A round-the-clock care, high acuity of patients, and improved technology have transformed intensive care units (ICUs) into increasingly complex and fast-paced environments where specialized care is provided on a 24-hour basis. Although the necessity of around-the-clock care is easily understood, the environment that is created and the resulting potential sleep disruptions are not always optimal for patients’ healing and successful outcomes. Multi-factorial issues, including noise, lighting, patient care activities, vital signs, phlebotomy, and medication administration have often been identified as potential causes of sleep disruptions in the ICU.

In a study on nocturnal interruptions of patient care in critical care units, a mean of 42.6 patient care interactions occurred each night, only 9 uninterrupted 2- to 3-hour periods of sleep were documented in 147 nights, and 62% of patients’ baths were performed between the hours of 9 PM and 6 AM.

Thirty-seven percent of sleep disturbances have been attributed to noise disruptions and patient care interactions. However, when patients’ perception of sleep quality in the ICU was examined, noise was not identified as the primary cause of sleep disruption. Research participants indicated that monitoring of vital signs and phlebotomy were the most disruptive to their sleep while in the ICU. Lighting was perceived as significantly less disruptive than most other factors measured.

In a study that used 24-hour polysomnography, which allows analysis of sleep/wake cycles in the ICU, researchers reported that noise was responsible for only 11.5% of sleep arousals and 17% of sleep awakenings. Moreover, the researchers found that ICU patients lost normal sleep cycles with a circadian rhythm, as evidenced by increased amounts of daytime sleeping. Total sleep time was redistributed over a total 24-hour period with the majority of sleep, 57%, occurring during the day and 43% of sleep occurring at night. A large amount of variance is clearly unaccounted for with respect to sleep disruption in the ICU.

**PRIME POINTS**

- Collection of blood samples for laboratory tests is associated with the greatest amount of nighttime exposure to light in ICUs.
- Peak light exposure occurred during those hours at the beginning and end of the nurses’ shift.
- Increasing the use of nighttime lighting may help minimize use of other more disruptive light sources.
The human body functions on a roughly 24-hour programmed internal clock referred to as the circadian rhythm. In humans, the primary stimulus responsible for synchronization of the circadian rhythm is the light-dark cycle.\(^7\) The suprachiasmatic nucleus in the hypothalamus is the site of the circadian pacemaker in humans. This area of the brain receives sensory input from specialized cells in the retina. Upon stimulation, the suprachiasmatic nucleus stimulates release or inhibition of melatonin, serotonin, cortisol, and other hormones that regulate various body functions. Melatonin is secreted in response to darkness, and has influence in inducing sleep as well as progression through the stages of sleep. Inhibition of melatonin production in response to bright light leads to increased alertness and wakefulness.\(^7\)

Napping is considered a causative factor in phase-shifting circadian rhythms. Napping may result in earlier awakening and, therefore, earlier exposure to light. When sleep length is shortened, creating a longer period of light exposure, the normal response of inhibition of melatonin production is diminished. The inhibition of melatonin production ultimately results in increased wakefulness.\(^9\) This pattern could help to explain why sleep is redistributed over the total 24-hour day in many ICU patients, with the majority of sleep occurring during the daylight hours.\(^3\)

The circadian rhythm has been linked to changes in blood pressure,\(^10\) cardiac output,\(^3\) respiratory system,\(^12\) hormone secretion,\(^11\) gastric secretion,\(^14\) and temperature.\(^13\) In addition, circadian rhythm has been implicated in effects on mood, mental status, and alertness.\(^16\) Circadian variations related to sleep loss can influence the healing process.\(^17\) Additionally, the timing of medication administration in many cases is linked to anticipated fluctuations in circadian rhythm.\(^18\) These physiological implications make maintenance of regular circadian rhythm vital to optimal health.

Circadian rhythm research has extensively documented the effects of light on phase shifting, or manipulations, of the circadian rhythm in healthy persons. Little research has been done on the circadian rhythms of the acutely ill. It is possible that this lack of research is a result of patients’ generally short stays in modern hospitals. However, the sickest and most vulnerable patients often have longer stays. With their increasing lengths of stay, the potential for circadian phase shifting in these patients is very high.

Light is an important environmental factor in the regulation of the normal circadian rhythm. Current nursing research has given the topic of lighting minimal study. Lighting in patients’ rooms is easily controlled by the bedside nurse simply flipping a switch. The potential effect that light has on patients’ health and positive outcomes could make this simple act one of great importance. The topic of light in the ICU, a topic that has great influence on a most basic human need of rest and sleep, clearly needs investigation. The specific research questions were (1) What is the total amount of time that patients in a Midwestern surgical intensive care unit (SICU) are exposed to artificial light between the hours of 10 PM and 6 AM? (2) What are the sources of this light? (3) What activities are, or are not, occurring in the hospital room while the lights are on?

**Methods**

This descriptive study was conducted in a 12-bed SICU of a Midwestern regional medical center. The mean daily census in this SICU is 7.4 patients, and the mean length of stay is 15.5 days.

**Sample**

The accessible population was 12 private hospital rooms in the SICU. Three rooms in the SICU were randomly selected when the researcher arrived each night. Study inclusion criteria included any light that was permanently fixed in the hospital room before admission and remained in the room throughout the hospital stay. Lighting in the room was labeled as follows: television, head-of-bed light, sink light, overhead light, and the wall safety-security night-light. Lights in the following situations were excluded: equipment light, light sources that may have been

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carried in by staff (eg, penlights or flashlight), ambient hallway lights, or lighting that came in through exterior windows from the street. As identified by verbal report from the SICU charge nurse, rooms of “overflow” patients, actively dying patients, and minors were not used. An overflow patient is one who would otherwise be on a unit offering less-intensive care but is in the ICU because of staffing or census constraints. Also excluded were rooms of patients who were not expected to survive the next 24 hours (those who received end-of-life comfort care). Do-not-resuscitate status was not an exclusionary criterion, as patients in those rooms may have been very healthy with a positive prognosis. In the unlikely event that a minor, younger than 18 years of age, was admitted to the SICU, that room also was excluded from observation.

Three SICU hospital rooms were studied per night. A total of 7 nights, 1 night for each day of the week, were studied. The total sample size was 21. Data were collected through nonparticipant, direct, focused observation by the first author.

Variables

Time. Time was measured to the nearest whole minute with a Seiko brand R-wave clock (model QHR008SLH).

Light. The light was identified as coming from 5 possible sources: (1) television, (2) head-of-bed light, (3) sink light, (4) overhead light, and (5) wall safety-security night-light. Patients had no control over the following light sources: sink light, overhead light, and the wall safety-security night-light. Lighting that a patient potentially had control over included the head-of-bed light, which the patient can control if he or she can reach the nurse call button, and the television, which the patient can control with a hand-held remote control.

Activity. Activity that occurred while the various light sources were on was noted on the audit sheet by using a preestablished numeric coding system. Possible examples of common activities included assessment, medication administration, bathing, vital signs, toileting, radiologic imaging (eg, radiographs), or laboratory tests. If no activity occurred while the lights were on, that also was noted.

Instrument

Data were collected on a paper-pencil type audit sheet designed by one of the researchers, the Light Activity Time Evaluation, or LATE sheet. One LATE sheet was used for each room observed. Time was monitored in 5-minute increments, with 12 increment intervals per hour. Space on the LATE sheet was allocated for the activity code for each time increment and light source. Time began at 10 PM and ended at 6 AM.

Interrater reliability of the audit sheet was established by joint probability of agreement before actual data collection. Calculations of the joint probability of agreement resulted in a correlation of 0.79. The primary researcher monitored and measured the 3 variables with the LATE sheet. Another researcher monitored and measured the same 3 variables for the same 3 rooms. Interrater reliability coefficients were calculated, and no changes to the LATE audit sheet were necessary before data collection.

Procedure

After approval was obtained from the institutional review board at the university and hospital, members of the SICU night staff were informed of the intent to observe the environment between the hours of 10 PM and 6 AM. This information was conveyed through attendance at a staff meeting. A brief introduction to the project was provided. Staff members were informed that the researcher would not be collecting data about them or their patients, that there would be no disruption to their usual routine, and that interaction with the researcher was not necessary and was discouraged.

Focus needs to be placed on how the multidisciplinary health care team can limit nighttime light exposure and interruptions of rest and sleep.
Charge nurses were informed of the inclusion and exclusion criteria so that they could inform the researcher when she arrived in the SICU if patients in any of the rooms met any of the exclusion criteria. The bedside nursing staff was not told that the researcher was studying light to avoid observation biases related to the Hawthorne effect. The Hawthorne effect in this study suggests that if staff nurses know that their behaviors are being monitored, they may in some way modify their behavior and thus influence study outcomes.¹⁸

The night of the week was randomly chosen 1 night at a time. The 7 nights of the week were marked individually on pieces of paper, placed together in a container, and selected 1 at a time by the researcher. Once a night had been chosen, it was discarded so that each night of the week was used only once.

The researcher arrived on the first night of data collection with an assistant researcher shortly before 10 PM. The first night of data collection was only for the purposes of assessing intrarater reliability of the data collection instrument and was not included in final data analysis. Each researcher completed her own individual LATE sheet for the same room. A percentage of agreement was calculated. After reliability was established, full data collection commenced.

The researcher arrived at the SICU on the predetermined night at 9:45 PM. In the 15 minutes before data collection, the researcher received information from the charge nurse regarding any excluded patient rooms and randomly selected 3 rooms to be studied that night from the remaining sample. Rooms were randomly chosen by placing the room numbers on slips of paper, placing them into a jar, and individually pulling out 1 slip at a time until a total sample of 3 had been selected. No one other than the researcher knew what 3 rooms were being observed.

The researcher positioned herself in the middle of the nurse’s station to afford the best view of the patients’ rooms. As the layout of this SICU is roughly horseshoe shaped, single positioning in the middle of the nurse’s station made it less obvious which rooms were being monitored, and therefore less likely that bedside nurses would feel watched over and potentially alter their behavior. Single positioning also allowed a limited view inside the hospital room, helping to ensure privacy.

At 10 PM, any lights that were on in the hospital room were marked on the data collection tool with the corresponding activity occurring at that time. The time that the lights were turned on was marked in green ink; the time that the lights were turned off was marked in red. The day of the week was also noted on the instrument. No room numbers, patient, or nurse identifiers were marked on the LATE tool. The researcher monitored until 6 AM. Time, to the nearest whole minute, was written in the appropriate 5-minute slot on the LATE sheet for the corresponding light source. The activity code was noted in the appropriate time increment. At 6 AM, the researcher marked which lights were on in green ink, what activity was occurring, thanked the staff, and left for the day.

On the second data collection night, a new night was randomly chosen from the jar and discarded. New data collection sheets were prepared and marked with the appropriate day of the week. The researcher again arrived at the SICU at 9:45 PM on the night of the next data collection. The procedure was repeated until all 7 nights of the week had been observed.

Data Analysis

Raw data were entered into the SPSS system, version 14.0, and univariate descriptive statistics were run for data entry errors before analysis. Descriptive statistics were calculated: mean, median, mode, range, standard deviation, and frequency.

Time was measured to the nearest whole minute. The total length of exposure for each source of light per hour was calculated. A cumulative hourly total for all 5 light sources was calculated; an 8-hour total of all combined light exposure was calculated.

Results

Time

Light was evaluated by the hour, revealing that the 10 PM hour had the lengthiest cumulative light exposure, at 63.3 (SD = 50.1) minutes. The 1 AM hour had the shortest light exposure, with a mean cumulative light exposure of 27.3 (SD = 34.5) minutes (see Figure).

Light Source

The light was identified as coming from 5 different possible sources: television, head-of-bed light, sink light, overhead light, and the wall safety-security night-light. The light source with the longest total duration of light exposure was the sink light, with a mean of 132.4 (SD = 105.0)
minutes. The second longest total duration of light exposure was the head-of-bed light, with a mean of 83.9 (SD = 144.8) minutes. The wall safety-security night-light had the shortest total duration of light exposure at 28.5 (SD = 106.6) minutes. Mean cumulative light exposure was 354.3 (SD = 251.6) minutes (Table 1).

Activity
Activity that was occurring, or not occurring, while the various light sources were illuminated was recorded. Fourteen possible different activities were monitored and recorded. These included physical assessments, bathing, medication administration, vital signs, toileting, obtaining samples for laboratory tests, respiratory treatments, physician visits, family visits, staff presence/direct observation, call light response, radiology, other, and none. The activity that was associated with the greatest amount of light exposure was obtaining samples for laboratory tests. The second activity most often recorded while the room light was on was “none” (Table 2).

Discussion
The purpose of this study was to describe how long light sources illuminated an occupied SICU room between 10 PM and 6 AM. Findings suggested that the peak light exposure occurred during those hours at the beginning and the end of the nurses’ shift. This finding suggests that nurses attempt to allow patients as much rest as possible throughout the bulk of nighttime hours. The nurses were often observed attempting to “group” patient care activities together. This observation indicates that many bedside nurses do attempt to limit nighttime interruptions as much as possible.

It was noted on one occasion that a different nurse assumed care responsibility for a patient in a studied room halfway through the shift. After the new nurse assumed responsibility for patient care, light use decreased dramatically the rest of the night. This observation introduces the idea that light use among nurses may be very individualized. Identification of nurses who are more likely to fail to reduce nighttime lighting, and the demographic characteristics of those nurses, is an important future study objective.

Previous research related to interruptions in patients’ nocturnal care in critical care units indicated that 62% of patients’ baths were performed between the hours of 9 PM and 6 AM.1 Monitoring of vital signs and phlebotomy were also found to be the most disruptive to sleep.2 In our study, the “disruptive” activity that occurred most frequently during light exposure was collection of blood samples for laboratory tests (phlebotomy). Clearly, this finding shows that ancillary departments can have a critical influence on the quality of patient care and overall outcomes. Focus needs to be placed on how the multidisciplinary health

---

Table 1

<table>
<thead>
<tr>
<th>Light source</th>
<th>Time</th>
<th>Television</th>
<th>Head of bed</th>
<th>Sink</th>
<th>Overhead</th>
<th>Night-light</th>
<th>Cumulative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td></td>
<td>45.1</td>
<td>83.9</td>
<td>132.4</td>
<td>64.3</td>
<td>28.5</td>
<td>354.3</td>
</tr>
<tr>
<td>Standard deviation</td>
<td></td>
<td>114.6</td>
<td>144.8</td>
<td>105.0</td>
<td>158.3</td>
<td>106.6</td>
<td>251.6</td>
</tr>
<tr>
<td>Median</td>
<td></td>
<td>0</td>
<td>10</td>
<td>110</td>
<td>0</td>
<td>0</td>
<td>309</td>
</tr>
<tr>
<td>Mode</td>
<td></td>
<td>0</td>
<td>0</td>
<td>59</td>
<td>0</td>
<td>0</td>
<td>359</td>
</tr>
</tbody>
</table>
Health care team can limit nighttime light exposure and interruptions to rest and sleep.

The category “no activity” was next most important—the lights were on but no care was being delivered. This finding was perhaps the most disturbing, suggesting a lack of simple vigilance on the part of the providers. The results of this study also have implications for nursing administration and how critical care units are staffed. Patients generally do not need to be bathed on the night shift. Shifting the focus on basic patient care from the night shift to other shifts could improve patients’ sleep and rest.

It was surprising to find that the single light source identified during this study for the sole purpose of nighttime use (the night-light) was the least used light source. This finding represents an educational opportunity for bedside nursing staff to increase the use of nighttime safety lighting. Increasing the use of lighting designed for nighttime use may help to minimize use of other, more disruptive, light sources.

Several limitations of this study should be noted. A simple inexpensive light meter could have been used to quantify the actual amount of light falling on the patient. In addition, whether the patient was awake, sleeping, or sedated during data collection and whether the actual presence of lighting had any measurable effect on the patient was not studied. The small sample size accounted for the large variability in the data. The obvious presence of the researcher on the nursing unit during direct observations was an additional limitation. If staff perceived that they were being observed, it is possible that they altered their usual behavior, invalidating the research findings. In addition, while the age of the nursing staff was unknown, another study limitation may be the aging of nursing staff in need of light to facilitate their nursing functions.

Potential implications for further study include using polysomnography and luxometers to identify actual interruption of critically ill patients’ sleep due to lighting levels, and interventional studies designed to reduce patients’ exposure to artificial lighting by altering bedside habits and behavior. In addition, the measurement of light in lux and the relationship with potential phase shifting of the circadian rhythm would be interesting. The results of this study could also be used to improve staffing and shift the focus

### Table 2  Frequency of activities per hour during entire study

<table>
<thead>
<tr>
<th>Activities</th>
<th>10 PM</th>
<th>11 PM</th>
<th>Midnight</th>
<th>1 AM</th>
<th>2 AM</th>
<th>3 AM</th>
<th>4 AM</th>
<th>5 AM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment</td>
<td>2</td>
<td>2</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Bath</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Medication administration</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Vital signs measurement</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Collecting blood for laboratory tests</td>
<td>1</td>
<td>4</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Respiratory therapy</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Call light</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Physician visit</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Family visit</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Staff present a</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>X-ray</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>None (no activity)</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>6</td>
</tr>
</tbody>
</table>

*Individuals such as the unit secretary or a certified nursing assistant, who “sit” in the room to ensure patient safety.*
Conclusion

Nighttime lighting and a good night’s sleep are critical to overall health, and healing cannot occur without it. As the popular media become increasingly savvy regarding sleep deprivation and its consequences, patients and their families will demand healing environments. Future research will assist health care providers to shed light on the importance of lighting as a critical environmental factor in regulation of the normal circadian rhythm and ultimately the development of restful surroundings.

References

Nighttime Lighting in Intensive Care Units
Heather Dunn, Mary Ann Anderson and Pamela D. Hill

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