

# Nighttime Sleep Disruptions, the Hospital Care Environment, and Symptoms in Elementary School-Age Children With Cancer

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Attention to symptom management is an important aspect of quality of life for children undergoing treatment for cancer (Hinds et al., 2004). Disturbed sleep is among the most frequently named symptoms and is reported by 30%–45% of children and adolescents with cancer (Baggott et al., 2010; Bhatia et al., 2004; Collins et al., 2000, 2002; Walker, Gedaly-Duff, Miaskowski, & Nail, 2010). Children and adolescents receiving chemotherapy report that sleep disturbances persist across treatment modalities (Baggott et al., 2010; Walker et al., 2010). Disturbed sleep patterns may persist following treatment and are associated with poorer neurocognitive outcomes among childhood cancer survivors (Clanton et al., 2011).

## Sleep and Hospitalized Children

Sleep is a complex, regulated bioenvironmental process essential for health and well-being. School-age children require 10–11 hours of nighttime sleep and awaken briefly 4–6 times each night at the completion of a typical 90–110 minute sleep cycle (Mindell & Owens, 2010; Sheldon, 2005). Consequences of disruption and deprivation of nighttime sleep are particularly concerning for children with cancer. Disrupted nighttime sleep alters normal hormonal regulation related to immune function, as well as natural killer cell activity and cytokine activity (Irwin et al., 1996, 2006; Van Cauter & Spiegel, 1999). Insufficient sleep is associated with poorer daytime functioning, cognitive impairment, mood and behavioral problems, and increased risk-taking behaviors (Mindell & Owens, 2010).

Hospital environmental stimuli, particularly sound and light levels and caregiver activities, are negatively correlated with sleep quantity and quality among children in pediatric intensive care units (PICU) (Al-Samsam & Cullen, 2005; Carno, Hoffman, Henker, Carcillo, & Sanders, 2004; Corser, 1996; Cureton-Lane

**Purpose/Objectives:** To describe nighttime sleep-wake patterns during a 12-hour night shift among school-age children with cancer receiving inpatient chemotherapy and relationships among nighttime sleep, environmental stimuli, medication doses, and symptoms during that shift.

**Design:** Exploratory, descriptive, multiple-case study.

**Setting:** Inpatient pediatric oncology unit at a tertiary pediatric hospital in the western United States.

**Sample:** 15 elementary school-age children with cancer receiving inpatient chemotherapy.

**Methods:** Wrist actigraphs measured sleep-wake patterns. Data loggers and sound pressure level meters measured bedside light, temperature, and sound levels. Medication doses and occurrences of pain, nausea, and vomiting were identified through chart review.

**Main Research Variables:** Minutes of sleep.

**Findings:** Sleep varied based on time of night ( $F = 56.27$ ,  $p < 0.01$ ), with sleep onset delayed past 10 pm. A basic mixed linear model identified significant fixed effects for sound ( $F = 50.87$ ,  $p < 0.01$ ) and light ( $F = 7.04$ ,  $p < 0.01$ ) on minutes of sleep. A backward regression model including sound, light, medication doses, pain, and nausea accounted for about 57% of the variance in sleep minutes ( $F = 62.85$ ,  $p < 0.01$ ).

**Conclusions:** Sleep was marked by frequent awakenings, limiting children's ability to experience full sleep cycles. Multiple factors—in particular, excessive sound levels—compromise sleep quantity and quality throughout the night.

**Implications for Nursing:** Efforts to develop and test individualized and system-based interventions to modify the hospital care environment to promote nighttime sleep are needed. Oncology nurses have the opportunity to influence the care environment at an individual level and to influence unit-based practices to promote a healthy nighttime sleep environment.

& Fontaine, 1997). Nighttime sleep is reduced and fragmented relative to age-related norms, and PICU nighttime sound levels consistently exceed 50 decibels (dB), with spikes to 103 dB (Carvalho, Pedreira,

& de Aguiar, 2005; Cureton-Lane & Fontaine, 1997). The World Health Organization (WHO) recommends average sound levels of 35 dB for hospital rooms in which patients are being actively treated. WHO further recommends that the maximum sound intensity for individual events at the patient's bedside not exceed 45 dB (Berglund, Lindvall, & Schwela, 1999).

Hospitalized children with cancer experience about 11.3 room entries and exits during an eight-hour night shift (Hinds et al., 2007). Frequent room entries are associated with fragmented nighttime sleep, with nighttime awakenings ranging from 0–40. Total nighttime sleep in the hospital is highly variable, ranging from 4.25–13.8 hours (Hinds et al., 2007; Hockenberry et al., 2010). Children experiencing more awakenings also experience greater fatigue and longer sleep duration, suggesting that more time spent in bed trying to sleep does not indicate better sleep quality.

## Sleep and Children Receiving Chemotherapy

Children and adolescents receiving chemotherapy in inpatient and ambulatory settings report poor sleep quality, indicating that sleep disturbances persist across treatment modalities (Baggott et al., 2010; Walker et al., 2010). Forty percent of children and adolescents reported difficulty sleeping prior to a cycle of myelosuppressive chemotherapy, and reports of difficulty sleeping did not change significantly at one and two weeks following receipt of chemotherapy (Baggott et al., 2010). Children and adolescents receiving outpatient treatment for acute lymphoblastic leukemia (ALL) experienced an average of 19.8 (SD = 4.1, range = 1–37) awakenings each night over a three-night period following treatment, and total nighttime sleep ranged from 6–9.5 hours (Gedaly-Duff, Lee, Nail, Nicholson, & Johnson, 2006). Sleep disturbances were reported by 87% of children and adolescents receiving maintenance therapy for ALL (Zupanec, Jones, & Stremler, 2010). Schedules for medication administration and side effects of medication were perceived as contributing to disrupted sleep.

Although previous studies have identified disrupted nighttime sleep among hospitalized children with cancer, limited knowledge exists about sources of disrupted sleep-wake patterns. Understanding sources of disrupted nighttime sleep-wake patterns, particularly those that are modifiable, can guide the development of individual- and system-based interventions to improve children's nighttime sleep and ultimately support improved quality-of-life outcomes.

## Purpose

The purpose of this study was to examine nighttime sleep-wake patterns and influences on sleep among children with cancer during an admission for inpatient

chemotherapy. Research questions guiding the study were

- What are the nighttime sleep-wake patterns during a 12-hour night shift (7 pm to 6:59 am) among school-age children with cancer receiving inpatient chemotherapy?
- What are the relationships between nighttime sleep, environmental stimuli, medication doses, and symptoms reported by children with cancer receiving inpatient chemotherapy during a 12-hour night shift?

## Methods

### Conceptual Framework

The University of California, San Francisco, Symptom Management Theory (SMT) (Dodd et al., 2001; Humphreys et al., 2008) guided this study. The inductive, middle-range theory locates the symptom experience, symptom management strategies, and symptom status outcomes in the context of three dimensions of nursing science: the person, environment, and health and illness. The focus of this exploratory study was the children's symptom experience of nighttime sleep-wake patterns. The study explored relationships between the symptom experience and the nursing dimensions of the child's bedside environment (i.e., bedside sound, light, and temperature levels), and the child's health and illness (i.e., number of medication doses, pain, nausea, and vomiting).

### Design

The study used a descriptive, exploratory, multiple-case study design (Yin, 2003). This within-subjects approach emphasizes replication across individual cases rather than identifying differences between groups. Case study research allows the inclusion of multiple sources of data and seeks to describe relationships within the larger context in which a given outcome variable is occurring. Investigator control of behavioral or contextual events is not required (Yin, 2003).

### Setting and Sample

Participants were patients on a 24-bed inpatient pediatric oncology unit at Primary Children's Medical Center, a tertiary children's hospital in Salt Lake City, UT, with private rooms and bathrooms and sleeping accommodations for one parent or caregiver. Fifteen elementary school-age children with cancer (10 boys, 5 girls) receiving inpatient chemotherapy three days or longer for either primary diagnosis of cancer or recurrent disease participated in the study (see Table 1). An a priori power analysis supported that the proposed sample size of 15 would yield at least 80% power with alpha set at 0.05 using a fixed-effects model analysis of variance.

Limiting participants to elementary school-age children maintained a developmental focus and minimized variance associated with known differences in sleep-wake patterns among preschool children or adolescents. Exclusion criteria were surgery during the admission or treatment for a secondary health condition requiring additional care. Children with brain tumors, developmental delays, or previously diagnosed sleep disorders also were excluded. Although the sample was heterogeneous with regard to diagnosis and treatment protocol, the routine inpatient nursing care associated with chemotherapy administration was similar for each participant.

## Measures

**Sleep:** MicroMini-Motionlogger® wrist actigraphs measured sleep-wake patterns. Actigraphs are devices about the size of a wristwatch containing a biaxial piezoelectric sensor that generates a voltage when the actigraph is moved. Sleep/wake states are identified by sampling the individual's movements several times per second. Actigraphy is a reliable and valid measure to detect sleep and assess disturbed sleep patterns, circadian rhythm disorders, and intervention effects (Morgenthaler et al., 2007; Sadeh, 2011). Actigraphy is highly correlated with polysomnography, the gold standard for measuring sleep in studies involving adults and children.

In the current study, the children wore actigraphs continuously on their nondominant wrists during the three-day-and-night data collection period. Data were transformed digitally and stored in the actigraph's internal memory in one-minute epochs (Morgenthaler et al., 2007; Sadeh, 2011). The Zero Crossing Mode, which counts the number of times per epoch that the activity signal crosses zero or very near zero, was used as a measure of motion (Ancoli-Israel et al., 2003). Parents and children identified bedtimes and times to awaken using sleep diaries to compare with actigraph data per the American Academy of Sleep Medicine's recommendation (Morgenthaler et al., 2007).

**Light, temperature, and sound:** Light and temperature levels in participants' rooms were measured using a HOBO® U12-012 Temp/RH/Light/External Channel Data Logger. The light sensor measures light intensity with a range of 1–3,000 lumens/ft<sup>2</sup>. The temperature sensor measures temperature from 0°C–50°C, with a resolution of 0.03°C and accuracy of  $\pm 0.35^\circ\text{C}$ . Sound was measured using an Extech Instruments model 407736 digital sound pressure level (SPL) meter connected to the external channel input of the data logger. The meter measures SPL from 35–100 dB, with a 0.1 dB resolution and an accuracy of  $\pm 1.5$  dB. Light, temperature, and sound levels were measured at 30-second intervals throughout the data collection period and stored in the data logger's internal memory. The devices (dimension = 26.25 x 12 x

**Table 1. Participant Characteristics**

| Characteristic                       | $\bar{X}$ | SD  | Median |
|--------------------------------------|-----------|-----|--------|
| Age (years)                          | 8.8       | 2.3 | 8.3    |
| Time from initial diagnosis (months) |           |     |        |
| Primary disease                      | 3         | 2   | 2.4    |
| Relapsed disease                     | 64        | 28  | 52.5   |
| Characteristic                       | n         |     |        |
| Gender                               |           |     |        |
| Male                                 |           |     | 10     |
| Female                               |           |     | 5      |
| Race or ethnicity                    |           |     |        |
| Caucasian                            |           |     | 14     |
| African American                     |           |     | 1      |
| Diagnosis                            |           |     |        |
| Leukemia                             |           |     | 8      |
| Sarcoma                              |           |     | 3      |
| Lymphoma                             |           |     | 2      |
| Other solid tumor                    |           |     | 2      |
| Primary versus relapsed disease      |           |     |        |
| Primary disease                      |           |     | 12     |
| Relapsed disease                     |           |     | 3      |
| N = 15                               |           |     |        |

8.75 cm) were placed on a cart next to the child's bedside. The devices did not interfere with patient care or the child's activities.

**Medication doses:** The number of medication doses administered during each two-hour interval was retrieved from each participant's medication administration record.

**Pain, nausea, and vomiting:** Children's ratings of pain, nausea, and vomiting episodes were identified from the medical record. Pain intensity was assessed using either the modified Wong-Baker faces scale or a 0–10 numeric rating scale per institutional standard based on patient preference. Both scales have been found to be reliable and valid approaches to pain assessment in school-age children (Tomlinson, von Baeyer, Stinson, & Sung, 2010; Voepel-Lewis, Burke, Jeffreys, Malviya, & Tait, 2011). Pain intensity was assessed at a minimum frequency of every four hours and was reassessed within 60 minutes following initiation of a therapeutic intervention.

Nausea intensity was assessed every two hours (four-point scale ranging from "none" to "severe") per institutional standard for patients receiving chemotherapy. Nausea was reassessed within 60 minutes following initiation of a therapeutic intervention. Vomiting episodes were identified based on the numeric count of episodes documented on the nursing flowsheet.

Whenever possible, nurses coordinated assessment of these symptoms with episodes when children awaken spontaneously, such as to use the bathroom. Institutional practice guidelines allow the omission of one assessment during the night shift if the child is asleep and if the symptom has been managed to the child and family's satisfaction.

Procedures

Institutional review board approval was granted for this study by the University of Utah. Children scheduled for admission for chemotherapy were reviewed with the oncology team on a weekly basis to evaluate initial eligibility. Families of all eligible participants were informed of the study and invited to participate in a sequential manner. An introductory letter explaining the study was distributed to families of all eligible children. During a routine preadmission phone call by the admission coordinators, parents of each eligible child were asked whether the investigator had permission to contact them. None declined to be contacted.

The investigator explained the study purpose and procedures to parents and children following the child’s admission to the hospital. Parental permission was obtained for all child participants, with written assent obtained from children aged 7 years and older. Two families declined to participate for reasons unrelated to the study purpose. One child withdrew from the study less than 24 hours after initiation of data collection because she was unwilling to wear the wrist actigraph. Study participation did not interfere with routine delivery of care, delay treatment, or increase the length of hospitalization.

Data collection began on the day of admission and continued for three days and nights. Although the day of the week on which data collection began varied among participants, bedside nursing care for patients receiving chemotherapy was consistent for all patients during each study night. Participants received a gift card incentive at the completion of data collection.

Statistical Analysis

SPSS®, version 16.0, was used for data entry and analysis. Analyses included within-subjects repeated-measures analyses emphasizing individual variation, which have greater sensitivity to detect individual differences (Keppel, 1991). Each two-hour time interval within each night for each child supported the use of a basic mixed linear model and backward regression analyses. A two-hour time interval was selected because it represents typical organization of nursing care during the shift. That approach provided 18 observations of each of the eight variables for each participant (144 observations per participant) for the three study nights.

Digitized actigraph data were uploaded for scoring and analysis using Act Millennium, version 3.10.13.1. Action-W, version 2.6, scored

individual digitized actigraph data files and identified minutes of sleep using the Cole-Kripke algorithm. Data files were scored for each 12-hour shift and for each two-hour time interval within each 12-hour night shift (e.g., 7–8:59 pm).

Stored data were downloaded from the data loggers into Excel® using HOBOWare® Pro software and then exported into SPSS®, version 16.0. Means of each variable for each two-hour time interval within each 12-hour night shift were used for analyses.

Results

Nighttime Sleep Characteristics

Table 2 presents a summary of children’s nighttime sleep characteristics during each 12-hour night shift (7 pm–6:59 am) during three nights. Nighttime awakenings exceeded school-age children’s typical 4–6 awakenings per night (Mindell & Owens, 2010), limiting children’s opportunities to achieve a full sleep cycle between awakenings. A within-subjects analysis of variance did not identify significant differences in minutes of sleep across each 12-hour night shift over the three nights ( $F = 1.93, p = 0.17$ ).

A summary of children’s minutes of sleep during each two-hour interval of each night shift is presented in Table 3. A basic mixed linear model analysis indicated that children’s total sleep minutes varied significantly based on time of night ( $F = 56.27, p < 0.01$ ), although a significant main effect for study night was not observed. Post-hoc analyses compared the estimates of fixed effects of each of the first five two-hour time intervals to the sixth interval (5–6:59 am). Children received significantly fewer minutes of sleep during each of the first three two-hour intervals (i.e., 7–8:59 pm, 9–10:59 pm, and 11 pm–12:59 am) compared with sleep minutes between 5–6:59 am ( $p < 0.05$ ). Minutes of sleep during the 1–2:59 am and 3–4:59 am intervals were not significantly different.

Environment Characteristics

A more complete description of sound, light, and temperature characteristics and changes in these variables during the night shift has been reported in Linder and Christian (2011).

Table 2. Nighttime Sleep Characteristics During 12-Hour Night Shifts

| Variable         | Night 1   |       |         | Night 2   |      |         | Night 3   |      |         |
|------------------|-----------|-------|---------|-----------|------|---------|-----------|------|---------|
|                  | $\bar{X}$ | SD    | Range   | $\bar{X}$ | SD   | Range   | $\bar{X}$ | SD   | Range   |
| Minutes of sleep | 476.8     | 115.6 | 335–650 | 458.5     | 64.4 | 344–535 | 437.8     | 93.5 | 280–590 |
| Awakenings       | 12.3      | 6.1   | 5–23    | 10.9      | 4.9  | 4–20    | 10.9      | 5.1  | 5–19    |

Mean nighttime sound levels exceeded 45 dB, corresponding to sound generated by moderate conversation. WHO recommends that average sound levels in rooms in which patients are being actively treated not exceed 35 dB (Berglund et al., 1999). Sound levels during each night shift were similar to those reported in critical care settings, with values as low as 40 dB with abrupt increases in excess of 80 dB. Sound intensity was greatest from 7–10:59 pm (Linder & Christian, 2011).

Maximum recorded light intensity was 20.1 lumens/ft<sup>2</sup>, less than the 30 lumens/ft<sup>2</sup> necessary for reading printed materials. Light intensity was minimal from 9 pm–6:59 am and was greatest during early evening hours (Linder & Christian, 2011).

Nighttime temperatures consistently were less than 75°F, which is regarded as the upper threshold for healthy sleep (Glaze, 2004). Temperature did not vary significantly during the night shift (Linder & Christian, 2011).

### Medication Doses

Medication doses were given throughout all six intervals each night (see Table 4), indicating frequent, ongoing clinical care activities at the child's bedside. No children received corticosteroids during the data collection period. Nine participants received medications during three or more two-hour intervals each of the three study nights. Medications included scheduled chemotherapy medications, as well as supportive care medications administered on a scheduled or as-needed basis. No children received prescribed sleep aids.

### Pain, Nausea, and Vomiting

Four children reported pain. Pain was attributed to episodic sources (e.g., headache, earache), with pain scores indicating mild to moderate pain. One child reported pain on two of the three study nights. The remaining three reported pain on one night only. All children reporting pain received analgesics with documented relief of pain. One child received a single dose of oxycodone. The others received acetaminophen. None received around-the-clock analgesics.

Five children reported mild or moderate nausea during the study. Nausea was most frequently reported on the first and third study nights. Only one child reported nausea on both the second and third study nights. The remaining four children reported nausea

| Table 3. Minutes of Sleep During Each Two-Hour Interval of a 12-Hour Night Shift |           |      |        |           |      |        |           |      |        |
|----------------------------------------------------------------------------------|-----------|------|--------|-----------|------|--------|-----------|------|--------|
| Time                                                                             | Night 1   |      |        | Night 2   |      |        | Night 3   |      |        |
|                                                                                  | $\bar{X}$ | SD   | Range  | $\bar{X}$ | SD   | Range  | $\bar{X}$ | SD   | Range  |
| 7–8:59 pm                                                                        | 29.6      | 40.7 | 0–105  | 19.2      | 25.8 | 0–72   | 10.3      | 26   | 0–94   |
| 9–10:59 pm                                                                       | 48.3      | 51.7 | 0–114  | 39.2      | 38   | 0–96   | 46.8      | 42.5 | 0–115  |
| 11 pm–12:59 am                                                                   | 81.5      | 34.3 | 15–120 | 86.3      | 26.3 | 35–119 | 80.4      | 39   | 0–111  |
| 1–2:59 am                                                                        | 103.5     | 11.4 | 15–120 | 103.2     | 22.4 | 29–120 | 92.2      | 25.5 | 43–120 |
| 3–4:59 am                                                                        | 106.5     | 8.2  | 84–116 | 106.6     | 11.4 | 79–120 | 104       | 12.1 | 78–117 |
| 5–6:59 am                                                                        | 106.5     | 9.1  | 89–119 | 103.9     | 14.2 | 66–116 | 104       | 12.6 | 79–120 |

on only one study night. One of these five children reported both nausea and pain during the study, although pain and nausea occurred on different nights. All participants received ondansetron every six hours as an antiemetic, with the first dose given prior to initiation of chemotherapy. Nine participants also received around-the-clock doses of adjunct medications (diphenhydramine with or without promethazine) for breakthrough nausea, starting the first night of admission. Another two participants received scheduled adjunct antiemetics on the third night of admission. Chemotherapy-related vomiting was infrequent. Three participants experienced vomiting, and each participant experienced only one episode during the three study nights.

### Sleep and the Hospital Care Environment

A basic mixed linear model analyzed the influence of sound and light on minutes of sleep within each two-hour time interval. Sound and light adversely influenced children's sleep, as demonstrated by significant fixed effects models for sound ( $F = 50.87, p < 0.01$ ) and light ( $F = 7.04, p < 0.01$ ). When controlling for the effects of sound and light, minutes of sleep were significantly different from 9–10:59 pm ( $t = 3.3, p < 0.01$ ), 11 pm–12:59 am ( $t = 4.6, p < 0.01$ ), and 1–2:59 am ( $t = 3.38, p < 0.01$ ), as compared with the 5–6:59 am interval. Those findings indicate that sound and light exerted an adverse effect on sleep throughout the night shift, disrupting children's sleep.

Associations among minutes of sleep, sound, light, temperature, number of medication doses, pain score, nausea score, and number of vomiting episodes during each two-hour interval were explored (see Table 5). Sleep quantity was strongly influenced by elevated sound levels at the child's bedside ( $r = -0.72, p < 0.01$ ), moderately affected by light ( $r = -0.36, p < 0.01$ ), and slightly influenced by room temperature ( $r = -0.13, p < 0.05$ ). Sleep quantity (minutes) ( $r = -0.28, p < 0.01$ ) and

**Table 4. Summary of Medication Doses for Each Study Night**

| Variable              | Night 1               |                            | Night 2               |                            | Night 3               |                            |
|-----------------------|-----------------------|----------------------------|-----------------------|----------------------------|-----------------------|----------------------------|
|                       | Receiving Medications | Dose Range Per Participant | Receiving Medications | Dose Range Per Participant | Receiving Medications | Dose Range Per Participant |
| 12-hour shift summary | 15                    | 1–12                       | 14                    | 0–10                       | 14                    | 2–10                       |
| 7–8:59 pm             | 12                    | 1–4                        | 12                    | 1–5                        | 12                    | 1–5                        |
| 9–10:59 pm            | 6                     | 1–5                        | 6                     | 1–3                        | 9                     | 1–3                        |
| 11 pm–12:59 am        | 11                    | 1–4                        | 11                    | 1–4                        | 11                    | 1–2                        |
| 1–2:59 am             | 6                     | 1–2                        | 5                     | 1–2                        | 4                     | 1–2                        |
| 3–4:59 am             | 5                     | 1–2                        | 4                     | 1–2                        | 6                     | 1–2                        |
| 5–6:59 am             | 9                     | 1–2                        | 11                    | 1–2                        | 11                    | 1–2                        |

*Note.* The median number of medication doses per night over the course of each 12-hour shift was four for night 1, five for night 2, and six for night 3.

sound levels ( $r = 0.22$ ,  $p < 0.01$ ) were significantly associated with number of medication doses, indicating that nighttime nursing care activities contributed to increased bedside noise and less sleep.

A backward multiple regression model identified variables predictive of sleep minutes within each two-hour interval. Because of the exploratory nature of this study, a backward regression model allowed for consideration of more variables (probability of  $F$  to remove  $\geq 0.1$ ) in the final regression model. Variables were entered in three blocks: the environment (e.g., sound, light, temperature), clinical care (e.g., number of medication doses), and symptoms (e.g., pain, nausea). Because of the exploratory nature of this study, the distressing symptom of nausea was included in the regression analysis, although nausea was not significantly correlated with sleep minutes. The final model (sound, light, medication doses, pain, and nausea) was significant in predicting sleep minutes within each two-hour time interval, accounting for about 57% of the variance ( $F = 62.85$ ,  $p < 0.01$ ) (see Table 6).

## Discussion

Study findings were consistent with the SMT, supporting hypothesized relationships between the symptom experience of children's nighttime sleep-wake patterns and the nursing science dimensions of the child's bedside environment and the child's health and illness (Humphreys et al., 2008). Nighttime sleep-wake patterns were influenced adversely by the nursing science dimensions of the environment (i.e., sound and light levels) and children's health illness states (i.e., medication administration and symptoms). Those identified relationships provide support for clinical

interventions to improve nighttime sleep, as well as future research.

## Sleep Characteristics

Sleep quantity and quality were impaired in elementary school-age children with cancer compared with those for healthy school-age children (Mindell & Owens, 2010). Sleep onset often was delayed past 11 pm, much later than typical parent-reported bedtimes for these children. Sleep characteristics identified in this study are consistent with those previously reported among hospitalized school-age children and adolescents with cancer, as well as critically ill children (Corser, 1996; Cureton-Lane & Fontaine, 1997; Hinds et al., 2007). Children's sleep was fragmented, with an average of more than 10 awakenings during each 12-hour night shift. Those frequent awakenings limited children's ability to achieve full sleep cycles, which may compromise physiologic and psychological well-being.

## Influence of the Hospital Environment

The environment (i.e., sound and light levels) had the greatest influence on sleep minutes, accounting for the greatest proportion of the variance in the final regression model. Sound levels consistently exceeded WHO recommendations for a healthy sleep environment throughout the night shift and were similar to those previously reported in pediatric critical care settings (Berglund et al., 1999; Carno et al., 2004; Carvalho et al., 2005; Corser, 1996; Cureton-Lane & Fontaine, 1997; Linder & Christian, 2011). These findings emphasize the significance of the hospital care environment and its adverse influence on nighttime sleep quantity and quality.

## Influence of Medication Administration and Symptoms

Consistent with reports from previous studies, medication administration and children's symptoms contributed to fewer minutes of sleep in each two-hour interval (Corser, 1996; Cureton-Lane & Fontaine, 1997; Hinds et al., 2007). Much of the nighttime nursing care responsibilities for children receiving chemotherapy centers on medication administration and related supportive care. Most medications were administered via IV, with each dose representing at least two room entries and potentially increased sound levels contributing to sleep disruption. Patterns of medication administration suggest that medication doses were scheduled to minimize disruptions during times when sleep was most likely to be established. The majority of children, however, did receive medications during the 11 pm–12:59 am interval, which may have contributed to delayed bedtimes.

In contrast, reported nausea and vomiting episodes were less frequent than those in a study addressing symptoms among children receiving chemotherapy in which about 82% of participants reported nausea and 41% of children and 48% of adolescents experienced vomiting (Hockenberry et al., 2010). However, those children and adolescents received highly emetogenic chemotherapy compared to the participants in the current study.

The percentage of children experiencing pain was less than that previously reported among hospitalized children and adolescents with cancer (Jacob, Hesselgrave, Sambuco, & Hockenberry, 2007). However, the current study only included children who were receiving chemotherapy and not those who had been admitted for treatment-related complications. Children in this study were at a point in their treatment continuum when pain associated with the onset of their disease may have subsided.

### Limitations

Limitations of this study include a small, heterogeneous sample of children with primary diagnoses and

relapsed disease and the use of a cross-sectional design. Because the study's focus was to explore influences on sleep during the 12-hour night shift, study findings are limited to a report of sleep characteristics occurring from 7 pm–6:59 am. The majority of participants were Caucasian, limiting generalization of findings to other racial or ethnic groups. Because this study included only children receiving inpatient chemotherapy, findings may not be generalizable to other subgroups, such as children admitted with fever and neutropenia, or children admitted for hematopoietic stem cell transplantation.

Using institutional measures for pain and nausea is a limitation because the reliability and validity of the nausea assessment tool have not been evaluated in larger studies. Although these tools are intended to be used as patient-report measures, nurses' use of these measures may be inconsistent. As such, these symptoms may have been underreported. However, both pain and nausea were included in the final regression model as adversely affecting nighttime sleep.

### Clinical Implications

The negative influence of persistent, elevated sound levels on nighttime sleep quantity and quality was demonstrated. Clinical practice implications include improved efficiency of hospital admissions processes for children receiving chemotherapy to reduce the number of medications and associated elevated sound levels resulting in fragmented sleep during the night shift. For study participants, chemotherapy often was not initiated until after the start of the night shift, and hyperhydration continued through the night shift, thereby disrupting sleep. Scheduling chemotherapy to prevent sleep disruptions would facilitate sleep of hospitalized children. Turning down the lights on the unit at an hour that coincides with typical bedtimes for young school-age children may serve as a cue for staff to provide a quieter care environment.

Attention to the assessment and management of other symptoms has the potential to improve nighttime

**Table 5. Correlations Among Minutes of Sleep, Environmental Variables, and Clinical Variables Within Each Two-Hour Interval of a 12-Hour Night Shift**

| Variable         | Sound   | Light   | Temperature | Medication Doses | Pain Score | Nausea Score | Vomiting Episodes |
|------------------|---------|---------|-------------|------------------|------------|--------------|-------------------|
| Sleep minutes    | −0.72** | −0.36** | −0.13*      | −0.28**          | −0.18**    | −0.05        | 0.02              |
| Sound            |         | 0.31**  | 0.1         | 0.22**           | 0.07       | −0.04        | 0.04              |
| Light            |         |         | 0.08        | 0.12             | 0.06       | 0.04         | −0.03             |
| Temperature      |         |         |             | 0.05             | 0.02       | 0.05         | 0.02              |
| Medication doses |         |         |             |                  | 0.06       | 0.11         | 0.01              |
| Pain score       |         |         |             |                  |            | −0.04        | −0.02             |
| Nausea score     |         |         |             |                  |            |              | 0.08              |

\*  $p < 0.05$ ; \*\*  $p < 0.01$  (one-tailed)

**Table 6. Variables Included in the Final Backward Regression Model**

| Variable         | B     | $\beta$ | t      | p        |
|------------------|-------|---------|--------|----------|
| Sound            | -6.7  | -0.65   | -14.27 | < 0.01** |
| Light            | -1.62 | -0.12   | -2.66  | < 0.01** |
| Medication doses | -5.82 | -0.13   | -2.88  | < 0.01** |
| Pain             | -6.95 | -0.12   | -2.89  | < 0.01** |
| Nausea           | -8.88 | -0.08   | -1.74  | 0.04*    |

\*p < 0.05; \*\*p < 0.01 (one-tailed)

B—unstandardized coefficient

sleep. Pain, nausea, and vomiting each contributed to a small but significant component of the variance in reduction of sleep minutes. Symptom profiles of children with cancer can change over time based on episodic events, such as infection, or as a result of the child's disease and treatment, emphasizing the importance of ongoing assessment and management of symptoms to prevent sleep disruption throughout the child's hospitalization (Collins et al., 2000, 2002; Gedaly-Duff et al., 2006; Woodgate, Degner, & Yanofsky, 2003).

## Implications for Future Research

Intervention studies to establish effective strategies to improve sleep quantity and quality for children with cancer in the hospital setting are needed. Individualized developmental care-based interventions have been successfully implemented in newborn intensive care unit settings (Als & Gilkerson, 1997). Similar interventions have not been trialed in other pediatric populations. Interventions may include individualized, tailored interventions to improve sleep hygiene and interventions aimed at modifying the hospital care environment, including maintaining usual bedtimes and minimizing disruptions. Institution-based interventions may include structuring chemotherapy admission processes to minimize the number of nighttime sleep disruptions.

Studies comparing children's sleep patterns during hospitalization with sleep patterns in the home setting are needed, as are studies identifying changes in sleep patterns across the cancer treatment continuum. Understanding how sleep patterns change during treatment may guide the development of interventions designed to improve sleep. In addition, research is needed to identify the consequences of disrupted nighttime sleep for children in the hospital setting.

## Conclusions

The study demonstrates the significant negative influence of the hospital care environment on sleep quantity and quality among hospitalized school-age children with cancer. Findings from this study support relationships among the experience of disrupted nighttime sleep and the nursing care dimensions of the environment and the child's health and illness state, as illustrated in the SMT, as well as provide guidance for the development of future interventions to improve nighttime sleep. Hospital-based interventions to minimize nighttime noise levels, as well as changing processes to accommodate earlier chemotherapy administration times, may help promote developmentally appropriate bedtimes, reduce nighttime disturbances, and improve children's nighttime sleep. Efforts to improve sleep outcomes have the potential to contribute to improved quality of life not only during treatment for cancer, but also into long-term survivorship.

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## References

- Al-Samsam, R.H., & Cullen, P. (2005). Sleep and adverse environmental factors in sedated mechanically ventilated pediatric intensive care patients. *Pediatric Critical Care Medicine*, 6, 562-567.
- Als, H., & Gilkerson, L. (1997). The role of relationship-based developmentally supportive newborn intensive care in strengthening outcome of preterm infants. *Seminars in Perinatology*, 21, 178-189.
- Ancoli-Israel, S., Cole, R., Alessi, C., Chambers, M., Moorcroft, W., & Pollak, C.P. (2003). The role of actigraphy in the study of sleep and circadian rhythms. *Sleep*, 26, 342-392.
- Baggott, C., Dodd, M., Kennedy, C., Marina, N., Matthay, K.K., Cooper, B.A., & Miaskowski, C. (2010). Changes in children's reports of symptom occurrence and severity during a course of myelosuppressive chemotherapy. *Journal of Pediatric Oncology Nursing*, 27, 307-315. doi:10.1177/1043454210377619
- Berglund, B., Lindvall, T., & Schwela, D.H. (1999). *Guidelines for community noise* (pp. 55-66). Retrieved from <http://www.who.int/docstore/peh/noise/Comnoise-4.pdf>
- Bhatia, S., Jenney, M.E., Wu, E., Bogue, M.K., Rockwood, T.H., Feusner, J.H., . . . Kane, R.L. (2004). The Minneapolis-Manchester Quality of Life instrument: Reliability and validity of the Youth Form. *Journal of Pediatrics*, 145, 39-46. doi:10.1016/j.jpeds.2004.02.034
- Carno, M.A., Hoffman, L.A., Henker, R., Carcillo, J., & Sanders,

- M.H. (2004). Sleep monitoring in children during neuromuscular blockade in the pediatric intensive care unit: A pilot study. *Pediatric Critical Care Medicine*, 5, 224–229.
- Carvalho, W.B., Pedreira, M.L., & de Aguiar, M.A. (2005). Noise level in a pediatric intensive care unit. *Jornal de Pediatria*, 81, 495–498. doi:10.2223/JPED.1424
- Clanton, N.R., Klosky, J.L., Li, C., Jain, N., Srivastava, D.K., Mulrooney, D., . . . Krull, K.R. (2011). Fatigue, vitality, sleep, and neurocognitive functioning in adult survivors of childhood cancer: A report from the Childhood Cancer Survivor Study. *Cancer*. Advance online publication. doi:10.1002/cncr.25797
- Collins, J.J., Byrnes, M.E., Dunkel, I.J., Lapin, J., Nadel, T., Thaler, H.T., . . . Portenoy, R.K. (2000). The measurement of symptoms in children with cancer. *Journal of Pain and Symptom Management*, 19, 363–377.
- Collins, J.J., Devine, T.D., Dick, G.S., Johnson, E.A., Kilham, H.A., Pinkerton, C.R., . . . Portenoy, R.K. (2002). The measurement of symptoms in young children with cancer: The validation of the Memorial Symptom Assessment Scale in children aged 7–12. *Journal of Pain and Symptom Management*, 23, 10–16.
- Corser, N.C. (1996). Sleep of 1- and 2-year-old children in intensive care. *Issues in Comprehensive Pediatric Nursing*, 19, 17–31.
- Cureton-Lane, R.A., & Fontaine, D.K. (1997). Sleep in the pediatric ICU: An empirical investigation. *American Journal of Critical Care*, 6, 56–63.
- Dodd, M., Janson, S., Facione, N., Faucett, J., Froelicher, E.S., Humphreys, J., . . . Taylor, D. (2001). Advancing the science of symptom management. *Journal of Advanced Nursing*, 33, 668–676.
- Gedaly-Duff, V., Lee, K.A., Nail, L., Nicholson, H.S., & Johnson, K.P. (2006). Pain, sleep disturbance, and fatigue in children with leukemia and their parents: A pilot study. *Oncology Nursing Forum*, 33, 641–646. doi:10.1188/06.ONF.641-646
- Glaze, D.G. (2004). Childhood insomnia: Why Chris can't sleep. *Pediatric Clinics of North America*, 51, 33–50.
- Hinds, P.S., Gattuso, J.S., Fletcher, A., Baker, E., Coleman, B., Jackson, T., . . . Pui, C.H. (2004). Quality of life as conveyed by pediatric patients with cancer. *Quality of Life Research*, 13, 761–772.
- Hinds, P.S., Hockenberry, M.J., Rai, S.N., Zhang, L., Razzouk, B.I., McCarthy, K., . . . Rodriguez-Galindo, C. (2007). Nocturnal awakenings, sleep environment interruptions, and fatigue in hospitalized children with cancer. *Oncology Nursing Forum*, 34, 393–402.
- Hockenberry, M.J., Hooke, M.C., Gregurich, M., McCarthy, K., Sambuco, G., & Krull, K. (2010). Symptom clusters in children and adolescents receiving cisplatin, doxorubicin, or ifosfamide [Online exclusive]. *Oncology Nursing Forum*, 37, E16–E27. doi:10.1188/10.ONF.E16-E27
- Humphreys, J., Lee, K.A., Carrieri-Kohlman, V., Puntillo, K., Faucett, J., Janson, S., . . . UCSF School of Nursing Symptom Management Faculty Group. (2008). Theory of symptom management. In M.J. Smith & P.R. Liehr (Eds.), *Middle range theory for nursing* (2nd ed., pp. 145–158). New York, NY: Springer.
- Irwin, M., McClintick, J., Costlow, C., Fortner, M., White, J., & Gillin, J.C. (1996). Partial night sleep deprivation reduces natural killer and cellular immune responses in humans. *FASEB Journal*, 10, 643–653.
- Irwin, M.R., Wang, M., Campomayor, C.O., Collado-Hidalgo, A., & Cole, S. (2006). Sleep deprivation and activation of morning levels of cellular and genomic markers of inflammation. *Archives of Internal Medicine*, 166, 1756–1762. doi:10.1001/archinte.166.16.1756
- Jacob, E., Hesselgrave, J., Sambuco, G., & Hockenberry, M. (2007). Variations in pain, sleep, and activity during hospitalization in children with cancer. *Journal of Pediatric Oncology Nursing*, 24, 208–219.
- Keppel, G. (1991). The single factor within-subjects design. In G. Keppel (Ed.), *Design and analysis: A researcher's handbook* (3rd ed., pp. 334–365). Upper Saddle River, NJ: Prentice-Hall.
- Linder, L.A., & Christian, B.J. (2011). Characteristics of the nighttime hospital bedside care environment (sound, light, and temperature) for children with cancer. *Cancer Nursing*, 34, 176–184. doi:10.1097/NCC.0b013e3181fc52d0
- Mindell, J.A., & Owens, J.A. (2010). *A clinical guide to pediatric sleep: Diagnosis and management of sleep problems* (2nd ed.). Philadelphia, PA: Lippincott Williams and Wilkins.
- Morgenthaler, T., Alessi, C., Friedman, L., Owens, J., Kapur, V., Boehlecke, B., . . . Swick, T.J. (2007). Practice parameters for the use of actigraphy in the assessment of sleep and sleep disorders: An update for 2007. *Sleep*, 30, 519–529.
- Sadeh, A. (2011). The role and validity of actigraphy in sleep medicine: An update. *Sleep Medicine Reviews*, 15, 259–267. doi:10.1016/j.smrv.2010.10.001
- Sheldon, S.H. (2005). Polysomnography in infants and children. In S.H. Sheldon, R. Ferber, & M.H. Kryger (Eds.), *Principles and practice of pediatric sleep medicine* (pp. 49–71). Philadelphia, PA: Elsevier Saunders.
- Tomlinson, D., von Baeyer, C.L., Stinson, J.N., & Sung, L. (2010). A systematic review of faces scales for the self-report of pain intensity in children. *Pediatrics*, 126, e1168–e1198. doi:10.1542/peds.2010-1609
- Van Cauter, E., & Spiegel, K. (1999). Circadian and sleep control of hormonal secretions. In F.W. Turek & P.C. Zee (Eds.), *Regulation of sleep and circadian rhythms* (pp. 397–425). New York, NY: Marcel Dekker.
- Voepel-Lewis, T., Burke, C.N., Jeffreys, N., Malviya, S., & Tait, A.R. (2011). Do 0–10 numeric rating scores translate into clinically meaningful pain measures for children? *Anesthesia and Analgesia*, 112, 415–421. doi:10.1213/ANE.0b013e318203f495
- Walker, A.J., Gedaly-Duff, V., Miasowski, C., & Nail, L. (2010). Differences in symptom occurrence, frequency, intensity, and distress in adolescents prior to and one week after the administration of chemotherapy. *Journal of Pediatric Oncology Nursing*, 27, 259–265. doi:10.1177/1043454210365150
- Woodgate, R.L., Degner, L.F., & Yanofsky, R. (2003). A different perspective to approaching cancer symptoms in children. *Journal of Pain and Symptom Management*, 26, 800–817.
- Yin, R.K. (2003). *Case study research: Design and methods (Applied social research methods series)* (3rd ed., vol. 5). Thousand Oaks, CA: Sage.
- Zupanec, S., Jones, H., & Stremler, R. (2010). Sleep habits and fatigue of children receiving maintenance therapy for ALL and their parents. *Journal of Pediatric Oncology Nursing*, 27, 217–228. doi:10.1177/1043454209358890