Nocturnal Awakenings, Sleep Environment Interruptions, and Fatigue in Hospitalized Children With Cancer

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Purpose/Objectives: To describe nocturnal awakenings and sleep environment interruptions experienced by children and adolescents hospitalized for two to four days to receive chemotherapy and to assess the relationships among nocturnal awakenings, sleep environment interruptions, sleep duration, and fatigue.

Design: Longitudinal, descriptive design.

Setting: St. Jude Children's Research Hospital and Texas Children's Cancer Center.

Sample: 25 patients with solid tumors and 4 with acute myeloid leukemia.

Methods: Actigraphy, fatigue instruments, sleep diary, room entry and exit checklists, and blood samples.

Main Research Variables: Nocturnal awakenings, sleep environment interruptions, sleep duration, and fatigue.

Findings: The number of nocturnal awakenings per night as measured by actigraphy ranged from 0–40. The number of room entries and exits by a staff member or parent was 3–22 times per eight-hour night shift. The number of nocturnal awakenings was related to fatigue by patient report; patients who experienced 20 or more awakenings had significantly higher fatigue scores than those with fewer awakenings. Nocturnal awakenings also were significantly associated with sleep duration by patient and parent report.

Conclusions: Hospitalized pediatric patients with cancer who experience more nocturnal awakenings are more fatigued and sleep longer.

Implications for Nursing: Nurses may be able to control some of the factors that contribute to nocturnal awakenings and sleep environment interruptions that affect fatigue and sleep duration in hospitalized pediatric patients with cancer.

Key Points . . .

- Actigraphy is an accurate and low-burden method to noninvasively monitor nocturnal awakenings and sleep duration in children and adolescents who are hospitalized for as many as four days and nights for scheduled chemotherapy.
- Fewer nocturnal awakenings and sleep environment interruptions could improve sleep quality and lower hospital-related fatigue in hospitalized pediatric patients with cancer.
- Children and adolescents hospitalized for scheduled chemotherapy can experience as many as eight times the number of nocturnal awakenings that healthy children in their home sleep environments experience.

Sleep has a restorative function for children and adolescents because it provides a period of increased protein synthesis, cellular division, and growth hormone release that contributes to tissue renewal (Adam & Oswald, 1983; Lee & Stotts, 1990; Spenceley, 1993) and compensates for energy deficits acquired during daily functions (Amschler & McKenzie, 2005; Green, 1998; Hartmann, 1973). Hospitalized pediatric patients and their parents have reported that disruptions to patients' usual sleep patterns (delayed, prevented, or interrupted rest or sleep) occur to such an extent that hospital-related fatigue results and, in turn, patients' overall health status is affected negatively, even during brief hospital stays. Bed rest and sleep interruptions are two major disruptions to patients' typical daily functioning that occur during hospitalization. Combined, the two factors also contribute to hospital-related fatigue, immunosuppression (Palmblad, Petrini, Wasserman, & Akerstedt, 1979), anorexia, inability to concentrate (Fallone, Acebo, Arnedt, Seifer, & Carskadon, 2001), muscle wasting (al-Majid & McCarthy, 2001), and slowed physical healing (Corser, 1996). Accordingly, hospitalized children

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and adolescents likely are deprived of some of the restorative benefits of sleep. The number and type of sleep disruptions experienced by pediatric patients with cancer hospitalized to receive chemotherapy and the clinical correlates of their disrupted sleep have not been measured previously.

Sleep Quality in Hospitalized Children and Adolescents

Children hospitalized in general pediatric units experience a 20%–25% loss of their usual amount of sleep (Hagemann, 1981a, 1981b). Children in intensive care units lose as much as 54% of their usual amount of sleep (Corser, 1996; Cureton-Lane & Fontane, 1991, 1992) and can require one to seven weeks after discharge to return to their overall pre-illness sleep parameters (Corser). Hospitalized pediatric patients have identified that the following factors contribute to their disturbed sleep: noise, lights, lack of control, separation from parents, unfamiliar environment, loss of normal routine, anxiety, pain (Dogan, Ertekin, & Dogan, 2005; Jacob et al., 2006; Jarman, Jacobs, Walter, Witney, & Zielinski, 2002; Keipert, 1985; Warnock & Lander, 1998), and procedures completed during the nighttime hours (Lee, 1995). Two studies reported by Ivanenko, Crabtree, and Gozal (2004, 2005) indicated that certain patient characteristics (depressive symptoms, history of abuse) also contribute to altered sleep quality of hospitalized pediatric patients, as measured by actigraphy.

In an earlier study, Cloutier and Hinds (1999) sought to determine whether children and adolescents hospitalized for cancer treatment reported sleep-disruptive factors similar to those reported by children and adolescents hospitalized for other acute or chronic illnesses. The authors interviewed 10 patients aged 7–18 years who were hospitalized for two to seven days; eight indicated that their sleep was considerably poorer in the hospital than in their own homes. Patients who were aged 12 years or older (n = 5) reported that their bedtime in the hospital was one to four hours later than it was at home. When asked what made the positive difference in their sleep at home versus in the hospital, seven responded with examples of increased daytime activity at home and undisturbed nighttime sleep (Cloutier & Hinds). Sleep patterns of five hospitalized pediatric patients with cancer who were aged 6–11 years were measured in a time-series design (Kline, 1999). All five were enrolled on a standard-risk leukemia protocol (Pediatric Oncology Group 9605) and were receiving short-term (seven days), high-dose (≥ 40 mg per day) oral prednisone as part of their treatment for acute lymphoblastic leukemia. Sleep quality was measured by wrist actigraphy for 14 consecutive days (seven days prior to the prednisone pulse and seven days during the pulse). The patients showed similar sleep duration during the two seven-day periods ($t = 0.185$, $p < 0.85$) but higher activity during sleep (interpreted as poorer sleep quality) in the prednisone treatment week ($t = 2.79$, $p < 0.02$). The findings suggest that anticancer treatment is another factor that affects nocturnal sleep in hospitalized pediatric patients with cancer.

An observational project was completed at St. Jude Children's Research Hospital to document the number of nighttime sleep environment interruptions (e.g., entries and exits from patients' rooms) that 47 hospitalized pediatric patients with cancer experienced. The briefest uninterrupted sleep period that occurred without staff or family members entering or exiting the patients' rooms was 30 minutes, and the longest was four hours, three minutes. The number of times a staff member or parent entered or exited a patient's room ranged from 12–38 times per night (Hinds, 2001). The 47 patients were hospitalized for varied reasons (e.g., scheduled chemotherapy, management of fever or neutropenia, management of treatment side effects, end-of-life care); thus, the patterns of interruption were not specific to one reason, such as scheduled chemotherapy.

In summary, hospitalized pediatric patients with cancer are most likely to experience nocturnal awakenings, sleep environment interruptions, and diminished sleep quality because of a variety of factors, including disease characteristics, treatment factors, environmental characteristics, and changes in patients' usual activity levels. The factors, identified through actigraphy, self-report, and systematic observation, need to be considered in studies of nocturnal awakenings and sleep environment interruptions experienced by children and adolescents being treated for cancer.

Fatigue in Hospitalized Pediatric Patients

Fatigue is one of the three symptoms most frequently reported by male and female adolescents who are healthy (Mears, Taylor, Jordan, & Binns, 2004; Rhee, 2005); who have chronic conditions (Selvadurai et al., 2002); who are hospitalized for medical problems, including pulmonary, gastrointestinal, cardiovascular, oncologic, or neurologic conditions (Franck et al., 2004); who have just experienced endoscopic procedures (Samer Ammar et al., 2003); and who are hospitalized for life-threatening illnesses (Hinds et al., 2000; Hinds, Scholes, Gattuso, Riggins, & Heffner, 1990; Rosen, Bendel, Neglia, Moertel, & Mahowald, 2003). In these and subsequent studies in pediatric oncology, patients most frequently attributed their high prevalence of fatigue to altered sleep patterns, the hospital environment, and treatment-related factors such as certain medications (Bottomley, Teegarden, & Hockenberry-Eaton, 1996; Hinds et al., 1999; Hockenberry-Eaton et al., 1998).

Parents and healthcare providers of children and adolescents being treated for cancer also report patients' fatigue as a moderate to serious symptom (Gibson, Garnett, Richardson, Edwards, & Sepion, 2005). The reports were obtained using dissimilar methods, including multisymptom scales (Collins, 2002; Hinds et al., 1990; Mears et al., 2004), single-symptom instruments (Hockenberry et al., 2003), and diaries and telephone interviews (Franck et al., 2004; Samer Ammar et al., 2003; Wolfe et al., 2000), indicating that regardless of measurement method, researchers still had similar findings that reveal that fatigue is an intense and distressing symptom for pediatric patients with cancer. Improving the sleep experienced by hospitalized pediatric patients with cancer who are already at risk for hospital-related fatigue may prevent or diminish the likelihood of patients experiencing such fatigue, but the nature of the relationship between fatigue and sleep quality indicators first must be assessed.

Purpose

The purpose of this descriptive, longitudinal pilot study was to document the number of nocturnal awakenings and sleep environment interruptions experienced by children and adolescents hospitalized to receive chemotherapy for solid tumors

or acute myeloid leukemia and to determine whether sleep duration and fatigue are correlates of nocturnal awakenings and sleep environment interruptions. A secondary purpose was to assess the acceptability of wrist actigraphy to hospitalized children and adolescents as measured by their refusal or agreement to participate in the study. Key terms used in the study and their definitions are in Figure 1.

Study Framework

The theoretical framework that guided this pilot study was the Human Response Model (HRM) (see Figure 2). The HRM integrates biopsychological factors, individual characteristics or "person factors" that may be modifiable, environmental factors that represent potential risks to adaptation, and individual adaptations (or human responses) to altered health states and to therapeutic interventions designed to improve altered health states (Heitkemper, Levy, Jarrett, & Bond, 1995; Heitkemper & Shaver, 1989).

The four types of human responses are physiologic, pathophysiologic, experiential, and behavioral. The indicators of the HRM components considered in this study include age and gender as nonmodifiable person factors, the number of times staff or family members enter and exit a patient's room during nighttime sleep (11 pm–7 am) and the two hospital settings as environmental factors, hematocrit and hemoglobin levels as physiologic responses, disease diagnosis as the pathophysiologic response, fatigue as the experiential response, and sleep duration and nocturnal awakenings as behavioral responses.

Theoretically, changing one factor in the HRM can improve one or more of the other human responses (e.g., a decrease in sleep environment interruptions could improve sleep duration [behavioral response] and lower hospital-related fatigue [experiential response]). The relationships specified in the HRM are consistent with those identified in previous qualitative research on the factors than can cause or alleviate fatigue in children or adolescents with cancer (Hinds et al., 1999; Hinds & Hockenberry-Eaton, 2001; Hockenberry-Eaton et al., 1998; Hockenberry-Eaton & Hinds, 2000).

Methods

Settings and Sample

Two pediatric cancer centers participated in the study: St. Jude Children's Research Hospital and Texas Children's Cancer Center. The two centers admit 250–425 new pediatric patients with cancer annually. The study was approved by the institutional review boards at both settings. The eligibility of patients to participate in the study was determined by the study team members and the attending physicians for the Solid Tumor Team and Leukemia Team. A study team member approached parents about the study. Only after parental permission was given did the team member discuss the study with patients.

Eligibility criteria included the following: aged 7–18 years, enrollment on a frontline therapeutic protocol or clinical care guidelines for treatment of a solid tumor or acute myeloid leukemia, hospital admission for scheduled chemotherapy between the second and fifth courses of chemotherapy (based on clinicians' recommendations describing that during the first course of chemotherapy, sleep generally is diminished because of the stress of treatment and the novelty of hospitalization, and during the later courses of chemotherapy, sleep is influenced significantly by the cumulative effects of anticancer treatment), ability to understand the English language, ability to give assent according to institutional guidelines, and parental consent to participate.

Exclusion criteria included treatment for recurrent disease and inadequately controlled pain (defined as a score of three or higher on a five-point scale for two consecutive measurements) because of associated fatigue and sleep difficulties that may be secondary to variables (e.g., worry, fear, cytokines) other than those being measured in the present study (Jacob et al., 2006; NIH State-of-the-Science Statement, 2002; Sherman et al., 2004). Patients with central nervous system tumors also were ineligible because sleep problems have been associated with brain injury (Rosen et al., 2003). Given the exploratory nature of the present study, no exclusions were made on the basis of concurrent use of drugs that potentially affect sleep and fatigue, transfusion status, and hematocrit or hemoglobin levels. However, concurrent drug use was documented carefully and considered in the analysis.

Study Design

A study team member placed wrist actigraphs on patients' dominant wrists on the day of admission; nocturnal awakenings and sleep duration were measured according to a discriptive, longitudinal design as outlined in Table 1. Sleep environment interruptions also were documented on room entry and exit checklists that were completed each night by parents and staff members. Sleep and fatigue were monitored during the first two to four days and nights (including the day of admission, which was considered day 0/night 1) of one hospital admission for chemotherapy.

Fatigue was assessed by four instruments that were completed during the late afternoons. On day 0, patients and parents completed their respective fatigue instruments to determine patients' baseline fatigue levels. Patients, parents, and staff completed the instruments on days 1–3 to assess hospital-related fatigue.

Hematocrit and hemoglobin levels were determined by complete blood count testing of daily blood samples per standard care practices at both settings, and concurrent medications and transfusion records were monitored daily. Demographic factors also were recorded. Parents and staff members (physicians, nurses, nursing care assistants, and housekeepers) who worked the night shift completed the room entry and exit checklists, which were placed on patients' doors each night.

Sleep Measures

Wrist actigraphy: Patients wore a Mini-Motionlogger® AAM-32 (Ambulatory Monitoring, Inc., Ardsley, NY) wrist

Nocturnal awakenings: wake episodes that occurred between the onset and offset of each nighttime sleep interval as measured by actigraphy

Sleep duration: the total number of minutes scored as sleep during each nocturnal sleep interval as measured by actigraphy

Sleep environment interruptions: the combined number of times that staff and family members entered and exited a child's or adolescent's hospital room during an eight-hour night shift, including entries and exits that visibly disturbed the patient's sleep and those that did not as measured by parent and staff report on a room entry and exit checklist

Figure 1. Definitions of Key Terms

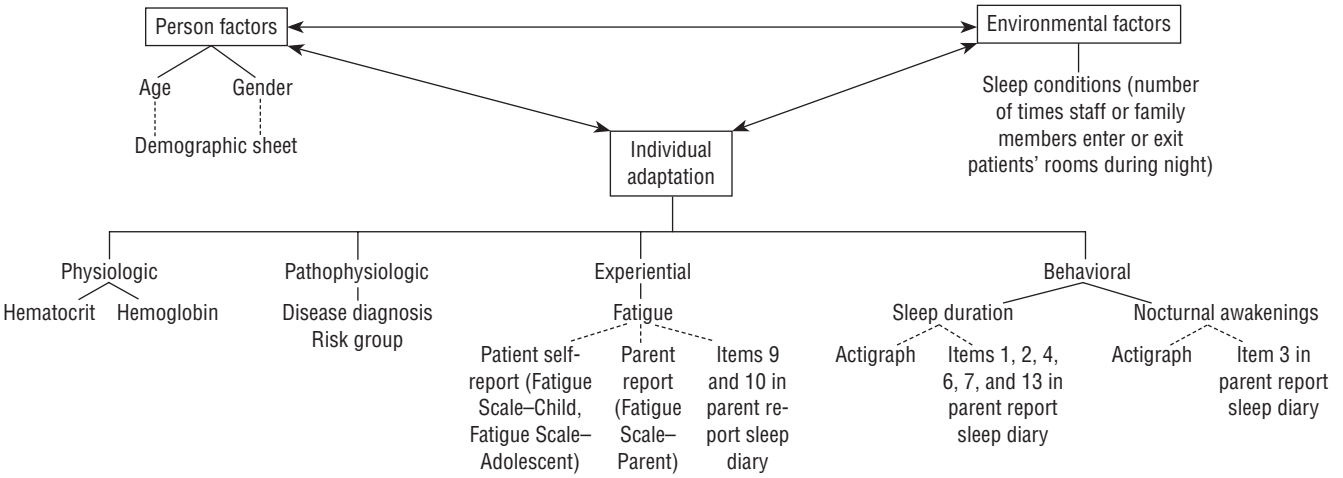

Figure 2. Human Response Model for Sleep and Fatigue in Hospitalized Pediatric Patients With Cancer

actigraph continuously from day 0–day 2 or 3 of their hospitalization. The epoch length was programmed to be one minute long. The accompanying scoring program computed nocturnal awakenings and sleep duration. An actigraph is a wristwatch-sized monitor that detects and records the wearer's movement. Thus, actigraphic measures are relatively high during waking hours and near zero during sleep. Analysis of actigraphic records reveals sleep-wake patterns that correlate closely with polysomnographic recordings of brain waves and behavioral observations (Sadeh, Acebo, Seifer, Aytur, & Carskadon, 1995; Sadeh, Hauri, Kripke, & Lavie, 1995; Sadeh, Lavie, Scher, Tirosh, & Epstein, 1991). Actigraphs have been used to monitor sleep in children and adolescents because they are relatively inexpensive and nonintrusive and can be used in the home environment. Actigraphy also has been used to validate parental reports of their children's sleep abnormalities (Sadeh et al., 1991); in this case, actigraphic data are more objective and accurate (Bringhurst, Waterston, Schofield, Benjamin, & Rees, 2004; Sadeh, 1994, 1996; Sadeh, Sharkey, & Carskadon, 1994).

Sleep diary: During days 0–3 of the study, parents completed a daily sleep diary consisting of a 15-item scale that measured parents' perceptions of their children's sleep and nap patterns during the previous 24 hours. The items were derived from a sleep questionnaire developed by Sadeh (1994) to identify characteristics of sleep such as latency, efficiency, duration, and quality. Additional items in the diary were related to naps, tiredness, and perceived energy level. Sleep diaries have been completed successfully by parents in a number of studies with minimal missing data, but the amount of missing data increases as the time in the study continues. The sleep diary can be completed in six to eight minutes.

Table 1. Sleep Study Design

	Day of Hospitalization			
Measure and Method	**0[a]**	**1**	**2**	**3**
Sleep				
Actigraphy	–	X	X	X
Sleep diary	–	X	X	X
Room entry and exit checklist	–	X	X	X
Fatigue				
Fatigue Scale–Child, Fatigue Scale–Adolescent	X	X	X	X
Fatigue Scale–Parent	X	X	X	X
Fatigue Scale–Staff	X	X	X	X
Physiologic factors				
Hemoglobin level	–	X	X	X
Hematocrit	–	X	X	X
Transfusion record	–	X	X	X
Concurrent medications	–	X	X	X

[a] Baseline fatigue was measured on the day of admission to the hospital.

Fatigue Assessment

The **Fatigue Scale–Child (FS-C),** a self-report instrument, was designed for children aged 7–12 years. It consists of 14 items that describe the intensity of fatigue during a 24-hour period on a five-point, Likert-type scale. Intensity ratings range from 14 (no fatigue symptoms) to 70 (high fatigue). The FS-C has been reviewed for face, content, and construct validity (with three factors emerging from the latter analysis: lack of energy, inability to function, and altered mood), and, in the most recent testing in a group of 149 pediatric patients with cancer, it was internally consistent (Cronbach's alpha of 0.84). The FS-C requires six to eight minutes to complete (Hinds & Hockenberry-Eaton, 2001; Hockenberry et al., 2003; Hockenberry-Eaton & Hinds, 2000). The daily Cronbach's alpha for the FS-C in the present study ranged from 0.64–0.72.

The **Fatigue Scale–Adolescent (FS-A)** was designed for children aged 13–18 years. The self-report instrument consists of 14 items that measure the perceptions of adolescents with cancer of their fatigue intensity on either a daily or weekly basis. Intensity ratings range from 14 (no fatigue symptoms) to 70 (high fatigue). The FS-A has been reviewed by panels composed of adolescents and healthcare providers for face and content validity. The FS-A requires four to five minutes to complete (Hinds & Hockenberry-Eaton, 2001; Hockenberry et al., 2003; Hockenberry-Eaton & Hinds, 2000). The daily Chronbach's alpha for the FS-A in the present study ranged from 0.76–0.96.

The **Fatigue Scale–Parent (FS-P)** consists of 18 items that measure parents' perceptions of their children's fatigue during the previous 24 hours on a five-point, Likert-type scale. Intensity scores range from 18 (no fatigue) to 90 (high fatigue). The

FS-P is used by parents of children and adolescents. The FS-P has been completed by 150 parents and has been found to be internally consistent (Cronbach's alpha of 0.87). Exploratory factor analysis yielded four factors: lack of energy, inability to function, altered sleep, and altered mood. The FS-P can be completed in four to six minutes (Hinds & Hockenberry-Eaton, 2001; Hockenberry et al., 2003; Hockenberry-Eaton & Hinds, 2000). The daily Cronbach's alpha for the FS-P in the present study ranged from 0.78–0.90.

The **Fatigue Scale–Staff (FS-S)** is a 10-item scale that measures staff's perceptions of a patient's fatigue during the previous 24 hours. Intensity ratings are on a four-point, Likert-type scale and range from 1 (no apparent fatigue) to 4 (almost always fatigued). Staff use the same instrument for children and adolescents. The FS-S, which has been reviewed for content validity by panels of healthcare providers of pediatric patients with cancer, is internally consistent (Cronbach's alpha of 0.87) and requires less than four minutes to complete (Hockenberry et al., 2003). The daily Cronbach's alpha for the FS-S in the present study ranged from 0.86–0.95.

Other Data Collected

Room entry and exit checklists allowed parents and staff members to document the times when they entered and exited a child's room from 11 pm–7 am and whether the child stirred or woke up during each entry or exit. A study team member compared the staff entry and exit times on the checklists with the medical record notations regarding drug or fluid administration and nursing note entries to confirm the accuracy of the checklist entries. When discrepancies were noted, the study team member met with the assigned night shift nurse within one or two subsequent night shifts to resolve them.

A study team member recorded patients' medication history, including chemotherapy regimens (e.g., agents, time of administration), on days 0–3, and patients' transfusion status, hemoglobin levels, and hematocrit measures for each 24-hour period during hospitalization.

Statistical Analyses

Descriptive statistics were applied to all study variables. Mixed-effect models were used to analyze the longitudinal change during the two to four nights of hospitalization. The authors assumed equal correlation between two consecutive observations. Random participant effect was included to address the heterogeneity of the study sample. The models were extended to include the independent variables that changed over time as time-varying covariates in addition to fixed covariates such as gender and site. Log transformation was used to analyze discrete counts (such as the number of nocturnal awakenings), and logit transformation was used to analyze discrete scores (such as from the FS-C, FS-A, FS-P, and FS-S) as well as the assumption of nomality (Rai, Lensing, Boyett, & Phipps, 2004). A higher value for significance, alpha = 0.10, was selected because of the exploratory nature of the pilot study and the minimal risk involved (Piantadosi, 1997).

Results

Twenty-nine of 30 eligible patients were enrolled during the 29-month period; one patient declined enrollment. The high participation rate was interpreted as indicative of the acceptability of study methods to hospitalized patients. Most of the study participants were female, Caucasian, and diagnosed with solid tumors. Participants were aged 7.36–18.16 years (mean age = 12.48 years, SD = 2.93) (see Table 2). Data from two patients were not included in the analysis: One patient completed only the day 0 study instruments and removed the actigraph, and the other's actigraph data included only extreme values, suggestive of instrument malfunction. Medical chart review showed that none of the study participants received sleep hypnotics or steroids during hospitalization. Participants were treated by one of 15 different chemotherapy regimens specific to their diagnoses.

Nocturnal Awakenings

The number of nocturnal awakenings ranged from 0–40 (median = 14) per night; the highest number of awakenings occurred on the final night of hospitalization. Only one patient had no sleep awakenings, and that was noted on only one night. Three (11%) patients experienced one to three awakenings during the first 30 minutes of the nocturnal sleep period. The longest nocturnal sleep period without awakenings for 19 (70%) patients was one hour on one to two nights; for six (22%) patients, the longest period without awakenings was two hours on one to two nights; and for two (7%) patients, the longest uninterrupted period without awakenings was four hours on one night. The number of nocturnal awakenings during the first night was significantly lower than that experienced during the second night ($t = -2.95$, $p = 0.017$).

Room entry and exit checklists revealed that parents and staff members entered and exited patients' rooms 3–22 times per night; the highest number of entries and exits occurred on the second night of hospitalization (see Table 3). The combined reports from staff and parents indicated that they visibly observed disturbance of patients' sleep as a result of their entry or exit 1–14 times per patient during each night shift; no sleep disturbance was detected for another 1–14 entries and exits per patient each night.

Nocturnal Awakenings, Sleep Duration, and Fatigue

The number of nocturnal awakenings was significantly related to fatigue over the course of hospitalization (n = 26,

Table 2. Patient Demographic Characteristics

Variable	n	%
Age (years)		
$\bar{X}$ (SD) = 12.48 (2.93)	–	–
Median (range) = 11.72 (7.36–18.16)	–	–
Gender		
Female	17	59
Male	12	41
Race or ethnicity		
Caucasian	21	72
African American	4	14
Hispanic or Latino	4	14
Diagnosis		
Solid tumor	25	86
Acute myeloid leukemia	4	14
Study site		
St. Jude Children's Research Hospital	17	59
Texas Children's Cancer Center	12	41

N = 29

Table 3. Descriptive Statistics of Variables Related to Sleep Quality

	Day of Hospitalization				
Variable	**0**	**1**	**2**	**3**	**0–3**
Sleep duration (minutes)					
N	–	24	26	22	27
$\bar{X}$	–	548.75	596.92	591.64	582.08
SD	–	125.82	139.82	136.94	133.75
Median	–	537.00	607.00	594.00	591.50
Range	–	255–808	303–829	322–815	255–829
Number of nocturnal awakenings					
$\bar{X}$	–	12.52	16.69	16.64	15.32
SD	–	6.13	5.63	10.33	7.68
Median	–	13.00	16.00	12.50	14.00
Range	–	0–30	1–23	5–40	0–40
Number of room entries and exits					
$\bar{X}$	–	11.40	11.40	11.00	11.30
SD	–	4.40	4.20	3.60	4.00
Median	–	11.00	13.00	11.00	11.00
Range	–	3–19	3–22	4–18	3–22
Hemoglobin level					
$\bar{X}$	9.87	9.21	8.98	9.60	9.55
SD	1.26	1.28	1.38	0.70	1.18
Median	10.10	9.45	9.20	9.70	9.80
Range	7.8–12.2	7.4–10.9	7.3–10.8	8.5–10.9	7.3–12.2
Hematocrit					
$\bar{X}$	28.78	26.60	26.00	27.85	27.75
SD	3.92	4.01	4.42	1.63	3.64
Median	29.45	26.80	26.15	27.60	28.60
Range	22.0–35.3	21.8–31.9	20.3–31.7	26.0–30.4	20.6–35.3

F = 5.71, p = 0.027) (i.e., the more awakenings experienced, the greater the fatigue reported by patients). The number of nocturnal awakenings also was significantly related to sleep duration over the course of hospitalization by patient report (n = 27 patients; F = 6.35, p = 0.014, unadjusted for baseline fatigue; F = 6.54, p = 0.013, adjusted for baseline fatigue) and by parent report (n = 25 parents; F = 7.87, p = 0.007). Thus, the higher the number of nocturnal awakenings, the longer patients slept.

Using an exploratory approach, the authors examined nocturnal awakenings first by descriptive statistics (see Table 4) and then by a histogram and scatter plot analysis to identify the minimum number of awakenings associated with the escalation of the patient-reported FS-C and FS-A fatigue scores. Twenty awakenings appeared to be the point at which higher fatigue scores were observed; 17 study participants experienced more than 20 awakenings in their nocturnal sleep during at least one night. Nocturnal awakenings then were examined using a mixed-model approach; scores were grouped by those with fewer than 20 awakenings per night and those with 20 or more awakenings per night. In the former group, fatigue scores were significantly lower (t = –2.13, p = 0.037) and sleep duration was significantly shorter (t = –2.72, p = 0.0084).

Physiologic and Demographic Factors

To assess the effects of demographic factors on nocturnal awakenings, one variable at a time (such as site) was included as a covariate in the mixed model. The number of nocturnal awakenings did not differ between the two study sites (F = 0.21, p = 0.6526). In addition, the number of nocturnal awakenings and changes in sleep duration and fatigue levels were not associated with age, diagnosis, gender, baseline fatigue levels, or length of hospitalization. The hematocrit and hemoglobin values also did not affect the parameters. In regard to changes in fatigue, the hematocrit and hemoglobin values were not related, as indicated by FS-C scores (F = 0.0, p = 0.97), FS-A scores (F = 0.10, p = 0.75), FS-P scores (FS-P [child]: F = 2.91, p = 0.12 and FS-P [adolescent]: F = 3.77, p = 0.08), and FS-S scores (FS-S [child]: F = 2.12, p = 0.17 and FS-S [adolescent]: F = 2.14, p = 0.17).

Sleep Diaries and Nocturnal Awakenings

A mixed-effect model analysis was used to assess the association between changes in the number of nocturnal awakenings as measured by wrist actigraphy and daily sleep diary data provided by parents (see Table 5). No significant associations were noted. The relationship between nocturnal awakenings and the daily sleep diary data also was analyzed using a Spearman correlational statistic. The question "How many other people were sleeping in the same room?" was negatively correlated with the number of nocturnal awakenings (rho = –0.29, p = 0.012). The finding indicated that when one or more people slept in patients' rooms, patients experienced fewer nocturnal awakenings. Nocturnal awakenings also were significantly related to the diary item "How many times did your child wake up during the night?" (rho = 0.22, p = 0.065).

A mixed model was used to assess whether actigraph measurement of nocturnal awakenings was related to the sleep environment interruptions as measured by the room entry and

Table 4. Descriptive Statistics of Fatigue Scales

Scale	Day of Hospitalization				
	0	1	2	3	0–3
Fatigue Scale–Child					
N	17	16	18	15	18
$\bar{X}$	16.59	22.69	23.22	23.33	21.41
SD	4.54	7.04	8.27	7.53	7.41
Range	9–24	13–43	9–39	12–38	9–43
Fatigue Scale–Adolescent					
N	8	9	9	7	9
$\bar{X}$	24.00	31.67	33.78	37.00	31.05
SD	5.93	9.49	11.69	12.75	10.81
Range	15–33	15–43	15–58	15–60	15–60
Fatigue Scale–Parent (child)					
N	18	18	18	16	18
$\bar{X}$	33.78	42.44	43.22	45.31	41.07
SD	10.62	10.44	11.66	12.77	11.97
Range	18–51	19–64	21–68	28–68	18–68
Fatigue Scale–Parent (adolescent)					
N	8	9	9	7	9
$\bar{X}$	41.00	42.89	44.33	40.71	42.36
SD	5.15	13.07	13.48	16.14	12.04
Range	34–50	22–69	20–68	24–66	20–69
Fatigue Scale–Staff (child)					
N	–	18	18	16	18
$\bar{X}$	–	16.28	16.33	15.00	15.90
SD	–	5.42	4.67	5.66	5.18
Range	–	9–25	9–23	9–29	9–29
Fatigue Scale–Staff (adolescent)					
N	–	9	9	8	9
$\bar{X}$	–	18.78	19.78	16.75	18.50
SD	–	4.63	7.38	7.98	6.60
Range	–	13–28	12–33	10–34	10–34

exit checklist data. Room entry and exit data were grouped according to whether an entry or exit appeared to disturb patients' sleep. The actigraph data were significantly associated with room entries and exits during which patients' sleep appeared to be disturbed ($p = 0.04$) but were not associated with entries and exits that did not appear to disturb patients' sleep ($p = 0.93$).

Discussion

The sleep experience of pediatric patients with cancer hospitalized at two pediatric cancer centers for two to four days and nights to receive chemotherapy for solid tumors or acute myeloid leukemia was assessed from the perspective of patients, families, and nursing staff. Although the study was not able to directly address the level of sleep or the extent to which restorative sleep was obtained by hospitalized patients, the findings do address the acceptability of wrist actigraphy and self-report instruments to patients and their parents, the frequency with which hospitalized pediatric patients with cancer experience nocturnal awakenings and sleep environment interruptions during nighttime hours, and the associated fatigue that resulted.

The patients in the present study experienced as many as 40 nocturnal awakenings during each night of their hospitalization. The awakenings may be attributed partially to the number of times that family members or staff members entered and exited patients' rooms during the nocturnal sleep period and visibly disturbed patients' sleep. Of interest was the finding that patients experienced fewer awakenings when parents or guardians were sleeping in the children's hospital rooms. The result could be secondary to the reduced number of times that parents entered and exited the rooms, but it also could be secondary to what staff members described as their concerted efforts not to awaken sleeping parents in patients' rooms or to children's comfort in having their parents in the hospital rooms contributing to a higher-quality sleep that is less vulnerable to certain environmental sounds or conditions. Fewer awakenings also were noted on the first night of hospitalization as compared to the second and third nights. Potential explanations include (a) the child or adolescent typically was admitted in the late afternoon or evening after a day of usual outpatient activity, whereas subsequent days of hospitalization may have altered the rest and activity ratio for each patient, (b) the prehydration routines of the first night of an admission that precedes a chemotherapy regimen administered during an inpatient stay may require fewer room entries and exits by staff members compared to the subsequent nights of chemotherapy administration and monitoring, or (c) the chemotherapy may itself affect the children's normal sleep cycles and contribute to more night awakenings.

The lack of association between the actigraph data and the items in the sleep diary kept by parents suggests that parents

Table 5. Relationship Between Nocturnal Awakenings Detected by Actigraphy and Seven Items on the Daily Sleep Diary Maintained by Parents

Diary Item	n	F	p
Did your child wake up during the night?	26	2.18	0.13
Did your child sleep restlessly?	16	0.03	0.97
How many other people were sleeping in the same room?	27	2.24	0.12
Was another person sleeping in the same bed?	27	0.81	0.37
Did your child seem tired during the day?	27	0.26	0.77
Did your child seem to have less energy than usual?	27	0.10	0.9
Were there any unusual events that could have affected your child's sleep?	27	0.01	0.94

may not be adequately aware of their hospitalized children's sleep parameters. The lack of association in the items related to the parents' impressions of their children's daytime fatigue could indicate the difficulty that parents experience when attempting to rate their children's subjective impressions or sensations. Also, the diary items themselves may not be adequately sensitive to children's sleep and fatigue experiences during hospitalization.

The differences in the number of nocturnal awakenings measured by actigraph and the sleep environment interruptions reported by family and staff could be attributed in part to underreporting by those entering and exiting the hospital room; however, a more complete explanation may include other sources of influence on sleep quality during hospitalizations, such as the effects of chemotherapy or disruptions that are external to study participants' hospital rooms. Study participants spontaneously reported being disturbed by announcements made over the hospital's public address system, noisy carts being pushed down the hallway, care procedures in and near patients' rooms, and staff conversations. The reports were documented in the study team members' field notes and are similar to disruptions documented in other studies of hospitalized pediatric patients, including noise, lights, lack of control, separation from parents, unfamiliar environment, loss of normal routine, anxiety, pain (Jacob et al., 2006; Jarman et al., 2002; Keipert, 1985; Warnock & Lander, 1998), and nocturnal care procedures (Lee, 1995). Some of the sources of sleep disruption can be controlled by nurses, and nurses' ability to do so needs to be ensured by hospital policy, work procedures, and educational interventions with staff members regarding the relationship between nocturnal awakenings and sleep environment interruptions and specific indicators of patient health status (Jarman et al.).

The study findings also identified that approximately 30 minutes was the briefest period of nocturnal sleep before an awakening occurred and that four hours was the longest period each night for hospitalized pediatric patients with cancer. The range was similar to that derived from the authors' previous observational data that consisted of more than 542 hours of night shift entries and exits from inpatient rooms of pediatric patients with cancer with more varied diagnoses and reasons for hospitalization. Nocturnal awakenings and sleep environment interruptions of the frequency documented in the study are very likely to affect overall sleep quality.

The relationships among sleep duration, fatigue, and nocturnal awakenings were not linear in the study. Longer duration of sleep time did not equate to lower fatigue or fewer nocturnal awakenings. More time in bed may result in less diurnal patient activity. More time in bed also could reduce the amount of time that a child with cancer is available to benefit from important adjunctive treatments such as rehabilitation, nutrition, and child-life experts.

The study results demonstrate a relationship between nocturnal awakenings and a clinical symptom—hospital-related fatigue. Associating a clinical symptom with nocturnal awakenings is an important first step toward examining the actual health effects that disrupted sleep has on pediatric patients with cancer during hospitalizations. Future studies can broaden this investigation of the effects of disrupted sleep on health during hospitalization by including indicators of immunosuppression, anorexia, ability to concentrate, and physical healing, among other relevant clinical outcomes. Although only a small number of person and treatment factors were considered in the pilot study, of note is that the change in fatigue during hospitalization was not associated with person factors (age and gender), diagnosis, or supportive care (e.g., lack of use of any soporific agents). Only sleep quality indicators (i.e., nocturnal awakenings and sleep duration) appeared to be associated with fatigue levels. The finding has particular implications for nurses because the sleep environment of a hospital rather than the characteristics of a patient, the disease, or its treatment can be affected most directly by nursing care. Future studies also could examine more personal and health characteristics, such as mood and health history, and their associations with sleep quality indicators.

The current study represents the first use of the HRM to guide a prospective clinical trial in pediatric oncology. Study findings support certain theoretical linkages in the model, but not all of them. Nocturnal awakenings (behavioral) did not differ by person factors (age or gender), physiologic factors (hematocrit or hemoglobin level), or pathophysiologic factors (disease type). However, nocturnal awakenings were associated with the experiential factor of fatigue (as measured by FS-C and FS-A) and the behavioral factor of sleep duration (as measured by actigraph). In addition, by reducing the number of sleep environment interruptions to fewer than 20, the experiential adaptation factor of fatigue is likely to be reduced in intensity. In summary, by attempting to minimize the number of nocturnal awakenings (experiential) and sleep environment interruptions (environmental), nurses may be able to affect patient behavioral adaptation variables. Additional assessments of the HRM in larger studies are needed to determine its ability to guide symptom research involving pediatric patients with cancer.

Conclusion

Pediatric patients with cancer hospitalized to receive chemotherapy are very likely to experience repeated nocturnal awakenings and sleep environment interruptions caused by a number of diverse sources. Because of those sleep disruptive factors, they also are likely to experience longer sleep duration periods and hospital-related fatigue. Such patients sleep longer but not necessarily better, and longer sleep periods may, in fact, interfere with daytime activity, which, in turn,

may adversely affect quality sleep during subsequent nights of hospitalization.

For the first time, research findings support a relationship between sleep quality and a clinical symptom, hospital-related fatigue in pediatric patients with cancer. Nurses can positively influence certain factors that affect patients' sleep quality by initiating work procedures and educational interventions with staff members regarding the relationship between nocturnal sleep interruptions and specific indicators of patient health status. By affecting factors that influence nocturnal awakenings and sleep environment interruptions, nurses can contribute to improved sleep quality and can prevent or minimize hospital-related fatigue in pediatric patients with cancer during hospitalizations for scheduled chemotherapy.

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