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Original research paper

The effect of cycled lighting in the intensive care unit on sleep, activity and physiological parameters: A pilot study

Marie Engwall[a,b,*], Isabell Fridh[a], Göran Jutengren[a], Ingegerd Bergbom[a,b], Anders Sterner[a], Berit Lindahl[a,b]

[a] *Faculty of Caring Sciences, Work Life & Social Welfare, University of Borås, SE-50190 Borås, Sweden*
[b] *Sahlgrenska Academy, Gothenburg University and the Institute of Health & Caring Sciences, Arvid Wallgrens Backe 1, SE 41346 Gothenburg, Sweden*

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ABSTRACT

Patients in intensive care suffer from severe illnesses or injuries and from symptoms related to care and treatments. Environmental factors, such as lighting at night, can disturb patients' circadian rhythms. The aim was to investigate whether patients displayed circadian rhythms and whether a cycled lighting intervention would impact it. In this pilot study ($N = 60$), a cycled lighting intervention in a two-bed patient room was conducted. An ordinary hospital room functioned as the control. Patient activity, heart rate, mean arterial pressure and body temperature were recorded. All data were collected during the patients' final 24 h in the intensive care unit. There was a significant difference between day and night patient activity within but not between conditions. Heart rates differed between day and night significantly for patients in the ordinary room but not in the intervention room or between conditions. Body temperature was lowest at night for all patients with no significant difference between conditions. Patients in both conditions had a natural circadian rhythm; and the cycled lighting intervention showed no significant impact. As the sample size was small, a larger repeated measures study should be conducted to determine if other types of lighting or environmental factors can impact patients' well-being.

Implications for Clinical Practice

- It is possible to detect circadian rhythms in ICU patients.
- Studies on the relationship between lighting and patients' circadian rhythm give the staff awareness on a topic that has not been a priority.
- Studies on lighting should increase staffs' interest in environmental scenarios that support patients' health and recovery in the ICU.
- Healthcare programs, aimed to support patients' circadian rhythms should be adapted to benefit patients in other departments and hospitals.
- Development of research methods concerning lighting and circadian rhythm are needed.

Introduction

Patients in intensive care units (ICUs) not only suffer from critical illness but also from symptoms related to their ICU care and treatments, such as sleep deprivation, nightmares, delirium, anxiety and post-traumatic stress (Baumgarten and Poulsen, 2015; Griffiths et al., 2007; Svenningsen et al., 2014; Tembo et al., 2013; Torheim and Kvangarsnes, 2014). The ICU environment is characterised by advanced technical equipment, high levels of care-giving and disturbing lights and sounds at night (Ayllon Garrido et al.,

* Corresponding author at: Faculty of Caring Sciences, Work Life & Social Welfare, University of Borås, SE-501 90 Borås, Sweden.
E-mail addresses: marie.engwall@hb.se (M. Engwall), isabell.fridh@hb.se (I. Fridh), goran.jutengren@hb.se (G. Jutengren), ingegerd.bergbom@gu.se (I. Bergbom), anders.sterner@hb.se (A. Sterner), berit.lindahl@hb.se (B. Lindahl).

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2007; Dunn et al., 2010; Stayt et al., 2015). The circadian rhythm (CR) is often disturbed in ICU patients (Kamdar et al., 2015; Patel et al., 2014), and CR disruption possibly causes ICU delirium and hampers recovery (Ehlers et al., 2013). The human body is programmed to maintain a 24-hour CR, and light is considered the most significant influence on this rhythm (Munch and Bromundt, 2012; Turner et al., 2010). Research has shown that disrupting the CR with unnatural night lighting causes health problems (Bedrosian et al., 2015; Bonmati-Carrion et al., 2014; Karatsoreos, 2012; Stevens et al., 2014).

CRs can be detected in sleep and wakefulness by polysomnography. In the ICU, sleep is characterised by being frequently awake, increased non-rapid eye movement (NREM) sleep stages 1 and 2 and reduced rapid eye movement (REM) sleep (Andersen et al., 2013; Elliott et al., 2013; Foreman et al., 2015). Sleep and activity can be assessed with an Actiwatch® device worn on the wrist to detect acceleration in the arm (Vinzio et al., 2003).

Melatonin levels, normally highest at night, can also detect CRs (Egi et al., 2006; Gehlbach et al., 2012; Olofsson et al., 2004). While ambient and bright light with short-wave blue light can suppress melatonin levels, dim and long-wave red light have less impact on melatonin (Wood et al., 2013). Exposure to brighter light during the day changes the CR as detected by a delayed melatonin peak in the evening (Hyun et al., 2002). Physiological parameters, such as heart rate (Nicoletti et al., 2015), blood pressure (Shea et al., 2011) and body temperature (Chan et al., 2012) are able to detect CR changes.

The lighting in an adult ICU sometimes disturbs sleep and CRs (Pisani et al., 2015). Patients rated sound and light as the greatest sleep disturbers in the ICU (Elliott et al., 2014). One study found 23% of the non-mechanically ventilated ICU patients indicated light levels were sleep-disturbing (Stewart et al., 2016). In previous research, illumination levels varied greatly between ICUs but were generally too low during the day. At night, levels are generally low but rise several times. During one 24-hour observation, illumination levels were measured at the patients' bedside. On average, the illumination was 318 lux during the daytime and 145 lux at night (Meriläinen et al., 2010). Hu et al. (2016) measured illumination levels in seven different ICUs near the patients' eyes. The levels ranged from 62 to 790 lux in daytime, 15–489 in the evening and 10–239 at night. Illumination levels were also measured at the patients' pillows: median daytime levels were 74 lux and at night 2 lux (Elliott et al., 2014). Another study found 52.2% of the assessed hospitals had illumination levels below the 2011 recommended European Standards (Dianat et al., 2013).

Intervention studies in ICU settings are rare and mostly carried out in the neonatal ICU (NICU) (Morag and Ohlsson, 2011). Some research found there was a reduction in fussing and crying behaviour (Guyer et al., 2012) and faster weight gain (Brandon et al., 2002) when premature infants were exposed to cycled lighting, darker at night, compared to constant dim light. In an adult ICU study, a reduction of noise and light at night resulted in more sleep and less delirium (Patel et al., 2014). In a review, Hu et al. (2015a) stated there was little evidence of improved sleep by using non-pharmacological interventions in the ICU to improve sleep; however, they did find some evidence that using eye masks and/or earplugs had positive effects on patients' sleep and decreased reports of delirium. Hu et al. (2015b) also found patients had significantly better sleep quality with an intervention combining the three aspects: using eye masks and earplugs and listening to 30 minutes of relaxing music during their post-operative period in the Cardiac Surgical ICU. There were no group differences with melatonin and cortisol levels between patients who received the intervention and those who had not.

Few studies report patients' experiences of the ICU lighting environment. However, in a cycled lighting intervention study (Engwall et al., 2015), patients indicated the lighting was pleasant. It also showed lighting levels affected sleep and both disturbed and supported a normal CR, calmed patients and contributed to them feeling safer. Today, we know that having a critical illness or injury in an ICU may lead to long-term health problems (Castillo et al., 2016; Needham et al., 2012; Zetterlund et al., 2012). As some of these problems may be caused by sleep deprivation and disturbances in CRs, it is important to investigate if different environmental factors can improve them. There is little intervention research on issues with the patients' environment. However, as environmental interventions are inexpensive and relatively safe, they should be evaluated (Mammen et al., 2014; Rashid, 2014; Ulrich et al., 2008; Ulrich et al., 2010).

Aim

The aim was to investigate whether patients had a normal circadian rhythm and whether a cycled lighting intervention could positively impact it.

Methods

Design

This pilot study used an experimental design. A cycled lighting intervention was set up in a renovated two-bed room (intervention room) following evidence-based design principles (Engwall et al., 2014). The intervention room had the cycled lighting, different ceiling material and walls and textiles in soft shades. These alterations may altogether have slightly contributed to an improved acoustic environment in the intervention room. Previous research showed a slight difference for distinctness of speech and reverberation (Johansson, 2014; Johansson et al., 2016). A standard room, without these alternations, functioned as the control (ordinary room). Both rooms faced north. Patients' activity, heart rate, mean arterial pressure (MAP) and body temperature were measured to determine patients' CRs over their last 24 hours of stay in the ICU.

The lighting intervention

The cycled system aimed to support a natural CR by mimicking normal daylight. It followed the 2011 European Standard recommendations of illumination in hospitals. The system was a combination of two main light sources (see Table 1). One light fitting was suspended 45 cm below the ceiling with indirect lighting shining upwards to avoid dazzling patients. The light fitting included two tubes, one with a warm colour temperature at 2700 Kelvin (K) and one with a cold colour temperature at 6500 K. There were two concealed lighting devices set at 2700 K. One was located behind the headboard approximately one metre above the floor, illuminating upwards and downwards. The other was placed along the skirting board around the floor to prevent shining directly on the patients and dazzling them.

The system worked in a series of 14 light scenes over a 24-hour period, which changed levels, colours and locations. It started at 7 a.m. with a warm colour at a low level. At 8 a.m., the level rose with the intention of waking the patient and suppressing his/her melatonin hormone level, and then it decreased slightly at 10 a.m. At noon, the lighting was even lower, giving daylight a chance to act. In the afternoon, the level was raised for a time and then lowered again in the evening. From 7 p.m., the night started with lower levels, and after 9.30 p.m., there was only floor lighting. The system was automatically controlled by software, but staff were able to control the lighting manually for emergency situations. In the ordinary room, the light sources included wall and ceiling lighting fittings. Normally only wall lighting was used during the day. At night, the wall lighting or night-time lighting (more commonly