Evidenced-based and sustainable design in a high tech hospital environment – a challenge for the future

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Introduction

Summary
The Intensive care unit (ICU) is the place of care for the most critically ill patients in hospitals. According to previous research the ICU environment can have a negative impact on the patients' recovery process. Critical illness together with constant nursing activities, strong lightning and noise especially in patient's room are believed to affect patients' physiological parameters and wellbeing negatively. Research has addressed the role of the environment in relation to the development of the most common side-effect of care in ICU, namely ICU delirium. In addition, there is a limited access to single rooms in Swedish ICUs. This means that patients with various diagnoses, gender and age are treated together in the same room. Moreover, as many ICUs in Sweden are aged and in need of renewals, in order to meet the demand of contemporary intensive care, several restoration projects are planned in the following years.

Aspects mentioned above have raised questions about how an intervention of the physical environment in an ICU could benefit the patients and their families. A literature search showed that there is little research about the impact of the physical environment on patients' health in this context and that there is a lack of reliable long term studies focusing on the relationship between the physical environment, health and recovery. Therefore this project was initiated by two experienced researchers, Professor I, Bergbom at the University of Gothenburg and Associate professor B, Lindahl at the University College of Borås, with the purpose to investigate if an intervention in the physical environment in an ICU patient room can improve patients' recovery process and wellbeing.

The project has an exploratory and descriptive design. The intervention is located at an ICU, in Western Sweden and implicates a rebuilt patient room. The refurbished room (experimental room) is equipped with sound absorbents behind the walls and ceiling, a cycled lighting system and a new interior decoration. An identical room has remained intact (control room), which makes it possible to compare data from two different environments. All research questions will be related to the sound environment, the light environment and the esthetic layout. The results from this project will be useful in the context of ICU, but also in other high tech environments.

The aim of this paper is to provide a description of the intervention project and present findings generated from a sound environment study.

Background

The goal and risks of care in ICUs

Intensive care is defined as advanced monitoring, diagnosis and treatment of impending or manifest failure of vital functions and is one of the most advanced levels of health care. In Swedish ICUs approximately 45 000 patients are cared for on an annual basis. In the year 2008 there were 88 ICUs in Sweden, 69 were mixed ICUs meanwhile the rest were specialized units like cardiothoracic, neuro, pediatric and infection ICUs (SIR, 2010). The goal of the intensive care is to prevent and treat failure in vital organs and help the patient towards a meaningful life. This means providing care from a person-centered perspective and paying attention to patients' lifeworld. Patients are supposed to be involved in their own care and treatment (Olsson et al., 2009, Timmins and Astin, 2009) which reasonably require a safe and secure environment. Providing a supportive and positive physical environment (from a research based perspective) that gives strengths to the patients will be fundamental for the

health care in future. Moreover, there is an interest from a socioeconomics perspective as ICUs consume a great deal of resources and the numbers of beds are limited. Thus there is a desire to shorten the lengths of stay and improve the recovery not only on from an individual perspective but also from a socioeconomic perspective (Siedel, 2006).

ICUs are technically dense environments and have a higher staffing rate compared to ordinary hospital wards. ICU settings are not only a place of care but also staff's working place. From an architectural point of view ICUs are considered to be one the most complicated places to design since there are difficulties in creating environments where technology and people can encounter and interact (Alasken, 2003). Constant activities in ICU settings together with the critical illness and poor design have also been linked to ICU delirium. ICU delirium is a state of acute confusion and the symptoms are very much like those that occur in patients with psychosis but in ICU delirium the symptoms develop over a short period and fluctuate over time (Granberg et al., 1996; www.mc.vanderbilt.edu/icudelirium/index.html, 2011). Mostly the state is declining in a few days, but recent research has found that the consequences of these complications are greater than previously understood. Patients with ICU delirium are at greater risk of dying in advance (Ely et al., 2004) and have a longer ICU and hospital stay (Thomason et al., 2005). This leads to higher costs and increased suffering. Moreover, patients with delirium are at higher risk of prolonged recovery and permanent disability (Girard et al., 2010). The psychological effects of ICU delirium have also been explored (McKinley et al., 2002, Roberts and Chaboyer, 2004, Lof et al., 2006). It has been found that patients with delirium experience and recall scary dreams and delusional memories in a higher degree than other severely ill patients (Ringdal et al., 2006, Roberts et al., 2006). Frequently, these unreal experiences develop in night time, and keep the patients awake. These recalls follow the patients for a long time, sometimes for years and causes, at worst, post-traumatic stress disorders (PTSD) (Jones et al., 2007).

The main cause of ICU delirium is still unknown but probably, it is a combination and interplay between physiological, psychological and environmental related factors. The physiological aspects have been investigated for many years and a number of risk factors have been found however, the psychological and environmental perspectives are less developed. High activity both day and night with high sound levels and unexpected noise might be precipitating factors. However, knowledge about noise and delirium is limited and more research is needed. A new study reports that patients with earplugs, reducing the surrounding sound level with 33 dB, experience mild confusion in a lower degree. Moreover, the same study showed that the onset of change in cognition was delayed compared to patients without earplugs (Van Rompaey et al., 2012).

In the recent years various clinical practice guidelines have been outlined for preventing ICU delirium but the primary focus has been on the pharmacological aspects (Jacobi et al., 2002, Pun and Ely, 2007) rather then non pharmacological interventions. However, there are few recommendations concerning preventive interventions like sleep protocols, activating programs, reduced sound levels by using sound absorbent materials. Never less there is a lack of knowledge about the outcomes of these effects and therefore, these directives are not prioritized. Since ICU delirium is an unwished condition (Girard et al., 2008, Ely et al., 2001a, Ely et al., 2004) resulting in an impaired quality of life it is important to find out if and how the physical environment prevent this condition and by this affect recovery process and wellbeing of the ICU patients and their families.

In the following sections the physical environment, sound and light in ICU are outlined and discussed in detail.

The physical environment

Previous research has found that the architecture of the emergency hospitals influences health and wellbeing of the patients (Dijkstra et al., 2006; Rashid, 2007). Bailey and Timmons (2005) describe that disturbing noise in hospitals can produce physiological responses like reduction of digestive secretions, raised heart rate, raised metabolism and an increase in oxygen consumption. Ulrich (2001) found that patients with natural views with trees visible from the windows had shorter postoperative stay, needed fewer moderate and strong analgesic doses and had lower postsurgical complications compared to patients looking out on a brown brick wall. Similar results are also found in reviews by Djikstra et al. (2006) and La Torres (2006).

Evidence-based design emphasizes the need of knowledge about the design and interiors of ICUs from a user perspective when developing sustainable and healing environments for the most critically ill and their families (Hamilton 2001; Rashid, 2010). Admission and care in an ICU together with critical illness is described as a traumatic life event for the patients but also for their families. Being critically ill means loss of control (Gjengedal, 1994; Johansson and Fjellman-Wiklund, 2005), experiencing stressful memories and nightmares (Samuelsson et al., 2007). Moreover, difficulties to communicate (Karlsson et al., 2012), experience of unreal events (Johansson et al., 2008) pain/discomfort (Fredriksen and Ringsberg, 2007) and environmental stress have been described in the literature (Samuelson, 2011). An observational study by Meriläinen and Kyngas et al. (2010) described how nursing activities in the ICU patient room frequently violated patients' personal turf. In this context the need of a supportive environment is important.

The first step in order to design the optimal, sustainable and supportive patient rooms in ICU would be to identify factors that support wellbeing. Next of kin's presence in ICUs has been identified to have a positive effect on patients' wellbeing and recovery (Kosco et al., 2000). Their presence gives hope and strength to the patient to keep on struggle (Bergbom and Askwall, 2000). A study by Olausson et al., (2012a) examined the interior design in ICU patient room from the next of kin perspective by using photo-voice methodology (Wang and Burris, 1997). The next of kin were asked to photograph various aspects of ICU patient room that they associated with a feeling. Then they were interviewed about their experiences of the design and interiors in the room. It was showed that the design and interiors are of paramount significance for the support that the next of kin could give (Olausson, et al. 2012a). The design of the patient rooms evoked various feeling e.g., fear and anxiety and was decisive for next of kin's wellbeing during their stay in ICU. They also described the lack of space as a major concern affecting privacy and intimacy during a fragile time. Moreover, the architectural design was identified as a contributing factor in overhearing sensitive information about neighbouring patients. This was experiences as a very heavy burden difficult to escape from. In addition, the design of the patient rooms and the lack of space played the major role if the families could stay close to the patient in the room or if they had to wait outside the room feeling powerless and running out of precious time. The need of being physically close to the patient and has also been highlighted in previous research by Leske (1991), Engström (2008) and by McKienan (2010). Moreover, lack of seats and chairs for purpose of visiting in the patient room was a sign of not being welcomed (Olausson et al., 2012a). Leske (2002) suggests interventions concerning intensive care environments are important to decrease families' anxiety.

Another study, using the same data collection methodology as above, examining patients' lived experiences of the design of the ICU setting showed that the ICU patient room as a place of care for critically ill patients was a very complex. The architectural design was vital for patients in order to feel safe and rest. For example the balance between proximity and distance to the world around the bed area was essential in feeling safe and secure in the room. A window with a view of nature was highly expressed as it made the patients feel alive and expanded the room (Olausson et al., 2012b – Manuscript in progress).

Sound environment

It is known that the levels of noise in ICUs are high since previous studies have shown mean levels of between 50-66 dB (A) during daytime in patients' rooms, with high peaks reaching 80 dB (A) (Akansel and Kaymakci, 2008, Bailey and Timmons, 2005, Ryherd et al., 2008). We also know that the sound environment is complex, one study found as much as 86 different noise sources in the ICU and in a High Dependency Unit (HDU) (MacKenzie and Galbrun, 2007). Noise from rubbish bins, general activity and talking were the most common (MacKenzie and Galbrun, 2007) and it is important to notify that only the talking generates approximately 74-81 dB (A) (Tsiou et al., 1998, Akansel and Kaymakci, 2008). This shows that noise control in ICU is a challenge. Unfortunately, today we do not know enough about the physical effects of these noises and an indication for that is that the sound levels in hospitals have increased in the last four decades (Busch-Vishniac et al., 2005). One of the aims of this project is therefore to investigate the physical effects of high sound levels and disturbing noise in critically ill patients.

Light

Light and its influences on patients' health are primary studied in neonatal intensive care, geriatrics and psychiatry. In a review describing the importance of a good health care environment, the presence of light was seen as a very important factor. Furthermore it was emphasized that good lighting and presence of daylight had a positive effect on the patient's opportunity to orientate, keep the diurnal rhythm and have a good sleep. Good lightening can also lower depression, reduce pain, stress, lengths of stay and mortality (Frandsen, 2009).

Our lives are affected by the daily rhythms surrounding us. Day/wakefulness and night/sleep rhythms in human beings are controlled partly by a native advanced system and partly by the light flux coming through the eyes. The native rhythm is regulated in the brain. This rhythm is a little bit different from the 24-hour rhythm (Saper et al., 2004). Due to this dislocation, the internal clock continuously has to synchronize through environmental factors. Here the most important factor is the light (Lack and Wright, 1993). The word circadian (from latin: circa diem), explains the situation between native rhythm and environmental rhythm which means approximately a day (Halberg et al., 2003). Due to this dislocation, the internal clock continuously has to synchronize through environmental factors. The most important factor is the light (Lack and Wright, 1993). Many physiological processes in our body have a circadian rhythm. Most of them, like sleep, wakefulness, temperature, urine production, hormone secretion etc., are responses to external stimuli like lightness, darkness combined with the internal "clock" (Hankins et al., 2007).

The hormone Melatonin is important for a good night sleep and the production are on the top level during the dark hours (Rea et al., 2005). Lights in short blue wave length suppresses nocturnal melatonin (Figuerio and Rea, 2010). The hormone cortisol affects metabolism, immune system, muscle and brain function. Bright light has a significant inhibitory effect at both rising and falling phase in cortisol secretion (Jung et al., 2010).

Previous research has addressed the importance of the circadian rhythm to humans as biological. Studies reveal circadian rhythms impact on human physiological and psychological functions (Rosengart et al., 2011). Research has shown that the patient's circadian rhythm when being cared for in an ICU is shifted as the treatment requires lightings that last all day (Perras et al., 2007). This fact may lead to long-term sleep disorders and the development of intensive care delirium (Weinhouse et al., 2009). By installing a cycled light environment which follows day and night rhythm, the patients may maintain a better and more normal circadian rhythm. It is of great importance to study how a cyclic light source affects the patient's health, wellbeing and recovery as there is an absence of knowledge from the ICU research field seen from an adult perspective. Studies investigating how circadian light sources affect patients are mainly from areas such as pediatric intensive care, psychiatry, dementia care and nursing homes. A significant difference has been found in prematurely borne children's levels of activity during day and night compared to premature babies who was exposed to dim lighting throughout the day. The level of activity compared between day and night was also increased (Altimier et al., 2005). Moreover, cycled light exposure reduced fussing and crying in very preterm infants (Guyer et al., 2012).

Significance

Despite advances in medical treatment the design of design of the ICU patient room has remain the same. There is lack of studies that address the importance of research concerning the physical environment in intensive care. It is therefore of great importance to carrying out research that illuminates the sound and light environment as well as design and the esthetic layout. The actual project is expected to generate knowledge about factors that can improve patients' health, recovery and wellbeing. This means that our research results can contribute with knowledge for the design of new intensive care units. The results can also be transferred to other health care areas and high-tech workplaces in general. However, the primary scientific challenge for our project is to develop knowledge about how the physical environment can be curative for critically ill people who are cared for in high -tech environments. There are studies today that have examined non-pharmacological treatment strategies for ICU delirium. As ICU delirium is associated with an increased mortality and prolonged hospital stay, it is most important to carrying out research that prevent and clarify relationships between ICU delirium and the environment. In addition, our project will provide insight into factors in the ICU environment that is related to patients' quality of life, length of stay and pharmacological needs, i.e. of economic interest.

Methods

Design

The project, which has an exploratory and descriptive approach, (the intervention) is located at a regional ICU in Western Sweden. The intervention implicates a rebuilt patient room (experimental room). An identical room has remained intact (control room), which makes it possible to compare data from two different environments. Light and sound levels are expected to be different between the two rooms. The experimental room has been equipped with a light system which follows the day/night rhythm in light levels and colors. In addition to this, the experimental room has been equipped with a sound absorbent ceiling and finally the experimental room is designed according to research findings from an opening systematic review of literature made by the research team.

The results of studies addressing ICU patient room (Olausson et al., 2012a; Olausson et al., 2012b manuscript in progress) will be compared later to patients' and next of kin's experiences of the esthetic layout and design in the experimental room. The same

methodology e.g., photo-voice and research interviews will be used in collecting data. These studies were conducted in ordinary designed patient rooms in three different ICUs in Sweden. The intervention room in the project is situated in one of these hospitals. The esthetic layout is changed by gathering the technological equipment of patients' sight, using a green wall color, changing ceiling from hole- covered ceiling to intact ceiling, providing comfortable chairs, headboards and organic textiles. Moreover, in the vicinity of the patient room a small green area with seats and a round table is provided. This green area can be accessed from both interventions room and control room and belongs to the hospital area meaning that only staff and inpatient have access to it.

Data collection

Light and sound levels are measured and registered regularly during the study period. The effects on caring and medical treatment will be studied and compared between the rooms from a person-centred view. Data will be collected from the existing protocols describing nursing treatment and observations together with medical documentation comprising data concerning the fulfilment of the patient's physiological needs, drug consumption and length of stay, mortality, wakefulness, nausea, pain, anxiety and complications. Furthermore demographic data will be registered. ICU-delirium will be estimated with established protocols e.g., CAM-ICU (Ely et al., 2001b). Light levels and present of resting periods will be registered with the help of Actiwatches®, which measure light levels and the motor activity of the patients. An "Actiwatch" is designed as a wrist watch and is fixed on the wrist or the ankle. The sleep is also estimated through observations. Data concerning recovery (time in general ward, return to work, amended housing) will be registered.

A cyclic lighting system

The data collection process concerning light and its effects on critically ill patients started in August 2012 and no primary results are yet available. This part will describe the shape and the design of the light innovation that will be used. A cyclic lighting system is installed in the intervention room and its intention is to follow and amplify the natural day and night light rhythm in light levels and colors of light. The system consists of different lighting sources as fluorescent tubes and led lamps. Together it creates 14 artificial lightings sources - a varying lighting environment that are designed and programmed by lighting engineers. It is automatically controlled by software. The system is designed to resemble the rhythm of the sun and therefore the light sources are placed in armatures in the ceiling and along walls and floor. The overall system view is to create a healing environment for the patient. Therefore the light coming from the armatures in the roof shines upwards which distribute the light without blending the patient lying in bed. The color of light varies in two different fluorescent tubes with 2700 Kelvin (K) and 6500 K. The system makes it possible to control levels from this tubes which make the lighting environment varying in color. During the 24 hours the system follows the same schedule every day and night. It starts up in the morning at 07.00 in a low and warm level and color. It then increases to the highest levels between 08.00 and 10.00. After that the artificial lighting decreases and the daylight from the windows increase and together they create a high level at the middle of the day. In the afternoon the artificial light increase again and reach the same levels as before noon. The levels than decrease furthermore in the evening and the colour became warmer. The led lamps down the floors distribute very low levels after 21.30 (Table 1). In table 1 the different amount of brightness is presented for each light setting.

Table 1. Descriptions of light settings concerning time, locations of lightings and levels in different Kelvin degrees in the intervention room. Illumination level in lux measured in January 2012.

Light setting nr	Time	Locations of lightings	Levels in % 2700 K*	Levels in % 6500 K**	Locations of lighting	Levels in % 2700 K*	Locations of lightings	Levels in % 2700 K*
0	7-8 am	Ceiling	10	5	Wall	15		
1	8-10 am	Ceiling	100	100	Wall	100	Floor	100
2	10-10.30 am	Ceiling	70	100				
3	10.30 am-1pm	Ceiling	37	85				
4	1-3 pm	Ceiling	23	52				
5	3-5 pm	Ceiling	70	100				
6	5-6 pm	Ceiling	37	85				
7	6-7 pm	Ceiling	23	52				
8	7-8 pm	Ceiling	14	15	Wall	1		
9	8-8.45 pm	Ceiling	10	5	Wall	15		
10	8.45-9 pm	Ceiling	6	1	Wall	7		
11	9 -9.15 pm	Ceiling	3		Wall	1		
12	9.15-9.30 pm	Ceiling	1		Wall	1		
13	9.30-7 am						Floor	80

* Levels in % of max levels in luminaires with 2700 K.
** Levels in % of max levels in luminaires with 6500 K

Data analysis

Data concerning light will be documented, analyzed and presented using descriptive statistics and multivariate analyses.

In order to gain a deeper understanding of the meanings of architecture and interior design as experienced by patients, next of kin and staff a qualitative and lifeworld approach will be applied. The informants will be invited to photograph various aspects of the experimental room that they associate with a feeling. The photos will be used for the purpose of reflection during the qualitative research interviews (Photo-voice methodology) (Wang and Burris, 1997; Kvale and Brinkmann 2008). Interviewing is a significant way for people to construct meaning and express their understanding of the ICU patient room. The interviews will be tape-recorded, transcribed into to text and then interpreted using a phenomenological hermeneutic method developed by Lindseth & Norberg (2004) rooted in a philosophical tradition (Ricoeur, 1976).

Ethical considerations

Research Ethics Committee approved the study (No 069-07). Our experience from similar studies is that there are no risks for the patients to participate. The patients in the two rooms will have the same monitoring, staffing and treatment. The project does not affect the normal operations. The studies are to follow the ethical outlined by World Medical Association according to the Helsinki Declaration.

Research results

Sound

In May 2007 we started the project with a pre-study and measured the sound levels of 13 patients at the actual ICU. Interviews were also carried out 2-35 days after patients' discharge. The results from this data collection period are published in two papers recently accepted to scientific journals (Johansson et al., 2012a, Johansson et al., 2012b). The sound pressure level measurements showed that the sound levels in the present ICU were lower compared to investigations made in similar environments (Ryherd et al., 2008) but still higher than desired. In the relatively small sample we found no correlation between high sound levels and the patients' recollections of being disturb. Nor did we see any connection between early signs of ICU delirium and high noise levels. In the interviews we found unexpectedly that the patients recalled a lot of sounds from their stay in the ICU. Some sounds were experienced as positive and helped the patients to orientate in time and place and to determine their actual status. Though, the sounds could also be of a different nature, more negative and create feelings of fear and insecurity. In one study (Johansson et al. 2012b), examining patients' lived experiences of the sound environment in ICU, we found that the vulnerable patient was exposed to an uncontrollable barrage of noise, where the patient had no chance to protect himself or take cover. One example of that was when a patient had to listen to when a surgical procedure was performed in the patient in the next bed. The treatment last for hours and the patients heard both the loud communication between the staff and noise from different equipment. At the same time she had to struggle with her own critical illness. She said she will never forget this night. The results above encouraged us to go further and therefore, next step in the intervention project will be to investigate the relationship between ICU delirium and noise in a long term perspective. Data collection started in August 2012.

Discussion

The research emphasizes the role of overall design of the hospital settings for the quality and delivery of care. It is believed that the design of health care buildings affect amongst other; interactions and individuals behaviors, feelings and peoples' satisfaction of care (Ulrich, et al., 2004; Blumberg and Solan Delvin, 2006).

According to Ulrich (2009) health care settings are designed by tradition from a functional perspective to deliver care. However, the growing body of research has provided knowledge about how physical environments in health care settings can affect peoples' wellbeing (Ulrich, et al., 2004). The concepts of evidence-based design and healing environments have been developed over years (Lawsson, 2010). Healing environments refers to the environments that are meaningful containing positive stimuli in order to make a difference for the patients' experience (Stichler, 2001).

The core of evidence-based design is to integrate reliable research results into process of creating supportive environments and health care buildings, in order to improve patients' outcome and quality of care (Ulrich et al., 2004). Integrating evidenced -based design and creating healing environments should be the vision of all hospital settings.

However working with improving the environments in health care settings and in particular in ICUs is a challenge for both health sciences and architecture. Patient safety, the need to provide privacy and to accommodate the technology as well as the staff's work environment are just some issues that need attention in the work with developing ICU environment

(Catrambone, et al., 2009). ICU settings are complex places as not only the critically ill patients' needs are to consider but also staff's and families' presence and needs are in focus. The patients are in the need of complex assessments, intensive therapy and constant vigilance. It is well known that the environment has a negative impact on patients. Loss of personal space, disturbed time orientation and being in a constant sensory overloaded place limit the possibilities to rest, sleep and heal.

The goal of intensive care is to provide the best care for the patients and their family and to support them during one of the most critical periods in life. This should include also consciously working with environment. Creating environments where patients can rest, heal and recover is essential. Interventions such as creating a quiet environment for being able to sleep, improving and maintaining a normal light rhythm and paying attention to the aesthetic layout of ICUs may contribute to better medical and nursing care outcomes and to a higher level of satisfaction.

There is no doubt about that noise and disturbing sounds in critical care areas are a challenge for the future as the environment is extraordinary contradictable. In the ICU the focus is the lifesaving interventions and for that purpose a critically ill person needs all the medical treatment and nursing care that is available. At the same time, the sounds from the technique and the activity provide sleep and rest and at worst also recovery. For example, a higher staff ratio increases patient safety, but at the same time the presence of staff generates higher sound levels. Moreover, our pre-study (Johansson et al., 2012 a) showed that we all experience sound differently; meaning that a sound that is acceptable for one patient could be unbearable for another. Another finding from the pre- study was that annoying noises could be more disturbing than high-pressure level sounds. Whether it is a demanding issue or not, something has to be done concerning the sound environment in the ICU. The critically ill patient is very vulnerable, mostly very tired, often sedated with drugs and sometimes also unable to communicate because of a tracheal tube connected to a ventilator. The ability to influence the situation is extremely limited which means that the responsibility of the sound control must lie with the organization and the design.

In the recent years several studies have investigating different interventions to reduce noise levels including educational noise reduction programs, behavioral modification using sound detection equipment and environmental alterations (Konkani and Oakley, 2011). Unfortunately no one has found one universal solution. On the contrary (Busch-Vishniac et al., 2005) have found that the average noise levels in hospitals have increased in the last 40 years which indicate that this important issue has been low prioritized and underestimated. One reason could be that the complexity and the contradiction overshadow the ideas and the possibilities how to overcome such a hard dilemma. Another reason could be that there is a lack of knowledge concerning the physical and psychological effects of noise in severely ill patients. Certainly we know that many patients suffer from the surrounding noise in the ICU since we in our interviews have found descriptions of situations where patients have been extremely exposed to unwanted sounds. Though, we do not know today if the majority of the critically ill patients are victims of complications, such as delirium and poor sleep, arising from these noises and disturbing sounds. Here is a huge gap of knowledge that has to be investigated. We hope that the results from the next step of this intervention project will clarify this.

A circadian lighting system is one way to create an environment that gives the patient a possibility to a normal day/night rhythm. The varying light levels, colors and the locations of the lighting sources are a good way trying to copy the natural light. It is not possible to do that

completely but this system could be a good compensation. We have not measured the patients' hormone levels to examine them but previous research in this field tells us that a typical day/night rhythm with light and darkness is regulating the levels in a healthy way. The situation that the system is automatically regulated makes it possible to control the amount and quality of light that expose the patient. In the control room an ordinary manual lighting system is still working. This system makes it possible for the staff or others to change the lightings after their own choices which create an unsafe situation concerning the lighting environment.

A similar system to ours is used in a Dutch nursing home (Spreeuwenberg et al., 2010). Here the lightings varied in levels and colour with illumination levels from 400 lx to 1300 lux during the day. The very high illumination levels are related to aging/disease of eyes and brain. Activity was recorded in ten clients and the results showed reduced activity at both day and nighttime. The researchers also stress a need for more research as people respond differently to dynamic light. The effects of the lightings with a cycled pattern are interesting and needs to be tested in a larger setting.

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