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The Effect of Noise and Light on Sedation in Critical Care Patients. A Cross-Sectional Study of Critical Care Nurses in Three Intensive Care Units in Norway

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Abstract

Background: International guidelines for pain, sedation, delirium, immobility, and sleep in critically ill patients recommend the use of noise and light reduction strategies to improve sleep. The aims of this study were: 1) to evaluate critical care nurses' (CCNs) perceptions regarding sources of noise and light in the intensive care unit (ICU), and 2) to identify factors associated with critical care patients' need for sedation when their sleep is disturbed by noise or light.

Methods: A cross-sectional study was conducted in three Norwegian ICUs (n = 193).

Results: A total of 87% of the CCNs stated that critical care patients were exposed to *noise*, and the most frequent sources were alarms from monitoring equipment (71%) and mechanical ventilators (70%), and nurses talking (65%). The results demonstrated higher odds for critical care patients needing sedation when sleep was disturbed by noise, if the CCNs reported that noise disturbed patients sleep (OR 3.05), and lower odds if the CCN was from ICU C (OR 0.39). Most CCNs (82%) answered that there was a difference in the level of light during day versus night, and that the most frequent source of light at night was from small lamps (46%). It was higher odds that the CCNs perceived that critical care patients needed sedation when sleep was disturbed by light if the light disturbed the patient's sleep in the unit (OR 4.78). There were lower odds if the CCNs was from ICU A (OR 0.32) or ICU C (OR 0.34).

Conclusion: The findings from this study indicate that CCNs use sedatives to induce sleep for critical care patients to compensate for environmental factors such as noise and light. Variations between ICUs indicate different sedation practices between Norwegian ICUs.

Keywords: *intensive care unit; critical care nurse; critical care patient; sedation; sleep; noise; light*

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Introduction

Sleep in patients in intensive care units (ICUs) is severely disturbed, and can be characterised as short, light, and fragmented (1). International guidelines for pain, sedation, delirium, immobility, and sleep (PADIS) recommend analgosedation in critically ill patients. Analgosedation is a strategy where patient pain and discomfort are managed first, before providing sedative therapy (2,3). Consequently, patients might be more awake during their ICU stay (4).

Several studies have identified that noise and light are factors that interfere with patients' sleep in ICUs (5–7). In addition, ICU survivors have reported a frequent recall of noise during their ICU stay (8). Sleeping disorders has a significant pathophysiological effect on critical care patients, because lack of sleep contributes to inhibiting the recovery of health, and is a predisposing factor for delirium, which is associated with increased mortality (2,9). A bundle concept of non-pharmacological strategies with comfort and patient-centred care, which includes control of the environmental factors such as noise and light, has therefore become a mainstay of ICU care (10–12).

Critical care patients are surrounded by high-tech equipment that supports and monitors vital signs (13). To avoid interrupted sleep, the World Health Organization recommends a sound level of below 35–40 decibels (14). However, high levels of sound are frequently reported in ICUs (5,6). Technical equipment is also a source of light in ICU environments, and light at night is a common cause of sleep interruptions (7,15). Consequently, the patient's circadian rhythms are misaligned and disrupted, which in turn may interfere with their critical condition (9,16). To handle different sources of noise and light in the ICU, further studies investigating sources of noise and light in ICUs are needed.

Critical care patients are subjected to both noise and light during their ICU stay, which makes it challenging for the critical care nurse (CCN) to facilitate sleep for the patients. The PADIS guidelines recommend a non-pharmacological intervention to facilitate sleep (2,3). However, this might not always be feasible or appropriate in all clinical settings (17,18). CCNs assess the patient's condition and facilitate recovery, including deep natural sleep. In several countries, CCNs have a delegated mandate to give medication on indication, and studies indicate that CCNs frequently use hypnotics to facilitate sleep (19,20). However, sedatives are not recommended, and sedatives might even potentiate the challenge of achieving deep, natural sleep (2,3). There remains a lack of studies demonstrating sedation practice when a patient's sleep is disturbed by noise or light. The aims of this study were: 1) to evaluate the CCNs' perceptions regarding sources of noise and light in the ICU, and 2) to identify factors associated with critical care patients' need for sedation when their sleep is disturbed by noise or light.

Methods

This study is reported in adherence with the STROBE statements for reporting cross-sectional studies (21).

Design

This survey had a cross-sectional design.

Setting

CCNs working in ICUs at three different hospitals were included. The hospitals were located within three different regions in Norway. In total, these hospitals cover approximately one million inhabitants. All three units were mixed medical/surgical ICUs, had both single and multiple occupancy bedrooms, and treated patients of all ages. ICU A was a ten-bed unit at a university hospital, ICU B was a seven-bed unit at a regional hospital, and ICU C was a five-bed unit at a regional hospital.

Development of a questionnaire

A questionnaire was used for data collection. Results presented in this paper are part of a larger survey. The first part of this questionnaire had questions about the administration of sedative medications, the use of guidelines and directives for sedation, and the use of assessment tools for sedation, as published by Nystrøm et al. (22). The first part of the questionnaire did not evaluate noise and light in the ICU. Therefore, we developed a part 2, based on relevant literature (11,14) and discussions with experienced physicians and CCNs, where questions about noise and light were added to the questionnaire. Five experienced CCNs (including one with MSc and one with PhD) pilot-tested a draft of the questionnaire. To test for content validity and usability, the wording and content of the questions, the response categories, and the time spent to fill in the questionnaire were evaluated. Only minor changes in the wording and the layout were made after the pilot-test.

The final version of the questionnaire consisted of the following items with answer categories on five-point Likert scale.

Sources of noise in the ICU, such as alarms from mechanical ventilators and nursing activities, had the answer categories 'never', 'to a small extent', 'occasionally', 'often', and 'always'.

CCN's perceptions of noise in the ICU, such as whether 'critical care patients are exposed to noise', and 'noise disturbs their sleep', had the answer categories 'never', 'rarely', 'occasionally', 'often', and 'always'. 'Patients need sedation when sleep is disturbed by noise' had the answer categories 'disagree', 'partly disagree', 'unsure', 'partly agree', and 'completely agree'.

Sources of light during night, such as ceiling lamps, wall lamps and small lamps, had the answer categories 'never', 'to a small extent', 'occasionally', 'often', and 'always'.

CCN's perceptions of light in the ICU, such as 'difference in light during day versus night' and 'light disturbs patient's sleep', had the answer categories 'never', 'rarely', 'occasionally', 'often', and 'always'. 'Patients need sedation when sleep is disturbed by light' had the answer categories 'disagree', 'partly disagree', 'unsure', 'partly agree', and 'completely agree'.

Participants and recruitment

A convenience sampling method was used to recruit participants. CCNs at the three units (n = 221) were invited to participate. Registered nurses, head nurses and those on sick leave were excluded from the study. Each CCN received both written and oral information in advance, and several reminders were issued during data collection. Between October 2015 and March 2016, paper-based questionnaires were distributed to the CCNs on the units education days (ICU A and ICU C) or in clinical practice (ICU B). The CCNs submitted the completed forms in sealed boxes at each unit.

Analysis

All answers from the five-point Likert scale were dichotomised to 'yes'/'no' to make the presentation of the results more clinically relevant (23). The answer categories 'often', 'always', 'partly agree' and 'completely agree' were coded 'yes', and the response categories 'never', 'to a small extent' and 'occasionally'; 'never', 'rarely' and 'occasionally'; and 'disagree', 'partly disagree' and 'unsure' were encoded 'no'.

A descriptive analysis was presented with numbers and percentages. To test for difference between ICUs, a chi-squared test was performed. In order to identify possible factors associated with a patient's need for sedation when sleep was disturbed by either noise or light (outcome variable), factors at the unit (such as type of unit, whether critical care patients were exposed to noise, whether noise disturbed patients sleep, whether there was a difference in light during day and night, and whether light disturbed patients' sleep) and demographic variables of the CCNs (such as age and experience) were analysed using logistic regressions, to obtain an odds ratio and 95% confidence interval with the outcome variables (24,25). Significant level $p<0.05$. No confounding was present as the correlation between the variables was below 0.7 (24,25). Values were assumed to be missing at random, ranging from 0 to 4. All analyses were performed with the IBM Statistical Package for the Social Sciences (SPSS) Statistics version 27 (26).

Ethics

The study was approved by the Norwegian Centre for Research Data (ref. 44726) and the head leaders at all included ICUs. The procedure for approvals were similar for all three included ICUs. Participation was based on the guidelines for ethical research contained in the Declaration of Helsinki, and on willing, informed consent (27). A returned, completed questionnaire was considered to constitute written consent to participate. Data was processed anonymously and confidentially, and CCNs cannot be identified from the findings presented. Data was stored in a password-protected computer.

Results

Descriptive results

In total, 87% of the CCNs returned the questionnaire (n = 193). Demographic data is reported in Table 1.

Table 1 Demographics

	All respondents (n = 193)	Hospital A (n = 56)	Hospital B (n = 77)	Hospital C (n = 60)
Women, n (%)	172 (89)	46 (82)	73 (95)	53 (88)
Age in years, mean (SD)	46 (8.5)	46 (8.1)	48 (8.4)	45 (8.8)
Experiences as ICU nurse, mean (SD)	13 (7.9)	14 (7.6)	12 (8.6)	12 (7.3)

SD: Standard Deviation; ICU: intensive care unit

The most frequent sources of *noise* were reported to be 'alarms from monitoring equipment' (71%), 'alarms from mechanical ventilators' (70%), and 'nurses talking' (65%). There were significant differences between the units regarding whether 'telephones', 'nurses talking', 'relatives' or 'trash cans' were the sources of noise. When CCNs were asked about their perceptions of noise in the ICU, 87% answered that 'critical care patients were exposed to noise in the unit', 58% answered that 'noise disturbed patients' sleep in the unit', and 66% answered that 'critical care patients need sedation when their sleep is disturbed by noise'. For all these questions, there was significant variation between the ICUs.

The most frequent sources of *light* at night were from 'small lamps' (46%). For 'wall lamps' (ranging from 2% to 49%) and 'light from ceiling lamps' (ranging from 2% to 31%), there was a significant difference between ICUs. When CCNs were asked about their perceptions about light in the ICU, 82% answered that there was a 'difference in light during day versus night', 26% answered that 'light disturbs patients' sleep', and 45% answered that 'critical care patients need sedation when their sleep is disturbed by light'.

Table 2 Sources of noise and light in ICU and CCNs perception of noise and light in the ICU (n = 193)

	All respondents		ICU A		ICU B		ICU C		x^2 test
	n = 193	(%)	n = 56	(%)	n = 77	(%)	n = 60	(%)	
Sources of noise in the ICU									
Alarms from mechanical ventilators	135	(70)	38	(68)	59	(77)	38	(63)	0.223
Alarms from monitoring equipment	136	(71)	40	(71)	59	(77)	37	(62)	0.160
Suction procedures	99	(51)	27	(48)	40	(52)	32	(53)	0.809
Telephones	67	(35)	19	(34)	36	(47)	12	(20)	0.005*
Physicians on visit	47	(24)	19	(34)	16	(21)	12	(20)	0.147
Nurses talking	126	(65)	44	(79)	58	(75)	24	(40)	0.001*
Relatives	43	(22)	22	(40)	14	(18)	7	(12)	0.001*
Trash can	18	(9)	1	(2)	17	(22)	0	(0)	0.001*
Radios	0	(0)	0	(0)	0	(0)	0	(0)	
Nursing activities	70	(36)	24	(43)	27	(35)	19	(32)	0.438
CCNs perceptions of noise in ICU									
Critical care patients are exposed to noise	167	(87)	54	(96)	65	(84)	48	(80)	0.027*
Noise disturbs patients sleep	111	(58)	48	(86)	41	(53)	22	(37)	0.001*
Patients need sedation when sleep is disturbed by noise	128	(66)	44	(79)	56	(73)	28	(47)	0.001*

(*Continued*)

Table 2 (*Continued*)

	All respondents		ICU A		ICU B		ICU C		x^2 test
	n = 193	(%)	n = 56	(%)	n = 77	(%)	n = 60	(%)	
Sources of light during night									
Ceiling lamp	33	(17)	8	(14)	24	(31)	1	(2)	0.001*
Wall lamp	44	(23)	5	(9)	38	(49)	1	(2)	0.001*
Small lamps	89	(46)	22	(39)	41	(53)	26	(43)	0.245
CCNs perceptions of light in ICU									
Difference in light during day versus night	158	(82)	51	(91)	50	(65)	57	(95)	0.001*
Light disturbs patients sleep	51	(26)	18	(32)	21	(27)	12	(20)	0.323
Patients need sedation when sleep is disturbed by light	86	(45)	23	(41)	41	(53)	22	(37)	0.126

Abbreviations: CCN = critical care nurse; ICU = intensive care unit. Reported answers are presented dichotomized as yes = often/always or almost agree/agree

Sedation practice when critical care patients' sleep is disturbed by noise

Table 3 shows factors that are associated with critical care patients' need for sedation when their sleep is disturbed by *noise*. The multiple model shows higher odds for 'critical care patients need sedation when their sleep is disturbed by noise' if the CCNs reported that 'noise disturbs patients' sleep' (OR 3.05), and lower odds if the CCNs were from 'ICU C' (OR 0.39).

Table 3 Factors associated with critical care patients need for sedation when sleep is disturbed by noise (n = 187)

	Single model		Multiple model	
	OR*	95% CI	OR*	95% CI
Factors at the unit				
Critical care patients are exposed to noise	4.68*	(1.95–11.23)	2.16*	(0.79–5.89)
Noise disturbs patients sleep	4.58*	(2.42–8.67)	3.05*	(1.39–6.68)
ICU (ref. ICU B)				
ICU A	1.38*	(0.61–3.10)	0.85*	(0.33–2.16)
ICU C	0.33*	(0.16–0.67)	0.39*	(0.18–0.86)
Demographic variables of the CCNs				
Age	1.01*	(0.90–1.05)	1.02*	(0.96–1.09)
Experience as CCN	1.00*	(0.98–1.04)	0.99*	(0.92–1.06)

Abbreviations: CCN = critical care nurse, ICU = intensive care unit, OR = odds ratio, CI = confidence interval

Sedation practice when critical care patients' sleep is disturbed by light

Table 4 shows factors that are associated with critical care patients' need for sedation when their sleep is disturbed by *light*. In the multiple model, there were higher odds if the critical care patients need sedation when their sleep is disturbed by light if 'light disturbs sleep in the unit' (OR 4.78). There are lower odds if the CCNs are from 'ICU A' (OR 0.32) or 'ICU C' (OR 0.34).

Table 4 Factors associated with critical care patients need for sedation when sleep is disturbed by light (n = 187)

	Single model		Multiple model	
	OR*	95% CI	OR*	95% CI
Factors at the unit				
Difference in light during day and night	1.09*	(0.52–2.28)	2.46*	(0.99–6.15)
Light disturbs sleep in the unit	4.37*	(2.18–8.75)	4.78*	(2.25–10.15)
ICU (ref. ICU B)				
ICU A	0.61*	(0.31–1.23)	0.32*	(0.14–0.76)
ICU C	0.51*	(0.26–1.03)	0.34*	(0.15–0.77)
Demographic variables of the CCNs				
Age	1.03*	(0.97–1.04)	0.95*	(0.89–1.01)
Experience as CCN	1.01*	(0.98–1.05)	1.08*	(1.01–1.15)

Abbreviations: CCN = critical care nurse, ICU = intensive care unit, OR = odds ratio, CI = confidence interval

Discussion

To our knowledge, this is the first study demonstrating an association between CCNs' use of sedatives to induce sleep for ICU patients as compensation for environmental factors such as noise and light during the night. We found that a large majority of the responding CCNs agreed or strongly agreed that noise and light disturbed sleep at night for the ICU patients. Furthermore, we identified a difference in CCNs' perceptions across three ICUs.

Our findings showed a relationship between the CCNs' awareness of noise and light and the need for sedatives to induce sleep. This indicates that, on the personal level, CCNs might use sedative medications to compensate for disturbing environmental factors, which may result in higher dosages, leading to potentially negative consequences such as increased time on mechanical ventilation, longer ICU stay, higher mortality, greater cognitive decline and more psychological complications (28–30).

One study indicates that people have different sensitivity to what they perceive as noise, which makes people react differently to the same sound level (31). This is more a personality trait that is influenced by individual perspectives and behaviours that contribute to the decision-making process of choices. Consequently, CCNs may have different responses to the same sound level, which can lead to a mismatch between the nurse's interpretation of symptoms and the patient's perceived symptoms (32,33). One study suggests that nurses do not assess a patient's discomfort systematically, resulting in CCNs individually interpreting what is in the best interest of the patient (17). In contrast, a patient's self-reporting is the gold standard when it comes to both symptoms and discomfort. *Inconforts des patients de reanimation* (IPREA) is a recommended and validated questionnaire where patients self-report 18 ICU-related discomforts, including light and noise (34–37). Using the IPREA questionnaire to assess comfort in ICU patients, to facilitate the inclusion of local interventions to reduce discomforts, is shown to reduce both self-perceived discomfort and post-traumatic stress disorder (35,38). In

the future, the use of self-reported questionnaires, such as IPREA, should be used to improve unit-specific problems such as noise and light.

On a system level, we found a significant difference between the ICUs. This might indicate different cultures for both awareness of disturbing environmental factors and for sedation practice. However, CCNs from both university and regional hospitals were included in this study, which might represent some important dissimilarities between the units, for example related to patient characteristics (e.g., severity of illness) or the construction of the ICUs (e.g., units with single rooms may provide lower levels of noise and light, versus units with shared rooms). A recently published paper indicated that analgosedation is implemented in different degrees across ICUs in Norway (22). A review identified that sedatives were mainly administered as continuous infusions, added with boluses as needed (3). However, one study reported a significant differences across ICUs regarding the use of continuous infusion versus bolus dosages of sedatives (22). A multicentre study did not find a significant difference in clinical outcomes between no sedation and lighter sedation practice (39). In addition, there is an increased trend of using dexmedetomidine, clonidine, and remifentanil, and a decreased use of benzodiazepines, in the past 20 years. There is therefore still a need for more and stronger evidence for clinical outcomes after implementing the PADIS guidelines (3,40,41).

The CCNs perceived that there was a high level of noise in their ICUs, and the sources of noise were most frequently alarms or nurses talking. These results are in accordance with other studies (32,42). Measures of the sound level in ICUs are shown to be high throughout the day, especially during oral nursing reports (43). Another study showed that alarm limits are seldom set at an appropriate level (44). It therefore seems to be easy for the CCNs to ignore alarm sounds, which results in sound levels becoming a burden for patients, making it difficult for them to sleep and rest. The association between disturbing environmental factors and the development of delirium is well-known, which in turn might result in adverse outcomes and even increase the mortality (45,46). One study suggests that more reliable alarms may increase the precise response of the CCNs, and thereby both increase patient safety and reduce noise pollution (47).

A large majority of the responding CCNs agreed or strongly agreed that there was a difference in light during day versus night, which indicates a strategy of circadian rhythm in their ICU. However, there were variations between units, and at one unit fewer CCN reported a systematic use of difference between night and day. To maintain normality and to facilitate sleep for the ICU patients, it is recommended to implement a circadian rhythm in the ICU (2,3). Conflicts might therefore arise between what is in the best interest of the patient and what is in the best interest of the nurse. The shift work schedule and night workload for nurses, in addition to factors that enable nurses to make good observations at night, may require light in the patient's room (48). This conflict should be discussed in the ICUs to find a balance between good working conditions for the CCN and optimal comfort for the patient.

Several studies show that the implementation of guidelines regarding the management of pain, sedation, and delirium has been challenging in clinical practice, however, quality improvement has been shown to have a good effect (49–52). Factors including implementation planning, training, effective documentation, and reflections are identified as promoting implementation (53,54). A multimodal approach, such as comfort and patient-centred care without excessive sedation (eCASH), has also been proposed (11). In addition to interventions such as pain-relief first and the comprehensive use of spontaneous mechanical ventilation settings, it is important to highlight nursing actions – for example, reducing noise and regulating light in accordance with the circadian rhythm (55).

Strengths and limitations

A strength in this study was a high response rate, and respondents were included from three different ICUs at three different hospitals, thereby making the findings generalisable or at least transferable to other ICUs in Norway. There were few missing values in the study, which strengthens the face validity. It is a strength that the questionnaire was pilot-tested before start-up. Another strength is that the participants in the study were clinicians who work closely with ICU patients, which strengthens the content validity of the study.

The questionnaire used in this study has not been psychometric-tested for reliability and validity, which is the main limitation in the study. The questionnaire has been constructed based on relevant literature and discussions with experts, but not using a validated questionnaire might influence the content validity in the study. Data used in this study is from 2015–2016, which might affect the answers, as guidelines for sedation practice has changed the last years. Another weakness is that only CCNs were included in the study, not registered nurses. The staff of other ICUs may include registered nurses.

Conclusion

Even though there are clear international guidelines for managing pain, sedation, delirium, immobility, and sleep in critically ill patients, the present study showed perceived variations in sedation practice between ICUs in Norway. The findings indicated that CCNs used sedatives to compensate critical care patients lack of sleep during the night. Important factors were identified as affecting the CCNs' perception of whether noise and light were a contributing factor for sleep interruption. The most important factors for noise in the ICU were reported to be alarms from technical equipment and nurses talking together. The most important factor for light in the ICU at night was light from small lamps.

Further studies should involve the implementation of analgosedation, with a specific focus on management of sleep using the analgosedation approach. In addition, studies evaluating which actions nurses perform to reduce noise and light should be performed.

To attain the goal of minimising the strain experienced by an ICU patient during a stay in intensive care, this paper recommends that ICUs carry out quality improvement, including a clinical audit, to explore the practice of sleep and sedation in critical care patients.

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