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ORIGINAL RESEARCH
PAPER



The application of emotional design in lighting for Chinese healthcare spaces

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ABSTRACT

With the development of time, people have more emotional needs for interior spaces. Interior lighting design is an extremely important part of interior design, especially in children's healthcare. In order to meet the needs of child patients and healthcare professionals for ward lighting, it is necessary to comply with various standards while also designing emotionally, emphasizing the positive effects of light on the psychology and health of the user. A literature research approach was used to combine the current status of interior lighting in healthcare spaces, culminating in the integration of the concept of emotional design into the lighting design of children's wards.

KEYWORDS

healthcare space, interior design, children's wards, lighting design, emotional design

1. INTRODUCTION

According to the National Bureau of Statistics [1], as of 2022, China's population of children under the age of 14 has reached 260 million, occupying a significant proportion of the population. Behind this statistic highlights the importance of hospitals as key institutions for maintaining children's physical and mental health. Among the many functional spaces in hospitals, children's wards are particularly critical, not only providing basic medical services (recuperation, infusion and treatment for children), but also carrying the demand for a comfortable hospital environment for them. In view of this, the interior environmental design of children's wards, especially lighting design, should receive more attention.

In the past few years, the Chinese government has successively launched the Outline of the National Medical and Healthcare Service System Plan, 2015–2020 and the Programme for the Development of Chinese Children, 2021–2030 [2], and has stepped up efforts to renovate and expand hospitals nationwide. The implementation of these policies has not only promoted the overall upgrading of medical facilities, but also provided an opportunity to improve the environment of children's wards.

However, at present, the design of most domestic children wards still tends to be adult-oriented, dominated by white walls and cold lights, an environment that is prone to fear for young children who are psychologically more vulnerable [3]. With advances in medical lighting technology and increased awareness of the comfort of medical environments, more and more research is beginning to focus on how to improve the psychological and physical health of children patients through design. In this context, affective design - a design concept that aims to stimulate and regulate human emotional responses - is particularly important in children's healthcare environments. Children, as a special group, perceive and react to their environment very differently from adults, which require that their emotional

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and psychological needs must be fully considered when designing children's healthcare environments.

Three aspects will be studied: the spatial layout of children's wards, the design of the lighting environment and the actual needs of hospitalized children. Through comprehensive research, this paper aims to explore and analyze the strategies of lighting design in children's wards, with a view to establishing a good visual experience and a comfortable therapeutic environment for children in children's wards.

2. EMOTIONAL DESIGN OVERVIEW

Professor Donald Norman in "Design Psychology" introduced the affective The concept of Emotional Design [4]. The professor believes that human emotions can be divided into three levels: "instinct", "behavior" and "reflection", of which "instinct" is the direct response of the human body to external stimuli. The "instinct" is the direct response of the human body to external stimuli. "Behavior" is the direct domination of the brain over the human body; "reflection" is a high-level brain activity that is reflection is high-level brain activities, which are the examination, introspection and further thinking of "instinct" and "behavior". Emotional design is a design element based on these three levels of emotion. The design is based on visual aesthetics and pleasure, function and efficiency, cultural connotation and emotional belonging. And emotional belonging are the key elements of emotional design. The key elements of emotional design are.

3. CURRENT ISSUES IN CHILDREN'S WARD LIGHTING

According to the document "China Children's Hospital Industry Supply and Demand Analysis and Prospect Forecast Report" released by China Prospective Industry Research Institute 2022, it can be seen that part of the report is based on the objective measurement statistics of children's wards in a number of general hospitals in China. In terms of the types of children's wards, due to China's large population base and high demand for beds, most of the pediatric wards in general hospitals are now double and triple rooms, and there are a small number of single VIP wards and multi-room wards for families with different conditions to choose from. According to the requirements of the national standard GB/T 5700:2008 [5], the authors analyzed the spatial function of the wards and measured the information of the ward's lamps and lanterns as shown in the table, and collected the ward's horizontal illuminance, luminance and color temperature and using the center spread method of illuminance measurement to arrange the measurement points, focusing on measuring the lighting parameters of the lamps and lanterns (Fig. 1).

In the current domestic children wards, although the lighting environment can basically meet the basic lighting needs, these lighting systems are mostly integrated and customized by design companies, resulting in lighting effects that may still be inadequate in terms of aesthetics and visual health [7]. Therefore, there is a need for more in-depth discussion and research on the lighting environment in children wards.

the photo of the hospital	Name of Hospital	Colour Temperature (K)	Llumination Value (LX)	Lighting Method
	a) Shanxi Children Hospital's	4600	Floor:202 Bed Surface:286 Bedside:337	Down lighting Down lights Panel Light Underfloor Lamp
	b) Guang Xi International Zhuang Medical Hospital	5500	Floor:101 Bed Surface:152 Beside:126	Down lighting Down lights Underfloor Lamp Integrated Line Lights
	c) Sichuan Fushun Children's Hospital	6000	Bed Surface:205 Beside:215	Down lighting Down lights Grille light panels

Fig. 1. Measurement of lighting data in research wards (Source: a) with the copyright permissions from Y. Zhang, [6], b) Author's photography, 2022, c) Author's photography, 2022)



Currently, the lighting design of children wards usually adopts a combination of general and local lighting. Direct light source luminaires are installed on the ceiling of the ward to provide down lighting, and this layout illuminates the entire ward space. Illuminance levels in children wards have been measured to be in the range of approximately 98–340 lx, with color temperatures ranging from 4,700 to 6,000 K [8]. Bedside medical equipment is often fitted with integrated direct light luminaires to provide localized lighting. In addition, ward entrances and walkways are often fitted with down lights in the ceiling, again providing down lighting.

Below the description of specific lighting status issues is listed.

3.1. Poor quality of internal lighting environment

Children are mostly between the ages of 3–10 years old, and their visual physiology is also different from that of adults [9], as evidenced by the high transparency of the lens of the eye, and the fact that their sleep-wake cycles is in the process of changing, so they are more sensitive to the visual perception of light. Some of the lamps are old, damaged lamps cannot be replaced in a timely manner, as well as children's ward lamps used for a long time has not been replaced, resulting in reduced performance, the phenomenon of weak light effect. The poor quality of light source of lamps and lanterns has led to the substandard color rendering of some lamps and lanterns, and the color rendering of some lamps and lanterns has not yet reached the national standard of not less than Ra80. Stroboscopic serious, inconsistent color temperature, low light efficiency, so that the lighting effect is greatly reduced. Although most of the children's wards lighting design can meet the basic lighting and other needs, but the lighting quality still needs to be improved.

3.2. Lighting lacks human touch

Lighting in children's wards doesn't play a sufficient role in providing emotional value to the user, the user lacks a sense of comfort, and the lighting doesn't fulfill its role in regulating the physical health and psychological state of the human body. Existing hospital lighting design usually only use the traditional neutral cool color temperature and direct light source, lighting design lacks the ability to regulate mood [10]. In the control mode, it is difficult to ensure the privacy of the light and flexible switching of multiple lighting scenes. In the design of the lighting mode, the convenience and popularity of the later operation and management are not considered.

3.3. Focus area illumination to be upgraded

Since the existing lighting fixtures in the wards are only ceiling downlights and grille panel lights at the end of the beds, and there is no switching between different visual operation scenes, so it makes it difficult for doctors and nurses to concentrate, efficiently and accurately examine

and care for patients. In some hospitals in China, the artificial lighting setup still remains at the minimum lighting standard of ordinary wards, lacking a hierarchical and stratified lighting system. The design of the lighting scene model lacks consideration of the convenience and popularity of the later operation and management.

4. EMOTIONAL DESIGN PRINCIPLES FOR LIGHTING IN CHILDREN'S WARDS

4.1. Comfort principle

Compared with adult patients, children are a special group who are more prone to anxiety and fear [11]. Therefore, important factors (lighting method, color temperature and illuminance) should be dealt with in the lighting design to ensure that there is an appropriate level of illuminance in the room to facilitate indoor activities, and at the same time, to give a sense of relaxation with a harmonious, stable and soft light to create a vivid indoor mood and atmosphere, so as to make people feel happy psychologically, and to reduce the sense of anxiety in children.

4.2. Safety principle

Safety is the most basic human need for lighting. The lighting design of children's wards should be considered in all processes from construction to commissioning to ensure its safety. Ward lamps and lanterns in the wires are prohibited to take the open wire; to avoid naughty children will be broken wires, triggering the risk of electric shock. In the selection of lamps and lanterns, should try to avoid harmful heavy metals and formaldehyde and other substances and comprehensive consideration of children's physiological specificity and limit the requirements of glare, and consider the safety of the light source of the lamps and lanterns irradiation. There is also the need to choose energy-saving, environmentally friendly, efficient, and safe new lighting equipment.

4.3. Ecological principle

The ecological principle of lighting design focuses on the energy-efficient and healthy characteristics of lighting.

For energy efficiency, the focus is on using as little power as possible to obtain the required lighting, while at the same time being able to generate economic benefits. However, it should be noted that energy saving cannot be achieved by reducing the standard of lighting in the indoor environment, and must be optimized with the help of modern science and technology to optimize the efficiency of lighting products.

The health of the lighting design, refers to the lighting source spectral composition does not contain infrared light and ultraviolet light and other harmful light. If long-term exposure to ultraviolet radiation, will seriously damage the retina, lens and choroid, resulting in lens lesions and cataracts and other diseases [12].



5. EMOTIONAL DESIGN METHODOLOGY FOR LIGHTING IN CHILDREN'S WARDS

5.1. Intelligent design

5.1.1. Natural light simulation. Based on the selection of stable luminaire products, the use of intelligent sensor-based control is increased. In some special cases, the use of variable color temperature dimmable luminaires in children's wards that lack daylight simulates natural light and helps to regulate the user's biorhythms (Fig. 2). Based on the selection of stable luminaire products, the use of intelligent sensor-based control is increased.

5.1.2. Acousto-optic linkage. Intelligent lighting systems can be integrated with sound and music systems to create a more comfortable environment. Soft music can help patients relax and reduce anxiety. In addition, sound and light linkages can be used to remind medical staff or patients about specific events or medication usage.

5.1.3. Human infrared sensor light fixtures. In order to take care of the inconvenience of patients, the night light can be arranged in the aisle area of the foot lamp and evenly arranged soft light strip, can sense the activities of people within three meters around, when the human movement cannot be sensed, the light will be automatically extinguished, and when there is enough natural light during the day, it will not be lit, reducing the consumption of lighting (Fig. 3).

5.2. Emotional design

5.2.1. Rest and recreation model. This design mainly adopts four kinds of lamps and lanterns: bedside wall lamp, LED lamp disc, down light and linear lamp. Down light and linear lamp combine to provide lighting for the entrance area; LED lamp disc through the secondary ceiling reflection, soft indirect light irradiation on the floor, bringing uniform lighting for the whole space. The back of the bed against the wall is made of imitation wood pattern printed alloy steel plate combined with silicone ceramic plate, installing 180° out of the light of the bedside wall lamps, the light source is hidden in the slot, the light is switched on from the underside of bedside wall lamps, and the lamps emit diffuse reflections on the two sides of the head, to avoid the glare of the head, and to ensure that the illuminance under the state of reading, and to alleviate the fatigue of the eyes.

The rest and recreation model (Table 1) uses a combination of general lighting and layout accent lighting, with switches controlled from the head of the bed so as not to disturb other children in the ward. Down light wall lamps diffuse light on both sides, 4,000 K neutral white light produces a soft light [13], and at the same time to ensure that the illumination of the reading area, the eyes will not feel tired, the spirit will also be relaxed (Fig. 4).

5.2.2. Diagnostic and nursing care model. As with the lounge and entertainment modes, the design also uses four types of lamps: a bedside wall lamp, an LED light tray,

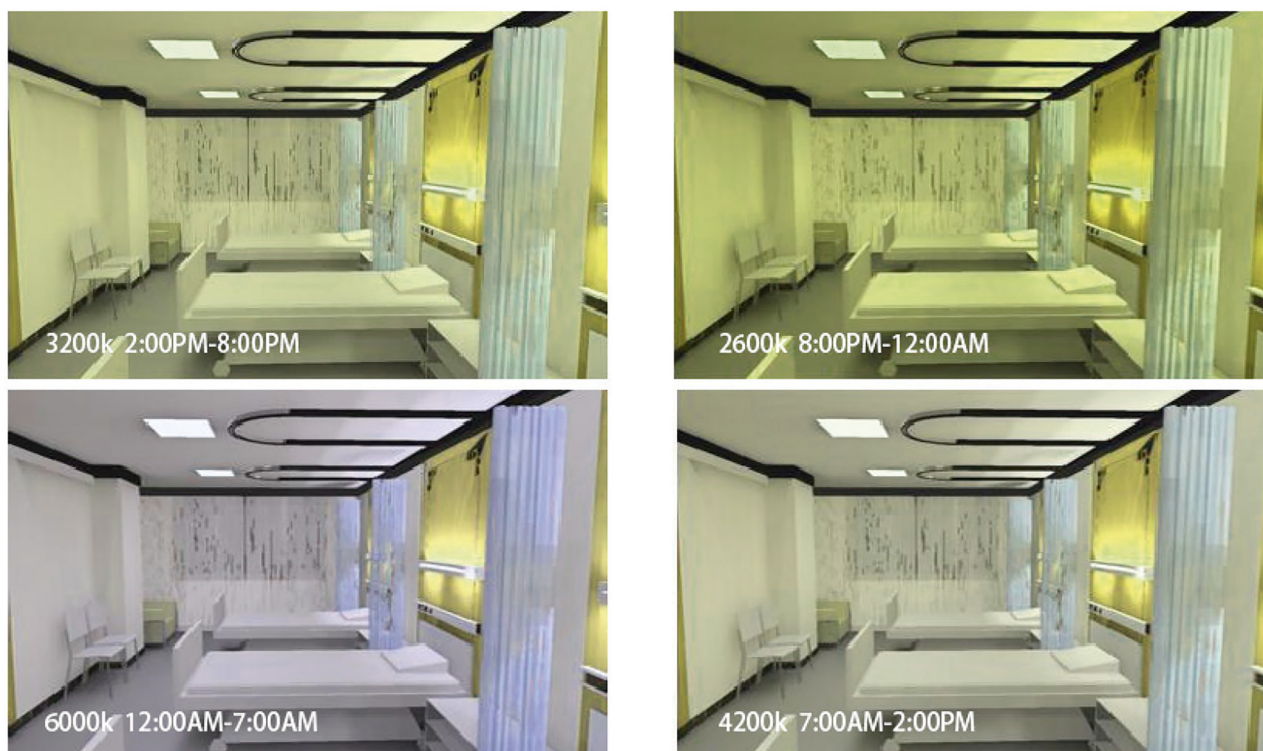


Fig. 2. Simulates natural daylight color temperature over time (Source: Author's production of renderings)



Fig. 3. Human infrared sensor light fixtures (Source: Author’s drawing with software)

Table 1. Luminaire parameters							
Luminaire	Power (W)	Luminous flux (lm)	amount	Mounting Height	Color temperature (K)	Dimming value	Luminaire size (mm)
	20	2,160	3	1.36 m	4,000	100%	930 × 95
	36	3,200	3	2.75 m	4,000	30%	598 × 598
	18	1,750	1	2.75 m	4,000	70%	144 × 107
	5	450	10	2.70 m	4,000	100%	500 × 95

Source: the Authors.



Fig. 4. 3D_{max} renderings (Source: the Author’s production of renderings)

a down light and a linear lamp. In addition to the bedside wall lamp, the rest of the lamps and lanterns function the same as the rest and recreation mode, the only difference is that the bedside wall lamps are no longer only three directions, but through the full light, to meet the medical staff to check the room infusion and other key lighting illumination requirements.

In the diagnostic and nursing care model (Table 2), it is first necessary to ensure that the local brightness requirement of the medical staff’s working surface is greater than 300 lx, and the lamps need to have a high Color Rendering Index (CRI) to be able to clearly see the body surface characteristics and emotional changes of children [14]. Secondly, the overall brightness in the ward is uniform; the bedside wall lamps and secondary reflection lamp panels are all bright (Fig. 5).

Table 2. Luminaire parameters

Luminaire	Power (W)	Luminous flux (lm)	amount	Mounting Height	Color temperature (K)	Dimming value	Luminaire size (mm)
	36	5,600	3	1.36 m	3,000	70%	930 × 95
	36	3,200	3	2.75 m	3,000	50%	598 × 598
	18	1,750	1	2.75 m	4,000	100%	144 × 107
	5	450	10	2.70 m	3,000	100%	500 × 95

Source: the Authors.



Fig. 5. 3D_{max} renderings (Source: the Author’s production of renderings)

5.2.3. Night-time patrol model. Night patrols do not require too much light and only three types of lamps are used, namely, the lower sensor light band, foot well light and bedside wall light (Table 3). When sleeping the bedside wall lamp of the upper light out of the night light is turned on,

to meet the night patrol, activity lighting needs; bedside table under the induction soft light strip 3 W m^{-1} , can provide the basic lighting of the ground [15], but also will not have too much brightness caused by the decline of light and dark adaption; in the entrance and the corners of the aisle wall to install the foot lamp, you can improve the convenience of the night time activities. By means of intelligent sensing, the soft light bar under the bedside table and the footlights are automatically activated during night-time activities, and the lights come on when people come and go (Fig. 6).

5.3. Sustainable design

Lighting power expenditure has always been a major part of hospital power consumption. China’s building lighting design standard GB 50034: 2013 [16] clearly specifies the lighting power density limit. Therefore, combining intelligent lighting control, upgrading the existing lighting system and rationally allocating energy is an important way to achieve sustainable development. Sustainable hospital lighting design helps hospitals to rationally allocate electric energy and save operating costs during construction and operation [17].

Table 3. Luminaire parameters

Luminaire	Power (W)	Luminous flux (lm)	amount	Mounting Height	Color temperature (K)	Dimming value	Luminaire size (mm)
	3.0	60	3	0.17 m	2,700	100%	750 × 50
	0.4	100	3	0.30 m	2,700	100%	95 × 95
	1.0	100	1	1.36 m	2,700	100%	930 × 95

Source: the Authors.





Fig. 6. 3D_{max} renderings (Source: the Author's production of renderings)

6. CONCLUSIONS

Improved lighting design for children's hospital wards through emotional design. It meets the need for better quality and humane lighting with an emphasis on comfort, safety, and ecology. This research contributes to the field by proposing a new approach that integrates intelligent, emotional, and sustainable design methods. This approach has important implications for improving healthcare environments for children, potentially affecting their mental and physical health. The findings of this paper can inform future research and provide technical support in lighting to further improve children's healthcare environments.

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