Effect of Noise Reduction Methods in the Intensive Care Unit on Sleep Deprivation and Incidences of Delirium

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Abstract

Sleep deprivation is a common problem in the intensive care unit because it can increase rates of delirium, impede proper recovery, lead to longer hospital stays, and increase health care costs. This study aims to review three randomized controlled trials that observe the effect of noise reduction methods in improving sleep quality among intensive care patients. One study compared rates of delirium among those use earplugs and those who do not. Two other studies found that interventions such as earplugs, eye masks, and melatonin have proven to improve sleep quality. While interventions such as earplugs may be uncomfortable for some patients, it is reasonable it to at least offer these products to those who may want it. This can in turn improve patient satisfaction rates, decrease hospital length of stays and reduce healthcare costs. Moreover, these interventions are safe, cost effective, and easy to implement.
Introduction

Background

Sleep deprivation is a common problem that is not limited to the healthcare setting. It occurs due to lack of sleep or sleep quality, and causes decreased attentiveness, fatigue, and poor cognitive function (Weinhouse et al., 2009). Since restorative sleep is essential for proper healing, this problem is exacerbated in the health care setting, and is associated with increased incidences of delirium that range from 20% to above 80%, depending on pathology of disease (Rompaey, Elseviers, Drom, Fromont, & Jorens, 2012). Those requiring higher acuity care in settings such as the intensive care unit may have a more difficulty dealing with sleep deprivation and are often more prone to its adverse health outcomes. In the clinical setting, sleep deprivation is associated with effects such as delirium, worsened immunity, endocrine imbalances (Huang et al., 2015), slower healing, and “ICU psychosis,” a clinical condition describing confusion, restlessness, memory loss, and judgment impairment (Topf, Bookman, & Arand, 1996).

Unfortunately, getting adequate and restorative sleep in the intensive care setting is almost impossible due to the frequent interruptions that are made for a wide variety of reasons, ranging from pain related to illness, to routine interventions such as hourly pupillary checks. Other factors that may disrupt sleep quality in the hospital setting include procedures such as x-ray scans, regular blood draws, ventilator discomfort, and medications that disturb REM sleep such as sedatives or steroids (Brummel & Girard, 2013).

Many studies have been conducted that test the effect of various interventions on how they can improve sleep quality. Key studies have tested the effects of earplugs, eye masks, and melatonin. Van Rompaey and colleagues (2012) conducted a study regarding the use of earplugs on sleep quality and incidence of delirium; Sixty-nine patients sleeping with earplugs were
compared to sixty-seven patients who did not. Those who used earplugs developed delirium at a 43% lesser rate than those who did not, and reported to have better sleep quality (Rompaey, Elseviers, Drom, Fromont, & Jorens, 2012). Another research study found that subjects who used earplugs and eye masks had longer REM, less arousal (p<0.05), and elevated melatonin levels (p=0.002) in comparison to those who did not. The study found evidence that the use of earplugs and eye masks regulate melatonin and cortisol levels (Hu, Jiang, Chen, & Zhang, 2010). Despite research and evidence that sleep deprivation remains a big problem in the intensive care unit, simple interventions such as offering earplugs have still not been implemented (Rompaey, Elseviers, Drom, Fromont, & Jorens, 2012).

This clinical problem is significant because even though many factors can disrupt sleep quality, one modifiable risk factor that nurses can help to change is noise reduction. This alone can greatly improve sleep quality. Noise has become an increasing problem as technology has advanced (Topf, Bookman, & Arand, 1996). Noises may come from equipment, alarms, phones, beepers, staff talking, etc. In a randomized controlled trial, 60 subjects were assigned to either sleep in a simulated ICU environment or in a quiet environment and self-rate their sleep quality. Subjects in the quiet environment fell asleep significantly (p<0.001) faster, slept longer, awakened less, and had better sleep quality (Topf, Bookman, & Arand, 1996). Thus, evidence suggests that noise remains an obstacle that prevents patients from receiving adequate and restful sleep. As a result, healthcare providers should be proactive in promoting a quiet environment in order to foster restful and restorative sleep.

**Significance to Nursing Practice**

As patient advocates, nurses should promote interventions that are effective in improving patient outcomes. Since patients in the intensive care unit may have decreased levels of
consciousness and less autonomy, it is important for nurses to be proactive as patient advocates and make sure that patients receive the best evidenced-based care. While it may not be feasible for nurses to reduce noise levels from equipment, alarms, etc., methods of noise reduction such as earplugs should be implemented. Noise reduction strategies such as earplugs are a good cost effective and low-risk way of promoting sleep (Litton, Carnegie, Elliott, & Webb, 2016). This paper will look at evidence that evaluates the effectiveness of noise reduction methods such as earplugs as an intervention for patients in the intensive care unit.

**Methods**

Key words used to narrow the search included “earplugs,” ”melatonin,” “sleep deprivation,” “delirium prevention,” “intensive care unit,” and “critical care.” A combination of these key words generated the research articles used for this paper. The databases used in this study were PubMed, CINAHL, The Cochrane Library, and Google scholar. Results were limited by “English language only,” adults older than 18 years, and full text. Some of the PubMed articles were limited by randomized controlled trial. Limiting the articles that were searched using combinations of the above key words yielded on average 50 to 100 results in the databases, from the original 300 articles.

Studies chosen for Tables of Evidence were based on relevance and reputation. The studies must not only have existing evidence on the clinical problem but also provide clinical implications in nursing practice that are feasible, since the purpose of this paper aims to promote the implementation of interventions.
Results

A common theme found among the three studies was that interventions used to reduce noise and light at night contributed to improved sleep perception and sleep quality in the intensive care unit. In each of the studies, researchers manipulated the noise and light in the environment by using earplugs and eye masks. In addition, melatonin was included as an intervention and measured as an outcome via blood levels. Different outcomes were assessed in the studies; Van Rompaey and colleagues (2012) used the NEECHAM and Richmond Agitation Sedation scales to assess for delirium. Hu et al., (2010) and Huang et al., (2015) focused on assessing sleep quality.

Additionally, different measures were used to assess sleep quality; Hu et al., (2010) and Huang et al., (2015) both assessed sleep quality subjectively through self-perception, and objectively through polysomnography. Huang et al., (2015) assessed melatonin as both an outcome and an intervention, whereas Hu et al., (2010) only used melatonin as an outcome measure. Hu and colleagues (2010) also measured sleep quality through urinary excretion of cortisol and melatonin, polysomnography, self-rating scale, and the Spielberger State-Trait Anxiety Inventory. In addition, Huang and colleagues (2015) used polysomnography, serum melatonin, self-ratings, and anxiety levels. For both of those studies, total sleep time, sleep onset latency, REM latency, amount of light sleep, amount of REM sleep, and number of arousals and awakenings were recorded.

Improved sleep quality with the use of earplugs and eye-masks

Hu et al., (2010) and Huang et al., (2015) both found that sleep quality decreases when exposed to noise and light (NL). Subjects who used earplugs and eye masks (NLEE) had longer REM, less arousal, and elevated melatonin levels. Subjects in the NL group had on average 3.6%
less REM sleep, 8 minutes longer sleep onset latency, and 3 times fewer arousals compared to the NLEE group (Hu, Jiang, Chen, & Zhang, 2010).

Huang et al., (2015) conducted a similar study to Hu et al., (2010) in which a simulated ICU noise and light environment caused worsened sleep quality. NLEE subjects had a slightly longer total sleep time (385 minutes compared to NL 369 minutes). NLEE had a statistically significant (p=0.01) increase with a higher sleep onset latency of 46.6 minutes in comparison to NL 71.4 minutes. NLEE had significantly (p=0.001) fewer awakenings, averaging 5 times less than those in NL. Those under NL had sleep anxiety level of 46, whereas NLEE had sleep anxiety level of 33 (p=0.000). NL had sleep quality 6.1, in comparison to NLEE’s sleep quality 3.4 (p=0.000) (Huang et al., 2015).

**Decreased incidence of delirium**

Rompaey et al., (2012) focused specifically on the incidence of delirium, and found that those who used earplugs developed delirium at a lower rate than those who did not. Those in the control group showed a 60% in cognitive disturbances, in comparison to 35% in the intervention group. Patients sleeping with earplugs showed a statistically significant improvement in sleep quality after one night (p=0.042). Moreover, in the self-reported sleep perception, about half of the intervention group reported to have good sleep, whereas only a quarter of the control group reported good sleep. Those who used earplugs scored a median NEECHAM score of 26, whereas the control group scored 24 (p=0.04). (Rompaey, Elseviers, Drom, Fromont, & Jorens, 2012). Overall, the use of earplugs was helpful in improving sleep quality and reducing incidences of cognitive disturbances.
Discussion

The three studies recognize the issue of sleep deprivation in the intensive care unit, and seek to understand how noise reduction methods can help improve sleep quality. Intervention groups were compared to a control group of a recorded baseline critical care environment to observe effects on sleep quality. Interventions between studies varied, but included melatonin, earplugs, and eye masks.

A strength in drawing conclusions from these three studies is that each of them observed sleep quality, but measured it in different ways. Choosing studies that look at sleep quality as an inclusion criterion allows comparison and summarization of results. Van Rompaey et al., (2012) focused on rates of delirium, while Hu et al., (2010) and Huang et al., (2015) used the polysomnography and self-perception ratings. Hu et al., (2010) and Huang et al., (2015) also used very specific measurements that helped quantify sleep quality, such total sleep time, sleep-onset latency, REM latency, amount of light sleep, amount of REM sleep, and number of arousals or awakenings. They also measured urine excretion, serum melatonin, and serum cortisol. Huang et al., (2015)’s study is more reliable because it includes more of both subjective and objective measurements of sleep quality compared to others. While other measures aim to provide evidence of sleep quality, it is ultimately the self-perception ratings that provide most value to the study.

The three studies were also all randomized controlled trials, one of the highest levels of research. This improves internal validity because providing raw data allows the reader to draw conclusions, thus reducing bias. Randomized controlled trials are the most direct way of studying how a specific intervention changes an outcome. The studies were also double blinded, which further helps to eliminate selection bias. Van Rompaey et al., (2012) and Huang et al., (2015)
assigned subjects by using an independent nurse researcher that used a computer program to randomize assignments. Their studies have less bias and more internal validity, in comparison to Hu et al., (2010)’s study, which did not mention method of assignment.

Fidelity of interventions were maintained by making sure earplugs and eye masks were worn for the same amount of time. They were given to patients to use from 20:00 to 06:00. Using playback recordings of sound in the intensive care unit allowed subjects to be exposed to a similar range of decibels, and gives consistency across all intervention groups. This helps control for other variables that could confound the results.

One weakness is that all of the studies used convenience sampling, increasing the risk of selection bias. Van Rompaey et al., (2012)’s subjects were all patients from Antwerp University Hospital. Hu et al., (2010) recruited subjects by posting advertisements at the Second Affiliated Hospital and offering 200 Yuan. Another weakness is that there were not a large number of subjects. Hu et al., (2010) had only 14 subjects who underwent each of the 4 interventions. Huang et al., (2015) had a total of 40 subjects, with each intervention group having 10 subjects. Due to the small number of subjects, a single dropout or instance of noncompliance could easily skew data. For example, several subjects from Huang et al., (2015)’s study complained of the discomfort of earplug use. Aside from one dropout in Hu et al., (2010)’s study due to significant insomnia, there were no other dropouts. Dropouts could skew data and result in accuracy of calculations.

Overall, the studies show that earplugs are effective because they improve sleep quality. Though some patients from Huang et al.’s (2015) study complained that earplugs were uncomfortable, evidence shows that those who did use earplugs had improved sleep quality. Since earplugs are cost effective, it is reasonable to at least provide patients with the option of
using earplugs. The results from these studies are applicable to any patient in the critical care setting, further attributing to external validity.

**Implications**

From the three studies, evidence has shown that earplugs and eye masks are effective at improving sleep quality. Evidence points to reduced rates of delirium as a direct effect of implementing the use of earplugs as an intervention to improve sleep quality (Rompaey, Elseviers, Drom, Fromont, & Jorens, 2012). As a patient advocate, nurses should advocate for changes that will bring about evidence-based practices.

Change in practice is always a barrier because implementing a change costs time, effort, and money. Training every nurse to adopt this practice requires time for education. Moreover, while earplugs may seem individually inexpensive, costs still add up. It is also difficult to implement a practice that has not been widely studied or if the expected results are not concrete and calculated.

While some participants have complained of earplug discomfort, evidence has shown that it could lead to potential benefits for both the patient and the hospital. As a result, it is reasonable to at least have earplugs and eye masks in stock at the hospital to offer to patients. Improved sleep recovery could in turn reduce rates of delirium, facilitate proper and faster recovery, shorten length of stay in the hospital, and ultimately reduce healthcare costs. These implications are applicable to not only the intensive care unit but also to any inpatient hospital setting where a patient may benefit from additional intervention for good sleep.

Further research can include studies on how sleep quality affects the recovery process. This can help to draw more direct implications, and resultanty allow nurses to promote the implementations of these interventions with more urgency. The relationship between sleep
quality and recovery process can be difficult to examine in the inpatient hospital setting, but it is important to further examine this topic since it can have such a large impact on rate of recovery, hospital length of stay, and healthcare costs. Further research can examine whether length of stays in the hospital changes after the implementation of earplugs to determine whether these cost savings can be used to justify the cost of earplug interventions.

**Conclusion**

Based on examining the three studies, it is evident that using earplugs and eye masks at night improves sleep quality. The use of earplugs reduces noises that characterize the critical care environment. Constant bed alarms, phones, IV pumps beeping, and more interruptions disturb patients’ sleep. The three studies found that interventions to improve sleep have been proven to decrease rates of delirium and sleep quality. Outcome measures included increased sleep onset latency, total sleep time, number of awakenings, and more.

There exists a gap between this existing data and current standards of practice. Offering earplugs and eye masks for patients in the intensive care unit is not a standardized practice today. Nurses play an important role as patient advocate and can make a big difference in the quality of care by advocating for evidence-based practice. Thus, nurses should advocate for these changes to take place. By appealing to best practices, nurses have the potential to change healthcare practices and welcome further innovation.
<table>
<thead>
<tr>
<th>STUDENT NAME: Veronica</th>
<th>STUDENT NAME: Veronica</th>
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<tbody>
<tr>
<td><strong>Table of Evidence (TOE): Problem Area</strong></td>
<td>Noise reduction methods in the ICU to improve sleep and reduce delirium</td>
</tr>
<tr>
<td><strong>Author</strong></td>
<td>Van Rompaey, B., Elseviers, M., Van Drom, W., Fromont, V., &amp; Jorens, P. G. (2012).</td>
</tr>
<tr>
<td><strong>Research Questions/Hypotheses</strong></td>
<td>To see the effect of wearing earplugs at night on delirium and sleep quality in the intensive care unit</td>
</tr>
<tr>
<td><strong>Purpose</strong>:</td>
<td>The effect of earplugs during the night on the onset of delirium and sleep perception: a randomized controlled trial in intensive care patients.</td>
</tr>
<tr>
<td><strong>Design/Method(s)</strong></td>
<td>Randomized controlled trial (intervention vs control group without earplugs)</td>
</tr>
<tr>
<td><strong>Sampling Method</strong>:</td>
<td>Non probability convenience sample from Antwerp University Hospital</td>
</tr>
<tr>
<td><strong>Inclusion Criteria</strong>:</td>
<td>Expected length of hospital stay &gt;24 hours, adults &gt;18 years old, Dutch or English speaking, minimum GCS score 10</td>
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<tr>
<td><strong>Exclusion Criteria</strong>:</td>
<td>Patients with known hearing impairment, dementia, confusion, delirium</td>
</tr>
<tr>
<td><strong>Grouping</strong></td>
<td>Patients who needed to be sedated</td>
</tr>
<tr>
<td><strong>Size</strong>:</td>
<td>136 participants; 67 control group 69 intervention group no dropouts after trial started</td>
</tr>
<tr>
<td><strong>Independent variable(s): Concept &amp; Measurement</strong></td>
<td>Intervention group: no earplugs at night</td>
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<tr>
<td><strong>Dependent variable(s): Concept &amp; Measurement</strong></td>
<td>Control group: earplugs at night</td>
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<tr>
<td><strong>Measurement</strong>:</td>
<td>Delirium was assessed on the validated NEECHAM scale</td>
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<tr>
<td><strong>Related Variables</strong>:</td>
<td>Richmond Agitation Sedation Scale</td>
</tr>
<tr>
<td><strong>Control Group</strong></td>
<td>Sleep perception reported to patient in response to 5 questions</td>
</tr>
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| Effects of earplugs on nocturnal sleep, melatonin, and cortisol levels |
| **Purpose**: | To observe the effects of earplugs and eye masks on nocturnal sleep, melatonin, and cortisol levels |
| **Design**: | Randomized controlled trial |
| **Sampling Method**: | Non probability convenience sample at Sleep-breath Disorders Center at the Second Affiliated Hospital, Fujian, China |
| **Inclusion Criteria**: | Control group: baseline Group 1: ICU noise and light |
| **Exclusion Criteria**: | Group 2: ICU noise and light plus earplugs and eye masks |
| **Measurement**: | Urinary excretion of 6-SMT and cortisol |
| | Urine was also analyzed for melatonin and cortisol levels |
EFFECT OF NOISE REDUCTION METHODS

Methods:
Sleep was studied in 14 subjects. Conditions that subjects were exposed to include baseline, exposure to ICU noise and light (NL), and NL plus earplugs and eye masks (NLEE).

Subjects were hooked up to EEG, eye movement and sub-mental electromyogram (CHin EMG) in the sleep laboratory. During NL and NLEE nights, recorded ICU noise was played and fluorescent lights turned on.

Nocturnal urine was collected between 10 p.m. and 7 a.m. on baseline, NL and NLEE nights.

Exclusion Criteria:
PSG on the adaptation night found any sleep disorder including sleep apnea, narcolepsy, chronic insomnia or restless leg syndrome. Female subjects were excluded while they were menstruating.

Size:
14 subjects each underwent the 4 interventions (8 females and 6 males, aged 21 to 70 years, mean 31.07 ± 15.64 years)

1 dropout due to significant insomnia

Intervention groups were exposed to an ICU environment at Fujian Hospital. A sound meter ensured playback of the ICU environment in a similar range of decibels to that recorded. Subjects in the intervention group (NLEE) wore earplugs with 29 dB noise reduction rating and eye masks during experimental night.

Sleep assessed by polysomography

Subjective sleep quality: Subjects self-evaluated sleep quality on a scale of 0 to 10 (0 = excellent, 10 = poor) and state anxiety level using the Spielberger State Anxiety Inventory (SAI) on the morning after every experimental night.
### Purpose:
To determine whether earplugs, eye masks, or melatonin would be the best intervention for sleep deprived patients in the intensive care unit.

### Design:
Randomized controlled trial
The study protocol was formally approved by the Institutional Review Board of Fuzhou Children’s Hospital (approval number 2014–001) and by the Chinese Clinical Trial Registry (approval number ChiCTR-IPR-14005458).

### Sampling Method:
Non probability convenience sample from Fuzhou Hospital

### Methods:
40 subjects slept under a baseline night, and then were randomly divided into 4 groups: noise and light, noise and light plus placebo, noise and light plus earplugs and masks, and noise and light plus melatonin.

Randomization performed using a computer-generated schedule independent of treatment personnel. Study was double blinded; subjects in the melatonin and placebo groups did not know they were receiving active therapy, nor did their clinicians.

### Independent Variables:
- Control group: baseline
- Intervention group 1: noise and light
- Intervention group 2: noise and light plus placebo
- Intervention group 3: noise and light plus earplugs and masks
- Intervention group 4: noise and light plus melatonin

### Dependent Variables:
Sleep quality
Best intervention result

### Measurement:
Polysomnography, serum melatonin levels, and self-ratings of perceived sleep quality and anxiety levels were used to measure sleep quality.

Total sleep time
Sleep-onset latency
REM latency
Amount of light sleep
Amount of REM sleep
Number of arousals and awakenings

### Exclusion Criteria:
History or current diagnosis of other sleep disorders (restless leg syndrome, periodic leg movements with arousals, narcolepsy, REM behavior disorder, circadian rhythm sleep disorder, breathing-related sleep disorder, parasomnia), reduced hearing acuity (>20 dB hearing loss at a single frequency, blindness, history of alcohol or medication abuse, occupational history that included shift work or recent significant travel across three or more time zones within the prior two weeks, participants with an apnea-hypopnea index >15 or a periodic leg-movement arousal index >15, and known allergy to melatonin

### Size:
40 subjects
10 subjects per group, no dropouts
References


Van Rompaey, B., Elseviers, M., Van Drom, W., Fromont, V., & Jorens, P. G. (2012). The effect of earplugs during the night on the onset of delirium and sleep perception: a randomized controlled trial in intensive care patients. *Critical care,* 16(3), R73-.