Journal of Engineering and Applied Sciences 14 (13): 4307-4311, 2019
ISSN: 1816-949X

Design of Mixed Lighting System for an Intensive Care Unit in Cartagena City

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Abstract: The aim of this researcher is design a system of mixed lighting for intensive care unit in the city of Cartagena. The lighting design was performed according to the recommendations of the technical regulations lighting and public lighting, Resolution No. 180540 of March 30, 2010 issued by the Ministry of Mines and Energy. The proposed redesign allows medical personnel per form various tasks with different lighting requirements and reduce eye strain, preventing impairment of visual acuity in health workers and improve working conditions. Concluded that the new lighting system will improve lighting, reduce errors and accidents and increase patient safety. By employing natural and artificial lighting also improves circadian cycle in workers with strenuous working hours e positively influences mood and patient recovery.

Key words: Lighting, design, working conditions, prevention, patient, recovery

INTRODUCTION

The health sector worker is exposed to a variety of risks, the most recognized and inherent in their activity biological type other risks in this psychosocial staff are due to the high mental burden and responsibility and musculoskeletal injuries due to physical burden related to their work. The health institutions make greater emphasis on prevention such risks. However, certain risks of physical type as noise, lighting and thermal comfort are poorly evaluated by organizations and therefore, little considered within the continuous improvement in the management system of safety and health at work, this may be due to the belief these were estimated within the building design.

Lighting is an essential for preserving eye health worker factor, plus lighting levels according to each task has positive effect on reducing errors and accidents at work. Rodriguez relate the appearance of effects both physiological and psychological level on the worker who works long hours under artificial light, so, it is essential include in lighting designs the possibility of using natural light.

Specifically, in Intensive Care Units (ICU) care is provided mainly in cubicles patients where diverse health professionals such as nurses, respiratory therapists, psychologists, nutritionists, social workers, intensivist physicians and practicing physicians in various specialties such as surgery, neurology, pulmonology, orthopedics, cardiology and other specialties, according to the pathology the patient. Therefore, lighting levels for performing various tasks of medical personnel vary considerably with ranges which can range from 200-2000 Lux.

Some background on conditions of insufficient lighting health workers have been documented inemergency room, surgery and intensive care units in the work done by Janosik and Kuiagowska (2007) and Manrique (2010). Addition, the study by Brown and Sierra (2016) described the levels of lighting in nursing jobs inemergency and intensive care units of a lending institution health (IPS) of Cartagena. In this, it was reported that 91% of posts evaluated work does not meet the values required by the standard to perform nursing tasks (Brown and Sierra, 2016). Given this variability and the results obtained by Brown and Sierra in Unit Pediatric Intensive Care (PICU) of IPS Cartagena, this study originated.

Objective: Design a system of mixed lighting for intensive care unit in the city of Cartagena which allows the improvement of working conditions of health workers as well as safety and quality patient care.

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MATERIALS AND METHODS

Design development took into account the recommendations of the technical regulations lighting and public lighting, Resolution No. 1 80540 of March 30, 2010 issued by the Ministry of Mines and Energy.

Demands lighting of health personnel in ICU: Lighting levels were established according to what described in the technical regulations lighting and public lighting, Resolution No. 180540 of March 30, 2010 issued by the Ministry of Mines and Energy (MME., 2010), the UNE EN 12464-1 lighting of workplaces issued by European Committee for Standardization 2003 (ECS., 2003) and the colombian technical regulations for evaluation and control and lighting brightness centers and jobs issued by the Ministry of Labor and Social Security 2003 (MLSS., 2003) reference being higher values which are listed in Table 1.

Diagnostic lighting conditions PICU study: In the study, by Brown and Sierra is observed that most of the jobs of the PICU, meet the standard in the day for tasks that demand is between 500-1000 Lux but tasks such as resuscitation or resuscitation and surgical procedures higher demands not enough to be performed in patients with cubicles recommended lighting levels. Similarly, night lighting levels do not meet for any task (Brown and Sierra, 2016).

Compliance with the standard unit during daytime is mainly due to the existence of small windows that letnatural light, there by improving the light striking cubicles patients during day but glares generated during the early hours of the morning, factor that must be taken to avoid disturbing workers. Furthermore is important note that day time evening average is close tominimum required by current regulations such as shown in Fig. 1, more does not reflect reality throughout the workday.

Techniques in the design features: According to the technical guide for energy efficient lighting for hospitals and primary care centers issued by the Spanish Committee lighting lighting systems must comply with the recommendations of quality and visual comfort, creating pleasant environments and comfortable for users of facilities and rationalize the use of energy facilities the highest possible energy efficiency (Institute for Diversification and Saving of energy (IDAE) and Spanish Lighting Committee (CEI., 2001) these guidelines support the proposed design. As for savings is known that while some measures of organizational type can help reduce costs, combining them with a change of more efficient technologies is achieved best results (Silva and Milanes, 2013). Given these recommendations are described below different technologies considered for design type Luminaire (Fig. 1).

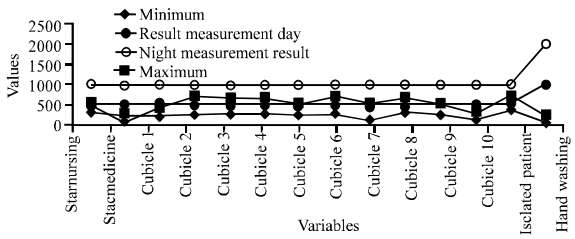

Fig. 1: Castano and Sierra, 2016; results measurements lighting UCIP daily average-night

With features like energy efficiency, color rendering index CRI, operating temperature, intensity luminous flux loss level of light intensity provided by the manufacturer different types of lighting was examined and chose use LED lights Light Emitting Diodes for design due to the advantages offered by its quality and diversity, consistent with the recommendations of McLean-Conner (2011) well as Silva and Milanes (2013) this type of luminaire allows a better view and increases the perception of depth and detail.

In relation to index color reproduction for medical personnel to observe details and appearance of the patient is critical this technology allows better reproduction very similar to daylight color, given its high color rendering index was determined to be very close to 90-95%.

As for the color temperature, expressed in Kelvin (K) and refers to the perception of light, between warmer lower temperature will be and the more cold be higher that temperature. This varies in a range between 1990 K and compared with the candle light and the maximum values exceed 12,000 K and is seen as a blue gas flame. Health rapid patient recovery when desired can handle lighting in warm areas with a color temperature of about 3500 K but if instead what you want is a waken a patient after removing sedation can handle a colder temperature near 4500 K for faster a wakening. These factors in turn influence aspects such as faster rotation of beds and increased productivity of the intensive care unit.

No doubt the intensity of light output, its relation to energy consumption per lumen and a loss factor of near by luminous flux to 90% ensure a longer life and considerable energy savings as has been shown in some studies (Silva and Milanes, 2013; Ochs *et al*., 2013).

Wireless lighting design: The design of lighting system must allow wireless power using a web application and

Table 1: Demands lighting required for tasks of health personnel in UCI (Prepared)

		Lighting levels in Lux		
Profession	Task to perform	Min	Middle	Max
Physician intensivist	Review	500	750	1000
	Resuscitation resuscitation	1000	1500	2000
	Procedures QX	1000	1500	2000
Surgical	Procedures QX	1000	1500	2000
Neurologist	Review			500, 750, 1000
Neurosurgeon	Review			500, 750, 1000
Pneumology	Review			500, 750, 1000
orthopedist	Review			500, 750, 1000
Cardiologia	Review			500, 750, 1000
Therapist respiratory	Monitoring and treatment			500, 750, 1000
Psychology	Consultation			200, 300, 500
Social worker	Consultation			200, 300, 500
Nutricion	Consultation			200, 300, 500
Enfermeria	General	100	150	200
	Observation and treatment	500	750	1000
	Laboratory samples collection	500	750	1000
	Bathroom			200, 300, 500
	Medicine preparation	500	750	1000
	Readingmedical histories	500	750	1000
All	Handwashing	1000	1500	2000

using devices with internet access as smartphone, you can control and configure the lighting levels according to the task atand allow storing the received values by a sensor.

Alcala (2007) used the device or home automation systems with dedicated wireless communication networks Zigbee because it is a protocol for free use, this allows a cost" that allows autonomous control oflighting system preprogrammed according to the needs (Alcala, 2007). Design Lights Consortium corporations as DLC., (2017) technologies have been developed such as "Daylight Harvesting for Interior systems" for controlling the color change and the light level present in an area luminaire, automatically, using sensorsand network interfaces for this purpose (DLS., 2017).

On other hand, systems for varying the lighting level using attenuators have advantages over automated systems for its ease of use and management by users also are installed near the luminaire without large financial investments.

The use of either system, to change the light level without having to go to the place where the switch, improving times, reducing errors by graduating the required level and use of unnecessary energy by having an abundant lighting activity requiring less.

Regulation entada windows lighting: By Barrios *et al.* (2013) and Marchwinski (2014) in their research mention the existence of various types of glass technologies that allow modulation of luminous and solar transmittance; among which may be mentioned particles Suspended (SPD) Devices, Liquid Crystal Devices (LCD), Electrochromic (EC), GC gasocromicos technology and micro-shutters. According to the analysis by Barrios *et al.* (2013), SPD technology offers the advantage touser a different level of dye and therefore, the transmission characteristics can be changed at will to suit any particular external environment; however, in terms of energy consumption it is more expensive because the need for a current color change but offers more privacy and responds well to reduce heat Sun. Also Ghosh *et al.* (2017), he states that SPD is advantageous over other technologies using electric current because it is powered by Alternating Current (AC) that allows connect directly with the main power supply of the place, allowing the change in their status of "opaque" to transparent when applied voltages of 0-110 V. Addition this technology is suitable for hot weather and Summer (Anonymous, 2017).

Colombia has companies that produce or distribute glass and windows with this technology, the design of the windows was made simply in terms of its architecture because it must allow for cleaning rectangular two bodies with dimensions of 1.2 m high and 2 m wide installed 1 m he floor and glass that allow regulate the natural light at the user which it is considered a factor favoring visual task performance and comfort is the use of natural light while avoiding glare.

Measurements lighting *in situ*: Currently there different programs installed on mobile devices and computers, so that, the user can measure light levels in Lux or candelas per unit area for which use camera and even some have a timer in the case of that you need place the meter in a place with limited access. Also providevalue minimum, average and maximumand generates graphs both instant light levels,

average. According to Arceo, this type of program allows a more dynamic interface between information and the user can inform instantly and agile results which can also share with other stakeholders such as the maintenance team facilitating and improving maintenance. It is also simple and easyuse tool. Importantnote that these measurements may not be used within the safety management system and health at work for which backed by Colombian and International Regulations and Sanitary Equipment Assessment elaborates qualified staff for this function were used. However, for the purposes of the project can be implemented this technology.

Because the proposed design allows the worker will graduate levels of natural light, the complementary use of these programs allowto check lighting levels required for each task and avoid glare. While it could be considered as an additional task for health workers also, it allows staff tend adequate working conditions and selfcare.

RESULTS AND DISCUSSION

Calculations lighting system technical regulations lighting and public lighting: Resolution No. 180540 of March 30, 2010 issued by the Ministry of Mines and Energy. Cubicle dimensions correspond to width 2.83.3.3 m long and 3.2 m high. The job is the patient care bed whose dimensions are a length of 2.12. 0.9 m width. A variable height between 60-95 cm. Addition to the maximum value calculations required for the different tasks performed in this position for 2000 Lumens work it was taken. The ceiling lights will be placed at a height 3.2 m.

With these data the total luminous flux was determined and the need for two fixtures per cubicle was determined with the following specifications: overall efficiency of 89.5 Lm/W, index color rendering 85, color temperature between 3000-4000 K, power consumption 23-46 W of 39,000 h of use and light intensity index lost 90 which ensures that the light outputnot decline by more than 10% to reach the number of hours of operation. And the possibility of attenuation or 0-10 V dimerization. You need install a control module dimerization per cubicle and for wireless control peak with accessories for wall mounting, finally, a radio frequency repeater (Fig. 2-5).

Costs $1,685,000 per cubicle^{00} weights in relation to lighting control, the window with the liquid crystal has a $13,315,000^{00} pesos for a total of $15,000,000^{00} weights. Then a real photogra phic image of the cubicle study and three images showing the proposed changes is shown.

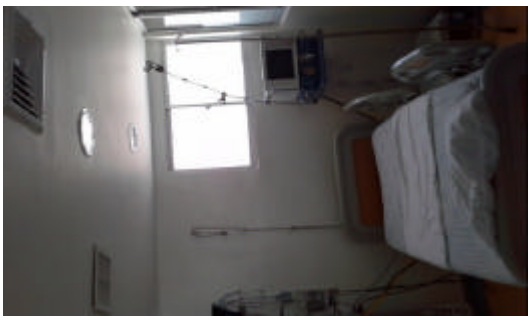

Fig. 2: Current conditions of natural and artificial lighting in PICU intervened (Real Cubicle PICU)

Fig. 3: Natural lighting conditions redesign PICU in the morning (Own)

Fig. 4: Natural lighting conditions redesign PICU at noon (Prepared)

Fig. 5: Natural lighting conditions redesign PICU at night (Own)

CONCLUSION

The benefits of the new lighting design not only improve working conditions for health workers but also impacts on the safety of this and the patient as adequate lighting contributes in reducing the accident and the error rate by reducing the occurrence of adverse events. Also, it contributes to substantial energy savings by using the illumination required for each task and then to reduce the lighting to the level of patient observation. On other hand

for both workers and patients, the entry of natural light through windows technology that controls passage of natural light and avoid glare improves mood and prevents disturbances caused circadian cycle due to long working hours, contributing to the decline extended stay of patients in intensive care units. Also, offers a substantial advantage in terms of hygiene against black out curtains type or systems addition durability it is higher, so, it is a long term investment.

Another advantage is that this type of technology in windows is that decreasing heat transfer, substantially lower energy costs for temperature control within the UCI. Besides the fact of implementing a programmable lighting control system according tasks, helping to raise awareness in selfcare in health care workers which according to Ulrich (2016) often sets its concern in the patient's health and neglects his.

Finally, integrated risk in companies the country, from the view points both quality of care and safety of workers, management would achieve significant gains in the safety culture of the institution and greater involvement of workers both the quality of care given as selfcare. Addition greater management commitment for the care of the environment by reducing green house gas and energy savings by lowering costs and number of repairs or maintenance achieve common goals, agreeing with that expressed by Silva and Milanese (2013) and Ochs *et al.* (2013).

ACKNOWLEDGEMENT

Fundacion universitaria Tecnologico Comfenalco, Cartagena-Colombia

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