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HUMAN-CENTERED ENVIRONMENT DESIGN IN INTENSIVE CARE UNIT

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ABSTRACT

Because of high risk and instability of the patients in Intensive care unit(ICU), the design of ICU is very difficult. ICU design, auxiliary building design, lighting design, noise control and other aspects can also enhance its management. In this paper, we compare ICU design in China and Holland based on related standards. We also premeditate the indoor environment from planning perspective, analyze patients, their families, medical staff and space requirement to conduct research in ICU design. With the social progress and science development, we more and more emphasize human-center design. All of our goal is to provide comfortable and effective ICU environment for patients, their families and medical staff, satisfying the demands of different needs and balancing the economy, quality and efficiency.
Keywords: *Human-Centered, Industrial Design, Medical Environment, Intensive Care Unit*

1. INTRODUCTION

Intensive Care medicine originated from the 1960's, when the acute anterior poliomyelitis epidemic was spreading. In response to this hospitals established the Intensive Care Unit (ICU) for these "special" patients with the purpose of better nursing . The function of ICU ward is to reserve patients' life when they are suffering the failure of some organs. The university medical centers have designated intensive-care areas for certain specialties of medicine, depending on the needs and resources of the hospital, whereas the regional hospitals have one general ICU [1]. The ICU is a data-rich environment containing a wide variety of medical equipment used by a multidisciplinary team [2]. A good collaboration and communication within this multidisciplinary team is extremely important for the well being of the patient. Next to this, the psychological, social and other related factors are closely related to patient's health. World Health Organization emphasizes the satisfactory of physiology, psychology and society when it defines the word "Healthy". More and more hospitals are creating a better environment for recovery, improving the healing efficiency based on the needs of patients.

According to the statistics, the average time of one patient spends in ICU ward is three to four days for medical therapy, four to five days for surgical treatment, and seven to nine days for relying on artificial respiration care . During their stay in the ICU, patients are connected to different medical equipment, like bedside monitor, infusion pump and volumetric pump, mechanical ventilator and the patient data management system, etc. These medical equipments are highly advanced and mostly equipped with alarms that signal the nurse when a bodily function exceeds certain preset values. Since patients are very vulnerable in this stage that they are very sensitive to the sound of different medical equipment, medical staff and other patients . In addition, the high mortality rate caused great psychological pressure on patients. This will result in fear, anxiety, tension, irritability and other psychological disorders on patients, which will affect their sleep . Previous studies indicate that an adequate quality sleep is very important for the patient's recovery [3].Quite and comfortable medical environment can ease patients' mood and help their to recovery. Noise will influence the physiological and psychological condition of the patients and medical personnel. Many researches have indicated that plenteous sleeping had a huge influence on the patients' recovery process, because it will directly influent patients' restored speed and immune ability . A good layout of ICU, a quite environment, family support, sufficient light and clean space, will increase the patients comfort. Good clean design

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can effectively control the infection. Strict compliance with medical direction, to prevent cross-infection.ICU ward need to provide high quality care to patients in strict accordance with clean hierarchy to reduce infection. A clear distinction between clean areas, semi-clean area, the contaminated area, the district is relatively independent of spatial concentration of the same arrangement of cleanliness, in order to reduce mutual interferential pollution.

Although the patient's condition will not be cured immediately, but by creating these conditions the care to patients and their families can be improved .Currently, many ICU's are not designed from a human-centered perspective, neglecting the physiological and psychological needs of the patients.Teamwork is highly important in the ICU design, understanding the needs of different people, Is the foundation and basis of the ward for people.

This paper is to investigate and compare differences among ICU's in different countries from a human-centered design perspective with a focus on planning, lightening, noise control and hygienics. The research contents include patients, their families, hospital staff, and ICU ward design engineers. Through interview and discuss with these relevant personnel the actual status of the ICU ward is evaluated and their expectation in the future is mapped out. Two hospitals in China; the Shaanxi Provincial People's Hospital and the First Affiliated Hospital of Medical College of Xi'an Jiaotong University is studied and compared with the Catharina Hospital in Eindhoven the Netherlands.

2. MATERIALS AND METHODS

From July till October 2011, the field research has been carried out in the Catharina Hospital in Eindhoven, Netherlands and Shaanxi Provincial People's Hospital in China. Besides the field research, a desktop research including a search on building and health codes and literature has been done. On the one hand the different users of a ICU ward, including patient, patient's family, hospital staff and design engineers have been interviewed in order to evaluate the current condition of the ICU's and map out the expectations of all aspects users. On the other hand literature research on the topics of construction planning, lightening, noise control and hygenics has been done to get the actual status of the ICU and in the regulations, conditions and trends. The results were analyzed and compared to draw the conclusions.

3. RESULTS

Planning and construction

The ICU planning and construction is divided into the sections as shown as follows.

The shortest distance and rescuing time

Compare the working process relationship of ICU ward and other departments, we extract the departments with high timeliness requirements. When planning the ICU ward in Catharina hospital, these departments should be constructed and arranged to achieve the shortest rescuing time for patients through horizontal and vertical mode of transport.

Intensive care represents the highest level of continuing patient care and treatment. Optimal design can minimize patients's displacement distances.

Reasonable and adequate supporting space

The basic supporting space in ICU includes: physicians' offices, offices, staff lounge, central nurse station, treatment room, dispensary room, equipment room, changing room, clean room, sewage waste treatment room, duty room, bathroom and so on. Reception room, laboratory, nutrition room, preparing room, visit gallery can be added if the conditions are permitted. Adequate auxiliary rooms and public space can meet users' needs and reflect the care from hospital.

In the survey, we find that hospitals in China focus on the quality of ICU ward, but seldom care about supporting space; while those in Netherlands, the supporting spaces including storage area for case notes, relatives' rooms, kitchen facilities, reception area etc are complete.

Fig. 1 China's Icu Ward

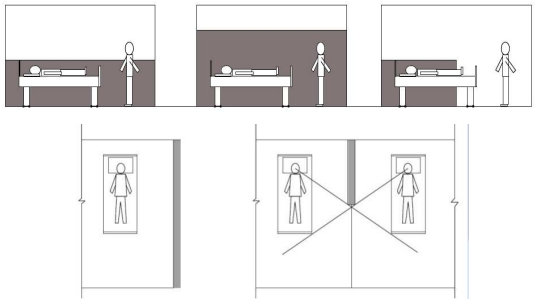

Fig. 2 Line Of Sight Analysis

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Fig. 3 Lack Of Support Space

While interviewing with medical staffs, the inadequate setting of lounge is the main problem in the design. The working intensity in ICU is extremely large (Figure 1). Average working time is about 10 hours. Providing adequate lounge is very necessary. But in the reality, many medical staffs have no lounge, and they can only rest in the dressing room (Figure 2).

In the research process, we found many family members are waiting in the corridor, and some even spend night in the stairwell with small bed (Figure 3). Stairwell is designed for the sudden and unexpected situation such as fire and earthquake. These behaviors will seriously affect the normal building traffic. Because patients in ICU usually have low immunity, the family members accompany them directly may cause cross-infection in some extent, bring serious harm to the patient's life. For the lack of accompanying system in hospital, access system is very strict. Which result in misunderstanding of many patients' family members. This will undoubtedly bring varying degrees of collisions among hospital, patients' families and patients.

The layout of ICU wards in Eindhoven is usually the sharing and single form. The hospital also arranges three lounges with separate toilet for patients' families. This kind of user-friendly design is very welcome. A reception with telephone exchange system is placed near the entrance of ICU ward. If the patient's condition is allowed, they can communicate by telephone. This design can not only provide a quiet environment for patients, but also comfort and encourage the patient. Thus reduce the infection rates uttermost. while in China, there are only a few new ICU ward reach this level.

When patient is dying, family members are always needed nearby. So ICU ward in Lena Kaiser Hospital set a separate room for this function. This will inevitably affect others, but can be solved through the arrangement of buffer zone, which is isolated from the main area. Now many large hospitals use this settlement in ICU, more convenience and more human-centered, which is highly praised.

Privacy and observation

The flexibility of ICU ward is also important. Based on the needs of the recovery environment in the hospital, the ICU can be divided into different patient rooms: open, semi-open and completely isolated. Research in two Chinese hospitals showed that the ICU ward both had a big room. The nurse stand in the center of the room, thus can get an easy observation of the patient's situation. Each bed is separated by curtain. Curtains are frequently used solutions to create some privacy in an open space as shown in figure 2. Different options are possible like shown in figure 3. This approach is relatively simple, but the curtain is also easy to be damaged and contaminated, requiring regular disinfection. Curtain' sound isolation is not so good, and it will affect the treatment of other patients. Thus screens of glass or other materials like metal may be a better option, which not only meet the patient's psychological needs for private space but aoso maximize the convenience of observation for doctors.

Noise environment

Administration Guide in China clearly pointed out that "in addition to the patient's call signal, the alarm sound from monitoring instrument, the telephone ringing, voice from printers and other equipment all belonged to ICU noise." These voices should be minimized to the smallest level as long as it does not affect the normal operation [4]. The recommendations of the International Association for the noise are illustrated in Table 1.

Table 1 Smallest Level Of Noise In Different Time Of A Day

Time	During the day	In the evening	At night
Smallest level of Noise	45db	40db	25db

At the same time, a lot of medical equipment' sound (the patient's medical equipment as well as the medical devices around), the voice of doctors and nurses' station, and other sound will pose different degrees of impact on the patient's rest. ICU in Catharina hospital use isolated ward (double/single), connected with a corridor. Each ward has a sound effect glass door (FIG.4,5). The nurses' station is separated from ward, with a special sound absorbing wall treatment (FIG.6).Nurse can see through the windows to get the patient's condition and meanwhile the patient has a quiet and comfortable therapeutic environment (FIG.7).

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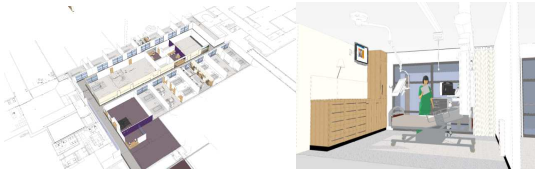

Fig. 4，1 ICU Unit Of Catharina Hospital

Fig. 6Central Nursing *Fig. 7 ICU Of Catharina Hospital Tationin*

Lighting environment

ICU should have good lighting conditions. Light has a very strong impact on person's physical and psychological situation. Here, the lighting including natural light and artificial lighting. In Construction guide of ICU ward abroad, the intake of natural light is very important.

According to the relevant statistics, the average time one patient spends in ICU ward is medical 3 to 4 days, surgery 4 to 5 days, relying on artificial respiration care about 7 to 9 days [5，6].Patient spends a long time in ICU, they cannot move and communicate with outside, cannot breathe fresh air, suffer the torture of pain and huge psychological pressure [7,8]. Through natural, they can feel the desire for life, feel the alternating day and night to ease the psychological dull, depression, sadness and fear, which is good to the patient's recovery [9,10]. To create a user-friendly recovery environment needs many detail design (e.g. convert concepts of time by clock, calendar and other things). Lighting system is also very important, the ICU should choose good light source color, illumination cannot be less than the 1501X, and can mediate according to different needs.

In the domestic ICU survey, Because of high demanding of cleanliness, most wards are laminar flow chamber, enclosed by solid walls, lighting area is much smaller compared to the general wards, and some even don't have windows. There is another reason for small windows in ICU, Because it must meet the need for sufficient physical testing instruments hanging wall. Most ICUs are airtight, the only ventilation measure is through central air-condition. There is no direct air exchange with outside. ICU ward in Catharina hospital, Netherlands, either double or single room, have large window about $5m^2$ (FIG.8). The designer admitted, the window is designed lower than general design of windows so as to enable the patient lying on the bed can see the trees and blue sky outside through the window. Light can affect the patient's psychological, and patients need plenty of sunlight.

Fig. 8 ICU In Catharina Hospital

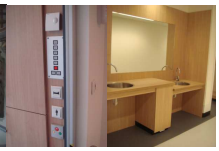

Fig.9 ICU Room

Clean design

Health care environment is an extremely complex and dangerous environment, people carrying various viruses and bacteria in and out with no awareness everyday. Some bacteria and viruses do not pose a threat to healthy people, but for patients, especially patients in ICU, a small aspect of any negligence may result in irreparable regret. Infection is most common adverse event in ICU wards, relevant research shows that many bacteria, especially those have immunity, can survive for months in the hospital l[11]. Some diseases are transmitted to patient from the environment, although people are constantly exploring new ways to improve the efficiency of cleaning. Prevention is still the most effective way. Hand hygiene is an important and effective prevention of infection and measures for hospital stuff [12,13]. The staff themselves needed to have good self-awareness. It can be better to remind staff to wash their hands; replace sterile gloves, Which can prevent cross-infection risks to patients effectively .

ICU ward in Catharina hospital is developing small spaces (single, double). Thus more and more attentions are taken on the cleaning equipment and facilities (FIG.9). Some details, such as set-up of hand-washing stations, configuration of cleaning equipment, ward's door design (for entrance of people, opened small; for the bed, open big) can minimize the possibility of infection effectively. These configurations and equipment will certainly increase the cost of the ward, but are very beneficial in the long term. A clean environment will provide a sense of security to patients, their families and staff and control the infection effectively.

4. DISCUSSION

Through literature review we found that different countries focus on different aspects when set up the norms and guidelines. Netherlands focused on the medical intensive care capabilities and medical environment, it paid more attention to integrated design team and meet the medical working function

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from a different perspective. Based on actual national conditions China's construction and management guidelines are focused on the ward infrastructure. There are the basic norms for the Requirements for the hospital, ICU size and requirements, staffing.

Through the field research, we find that there is still a gap between China and western countries. The problems in present ICU's environment design can be improved by the result of related researches. This paper summed up the characteristics and actual condition of ICU ward in different countries, and provided some improved suggestions based on the research results.

The difference of the ICU ward in two different countries (Table 2), taking into account the money, quality, efficiency and how to achieve balance among the three main points. And then we tried to meet the people's various needs and create a humane medical environment.

Table 2 Comparison Of The Environment

Two Chinese hospitals	Hospital in the Netherlands
Auxiliary space is not enough	Auxiliary space is enough
natural light is not enough Artificial lighting is enough	natural light is enough Artificial lighting is enough
Because it is an open design, so the noise is relatively large	Because the design is isolated, so the noise is relatively mall
Basic cleaning methods	Flexible cleaning methods
Open wards	Isolated ward (double/single)

Results from analysis and comparison show that the hardware of hospitals in China is worse than that in Dutch hospitals. Survey in hospitals in China illustrated that the hospitals are intended to use Open flat, with a nurses' station located in center. it can lower treatment expense and provide more intensive care to meet the basic treatment needs under the existing economic level. With the rapid development of the Chinese economy, many health care institutions are continuing to learn from foreign outstanding user-friendly design in order to meet the needs of more people at different levels. Dutch health care environment and quality is better for the recovery efficiency, Doctor-patient work therapy environment is more comfortable. But the patient's medical costs are higher which also gives the patient and the insurance company a lot of pressure. So for this feature in the assessment of disease management for patients, the need for ICU care is particularly important.

As there is increasing demand for the healthcare environment, a good healing environment is more important for the people. Humane medical care space and environment is highly demanded. Creating a "healthy" hospital medical environment is the aim for modern hospitals in different countries.

ICU ward can create a good healing environment for patients based on the user's physical, psychological needs. Such an environment can helps ease patients' stress, anxiety and other negative emotions; and it also provides efficient, comfortable work environment to ease the pressure of high-intensity work. User-friendly design should focus on every details. It should take into account people's feelings and experiences when carried out the basic functions. And in the process, communication is very important, like the communication between patients, doctors, family members, architects, interior designers, industrial designers, etc. Communication can have a quick response to the problem the next step is to assess the problem, weigh the economic, quality, efficiency, relationship to solve problems.

5. CONCLUSION

As an important medical space in modern hospitals, the design of ICU should be carried out by a team consisted of multi-disciplinary needs to analyze the status of the current study, from the users' point of view, it should create a comfortable, efficient healing work environment to meet people's different needs. With the high-tech development, it also should focus more on the emotional balance. And at the same time meet the economic, quality and efficiency of the triangular pattern. A good ICU ward environment is not achieved through the improvements of one part, but the macro-control of different needs based on the understanding of the relationship among each part. This paper is only based on a few points to start to study the ICU units from the perspective of human cells. There are many elements that need to be further integrated research and study, which also requires the discussion between architects, planners, doctors, patients, etc. In this way, a better human medical space can be achieved in the future.

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