The Daylighting Effects in Hospital for Healing Patients

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ABSTRACT

The daylight, which means the natural light, provides the high quality lighting and visual comfort. In hospital, the psychological stability of patients with a good medical service influences on the patients' complete recovery. This study was conducted to identify the effect of the daylight on the treatment period of patients and medical outcomes in hospitals. Two major variables were the direction of the wards and the hospitalization period of various kinds of patients.

The patients' data were from two hospitals in Seoul. The patients were classified by names of diseases and by the direction of patient rooms. To evaluate the visual environment in patient rooms, illuminance and luminance distributions were calculated through the computer simulation. Then statistical tests were applied in order to verify if the natural light reduced the hospitalization period of patients. The study also identified names of diseases that were very responsive to the amount of the natural light inside the patient rooms.

This information can be used as a basis for developing guidelines to design optimal healing environments in hospital. Likewise, the results can be applied to medical treatment facilities, recreation centres and hospitals as well.

KEYWORDS: Daylight, Daylighting analysis, Patient's Hospitalization time, Radiance

1. INTRODUCTION

Visual activity of human is one of the most important information sources for human to perceive something and to deicide behaviours, and human depends over 80% on the sense of sight for collecting information from the surrounding environment. This is possible because of light. Humans perceive light or subjects by the luminance level, which is a photometric measure of the amount of light in a given direction. The physiological and psychological reaction of a human body to the external visual stimulus is complicated. In Korea, however, there is little grounding data to examine the complicated relationship between the reaction of human and the light stimulus.

Over the decades the effort to reduce energy consumption in architecture has grown as energy expense was on the rise. If people use the natural light more efficiently, they can not only save energy, but also improve the ability of operation performance. People can create the dynamic atmosphere by making the visual environment brighter and comforter with the natural light, too. In recent researches, it has been reported that the daylight is good for physical and psychological health of the inhabitants (Hutchison, 2000). Here is the brief summery of the previous researches about the influence of the amount of the daylight on the human body. The result of the comparison with students in the classroom with big windows and students with small windows was very different not only in their health and behaviours, but also in their relationship, and particularly in their concentration during a class (Kuller, 1992). The academic results of the students in the classroom with the wider windows were 7 - 18% higher than those with the smaller windows on the average, too (Lisa, 2002). The result

of the 72hours intensive treatment for two patients who were mentally disordered after surgical operation at hospital also showed that the patient in the room with windows was improved much sooner than the other patient in the room without any windows (Wilson, 1972). Daylight is important for the bodily tissue, and has a great effect on the human health system and recovery (Monz, 2001). When human, animals and plants are under the unfiltered natural light, they can live healthier and longer. In the ultraviolet light, which is included in the daylight, the vitamin D and minerals are produced, and these materials improve immunity and lower cholesterol levels (Ott. 2004).

The previous researches proved that the daylight had the positive effects on human inside building as above. In Korea, however, there has been minimal research regarding the influence of the daylight on the human body, and there is little data on it, either. Therefore the aim of this research is to provide the basic data for examining the relation between human and the daylight by analyzing the hospitalization period, and to analyze the correlation between the amount of the daylight in patient rooms and the hospitalization period.

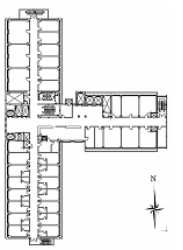
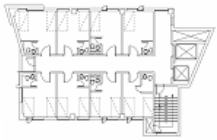
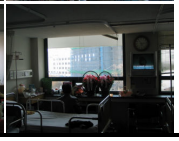
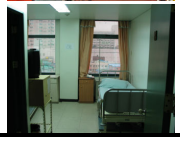
We made a comparative study of two hospitals in Seoul, the H-hospital and the K-hospital. The data from the H-hospital were classified by the direction of the wards, and those from the K-hospital were specified by names of the diseases. We divided the patient rooms of each hospital based on their direction, the north and the south, and then analyzed the daylight environment in the rooms.

2. OVERVIEW OF THE SAMPLE HOSPITALS

The data about the hospitalization were from the H-hospital in Haengdang-dong, Seongdong-gu, Seoul, and the K-hospital in Cheongnangni-dong, Dongdaemoon-gu, Seoul, and the data were classified by the directions of the wards and the names of the diseases. The H-hospital is located in a downtown, and it is a detached-style building, which means that the main building is connected with the 3 annexes. The main building is with twenty-one stories above ground and two below, and the wards are placed between 6th and 21st floor. The main axes of each building are toward the north - south and the east - west. In the H-hospital, every floor has different departments. We researched the data from every ward between 6th and 15th floor except the department of obstetrics and gynecology and the newborns' rooms on the 6th floor.

The K- hospital is the concentrated-style building, which means that there is just one big building. It has ten stories above ground and two below. The wards are between 5th and 9th floor, and the main axis is toward north-south. We analyzed the data only from the orthopedics out of the medical wards, the otolaryngology, and the orthopedics. Table 1. illustrates the interior-exterior views and the floor plan of both hospital.

Table 1. The interior-exterior views, and the floor plan of both hospital

	H-hospital			K-hospital		
	South	North	Plan	South	North	Plan
Exterior						
Interior						

3. DATA ANALYSIS

To compare and analyze directly the recovery period under the natural light in each room, we researched on the assumptions as follows;

1) Every patient who left the hospital is cured completely.
2) The rate of the sudden discharge from hospital is the same at every ward in every hospital.
3) Only the natural daylight out of the indoor environments is considered, and not considered other variables in the rooms.
4) Every environmental factor is the same except the daylight.
5) The medical skill of doctors and nurses is the same at each ward in every hospital.

3.1. Statistic analysis of the data about the hospitalization period

The data of the hospitalization period in the H-hospital was one-year-data between January 1st and December 31st in 2004, and it was the analysis of about 6,000 patients' data in the 11 wards from 7 floors. The data of the K-hospital was the analysis of the hospitalization period of 2,000 patients in the orthopedics based on their symptoms for 3 years between January 1st in 2002 and December 31st in 2004. Every data of each hospital was classified by the departments, and by the direction. We considered the patients with a same disease as one group when we analyzed the recovery period and we ignored the other factors such as the relative seriousness of an illness, whether there is a nurse beside the patient or not, and the existence or non-existence of the complication as we assumed above. Temporary patients who stayed under 4 days or patients who died during the treatment were excluded from the sample.

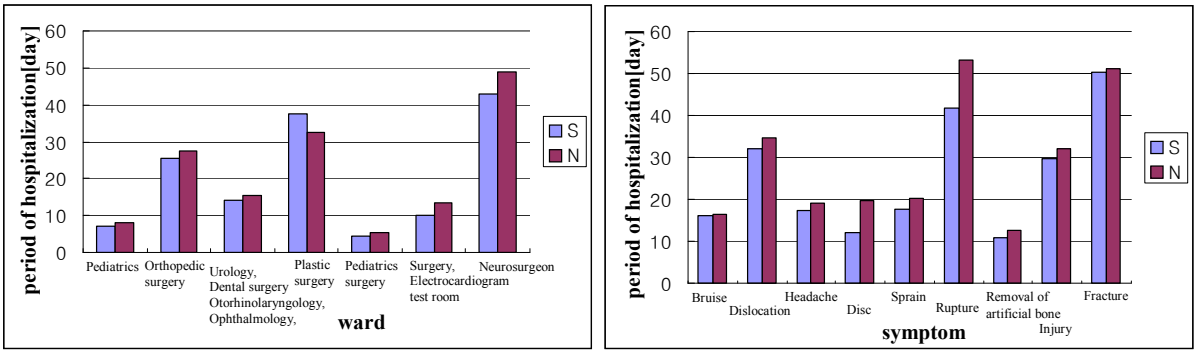
We performed the frequency analysis and the T-test using the SAS (Statistical Analysis System) program. In the T-test, the null hypothesis (H0) was that days of the hospital treatment in the southern wards and those of the northern wards were the same ($\mu1=\mu2$), and the alternative hypothesis ($H\alpha$) was that days of hospital treatment were different between the two wards, which meant the patients in the south stayed less than those in the north did ($\mu1-\mu2<0$). Only in case of the plastic surgery, patients in a southern room stayed more than those in a northern room, so the alternative hypothesis was that days of hospital treatment in the northern wards were shorter than days in the southern wards ($\mu1-\mu2>0$). The confidence level is 95%, so the critical value, α which meets the significance level, became 0.05. The adaptation of the null hypothesis and the rejection were decided through calculating the statistic by the direction of each ward, and then comparing it with the critical value.

Table 2. indicates t-value according to the degree of freedom and t-statistic value conducting the T-test by the type of the wards in H hospital. When comparing with t-value and t-statistic value conducting the T-test, the latter was higher. It means t-statistic value is within rejection area. Thus, the null hypothesis was rejected, but the alternative hypothesis was adopted. That is, when comparing patients in the southern ward and northern one by the type of wards with 95%(α =0.025) of confidence level, the period of the hospitalization of patients in the southern ward was shorter, whereas a plastic surgery showed the period of the hospitalization of patients in the northern ward was shorter. However, pediatrics didn't meet the level of significance.

Fig.1 shows the days of hospital treatment on the vertical axis and each ward of hospital and symptom on the horizontal axis and 'S' stands for southern ward, 'N' for northern ward. Table 3. shows direction and wards of both H -hospital and K-hospital respectively and also the number of patients and the average days of hospital treatment according to symptom.

Table 2. T-value and T-statistic value according to the degree of freedom by the type of the wards in H hospital

Ward	Degree of freedom	T-value (α=.025)	Result of the T-statistic value
Pediatrics	130	1.980	2.066
Orthopedic surgery	77	2.000	2.04
Urology, Otorhinolaryngology, Ophthalmology, Dental surgery	253	1.960	2.642
Plastic surgery	63	2.000	2.879
Orthopedic surgery	87	2.000	0.688
Surgery, Electrocardiogram test room	99	2.000	2.289
Neurosurgeon	40	2.021	2.358



(a) H-hospital (b) K-hospital

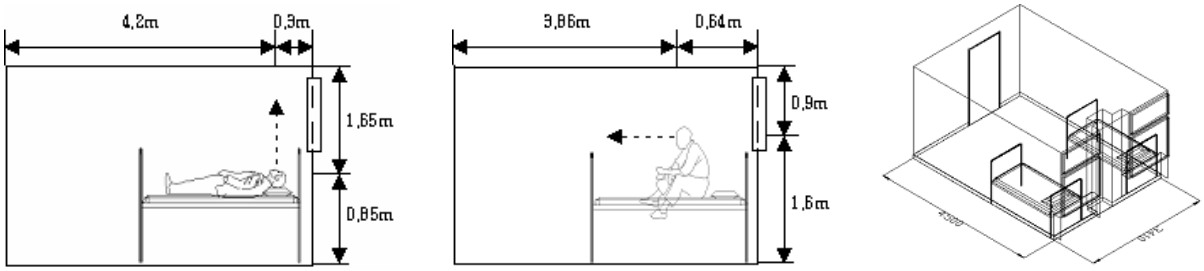
Figure 1. The comparison of the period of the hospitalization of patients according to the wards where they are facing to north and south in the H-hospital and K-hospital

Table 3. The days of hospital treatment of patients in the H-hospital and K-hospital

H-hospital			K-hospital		
Ward	Days of hospital treatment		Symptom	Days of hospital treatment	
	Southern ward (persons)	Northern ward (persons)		Southern ward (persons)	Northern ward (persons)
Pediatrics	7.1(72)	8.1(60)	Bruise	16.3(30)	16.5(50)
Orthopedic surgery	25.4(51)	27.6(48)	Dislocation	32(48)	34.7(50)
Urology, Otorhinolaryngology, Ophthalmology, Dental surgery	14(79)	15.5(186)	Headache	17.2(146)	19.0(179)
			Disc	12.1(48)	19.6(49)
			Sprain	17.6(114)	20.3(103)
Plastic surgery	37.4(24)	32.4(38)	Rupture	41.8(38)	53.3(38)
Pediatrics surgery	4.4(122)	5.3(56)	Removal of artificial bone	10.8(44)	12.8(34)
Surgery, Electrocardiogram test room	10.2(119)	13.5(90)	Injury	29.8(55)	32.2(50)
Neurosurgeon	43.0(26)	49.0(22)	Fracture	50.3(149)	51.1(147)

3.2 The analysis of the daylight

RADIANCE program was used to analyze the illuminance and luminance of the K-hospital. In order to measure the exact characteristic of reflection(RGB value) for the ceiling, wall, floor, and other furniture of K-hospital, we applied to data base using a spectrometer and performed simulation according to patients' eyes and wards modeled in 3D by using AutoCAD. For the preparatory stage to analyze the daylight in each ward, each value of the property of the matter of ward was measured by a spectrometer and, by using AutoCAD, it was analyzed according to patients' eyes ,considering two cases that are the ones of lying patients' in the bed or sitting on. Fig.2 shows patients' eyes according to their poses, that is, location of measurement.



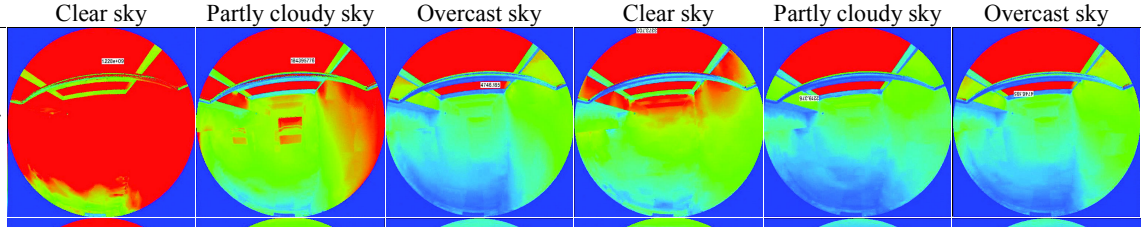
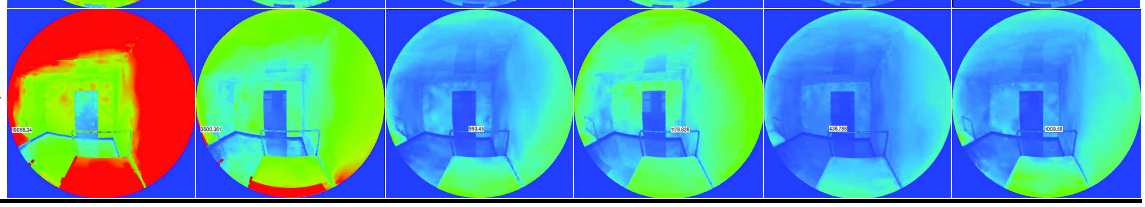
(a) in the case of lying (b) In the case of sitting (c) 3D modeling

Figure 2. Patients' view direction and 3D modeling of ward in the K-hospital

3.3 the result of analysis of the daylight

Each ward was classified north and south according to direction and clear sky, overcast sky, particle cloudy sky according to the state of the sky, and the vernal and autumnal equinox(Mar and Sep 21st), the summer solstice(June 21st),the winter solstice(Dec.21st) according to seasons based on noon. The luminance was analyzed by dividing into the case of lying and sitting in the bed according to the patients' poses. Table 4. indicates the images of the luminance in K-hospital, which show the state of the sky when it is the vernal equinox(Mar. 21st) at noon, the poses of the patients in the ward (in the case of lying, in the case of sitting) and direction(south, north). As a result of analyzing the luminance of the wards of K-hospital according to direction of south and north, the southern wards show much higher the luminance distribution.

Table 4. Luminance distribution in ward of K-hospital(on the vernal equinox at noon)

	Southern ward			Northern ward		
	Clear sky	Partly cloudy sky	Overcast sky	Clear sky	Partly cloudy sky	Overcast sky
In the case of lying						
In the case of sitting						

4. THE EFFECT OF THE DAYLIGHT ON INPATIENTS

The luminance in southern ward was shown much higher than northern ward and patients in southern ward tend to stay shorter than patients in northern ward. In the H-hospital, it was observed that the period of the hospitalization in the southern ward was 8% shorter in the case of orthopedic surgery, 18.1% in pediatrics surgery, 9.6% in urology, otorhinolaryngology, ophthalmology, dental surgery, 13.3% in pediatrics, 24.4% in surgery, electrocardiogram test room but plastic surgery was rather shorter in the northern as 13.5%. In the case of K-hospital, patients in southern ward tend to stay shorter according to their symptoms. the results are as follow; bruise 1.5%, dislocation 7.7%, headache 9.4%, disc 38%, sprain 13.5%, rupture 21.6%, removal of artificial bone 15.7%, injury7.4%, fracture 1.7%

From Table 5., 9 out of 10 wards in the H-hospital indicated that the days of hospital were considerably short in the southern ward in which the illuminance and luminance was high, but the plastic surgery was rather shorter in the northern ward. 7 out of 9 symptoms in K-hospital, the patients in the southern ward stayed much shorter, and there's not big difference between the patients with bruise and fracture.

5. CONCLUSIONS

The summaries of this study are as follow;

· According to the result of analysis the illuminance and luminance of the wards in the K-hospital based on direction of south and north, as it goes from overcast sky to clear sky, the difference between the southern ward and northern ward of the maximum luminance level become high, and the southern wards show much higher luminance distribution.

Table 5. Difference of the period of the hospitalization in the southern and northern wards

H-hospital		K-hospital	
Wards	Difference of the period of the hospitalization (%)	Symptom	Difference of the period of the hospitalization (%)
pediatrics	13.25	Bruise	1.53
orthopedic surgery	8.01	Dislocation	7.69
Urology, Otorhinolaryngology, Ophthalmology, Dental surgery	9.61	Headache	9.35
		Disc	38.29
		Sprain	13.31
Plastic surgery	-13.49(N)	Rupture	21.60
Orthopedic surgery	18.08	Removal of artificial bone	15.69
Surgery, Electrocardiogram test room	24.43	Injury	7.40
neurosurgeon	12.24	Fracture	1.70
Average	19.84	Average	8.52

Note) Difference of the period of the hospitalization = (the days of the hospitalization of patients in the southern ward - the days of the hospitalization of patients in the northern ward)×100 / the days of the hospitalization of patients in the northern ward

· According to the result of analysis of the period of the hospitalization based on direction of south and north both H-hospital and K-hospital, the patients in the southern wards tend to stay shorter than in the northern, by 19.84%, 8.52% respectively.
· The amount of the daylight coming inside the hospital affects the period of the hospitalization of patients and it gives positive effect shortening the period of the hospitalization of patients.
· This study can provide basic data to cure patients in the hospital and reminds architect designing hospital and related building that how importance of consideration of the amount of the daylight and planning wards it is.

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