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Schledermann, Kathrine Marie; Bjørner, Thomas; Mullins, Michael; Skov Hansen, Torben

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Identifying Nurses' Perception of a Lighting Installation in a Newly Built Hospital

Schledermann, Kathrine (1)(3), Bjørner, Thomas (2), Mullins, Michael (2), and Hansen, Torben (3).

(1) Aalborg University Copenhagen, Denmark, kas@chromaviso.com; (2) Aalborg University Copenhagen, Denmark; (3) Chromaviso, Denmark.

Kas@chromaviso.com

Abstract. Prior to the installation of new integrative lighting systems, perceived experiences by nurses of the existing lighting were collected as a baseline study through interviews at two newly built hospital units in Denmark. This paper addresses the advantages and barriers that the current lighting application presents for the nurses' work-practice. The study found that ten out of twelve of the interviewed staff at the Neurointensive Care Unit (neuro-ICU) and Postanesthesia Care Unit (PACU) prefer to work in relatively dark conditions. The interviews revealed how light and darkness are perceived as important to the staff for entraining the circadian rhythm of the patients; this was manifested in their working routines. An identification and description of nurses' experience will guide and inform future implementation of integrative lighting systems at neuro-ICU and PACU to ensure patients' sleep quality and recovery, improve visual comfort for the staff, enhance the degree of perceived usefulness of the lighting systems and facilitate technology acceptance. The study concludes that there is a need for implementing differentiated lighting design for the different units and contexts in the hospital, in contrast to a 'one-size fits-all' lighting implementation.

1. Introduction

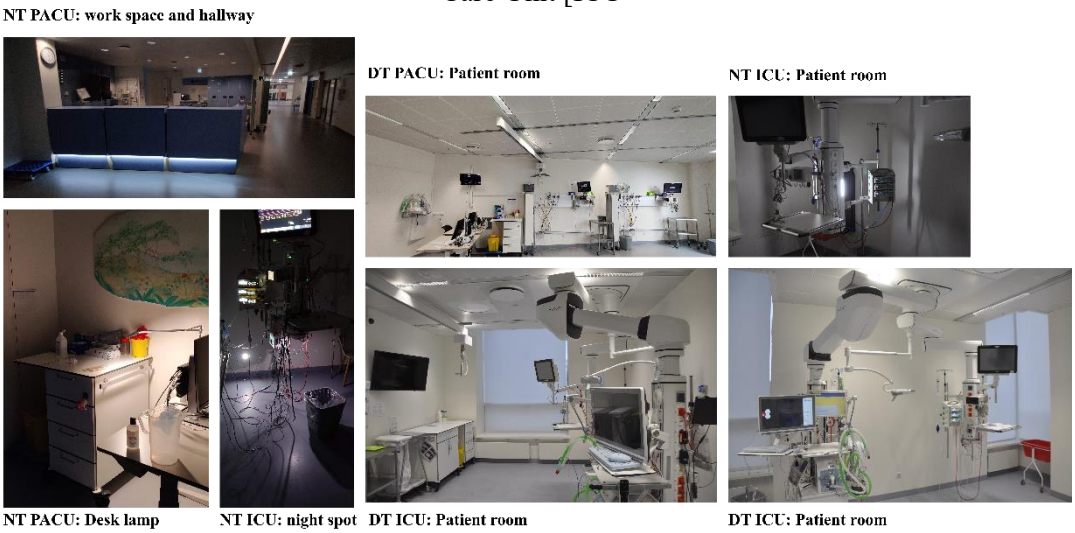
Health-care work environments have received growing attention in research during the past decades [1]. This can be explained by the significant effects of the physical indoor environment on patients and staff, when designed correctly e.g., the right light at the right time. It is already well documented how light not only enables us to adequately see in specific work environments, but also its importance for physical and psychological functioning [2–5]. In previous studies, work environments for hospital staff have been discussed in relation to carrying out nightshift work, as light has been shown to have an impact on health and well-being (e.g., quality of sleep) of staff, reduction in occurrence of errors and productivity increase [6–11]; additionally, shift work and work at night have gained increasing focus in lighting research due to the interest in preventing work-related, long-term diseases such as breast cancer and fatigue, which have been linked to nightshift schedules in recent papers [7,12–16]. There is thus a documented need to improve safety, performance and health in the workplace by reducing circadian misalignment [9,17–19], particularly for shift workers. As a response to the issue at hand, researchers have stressed the need for attention to the design of lighting for individuals that do shift work and sleep at atypical hours, towards achieving a positive effect on performance and circadian regulation. Past research has also highlighted individual differences in light sensitivity and preferences, suggesting implementing complementary individual lighting solutions at work [9,17]. The focus of past research has to a large extent been on non-image forming (NIF) effects of light; consequently, there are few studies applying a qualitative framework of methods to staff's perception of lighting. As previously argued [20], this might be explained by the complexity of applying such methods to real-life cases, and the difficulty of studying lighting conditions in real-life situations, where field research at hospitals can present the researcher with difficult access and ethical issues. The number of studies focusing on nurses' perception of lighting

in health care environments is however, growing steadily [21,22]. For instance, McCunn et al. [24] conducted a content analysis of open-ended responses, concluding that controllability of brightness levels was among the most valued attributes of lighting, together with better task lighting. In addition, Davis et al. [23] found that nurses working in a 'contemporary environment-of-care lighting system' (zone divided luminaires with separate control, night-time lighting, dimming) compared to a 'traditional environment-of-care lighting system' (simple switching controls and without dimming) perceived the lighting to be of higher quality, reported fewer complaints from patients and needed less additional light sources to perform tasks. Based on their analysis, suggestions were made for future implications for practice. Although some, albeit few, previous papers deal with these implications, there is a need to obtain a deeper understanding of the practical challenges that lighting systems have for work situations in hospital units. On this basis, the research question underlying this study was how do nurses working at a Neurointensive Care Unit and Postanesthesia Care Unit use a lighting system and adjust it to their and the patients' needs? The novelty of this paper lies in its identification of the advantages and barriers that the lighting system poses for the work of the nurses during different working hours. Moreover, the paper presents a qualitative field-study conducted at a newly build hospital. An identification and description of nurses' experience can guide and inform future implementation of integrative lighting systems at the neuro-ICU and PACU to ensure patients' sleep quality and recovery, improve visual comfort for the staff, enhance the degree of perceived usefulness of the lighting systems and facilitate technology acceptance. Perceived usefulness and technology acceptance is defined in the study according to the technology acceptance model [23]. Perceived usefulness relates to whether the lighting is beneficial for tasks and workflow, that it has a positive impact on job efficiency and that it supports the care of patient and their needs. Visual comfort is related to the judgement of brightness and colour temperature of a room, and are concepts related to appraisal and visual capabilities [24,25]. Thus, visual comfort often affects perceived usefulness, as it can affect the staff's capability to perform tasks with varying degrees of accuracy. Visual comfort is also connected to perception of adequate light or having enough options to adjust the lighting. In this paper, it refers to whether the nurses perceive the light to be adequate for their ability to perform a task; visual comfort relates primarily to illuminance but can also refer to light settings.

2. Setting and Lighting Installation

The study was conducted at a Neurointensive Care Unit (neuro-ICU) and a Postanesthesia Care Unit (PACU) located in a new facility under the Neuroscience Centre that is part of Copenhagen University Hospital, Rigshospitalet in the Capital Region of Denmark. The two units opened in September 2020 and are located on the second floor which are adjacent to each other with the capacity of 12 ICU-beds, 8 daytime and 4 night-time PACU-beds. The neuro-ICU treats patients with acute brain and nerve injuries caused by, for example, strokes, brain tumours and traumatic brain injuries. In the neuro-ICU, the patients have single-bed rooms and are monitored 24-hours a day, whereas at PACU, the rooms are designed to accommodate multiple patients with up to five beds, as the patient turnover is more frequent with a maximum of one night observation. After half a year in service, a renovation of the lighting was commissioned requesting an integrative lighting solution that supports the working environment and entrains the biological 24-hr sleep-wake cycle of patients and staff. This paper presents findings of the nurses' experience of the lighting prior to this renovation. The interior of the department comprises a dark, blue-grey linoleum floor and white-painted walls. The rooms have large window sections that allow daylight to illuminate the rooms during the day. When compared with a standard patient-room, the neuro-ICU is a highly technical environment containing three computer screens and four machines attached to the patient that constantly radiate light and sound. The nurses have a working station with a computer and screen at one end of the room, where they can document their work and the treatment of patients.

Illustration 1. Daytime [DT], Night-time [NT], Postanesthesia Care Unit [PACU], Neurointensive Care Unit [ICU



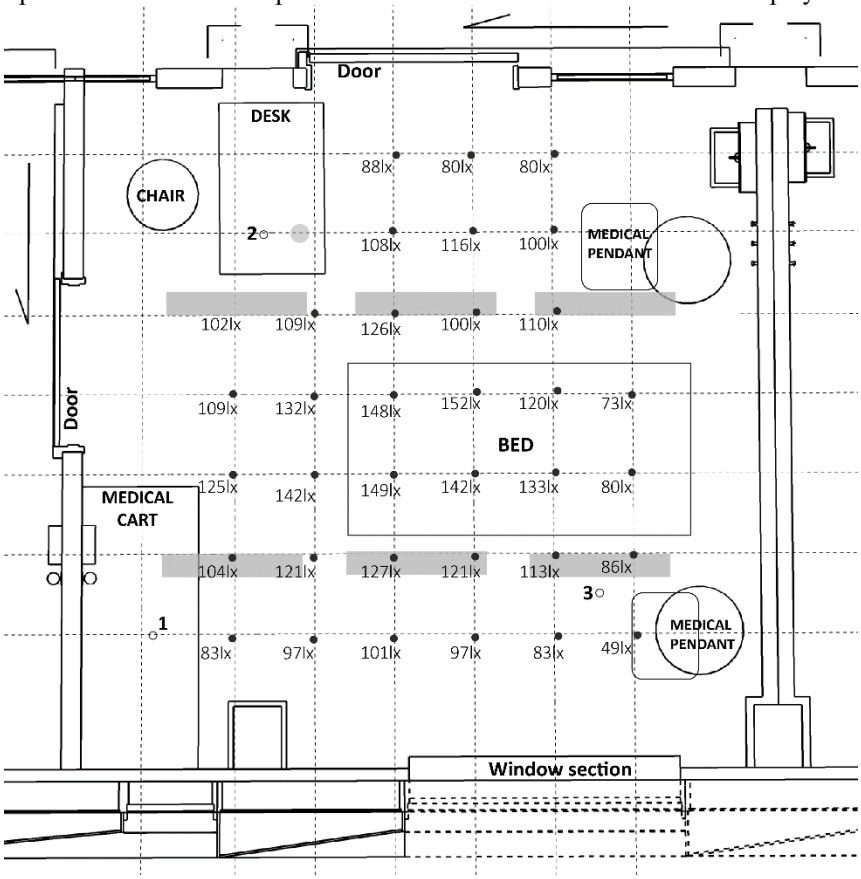
The lighting consists of six linear profiled luminaires by Zumtobel (Tecton C LED4000-840 L2000 WB, Dali controlled) fitted in the ceiling (K= 4000, CRI= min. 80) with five options for control, an adjustable table-lamp (model: Kelvin Edge by Flos, K=2700/3200, CRI=90) with three possible settings, and an examination lamp (Maquet Lucea, K=4500, CRI=95). Around the bed, there are in addition three light sources (uplight, horizontal downlight 1m from the floor and vertical illumination at the height of the bed's headboard) integrated in a critical-care pendant (Maquet Moduevo) developed by Maquet, Getinge. Additionally, the nurses have a pencil light (flashlight) of the brand Abena (K=3000, Ra=99.5). The hallway lighting consists of a continuous LED by Zumtobel (Tecton C LED2000-840 L1000 WB, Dali controlled) located on the left side of the ceiling. There are three open workspace areas in the department, which have spotlights (model: Pleiad G3 CMP) by Fagerhult fitted in the ceiling and, at the desk, Flos table lamps (Kelvin Edge). Zumtobel LED was also used for the medicine dispensary, cleaning and storage spaces. Below each patient bed, a small square-shaped luminaire was fitted in the wall, intended for orientation light at night (Berker B.7) that was intended for night-time use. The ceiling luminaires had four options for adjusting illuminance: 25% intensity, 50% intensity, a manual dimming option where the lighting increased in steps (see table 1 for ratio of min. and max intensity), a night function (luminaire behind bed) and an option to switch it off. At night and in the evening, the nurses often used 25%, the desk lamp, the flashlight, the luminaire behind the bed and/or the uplight on the critical-care pendant. The nurses also manually adjusted the illuminance themselves.

Figure 1 shows the distribution of illuminance (lx) of the ceiling mounted linear profile luminaires set to 25% intensity in a standard neuro-ICU patient room (5.8*5.12*2.80m), measured with a Konica Minolta CL-500A spectrometer. 37 measured points were taken at floor level with 9 cm from floor to the light sensor. The measurements were taken horizontally with approximately 0.6 m between measured points. No daylight was present, as the measurements were taken after dark. The glass windows between the room and hallway were covered by white, shade blinds. The window facing the streets were also covered by blinds. Lights from three screens, though on standby mode, and a narrow glass window in the door radiated additional light in the room. The average illuminance of the room were 109 lx and correlated colour temperature (CCT) of 3986 K with a uniformity of 0.4. Besides these, measurements were taken at three identified work-zones: 1) the medical cart 2) the desk and 3) by the bedside (table 1). Measurements at the bed were taken on the right side of the headboard, where the medical equipment and monitors are located, and the nurses often worked from this side of the bed. The respirator was located on the left side of the bed, as well as an extra working station with a computer screen.

Table 1. Photometric measurements of the ceiling luminaires and desk lamp.

Location	**1. Medical cart:** Horizontal measurements taken at 95cm from floor and 45cm to wall		**2. Desk:** Horizontal measurements taken at 76 cm from floor to desk		**3. Bed (right side of headboard):** Vertical Measurements taken at 173cm from floor. Looking toward patient with head tilted in a 25-degree angle.	
Setting	**Lx**	**CCT**	**Lx**	**CCT**	**Lx**	**CCT**
25% intensity	77	3992	118	3984	81	4018
50% intensity	163	4001	238	3995	136	4023
Min. intensity	3	4081	4	4047	2	4647
Max. intensity	324	4007	481	3997	370	4019
Only light from desk lamp	3*	2831	3*	2868	-	-
	*Desk lamp pointed towards medical cart giving ambient illuminance		*Desk lamp positioned behind computer screen. A setup that the nurses chose to create indirect light)			

Fig 1. Illuminance measurements of ceiling luminaires in a standard neuro-ICU patient room (2021/09/01 at 21:45-00:30). The grey boxes illustrate the position of six profile luminaires. The grey circle on the desk illustrates the position of the desk lamp. Numbers 1-3. refer to the measurements displayed in table 1.



3. Method

3.1. Participants

The participants in the study were healthcare staff working in the neuro-ICU or PACU at Copenhagen University Hospital. 12 nurses (1 male, 11 females) out of 20, were recruited by a researcher employed at the neuro-ICU. All 12 nurses did not have fixed working hours, but had rotating day, evening and nightshifts, except one nurse who worked only day and evening shifts. The participants were selected based on inclusion/exclusion criteria. The recruitment was based on qualitative quota sampling [26], where the recruiter divided the participants into two pre-defined groups: 25-39 years (n=10) and above 40 years old (n=10). For eligibility in the study, the participants had to be able to communicate about their work-routines and work environment in Danish or English, had worked at the institution for a minimum of two months at the point of inclusion, worked a minimum of 25 hours per week at the department, regularly worked either day, evening and nightshift, or a combination of these, and were willing to participate in more than one interview. The participants knew about the upcoming re-installation of lighting.

3.2 Ethics

All participants in this study are anonymized by ID numbers, meaning that all data are labelled with appurtenant ID numbers, time of data collection and date. We followed the SRQR standards for reporting qualitative research [27]. Prior to voluntary participation, all participants completed an informed consent form that included the right to withdraw at any time, the right to refuse to answer the questions and a guarantee of the participants' anonymity. We applied special ethical considerations for access, permission and data handling within the healthcare sector. As the data was collected during the covid-19 pandemic, safety measures were applied, and guidelines were upheld. All sensitive information about patients from the interviews and observations was anonymised; likewise, names and information of colleagues or external people e.g., family and friends. The work carried out by the staff was respected, with granted permissions to observe and allowance for interruptions for attention to patients or colleagues. In these instances, the interviews and audio recorder were paused. The researcher making observations attempted to be as unobtrusive as possible, by respecting when there were situations where observations were not appropriate. This study received ethical approval (ID2021- 020-00540) by an ethics committee at Aalborg University and the research protocol was described and approved by the head of the Neuroscience Centre at Copenhagen University Hospital.

3.3 Procedure

The study was conducted between 29th May and 1st July 2021. Semi-structured interviews focused on the staff's experience with the lighting and were conducted in a patient room, either empty or with the patient present, depending on the nurses' preferences. The method employed was similar to [20], a study in a nursing-home context. The questions in the interview started with an introduction where the interviewee was asked to introduce themselves, i.e., education, what shifts they typically work, their work experience, etc. Then the interviewee was asked in brief to explain a typical day, including tasks and routines. This question was raised for the interviewer to get acquainted with the context and flow of working at a neuro-intensive care unit. The next set of questions focused on the lighting, i.e.: "During a shift day/evening/night, what lighting sources and settings do you typically use?", followed by: "Why?", "What is your experience of the lighting?" and "Do you notice the lighting?". The interviewee was also encouraged to give examples of when they used the different fixtures or settings, e.g., what lighting sources they used for different tasks, how they affected the task at hand, the difference in their use of lighting at different times of day, whether they adjusted the illuminance level, etc. Questions about the experience of controlling the lighting were also raised, together with a discussion on the different light settings and the shading system. The interview often ended with questions about improvements, e.g., whether there was something they were missing, or whether they felt they had the lighting they needed to complete their tasks and the patient's needs.

3.4 Data analysis

The transcription process consisted of two phases; firstly, the audio-file from interviews were auto-transcribed using the software Sonix; and secondly, the text was read while listening to the audio simultaneously. The interview material was coded in positive and negative comments about the lighting system [28]. These comments were divided in categories, summarised and are presented in table 2.

4. Findings

The study found that an overarching theme was that the patients' needs act as a driver or motivation for the nurses' use and adjustment of the lighting. In particular, five themes were found identifying advantages and barriers to the existing lighting system (table 2). The identified barriers relate primarily to mornings, evenings and especially night-time, while the nurses could rely on natural daylight during the day.

The nurses' choice of light setting was related to the patient's well-being, to care and create a comfortable environment for them and their recovery. In parallel, the staff struggled with their own visual needs and execution of tasks, due to inadequate light settings or not having enough lighting. It was challenging for the staff to find a light setting that fitted both the patients' and their own needs; consequently, the staff prioritized the patients' well-being. This conundrum was present primarily in the early morning hours and night-time. The interviews showed that the nurses were deeply focused on creating the optimal environment for the patient's recovery, especially their sleep, regardless of whether the patient was unconscious (theme 4 and 5). For this reason, few light sources were employed despite the large variety in tasks that are performed during evenings and nightshifts; this was criticised by the staff (theme 2). A night-shift nurse explained it as:

"Even if we do have the curtains down, then it is rather bright in these patient rooms, with this light (referring to the light sources in the room). […] Or else, it is with the small flashlights we use, because it is important that it is dark… Also, I have a bit of light from the computer and such, but it is primarily the pupil light we use or else we have a small night lamp behind the bed that we can switch on and that gives enough light" [ID2, nightshift].

The nurses expressed that the use of the sparse light sources and dim light settings was primarily to shield the patients from bright light, in an attempt to prevent disturbances to the patients' sleep-wake cycles. The latter is especially important as it is common for patients admitted to an ICU to experience delirium [29]. Two of the nurses also pointed out that the reason they only used few of the luminaires was in lack of introduction to the lighting and the various options: *"One of the reasons why I don't use much of the lighting is due to the lack of introduction to the lighting, such as how do we switch it on, when is it appropriate to have it switched on, what is the purpose of the lighting, and how is it intended to be used?" (ID11, night shift).* Even though the rooms had multiple light sources and settings to choose from, the staff found it challenging to set the lighting to the desired level. The nurses expressed the need for something in-between their current settings (theme 4). This related to the option for setting the desired illuminance and CCT. A nurse explains the light settings and how she perceives them: *"you have options, but then after all not really, because the lighting outcome is not great. There isn't really anything in-between, either we have the lighting switched off entirely or we have it on. The difference between 25% and 50% is not that evident" (ID3, evening shift).*

In the Postanesthesia Care Unit, where multiple patients were present, this experience also related to having either the entire room lit up or having no light at all. The nurses expressed lacking an option to control the luminaires individually (dividing the room into zones) or having a lamp near the headboard to avoid having to disturb all the patients when checking up on one individual (theme 4). As a result, the medical flashlight was used if the task was not too complicated. The nurses critiqued this part of the lighting system, as it put them in a situation where they had to decide whether to turn on all the luminaires for the task and thus potentially disturb multiple patients. The medical flashlight was commonly used as a light source: Eleven out of twelve nurses interviewed mentioned that they primarily used a medical flashlight (also referred to as the 'pupil light' that is meant for checking pupil response), the light on the medical vertical pendants or the desk-lamp, when performing tasks after dusk, e.g., for

checking the amount of urine in the drainage bag, checking the patient's skin or checking the medical dispersion system that is connected to the patient by a tube. The desk lamp was appraised by the nurses due to its warmer colour temperatures, that they could rotate the luminaire and tilt the light source to a desired angle (theme 2).

Additionally, the nurses switched off the computer screens after use, and found rather creative methods to shield the patients from light, putting a pillow cover over the machines, adding coloured post-it notes on the night lamp behind the bed to dim it or angling the examination lamp over the patient's bed towards the floor away from the patient for some ambient light.

Besides adjusting the illuminance in the room with the electrical lighting, they used internal curtains. However, the internal curtains had not been a part of the building interior from the very start (automatic external solar blinds were the only shading option). The complaints about the curtains were not merely about creating a dark environment or blocking out heat but were also about creating privacy for the patients, as the rooms in this section of the hospital had partly glass walls and were located opposite to residential buildings or towards the hallway that had glass walls.

4.1. Light cycles

Another critique of the ceiling light was of it being static or, in other words, it's lack of being dynamic. ID12 referred to their previous department where the lighting in the morning automatically changed in illuminance and CCT – "like a sun rising" *(ID12, dayshift)* (theme 4). Likewise in the afternoon (4pm), the nurses stated they needed more soft lighting. Although they appreciated having a dimmer for controlling the illuminance, the dimming function provided were experienced as limited. ID3 explained that they preferred the previous lighting system (that they had in their previous department) more than the new one, because of having more options to grade the lighting and make it dimmer than with their current lighting system.

4.2. Visual performance

Another explanation for the sparse use of light was connected to the amount of experience with certain tasks: some tasks the nurses know 'like the backs of their own hands', and as such are not tasks that require much light. As a nurse working at the neuro-ICU expressed: *"You quickly get used to perform your routines in darkness or with dim light" [ID7, nightshift].* Besides creating an optimal environment for the patients, the use of dim or no light at night was also connected to the staff's own visual perception of the lighting; they found it comfortable to work in darkness as the bright and cold light gave them tired eyes and headaches (theme 2).

The nurses wanted to have an adequate amount of light at the area of the patient. For example, the examination lamp (providing high levels of illuminance) above the bed was described as being useful for technical tasks, such as attending wounds, applying stitches, checking the drain attached to the patient's skull or inserting a catheter, etc. ID1 explained that they have an adequate amount of lighting for these kinds of tasks.

However, five nurses were unsatisfied with lighting for tasks at the medical chart (theme 1). These tasks include finding medical kits, preparing liquid bags, drawing medicine into syringes, food formulars, etc. The PACU nurses used the desk lamps instead of the ceiling light, when for instance managing medical kits at the stationary cart located in one the corner of the room; however, it is not at every medical chart that they had a desk lamp at close range.

As a result, they worked in darkness or used the flashlight. ID3 explains her routine*: "Actually, in the rooms we use them [desk-lamps] to create a little more like ... to have more light I mean. When we have to go to the room to treat the patient, then we turn on the lights [the desk lamps] near the medical cart opposed to turning on the big light [ceiling luminaires]. That gives a tiny bit of light in there, and we turn it off again once we leave the room"[ID3, evening].* ID8 also confirms this and explain that often the only option is to turn on the ceiling luminaires because they must check that they have the correct medicine, which results in stressing the patients. The practice of using the desk lamp to illuminate the room was also addressed by neuro-ICU-nurses who sometimes raised the desk-lamp to

shine light towards the medical cart. The interviews also revealed that the nurses found the lighting intuitively, however, in some interviews the comments were both positive and negative. For example, ID3 explained that it intuitive to control the lighting, but at the same time found the light settings did not match her expected outcome.

4.3. Hallways and work environment

Compared to the neuro-ICU, where staff spend a major part of their shifts in one patient's room, PACU-nurses spend a large part of their shift in the open office environment, situated between the hallway and the patient rooms. The PACU nurses criticized the hallway lighting (theme 4), as they were unable to control the lighting in their part of the department. The hallway lighting was controlled for the entire department at the farther end of the neuro-ICU. The open office space lighting and hallway lighting was described as very bright and was pointed out as an issue because of the glass walls between the hallway and patient rooms, where the lighting due to its high illuminance created discomfort for the patients. Moreover, staff working late wished to turn off the lighting in the hallway and have the dimmest lighting in the open office space. As ID3, 8 and 10 argued, if they needed more light, they would employ the desk lamps.

Table 2. Perceived advantageous and barriers of the installed lighting system through accumulated codes from interview statements.

Themes		**Perceived Advantageous** (neuro-ICU and PACU)	**Perceived Barriers** (neuro-ICU and PACU)
1.	**Visual performance**	Having bright light to read is good (ID3).	Not having light for tasks at the medical cart (issue at night) (ID1, 5, 7, 8, 10)
		In the patient room it is bright enough for most tasks. The flashlight is suitable for tasks such as checking the pupil response or drain can be done with the flashlight (ID2, 9, 11)	
2.	**Light at night**	The desk lamp is useful as it is flexible and can be angled to how we find it suitable (ID2, 3, 4, 11, 12). "My good friend at night" and it is sufficient for most tasks at night as you can adjust the angle (ID11).	Difficult to make the room dark despite having curtains down. (ID2, 3, 5, 6, 7)
			At night, the lighting is too bright and too cold (ID3, 5, 7, 8, 11, 12). It makes you feel hungover (ID11) and causes headaches (ID8).
3.	**Perceived ease of use**	It is easy to use and intuitive (ID1, 2, 3).	Having lighting controls that do not match the description (ID3) and the controls are not logical (ID8). The controls are sensitive: you need to be careful when pressing a setting if you do not want a room that is very bright (ID11).
4.	**Light adjustment**	Being able to adjust the intensity of the light is appreciated (ID1, 2, 3, 11) including the hallway that has been dimmed (ID3). For example, when a new patient is admitted, they turn on the brightest light to make sure	Not having the option to set individual lighting for the patients in the Postanesthesia Care Unit (light zones) (ID3, 8) [exclusive to PACU]
			Lack of an option to dim the light or turn it off in the hallway and work environment around dusk and at night.

		nothing is critical with patient they must attend to, then they dim it.	Staff working nightshifts find it uncomfortable to work in and set it to the lowest value (ID3, 6, 7, 8, 10) [exclusive to PACU]
			Missing functions that are in-between. The lighting controls either provide too much light or too little. In the evening, staff lack the possibility to illuminate the room without having to turn on the ceiling luminaries (ID3, 5, 8, 12). The light sources on the medical pendants are considered too bright and shine directly on the patients (ID2, 12). The electrical light is the same all day around, it does not change during the day. You do not experience the sun slowly rising it is from pitch dark to fully lit (ID12).
5.	**Atmosphere**		The lighting does not support the creation of warm context for e.g., a family member visiting a patient, family members saying farewell to a loved ones (LED candles are used instead) (ID1) or a hospitalized kid who are scared (ID8).

5. Conclusion

The analysis of twelve interviews identified possible factors that may influence the nurses' experience of their work environment at a modern hospital department from 2020. The nurses' experience of lighting for a good work environment, for example a dark room, can be related to their ability to provide care for the patients, who are the centre of most of their tasks; and secondly, the possibility to carry out the tasks as intended (visibility). The interviews revealed that the nurses working on nightshifts are frequently placed in a quandary, where they must choose between adjusting the light for their own visibility to conduct the task or for the patient's well-being. Similar findings [30] revealed difficult visual task performance for the nurses at night, balancing both the task performance and the patient's well-being. Some nurses also revealed how they became used to working in darkness or dim lighting. The study found that the nurses regularly were obliged to either turn on bright ceiling luminaires or work without any additional light in the room. As a result, the flashlight is often employed for performing tasks. This inclination to use the flashlight or desk lamp as a substitute for the ceiling light has also been found in other studies [18], but it is also interesting that the nurses are missing light settings between either on or off. The nurses use dim illumination at night and try to create darkness in the rooms, however, they also point out the challenge of creating dark environments in the hospital due to devices, windows, shading and light pollution from streetlights. The interviews showed that the staff were discontented and frustrated with the current lighting installation, however, they also revealed that the nurses appraised the option to dim the lighting and having a luminaire that can be tilted and adjusted to a specific angle. The findings show the importance of including health-care staff in the early phases of planning and the strength of evaluating the installation to create sustainable work environments that support health and wellbeing of patients and healthcare workers where the lighting is adapted to their needs. Further studies are required to investigate if the findings in this study also apply to other types of hospital departments or to other types of lighting systems. Based on the findings, we have listed some recommendations for practice implementation:

- Introduce the staff to the lighting and teach them how to use the lighting, when it is appropriate to use, what the different light settings are intended for and how light can affect the 24hr sleep-wake cycle.
- Design lighting that is tailored to the different department's needs
- Zone divided lighting, e.g., for patient rooms with multiple beds, individualized lighting is important to minimize the disturbance of other patients and for staff who might have different preferences
- Having lighting for task-areas used for handling medical kits and medicine (e.g., medical cart)
- Having light settings with different CCTs to accommodate different tasks and needs (e.g., the need for creating calm atmospheres)
- Consider indirect light to minimize glare and for tasks at night that require minimal visibility
- Having curtains for windows and glass walls to block out streetlighting at night and to create a sense of privacy
- Having task lighting that is focused by the bed but also with some ambient and soft illuminance
- Position and distribution of light fixtures should be carefully considered. Carefully consider various rooms that is frequently occupied including medicine rooms and workstations
- Designing a dynamic lighting profile that automatically entrains the circadian rhythm of patients and staff. Including light setting(s) (long-wavelength light) designed specifically for nightshift workers, with minimum disturbance of circadian rhythm and a high CRI

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