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The effects of lighting in a long-term care center for visual conditions and illuminance levels on the elderlySakda Seesophon^{1,2}, Orawan Buranruk^{1,2,*} and Yingsawad Chaiyakul³¹Research Center in Back, Neck, Other Joint Pain and Human Performance (BNOJPH), Khon Kaen University, Khon Kaen, Thailand²School of Physical Therapy, Faculty of Associated Medical Science, Khon Kaen University, Khon Kaen, Thailand³Faculty of Architecture, Khon Kaen University, Khon Kaen, Thailand

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Abstract

The elderly are vulnerable groups due to the physiological and psychological changes they are undergoing. The natural deterioration of vision leads to impairment and is often the cause of injuries sustained due to falling. In the living it is essential to promote health and safety which requires sufficient lighting levels. This research aims to investigate the level of lighting in a long-term care center and to study influences of lighting factors affecting satisfaction levels on visibility of the elderly. Lighting levels were measured by an illuminance meter and a questionnaire was administered on visibility from 42 elderly residents. The results showed that illuminance levels of all areas in the long-term care center were lower than illuminance levels suggested in guidelines for lighting design for the elderly. The surveyed illuminance values were also lower than required illuminance levels under current government regulations, where the appropriate illuminance should be 500 lux for the activities room. However, the elderly were satisfied with the existing visual conditions. Thus, knowledge of how to use indoor lighting to ensure healthy and safety and awareness of the effect of insufficient lighting in the living environment is required.

Keywords: Illuminance, Lighting levels, Long-term care center, Elderly satisfaction, Elderly

1. Introduction

Entering an aging state is a challenge that every country has to confront, especially in aspects of public health services, and to undertake medical care of illness and chronic diseases that comes from the decline of properly working physical systems [1]. It is found that many of the elderly in Thailand cannot help themselves more than 5% [2]. A thought to establish long-term care centers for the elderly, therefore, is caused by those problems to support rapid increase in the number of the elderly and to facilitate all medical care for a higher quality of life.

When people are aging, physical changes will occur in many aspects and in the form of deterioration, especially in eyes and vision [3,4]. This change can reduce visibility of the elderly, lead to visual impairment, and result in the development of some eye diseases. A study of trends on eye health of Thai elderly found that 48.8% of them have blurred vision and the first three diseases among them are cataract, glaucoma and age-related macular degeneration (AMD), respectively [5]. If medical care is not provided for the elderly correctly, they will ultimately lose their sight and be blind. Losing their sight will have a massive impact on quality of life, both physical and mental aspects. In the physical aspect, they will suffer with difficulties in their daily activities, cannot read books or works that require a high level of fineness [6]; while anxiety, irritability and annoyance are plaguing their mental health. Moreover, in

the social aspect, they will have low levels of social interaction, need to depend on other persons for their living and be affected by relationships in their families [7]. The most significant factor for visibility of the elderly is lighting, proper and sufficient lighting to compensate for reduced visibility of the elderly. Meanwhile, lighting also has its property for treating disorders or illness in the elderly stages such as insomnia, seasonal affective disorder, and Alzheimer [8-10].

Therefore, light plays a significant role in designing residences of the elderly because lighting level affects the circadian system and sleep patterns. It is also related to activity rhythms affecting behavioral and emotional expression [11]. Furthermore, lighting also affects postural stability, gait pattern and can be directly correlated to rates of falling caused by disability and infirmity in the elderly. From previous studies, it is found that level of insufficient lighting makes poorer postural stability and will increase higher fall risk [12]. At the same time, it will make the gait pattern of the elderly change to bad direction i.e. affecting lower step length, shorter stride length and higher velocity [13]. On the other hand, a recent study in Norway found that improvement of the lighting system in residences lead to a statistically significant increase in the quality of life [14].

Due to decreasing visibility, the elderly need to have greater quantities and quality of lighting compared to other people. For this reason, related agencies then set standards/recommendations for designing proper lighting in a residence and long-term care center of the elderly who are regarded as a vulnerable group and need some special care. Hence, this research aims to explore the existing lighting conditions in long-term care centers and to study influences of lighting factors affecting satisfaction on visibility of the elderly by measuring the illumination levels and using a questionnaire to survey their satisfaction levels with lighting characteristics and conditions. The anticipated outcomes will reveal the factors of visual environment affecting to elderly satisfaction for visual conditions in long-term care centers.

2. Materials and methods

2.1 Data Collection

This research collected data from a long-term care center in Khon Kaen Province, the facility was expected to be a model for the long-term care center for the elderly at the Northeast and the national level. The study of lighting level in the long-term care center was conducted by measuring lighting levels during July 2020 with an illuminance meter (Konica Minolta T-10A). The area of this center consisted of the elderly clinic, the elderly recreation and holistic health promotion room, physical therapy clinic, Thai traditional medicine clinic, massage room, physical therapy room and the elderly club activities room. For measurement of lighting levels in each room, the researcher divided each room into grids with a size of 1 x 1 square meter. Then, the lighting level was inspected at a distance of 80 centimeters above the ground, a measured value at the middle of each grid was calculated to find the library average lighting level of such rooms [15].

In regards to studying the influences of lighting factors affecting satisfaction levels on visibility of the elderly, this research conducted a thorough assessment of the residents satisfaction with lighting levels of the elderly club activities room. A questionnaire used in this study was in the form of a measure that relied on 7 levels of word classification [16,17]. Components used in the assessment are shown in Figure 1.

Like	1---2---3---4---5---6---7	Dislike
Comfortable	1---2---3---4---5---6---7	Uncomfortable
Too bright	1---2---3---4---5---6---7	Too dark
Difficult	1---2---3---4---5---6---7	Easy
Cool tone	1---2---3---4---5---6---7	Warm tone
Unsatisfied	1---2---3---4---5---6---7	Satisfied
Blurred	1---2---3---4---5---6---7	Clear
Calm	1---2---3---4---5---6---7	Arousing
Rough	1---2---3---4---5---6---7	Smooth

Figure 1 The subject used a seven differential scale to give an opinion about visual conditions using nine parameters.

Data was collected from 42 people residing at the center who did activities regularly in the elderly club activities room from June to August 2020. The total number of members in the long-term care center in August 2020 was about 80, if they did not join more than 80 percent of activities, they were excluded. It was found that roughly 50 residents regularly participated in the activities. Eight of the elderly did not wish to provide data. As a result, the data was collected from 42 participants, accounting for 84 percent of the total.

2.2 Data Analysis

Lighting levels were measured and compared with values required by Thai regulations and recommendations. Descriptive statistics used in this research were minimum, maximum, mean and standard deviation (SD).

The satisfaction on visibility of the elderly was calculated from 7 levels of satisfaction value and data were presented by frequency tables for sociodemographic characteristics of the subjects. Statistics used were frequency, percentage, mean and standard deviation (SD).

Parametric statistics used for testing of the mean difference was one sample t-test. Pearson's correlation coefficient was used to find the relationship between illuminance level and satisfaction on visibility of the elderly by determination at .01 significance level. Data in this study were analyzed by SPSS statistics version 26.

3. Results

This long-term care center has been opened since 2017, supported by budget and medical personnel by the government, and opens from 8.00 am till 4.30 pm, Monday to Saturday. In the area of this center, there is an elderly clinic, recreation and holistic health promotion room, physical therapy clinic, Thai traditional medicine clinic, massage room, physical therapy room and elderly club activities room. The activities of this center include physical examination and health promotion for the aging by a multidisciplinary team and participating in various activities such as dancing, paslop, aerobic dance, and handcrafts making. The building structure was concrete, the lighting system designed for using artificial light which consisted of light bulbs and lamps that were mounted on the ceiling. The type of lamp was fluorescent in all areas.

For the measurement of lighting levels, it was found that all areas have very low lighting levels that is below suggested values for the residences and guidelines for indoor lighting design by Illuminating Engineering Association of Thailand (TIEA). In addition, the results of lighting levels are lower than that required by lighting levels standard law from the Department of Labour Protection and Welfare (DLPW) as shown in Table 1. At the time of the lighting measurement level, there was a clear sky covered with some clouds at the external environment of the center and sunshine entered in the center' area from the south-west direction. From inspection of this center's environment, it was found that the luminaires lacked maintenance. There were three bulbs out of order in the elderly recreation and holistic health promotion room, one in the physical therapy room and another four luminaires in the elderly club activities room, respectively.

Table 1 Lighting levels of all areas in long-term care center.

Location	Lighting level (lux)				Recommended lighting level*	TIEA**	DLPW***
	Min	Max	Mean	SD			
Elderly clinic	180	220	206.52	18.32	1000	500	400-500
Recreation room	103	180	153.10	25.69	300	300	300
Physical therapy clinic	112	317	187.54	35.80	1000	1000	400-500
Thai traditional medicine clinic	95	113	96.13	16.24	1000	500	400-500
Massage room	57	100	72.71	22.35	300	300	300
Physical therapy room	178	240	213.33	20.46	1000	1000	400-500
Elderly club activities room	85	1051	282.67	256.50	500	500	300

* Recommendation by van Hoof et al. (2010) [18]

** Illuminating Engineering Association of Thailand [19]

*** Department of Labour Protection and Welfare [20]

Table 2 shows sociodemographic characteristics of the 42 samples. Analysis results of the research data revealed that most of the elderly were female at 37 persons or accounting for 88.1%, married at 38 persons or accounting for 90.5%, aged between 60-69 years old at 35 persons or accounting for 83.3%, graduated in secondary education level at 17 persons or accounting for 40.5%, did not work/unemployed/retired at 39 persons or accounting for 92.9%, had

their monthly income lower than Baht 5,000 at 29 persons or accounting for 69.0% and did not wear eyeglasses at 36 persons or accounting for 85.7%.

Table 2 Sociodemographic characteristics of the subjects.

Variable	Details	Subjects (n=42)
Gender	Male	5 (11.9%)
	Female	37 (88.1%)
Marital status	Single	4 (9.5%)
	Married	38 (90.5%)
Age	60 – 69-year-old	35 (83.3%)
	70 – 79-year-old	7 (16.7%)
Education level	Lower than secondary school	15 (35.7%)
	Secondary school	17 (40.5%)
	Bachelor's degree	10 (23.8%)
Occupation	Private business	2 (4.8%)
	Government officer	1 (2.3%)
	Unemployed	39 (92.9%)
Income	Lower than 5000 Baht/month	29 (69.0%)
	5001-10000 Baht/month	11 (26.2%)
	10001-15000 Baht/month	2 (4.8%)
Glasses	Yes	6 (14.3%)
	No	36 (85.7%)

Table 3 shows the satisfaction results on visibility of the elderly towards lighting arrangements in the elderly club activities room. Assessments were conducted with 7 components consisting of; preference, eye comfort, brightness, easy to read, color tone, satisfaction, clarity, tranquility and smoothness; it is found that the elderly had a moderate level of preference (Mean=4.12, SD=0.92), eye comfort in a moderate level (Mean=4.43, SD=0.83), felt that the room was in a moderate level of darkness (Mean=4.55, SD=0.74), easy to read in a moderate level (Mean=3.55, SD=0.83), felt that the room was in a moderate level of cool tone (Mean=3.12, SD=0.80), satisfied with in high level of lighting (Mean=5.05, SD=0.94), clarity in a moderate level (Mean=4.14, SD=0.68), felt that the room was high in tranquility (Mean=2.97, SD=1.05) and felt that lighting was in a moderate level of smoothness (Mean=3.90, SD=0.76), respectively. These results reveal that the elderly were satisfied with working and living at a long-term care center.

Table 3 Satisfaction of visual environment in elderly activities room and relationship with illuminance level.

Components	Mean	SD	Pearson Correlation	p-value
Preference	4.12	0.92	-.230	.142
Eye comfort	4.43	0.83	.051	.749
Brightness	4.55	0.74	.391	.010*
Easy to read	3.55	0.83	-.105	.510
Color tone	3.12	0.80	-.270	.084
Satisfaction	5.05	0.94	.182	.248
Clarity	4.14	0.68	-.425	.005*
Tranquility	2.97	1.05	-.402	.008*
Smoothness	3.90	0.76	-.163	.301

*Correlation is significant at the 0.01 level.

The comparison between illuminance levels in the elderly club activities room and satisfaction with visibility 7 components scale, found that in aspects of brightness, clarity and tranquility had a relationship with lighting level in the elderly club activities room with a statistically significant (p -value = .010, .005 and .008, respectively). Especially, only the aspect of brightness had a positive relationship i.e. increasing the lighting level in the elderly club activities room also made the elderly feel brighter, whereas increasing too much lighting levels in the room their sights would lead to blurred and unpeaceful (arousing) state. Lighting design for the elderly should also be considering the factor of glare. If an activity requires a high level of light which can cause glare, glasses should be provided to reduce the light entering the eyes that can cause irritation.

4. Discussion

The study's results indicated that all areas have very poor lighting levels and lower than suggested values for living environments of the elderly and less than the recommended guidelines for indoor lighting design from Illuminating Engineering Association of Thailand. Additionally, the lighting levels were lower than that required by lighting levels standard law from the Department of Labour Protection and Welfare. Although the elderly were satisfied with the lighting level in the center, it was lower than suggested values or guidelines for the living environment of the elderly in all areas.

The study of lighting levels in the long-term care center revealed that lighting levels in all areas of this center were lower than suggested values to design residences for the elderly. This reflected problems that might be happening to the health of the elderly who came to use services in this center in the long-term. The area survey found that electrical systems including bulbs and lamps lacked maintenance and it could be seen that a number of them were damaged and out of order and this was supporting evidence to indicate that the lighting levels in this center were insufficient. Measuring the lighting level by an illuminance meter in all areas found that the area for doing activities close to windows and sunshine could be entered had higher value of lighting levels than suggested. Therefore, natural light might be an option to utilize to improve the lighting levels in this center. From previous international studies, it was found that an option for a sustainable solution was providing the elderly health care provider and related medical personnel with correct knowledge and understanding on the importance of lighting level effects on the health of the elderly. After that the inspection of the lighting system shall be conducted to improve it for efficient working e.g. installing additional lamps, cleaning all bulbs and lamps and establishing a preventive maintenance system to prevent problems caused by lighting systems in the future [21,22].

For the study of satisfaction towards lighting levels in the elderly club activities room, it was found that the elderly are satisfied with existing levels, although the lighting level in all areas was lower than suggested values. This phenomenon might be caused by many factors; the first one might come from self-adaptation of the elderly because this long-term care center had been opened for more than 3 years and the elderly did activities in this lighting level throughout the duration of that time. Therefore, if there was a problem of visibility, the elderly would have adapted or moved to solve such a problem by themselves e.g. in the case where the elderly felt that the room was too dark and uncomfortable for reading, the elderly would change their positions by moving to other places with sufficient lighting such near a windows or wearing eyeglasses for detailed work and etc. This made the elderly feel that lighting levels were not a problem when doing activities in this center [23].

The next factor was that the elderly did not think that lighting levels were a concerning factor regarding health effect. The results suggested that the elderly had no knowledge about effects that might have happened to themselves from doing activities in the areas with insufficient lighting. Moreover, the lighting level was not designed and calculated for current residences. Participating in activities in this long-term care center that had complete facilities, therefore, the elderly were satisfied without placing importance on values of lighting levels.

The last factor was that the elderly felt that reduced visibility was a normal phenomenon i.e. the elderly accepted that when their ages were higher their eyes would decline and eye diseases would occur such as cataract, glaucoma, vitreous degeneration, etc. and these disorders could not be avoided. Competency in doing activities together with people in the same age group and with no need to rely on their relatives was regarded as a point of satisfaction and good quality of life. A reason was caused by a lack of knowledge among the elderly about proper lighting level to compensate for their reduced visibility [24,25].

Arranging proper lighting for the elderly to do activities in daily life was significant and should not be ignored. Good lighting could increase ability to perform activities of daily living (ADLs), to upgrade the elderly's quality of life (QoL), to enable the elderly for self-reliance and to decrease further reliance in the future.

5. Conclusion

Sufficient lighting is necessary for the living of the elderly as an enhanced factor for better visibility despite having age-related decline of vision systems. However, the elderly who participated in activities with poor lighting level were more likely to be satisfied. Hence, the elderly and the elderly care provider should be supported with knowledge of the benefits of lighting and information about the arrangement of adequate lighting levels in the living environments of the elderly.

6. Ethical approval

This study is reviewed and approved by the Khon Kaen University Ethics Committee for Human Research (HE631164).

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