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Characteristics of the Nighttime Hospital Bedside Care Environment (Sound, Light, and Temperature) for Children with Cancer

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Abstract

Background—Children with cancer must cope not only with their disease and its treatment but also the environment in which treatment is given. The intensities of sound and light levels required to perform necessary patient care may result in a disruptive nighttime care environment.

Objective—The purpose of this study was to describe nighttime patterns of environmental factors, sound light, and temperature levels, at the bedside of children with cancer receiving inpatient chemotherapy.

Methods—Participants were 15 school-age children receiving chemotherapy on an inpatient pediatric oncology unit. Sound, light, and temperature in the child's room were measured continuously using a digital sound pressure level meter and an external channel data logger.

Results—Mean nighttime sound levels were 49.5 dB (SD=3.1; range 34.6–84.8 dB). Sound and light intensity were greatest early in the shift and decreased through the night. A basic mixed linear model identified significant main effects of time of night for both sound ($F=50.42$, $p<.01$) and light ($F=12.43$, $p<.01$).

Conclusions—Study findings identified a bedside care environment with persistently elevated sound levels and abrupt increases in sound intensity throughout the night. Such a disruptive nighttime environment is not conducive to restful nighttime sleep and may serve as an additional source of physiologic and psychologic stress for hospitalized children with cancer.

Implications for Practice—Efforts are needed to identify modifiable sources of nighttime sound and develop interventions to reduce nighttime sound. Collaborative efforts to organize clinical care to minimize nighttime disruptions may lead to reduced bedside sound levels.

Introduction

Children with cancer must cope not only with their disease and its treatment, but also the environment in which treatment is given. Children with cancer often have greater acuity levels than other pediatric medical-surgical patients, in part because of the intensity of nursing care activities, including number of medication doses, and the symptoms that the child is actively experiencing. These increased patient care needs often lead to increased interactions with members of the health care team, which can persist into the nighttime hours. As a result, the intensities of sound and light levels required to perform necessary patient care may result in a nighttime bedside care environment that may disrupt sleep and

may not be conducive for hospitalized children with cancer to obtain adequate levels of nighttime sleep.

Studies investigating nighttime sound and light intensity in pediatric and adult critical care settings have identified levels in excess of World Health Organization (WHO) standards for health care settings.¹⁻⁷ These studies also have identified increased sound and light levels, as well as interactions with health care providers, as significant predictors of fewer nighttime sleep minutes and greater fragmentation of sleep.^{1,4,8} To date, no studies have investigated sound and light levels in either pediatric or adult inpatient oncology units. Further, changes in these environmental characteristics across the course of a night shift have not been investigated in previous pediatric or adult studies. Moreover, this is the first study to examine direct measures of sound, light, and temperature at the bedside of children hospitalized in an inpatient pediatric oncology setting.

Purpose

The purpose of this study was to describe nighttime patterns of environmental factors (sound, light, and temperature levels) at the bedside of school-age children with cancer who were receiving chemotherapy in the inpatient setting. Research questions guiding this study were:

- What are the levels of sound, light, and temperature at the bedside of children hospitalized in an inpatient pediatric oncology setting during three consecutive 12-hour night shifts (7:00 pm to 7:00 am)?
- What are the patterns of sound, light, and temperature during a 12-hour night shift (7:00 pm to 7:00 am) over three consecutive nights for children hospitalized in an inpatient pediatric oncology setting?

Review of the Literature

Characteristics of the Inpatient Hospital Bedside Environment

Maintaining a nighttime care environment that is conducive to sleep is of particular importance for the child with cancer. Children with cancer must recover not only from the effects of their illness and its treatment but also must sustain normal growth and development. A disruptive nighttime care environment can compromise both sleep quantity and quality in acutely ill children.^{1,4,8} Compromised sleep, in turn, can lead to impaired immune function and neuroendocrine regulation of hormones which can affect growth and healing.⁹⁻¹¹ Altered sleep also is associated with other cancer-related symptoms, including fatigue, which can impact their quality of life.¹² As such, attention to the nighttime care environment is warranted. Identifying characteristics of the care environment can guide the development of interventions to promote a restful environment that can promote children's recovery and, ultimately, quality of life.

Sound intensity

Elevated sound levels are recognized by WHO as significant sources of environmental pollution with adverse outcomes on health and well being.¹³ Sustained indoor levels above 45 decibels (dB) interfere with normal activity and with communication. Individual events generating sound levels of 45 dB or greater are associated with disrupted sleep. Possible alterations in stress hormone secretion and immune function are associated with sustained exposure to sound levels of 65 to 70 dB.¹³

The WHO has established recommended sound levels for health care settings. The recommended average sound level for hospital rooms in which patients are being actively

treated is 35 decibels (dB) or less. The recommended maximum intensity for individual events at the patient's bedside is 45 dB.¹³

To date, studies investigating sound intensity in pediatric health care settings have been limited to critical care settings. In pediatric intensive care units (PICU), mean nighttime sound levels at the child's bedside were consistently reported as greater than 50 dB, with spikes to 120 dB.¹⁻⁴ For adults, similar findings have been identified in both critical care and medical surgical units, with mean sound levels ranging from 42 to 56 dB with spikes in excess of 80 dB.⁵⁻⁷

In both pediatric and adult critical care settings, greater nighttime sound levels are associated with reduced total sleep minutes and greater fragmentation of nighttime sleep.^{1-4,8} Children and adolescents with cancer have described noises and frequent disruptions in the hospital care environment as contributing to disrupted sleep as well as to fatigue.¹² In a recent study of 25 school-age children and adolescents receiving inpatient chemotherapy, counts of room entries and exits ranged from 3 to 22 with an average of 11.3 during an 8-hour night shift.¹⁴ Although this study measured counts of staff and family-reported room entries and exits, it did not measure sound and light levels associated with these entries and exits.

Light

Elevated light levels create an environment that is not conducive to nighttime sleep. The Illuminating Engineer Society recommends daytime light levels of 10–30 lumens/ft² for hospital rooms.¹⁵ The upper limit of this range, 30 lumens/ft², represents the recommended light level for reading printed material. Complete darkness is measured as zero lumens/ft².

Although light levels have been investigated less frequently in the nighttime health care environment, PICU studies identified average nighttime light levels at the child's bedside of 23.4 lumens/ft² with mean levels ranging from 45.3 lumens/ft² early in the evening to 17.1 lumens/ft² after midnight.⁴ Light levels ranged from relatively low levels at 5 lumens/ft² to a high of 140 lumens/ft², a value exceeding recommended levels for close work in laboratories. Increased bedside light levels were associated with decreased and fragmented nighttime sleep in the PICU.^{4,8} However, nighttime light levels at the bedside in patient rooms have not been investigated except for the ICU which is a different environment.

Temperature

Excessive temperatures have the potential to disrupt sleep continuity, and, therefore, may contribute to an adverse care environment. The upper threshold of recommended room temperature for healthy sleep is 75 degrees Fahrenheit (°F).¹⁶ Previous studies have not investigated temperature variation within the patient's room as a component of the nighttime care environment.

Study Methods

Design

An exploratory, descriptive multiple-case study design was used to describe characteristics of the nighttime hospital bedside care environment (sound, light, and temperature) for children with cancer and to describe patterns of sound, light, and temperature across the interval of a 12-hour night shift over three consecutive nights. This design emphasizes the context in which the phenomenon is occurring and does not require investigator control of behavioral or contextual events.¹⁷ Because environmental factors in the hospital setting which may contribute to disturbed sleep children with cancer are not well established, the

case study design, with its emphasis on the individual, was well-suited to this study due to its relatively small sample size. Reported findings were part of a larger study exploring environmental and biobehavioral influences on nighttime sleep of school-age children receiving inpatient chemotherapy.

Measurement of Environmental Variables

Sound—Sound was measured using an Extech Instruments model number 407736 digital sound pressure level meter.¹⁸ Sound measurements were obtained at 30-second intervals throughout each 12-hour night shift for three consecutive nights and stored in the internal memory of a HOBO U12-012 data logger. The sound pressure level meter measures sound pressure level ranges of 35 to 100 decibels (dB) with 0.1 dB resolution and an accuracy of ± 1.5 dB. This device is a Type 2 sound level meter, designed for measurement of environmental noise in residential, industrial, and commercial settings. The dimensions of the sound pressure level meter are $9.54 \times 2.68 \times 1$ inches.

Light and Temperature—Light and temperature levels in the child's hospital room were measured continuously using the HOBO U12-012 Temp/RH/Light/External Channel Data Logger.¹⁹ Light and temperature measurements were recorded at 30-second intervals throughout each 12-hour night shift and stored in the data logger's internal memory.

The data logger's light sensor measures light intensity with a range of 1 to 3,000 lumens/ft², and the temperature sensor measures from 0 to 50 degrees centigrade (°C) with a resolution of 0.03°C and accuracy of ± 0.35 °C. The data logger features 12-bit resolution measurements to support detection of greater variability in recorded data and is capable of storing up to 43,000 individual measurements.²¹ The data logger's dimensions are $2.3 \times 2.9 \times 0.85$ inches.

Procedures

Study Setting—The study setting was a 24-bed inpatient pediatric oncology unit in a tertiary-level children's hospital located in the Intermountain West of the United States. The unit serves children with immune-compromised conditions, including cancer, hematologic disorders, and hematopoietic stem cell and solid organ transplant. Each room is private with a private bathroom.

Institutional review board approval was granted for this study. Participant eligibility was reviewed with hospital staff prior to the child's scheduled admission for inpatient chemotherapy. Families who had expressed an interest in the study were contacted by the investigator at the time of the child's admission, and the study procedures were explained. Parental consent was obtained for all participants, and child assent was obtained from children seven years of age and older.

Study Sample—Participants were 15 children (10 boys and 5 girls) with cancer ranging from 5.4 to 12.3 years of age (mean = 8.8; SD = 2.3; median = 8.3) who were receiving inpatient chemotherapy. Fourteen children were white/non-Hispanic and one was African-American. Ten participants were receiving treatment for leukemia or lymphoma, and the remaining five were receiving treatment for solid tumors. Although this sample was heterogeneous with regard to cancer diagnosis, the nursing care procedures for children receiving chemotherapy in the inpatient setting were similar across diagnoses. As such, the patterns of nighttime environmental characteristics and clinical care activities were likely to be similar.

Eligibility criteria included children between 5 and 12 years of age receiving inpatient chemotherapy for three or more days as treatment for a primary diagnosis of cancer or for recurrent disease. Exclusion criteria included surgery during the admission or active treatment for a secondary health condition requiring additional nursing care interventions.

Because of the exploratory nature of this study and the relatively small sample size, variables were examined with the individual serving as the unit of analysis. Analyses emphasized individual variation through within-subjects analyses, which are more sensitive in detecting individual differences.²⁰ An a priori power analysis supported the proposed sample size of 15 to yield at least 80% power using a fixed-effects model analysis of variance with alpha set at 0.05.

Data Collection Procedures

Data were collected continuously for 12-hour intervals (7:00 pm to 7:00 am) over a three night period beginning with the first night of the child's hospitalization during a scheduled admission for chemotherapy. This time period was selected based on the oncology unit data and represents the average length of stay for children receiving inpatient chemotherapy.

The investigator was responsible for calibration and maintenance of study equipment. At the onset of data collection, data loggers were initialized using HOBOWare Pro Version 2.4.2 software.²¹ The sound pressure level meter and data logger were placed on the bedside supply cart in each child's room. The bedside supply cart was maintained in a consistent location in each child's room and was approximately 48 inches from the child's bedside. This location also did not interfere with participants' daily activities or nursing care activities. The two devices were attached to a frame made of polyvinyl chloride pipe to ensure that they remained in place during the data collection period. The combined dimensions of the devices and frame was $10.5 \times 4.75 \times 3.5$ inches. Parents, child participants, and staff nurses did not have additional responsibilities related to the data collection procedures.

Data Analysis

Stored environmental data were downloaded from the data logger into a laptop computer for analysis using HOBOWare Pro software. Numeric data were downloaded directly into Excel and then transferred into SPSS Version 16.0 for the Macintosh for data analysis.²²

Characteristics of sound, light, and temperature environmental variables at the children's bedside during each 2-hour time interval were calculated using descriptive statistics (mean, standard deviation, and ranges). Basic linear mixed models were undertaken for each of the environmental variables to identify patterns based on night and time interval, as well as to test for a night by time interval effect. The linear mixed model has an advantage over the general linear model in that it does not assume independence of observations and, therefore, is able to manage data when serial dependency may be present.²³ Each variable was measured over six 2-hour intervals over three nights with 45 observations for each 2-hour interval, for a total of 270 observations per night, with 18 observations per participant for each of the three environmental variables over three consecutive nights.

Results

Description of Environmental Variables

Because measurements were obtained at 30-second intervals, each 12-hour night shift included 1440 individual measurements for sound, light, and temperature environmental variables. Means of each variable were calculated for each 2-hour time interval (e.g., 7:00 –

8:59 pm, 9:00 – 10:59 pm) within each 12-hour night shift. A descriptive summary of sound, light, and temperature within each 2-hour time interval for each of the three study nights is presented in Table 1.

Sound—Sound levels within the child's hospital room were consistently greater than WHO's recommended 35 decibels (dB) or less for a healthy sleep environment.¹³ Although sound levels did decrease during each night, the mean lowest levels were 46.4 dB – a measurement that was more than 10 dB above the recommended level. Because measurement in dB represents logarithmic units, an increase in 10 dB translates to a ten times increase in sound intensity level. To the human ear, a gain of 10 dB is perceived as being twice as loud, meaning that 45 dB would be perceived as twice as loud as 35 dB. In comparison, mean sound levels in this study were approximately 5 dB less than that reported in a pediatric critical care setting. The range, however, was similar with values as low as 40 dB with abrupt increases in excess of 80 dB.^{1–4} All children experienced spikes in nighttime sound levels comparable to those generated by moderate traffic or loud conversation. Average nighttime sound levels at the bedside for this sample of children were similar to those generated by moderate conversation or rainfall.

Light—Overall light intensity was low with a maximum recorded value of 20.1 lumens/ft². Light intensity was greatest during the first nighttime interval, consistent with the time when children were least likely to be sleeping. Light intensity was lower at minimal levels during the second through sixth time intervals with minimal variation. These values are consistent with light intensity that is conducive to sleep.¹⁶ The values also suggest that nighttime nursing care activities were able to be completed without generating increased light intensity at the children's bedside.

Temperature—The average nighttime temperature within participants' rooms was less than 75 degrees Fahrenheit (°F), which is regarded as the upper threshold for recommended room temperature for healthy sleep.¹⁶ Minimal variation in temperature was present across each night time interval suggesting that significant fluctuations in temperature, a potential source of disturbed sleep patterns, were not occurring.

Patterns of Environmental Variables Within Study Nights

Sound—A significant main effect for time of night was observed ($F = 50.42, p < .01$), indicating that sound levels were significantly different based on 2-hour time interval during the 12-hour night shift. Mean sound levels during each 12-hour night shift did not vary based on study night ($F = .45, p = .64$). A significant study night by time interval effect was not observed ($F = .57, p = .84$), suggesting that the interaction of the given study night and time of night did not influence sound levels.

A comparison of differences between the six 2-hour nighttime intervals was conducted for sound, light, and temperature (Table 2). Sound levels were significantly greater during the first two time intervals [7:00 – 8:59 pm ($p < .01$) and 9:00 – 10:59 pm ($p < .01$)] compared with the sixth time interval (5:00 – 6:59 am). Significant differences were not identified between the third ($p = .34$), fourth ($p = .78$), and fifth ($p = .92$) time intervals as compared with the sixth. These findings indicate that sound levels were significantly greater during the first four hours of the 12-hour night shift compared with the remaining eight hours and that sound levels between 11:00 pm and 6:59 am were similar.

It is important to note that these statistical differences also represent clinically significant differences between time intervals during the night. The difference of 7.25 dB between the first and sixth time intervals indicates a sound level that is more than four times more

powerful between 7:00 – 8:59 pm than at 5:00 – 6:59 AM. The difference of nearly 4 dB between the second and sixth time intervals indicates a sound intensity level between 9:00 – 10:59 pm that was more than twice as powerful as that between 5:00 – 6:59 am. Although sound levels did decrease through the night shift, mean sound levels between 5:00 – 6:59 am (47.4 dB) were more than 10 dB above the recommended level for healthy sleep.

Light—A significant main effect for time of night was observed ($F = 12.43$, $p < .01$), indicating that light levels were significantly different across 2-hour time intervals. Mean light levels during each 12-hour night shift did not vary based on study night ($F = 1.21$, $p = .31$). However, a significant study night by 2-hour time interval effect was observed ($F = 4.18$, $p < .01$), suggesting that the interaction of the given study night and time of night influenced light levels.

Differences in light levels between the six 2-hour time intervals were analyzed (Table 3). Comparisons identified significant differences between the second time interval (9:00 – 10:59 pm) ($p = .03$) compared with the sixth (5:00 – 6:59 am). These findings indicate that light levels were significantly greater between 9:00 – 10:59 pm compared with the remaining hours of the night shift. Significant differences in light intensity were not identified between other 2-hour time intervals compared with the sixth.

Although mean light levels were greatest during the initial two 2-hour time intervals of the night, overall levels were low relative to light levels that are necessary for reading or close work. Light levels were at their lowest during the between 11:00 pm and 6:59 am, providing an appropriate sleep environment. Low variability in light levels through the night also suggests that nursing staff were able to complete required patient care activities without causing disruptive increases in light levels.

Temperature—A significant main effect for time of night was not observed ($F = 1.61$, $p = .16$), indicating that temperature was not significantly different across the six 2-hour time intervals during the night. Mean temperature during each 12-hour night shift did not vary based on study night ($F = .03$, $p = .97$).

Discussion

Study findings identified a bedside care environment for children with cancer with persistently elevated sound levels throughout the night shift. Sound levels in children's rooms were consistently in excess of the 35 dB recommended by WHO for a healthy sleep environment during each 2-hour time interval of the night shift.¹³ Sound levels were similar to those identified in pediatric critical care settings and represented a sound intensity of greater than 10 times that of a healthy sleep environment even during the later hours of the night shift.^{1–4} These elevated sound levels are those recognized as being associated with disrupted sleep.¹³ Each 2-hour time interval also included abrupt increases in sound intensity of greater than 70 dB. All children experienced spikes in nighttime sound levels comparable to those generated by moderate traffic or loud conversation.

Findings reported in this study also complement those reported by Hinds and colleagues.¹⁴ Their study identified a range of 3 to 22 self-reported room entries and exits by staff and parents/visitors during the course of an 8-hour night shift (11:00 pm – 7:00 am). Together, findings from these studies suggest that individual clinical care-related activities occur throughout the course of the night shift and contribute to a disruptive nighttime care environment for hospitalized children with cancer.

In contrast to previously reported findings in PICU settings, light intensity levels were minimal in the private rooms during the nighttime hours when sleep was most likely to be established.⁴ These findings suggest that nighttime light levels are maintained at those which are conducive to sleeping. The light levels reported in this study also suggest that nursing staff are able to complete care activities without increasing light intensity in the child's room. Temperature within children's rooms was stable and at acceptable levels for nighttime sleep.

Study findings warrant closer examination of sources of excessive nighttime sound such as identifying sound levels associated with commonly performed care activities. Study findings also may guide the development of individual- and system-based interventions to create a healthier care environment for children with cancer. These may include organizing nighttime nursing care, when possible, based on patient/family preferences to minimize nighttime disruptions so that children may receive the restorative benefits of uninterrupted sleep. System-based interventions may include restructuring unit-based practices to facilitate daytime administration of chemotherapy medications and to minimize the frequency of cares that are necessary during nighttime hours.

In summary, the nighttime hospital care environment for children receiving inpatient chemotherapy is marked by excessive sound levels and abrupt increases in sound intensity that persist throughout the night shift. Such a disruptive nighttime environment is not conducive to restful nighttime sleep. This type of environment also may serve as an additional source of physiologic and psychologic stress that may adversely influence the health, response to chemotherapy, and recovery of children with cancer.

Study Limitations

Limitations of this study include a small sample size and a cross-sectional design. The organization of data into 2-hour intervals within each of the three study nights; however, did permit the use of the mixed linear model for within-night analyses. This study focused on the bedside care environment of hospitalized children receiving inpatient chemotherapy; therefore, findings cannot necessarily be generalized to other subgroups of hospitalized children with cancer, such as children with fever and neutropenia, or children undergoing hematopoietic stem cell transplantation. The study also did not seek to identify sources of increased sound or light intensity which may have resulted from nursing care, parents or visitors, or the child's activity within the room.

Implications for Research

Areas for future research include investigating sources of nighttime sound and their relative intensities in the inpatient hospital setting. Multiple sources of noise are present in the pediatric oncology patient's hospital room throughout the night, including nursing care activities, infusion pumps, high efficiency particulate absorbing (HEPA) filter fans, as well as the presence and activities of the child's parents or other visitors. The present study investigated only sound intensity level near the child's bedside, but did not distinguish the source of the sound.

Studies also are needed to delineate sources of sound that are potentially modifiable by pediatric oncology health care providers such as sound intensity associated with nursing care activities such as medication administration and routine patient monitoring and assessment. The contribution of parents and visitors to nighttime sound levels at their children's hospital bedside has not been investigated and warrants attention in future studies. Comparison of sound levels at the nurses' station, or in the hallways outside the child's hospital room, with

those occurring in the patient's room has not been studied. As sources of increased sound intensity are identified, intervention studies aimed at reducing nighttime sound levels and reorganizing nighttime clinical care activities which contribute to increased sound levels are warranted.

Studies investigating patient outcomes of exposure to excessive environmental noise are needed. To date, studies have identified associations between increased sound levels and impaired sleep in critically ill pediatric and adult patients.^{1,4,8,24,25} Associations between increased sound levels and measures of stress, including tachycardia and subjective reports of stress and annoyance, have been identified among intensive care nurses.²⁶ Future studies are needed to examine relationships between the care environment and children's physiologic and psychologic outcomes, including self-reported symptoms.

Implications for Clinical Practice and Policy

Implications for clinical practice and policy include evaluation of existing care delivery practices that may lead to increased nighttime disruptions and, as a result, increased bedside sound levels for children receiving chemotherapy. This includes attention to admission processes and facilitating daytime delivery of chemotherapy medications to prevent disruption of sleep during the night. Many pediatric chemotherapy protocols require prehydration fluids to meet specified urinary output parameters. When admissions occur later in the day, actual initiation of chemotherapy may not occur until nighttime hours when adequate hydration is achieved. Scheduling admissions earlier in the day may facilitate earlier administration of chemotherapy medications and potentially reduce the number of nighttime disruptions that may be associated with increased nighttime sound levels.

Examination of unit-based nursing care routines and how these routines are organized within the course of a night shift may reduce nighttime sound levels. Strategies to decrease sound levels and abrupt increases in sound intensity may include collaboration with the multidisciplinary team to coordinate scheduling clinical care activities, such as medication doses, in a manner that minimizes nighttime disruptions. Attention to quiet hours or "lights out" for the unit may serve as an intervention that could lead to decreased sound levels within the patient's room. In the present study, the perceived sound intensity between 9:00 – 10:59 pm was nearly twice the level between 5:00 – 6:59 am. Additionally, light levels were not at their lowest levels until after 11:00 pm. For many school-age children, routine bedtime hours occur around 9:00 pm. Maintaining home sleep routines would facilitate sleep in hospitalized children with cancer. However, persistently elevated sound levels do not create an environment that is conducive to maintaining home sleep routines.

Conclusions

The study was the first to report direct measures of sound, light, and temperature levels during the night shift in an inpatient pediatric setting (outside of a critical care unit) and in a pediatric oncology setting. Further, this study reported changes in environmental variables within the night shift rather than mean values and ranges for the entire shift.

It is important to note that sound levels at children's bedsides in patient rooms consistently exceeded those recommended by WHO and were comparable with those reported in pediatric critical care units. Findings of this study emphasize the significance of increased sound levels in health care settings and the need to develop and test interventions to minimize noise intensity that may influence nighttime sleep of children receiving chemotherapy during the nighttime hours.

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Table 1
Summary of Sound, Light and Temperature by Time Interval Across Each Study Night

Night 1 (N=15)			Night 2 (N=15)			Night 3 (N=14)		
Sound dB	Light lumens/ft ²	Temperature °F	Sound dB	Light lumens/ft ²	Temperature °F	Sound dB	Light lumens/ft ²	Temperature °F
Time Interval (7:00 – 8:59 PM)								
Mean	55.1	8.0	72.9	55.3	3.1	73.0	54.6	2.9
SD	5.4	2.3	0.3	4.7	0.8	0.1	4.8	2.3
Range	41.9 – 84.3	0.4 – 33.3	70.9 – 75.8	41.9 – 78.6	0.4 – 15	69.9 – 76.9	40.4 – 82.0	0.4 – 20.1
Time Interval 2 (9:00 – 10:59 PM)								
Mean	52.6	1.8	72.6	52.2	1.4	72.9	51.3	3.2
SD	4.7	1.1	0.2	4.8	0.4	0.1	4.8	1.3
Range	42.1 – 83.2	0.4 – 15	70.7 – 75.8	41.6 – 84.8	0.4 – 9.9	70.4 – 76.7	40.5 – 80.0	0.4 – 17.9
Time Interval 3 (11:00 PM – 12:59 AM)								
Mean	47.6	1.0	72.5	48.8	1.1	72.8	48.3	1.1
SD	2.5	0.2	0.2	3.0	0.4	0.1	4.2	0.2
Range	41.5 – 73.0	0.4 – 1.1	70.4 – 77.4	42.2 – 72.2	0.4 – 13.5	70.4 – 76.0	40.7 – 78.9	0.4 – 13.5
Time Interval 4 (1:00 – 2:59 AM)								
Mean	46.4	1.0	72.6	47.5	1.0	72.6	47.1	1.0
SD	1.1	0.2	0.1	1.9	0.2	0.1	2.7	0.2
Range	41.8 – 63.7	0.4 – 1.1	70.4 – 78.1	42.2 – 83.2	0.4 – 1.1	70.5 – 74.7	40.1 – 74.1	0.4 – 1.1
Time Interval 5 (3:00 – 4:59 AM)								
Mean	46.7	1.0	72.6	47.7	1.0	72.6	47.4	1.0
SD	1.5	0.2	0.1	1.7	0.2	0.1	1.5	0.2
Range	41.8 – 76.1	0.4 – 1.1	70.5 – 78.3	41.8 – 75.2	0.4 – 1.1	70.5 – 74.9	41.6 – 80.8	0.4 – 1.1
Time Interval 6 (5:00 – 6:59 AM)								
Mean	46.8	1.0	72.6	48.1	1.3	72.7	47.3	1.1
SD	2.2	0.2	0.2	2.0	0.6	0.2	2.0	0.2
Range	34.6 – 78.7	0.4 – 1.1	69.9 – 78.3	41.2 – 75.2	0.4 – 17.2	70.4 – 74.9	39.5 – 71.7	0.4 – 1.1

Table 2

Comparisons of Estimates of Fixed Effects of Time Interval of Night on Sound Level

Time of Night	Estimate	Standard Error	t-value	p
Time Interval 1 7:00 – 8:59 PM	7.25	1.07	6.75	<.01 ^a
Time Interval 2 9:00 – 10:59 PM	3.96	1.03	3.83	<.01 ^a
Time Interval 3 11:00 PM – 12:59 AM	.92	.97	.95	.34
Time Interval 4 1:00 – 2:59 AM	-.24	.86	-.27	.78
Time Interval 5 3:00 – 4:59 AM	.06	.67	.10	.92
Time Interval 6 5:00 – 6:59 AM	--	--	--	--

^a p < .01 (2-tailed)

Note: The basic mixed linear model automatically sets the estimate of Interval 6 to zero. The estimated fixed effects of the other five intervals are compared with Interval 6.

Table 3

Comparisons of Estimates of Fixed Effects of Time Interval of Night on Light Level

Time of Night	Estimate	Standard Error	t-value	p
Interval 1 7:00 – 8:59 PM	1.84	1.02	1.81	.07
Interval 2 9:00 – 10:59 PM	2.16	1.02	2.13	.03 ^a
Interval 3 11:00 PM – 12:59 AM	0.00	1.00	0.00	1.0
Interval 4 1:00 – 2:59 AM	-.01	.96	-.02	.99
Interval 5 3:00 – 4:59 AM	-.01	.83	-.02	.99
Interval 6 5:00 – 6:59 AM	--	--	--	--

^a p < .05 (2-tailed)

Note: The basic mixed linear model automatically sets the estimate of Interval 6 to zero. The estimated fixed effects of the other five intervals are compared with Interval 6.