper, allow me to extend my heartfelt thanks to all of you who have enthusiastically supported and encouraged me. Thank you very much for your help and concern.

ABSTRACT

A growing number of people are beginning to pay attention to the healthcare environment design, not only to meet the needs of treating patients, but also to consider the psychological demands of clinical staff. Patient safety and quality of care all depend on creating an efficient and effective working environment for clinical staff. In China, some obstetric designs have prevented the space and rooms from reaching its maximum efficiency. In addition, some imperfect functions have reduced staff efficiency and causing social dissatisfaction. Relatively few studies have investigated the impact of the physical environment on staff.

The study focused on the effect of the design of obstetrical nursing units on clinical staff efficiency to develop a high-quality and efficient healing environment. It presented a method that combined practical and theoretical to the investigation of the spatial and social attributes of obstetrical nursing units. Evidence-based design theory was used to investigate obstetrics in three hospitals including corridors, nurse stations, wards and physical environment, and interviews and questionnaires were also conducted to understand the needs of clinical staff. The layouts of nursing unit were simulated by measuring the spatial properties of the three floor plans based on space syntax theory. A comparative analysis of the results found that hospital design often needs to balance multiple constraints, for example, the balance between improving the efficiency of staff and protecting the patient privacy. The study proposed improvement recommendations for nursing units, and the methods that can be applied to environmental and behavioral studies in other researches. In addition to spatial layout design, architects need to consider other influencing factors, including the location and scale of the building, economic budget, and users' psychology.

Keywords: Evidence-based design, Healthcare design, Obstetrics, Space Syntax, Spatial design

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NOMENCLATURE

BUDSET	Birth Unit Design Spatial Evaluation Tool
DH	Department of Health
EBD	Evidence-based design
EWEC	Every Woman Every Child
FCMC	Family Centered Medical Care
GH	General Hospitals
ICU	Intensive Care Unit
LpCp	Listening to people to Cure people
MCHH	Maternal and Child Health Hospital
SHCC	Sindh Health Care Commission
VGA	Visibility Graph Analysis
WHO	Word Health Organization

CHAPTER I. INTRODUCTION

1.1 Research Background

1.1.1 Relevant Policy Guidelines

In the new global health, pregnant women health has become a widespread concern of all sectors of society. ‘By leaving no one behind when it comes to health’. On 2018 International Women's Day, Word Health Organization (WHO) called for every girl and woman in the world have access to quality and affordable health care, treated and respected as equals. Policy strategies establish goal care standards for improving quality of healthy pregnant women in healthcare facilities (Perloff, 1992; WHO, 2016, 2018a). Department of Health (DH) from the UK proposes policies that call for women-centred, user-friendly services that provide choice and continuity of care (DH, 2013).

Every Woman Every Child (EWEC) Global Strategy (2016-2030) aims at improving health and achieving prosperity and sustainable development, which is for Women's, Children's, and Adolescent's Health (EWEC, 2015).With the full implementation of China’s two-child policy, the government actively encourages and guides social forces to develop healthcare facilities based on the ‘Opinions of the CPC Central Committee and the State Council on Deepening the Reform of the Medical and Health System’. Since the latter half of the 1980s, the state and federal government provided substantial public funds to the support of maternal and child health in America (Hill, 1992). Therefore, pregnant women health is a growing public health concern worldwide.

1.1.2 The Status Quo of Obstetrics

The design of Chinese hospitals is influenced by factors such as ideological concepts, economic conditions, history and culture, and most of them only meet the basic requirements for use. Contemporary developed countries rationally develop hospital buildings based on evidence-based design concepts. There is a significant gap in quantity and quality of hospital construction design in China. Healthcare facilities cannot meet people's needs for a quality healthcare environment under current economic and social development (Hao, 2012).

Obstetrics unit is one of the most specialized nursing units, which is dedicated to the care of pregnant women. With the improvement in the quality of living standards, the design requirements of the obstetrics unit becomes increasing and the non-hospital atmosphere of humanization and family-oriented service are emphasized (Kobus, 2008). Patient-centered care has played an important role in the unit (Pope, Graham, & Patel, 2001). About 830 women die every day from pregnancy or related complications worldwide. Women can avoid the risk through high quality care during pregnancy and during childbirth (WHO, 2018b).Women's health depends on not only the healthcare technology but also on the healthcare environment, which combines social and cultural factors(Simoes, Brucker, Krämer, &Wallwiener, 2015).

The design of unit has put great impact on healthcare, environmental and psychological factors also affect staff efficiency. For example, the layout of the plan was complicated, and the space was not easily accessible. The layout of the ward was unreasonable and did not provide relations with the necessary rest space. The mixed flow of patient, staff, and visitor leads to a large traffic flow in the unit, which was likely to cause congestion. The layout design lacks a single channel for clinical staff(Xian, 2015). Moreover, ignoring clinical staff' needs and their physical and mental health in hospital designs may negatively affect staff efficiency and result in some defective social impact.

1.1.3 The Future Challenges of Obstetrical Nursing units

Healthcare facilities today have not been able to fully realize their potential for spatial high efficiency and often cause inefficiency (Fitzpatrick, 2003).The layout of nursing units affects the behavior of staff, especially walking and communication, and the quality of care of patients. The nursing units are generally composed of wards, medical rooms and nurse stations. In the past most units were built using a traditional centralized model, which features a large centralized nurse station. The new design recently proposed has achieved a decentralized model, which is characterized by the fact that the nurse station is distributed among the wards (Gurascio-Howard & Malloch, 2007). However, there are few qualitative researches on staff views on the design of nursing units and their influence on the communication of nursing teams. Future challenges require further identification of knowledge shortages in these healthcare designs. Nursing units have been improved to reduce staff error and stress in the work environment and to achieve higher levels of social support.

Obstetrics is faced with many challenges, not only in clinical needs of clinical innovation, but also in sociology, psychology, architecture in many areas have been concerned about improving the patient's treatment environment for humane medicine (Simoes et al., 2015). Because of the Two-child policy in China, several older women attempting to have children is increasing, which caused the risk of pregnancy-related complications higher(Li & Deng, 2017; Zhang, Zhao, & Wang, 2018). The Obstetrical design is also facing new challenges, for example, assessing how the space to be used more effectively and addressing the needs of patients, visitors and staff during the design process (Schaumann, Pilosof, Date, &Kalay, 2016). Exploring solutions strategies to address these challenges should therefore be urgently pursued (Li

& Deng, 2017).

1.2 Research Aim and Objectives

1.2.1 Research Aim

The project was to improve the clinical staff efficiency by identifying issues of inefficiency in nursing work processes, to develop a high-quality and efficient healing environment. The study investigated the spatial layout of obstetrical nursing units through Evidence-Based design of healthcare space, the assessment and improvement of existing facilities to create a safe and humanistic physical environment. The outcome will eventually be applied to the practice of space design.

1.2.2 Research Objectives

- To develop evidence-based design guiding framework for the obstetrical nursing units.
- To identify the needs of the clinical staff experience during the stay and develop for staff.
- To promote staff efficiency and avoid the increasing risk of staff errors by improving the spatial layout.

1.3 Research Questions

Pursuant to the research aim, the following questions are explored.

1. Where are the main problems relating to the staff efficiency in obstetrics?

2. What are the needs of the clinical staff for the work environment?

3. What physical improvement can be made to enhance the space design to improve staff efficiency in obstetrics? (layout of space/ ward)

1.4 Research Framework

The focus of the study is the spatial layout of nursing units on the staff efficiency. Through literature review, field research and questionnaire surveys, the study on obstetrical space has revealed the related recommendations to improve staff efficiency (Figure 1.1).The research was divided into four parts: 1) through the literature review and combing the relevant theories involved in the design of healthcare facilities; 2) identification of the current problems in obstetrics through the field investigations;3) analysis and verification of the data through software simulation; 4) summary of the main results on the space design of the nursing units.

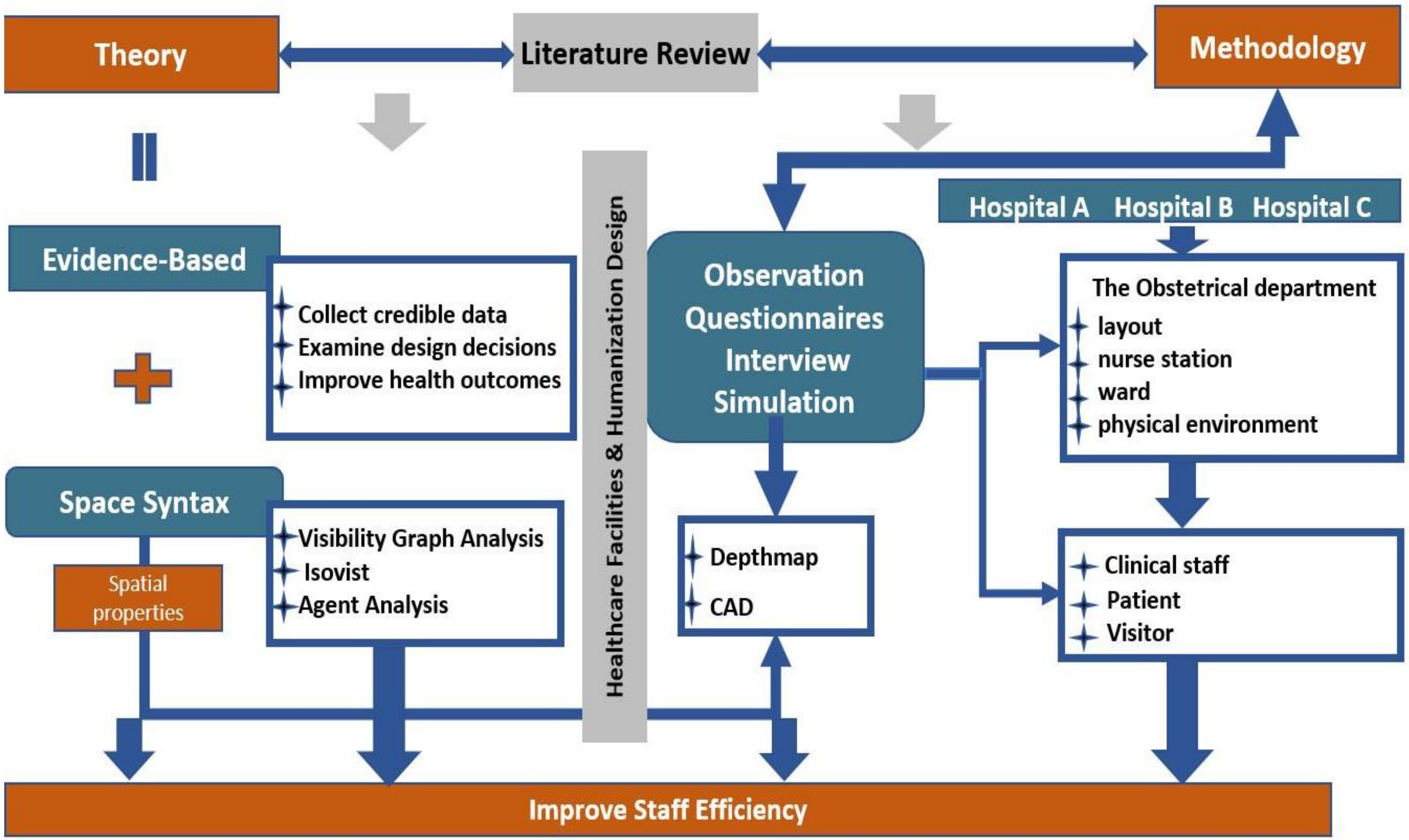


Figure 1.1 Research Framework.

CHAPTERⅡ. LITERATURE REVIEW

2.1 Evidence-based Design in Healthcare Facilities

Evidence-based design (EBD) has grown rapidly and applied widely to healthcare in recent years (Ulrich et al., 2008). The concept of EBD is a process used by search for evidence to achieve available information and applied in practice (McCullough, Sigma Theta Tau, & ebrary, 2010; Trochelman, Albert, Spence, Murray, &Slifcak, 2012). EBD not only provides high-quality treatment for patients and families in the healthcare field, but also applies to healthcare facilities design, which can help architects collect credible data to build a bridge between design and hospital (Hamilton, FAIA, & FACHA, 2003). Using research findings to examine design decisions can improve the quality of care and the physical environment and provide a certain amount of evidence for the design (Becker, Bonaiuto, Bilotta, &Bonnes, 2011; McCullough et al., 2010).

Numerous healthcare studies have attempted to explain how EBD affects the health outcomes of the environment, and how it affects the quality and safety of care (Djukic&Marić, 2017; McCullough et al., 2010; Trochelman et al., 2012). In an investigation into hospitalized patients and their families, Trochelman et al. (2012) found physical environment influences patients' satisfaction and staffs' quality of care, how to assessment of healthcare providers and systems by EBD to address the need of users should be advocated. Ulrich et al. (2008) reviewed that the design of hospital physical environment links to healthcare outcomes with literature in 2004.The article analyzes patient safety, patient outcomes, and employee outcomes, and concludes several design strategies that can influence health outcomes through evidence. The study covered a wide range of recommendations from a wide range of industries, including executives, architects and other stakeholders. The patient room, with standardized and repetitive features, is the most common space in the healthcare facilities, where patients spend most of their time and receive treatment for recovery. The critical situations and efficiencies of real room or unit testing are simulated to create a patient-centered and family-friendly ward based on EBD theory. The simulation can reduce unnecessary costs in large scale construction (McCullough et al., 2010). EBD plays an important role in making the hospital safer, is better able to cure patients, and better create a working environment (Djukic&Marić, 2017; Huisman, Morales, van Hoof, &Kort, 2012).

Although EBD can improve patient care and medical outcomes and is widely used in healthcare facilities research, some studies have been found to be defective. Some architects worried EBD could result in regulation and limitation of creativity and ignore the challenges of new possibilities in design(Hamilton et al., 2003). EBD cannot be described as a complete discipline currently. It can provide better design suggestions for architects, but does not guarantee gaining better outcomes because the standardized strategies may not be applied to all facilities at the same time (McCullough et al., 2010). Rashid (2013) stressed the gap between design research and practise, the limitation on EBD for knowledge categorization and acquisition. He discussed how to overcome the limitation which encouraged a direct expansion of the experimental type of empirical knowledge and is more inclusive in his research design approaches. However, the main weakness of the study is the failure to address how to build the specific knowledge mechanisms in the different fields and what the way is to gain experimental knowledge across fields.

The design of healthcare facilities which is a complex and multivariate challenge, should consider medical, technical and social issues at the same time(Hicks, McGovern, Prior, & Smith, 2015). In a recent study conducted by Hamed, El-Bassiouny, and Ternès (2017), it was shown that achieving patient well-being and sustainable healthcare services need to focus on the aspects of plants, patient safety, and single rooms. Other aspect, a skillful wayfinding system is also important. The EBD research process also needs to be performed during obstetric design (Huisman et al., 2012). It is important to adopt EBD to improve the obstetrical outcomes, diminish the psychological discontent of patients and the impression of anxiety (Djukic&Marić, 2017).

2.2 Obstetrics Unit Overview

2.2.1 Introduction of Obstetrics Design

With the improvement of people's living standard, obstetrics unit moved toward becoming patient-centered medical homes, and the demand for providing comprehensive behavioral healthcare is growing (Poleshuck& Woods, 2014). Sindh Health Care Commission (SHCC) described that the Obstetric unit provides safe prenatal care, delivery and post-natal care for mothers and their babies. The number of wards and the size of the relevant service areas should meet obstetrics workload requirements according to the Operational Policy(SHCC, 2014). DH said that each environment should be designed to meet the needs of the family and staff. The goal is to provide safe care for mothers and babies in a comfortable situation, to provide a relaxing environment to promote normal physiological processes, to achieve privacy protection, self-management and enhance family enjoyment (DH, 2013).The Obstetric unit consists of six functional areas (Table 2.1). The relationships of functional areas are shown in Figure 2.1.

Table 2.1 The description of functional areas in Obstetrics (SHCC, 2014).

Areas	Functions
Reception area	·use for the registration of pregnant women ·provide a certain waiting space
Inpatient area	·meet the needs of prenatal and post-partum patient Note: The number of beds ultimately depend on the specific conditions of service (patient demographics, operating policies, and cultural issues).
Birthing area	Assessment, labor, delivery (with/without intervention), bonding between mother and child, resting and recovery, and finally transfer to inpatient ward or discharge
Nursery area	The general care nursery provides general care for healthy babies. Note: Practise 'rooming-in' allowing mothers and infants to remain together – 24 hours a day in China.
Shared support and staff area	·share spaces, support equipment ·provide support and waiting areas between different areas ·educational space can be shared with other units Note: The size should increase proportionally.
Operating rooms and support facilities	If provided in obstetrics, the operating room and supporting room should have complete facilities Note: The time from the birthing area to the operating room ideally should not be more than three minutes. Assessing the distance between the delivery area and the delivery area. The operating room should consider the average travel speed and whether it involves lifts.

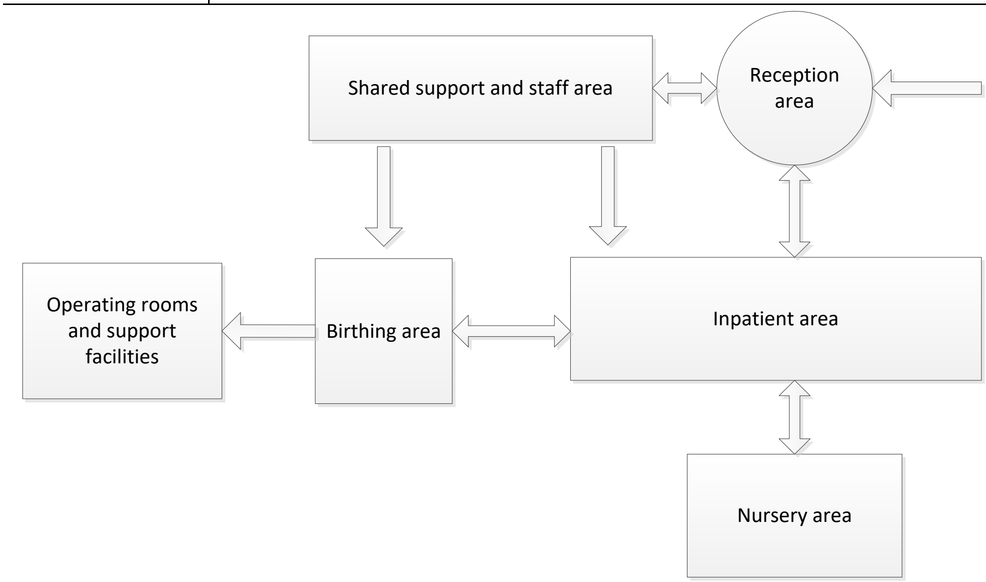


Figure 2.1 The relationships of functional areas in Obstetrics.

Obstetrical unit design should comply with standards and associated requirements. The SHCC Guidelines are briefing, design and approval for healthcare facilities. It mentions that traffic of the obstetric unit should prohibit non-related traffic through the unit. An Intensive Care facility is better to be provided for obstetric use (SHCC, 2014). China Standard ″Architectural and design code for general hospital″ introduced briefly the obstetric unit and its environmental control measure based on our national conditions. For example, the arrangement of the beds should be parallel to the single row of the wall of the lighting window, generally no more than 3 beds, and in special cases, no more than 4 beds. Some of the current obstetric unit design standards and associated requirements are shown in Table 2.2.

Table2.2 The current Obstetrics unit design standards and associated requirements(SHCC, 2014).

Items		Standards and Associated Requirements
Environmental Considerations	Natural Light	All patient rooms (mothers and babies) must have natural light.
	Privacy	Direct views into the room from the outside, both through the windows and through the door should be avoid.
	Acoustics	Sound absorption and insulation techniques should be applied
Space Standards and Components	Doors	Appropriately sized and located doors shall be provided for emergency bed transfer to the Birthing or Operating Units.
	Ergonomics	The net width of the door of the ward shall not be less than 1.10m, and the windows and doors shall be provided with observation windows.
Safety and Security		The number of access points to the unit should be minimized and all entry points should also be controlled through an Access Control System.
Finishes		The ward should create a homely, non-clinical ambience, and colors should be chosen carefully to avoid an adverse impact on the skin color of patients and neonates, particularly of jaundiced babies.
Building Service Requirements	Lighting	All High Dependency Care areas such as birthing suites, birthing/assessment rooms, nurseries and areas for the examination/resuscitation and bathing of babies are to have dimmable color-corrected lighting.
	HVAC	The birthing rooms and nurseries should be serviced by individual HVAC systems. The temperature control devices should be located within the room and should only be accessible to the staff.
	Communications	Annunciator panels should be in strategic points within the hospital circulation area and should be of the “non-scrolling” type, allowing all calls to be displayed at the same time.
Infection Control		Each birthing room should have a scrub basin. Each patient room should have a hand basin. Each pair of isolation rooms should have a hand basin outside.

There are certain risk factors for female childbirth, and the design may play a role in helping or hindering the care of women. Design needs to achieve spatial flexibility and adapt to changing patient needs, as well as to promote the sharing of knowledge and workload of staff to provide an efficient working model. The obstetrical units provide safe prenatal care, delivery and post-natal care for mothers and their babies. The number of wards and the size of the relevant service area should meet obstetric workload requirements according to the prescribed policies. In this innovative qualitative study of developing the birth unit design spatial evaluation tool, Foureur et al. (2010) showed how to improve experiences and outcomes for pregnant women and build an optimized birth space. Kobus (2008) provided a detailed introduction to the obstetrical unit and considered key issues of user satisfaction, including function, service location, operational considerations, patient and work flow, and relationships with other departments. In the past decade, the obstetrical model was gradually transformed from LDRP (Labor/ Delivery/ Recovery/ Post-partum) to more flexible LDR (Labor/ Delivery/ Recovery) model. The benefit of this change was the flexibility to use the wards.

Since previous research in obstetrical space has focused on investigating the impact of interior design on patient experience and satisfaction, few attention has been paid to the impact of the design of nursing units or birthing units on clinical staff and clinical care processes (Hauck, Rivers, & Doherty, 2008;

Hodnett, Stremler, Weston, & McKeever, 2009).MASS. (2017) design group understands how design affects clinical processes, decisions and outcomes during childbirth. The team analyzed the floor plans of twelve different fertility facilities in the United States, from the smallest number of patients to the largest number of patients in the country. The survey revealed some striking relationships between the many design elements of the birth space and the care provided. The goal was to develop guidelines for designers to provide optimal care during childbirth.

2.2.2 The Situation of Obstetrics Design in China

Obstetrics unit is a special part of a hospital. As the living standards of materials have been continuously enhanced, many maternal hospitals have put forward higher requirements for the comprehensive environment, service quality, and professional level of pregnant women. More people want to pass through the most critical and most dangerous period of life in a beneficial hospital environment. In China, over 60% of women deliver in healthcare facilities(Qian, Smith, Zhou, Liang, & Garner, 2001). Over the past few years, Chinese hospitals have been aiming to improve the quality of hospital care. However, mechanisms to encourage humane and women-friendly evidence-based obstetric care have not been widely discussed in China. Xue and Chen (2016) investigated the internal space environment of two obstetrical wards in Shanghai, reflecting the inadequacies in the humanized design of the obstetrical wards in domestic hospitals, which made it difficult for the mothers to have a sense of belonging. It is suggested that the design concept of the living space should be used in the design to meet the psychological needs of the mothers under the premise of functional use. Some studies have found that the main problems of obstetrical environment in China are lack of auxiliary function space, lack of considerations of physical environment settings, such as the local light environment and sound insulation are poor in the ward; the lack of uniformity of the wayfinding system, rarely designed for pregnant women(Xian, 2015; Xue& Chen, 2016).

The overall interior design of a hospital must be based on the actual situation and be based on the current development trend of the entire service industry. The design of the interior space is considered humanized to keep patients and families in a warm, comfortable and pleasant medical environment. Most hospitals in China currently still adopt the traditional mode of nursing and childbirth. The maternal women at each stage of labor, childbirth, and post-partum recovery are constantly being transferred, which increases the risks in the process of maternal transfer and is not convenient for family members to escort. Patient's needs and evaluation standards for hospitals are constantly improving, and medical treatment has changed from a treatment-oriented to a full-scale social service (Cui, 2016). Cui (2016) proposed a Family Centered Medical Care model (FCMC). The LDR model mentioned in the previous literature, combined with FCMC's delivery method, has been introduced to China. Obstetrics design currently needs further research.

2.3 Relevant Studies

2.3.1 Current Approaches to Evaluating Healthcare Facilities

A main limitation of healthcare design research feasibility is the lack of evidence-based design and evaluation tools. There is no relevant information repository to help designers understand the potential impact of different design decisions, as well as factors to consider when making key decisions during the pre-construction design phase, and to assess the environment after construction and occupancy. To assess the hospital sustainability of the environmental, social and economic, the sustainable healthcare program has developed an evaluation tool that setting specific indicators are into a series of criteria and calculation formulas to score ranging from 0 to 100. These standards were defined by specific focus groups, including experts and professionals from different healthcare sectors. However, it is omitted how to measure the evaluation results (Bottero et al., 2015).

Because of the limitation of tool, it is impossible to measure an optimal space.

Considering that the space for childbirth influences the physiology of women in labor, Foureur et al. (2010) developed Birth Unit Design Spatial Evaluation Tool (BUDSET), to test the birth unit design for women and to assess the optimization. From four fields to evaluate and identified where fields need to improvement. It is advocated that tool test in obstetrics institution Australia. BUDSET provides assessment methods to predict architecture design and reduce costs, but further research is needed to verify the tool (Foureur et al., 2010; Foureur, Leap, Davis, Forbes, & Homer, 2011).

The hospital inpatient ward design has a large impact on healthcare facilities outcomes, although designers are often difficult to understand for decision making and post-occupancy evaluation. Quan, Joseph, and Nanda (2017)created evidence-based design checklists and evaluation tools for Medical-Surgical, Intensive Care and Obstetrics. The result was an evidence-based toolkit with a range of features to improve usability. These tools could effectively promote research evidence, provided valuable experiences for further improvement, and improved the process of designing and evaluating service facilities.

2.3.2 Space Syntax in Healthcare Facilities

Healthcare facilities design is a complex process that must consider many interdependent factors, such as economic limit, market demands, patient satisfaction and staffing (Morgareidge, Cai, & Jia, 2014). Space syntax is widely applied by designers, administrators, and researchers in healthcare facilities to allow them to optimize their facilities quantitatively and objectively (Morgareidge et al., 2014; Trzpuc& Martin, 2010). Spaceis defined as kinetic, interrelated and generated (Tweed, 2011). Using Space syntax can analyze how the space is connect to other spaces, and calculate the value of space (Sadek& Shepley, 2016).

Work environment has influence on clinical staff's job satisfaction and stress. Using space syntax theory to analyzed three different nursing units floor plans to confirm whether the space to support nurse communication (Trzpuc& Martin, 2010). Computer-aided architectural designing software is used to build the building model and extract topological information to meet the needs of users. Space syntax is used to analyze and evaluate the social properties of space (Jeong& Ban, 2011).

One important aspect of new hospital design is more focus on optimizing the use of space and visualize different but interrelated spaces. Cost estimations and budgets are made economically; users participation in the design process, and the economic space is limited to the design space. Harty, Jacobsen and Harty, Jacobsen, and Tryggestad (2015)findings show that the visualization can assess the development of future clinical practices and solve the emergent concerns in the processes of constructing (Harty et al., 2015).Space syntax theory uses graph theory mathematics to measure the various properties of the plan.Isovist is a collection of all points see at a given favorable position in space and can be graphically displayed and computed for spatial properties (Benedikt, 1979). The mathematical properties of isovists have potential relevance to human spatial perception and response (Stamps, 2005). Recent studies have suggested that the design of the space layout influences clinical staff observation on patient (Y. Lu, 2010; Pati, Hadi, & Zimring, 2016; Trzpuc& Martin, 2010). Visibility is one of the constructs in space syntax theory, which benefits of improved work efficiency and reduced patient falls and other injuries (Y. Lu, 2010; Sadek& Shepley, 2016). Physical visibility can be defined as allow staff directly to see into adjacent spaces by design features and locations in space, not to use monitor (Trzpuc& Martin, 2010).

Pati et al. (2016) analyzed 10 intensive care units (ICUs) to identify space layout shape and corridor width of nursing units are positive correlated with visibility. The limitation of this study is its small sample and hard to overall considering. Other factors also can have effect on staff visibility such as openings of door and windows, the location of bathrooms. Y. Lu (2010) introduced targeted visibility index (TVI) to measures the degree to which an observer can see all targets and links the environment to all aspects of the user.

Using ArsGIS version 9.2 platform (ESRI Inc., Redlands, CA) compare three nursing units with differing numbers of patient beds and concluded that the radial unit had the highest value. The studied benefits to staff to patient visibility can improve work efficiency and reduce not necessary injuries (Y. Lu, 2010).

Lee, Ostwald, and Lee (2017) proposed a method that combines visibility graph and isovist analysis to examine the spatial and social attributes of planning for aged care facilities. By measuring the aged care plans in three different groups of countries, it is then compared with an optimal plan. The results show that social and cultural factors may shape the design of the aged care environment and partly explain their international differences. Using this method helps to understand the relationship between space and cultural and social attributes in elderly care design.

Space is used by people. It is important to acknowledge that human behaviors in the environment for spatial distribution (Sadek& Shepley, 2016). Recent studies focus on visitor wayfinding in hospital, nurse walking patterns, patients preference and satisfaction (Haq& Luo, 2012). Wayfinding shows humans can reach space destinations in a familiar environment. A finding in a complex space environment can be thought of as a process of cognitive problem solving and decision making. Passini (1981) emphasis on wayfinding requires planning and executing a series of motion decisions. These movement decisions are influenced by several factors, including familiarity with the environment, as well as a clear space environment. Space syntax can simulate the route of agent to verify that the space is accessible. Gibson (1986) studied the agent-based human movement model, and the agent directly visually perceives the environment to guide his actions. The visually provided walk able route does provide proxy behavior that corresponds to human behavior. However, social and economic factors or other events can also affect the basic level of human behavior (Turner & Penn, 2002).

2.3.3 Human Behavior Simulation in Healthcare Facilities

Because of the gap between the design and practices, building could cause space inefficiency and not meet the demands of the user, the human behavior plays a crucial role in the design process (Buffoli et al., 2014). Schaumann et al. (2016) conducted two scenarios in which simulation of a medicine distribution procedure. The first simulation scenario is the scheduled, and the second involves interaction between visitors and nurses may be led to medical mistakes. After the simulation can finds where most interactions occurred. The experiment shows that the event based simulation approach is contribute to evaluate the complex hospital design. Morgareidge et al. (2014)presented a case study that optimize Yuma regional medical center emergency department by discrete event simulation and space syntax. This study shows that Space syntax is an effective tool for promoting decision-making and strength the link human behavior to space.

Spatial design affects clinical staff efficiency. Previous research findings nurses' movement are subject to space layout of a hospital unit, which they spend their work time in walking in the different space. Choudhary et al. (2010) explored a generalized linear model is aiming to study nurses' movement patterns, results from the model indicate that spatial properties of nurses' assignment have a predictable effect on the frequency of trips. Using syntactic variables of space conducted statistical analysis can derive the alternative layouts better (Choudhary, Bafna, Heo, Hendrich, & Chow, 2010).

2.4 Healthcare Facilities Humanization

2.4.1 Clinical Staff Efficiency

A well-designed built environment can create a significant contribution to nursing units safety and quality, efficiency and cost effectiveness of healthcare (Ulrich et al., 2008).There is evidence that due to pressure caused by noise, improper or inadequate ventilation of artificial lighting, and the confusing layout of nurse units can have a negative impact on staff (Sanderson et al., 2005). In addition, the key issues that affect the fatigue and stress of staff in the design of some nurse units are walking distance, visibility, and the design of relationship between wards and nurse stations (Seo, Choi, & Zimring, 2011). These design issues and their combinations may affect clinical staff efficiency, error possibility, stress levels, and overall job satisfaction. (Chaudhury, Mahmood, & Valente, 2009).

Huisman et al. (2012) investigated the impact of physical environmental factors on users and found that the evidence was limited. Most staff results are based on experience and have not been scientifically proven. Because most of these studies focus on the perspective of patient needs or from the designer's point of view. Healthcare facilities design is patient-centered and protect the safety and privacy of patients, many hospitals have provided more space and amenities for patients and families. This means that it is also crucial to design and build a new healthcare environment that understands the needs of staff and other stakeholders related to the built environment. The challenge of the main one-step study is the needs of employees and the integration of all these requirements into the built environment. Only in this way can the staff's work efficiency be improved.

With the beginning to conduct in-depth studies, researchers realize that protection of staff is equally important (Hilton, 2006). The impact of safety and quality of healthcare environment could result in clinical staff leaving, which arouse concern around the world. The nursing shortage in China is more serious than most developed countries (Zhu, Rodgers, & Melia, 2014). Understanding the job satisfaction among clinical staff is an urgent task, clinical staff's positive feelings could be influenced by healthcare facilities environment (H. Lu, While, &Barriball, 2007). Lin et al. (2013) interviewed 737 hospital medical directors using cross-sectional survey and studied that how reduce the effect of work stress on their wellness by interior facilities (Lin et al., 2013). Centralized nurse station could cause staff to walk longer and waste more time thereby effect their work efficiency (Seo et al., 2011). Therefore, to improve staff efficiency, the researcher must first find the factors that affect them.

2.4.2 The Design of Healthcare Environment

Humanization is a complex concept that need to understand the demands of users' psychological and physical, also contain security and protection perception, appropriate equipment and cozy spaces and soft qualities (Bosia, Marino, &Peretti, 2016; Capolongo et al., 2016). Addressing the impact of the physical environment on users is increasingly important in the design and construction of medical facilities. Healthcare environment can reduce stress and promote wellness. However, considering the needs of different users of healthcare facilities must have conflicting. A difficult but important challenge for designers to recognize and balance the difference between users (Ulrich et al., 2008). The design of healthcare environment need to be considered functional requirements and design standards, as well as various protocols. The design elements called soft qualities are added to those necessary features by Capolongo et al. (2016) to create healthcare space with high quality and meet user's emotional needs. Focus group be allowed users to participate in choices to better understand design, as well as built the bridge between designers and users.

Humanization is an important factor in the design of healthcare environment, Buffoli et al. (2014)introduced the Listening to people to Cure people tool (LpCp) that is an instrument to evaluate hospital humanization. By using questionnaire can achieve useful information to identify the validity of decision and the need of enhancement strategies. This tool is for the purpose to build designers and administrators more understand humanization and comfort levels to create an optimal healthcare environment for users. Simulated a room that is almost the same size as real to allow the clinical staff works in the space to test the functionality and efficiency of the layout and size. These mock approach can improve clinical staff satisfaction and reduce the cost (McCullough et al., 2010). In a study conducted by Seo et al. (2011), it was compared nurses' trips in a smaller Intensive Care Unit (ICU) and a larger ICU design for patient care. Because of the larger ICU outside each two patient rooms set a extra substation can allow the nurses walk stop and direct observation. This study finds that the existence of substations can reduce walking without affecting the efficiency of staff due to more space and needs to confirm research in the further research.

2.4.3 Nurse Stations

The nursing station is the main social communication and work area for nurses. Activities at the nursing station include inquiry, phone calls, monitoring, recording, distribution of medicine(Trzpuc& Martin, 2010).Review of the literature on the design of nurse stations is limited. Page and ebrary (2004) concluded that no design conclusion can be adopted by all hospital units. Because the layout of the different nursing units varies greatly, unit functions must be considered.

The position of the nurse station plays an important role in the layout and directly affects the work efficiency of clinical staff. Levy (2004) found that clinical staff needed to move back and forth between nurses and wards, spending a lot of time in the corridor. Previous studies have explored the differences between centralized nurse station and decentralized nurse station. Gurascio-Howard and Malloch (2007)validated the effectiveness of traditional centralized nurse station and decentralized nurse station designs. The centralized nurse station uses low-level computerization of the total patient care model, while the decentralized use of the team care model is highly computerized. The results calculated the time of interaction with the patient, the number of visits per nurse, and the patient's satisfaction with the response time. The study found that decentralized nurse station can save time on walking and spend more time on patient care. However, the communication between nurses and peers at the decentralized nurse station has decreased. An exploratory study compared nurses traveling in a smaller ICU and a larger ICU. The observed smaller units have only one centralized nurse station to observe the ward, while the larger unit has visibility from the centralized nurse station to the distributed substation observation ward. It turned out that the larger unit nurses did not go further and spent more time on medication, but they did interact less. This study shows that the presence of substation nurse stations and the distributed of medicines can reduce walking (Seo et al., 2011). In addition, Ulrich et al. (2008) points out that one study shows decentralized nurse station can reduce patient falls, but more rigorous research is needed.

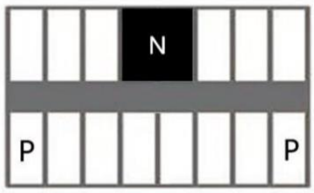
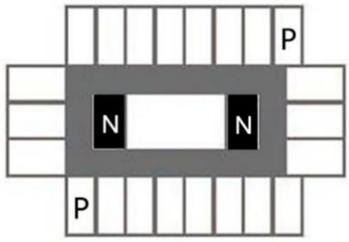
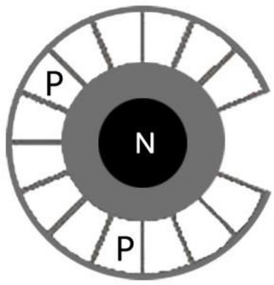
The design of nurse station has an important influence on the working environment and behavior of nurses. It is important to understand the proper nurse environment. Zborowsky, Bunker-Hellmich, Morelli, and O'Neill (2010)also investigated how the design of nurse stations affected nurses' use of space, noise levels, patient visibility, and perception of the work environment. Advances in information technology have enabled nurses to remove traditional centralized and assigned to smaller distributed workstations. They found a ‘hybrid’ care design pattern that combines decentralized nurse stations with centralized meeting rooms for staff interactions may increase the balance between computer technology and the continuing need for communication.

2.4.4 Nursing Unit Layouts

The form of the unit layouts are generally divided into a single corridor, double corridor and radial layout (Yi &Seo, 2012). Single corridor shows that the patient rooms are arranged along one side of the corridor and the other side are medical rooms. Double corridor patient rooms are located on both sides of the corridor and face nurse stations in the center. Radial corridor layouts allow the central nurse station to be visible to all patient rooms and there is no physical barrier to obstruct the visibility of patient rooms from the central nurse station. One side of the corridor is connected to the nurse station (Table 2.3). However, single corridor and double corridor are not such as this (Y. Lu, 2010; Seo et al., 2011).

Corridors often have multiple staff members entering and exiting at different points in time(Moran, Tentori, Gonzalez, Favela, & Martinez-Garcia, 2007).The form of the corridor is an important part of the layout design and will also affect the efficiency of staff. Previous research focused on the total walking distance of all activities of staff and the distribution of medications for walking (Gurascio-Howard & Malloch, 2007; Seo et al., 2011). The overall layout of the unit will affect the travel distance of staff. The adjacent path of the centralized nurse station may affect the work efficiency of staff. The path to the medicine treatment area or room should be carefully designed to avoid other people being highly visible to reduce walking distance and interruptions during treatment tasks. However, Yi and Seo (2012) proposed the opposite opinion that they observed the nurses during the distribution medicine period. The determination of the overall unit shape or the type of unit layout may not be a suitable predictor of the walking behavior of nurses. The path characteristics of functional spaces such as connecting wards and medicine treatment areas can better predict nurses' walking behavior.

Table 2.3 Three nursing unit layouts (Yi &Seo, 2012).

Layout Forms	**: Corridor N: Nurse Station P: Patient Room**	**Description**
Single Corridor		Patient rooms are arranged along one side of the corridor and the other side are medical rooms.
Double Corridor		Patient rooms are located on both sides of the corridor and face the nurse stations in the center.
Radial Corridor		This layout allow the central nurse station to be visible to all patient rooms and there is no physical barrier to obstruct the visibility of patient rooms from the central nurse station.

CHAPTER III. RESEARCH DESIGN & METHOD

3.1 Research Design

The research used Evidence-Based design and Space Syntax theory to support exploration of the future unit design. It was conducted in two phases to well understand the spatial layout in obstetrical department and clinical staff's needs of physical environment and improve the design of spatial layout to improve staff efficiency. The first part of research involved investigation of obstetrical department in hospitals using observation, interviews and questionnaires survey of spatial layout on obstetrical staff for data collection. The second part was Depthmap software simulation used to obtain relevant spatial properties and comparison of it between different hospitals. The ethics consideration was made in relation to the research process.

3.1.1 Research Samples

The research samples were chosen in a city in Anhui province, China, which has the characteristics of South China hospital architecture. Initially, the four most influential hospitals were considered for investigation in this city, including one Maternal and Child Health Hospital (MCHH) and three General Hospitals (GH). The researcher contacted the managers from obstetrics of four hospitals and expressed the desire for investigation. One hospital was excluded from research because they refused to participate in the survey. Eventually, three hospitals were included in this study. Hospital A is a specialist hospital with 123 beds, the other two hospitals are general hospitals. The obstetric unit within these two hospitals are relatively small with the bed capacity of 25 and 36 respectively (Table 3.1).

Table 3.1 Information of hospitals participating in the study.

Site	Code	Type	Date completed	Building area	No. of beds In Obstetrics	No. of staff In Obstetrics
Anhui province, China	Hospital A	Maternal and Child Health Hospital	1974	50900 ㎡	123	134
	Hospital B	General Hospital	1965	51000 ㎡	25	26
	Hospital C	General Hospital	1958	77400 ㎡	36	56

3.1.2 Ethics Consideration

Ethics is defined as correct behavior and principles and does not do any harm to people (Ellis & Becker, 1982). The research involved the participation of people and field study in three hospitals. Ethical approval was acquired from the Research Ethics Sub-Committee of the University of Nottingham, Ningbo. For high-quality research practices, the Research Ethics Checklist (Appendix A) concerned the ethical issues. The Participant Information Sheet (Appendix B) provided the volunteers with basic information for the survey, 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. Firstly, the researcher contacted the recruited hospitals to explain the research aims and obtained the permission. Secondly, the researcher contacted the head nurse of the hospitals to discuss the details of questionnaires. Thirdly, the researcher explained to clinical staff the purpose of the research and asked them to sign the participant consent form and relevant documents under the participant full agreement. With clinical staff consent, the researcher utilizes them free time to conduct interviews with them and conduct questionnaires survey. Participants have the right to choose whether to participate in the survey.

3.2 Methods

3.2.1 Observations and Measurements

Observation is a necessary method to understand a field and to study human daily life activities (Oeye, Bjelland, &Skorpen, 2007). The possible problem can be found by the analysis of behavior and environment in observations (Pridham& Hansen, 1980). It was noted that the researcher must not disturb the hospital's normal operating procedures during the study, not affect patient's rest and clinical staff’s work.

The researcher developed a plan through literature review and consultation obstetrical staff before the observation. Firstly, extensive literature was searched with key words such as Evidence-Based design, nursing unit design, healthcare environments, humanization design and obstetrics. The researcher found that other researchers were concerned about the issue and whether it was worthy of further research or gaps. Secondly, asking clinical staff who work in the obstetrics to obtain an overview of their work and the working environment. Finally, setting a list where special observations and further inquiries were required.

The research conducted for five days in three hospitals in total that observed obstetrical physical environment and clinical staff work behavior. The researcher arrived at the hospital in the morning and went to the obstetric unit to talk to the head nurse who had been contacted. Firstly, the nurse who was assigned by the head nurse took a tour and introduced the basic situation of obstetrics. Then, the researcher observed independently and paid attention to the situation without disturbing others. Observing the layout of obstetrics and the physical environment such as lighting, ventilation, color, and the movement of clinical staff. More focus on corridor forms, nurse station patterns and ward environment. The dimensions of the space were measured to draw the layout for later analysis. Observations were recorded without any images of people. The research not only needs to understand academic knowledge of this field, but also concern human interaction in the social background by deep observation of obstetrics(Lofland, Snow, Anderson, &Lofland, 2006).

3.2.2 Interviews

The study requires some notable questions about interviewing clinical staff and preparing for further questionnaires survey. Clinical staff were used to follow up interviews during the rest time at the nurse station. It is important to listen to staff suggestions because it allows the researcher to identify problems that need to be solved. Interviews were regarded as a powerful tool for the researcher to interact with participants and to consider from the perspective of the participants (Bick, Rycroft-Malone, &Fontenla, 2009). Participants' interviews followed a semi-structured interview guide, which was a natural and flexible way. The researcher provided open and closed questions that participants discussed(Gillham, 2000). A series of interviews with 10 clinical staff was conducted in the obstetric unit of three hospitals, including 1 doctor in hospital B, the head nurse of each hospital, 6 nurses in three hospitals (Table 3.2). The researcher did not attempt to collect extensive description in this survey, but rather more understood the work environment of the clinical staff and their needs and found aspects worth studying to prepared for the further questionnaires survey. Interviews questions were divided into five parts: nursing work flow, space layout, nurse station, ward and physical environment, including participants feeling of their work environment and where need to improvement.

Table 3. 2 Demographics of clinical staff participating in the study

Characteristics		Gender		Age		Occupation	
		Male	Female	<40	>40	Doctor	Nurse
Number of participants	Hospital A	0	2	1	1	0	2
	Hospital B	0	5	4	1	1	4
	Hospital C	0	3	2	1	0	3
Total		0	10	7	3	1	9

3.2.3 Questionnaires Survey

Questionnaire survey is an important part of study design. The questionnaire not well design will affect the quality of data collected. The researcher need to review existing standardized questionnaires and list all the variables to be evaluated in the study before conducting the questionnaire (Maninder Singh, 2017). It is worth noting that controlling the number and length of questionnaires avoids allowing participants to spend much time affect quality of data collected (Hubbard, 1939). The researcher can use open or closed questions depending on the study and pay attention to the setting of answer options that need to cover all possibilities. Questionnaires questions were developed based on the observations and interviews for obstetrical environment and clinical staff. A self-designed closed questionnaire focusing on obstetrical space design, for clinical staff, consisted of 20 questions (Appendix D). The questionnaire was divided into four parts, obstetrical layout, obstetrical nurse station, obstetrical ward and obstetrical physical environment, each section created definition for easy understanding of participants. The purpose of the questionnaire was to understand the needs and suggestions of the clinical staff for spatial design to develop efficient obstetrics design. The researcher considered participants views to enhance space design, assessed and improved existing facilities to create a safe and humanistic obstetrical environment. The questionnaire conducted a pilot in which the researcher asked 10 questions to clinical staff at the beginning. It was modified based on the feedback from the participants.A total of 100 clinical staff participated in this survey by filling out the survey forms at their workplace or online. Statistical analysis was performed by using Excel.

3.2.4 Space Syntax

The purpose of space syntax is to understand the configuration of space itself, especially the process of it and the meaning of society (Bafna, 2003).Hillier (1988) pointed out that spatial syntax is a relational system of social role and is available to describe the change in spatial settlements and buildings. Space syntax theory uses topological mathematical methods, quantifies the relationship between spaces, provides a computer tools for calculating the relational properties of spaces, and presents the results using graph theory (Sadek& Shepley, 2016). Space syntax was proved to relate to human movement in the building environment and can present visibility of a point in the open space environment. Spatial configuration influences space movement patterns.

3.2.4.1 Depthmap Software Simulation

Traditional computer-aided architecture design systems can only draw graphics and geometric information, and cannot manage the semantic information about components and space (Jeong& Ban, 2011). Space Syntax is a solution for assessing spatial social attributes based on buildings (Hillier, 1988).Depthmap is a software based on space syntax theory which helps understand the structure of spaces and human movement behavior (Hillier, 1996a).Combining AutoCAD and Depthmap to analyze the layout of the three obstetrics was based on the space syntax theory. According to the space observations and measurements, the layouts of the obstetrics of the three hospitals were obtained, and the computer software AutoCAD was used for drawing. The disadvantage was that there may be mistakes in plans, but it should not affect the overall result of the software simulation. The AutoCAD floor plans were converted to dxf format and imported into Depthmap software for simulation and analysis.

3.2.4.2 Visibility Graph Analysis (VGA)

Braaksma and Cook (1980) offers an approach for measuring human orientation and visibility in the transportation, transforming into indices for visibility. They suggest that Visibility analysis can be applied to future layout plans and wayfinding system. A Visibility Graph Analysis (VGA) presents something about visibility relationships between spaces in the project. It is particularly important to address issues related to spatial perception from a situated position. Visibility graph describes a high-resolution picture of the spatial configurations ofa layout. The measures depend on the layout plan size. Depthmap each grid all represents a value, the software divides the highest and lowest values of the entire plan into 10 levels and expressed in different colors. Higher values are shown by redder, and the bluer represent lower values (Figure 3.1). Each node falls within the area and shows the color of the area.

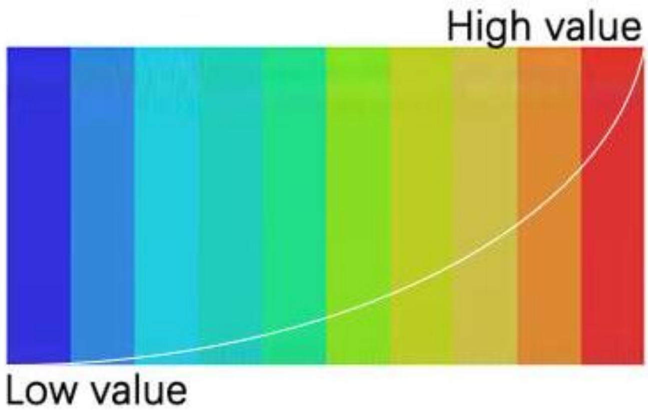


Figure 3.1 Color 10 levels distribution.

In this study, VGA was used to measure the four spatial properties that Connectivity, Visual Integration [HH], Visual Clustering Coefficient, and

Visual Step Depth of Nurse Station of the three plans for obstetrics. Because of building space is related to human dimension, preferably to be 0.5 to 0.55m to match human scale. This simulation was chosen a sensible grid spacing that 0.5m, and calculated plans using Depthmap. The result of these three plans were compared and analyzed. The four properties of VGA as defined by using space syntax theory to study the obstetrical layout plan could determine the design direction of units that enhance clinical staff efficiency. Each property was described in Table 3.3.

Table 3.3 Four properties of Visual Graph Analysis.

Spatial Properties	Description
Connectivity	Connectivity measures the number of spaces immediately connecting a space of origin (Hillier, 1988).
Visual Integration [HH]	Measures visual distance from all spaces to all others (Hillier, 1996).
Visual Clustering Coefficient	The degree of visual limitation of spatial boundaries. The visibility of each node is affected by the surrounding boundaries (Space Syntax: a very short introduction, 2014).
Visual Step Depth	Determine a choice set and then calculate the shortest visual depth from this choice set to any node within the system (Space Syntax: a very short introduction, 2014).

3.2.4.3 Isovist

Benedikt (1979) introduced an isovist that can be calculated for a particular point can see the size and shape of all points in a space and environment. The aim is to suggest a new way to described architectural space to quantify study. It is seemed as related to architecture behavior and perception, especially in aspect of the privacy and view control. The size and shape of isovist depends on which points in the region are, and what the surrounding environment is(Fignre 3.2). Using Depthmap can calculate the properties of the isovist that show isovist area and perimeter, drift angle and magnitude, maximum and minimum radial, and occlusivity (Table 3.4).The properties of the isovist construction are shown in Figure 3.3.

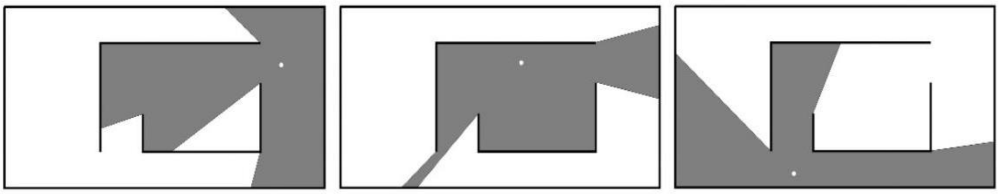


Figure 3.2 There are three viewing points in the same plan respectively show the different size and shape isovists that visual angles are full isovist (360 degree) (Benedikt, 1979).

Table 3.4 Properties of Isovists(Lee et al., 2017).

Spatial Properties	unit	Description
Isovist Area	㎡	Area of a view field polygon. The smaller the area, the easier it is to hide and the greater the feeling of constrained.
Perimeter	m	Circumference of a view field polygon.
Drift Angle	°	Represents the angle of a line drawn between the viewing position and the center of the isovist polygon (gravity).
Drift Magnitude	m	The distance between the location from the viewing and the centroid of the isovist. This variate is used to measure the center of spaces and along the center-lines of roads.
Max Radial	m	Radial is means from the viewing position to the length of the line that blocks the further line of sight. Max radial is the maximum visible distance.
Min Radial	m	The shortest radial line a person can see.
Occlusivity	m	The length of the open edges of the isovist and is an indicator of mystery.

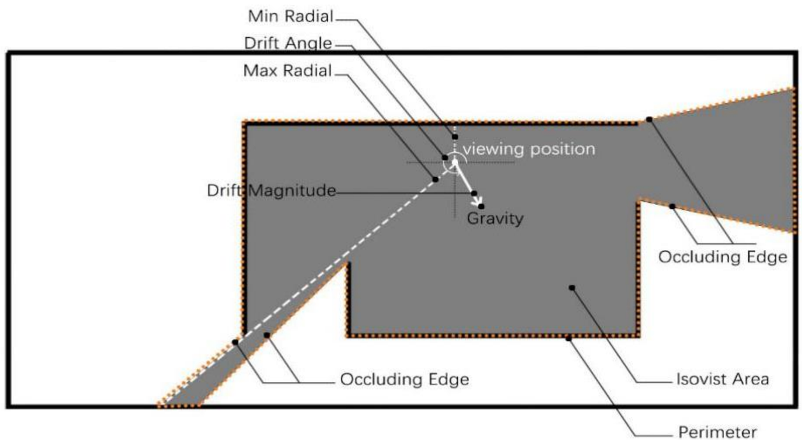


Figure 3.3Isovist viewshed (grey-shaded polygon) from a position in a plan is shown.

In this study, isovists were used to examine corridors and nurse stations of three plans to study clinical staff efficiency and space experience. Corridors are connective of the entire plan where the clinical staff go through daily and the inspection of the room, the distribution of drugs, and the daily communication. Nurse station is where the clinical staff stay the longest, including daily records, making prescriptions, and patient consultation. The most important is the position of favorable observation because it represents the space experience that needs to be explored.(Benedikt, 1979). The researcher chose a centrally located or isovist path for the most convenient observation of clinical staff. The limitation was that the choice of different visual point may lead to different results, but only examined one position in here. Visual can be chosen to have the different viewing angles, in this study choose full isovist (360 degree) was going to be created at the point have located. The mean results for each plan for isovist area and perimeter, drift angle and magnitude, maximum and minimum radial, and occlusivity are then derived.

3.2.4.4 Agent Analysis

The relationship between the spatial layout and the movement pattern is a movement pattern that determines the spatial pattern of the pedestrian route leading to social function (Hillier et al., 1987).Turner and Penn (2002) explained behavior of agents in space help to understand standard individual activities behavior and reaction to space activities. They developed an Agent's model architecture to simulate natural movement patterns in buildings and cities. The Agent depends on visual perception within the surrounding environment through visual devices change the route. This model presents the visible dynamics guide individual movement that the process of occupation in space. The Old Tart Britain was simulated about axial connectivity and visibility connectivity by Space Syntax. As seen in Figure 3.4, the left diagram is the actual paths of people movement. In addition, the right diagram is a spatial accessibility simulation results based on the floor plan. The redder color displayed the more accessible space.

Depthmap simulation agent behavior generates different aggregate behavior patterns in three plans by controlling parameters and rules. The researcher set 200mm grid to match human scale. To rule out prejudice when observing movement behavior, the researcher should randomly select agent to start from a predetermined starting point and observe the route they have traveled. Tracking may be stopped when people leave the area of interest, arrive at a pre-set destination, or after a period. The release rate is means agents per time step is 0.1 and from any location. Recording trails for 50 agents in standard movement rule. Finally, the three figures were exported and compared.

Figure 3.4 Old Tart Britain's people flow and visibility connectivity simulation results by Space Syntax.

CHAPTER IV. DATA COLLECTION & ANALYSIS

4.1 Introduction

It is vital for the validity that precise data collection in use of scientific data in databases (Roepstorff, Petersen, & Berthelsen, 2015). Data collection took place in February 2017 after Ethics Sub-Committee permission. The study was conducted by collecting data systematically in a city in Anhui province, China and all the information collected in Chinese was translated into English. During the observation of obstetrics in each hospital, data was collected through photograph about physical environment, field notes include dimensional measurement and the problems identified. When conducting the interviews, the researcher recorded the clinical staff responses by taking notes. The researcher input the data collected from the paper questionnaires into the computer and used the excel to sort the data which makes a comparison and analysis of various image graphs.

The exploratory study were related to following factors: (a) analysis the characteristic of layout plan of obstetrics in three hospitals; (b) observation and findings currently existing problems in obstetrics and where need to improvement; (c) understanding the needs of the clinical staff and satisfaction; (d) analysis of how to improve the clinical staff efficiency; (e) how the space syntax theory can be analyzed in obstetrics floor plans to provide the outcome of improve clinical staff environment. The collection of survey results described and discussed the design of the existing obstetrics plan from the application of space syntax and provided data on the information collected through interviews.

4.2 Observations

The researcher carefully observed the spatial layout in obstetrics under the guidance of clinical staff. In the process of the observation, the researcher believed that the obstetrical atmosphere was pleasant, the clinical staff were full of energy, and the communication was relaxed and enjoyable. The researcher generally observes interactions between patient and relatives, work flows and behaviors near the nurse station. Nurse station looked very crowded in the Hospital B, and the inquiry table of linear pattern could write medical records and communicate with patients (Figure 4.1). There were also two computers for nurses to record information. However, it does not seem to meet the needs of nurses and often requires queuing. Nurses were very busy, and they needed to walk back and forth in the corridors, even need to push the medical trolleys. They have some regular activities every day, including checking rooms, distributing medicines, listening to fetal heart rate, fetal heart rate monitoring, newborn care, maternity care, etc.

Figure 4.1 Nurse station of obstetrics in Hospital B.

4.2.1 Plan Review and Analysis

The researcher drew the floor plans of three obstetrics based on observation and measured dimensions refer to the diagrammatic drawings given by the hospitals. Table 4.1 describes statistics for obstetrical plans in three hospitals in this study. The floor plans are shown in Figures 4.2, 4.3, and 4.4.

Table 4. 1 Descriptive Statistics for Obstetrical Floor Plans Analyzed.

	Floor	Square Footage (Obstetrics Plan)	Configuration	Corridor Form	Nurse Station Pattern
Hospital A	5F-7F	2530 ㎡	Centralized (2 areas)	T-shaped single form	U shape Linear
Hospital B	4F	1238 ㎡	Centralized (1 area)	Single form	Linear
Hospital C	6F	1085 ㎡	Centralized (1 area)	Single form	Linear

The centralized plan of Hospital A is divided into area A and area B, which are distributed in an L shape. The wards are on one side and the medical rooms on the other. Each area has a nurse station that the location is near the entrance, the area A nurse station is U shape pattern and B is linear pattern, but nurses cannot observe all patient rooms while staying in it. The area A nurse station is bigger than B because there are more beds in area A. No distributed substations were provided. The nurse daily work journey go there and back between the ward and nurse station. Dotted lines show path movement in the entire plan and corridors are T-shaped single corridor form. There is natural light on both sides of the corridor. A straight corridor is useful for keeping a view of a corridor, but it weakens the view around the corner, and the clinical staff need to back and forth to check rooms that means the actual path will be doubled lead to low efficiency. The types of patient rooms are single rooms, double rooms, triple rooms and VIPs, and bathrooms in the room are close to the corridors and each room has its own balcony.

The plan of Hospital B looks like a rectangle, which is smaller than Hospital A and has three functional areas. The southern side of the plan are patient rooms, and opposite are medical rooms and the delivery room is located at the corner of the entire plan. The number of wards in hospital B is much lower than that of A. The plan only has one nurse station in the center of the ward area, which have no distributed substation. The corridor is the form of the linear rely on the artificial light because of no natural light on both sides. The patient room has no balcony and the other layout is like Hospital A.

The entire layout and area of the Hospital C is roughly the same as that of the Hospital B, which is divided into 3 areas, and is also a single corridor, a nurse station. The only difference from the layout of the other two hospitals is that the bathroom of the room is close to the external wall. It is suspected that this does not block the clinical staff observation of the patient vision, but it may have a certain impact on the natural light of the room. It will be discussed in the later chapter.

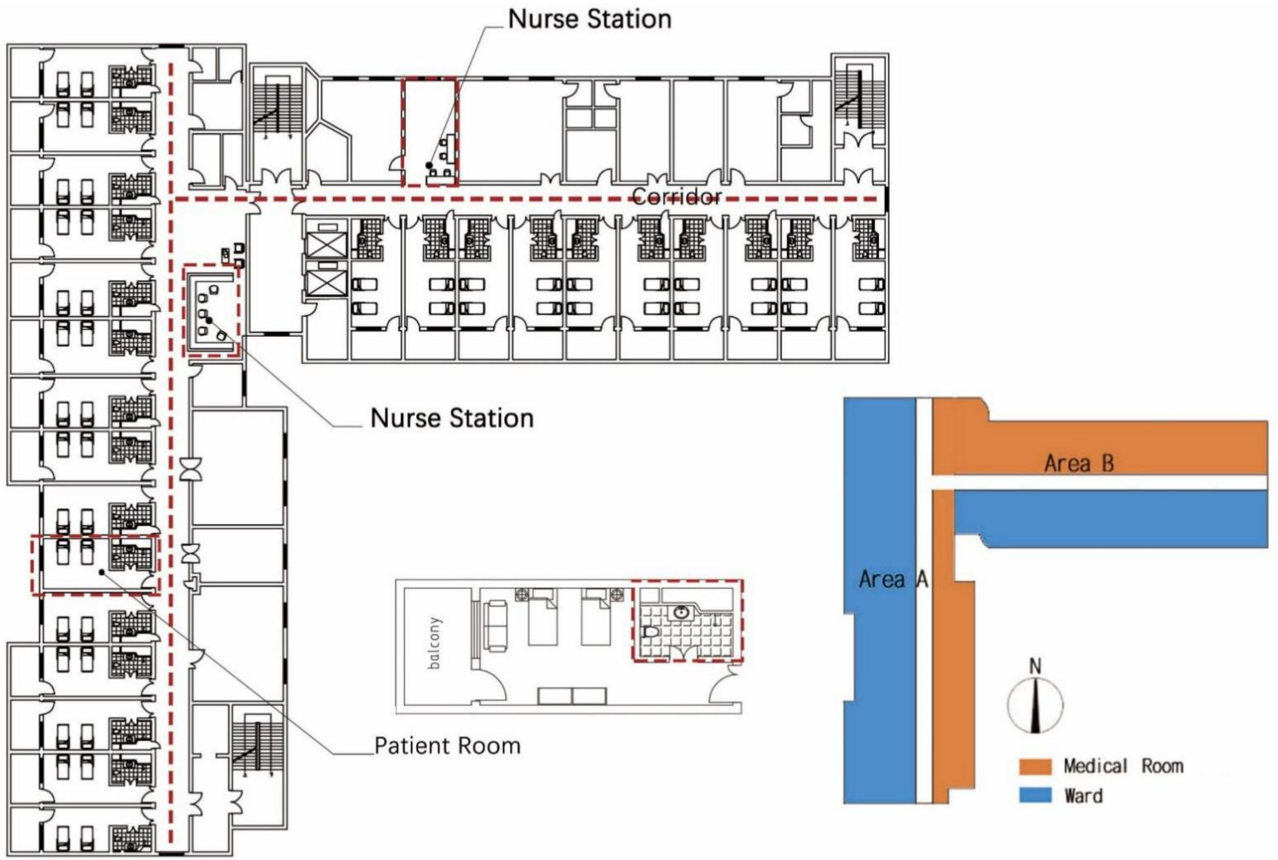


Figure 4.2 Hospital A: Centralized obstetrics plan (2530 square meter) with two pods, each with a nurse station, the different numbers of patient rooms and medical office rooms. The size of the nurse stations is different and close to the ward.

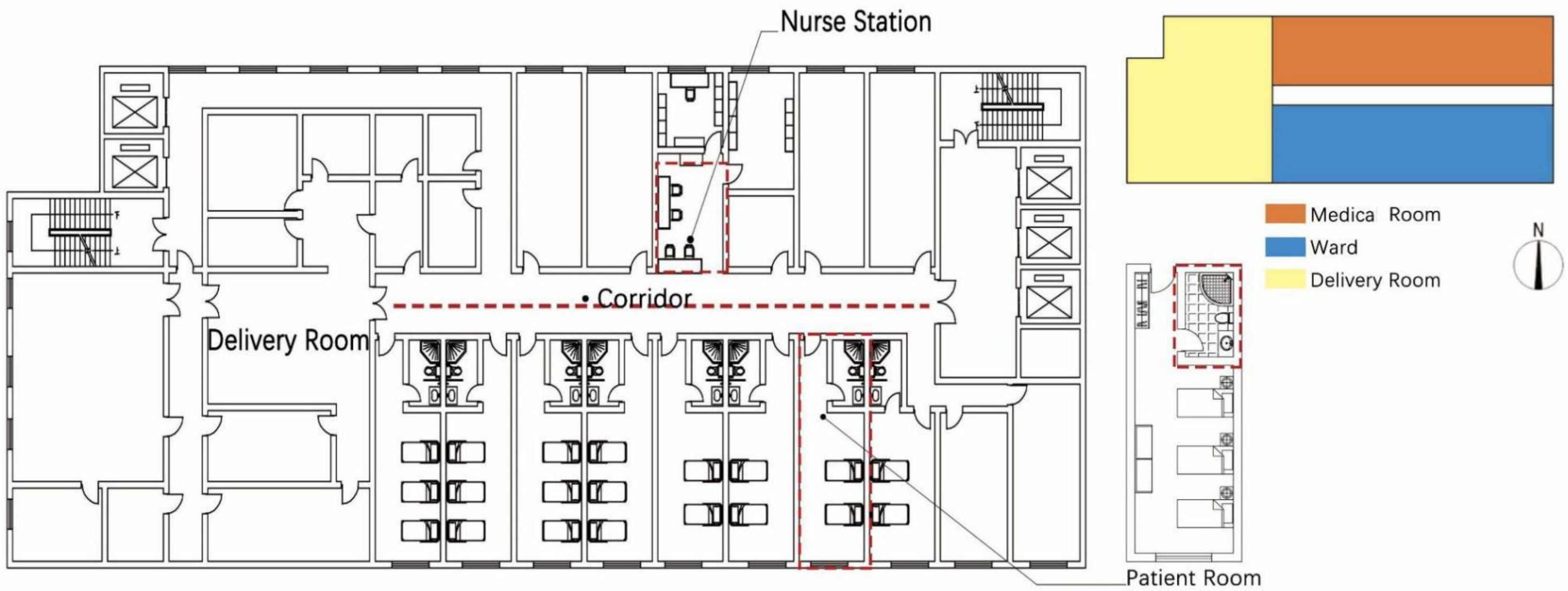


Figure 4.3 Hospital B: Centralized obstetrical plan (1238 square meter) with one pod that have one nurse station site in the center of the ward, the different numbers of patient rooms, medical office rooms and delivery room.

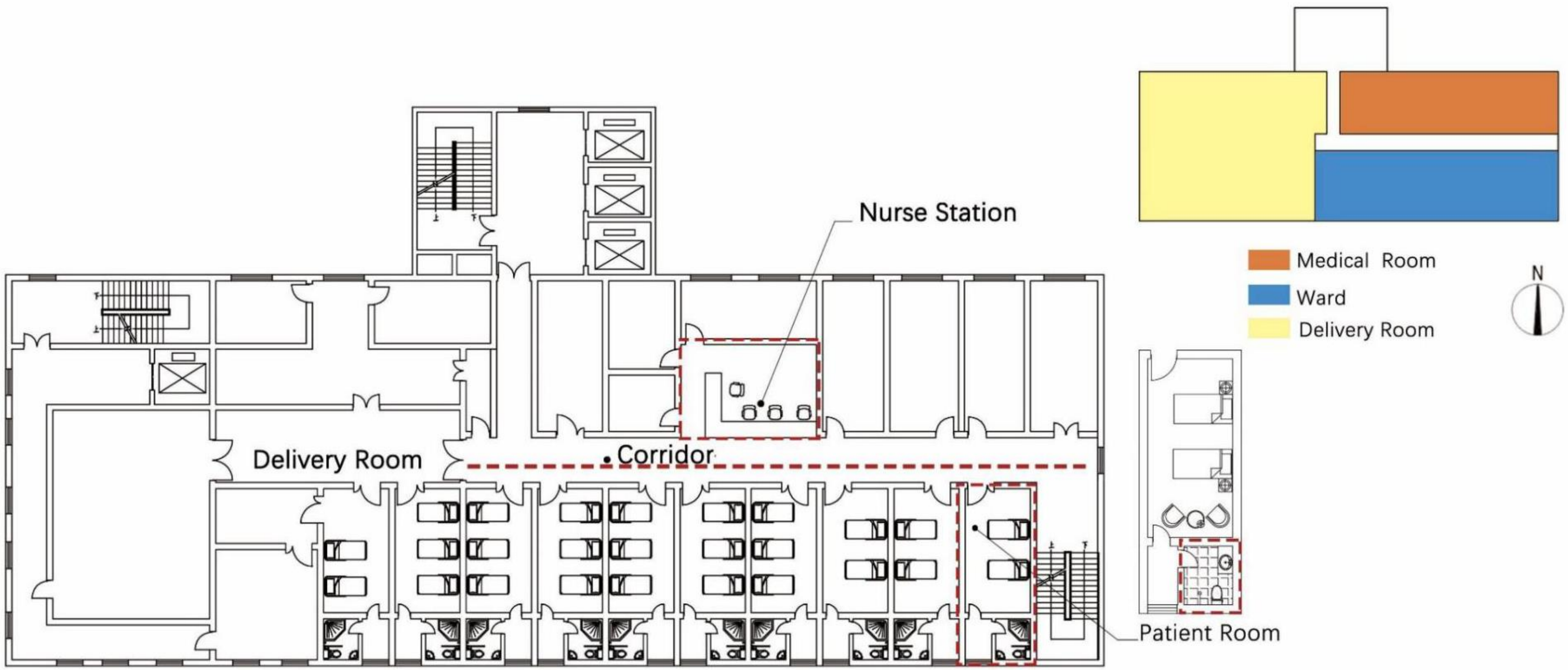


Figure 4.4 Hospital C: Centralized obstetrics plan (1085 square meter) with one pod is similar with Hospital B.

Review of these three plans shows that improving clinical staff depends greatly on the unit layout plan, e.g. the corridor form, the position of nurse station. More complex plans (Figure 4.2) provide different views need more viewing points than more simple plans (see Figure 4.3, 4.4). Hospital A is a relatively complex plan and is designed two branches that area A has more patient rooms than area B, but there is only a relatively large nurse station. Too long corridor seems to decrease the staff efficiency and add a roundtrip path, may not take care of the innermost ward in time. The design cores would reduce the path of cycle lines to decrease the walking time for distribution of medical and check rooms. The plan of hospital B is simple because this is a general hospital, which is the department of obstetrics on a smaller scale. The nurse station in the ward center is more convenience for staff to check patient rooms than near the entrance. However, the layout of the nurse station is unreasonable that the space is too small, and the furniture does not meet the needs of nurses, and the size of the nurse station at hospital C is relatively reasonable. The location of the delivery room is designed nearby the ward in the same floor the different from the independent of the hospital A. This depends on the size of the hospital and suggests that the most idealized object is to build a delivery room next to the operating room to handle emergencies quickly. This suggestion is made in the following interviews.

4.2.2 Observations in Obstetrics

The researcher observed the physical environment of three Obstetrics within 5 days and recorded by taking pictureswithout showing people face. The following findings were found in obstetrics that were further interviewed by clinical staff.

Figure 4.5 Observations in obstetrics.

• Obstetrics only has centralized nurse station (Figure 4.5 a).

Each nurse station consists of the inquire desk and treatment room and Hospital B also has head nurse office. The common feature of the nurse station in three hospitals are centralized no one has distributed substation. Hospital A only has two nurse station and the corridors is too longer that could affect the staff efficiency. The distributed substation could spend less time on medicine distribution procedure and spend more time in patient rooms (Gurascio-Howard & Malloch, 2007).

• The glass window in the ward's door is covered (Figure 4.5 b).

The door initially can be observed the situation in the patient room by the glass window. But then the glass window was covered by relatives to protect their privacy and prevent anyone from seeing the room inside the door. Whether it will affect clinical staff observation of the patient room requires further interviews with staff.

• The multi patient room do not have separate breastfeeding space (Figure 4.5 c).

The Obstetrical ward has a special behavior that the mothers need to be breastfeeding the baby in the room and how to protect the privacy of the mothers in the multi patient room. The researcher found that the curtain blocked the sight of the two adjacent beds and combined the beds into separate small spaces to help the mother complete breastfeeding. However, the space is too small, and it is worth considering whether it is necessary to build a separate private breastfeeding space in the multi patient room.

• Corridor without natural light (Figure 4.5 d).

The location of the Hospital B delivery room resulted in no natural light in the corridors. It can only rely on artificial light for illumination. Whether natural light can be replaced by artificial light, and without affecting staff efficiency.

4.2.3 Interviews

The researcher asked questions about the development of observations to further understand from the literature review and prepared for setting up the questionnaire. These problems will be discussed in the later chapter. The interviews were conducted with 10 clinical staff selected from three hospitals. A series of closed questions were divided six sections directly presented to participants, followed by open questions need to describe their demands of the workplace and put forward their suggestions (Table 4.2).

Table 4.2 Interview clinical staff records.

Interview____ Clinical staff		
Sections	**Questions**	**Answers**
A. Obstetrical Care Workflow	Q1. How long will you be at work?	·Day shift (A): 8.00-12.00am 2.30-5.30pm ·Morning shift: 12.00-14.30pm ·Swing shift (P): 5.30-12.00pm ·Night shift (N): 12.00-8.00am
	Q2. What is your daily work schedule?	Every day needs to check the room, deal with doctor's orders, make beds, distribute medical, listen to fetal heart rate, heart rate monitoring, newborn care, maternity care
B. **Obstetrical Layout Plan**	Q3. About the location of the delivery room in the layout?	·Hospital A is a separate layer ·Hospital B and C is located at the end of the layout ·The best advice is that the delivery room is opposite the operating room.
	Q4. What do you think of the scale of the corridor? Does it have an impact on staff efficiency?	·Need to be wider or Not sure ·The large flow of people in obstetrics ·Too narrow or too long could reduce staff efficiency
C. **Obstetrical Nurse station**	Q5. About the location of the nurse station? How can improve your work efficiency?	·The emergency room is near the nurse station ·Nurse station is located at the center to the ward ·Nurse station be close to the obstetrical entrance ·The doctor office is near the nurse station
	Q6. Do you have any suggestions on the design of the nurse station?	·Need more space ·Need two or three computers ·Need more cabinets
D. **Obstetrical Ward**	Q7. Is it necessary to set up separate breastfeeding spaces in a multi patient room?	·no need ·regarding the privacy of the mother, there is a circular orbit on the bed and the curtain is closed
	Q8. Is the glass window on the ward door covered by relatives affecting the staff observation?	·no impact ·need to open the door rather than see through the glass and conduct a one-on-one investigation
	Q9. Do you think that the location of the bathroom is close to	·no effect ·better to close to the corridor ·Close to the window will occupy the natural

	the corridor and will affect the staff to observe the patient line of sight?	light
E. **Obstetrical Physical Environment**	Q10. What about the natural light condition of the medical staff room or public activity space or ward?	·Staff office has natural light ·Corridor without natural light, depend on the artificial light ·Ward need natural light, baby needs sun exposure, reduce jaundice
F. Demand	Q11. What are the other needs of patients and their families?	·High demand for single rooms ·Obstetrical layout requires the provision of public toilets for use by visiting family members

When asked, ‘About the location of the delivery room in the layout?’ one doctor responded, ‘The delivery room of Hospital B is located at the end of the layout and close to the ward. Not only does the corridor lack natural light and it is inconvenient to require surgery. The anesthesiologist needs to come from downstairs and it will be a waste of time. So, the best advice is that the delivery room is opposite the operating room.’ When asked about nurse station, (1) some participants proposed that the nurse station be close to the obstetrical entrance to facilitate inquiry; (2) some participants think that the nurse station needs to take care of all wards; (3) the nurse station is close to the emergency room and the patient inside can be observed; (4) the nurse station is close to the doctor's office and is convenient for calling the bell; (5) nurses need 2-3 computers and 1 monitor. The number of cabinets is not enough, documents, cases, medicines, and instruments need to be placed; (6) clinical staff like to be surrounded to need privacy space. When asked, ‘Is it necessary to build separate breastfeeding spaces in a multi patient room?’ the participant said, ‘no need, taking into consideration the maternal physical condition, it is generally performed on a bed. Regarding the privacy of the mother, there is a circular orbit on the bed and the curtain is closed. Each bed has a curtain. Natural maternal mothers can get out of bed after 2h, Caesarean section can get out of bed after 24h.'

According to investigations and observations, it was found that glass in the middle of the ward had been affixed with paper by relatives. 'Is the glass window on the ward door covered by relatives affecting the staff observation?' According to the interview, the clinical staff felt that there was no impact because they need to open the door rather than see through the glass and conduct a one-on-one investigation. 'Do you think that the location of the bathroom in the obstetrical ward is close to the corridor and will affect the staff to observe the patient line of sight?' participant answered, 'no effect, but it is better to close to the corridor, and the window will occupy the lighting patient and need privacy.' The researcher asked the nurse about whether the family members were satisfied with the environmental facilities in obstetrics. One nurse pointed that families are now in high demand for single rooms and obstetrical layout requires the provision of public toilets for use by visiting family members.

The answers of clinical staff could give the researcher a better opportunity to understand more about their views on the layout of obstetrics and to establish questionnaires. The statements in the interview provided some views may contradict the results of the previous survey and will continue to be investigated in the questionnaires survey.

4.3 Questionnaires Survey

The survey used simple stratification and simple random sampling for clinical staff of the maternity department. First, the samples were divided into four groups: Hospital A, Hospital B, Hospital C and other hospitals. Then, according to simple random sampling, Hospital A, Hospital B and Hospital C issued the questionnaire directly on site, while other hospitals published the questionnaire online. A total of 100 samples were recruited in this survey and 84 responses were eventually received. The Participant Consent Forms were signed to indicate that collection data can be analyzed and then the original data was secret saved. The data was imported into computer analysis and presented as table or chart. Nurses made up 83 percent of the whole participants, doctor provided 17 percent. The questionnaire was divided four sections and all questions of questionnaire survey seen in Appendix Ⅳ.

4.3.1 Obstetrical Layout

In the first section, obstetrical layout shows the layout of space, including public space and indoor. Of the 84 samples surveyed, obstetrical layout of most hospitals was single corridor pattern, accounting for 69% of the total, three times that of the double corridor pattern. The minimum number of radical corridor pattern was only 3.6%, which was the same as the percentage of other models. (Figure 4.6). The table 4.3 illustrates relevant information of the different form corridors. According to the table, participants considered that 52.38% of corridors with natural light in all current forms of obstetrical layout and 47.62% of corridors without natural light. The single corridor pattern without natural light accounted for 35.71%, which was the highest figure among the all layout form, followed by single corridor pattern with natural light, 33.33%. In addition, the lowest proportion, 1.19%, belonged to radical corridor pattern and other pattern without natural light. Most participants believed the corridor width and length of the current obstetrics were moderation, represented 69.05% and 63.10% respectively. 15.48% of participants considered that the current corridor was narrow, while the corridor was believed too narrow and too spacious provided the same lowest one: 1.19%. As regard to the corridor length, the second highest figure provided 16.67% which participants thought the corridor was long, followed by 10.71% considered the corridor was too long, of which the proportion of double corridor accounted for 8.33% more than that of the single corridor.

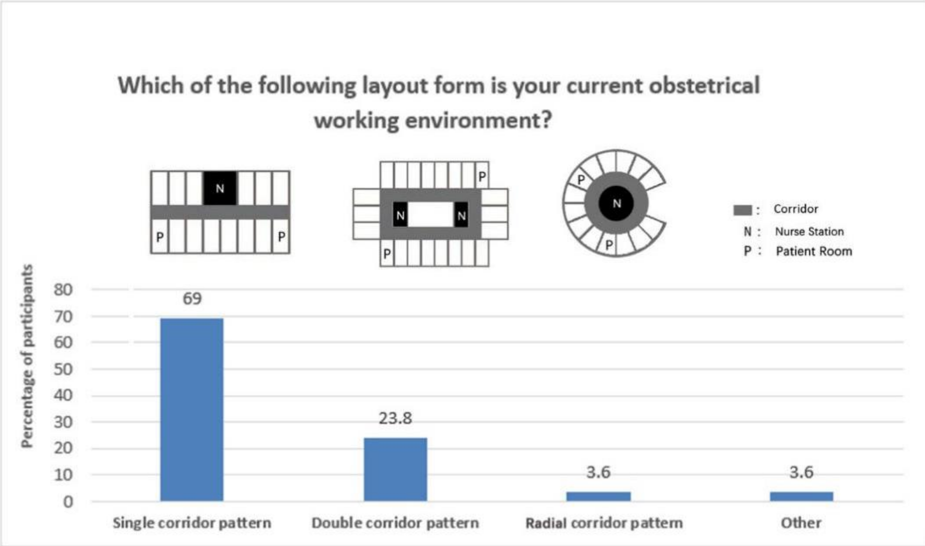


Figure 4.6 Statistics on obstetrical layout form.

Results on the effect of the width and length of the obstetrical corridor on work efficiency are shown in Figure 4.7. Most participants agreed that the corridor affected their work efficiency, with a width impact of 38.1% and a length impact of 45.2%. As can be seen from the bar chart, 33.3% of participants disagreed with the width and length of the corridor affecting work efficiency. Few participants strongly agreed that corridors affect work efficiency

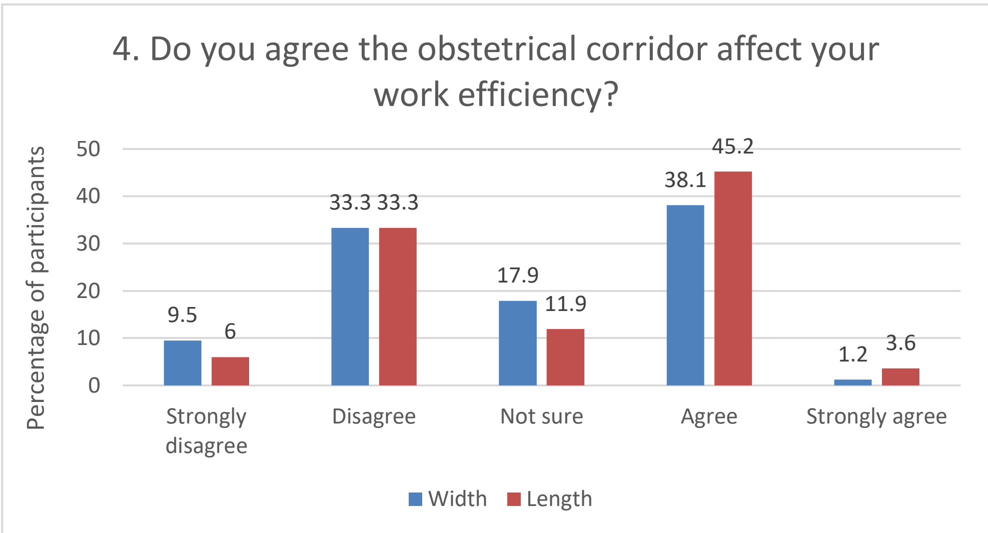


Figure 4.7 Statistics on the effect of the width and length of the obstetrical corridor on work efficiency.

Table 4.3 Corridor related data.

		Q1. Which of the following layout form is your current obstetrical working environment?				
		1.Single corridor pattern	2.Double corridor pattern	3.Radical corridor pattern	4.Other	Base
Q2. Are there any natural light in your current obstetrical corridor?	1.Yes, there are	33.33%	14.29%	2.38%	2.38%	52.38%
	2.No, there are not	35.71%	9.52%	1.19%	1.19%	47.62%
	Base	69.05%	23.81%	3.57%	3.57%	
Q3. How do you think the corridor width of your current obstetrics?	1.Too narrow	1.19%	0.00%	0.00%	0.00%	1.19%
	2.Narrow	13.10%	1.19%	1.19%	0.00%	15.48%
	3.Moderation	47.62%	16.67%	2.38%	2.38%	69.05%
	4.Spacious	5.95%	5.95%	0.00%	1.19%	13.10%
	5.Too spacious	1.19%	0.00%	0.00%	0.00%	1.19%
	Base	69.05%	23.81%	3.57%	3.57%	
Q4. How do you think the corridor length of your current obstetrics?	1.Too short	1.19%	0.00%	0.00%	0.00%	1.19%
	2.Short	8.33%	0.00%	0.00%	0.00%	8.33%
	3.Moderation	48.81%	9.52%	2.38%	2.38%	63.10%
	4.Long	8.33%	5.95%	1.19%	1.19%	16.67%
	5.Too long	2.38%	8.33%	0.00%	0.00%	10.71%
	Base	69.05%	23.81%	3.57%	3.57%	

4.3.2 Obstetrical Nurse Station

The second section was a series of obstetrical nurse station questions. Figure 4.8 describes the current and staff favorite obstetrical nurse station pattern. For the obstetrical nurse station currently surveyed, the linear pattern was the largest, with 52.4%, the figure for U shape pattern represented 33.3%. However, U shape pattern accounted for 56% of staff favorite nurse station, followed by Arc shape pattern, 26.2%. The linear pattern provided only 16.7%. There were staff presented need more cabinets in nurse station during the inform interview. The researcher investigated whether need more cabinets meet the needs of staff (Figure 4.9). Up to 46.4% of staff believed that current cabinets cannot meet the needs of their work. Conversely, there were 38.1% staff considered that can satisfied their demands.

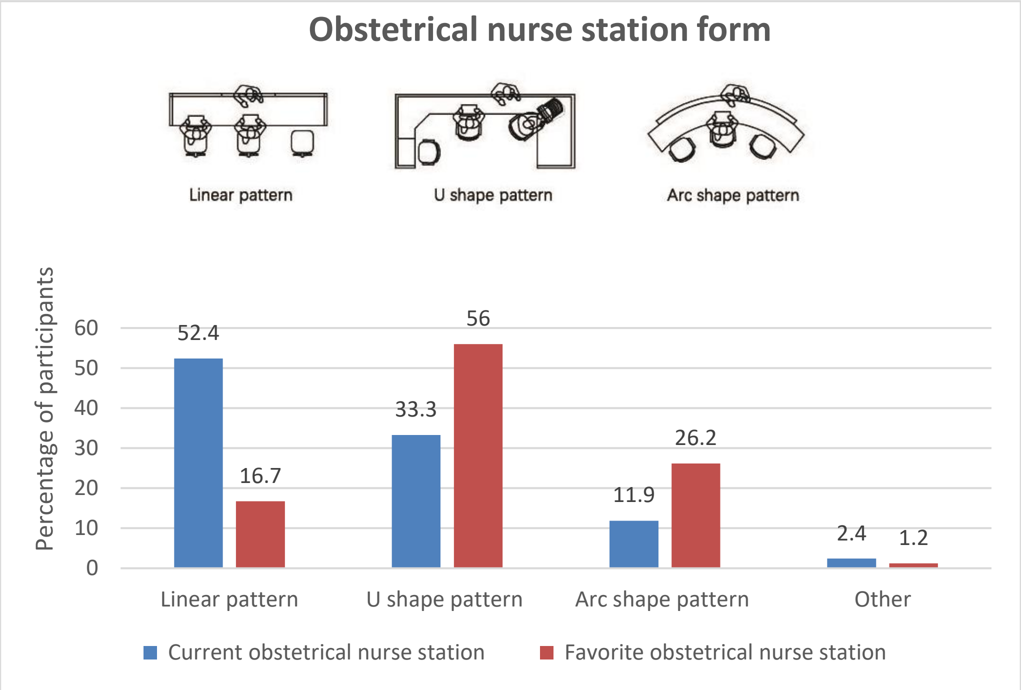


Figure 4.8 Statistics on current and staff favorite nurse station form.

The color of the nurse station and the ward is too bright and easy to be irritating, which is not conducive to physical and mental relaxation, so choose a color with low saturation. Figure 4.10 statistics on the favorite color of staff of nurse station and ward. Pink was the highest percentage, accounting for 35.7% in nurse station and 42.9% in ward. The second higher proportion was light blue, which only slightly lower than pink in the staff favorite nurse station, accounting for 34.5%.

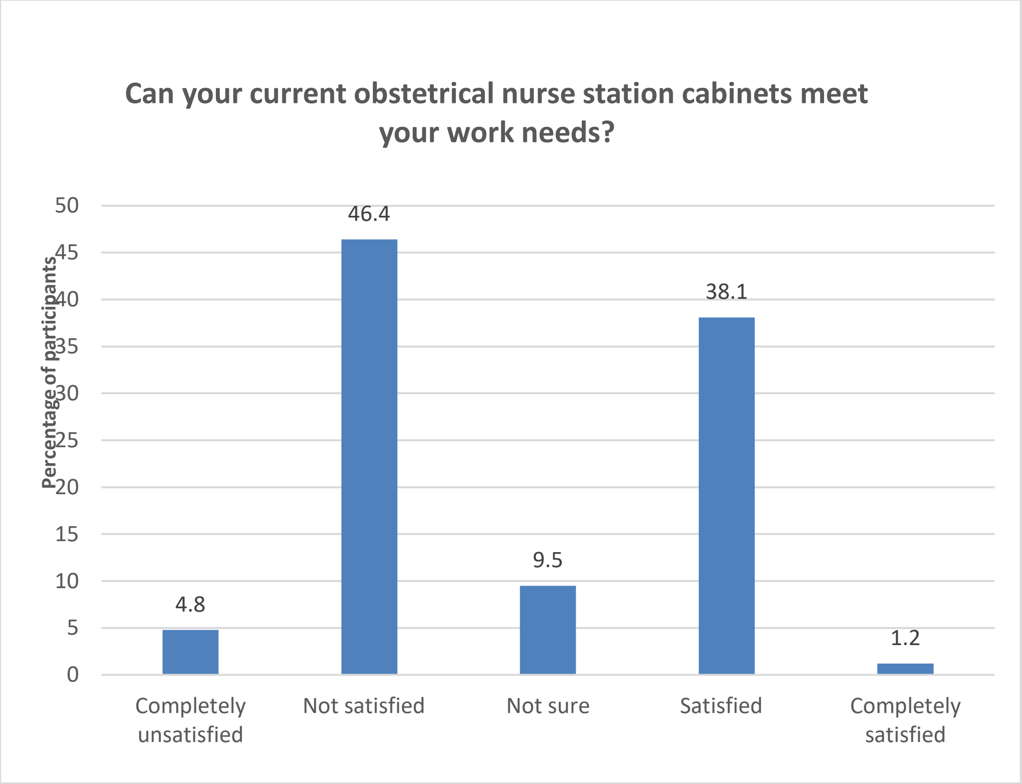


Figure 4.9 Statistics on obstetrical nurse station cabinets demands.

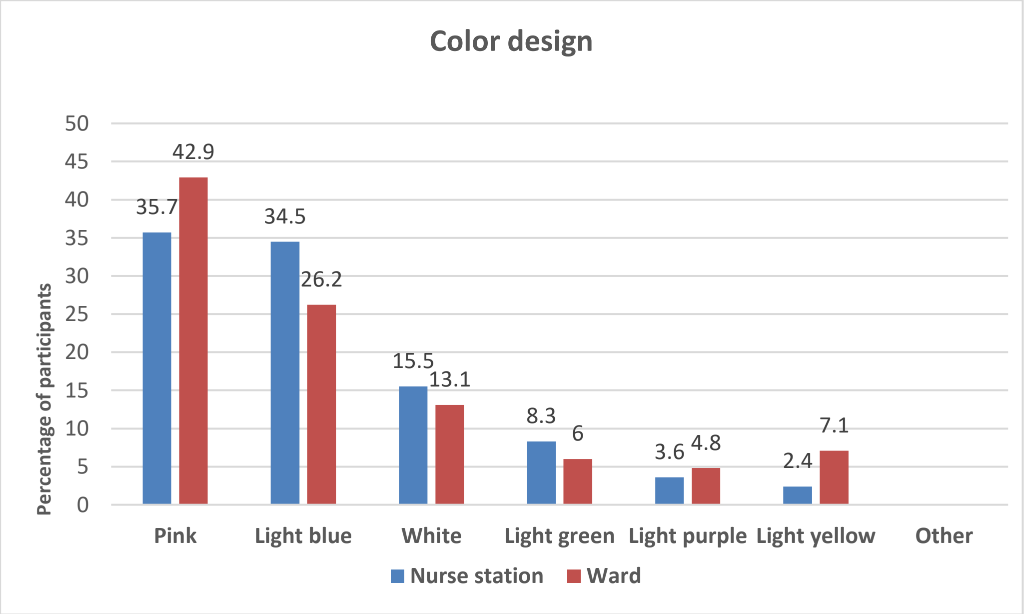


Figure 4.10 Statistics on staff's favorite color of nurse station and ward.

4.3.3 Obstetrical Ward

Obstetrical ward conducted questionnaires survey for clinical staff. Patient and family member currently have high demand for single rooms according to interviews. Then, there were 78.6% staff considered two patient lives in one obstetrical room most reasonable (Figure 4.11), which was the highest percentage among the five options. 15.5% of staff chose one patient living in one room. The other votes were relatively low.

The multi-patient room was whether need to set separate private breastfeeding space (Figure 1.12). Staff believed that private breastfeeding space was the largest proportion, accounting for 58.3%, followed by completely required accounted for 29.8%. Not required and not sure represented lower percentage, 7.1% and 4.8% respectively.

Figure 4.13 contains the location of the bathroom in the obstetrical ward is close to the corridor whether will affect the staff to observe the patient line of sight. 32.1% of participants considered no effect whereas there were 31% that believed have an effect. There were 28.6% of participants showed not sure.

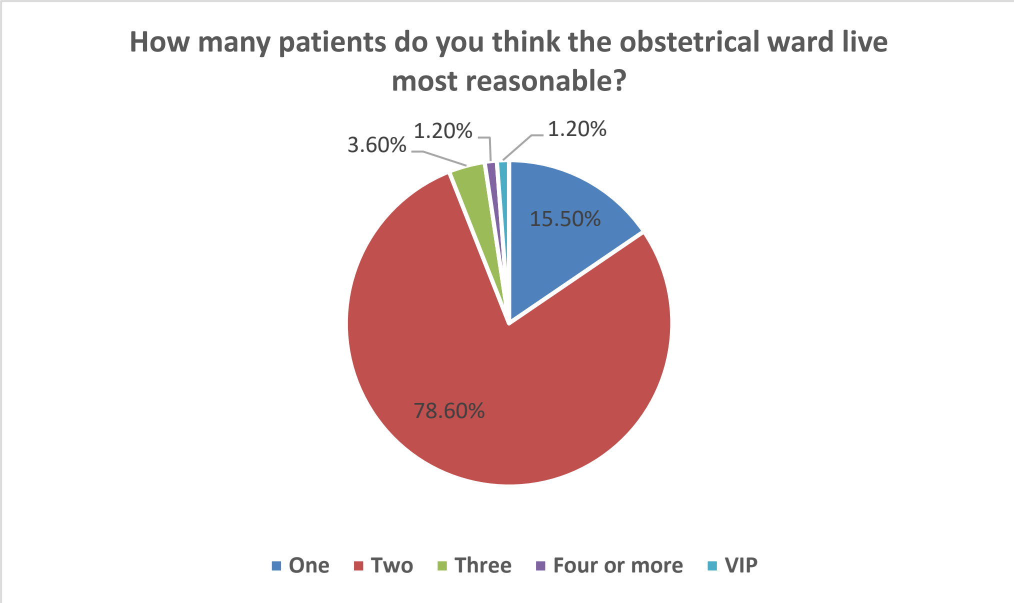


Figure 4.11 Statistics on the most reasonable number of patients on ward.

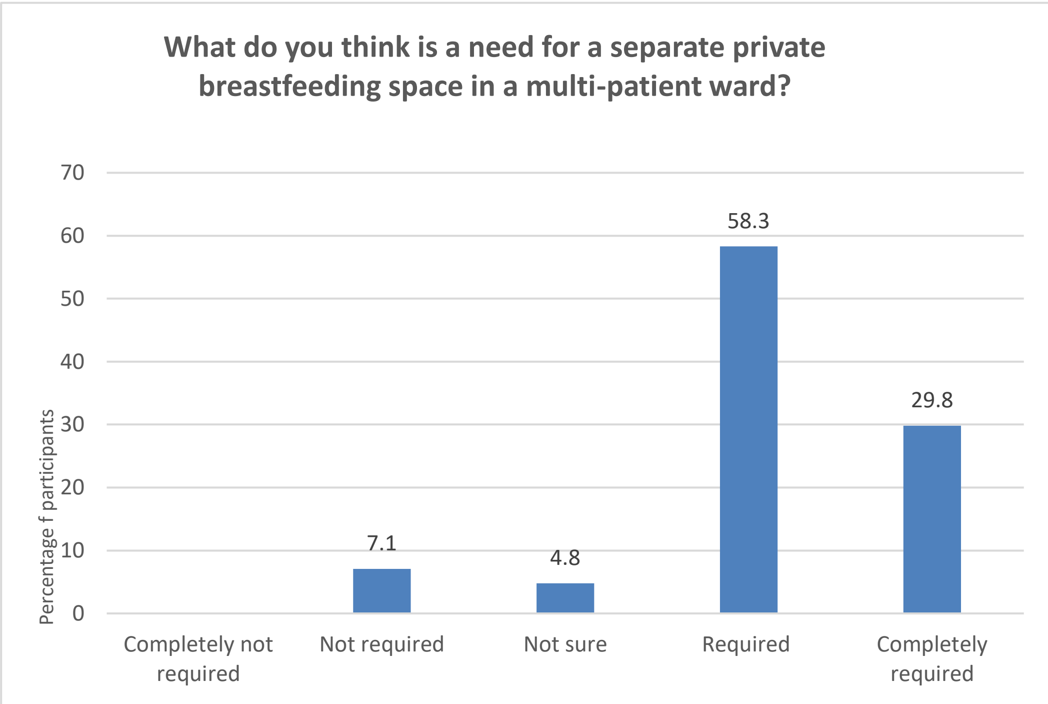


Figure 4.12 Statistics on whether need to set separate private breastfeeding room in a multi-patient ward.

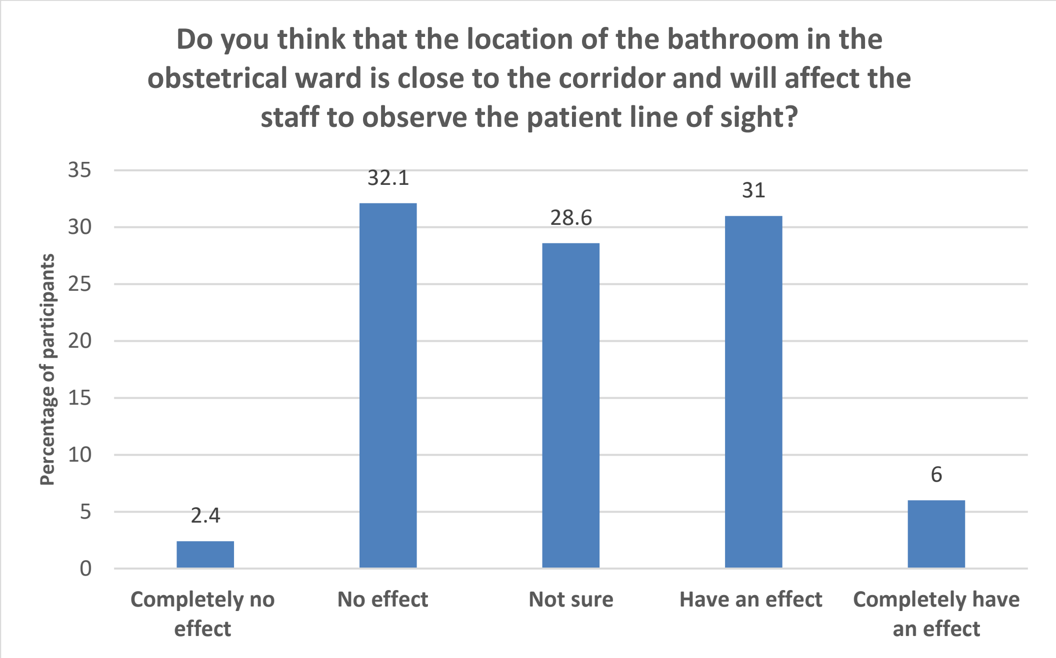


Figure 4.13 Statistics on the location of the bathroom in the obstetrical ward is close to the corridor whether will affect the staff to observe the patient line of sight.

4.3.4 Some of Issues

The researcher listed some issues of improving efficiency and asked staff whether they agreed to them, which were rated from strongly disagree to strongly agree (Figure 4.14). These issues were divided into three sections and a total of 18: obstetrical layout, nurse station and obstetrical physical environment (Table 4.4).As can be seen from the chart, most staff agree or strongly agree with these issues, but few staff disagree or strongly disagree. For instance, the third issue the delivery room is located at the end of the entire plan. 10.7% of staff showed disagree. 4.8% of staff disagree that nurse station is around to provide some rest waiting space and the percentage of staff provided 1.2% expressed strongly disagree. If corridor without nature light, artificial light can be used instead. There were 10.7% staff not sure and disagree accounted for 7.1%, strongly disagree represented 2.4%, which could without nature light affect their work efficiency.

Table 4.4Issues of obstetrical for improving staff efficiency.

Sections	Issues
Obstetrical Layout	1. Corridors have natural lighting
	2. The office space of the medical staff has natural lighting
	3. The delivery room is located at the end of the entire plan
	4. The delivery room is set up staff, patient and sewage passage
	5. Emergency green channel keep unblocked
	6. The drug has a separate streamline
	7. Sewage passage leads directly to the polluted area
Nurse Station	8. The doctor's office is near the nurse station
	9. The emergency room is near the nurse station, and allow staff to observe the patient inside
	10. Nurse station is located at the center to the inpatient area
	11. Nurse station is around to provide some rest waiting space
Obstetrical Physical Environment	12. Corridor without natural light, artificial light can be used instead
	13. Ensuring indoor artificial light is soft
	14. Setting special observation light and night light for clinical staff
	15. Ensuring indoor natural ventilation
	16. Improving ward doors and windows sound insulation
	17. Setting a mute mark in the corridor
	18. Adding green plants indoors

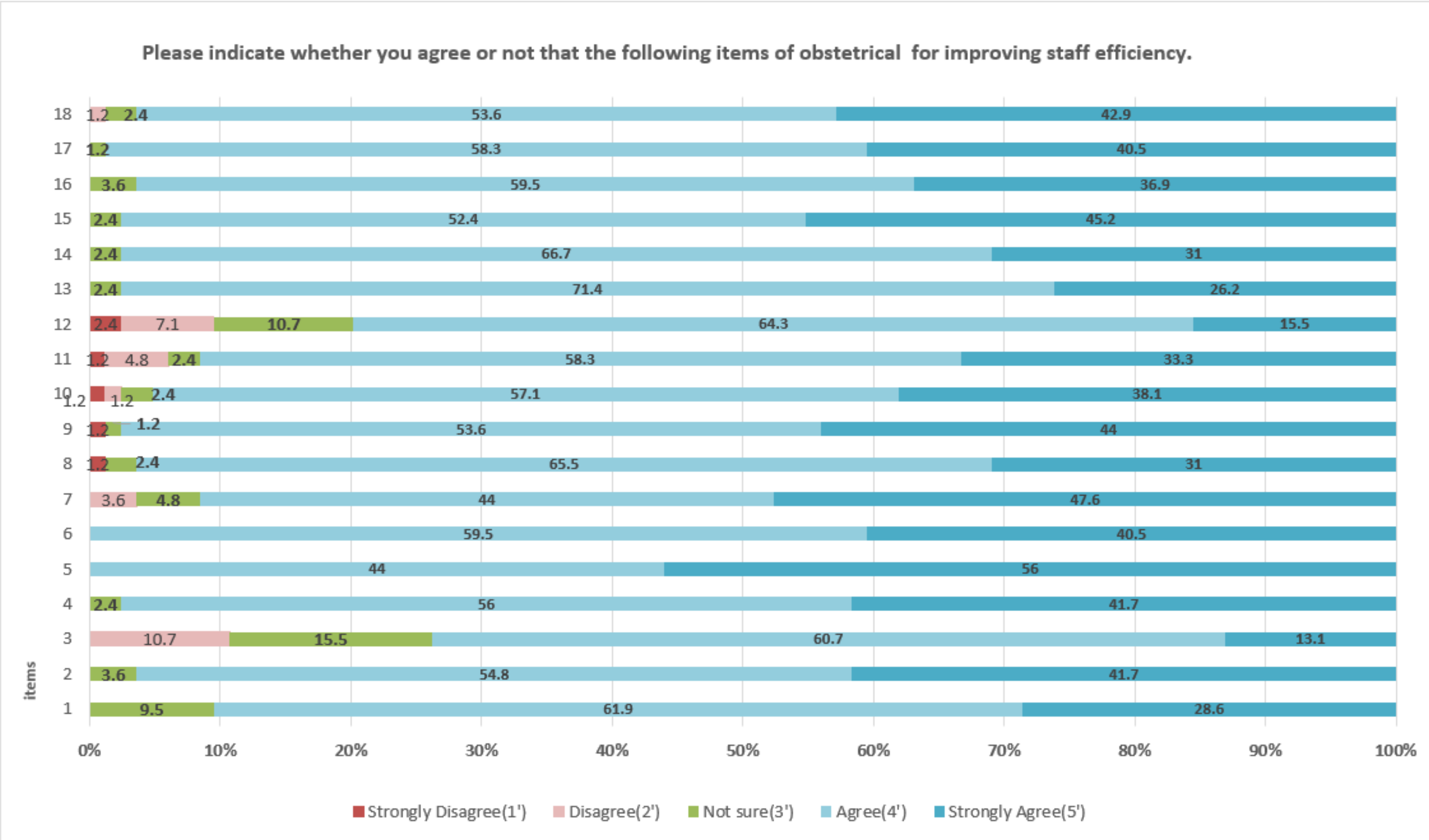


Figure 4.14 **Statistics on five degrees of consent for some of items of improving employee efficiency.**

4.4 Simulation

The plans of the three hospitals investigated were conducted with software simulation analysis based on space syntax. In the present study, three plans only analysed interior space excluding all furniture and doors and focused on the influence of the spatial layout plan of obstetrical nursing units on clinical staff efficiency, to improve the work environment. Using space syntax theory to compare three plans could help to acquire design strategies for future hospital design that enhance staff satisfaction. The study presented visual properties of a layout includedVGA and Isovist, and simulation human behavior conducted Agent Analysis.

4.4.1 Visibility Graph Analysis (VGA)

The VGA presents several properties about visibility relationships between spaces in the study. The layout plan was divided into numerously small grids, and each of the grid spacing that 0.5m (hidden grid in Figure 4.15-4.20). Each grid can be treated as a node of a highly connected graph. Connectivity measures the number of spaces immediately connecting a space of origin (Hillier, 1988).

Figure 4.15 shows visibility graphs with connectivity values of three hospitals, each color in the plan represent different values for connectivity. According to the value of connectivity, from high to low, divided into ten numerical segments corresponding to 10 colors, the redder of color that the value is higher whereas the bluer of color that the value is lower. As can been seen from the graph, corridors of three hospitals all have higher connectivity (reds and oranges) than the other locations. The actual simulation results should refer table 4.5. By contrast, Hospital A has the highest average level of connectivity (C=272.80), although the areas of red colors look like less than those of Hospital B and C, it has two vertical corridors, has more areas of warm colors. Compare with three hospitals, the maximum connectivity value (C=1581) was the location of two vertical corridors intersect in hospital A. In real space systems, the higher the connectivity value of a space, the better the space accessibility. Three hospitals were single corridor layout, the room on both sides were isolated presented low connectivity values (blue). In contrast, Hospital A has more the areas of dark blue than others, concentrate on the areas of bathroom and balcony. Hospital B and C the areas of dark blue were focus on bathroom because they without balcony. Therefore, bathroom and balcony have poor connectivity.

The visual integration values for Hospital B (VI=4.73) was the highest compared to Hospital A and C (VI= 4.40 and 4.69) possible depend on single corridor and shallow layout. The hospital A has two vertical corridors with the lowest degree of integration (Figure 4.16), but as a specialized hospital, more integration was expected. A highly integrated space is highly accessible, and the degree of integration measures the potential for space to attract traffic. Likewise, the corridor is easier to attract attention to the line of sight compared to other locations. The design of the corridor as the bridge connecting the space and the main traffic space is very important. The length and width of the corridor will affect the line of sight of the surrounding environment. Depth exploration the corridor of different lengths could lead to impact on visual. The plans of Hospital A were simplified and transformation. The new plan consists of two spaces and a connecting channel, then stretches the plan channel to a new plan (Figure 4.17).Comparing the two plans found that the length of the channel has a great influence on the property of visual integration the of whole system. When the channel is short, the channel is the place where the line of sight is the highest level of integrated in the whole system, the average value (VI=22.60) was higher than plan A1 (VI=18.16). It is very convenient to see the situation of two spaces in the channel sever as a function of observation not only as a traffic channel. When the channel is stretched to a very long condition, the visual integration value of the channel is significantly reduced, and as soon as the channel is out of the line of sight, the visual integration value immediately increases. The channel itself becomes a more independent space only as a connection function.

Table 4.5Spatial properties (C: Connectivity, VI: Visual Integration [HH], VCC: Visual Clustering Coefficient, VSDNS: Visual Step Depth of Nurse Station)

		Hospital A	Hospital B	Hospital C
C	**Average**	272.80	214.67	211.56
	Minimum	0	17	5
	Maximum	1581	879	772
VI	**Average**	4.40	4.73	4.69
	Minimum	1.48	2.37	2.03
	Maximum	9.68	9.00	8.71
VCC	**Average**	0.80	0.78	0.75
	Minimum	0.36	0.35	0.36
	Maximum	1	1	1
VSDNS	**Average**	2.06	2.416	2.09
	Minimum	0	0	0
	Maximum	4	5	5

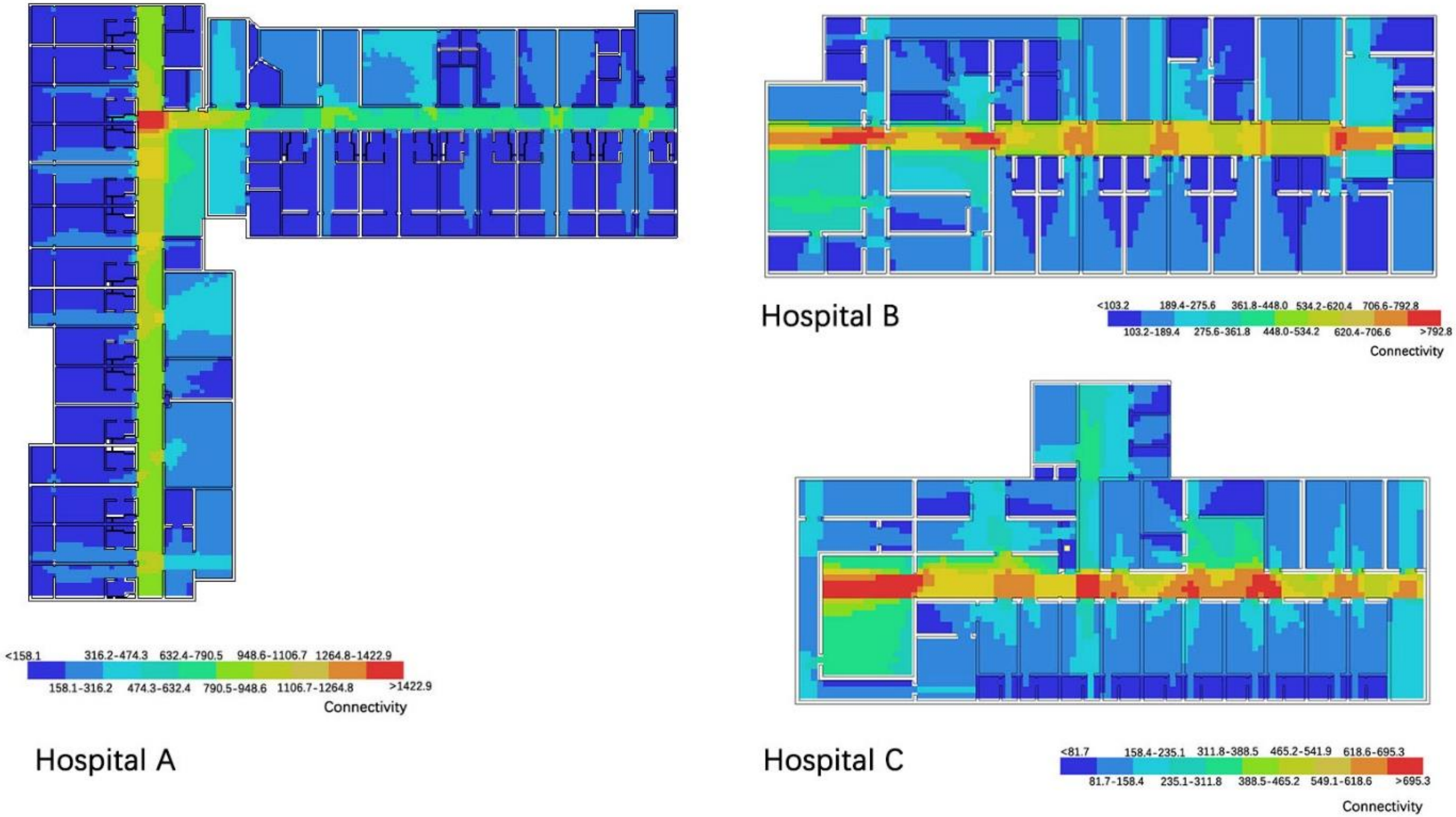


Figure 4.15 Visibility graphs with connectivity values of three hospitals.

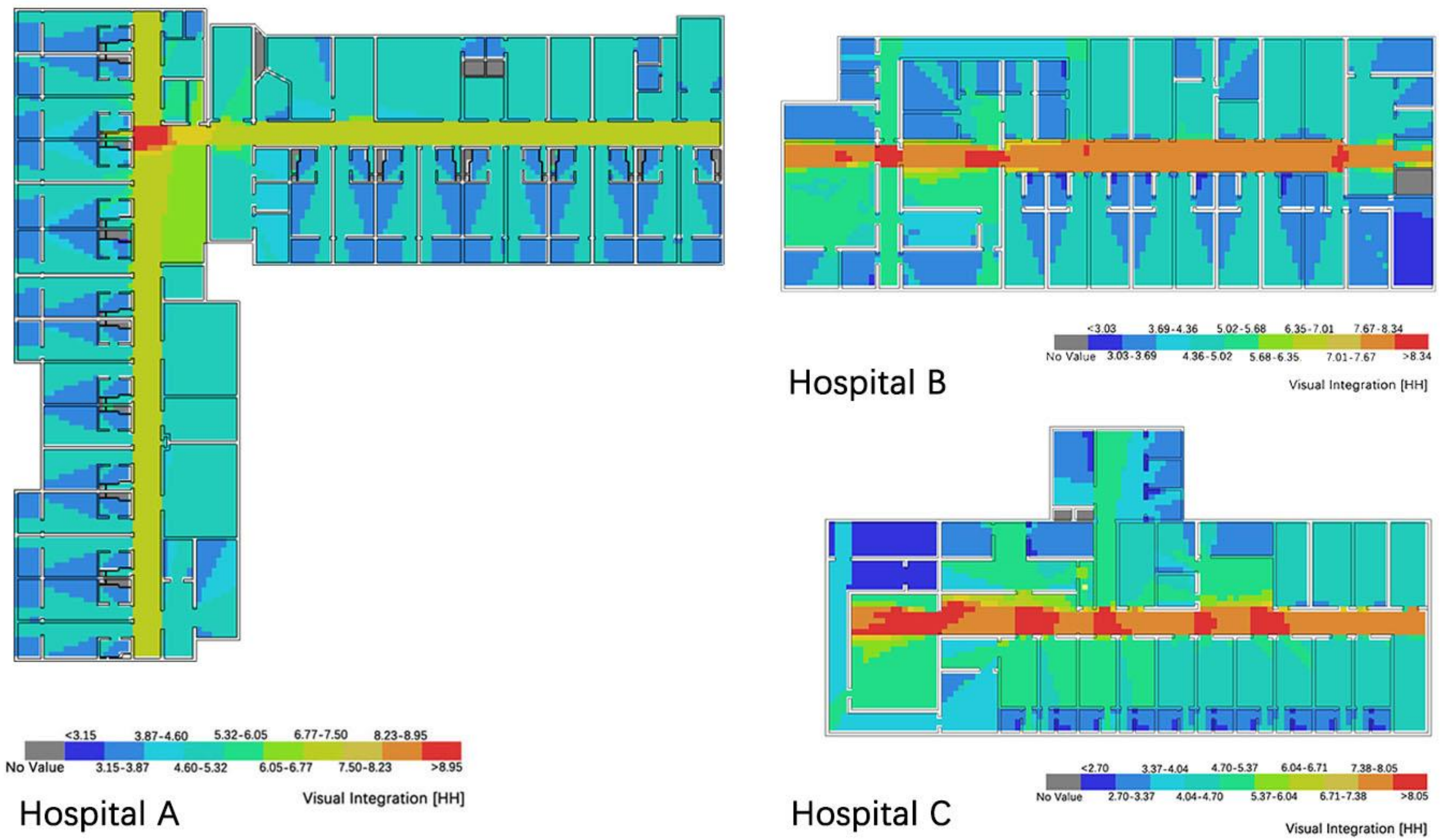


Figure 4.16 Visibility graphs with visual integration [HH] values of three hospitals.

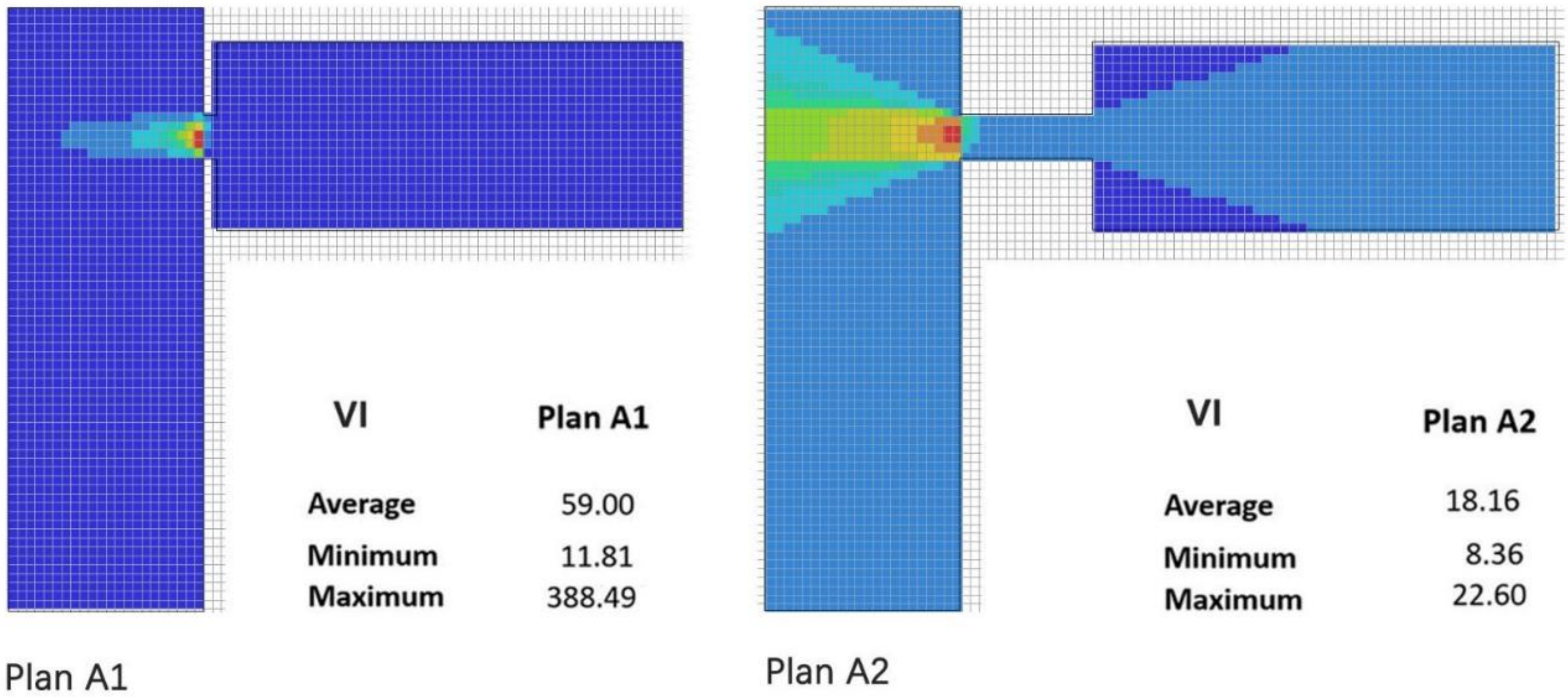


Figure 4.17 Visibility graphs with visual integration [HH] values of two plans.

Figure 4.18 illustrates that visual clustering coefficient that the limits of the visual effects of spatial boundaries. The redder area shows the more intense sheltered that the more visually limitation of the spatial boundaries around it. Conversely, the closer to the blue area means this grid suffer less sheltered that the spatial boundaries have less limitation. The nurse stations of the three hospitals were in bluish-green area, with less sheltered space to easier be found. The location of the bathroom in the ward has an influence on the line of sight. The bathrooms of Hospital A and B are close to the corridor that block the view of the ward from the outside, while the bathroom of Hospital C have no effect on the line of sight because it close to the exterior wall. According to Table 4.4, the highest VCC value is Hospital A (VCC=0.80), because the spatial boundaries of the bathroom and balcony have a strongly limitation. Most of the corridors were in the bluish-green area, except for a few areas that appear red in hospital A, which the vision hard to see requires the installation of monitors to prevent accidents. However, the redder of color also represent more privacy in the space. The designer should consider what behavious need to set private space.

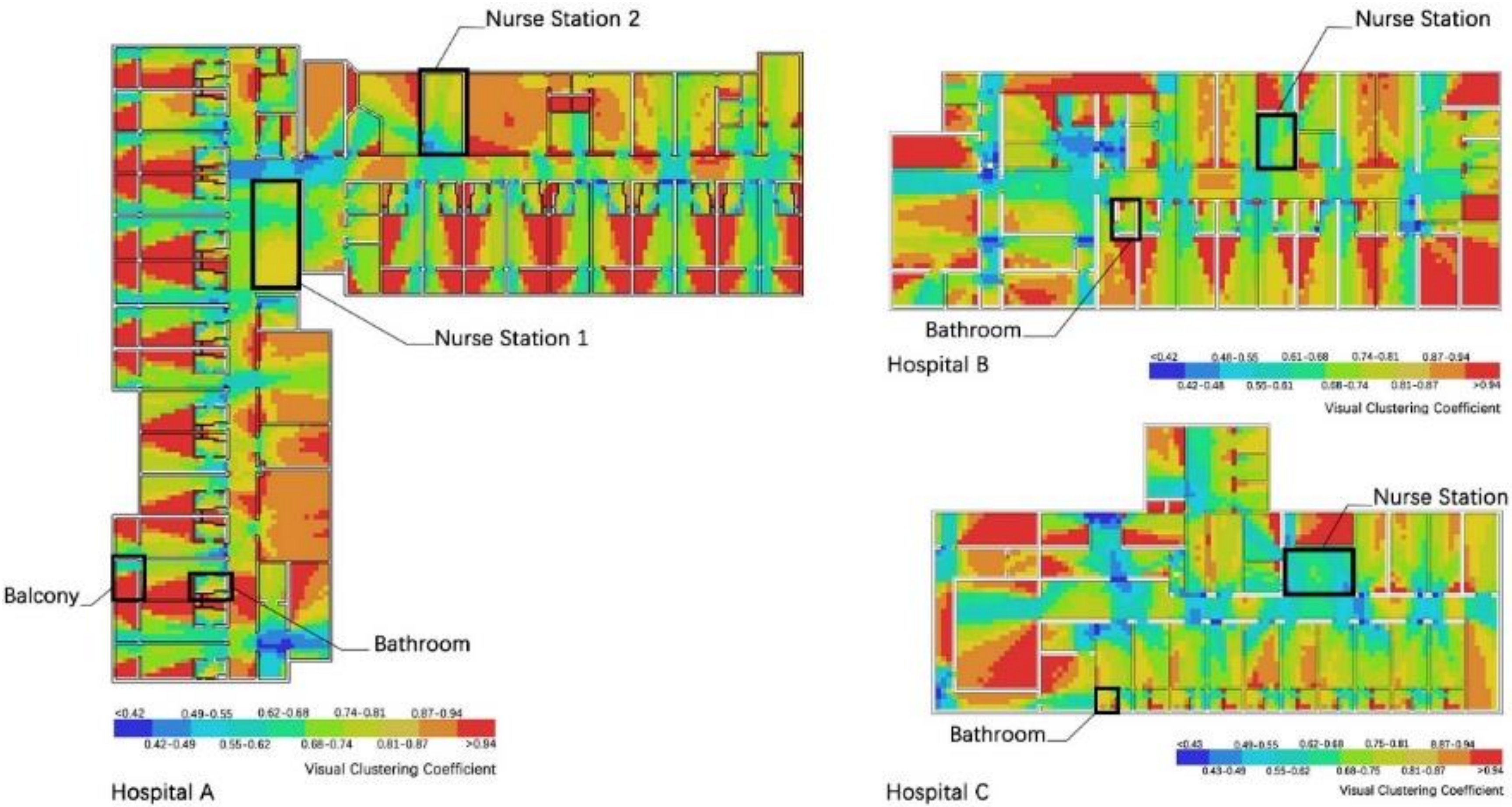


Figure 4.18 Visibility graphs with visual clustering coefficient values of three hospitals.

Figure 4.19 contains looking outward from nurse stations (highlighted in blue) and go through several lines of sight for any other grid in the plan. Hospital A only need to go through four visual step depth values and VSDNS average values is the lowest, 2.06 (Table 4.4), and connectivity is the highest among the three hospitals, indicating that A hospital plan is shallower and accessible because it has two nurse stations to observe the ward of two areas separately. Hospital A was assumed to has only nurse station 1 or 2 and the plan was calculated again. The distribution of color in the plan changed significantly (Figure 4.20) and the visual step depth average values also increased. Only the value of nurse station 1 was 2.45 and only has nurse station 2 the value was 2.62, while two nurse stations were combined the value was sharply reduced to 2.06 (Table 4.5). The smaller the value of VSDNS represent the easier to see the whole plan and the higher the spatial accessibility. The different areas of nurse station can cause the different results. To decrease VSDNS value could increase the number of nurse stations or change the areas are depend on the different plans.

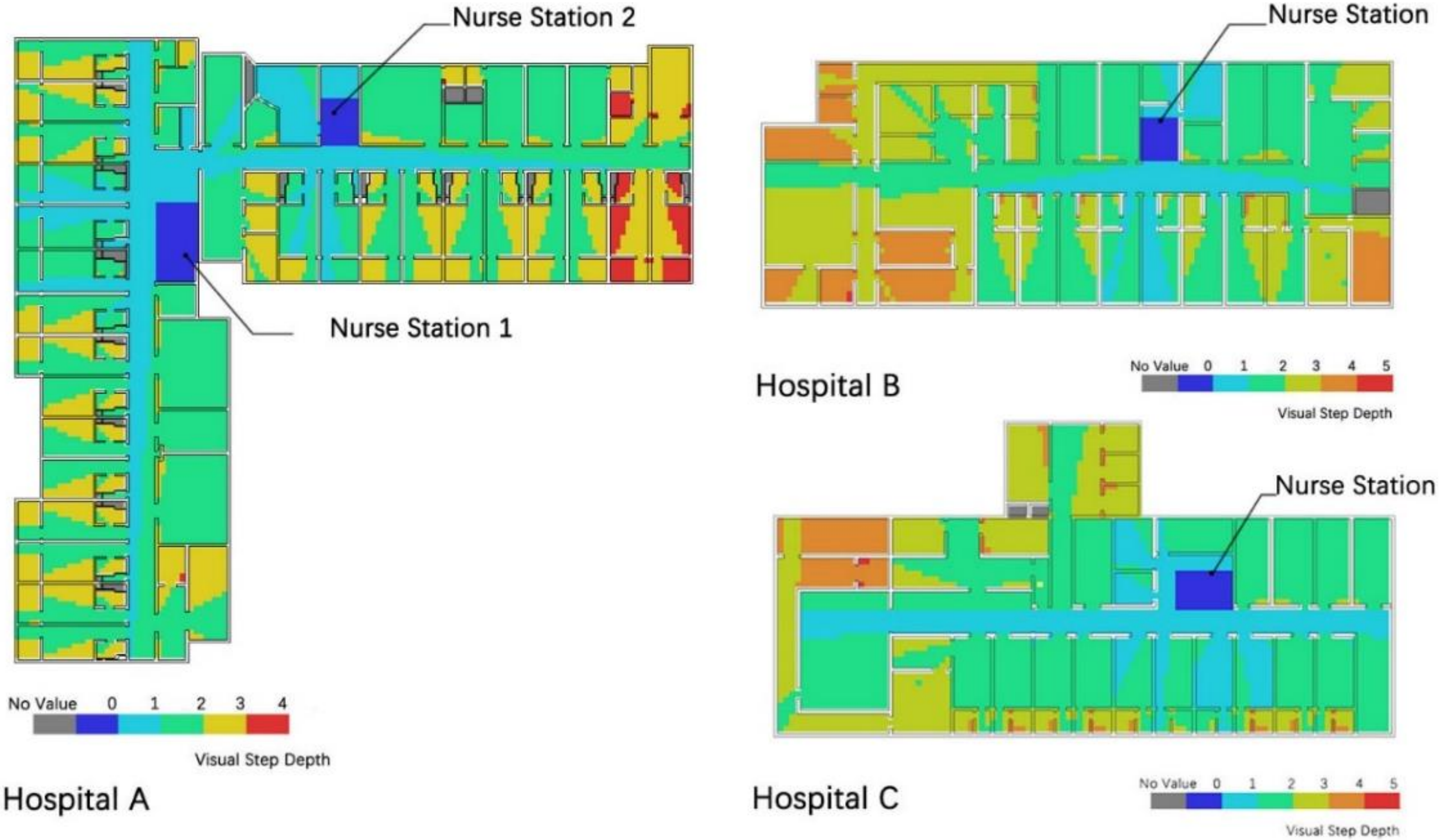


Figure 4.19 Visibility graphs with visual step depth values of three hospitals.

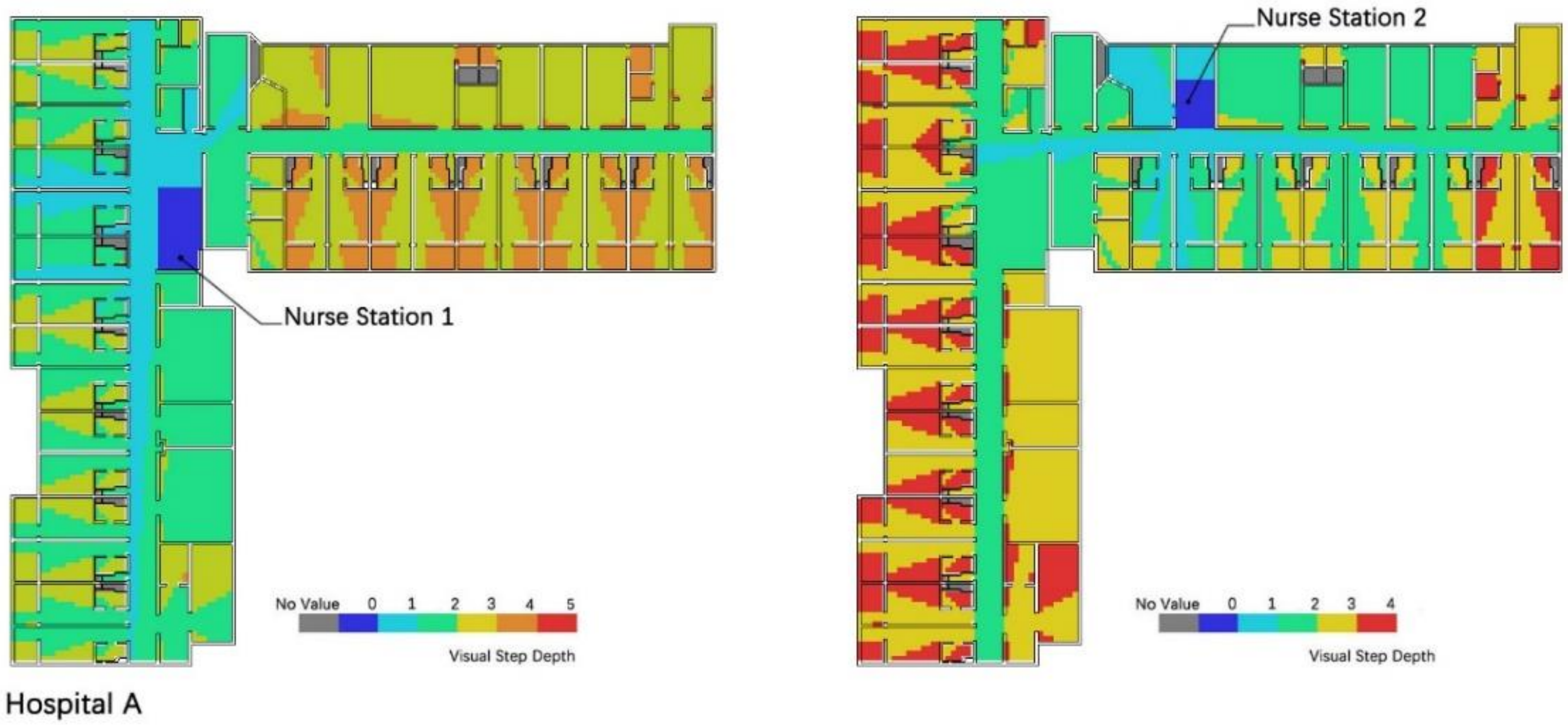


Figure 4.20 Visibility graphs with visual step depth values of two nurse stations in hospitals A.

Table 4.6 Spatial property: Visual step depth values of two nurse stations (VSDNS) in hospitals A.

	Hospital A	Nurse station 1	Nurse station 2	Nurse station1+2
VSDNS	**Average**	2.45	2.62	2.06
	Minimum	0	0	0
	Maximum	5	4	4

4.4.2 Isovist

Isovist is a set of sights at all points of a 2D polygon seen from a certain point in space through a certain angle and its shape and size may change with location. The properties of isovist are quantified that pure geometric properties (such as area, perimeter) can be extracted (Benedikt, 1979).Table 4.6 shows average values of isovist properties of three plans. Due to the different sample size of the analysis in this study, the isovist area and perimeter may be affected by the plan area. The APR (Isovist area/ Perimeter ratio) has universal characteristics and could compare different sizes of buildings. Apparently, Hospital A average APR values (1.03) more than those in Hospital B and C (0.86 and 0.81) and was similar level of Isovit Drift Magnitude. The maximum radial was the largest visible distance in Hospital A, which was 16.83 meters, while the Isovist Occlusivity value was the smallest. Occlusivity (O) measured in meters is the length of the open edges of the isovist dimension, and OPR determined the ratio of Occlusivity and perimeter, which can represent no unit. The OPR of Hospital A was the lowest average value among three cases, 0.42, thereby indicating that plan shallower.

Conversely, Hospital C has the highest mystery that could easier hide (OPR=0.51).

Table 4.7 Average values of spatial properties (IA: Isovist Area, IP: Isovist Perimeter, IAP: IA/IP, IDM: Isovit Drift Magnitude, IMaxR: Isovist Max Radial, IMinR: Isovist Min Radical, IO: IsovistOcclusivity, OPR: IO/IP)

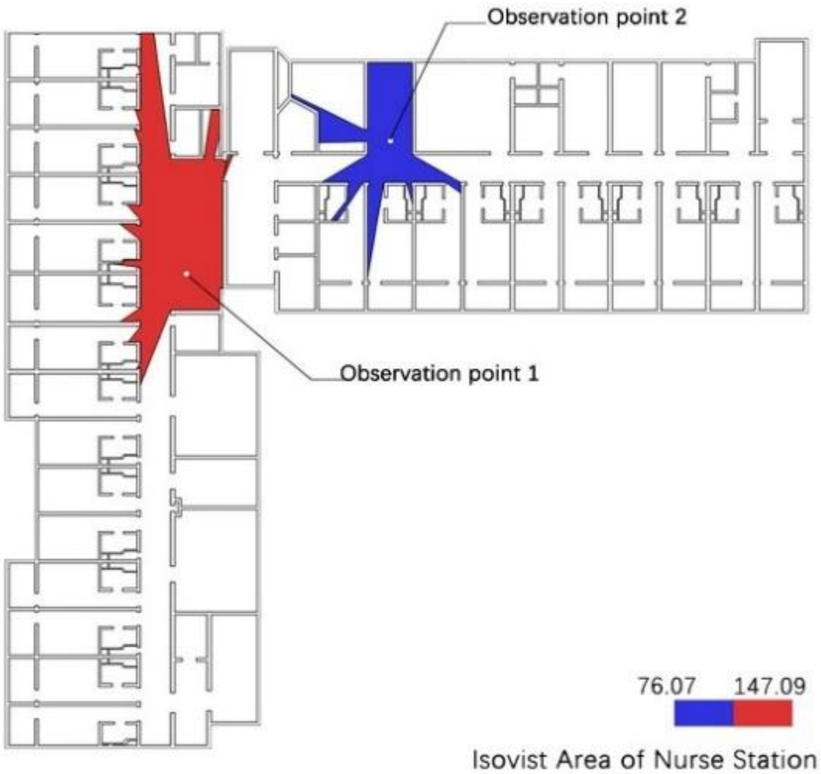
	IA (㎡)	IP(m)	APR	IDM(m)	IMaxR(m)	IMinR(m)	IO(m)	OPR
HospitalA	**67.43**	65.41	1.03	4.46	16.83	0.76	27.79	0.42
Hospital B	**52.85**	61.48	0.86	3.81	15.96	0.72	29.25	0.48
Hospital C	**52.8**	65	0.81	3.83	15.34	0.71	33.29	0.51
Avg	**57.69**	**63.96**	**0.90**	**4.03**	**16.04**	**0.73**	**30.11**	**0.47**
SD	**8.43**	**2.16**	**0.11**	**0.37**	**0.75**	**0.03**	**2.85**	**0.04**

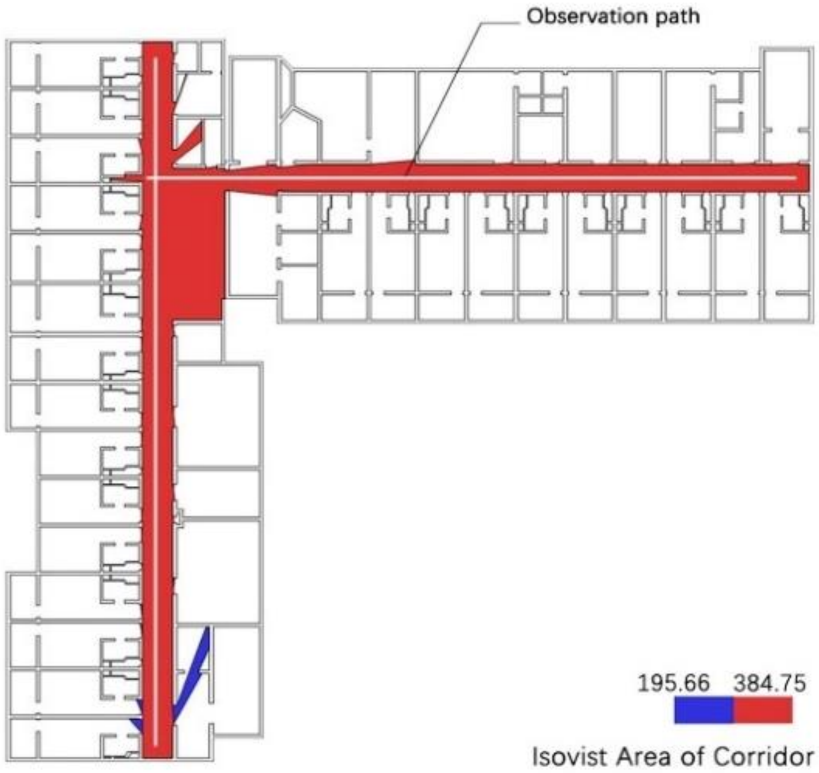
This study explored the depth of sight in specific areas at nurse station and corridors on each plan. Selected the best observation points for clinical staff of nurse station or created an observation path in corridors in three hospitals respectively to calculate 2D isovist maps and spatial properties (Figure 4.21). Visual can be chosen full isovist (360 degree) was going to be created at the point have located. The isovist properties were measured from nurse station and corridor in three hospitals (Table 4.7). Compared with the nurse station, the corridor has the stronger spatial experience, the higher level of area and perimeter and the maximum radial visible distance. In the corridor can see shorter values of radiation and OPR than in nurse station, thereby clinical staff daily work in the corridor experience the greater exposure and fewer mysteries. In contrast, the space of nurse station requires more opportunity to hide because of protect the privacy of staff.

Five properties were comparatively analyzed, including APR, Isovit Drift Magnitude (IDM), Maximum radial (IMaxR), Minimum radial (IMinR) and OPR. The nurse station and corridor in Hospital A have relatively high APR, IDM, and maximum radial distance from walls because it has the largest building footprint of the three plans, and that two vertical areas of layout cause the longest distance from the viewing and gravity. However, it OPR value was the lowest level among samples indicating the space more exposed. The location of nurse stations at Hospital A was close to traffic space has a lower level of occlusivity, compared with the nurse station in Hospital B was in the centre of ward has the highest level of mystery and it was not so easy to find. The IDM and IMinR of the nurse station at Hospital B were significantly lower than that of the others, shows hidden and narrow.

Table 4.8Isovist properties from nurse station and corridor in three hospitals.

		IA (㎡)	IP (m)	APR	IDM (m)	IMaxR (m)	IMinR (m)	IO (m)	OPR
Hospital A	**Nurse Station**	**111.58**	**101.95**	**1.09**	**3.05**	**17.61**	**2.67**	**49.58**	**0.49**
	Corridor	**321.42**	**242.38**	**1.33**	**21.15**	**61.09**	**0.73**	**88.52**	**0.37**
Hospital B	**Nurse Station**	**47.54**	**69.97**	**0.68**	**0.69**	**10.03**	**1.7**	**59.97**	**0.86**
	Corridor	**185.44**	**193.29**	**0.96**	**13.02**	**49.92**	**0.85**	**103.68**	**0.54**
Hospital C	**Nurse Station**	**78.55**	**129.12**	**0.61**	**2.02**	**12.39**	**2.3**	**86.69**	**0.67**
	Corridor	**100.04**	**125.48**	**0.80**	**1.78**	**22.84**	**0.8**	**72.59**	**0.58**
Avg		**140.76**	**143.70**	**0.91**	**6.95**	**28.98**	**1.51**	**76.84**	**0.58**
SD		**99.70**	**63.12**	**0.27**	**8.29**	**21.31**	**0.84**	**20.00**	**0.17**


Observation point 2
Observation point 1
76.07
147.09
Isovist Area of Nurse Station


Observation path
195.66
384.75
Isovist Area of Corridor

Hospital A

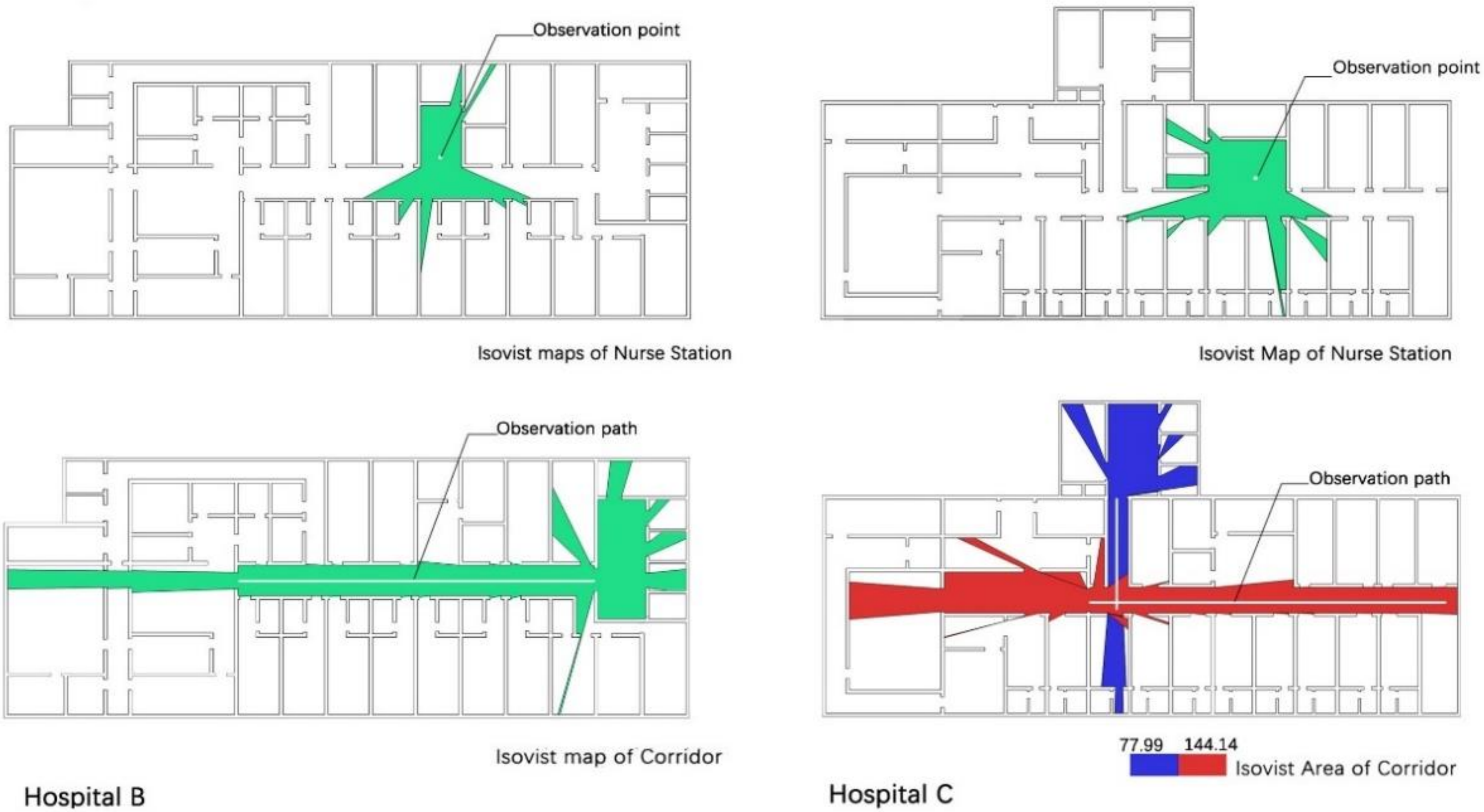


Figure 4.21 Isovist maps from two specific areas of three hospitals.

4.4.3 Agent Analysis

The study focuses on spatial layout to improve clinical staff efficiency. Concerned about the design of the space plan meanwhile also consider the impact of human behavior on space. It is difficult to study current human behaviors or social activities because it is not only affected by the physical environment but also suffer from other external factors. Turner (2002) designed a building model to simulate a natural movement using agents automatic choice for visual feature of the environment. This simulation can be implemented using agent analysis tools in the Depthmap. The agent model without considering other external factors contribute to better understand the cognitive basis of natural movement and standard individual sports behavious and response to space activities. The researcher observed three hospitals which space agents were easier to accessible and compared with the real world spatial functions with human behavious.

The experiment traced 50 agents after a fixed period (1000 steps), the number of agents per time step was 0.1. The tracking of the agent path was recorded, and the typical agent of the path image was shown in Figure 4.22. More agent paths represent this space for easier access. The agent tracking was compared with the connection between the three hospitals, regardless of whether the real space conforms to human behavior. As can be seen from six maps, most of the trace path concentrate on corridors, indicating the corridor is the area where people are most frequently activities and the results of connectivity are similar that the color shows warmer. The nurse stations of the three hospitals were in the red highlighted part of the map, and the tracking path was also relatively more than other areas, indicating that its space was more accessible and can be seen more easily it meets the needs of the nurse station design. However, the nurse station 2 at Hospital A has fewer tracking paths than the adjacent space on the right side, and the nurse station can be moved to the right at design time. The agent activities may be related to the size of the door opening or space. The limitation of this simulation that not consider the space function could cause some space has much agent paths but less times to access in the reality. Observing the wards of three hospitals found that the number of agent paths in many patient rooms was similar and would not cause a lack of attention due to their location away from the center of the plan. The clinical staff cannot ignore any patient room in the real work. In the real work, the clinical staff will check room on time and not overlook any patient, so the corridor should not be too long to improve staff efficiency.

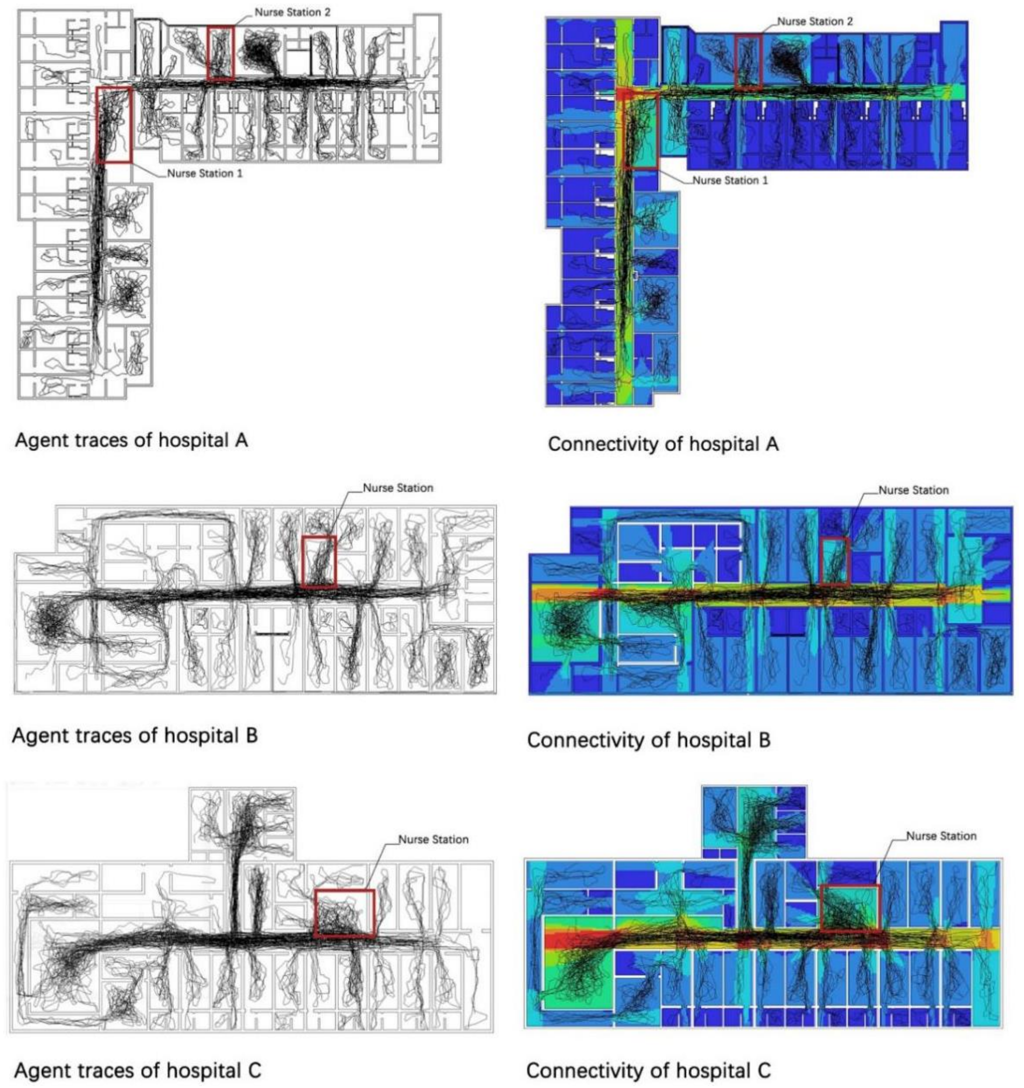


Figure 4.22 A comparison between agent traces and connectivity among three hospitals.

The software cannot tell the designer what to do, but the test floor plan can provide more evidence to support the design in a more accurate way. Based on these simulation results about connectivity, space management could be considered in the early design process rather than the stage of construction. For example, the space needs to be designed in a semi-closed pattern, and the limited effect of the spatial boundary can be measured by using the characteristics of the simulation display visual clustering coefficient. In addition, no space arrangement can prevent emergency escape routes. Based on the calculation results given by the software combining with the designer experience, the actual effect of line of sight shield can be corrected to achieve line of view control. Furthermore, visibility simulation helps architects to arrange the space with the best view as background, and could figure out the public, private space.

CHAPTER Ⅴ. DISCUSSION

5.1 Interpretation of findings

The study concerning on the impact of the spatial design on clinical staff efficiency to improve the work environment contributed to increasing the staff satisfaction. The efficiency and effectiveness of care is crucial to the hospital's social characteristics and patient safety. Evidence shows that spatial layout and environmental factors may lead to increasing staff pressure and increasing risk of error. Base on analysis of the results of investigation and simulation, some contradictory findings were found. The possible explanations for the expected and unexpected findings are speculated below: (a) The length and width of corridor on the impact of work efficiency and the layout of corridors at domestic and abroad were discussed;(b)The form of nurse station;(c) The effect of layout on clinical staff's observation of patient line of sight;(d) The improvement of ward space; (e) Physical environment such as light and noise on the impact of staff pressure. The results of this study were compared with other studies. Then, staff psychological and social problems have an influence on layout design, and the researcher discussed how to design the layout to influence staff efficiency and mood. Finally, the limitations of the current study were discussed.

5.1.1 Corridor

Bardram and Bossen (2005) pointed out that clinical staff were highly mobile and needed to communicate with each other, they must arrive at different locations to acquire information or resources (materials and tools).Clinical staff spenta large amount of time walking every day, thus the corridor design is crucial to reduce the degree of unnecessary mobility(Yousefi, 2011). The study by Hendrich, Chow, Skierczynski, and Zhenqiang (2008) found that nurses spent less time on patient care activities and spent more time on documents, nursing coordination, and drug treatment. In previous studies, walking had been identified as the nurse primary time consumer, and evidence suggested that nurses need to spend more time on patient care activities. The researcher paid special attention to the corridor and proposed a series of questions about the influence of corridor length and width on staff efficiency. The results of the questionnaires survey showed that most of participants considered their current corridors were moderation regardless of length and width, but many staff believed corridor affect staff efficiency, of which 45.2% of the respondents reported that the length of the corridor has effect on staff efficiency and 38.1% of that believed that it affected by the width. The simulation results also confirmed the size of the corridor cause the significant influence on the visual integration of the entire system. Surprisingly, the corridors of three hospital were measured to different size and corridors at Hospital A were apparently longer and wider than others, but it may be that most staff in the hospital without this awareness that the different sizes of the corridors could bring different experiences. The staff perception of the size of the corridor may be related to the location of the city, the size of the hospital, the economic situation, the needs of the person, and the personal experience (Lee et al., 2017).

Previous studies have shown that the type of unit layout, for example, light, single corridors, and double corridors, may affect the amount of nursing staff walking (Shepley, 2002; Shepley & Davies, 2003).Interestingly, the results of the survey showed that the current obstetrical work environment was the highest proportion of the single corridor, accounting for 69%. These findings indicate that most hospitals were in the form of single corridor in China, but according to the literature review, most of the surveyed staff in other countries prefer to work in radial units. (Ulrich et al., 2008). Sturdavant (1960)pointed that walking to the patient room in the radial units was reduced because nurses were better able to observe the patient from the nursing station, although the average time spent on the patient and the radial unit in the single corridor design were the same. Y. Lu (2010) conducted a simulation using ArcGIS version 9.2 platform that measure the number of beds seen from any location within three units and targeted visibility analysis for radial, single corridor, and double corridor units. The results found the radial was the best form. The reason why the layout of radial in China is not common may be related to cost, structure and concept (B. He, 2008). The number of beds in a radial unit is restricted by its plan form. In a radial system, the functional requirements and area requirements of the core area are relatively fixed. Therefore, increasing or shortening the size of the radial plan will bring about space waste and this is the contradiction between its round shape and the square functional room. Moreover, the form of possible radial unit is too limiting, and most architects are reluctant to adopt this form. Most hospitals in China at present use single corridor form in large numbers. In pursuit of better lighting conditions, but the limitation of is inefficient. When clinical staff walks to the end of the corridor, they need to return all the time, which means that the actual path will be doubled. Thereby, how to improve staff efficiency through layout design is a question worth exploring.

5.1.2 Nurse station

• The size of the nurse station

The size of the nurse station is directly related to the number of nursing beds, and the sizes of the nurse stations in the three hospitals studied are different. With the increase in the number of beds, the size of the nurse station should increase. Most form of nurse stations are divided into linear pattern, U shape pattern and Arc shape pattern. The questionnaires findings showed that currently the linear pattern was the largest but U shape pattern was staff's favorite nurse station. A possible explanation for this might be that the limitation of space size or shape. The U pattern has a semi-surrounding feature that can provide staff with a sense of security and a certain privacy space, even though the nurse station serves as a place for centralized communication. On the question of the cabinets demands, the staff mentioned that they needed more cabinets during the interview. The survey also found that 46.4% of employees felt that the current cabinets could not meet the demand. The cabinets can be used to store documents, cases, medicines, instruments etc. The architects may need to consider the needs of staff and protect their privacy when designing.

- Nurse station position and room layout

The results of the interviews and the questionnaires found that the position of the nurse station was contradictory. Some participants considered nurse station was located at the center to the ward, but others believed that be close to the obstetrical entrance. The same question was asked in the questionnaires survey. More than half (57.1%) agreed that nurse station was located at the center to the ward area. It seemed that these results were due to more convenience for staff to care about the whole ward area. However, the nurse station is close to the entrance of obstetrics to facilitate visitor inquiry. This finding suggested that the architects need to build comparisons based on actual conditions to decide which forms improve staff efficiency. The most important relevant finding was that the emergency room and doctor office should be near the nurse station.The efficiency of the actual care of the staff is increased by improving the layout of the room design. The inefficient room is kept away from the nurse station, architects trying to reduce the actual walking of the staff and reducing the distance between the most remote patient room and the nurse station.

- Nurse station centralized and distributed substation

The three hospitals had centralized nurse stations. Observation found that staff constant walking between the nurse station and the ward and often required to carry instruments caused increasing the extra workload.According to the researcher visiting some of larger hospitals in China, a detection instrument was placed in the corridors of several obstetrical patient rooms to allow staff to use them directly. Instead of the instrument being transported from the nurse station to the ward, then return to the nurse station. This greatly saves the walking time of staff and improves the efficiency of care. Prior studies have noted the importance of distributed substation.The purpose of the distributed substation is to bring the nursing team closer to the patients. A study on surgery department compared traditional centralized nursing stations with a new innovative distributed substation included the number of times access the patient room, nursing staff activities, and patient care times (Gurascio-Howard & Malloch, 2007). The new model consists of a centralized central station and a distributed substation between every two wards. It is equipped with a desktop computer, a tablet computer and two telephones to facilitate nurses to directly care for patients. It was found that the nurse at the centralized nurse station spent 28.9% of the time on the corridor, compared with only 6% to 12% of the distributed nurse in the corridor (Burgio, Engel, Hawkins, mcCorick, &Scheve, 1990; Gurascio-Howard & Malloch, 2007). The limitation of nurses in the distributed substation was that they need to spend more time communicating with other team members. Hendrich et al. (2008)pointed out that the location of supplies was also very important. Distributing and placing supplies near the nurse station could reduce staff walking. Several reports by comparing staff time spent in centralized and decentralized medicine systems found that the use of decentralized medication delivery times was reduced by more than 50%(Hibbard, Bosso, Sward, & Baum, 1981; Reynolds, Johnson, &Longe, 1978).

From the perspective of patient care, the advantages of a distributed substation outweigh the disadvantages. Distributed substation could spend more time in the ward and less time waiting in the nurse station and walking the corridor. Nurse in the distributed substation visiting the ward more frequently can better monitor the patient's condition and safety. However, nurse in the distributed substation feel a lack of contact with co-workers and less information exchange opportunities.

From the perspective of cost and staff management, clinical staff and centralized equipment at the centralized nurse station are suitable for small units. Although it could waste unnecessary time, it is beneficial to save costs and convenient communication between colleagues'. The placement of partial instruments or medicine in the corridor and the distributed substation could improve the efficiency of the staff, but it increases the unit's cost allocation, waste and pollution of medicine. This is more suitable for large units and needs to consider how to manage all supplies and equipment within the organization.

5.1.3 Visual influence

The bathrooms in Hospital A and B wards were located close to the inner corridor, but Hospital C ward bathroom was near the outer wall. Visual clustering coefficient values were measured using Depthmap simulation found that the bathroom was close to the corridor caused shield to the staff observation of the patient views from the outside, while it near the exterior wall has no effect on the sight. Interestingly, the participants in the questionnaire considered that the bathroom close to the corridor had no effect on the observed line of sight, which accounted for 32.1% of the total. This result also needs further exploration may be need a bigger sample size. A possible explanation for this might be that clinical staff felt that there was no impact because they wanted to observe the patient. They could not look across the door and needed to open the door for a one-on-one check.

The position of the bathroom in the ward is generally divided into two forms, one near the inner corridor and the other near the external wall. The most common method is the entrance of wards. Most of this design is likely to have a beneficial orientation with the ward and no occupy of the natural light. The arrangement of the bathroom along the exterior wall may be have no impact on the observation by clinical staff, or to avoid sunlight from the west. Another possible explanation for this is that the plan form such as in the radial plan, due to the lack of interior wall space, the bathroom also had to be arranged along the exterior wall.

In a similar situation, the ward glass door is covered by family members to protect their privacy and prevent other views outside the room. It is important to patient privacy for patient-centered care. The importance of visibility has been noted in prior studies. A study has shown that the ICU distributed substation has local visibility and does not increase nurse walking distance (Figure 5.1). Nurses can clearly see patients from each substation, but they cannot be seen from corridors that can protect the privacy of the patient and improve the efficiency of staff (Seo et al., 2011). These layouts of distributed substation and using partition walls to block views are worth learning. The researcher mentioning this point here is to hope that the architects can more accurately judge the advantage and disadvantage of various ways in the design to improve staff efficiency.

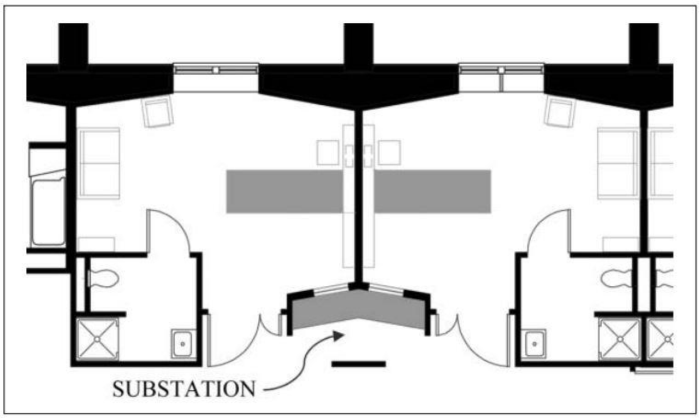


Figure 5.1 Distributed Substation for direct observation (Seo et al., 2011).

5.1.4 Ward

The environment of the ward is particularly important that staff often enter this place and patients stay for a long time for treatment and recovery, and relatives also come to visit. To improve the environment of ward is not only contribute to the patient health, but also help staff indirectly reduce the pressure and improve efficiency. The special behavior in the obstetrical ward is the mother need to frequently breastfeed the baby. Observation found that between two beds have a curtain isolation when patient conducted nursing or breastfeeding. The curtain blocked views between patients in two adjacent beds. However, curtains cannot surround the entire bed. When there are visitors in the room, it is inconvenient for the patient breastfeeding the baby. Whether it is necessary to build a separate private breastfeeding space in a multi-patient room is a question that may be worth being considered. The nurses interviewed showed that it is not necessary because of considering the post-partum women are physically weak, breastfeeding is usually performed in bed. An unexpected questionnaire found that most staff believe that private breastfeeding space was needed. It is hard to explain this result, but it might be related to protect the patient privacy while not considering the space size and cost. If the ward space is too small, a circular orbit could be used, and the beds could be surrounded with curtains, but this may result in a small enclosed space.

Clinical staff points out that patient and their families have increased demand for single room. As mentioned in the literature review, single room can decrease the risk of infection and reduce the need for patient transfer and better communication with staff (Page & ebrary, 2004). By increasing segregation capacity and promoting cleaning of rooms and maintaining air quality, single room can reduce air transmission, contact transmission and water transmission of acquired infections (Ulrich et al., 2008).Janssen, Harris, Soolsma, Klein, and Seymour (2001)who studied the obstetrical single patient room, indicated that privacy was stronger, equipment and supplies were more accessible, noise levels were reduced, and quality of care was higher. SHCC pointed out that patients with high privacy needs to avoid double rooms unless specifically requested by the operator. In addition, the ward should provide a pair of adjacent negative pressure isolation chambers with an anterior chamber to avoid the possibility of infectious diseases (SHCC, 2014).One unanticipated finding was staff preferring the double room accounted for 79% of the total, while single rooms only accounted for 15%. These results may be explained by the fact that staff considered the double room is more convenient to manage than single one, which can reduce their work pressure and provide a beneficial environment for patient to accompany each other so that they are not alone. Another possible explanation for the needs of patients and their families is that they want a relatively independent and private environment that can create a family atmosphere without causing mutual interference. This requirement may generally be due to families having more family members or being able to accompany them for a long time. A further study with more focus on ward space to improve the condition is therefore suggested.

5.1.5 Physical environment

Smith et al. (2001) found that high anxious nurses may be at risk of medical errors and poor performance, in addition to higher occupational wear. Although there is considerable evidence of the negative impact of stress on clinical staff, relatively few studies have investigated the impact of the physical environment on staff. The researcher made some suggestions through questionnaires to improve the physical environment of obstetrics to improve staff efficiency

(Figure 17). The results of questionnaires show that most participants considered to agree or strongly agree these issues, but a few staff present opposite or not sure about answers. For example, some of them disputed to the fact that artificial light could be used in the absence of natural light in the corridor. It may be that these participants do not like the closed space make people have negative emotions. The natural light and the scenery outside the window make people relieve stress. Several reports have shown that environmental conditions, including light, air quality and temperature, and lack of controllability over the environment, can cause stress on staff (Baum, Singer, & Baum, 1981; Evans & Cohen, 1987).

The Obstetrics is a special department full of happy atmosphere. The coming of a life is a happy event for every family and relatives together will inevitably bring voice too large and affect others. According to observation, the soundproofing effect of the wards was poor, and some clinical staff complained that the noise level made them more difficult to work. These results reflect those of Sanderson et al. (2005) who also found that the noise may be high in the hospital environment that was considered a source of distraction and stress for staff, resulting in decreased productivity, especially when monitoring the patient's vital signs. Improve noise may require strengthening the effect of soundproofing of the ward door or adding quiet sign to remind people in places. Smith et al. (2001) points that using a sound absorber to absorb noise can reduce the error rate. Further research should be undertaken to investigate the impact of noise on staff efficiency.

5.2 Influence factors

The researcher found potential conditions that may cause errors in the environment. The layout of unit is affected by various factors such as interior design, location, scale, economy, culture and behavior, etc. At the same time, different spatial layouts and environmental characteristics also affect the work efficiency of staff. The size of the corridors, the location of the nurse stations, the layout of the wards, artificial light, noise, and the visibility of the layout of units are some of the key issues that cause staff tiredness and stress. There is evidence that nurse efficiency, potential errors, stress levels, and job satisfaction affected by these design issues. The comparative study of the layout of all nursing units is based on specific cases. It is almost impossible to fully apply the experience of one case in other situations. The conditions of the three hospitals in the study were different, the number of these studies is insufficient, and their scope is also very narrow, but the results of each study are still valid in their context. Different nursing units can also explain the user's behavioral, psychological, health and social outcomes.

- Interior design

To explore visibility, the researcher simulated the spatial layout but did not include furniture. However, furniture, fixtures and equipment may all have some impact on visibility. The material of the furniture, the choice of color, and the form of placement could cause different spaces giving the user a different experience. The shape of the round and square furniture has different limits on space. For example, the researcher could use furniture to create a semi-closed privacy space or control access through furniture to create obstacles. It also brings people together and increases communication opportunities to reduce stress.

• Large units or small units

The large scale of hospital A is different from that of other two general hospitals in terms of design. The delivery room is an independent floor unlike the other two hospitals that are integrated with the ward. The unit is divided into two wards and two nurse stations are built respectively. A large-scale unit may need to focus on the walking distance of staff and rationally arrange the location of the nurse station to relieve the workload of staff. The functions of small-scale unit are relatively concentrated and protect the privacy of patient and staff. The impact of high intensive workload could have a negative impact on staff, including stress, safety, and the impact on patient safety and care satisfaction. Previous studies have found that for every additional patient per nurse, both the burnout rate and the dissatisfaction rate increase, at the same time, the risk of mistakes increases (Aiken, Clarke, Sloane, Sochalski, & Silber, 2002; Rogers, Hwang, Scott, Aiken, &Dinges, 2004). Major stress factors faced by global clinical staff, such as workload, time pressure and deadlines, and staff shortages (Dai & Wang, 2002; G. R. He, Li, & Gu, 2001). The architects not only need to meet the basic daily work needs of staff through space layout, but also consider the psychological needs of staff. Prior studies have noted the importance of the relationship between staff behavior, psychology and health. According to Lin et al. (2013), indoor plants, music, and private or personal spaces reduce the pressure on staff for work; art and exhibitions slow down the hospital's stressful atmosphere. Placing indoor plants is a natural way to provide strong links with life and reduce human mental stress and relieve physical tension (Venolia&Dadd, 1988). The questionnaire also showed the same results that most people agreed to add green plants in the space.

CHAPTER VI. SUMMARY AND RECOMMENDATIONS

6.1 Design Recommendations

This study investigated the functional layout of hospital obstetrical nursing units, streamline organizations, nurse stations, wards, and physical environment, combined clinical staff needs for wards, analyzed the insufficiency of space design and proposed improvement strategies for nursing units. The purpose of the current study was to improve the clinical staff efficiency and satisfaction by developing the obstetrical spatial layout, identify drivers of inefficiency in nursing work processes and nursing unit design. This essay presents a method combining practice and theory to investigate three hospitals, and then use space syntax theory to simulate the floor plans. The method shows the relationship between the spatial layout of the nursing unit and the humanization. A comparative analysis of the results found that some practices and theories are consistent, and some results are contradictory. The study displayed the nursing units of the common and specific design pattern inobstetrics. In addition to spatial layout design, the architects also need to consider several other influencing factors, including the geographical location and scale of the building, economic budget, interior design, and user psychology. The outcome will eventually be applied to the practice of obstetrics unit design.

The design of the corridor in the spatial layout is important. For example, Hospital A has the highest connectivity indicates that its layout has easier access in space. The software simulation in this study found that the length and width of the corridor as a connection will affect the line of sight of the surrounding environment.

Line of sight and path can be obtained through calculations. The spatial properties of these isovists can be used to adjust the layout of functional rooms. Nurse station design is an important part of the layout of nursing units. The number of nurse station spaces and cabinets needs to meet the demands of clinical staff which is determined by the size of the department. The nurse station is better in the form of an enclosure that provides a private space environment. Similarly, the patient room needs to protect the privacy of the patientbut does not affect the observation of the clinical staff. The study has found that generally hospitals only have centralized nurse stations, but according to previous studies shows that decentralized nurse stations could better contribute to reducing the workload of staff (Gurascio-Howard & Malloch, 2007; Ulrich et al., 2008). It is worth noting that investigations found that the obstetrical nursing unit plans of the three hospitals did not provide public toilets, but according to clinical staff response that public toilets were required in the plans to be used exclusively by visiting family members. This proposal also applies to other nursing units. Although it does not have any effect on staff efficiency, it also makes the healthcare environment more humanized and increases social satisfaction.

Table 6.1 Design Recommendations for nursing units

	Recommendations
1.	Corridor forms combined with geography, scale, economic considerations.
2.	The corridor is not too long and increase the walking time of staff.
3.	The nurse station in large nursing units can consist of centralized nurse station and distributed substation or decentralized instruments and medicine storage sites.
4.	Nursing stations are located in accessible and relatively exposed locations.
5.	The nurse station is better in the form of an enclosure.
6.	The nurse station spaces and cabinets need to meet the demands of clinical staff.
7.	The patient room needs to pay attention to the privacy of the patient without affecting the observation of clinical staff.
8.	Delivery room is better opposite the operating room (in general hospital).
9.	Nursing units should provide public toilets.
10.	Natural light, green plants, and leisure space can reduce the pressure on staff.

6.2 Implications for nursing units design

Most hospitals in China currently introduce international advanced medical models and medical facilities, but their relatively backward design also makes the nursing unit space still unable to exert its maximum effectiveness (Xian, 2015). In addition, some imperfect functions lead to nursing units that reduce the work efficiency of staff and have a poor social impact. By investigating the situation of the space of obstetrical nursing units and the needs of staff and combining the excellent literature, the researcher proposed a humanized design recommendation for modern nursing units.

Architects create nursing units that focus on the psychological impact of clinical staff to improve efficiency. In this study, space syntax theory was used to test the rationality of the space 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 the space accessibility. After the project design is completed, the simulation analysis can be carried out through software, which is both cost-saving and scientific.

In designing a unit, one of the problems is balancing staff efficiency, patient privacy, and treatment of environmental factors such as light, noise, and contact with nature. Hospital A is a large-scale nursing unit, there are two nurse stations, clinical staff need to back and forth between the nurse station and the wards, which increases staff workload and anxiety. An implication of this is the possibility that setting up distributed substation in the ward area or decentralize supply issues may greatly increase staff efficiency. Designs often need to meet multiple requirements and be limited to one another. For example, the designer makes the nurse station easier to find, the design space is too exposed, and the privacy of staff is ignored. At the same time, staff are more likely to observe patients without regard to patient privacy, but open environments may also increase noise levels.These findings are important for understanding how to improve clinical staff efficiency by designing nursing units. It can be used for future studies to compare the relationship between the spatial layout and humanization with more different cases.

6.3 Limitation of this study

There are several limitations in this study. One is the number of samples. Because the study time was limited to one year, only one city was surveyed. The number of hospitals in the city is limited, three most influential hospitals were considered for investigation in this city and analyzed by using space syntax theory. The plans of analysis are from a city, and a unified design style may produce similar results. Hospital B and hospital C floor plans are quite similar. Future research will require more time and site selection for optimization, and more samples may be more convincing. A small number of interviews and questionnaire data collected were also limiting factors in this study. This may be because the work of clinical staff is so busy that the data collected is relatively small. Communication between the researcher and users is a very important part that need to understand the demands of users.

The other limitation was that there is less literature on the design of the obstetrical nursing units in China. Most of the documents accessed are published in the United States or English. It is worth noting that the study of international literature on the design of obstetrics is also useful in China. The investigation and simulation play an important role in the obstetric unit design in China. Architects need to consider from the perspective of users and understand to balance the relationship between practical and theoretical needs. The study is expected to provide some information on China’s future obstetric design.

6.4Further Recommendations for Future Research

China is entering a period of rapid development of nursing unit construction. How to provide staff with a relaxed working environment under the premise of meeting functional conditions and create a healthy medical atmosphere for patients is the focus of designers. However, many healthcare institutions currently face the challenge of shortage of nursing staff. By improving the healthcare environment, clinical staff's work stress can be reduced, and social satisfaction can be improved to retain existing staff while creating a healthy working environment. Architects need to analyze changes in the physical environment and use theoretical frameworks to design a reasonable nursing unit. Due to size and cost constraints, space should be carefully analyzed to meet user goals and requirements, and to increase staff efficiency.

Architects need to design nursing units from a rational and human perspective. In addition to focusing on the safety of patients, future designs should also focus on the efficiency, safety, and health of clinical staff. The staff working environment should be user-centred and meet the psychological needs. Evidence-based design theory was used to conduct research on the healthcare environment. Under the theory of space syntax, the design of human behavior was validated and improved. Although the purpose of this study was to improve the work efficiency of clinical staff, one objective that remains to be explored was how to improve the ward space and improve the privacy of patients. The researcher speculates that in the future, the number of single patient rooms may be increased, and the integrated services will be provided, produced, and restored. A graphical design workflow of networked, adaptable and intelligent managed obstetrical units for the future could be proposed for engaging all stakeholders in the early design stage of a specialized or general hospital. The researcher will continue to explore hospitals with new methods that can improve patient safety and quality of care.

Appendix A：Research Ethics Checklist

University of Nottingham Ningbo

Research Ethics Checklist for Staff and Research 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.
<u>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.</u>

The principal investigator or, where theprincipal investigator is a student, the supervisor, is responsible for exercising appropriateprofessional judgement in this review.

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: Xiaoxuan LU

1.2: Status: ☐ Staff

☒ Postgraduate research student

1.3: School/Division: Faculty of Science and Engineering

1.4: Email address: ssxxl1@nottingham.edu.cn

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

1.6: Names of Supervisors (if applicable): Jun LU

	Yes	No
1.7: I have read the University of Nottingham's Code ofResearch Conduct and Research Ethics (2010) and agree to abide by it: http://www.nottingham.edu.cn/en/research/researchethics/ethics-approval-process.aspx	☒	☐
1.8: (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	☒	☐
1.9: When conducting research on people (Section 5) I will prepare both a participant consent form as well as a *participant 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:**

Evidence-Based Spatial Design to Improve Clinical Staff Efficiency in Obstetrical Nursing Units: Three Cases Studies in Anhui Province, China

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

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

Participant: Hospital staff

Q: Where are the main problems related to the staff efficiency in obstetrics?
Q: What the staff journeys should be adopted?
Q: What physical improvement can be made to enhance the space design to improve staff efficiency in obstetrics? (layout of space/ ward)

The purpose of the project is to improve the staff efficiency by developing the obstetrical space, to develop a high-quality and efficient healing space. Through Evidence-Based design of healthcare space, the assessment and improvement of existing facilities creates a safe and humanistic physical environment. The outcome will eventually be applied the practice of clinical design.

2.3: **Summary of method(s) of data collection**

Data collection using questionnaires, focus groups and informal interviews may also use observation methods. Collect large amounts of data through surveys,
understand the opinions and attitudes of the staff toward various topics and find out where obstetrical space needs improvement and reservation.

2.4: **Proposed site(s) of data collection**

The four hospitals in Ma Anshan, Anhui province, China.

- Ma Gang Hospital
- People Hospital
- Seventeen Hospital
- Maternity and Child Care Hospital

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

1. Contact the relevant staffof the above four hospitals to explain the research aims and obtain the permission.
2. Contact the head nurse of the hospital and issue questionnaires under her leadership.
3. Explain to the participant the purpose of the research and allow them to sign the participant consent and relevant documents under the participant full agreement.
4. After completing the questionnaire, thanks for the participant.

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 INVOLVING THE PARTICIPATION OF PEOPLE

If your research involves the participation of people all questions in Section 4 must be answered.

Please answer each question by ticking the appropriate box.

A. General Issues

	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 (*where applicable*) 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.	☒	☐

If you have not ticked any shaded boxes, please send the completed and signed form to the School's Research Ethics Officers, with any further required documents, for approval and record-keeping.

If you have ticked *any* shaded boxes**you will need to describe more fully how you plan to deal with the ethical issues raised by your research**. Issues to consider in preparing an ethics review are given below. Please send this completed form to the Research EthicsOfficer who will decide whether your project requires further review by the UNNC Research Ethics Sub-Committee and/or whether further information needs to be provided. Please note that it is your responsibility to follow the University's Research Code of Conduct and any relevant academic or professional guidelines in the conduct of your study. This includes providingappropriate information sheets and consent forms, and ensuring confidentiality in the storage anduse of data. For guidance and UK regulations on the latter, please refer to the Data Protection Policy andGuidelines of the University of Nottingham:

Policy - http://www.nottingham.ac.uk/%7Ebrzdpa/local/dp-policy.doc

Guidelines -http://www.nottingham.ac.uk/~brzdpa/local/dp-guidance.doc

Any significant change in the project question(s), design or conduct over the course of the research should be notified to the School Research Ethics Officer and may require a new application for ethical approval.

Signature of Principal Investigator/Researcher: Lu Xiaoman

Signature of Supervisor (where appropriate): Jun Lu

Date: 19/1/2018

Research Ethics Panel response

☒ the research can go ahead as planned

☐ further information is needed on the research protocol (see details below)

☐ amendments are requested to the research protocol (see details below)

School [signature] REO..

Date ...23/01/2018......

A. LIST OF POINTS TO CONSIDER WHEN SUBMITTING AN ETHICS REVIEW (taken from ESRC (2012) Framework for Research Ethics).

Risks

1. Have you considered risks to:
   - the research team?
   - the participants? Eg harm, deception, impact of outcomes
   - the data collected? Eg storage, considerations of privacy, quality
   - the research organisations, project partners and funders involved?
2. Might anyone else be put at risk as a consequence of this research?
3. What might these risks be?
4. How will you protect your data at the research site and away from the research site?
5. How can these risks be addressed?

Details and recruitment of participants

6. What types of people will be recruited? Eg students, children, people with learning disabilities, elderly?
7. How will the competence of participants to give informed consent be determined?
8. How, where, and by whom participants will be identified, approached, and recruited?
9. Will any unequal relationships exist between anyone involved in the recruitment and the potential participants?

10. Are there any benefits to participants?
11. Is there a need for participants to be de-briefed? By whom?

Research information
12. What information will participants be given about the research?
13. Who will benefit from this research?
14. Have you considered anonymity and confidentiality?
15. How will you store your collected data?
16. How will data be disposed of and after how long?
17. Are there any conflicts of interest in undertaking this research? Eg financial reward for outcomes etc.
18. Will you be collecting information through a third party?
Consent
19. Have you considered consent?
20. If using secondary data, does the consent from the primary data cover further analysis?
21. Can participants opt out?
22. Does your information sheet (or equivalent) contain all the information participants need?
23. If your research changes, how will consent be renegotiated?

Ethical procedures
24. Have you considered ethics within your plans for dissemination/impact?
25. Are there any additional issues that need to be considered? Eg local customs, local 'gatekeepers', political sensitivities
26. Have you considered the time you need to gain ethics approval?
27. How will the ethics aspects of the project be monitored throughout its course?
28. Is there an approved research ethics protocol that would be appropriate to use?
29. How will unforeseen or adverse events in the course of research be managed? Eg do you have procedures to deal with any disclosures from vulnerable participants?

Participant Information Sheet

Project Title/Topic: *Evidence-Based Spatial Design to Improve Clinical Staff Efficiency in Obstetrical Nursing Units*

Dear Participant,

Thank you for agreeing to participate in this questionnaire survey in connection with my *Master degree dissertation* at the University of Nottingham Ningbo. The project is a study of developing the optimal spatial design to improve the department of obstetrics staff efficiency in China.

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,

Xiaoxuan LU

Contact details:

Student Researcher: <Xiaoxuan LU and ssxxl1@nottingham.edu.cn>

Supervisor: <Jun LU and jun.lu@nottingham.edu.cn>

University Research Ethics Committee Coordinator, Ms. Joanna Huang

(Joanna.Huang@nottingham.edu.cn)

声明

论文题目：基于提高产科医护人员工作效率的空间优化

尊敬的参与者：

谢谢您参与这次问卷调查。这次问卷调查是我在宁波英国诺丁汉大学研究生论文相联系的。研究题目是基于提高产科医护人员工作效率的空间优化。

您是自愿参与此次问卷调查的。您可以在任何时候选择放弃这次的问卷调查，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。

陆小璇

联系方式：

研究员：陆小璇 ssxxl1@nottingham.edu.cn

导师：陆俊 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: *Evidence-Based Spatial Design to Improve Clinical Staff Efficiency in Obstetrical Nursing Units*

Researcher's name: Xiaoxuan LU
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 interview/data collection [*omit as appropriate*]. will be recorded/filmed [*omit as appropriate*].
- 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: <Xiaoxuan LU and ssxxl1@nottingham.edu.cn>
Supervisor: <Jun LU and 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： 基于提高产科医护人员工作效率的空间优化
研究者姓名： 陆小璇
导师姓名： 陆俊

- 本人已阅读声明，项目组织者已经向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（酌情省略）将会被录音/拍摄（酌情省略）
- 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的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：<陆小璇：ssxxl1@nottingham.edu.cn>
导师：<陆俊：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 D：Questionnaires survey

Obstetrical Space Optimization Design Questionnaire _ Staff

Definitions:

The purpose of the questionnaire is to improve the staff efficiency by developing the obstetrical space, to develop a high-quality and efficient healing space. Through your views to enhance space design, assess and improve existing facilities to creates a safe and humanistic obstetrical environment. The outcome will eventually be applied the obstetrical design, thank you for your participation.

Note:Please type in each question, generally only ONE option, unless otherwise specified.

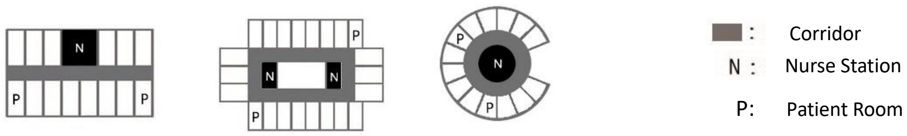
0. What is your occupation in the hospital?

☐Doctor ☐Nurse

A. Obstetrical Layout: Show the layout of space, including public space and indoor layout

1. Which of the following layout form is your current obstetrical working environment?

☐Single corridorpattern☐Double corridor pattern☐Radical corridor pattern☐Other



2. Are there any natural light in your current obstetrical corridor? (Corridor in the first question icon)

☐Yes, there are ☐No, there are not

3. How do you think the corridor width of your current obstetrics? (Corridor in the first question icon)

☐Too narrow ☐Narrow ☐Moderation ☐Spacious ☐Too spacious

4. Do you agree the width of the obstetrical corridor affect your work efficiency?

☐Strongly disagree ☐Disagree ☐Not sure ☐Agree ☐Strongly agree

5. How do you think the corridor length of your current obstetrics? (Corridor in the first question icon)

☐Too short ☐Short ☐Moderation ☐Long ☐Too long

6. Do you think the length of the obstetrical corridor affect your work efficiency?

☐Completely no effect ☐No effect ☐Not sure ☐Have an effect ☐Completely no effect

Obstetrical Space Optimization Design Questionnaire _ Staff

7. Please indicate whether you agree or not that the following contents of obstetrical layout forimproving the department of obstetrics staff efficiency.

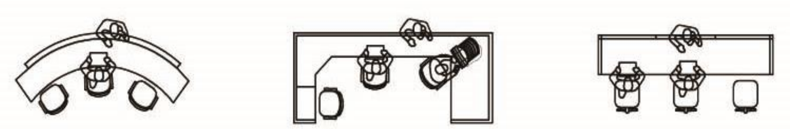
	Strongly Disagree (1')	Disagree (2')	Not sure (3')	Agree (4')	Strongly Agree (5')
1. Corridors have natural lighting	☐	☐	☐	☐	☐
2. The office space of the medical staff has natural lighting	☐	☐	☐	☐	☐
3. The delivery room is located at theend of the entire plan	☐	☐	☐	☐	☐
4. The delivery room is set up staff, patient and sewage passage	☐	☐	☐	☐	☐
5. Emergency green channel keep unblocked	☐	☐	☐	☐	☐
6. The drug has a separatestreamline	☐	☐	☐	☐	☐
7. Sewage passage leads directly to the polluted area	☐	☐	☐	☐	☐

If you feel that the layout of your obstetrics has other reasonable or unreasonable design, please specify. (Optional)

B. Obstetrical Nurse Station

8. Which of the following is your current obstetrical nurse station?

☐Arc shape pattern ☐U shape pattern ☐ Linear pattern☐Other



9. Which of the following is your favorite obstetrical nurse station?

☐Arc shape pattern ☐U shape pattern ☐Linear pattern ☐Other

Obstetrical Space Optimization Design Questionnaire _ Staff

10.Can your current obstetrical nurse station cabinets meet your work needs?

☐Completely unsatisfied ☐Not satisfied ☐Not sure ☐Satisfied ☐Completely satisfied

11.What are the functional rooms in your current obstetrical nurse station? (Multiple-choice)

☐Inquiry desk ☐Treatment Room（Medicine Room）☐Storehouse

☐Head nurse office ☐Other（Please fill in）

12. Which of the following color is your favorite color for the nurse station? (Through the literature research, high saturation, too bright colors are easy to irritability, not conducive to physical and mental relaxation, so to list the following colors)

☐White ☐Pink☐Light yellow ☐Light blue

☐Light purple ☐Lightgreen ☐Other(Please fill in)

13. Please indicate whether you agree or not that the following contents of obstetrical layout forimproving the department of obstetrics staff efficiency.

	Strongly Disagree (1')	**Disagree (2')**	**Not sure (3')**	**Agree (4')**	**Strongly Agree (5')**
1. The doctor's office is near the nurse station	☐	☐	☐	☐	☐
2. The emergency room is near the nurse station, and allow staff to observe the patient inside	☐	☐	☐	☐	☐
3. Nurse station is located at the center to the inpatient area	☐	☐	☐	☐	☐
4. Nurse station is around to provide some rest waiting space.	☐	☐	☐	☐	☐

If you feel that the nurse station of your obstetrics has other reasonable or unreasonable design, please specify. (Optional)

Obstetrical Space Optimization Design Questionnaire _ Staff

C. Obstetrical Ward

14. How many patients do you think the obstetrical ward live most reasonable?

☐One ☐Two ☐Three ☐Four or more ☐VIP

15. What do you think is a need for a separate private breastfeeding space in a multi-patient ward?

☐Completely not required ☐Not required☐Not sure ☐Required ☐Completely required

16. Which of the following color is your favorite color for the wall of the obstetrical ward?
(Through the literature research, high saturation, too bright colors are easy to irritability, not conducive to physical and mental relaxation, so to list the following colors)

☐White ☐Pink☐Light yellow ☐Light blue

☐Light purple☐Lightgreen☐Other(Please fill in)

17. What facilities do you think need to be equipped in the obstetrical ward? (Multiple-choice)

☐TV ☐Computer ☐Microwave oven ☐Refrigerator ☐Dining table

☐Disinfection cabinet (Disinfection bottle) ☐Bed sofa ☐Sofa

☐Other(Please fill in)

18. What facilities do you think need to be equipped in the obstetrical ward bathroom? (Multiple-choice)

☐Washbasin☐Toilet☐Shower☐Other(Please fill in)

19.Do you think that the location of the bathroom in the obstetrical ward is close to the corridor and will affect the staff to observe the patient line of sight?

☐Completely no effect ☐No effect ☐Not sure ☐Have an effect ☐Completely have an effect

If you feel that the ward of your obstetrics has other reasonable or unreasonable design, please specify. (Optional)

Obstetrical Space Optimization Design Questionnaire _ Staff

D.Obstetrical Physical Environment：Refers to all factors that affect health expect the patient itself: light, wind, air, noise, lighting, warmth, surrounding

20.Please indicate whether you agree or not that the following items of obstetrical layout forimproving the department of obstetrics staff efficiency.

	Strongly Disagree (1’)	Disagree (2’)	Not sure (3’)	Agree (4’)	Strongly Agree (5’)
1. Corridor without natural light, artificial light can be used instead	☐	☐	☐	☐	☐
2. Ensuring indoor artificial light is soft	☐	☐	☐	☐	☐
3. Setting special observation light and night light for clinical staff	☐	☐	☐	☐	☐
4.Ensuring indoor natural ventilation	☐	☐	☐	☐	☐
5.Improving ward doors and windows sound insulation	☐	☐	☐	☐	☐
6.Setting a mute mark in the corridor	☐	☐	☐	☐	☐
7.Adding green plants indoors	☐	☐	☐	☐	☐

If you feel that the physical environment of your obstetrics has other reasonable or unreasonable design, please specify. (Optional)

E．THANK YOU FOR YOUR TIME AND TAKING PART IN THE SURVEY!

21. If you would like a summary of results, please leave your contact details below.

Name：

E-mail：

Tel. No：

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