An Investigation of Existing Light Levels and Color Choices in Pediatric Hospitals in the United States

Sally R. Merriman and Paulette Hebert, Ph. D.
Oklahoma State University, Stillwater, OK

Design, Housing and Merchandising
College of Human Sciences

Introduction

Light and color are only two of the attributes in the built environment, however, it can be argued that these are two of the most important attributes. This study reviews current lighting conditions at three hospitals with pediatric units in the United States and were compared with IES recommendations. "Evidence-based design (EBD) is the process of basing decisions about the built environment on credible research to achieve the best possible outcomes (Malone, p.83). This study is used for the basis for an evidence-based design solution for Hospital Site A that was included in this study. When designers use the Theory of EBD Model, there is "great potential for transformational change within a healthcare organization that has the opportunity to design a new facility (Malone, et. al., 2010, p.77). This model integrates transformational leadership and culture with infrastructure bricks and clicks with re-engineered clinical and administrative processes (Malone, et. al., 2010, p.77). When these three things are combined and evolve there is positive change in the healing environment to improve patient outcomes (Malone, et. al., 2010, p.77).

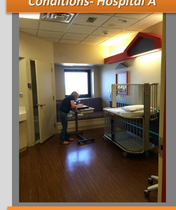
Purpose

Via empirical field examination of existing conditions in a pediatric unit at a large hospital in the southern Mid-West, researchers compared and contrasted current electric lighting levels for visual tasks (i.e., medical examination, reading, and administering medication) with those recommended by the Illuminating Engineering Society (IES). These empirical field examinations were compared and contrasted with two pediatric hospitals in the Northeast.

Method

During the research period, all of the visited spaces were unoccupied by patients or medical staff. Light levels were measured using a light meter and light sources were documented in field sketches and photographs. The light levels were documented with all the electric lights on and the windows open to allow for daylight. The light levels were then measured with all the electric lights off. The two numbers were then subtracted to find electric light levels only. These measurements were compared with the recommended values by the Illuminating Engineering Society (IES). The IES is considered to be the lighting authority in North America and most locally adopted codes are modeled on IES recommendations. The researchers also documented the Light Reflectance Values on the ceiling, floor and walls. Furniture floor plans were produced. These drawings, were sketched on-site and later converted to measured drawings utilizing AutoCAD software. Illuminance measurements were taken on horizontal and vertical work planes (i.e., bed surfaces, tabletops etc.) using a digital, Fisher Science Education light meter, model number S90198, which had been "quality certified and ISO 17025 accredited" by a calibration laboratory. Visual tables were identified and recommended values were referenced and compared to existing levels at the sites. The existing light reflectance values (LRV) were also estimated by matching existing wall, ceiling, and floor finishes in all standard areas to a Sherwin Williams' paint chip book with identified LRV. LRV may range from a low of 0% (darkest) to a high of 100% (lightest). The current luminaires' mounting locations and International Commission on Illumination (CIE) luminaire classification systems were also determined and documented. Mounting types and CIE distributions were compared to IES standards. Available CIE distributions for luminaires may include: direct, semi-direct, direct-indirect, general diffuse, semi-indirect, and indirect. These are based on "both the fraction upward and downward directed lumens, and the shape and intensity of the distribution (DiLaura, D. L., Houser, K., Mistrick, R., & Steffy, G. R., 2011)."

Figure 1. Photo of On-Site Conditions- Hospital A



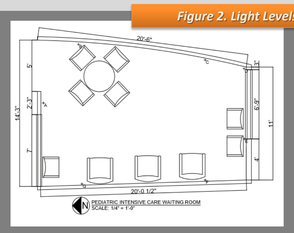


Figure 2. Light Levels in AutoCAD Partial Plan View- Hospital A

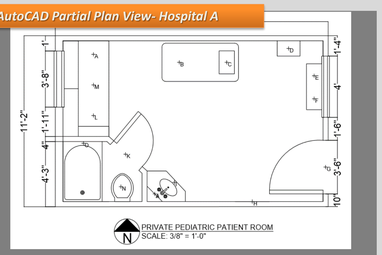


Figure 3. Photos of On-Site Conditions- Hospital B

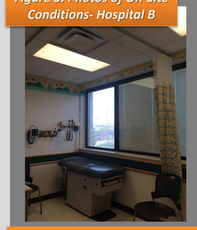
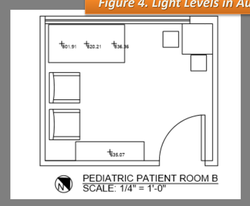


Figure 4. Light Levels in AutoCAD Partial Plan View- Hospital B



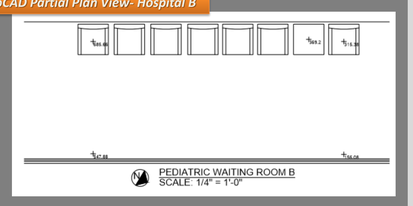
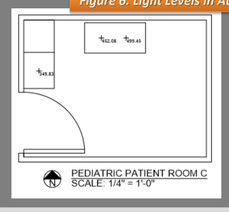
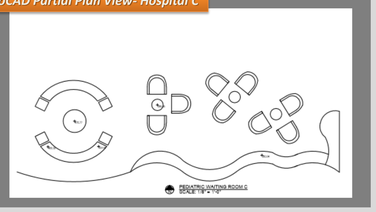


Figure 5. Photos of On-Site Conditions- Hospital C

Figure 6. Light Levels in AutoCAD Partial Plan View- Hospital C

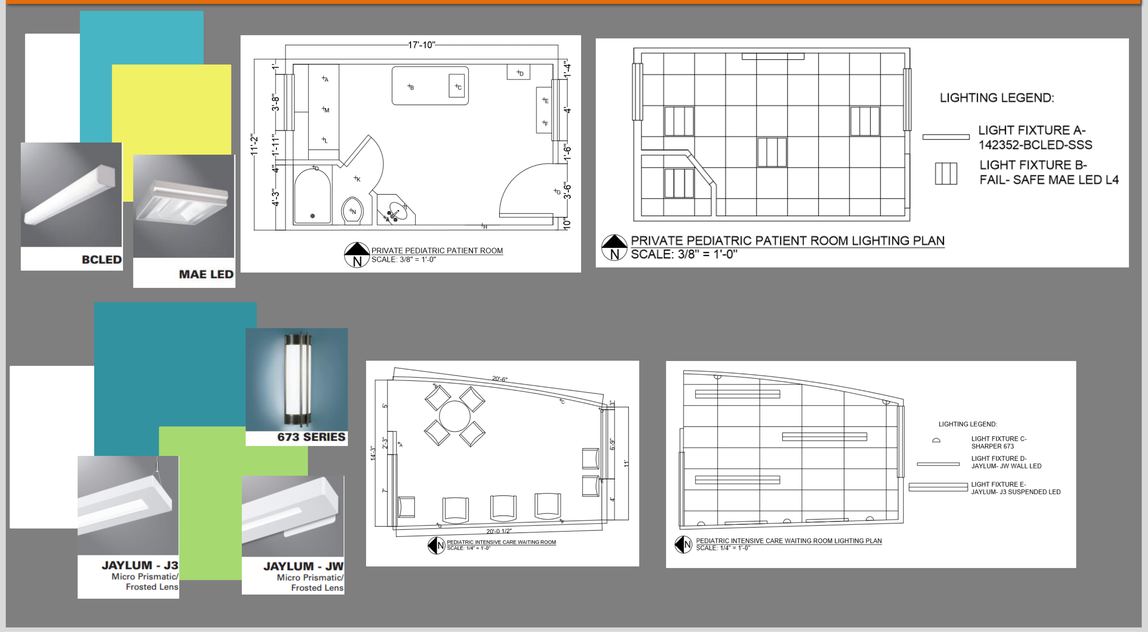




Discussion

Analysis of documented light level observations (N=37) revealed that five (n=6, 16.2%) of the existing lighting measurements complied within +/- 10% of the recommendations. At the head of the patient bed in Hospital A, the light levels were less than half of the recommended levels (44.8%) indicating *need*. In contrast, Hospital B's light level at the head of the bed were 160% of the recommendation, indicating waste. While Hospital C was the only one that complied within IES recommendation. These findings suggest the greatest deficiency in compliance was at the head of the patient's bed, where vitally important visual tasks may be required by clinicians. At Hospital B all of the measurements were +10% of the recommendations highlighting tremendous inadequacy in compliance to IES standards. All facilities should consider diversifying their light fixtures, especially in rooms with natural daylighting. Diversification would allow for various lights to be switched on while leaving others alone which is critical for adjusting for daylight. Having a variety of light fixtures allows ones' eyes to rest before absorption of more visual ques would occur. Hospital Site C also allowed for the mixture of LRVs which may have allowed for the designed to that populations' needs, utilizing bright, bold colors as focal points. There was some mixture of a dark green with a 22 LRV that gave a pleasant aesthetic. Both the Hospital Site C and Hospital Site B utilized the dark green in the patient rooms which may be contributed to color psychology mentioned previously.
Hospital Site A could take some design attributes into consideration from both of the nation's leading hospitals, from color choice to custom lighting fixtures that were found at Hospital Site C.

Proposed Design Recommendation for Hospital Site A



Reference

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Findings

Pediatric Patient Room A	Illuminance Levels in Lux: Horizontal or Vertical	In Situ Observation	IES Recommendation
A- Seating	Horizontal	**138.85**	150
B- Infant Bed	Horizontal	292.78**	500
C- Infant Bed	Horizontal	357.36**	500
D- Night Stand	Horizontal	133.47*	50
E- Work Counter	Horizontal	103.33**	300
F- Work Counter	Horizontal	104.41**	300
G- Entry	Vertical	90.42*	30
H-TV	Vertical	137.78*	50
I- Sink	Horizontal	442.4*	150
J- Mirror	Vertical	258.33*	200
K-I Door	Vertical	123.78*	30
L- Seating	Horizontal	105.49**	150
M- Seating	Horizontal	**147.47**	150
Pediatric Waiting Room A		**In Situ Observation**	**IES Recommendation**
A- Lockers	Vertical	152.85*	50
B- Wall/ Dining Area	Vertical	50.59**	150
C- Sink/Towel Dispenser	Vertical	37.67**	200
D- Corner of Waiting Area	Vertical	18.3**	150
E- Wall/Seating Area	Vertical	25.83**	150
F- Wall/ Resting Area	Vertical	81.81**	150
G- Wall/ Resting Area	Vertical	80.73**	150

Pediatric Patient Room B	Illuminance Levels in Lux: Horizontal or Vertical	In Situ Observation	IES Recommendation
A- Head of Bed	Horizontal	801.91*	500
B- Middle of Bed	Horizontal	820.21*	500
C-Foot of Bed	Horizontal	836.36*	500
D- Work Counter	Horizontal	635.07*	500
Pediatric Waiting Room B		**In Situ Observation**	**IES Recommendation**
A- Seating	Horizontal	685.66*	150
B- Side Table	Horizontal	369.2*	50
C- Seating	Horizontal	315.38*	150
D- Wall	Vertical	**156.08**	150
E- Wall	Vertical	547.88*	150

Pediatric Patient Room C	Illuminance Levels in Lux: Horizontal or Vertical	In Situ Observation	IES Recommendation
A- Foot of Bed	Horizontal	**452.08**	500
B- Head of Bed	Horizontal	**499.45**	500
C- Work Counter	Horizontal	349.83*	300
Pediatric Waiting Room C		**In Situ Observation**	**IES Recommendation**
A- Coffee Table	Horizontal	475.77*	50
B- Coffee Table	Horizontal	385.35*	50
C- Seating	Horizontal	456.39*	150
D- Seating	Horizontal	337.99*	150
E- Seating	Horizontal	280.94*	150

Comply within +/-10% if IES recommendations
* 10% or more than recommended according to IES Standards (waste)
** 10% or less than recommended according to IES Standards (need)

Light Fixtures- Patient Room	Existing	Proposed
Mounting	A) Wall B) Ceiling	A) Wall B) Ceiling
Distribution	A) Indirect B) Direct	A) General Diffuse B) Direct
Optical Control	A) Traditional switching B) Traditional switching	A) Dimmer driver B) Dimmer driver
Glare Control	A) Traditional diffuser B) Traditional diffuser	A) White opaque injection molded and plates. B) 2 lenses covers, one for exam and one for ambient

Light Source Attribute	Existing	Proposed
	Fluorescent	LED
Lamp Life	10,000 hours	50,000 hours
Lumens/Watt	450/ 9-13	450/ 4-5
Color Rendering Index	70-82	70-90
Correlated Color Temperature	2500-6000	2700-4200

Light Fixtures- Waiting Room	Existing	Proposed
Mounting	C) Ceiling D) Floor	C) Wall D) Wall E) Ceiling
Distribution	C) Direct D) Semi-Direct	C) General Diffuse D) Direct- Indirect E) Direct- Indirect
Optical Control	C) Traditional switching D) Traditional switching	C) Traditional Switching D) Traditional Switching E) Dimmer driver
Glare Control	C) Traditional diffuser D) Shade	C) Matte White Panel D) Frosted Acrylic E) Frosted Acrylic

Light Fixture Controls	Existing	Proposed
Traditional Switching		Daylight Harvesting
		Occupancy Sensors
		Traditional Switching with Dimming drivers