RESEARCH ARTICLE

Timing and Duration of Sleep in Hospitalized Children: An Observational Study

Ellen L. Cowherd, BA,[a] Ashley G. Sutton, MD,[a,b] Jennifer O. Vincent, MD,[a,b] Michael S. Humphries, BS,[a] Victor Ritter, BS,[a,c] Jason Fine, PhD,[a,b] Michael J. Steiner, MD, MPH[a,b]

ABSTRACT

BACKGROUND AND OBJECTIVES: Sleep during hospitalization is important, but data on children's sleep quality during hospitalization are lacking. We sought to document sleep duration and awakenings in hospitalized children and explore associations between sleep and chronic care complexity, home sleep quality, and late-night food consumption.

METHODS: Children aged 2 to 17 years admitted to a hospitalist service for at least 24 hours were approached for participation. Children were video recorded from 20:00 to 08:00. Paired investigators reviewed recordings and extracted data. Investigators blinded to sleep data separately extracted clinical and demographic information. Analyses included Spearman correlations and linear and generalized linear regression models with t and Wald χ^2 tests.

RESULTS: The mean time subjects (n = 57) initiated sleep was 22:35 (range: 20:00–02:47), with a mean sleep duration of 475 minutes (89–719 minutes). Subjects awakened 2.2 times (0–7 times, SD: 1.9) per night, on average, with the average total time awake during those awakenings of 55.7 minutes (2–352 minutes, SD: 75 minutes). In multivariate analysis, children with private insurance had longer sleep duration. Additionally, subjects who ate a snack after 21:00 went to sleep much later (odds ratio: 9.5; confidence interval: 2.6 to 34.9) and had 64 minutes less total sleep time and spent less time in bed than patients who did not eat late (P = .007).

CONCLUSIONS: Hospitalized children sleep less than recommended and experience frequent awakenings. Some demographic variables are related to sleep. Many hospitalized children also consume food at night, which is associated with later bedtime and less sleep. Future efforts to improve sleep in hospitalized children are needed.

www.hospitalpediatrics.org
DOI:https://doi.org/10.1542/hpeds.2018-0236

Address correspondence to Michael J. Steiner, MD, MPH, Department of Pediatrics, University of North Carolina School of Medicine, 231 MacNider Hall, 333 S. Columbia St, Chapel Hill, NC 27599. E-mail: msteiner@med.unc.edu

HOSPITAL PEDIATRICS (ISSN Numbers: Print, 2154-1663; Online, 2154-1671).

FINANCIAL DISCLOSURE: The authors have indicated they have no financial relationships relevant to this article to disclose.

FUNDING: No external funding.

POTENTIAL CONFLICT OF INTEREST: The authors have indicated they have no potential conflicts of interest to disclose.

Ms Cowherd conceptualized and designed the study, designed the data collection instruments, coordinated and performed data collection, and drafted the initial manuscript; Drs Sutton and Vincent supervised data collection, coordinated and performed data collection, and reviewed and revised the manuscript; Mr Humphries coordinated and performed data collection; Mr Ritter and Dr Fine supervised the analysis and interpretation of the data and reviewed and revised the manuscript; Dr Steiner conceptualized and designed the study, conducted initial analyses, and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.

[b]*Department of Pediatrics, School of Medicine,* [c]*Department of Biostatistics, Gillings School of Global Public Health,* [a]*The University of North Carolina at Chapel Hill, Chapel Hill, North Carolina*

Sleep is an essential physiologic function that impacts overall health. The American Academy of Sleep Medicine recommends children 1 to 2 years old sleep 11 to 14 hours, children 3 to 5 years old sleep 10 to 13 hours, children 6 to 12 years old sleep 9 to 12 hours, and children 13 to 18 years old sleep 8 to 10 hours.[1] Shorter sleep duration is associated with a wide variety of negative health and well-being outcomes, including poor emotional regulation and academic achievement and poorer quality of life,[2] greater adiposity and obesity in children,[3] hormonal changes and decreased physical activity and energy expenditure,[3–6] and dysfunction in immunity.[7] Continuous sleep is also important because interrupted sleep is associated with decreased cognitive capabilities and memory impairment.[8] Additionally, late-night eating contributes to less total sleep duration and higher BMI values.[9–11]

For hospitalized children, sleep is critical for recovery, energy conservation, and wellness.[12] However, the logistics of hospitalization may disrupt sleep at a time when its therapeutic benefits are most needed. In studies of children receiving intensive care or treatment of malignancy, the most common reason for nighttime waking is environmental noise, such as doors closing or monitor alarms.[12–14] Temperature, sleep position, pain, anxiety, and comfort of hospital beds also impact sleep quality for specific patient populations.[15,16] Minimizing sleep interruptions in pediatric hospital settings has implications for recovery and long-term prognosis.[12]

Our purpose in this study is to document directly observed duration of nighttime sleep and sleep awakenings in hospitalized children on a general pediatrics hospitalist service. We also sought to identify potential factors that impact sleep duration, such as baseline care complexity, parental report of home sleep quality, and late-night food and/or beverage consumption. We hypothesized that hospitalized children experience less sleep than recommended, potentially because of delayed initiation of sleep, illness, and hospitalization-related awakenings. We also hypothesized that increasing complexity of illness and late-night eating in hospitalized patients is associated with decreased sleep duration.

METHODS

Setting

The study was performed at a single-center, 150-bed academic tertiary care children's hospital within a larger health care system in the southeastern United States. Patients with general conditions requiring hospitalization at our center are placed on 1 of 2 hospitalist services. All rooms are single-patient rooms with a parent sleep area, and patients have a la carte ordering for meals at the time desired by the patient, with a wide selection of food options.

Study Population

A sample of English-speaking children aged 2 to 18 years old admitted over a 16-month period to either hospitalist service for at least 24 hours by 20:00 on the day of enrollment were eligible for inclusion. On nights investigators were available, a patient census for the hospitalist teams was obtained that contained name, age, duration of hospitalization, and room number for the 2 services to identify children for study participation. A maximum of 3 subjects could be enrolled each night based on recording equipment availability. A random-number generator was used to determine the order patients were approached for study enrollment each night. Guardian presence was required at enrollment. If a guardian was not initially present, the child was moved to the bottom of the randomly generated list to be reapproached later in the evening if 3 other patients had not enrolled. In addition to guardian consent, children aged 7 to 17 years provided assent for inclusion. At the time of enrollment, children were assigned a study number, by which they were identified on further participant-specific documentation to ensure blinding and proper maintenance of protected health information.

Procedures

After enrollment, each guardian completed the Tayside Children's Sleep Questionnaire (TCSQ) (Supplemental Fig 2), a previously validated 10-item questionnaire used to assess baseline sleep habits over the previous 3 months.[17] Additionally, the guardian answered 2 questions on the participant's typical caffeine consumption and recalled caffeine consumption on the day of observation. Next, a Canon M400 digital video camera was set up and secured in the patient room such that the bed was clearly visible. Recording was initiated for all subjects beginning at 20:00. Care providers, including the primary nurse, were notified of patient enrollment and a "Recording in Progress" sign was placed on the door to notify other staff before entering the room during the night. Recording was manually discontinued at 08:00 the next morning. Guardians were reconsented at that time in the event families no longer wanted to participate and/or wanted the recording deleted before review.

Data Extraction and Analysis

Data were extracted from digital recordings while viewed at double speed. Two investigators (E.L.C. and M.S.H.) each viewed the first 10 recordings to establish coding and questionnaire scoring consistency. Thereafter, 1 investigator coded each recording and questionnaire. The running time stamp in the recording was used to extract the following: attempted time of sleep initiation (determined by the initial time the child was in bed and in position to sleep), time of apparent sleep onset (determined by closing of the child's eyes and lack of movement), frequency and apparent reason for awakenings after sleep initiation, location of guardian (in bed with child, out of view, etc), lighting conditions in the room, and food and beverage intake. Food intake was scored as a snack, which was <2 foods, or a meal, defined as eating at least 2 different foods. Sleep duration was determined by calculating time between initiation of sleep and ultimate morning awakening. If children were still asleep when recording period ended, 08:00 was used as the time awake for sleep calculations.

One of 2 physician investigators (A.G.S. and J.O.V.), blinded to sleep data, reviewed the medical record of enrolled patients to obtain date of birth, race, sex, insurance provider, diagnoses, and medications.

Additionally, admitting diagnosis, chronic medical conditions, previous hospitalization history, and length of stay were also recorded. Diagnoses were grouped by system for analysis. To assess baseline chronic medical complexity and care use, we used the Medical Fragility Subscale from the Special Needs Program Care Coordination Intensity Tool as a care complexity tool (CCT) (Supplemental Fig 2), which was available online at the time of the study. In this CCT subscale, Likert scoring is used to assess degrees of complexity and use on the basis of the number of medical specialists, frequency of clinic visits, emergency department use, hospitalizations and length of stays, technology needs, and number of medications used long-term. Possible total CCT scores range from 1 to 35 on the basis of answers in subset categories. Investigators who designed the tool have subsequently grouped patients by categories of medical fragility on the basis of scores; however, we used raw scores as continuous variables.[18,19]

Mean, SD, and range were used to summarize continuous measurements. Categorical characteristics are presented as counts and proportions. Unadjusted analysis was performed by using Spearman correlations to explore associations between sleep outcomes with age, BMI, and questionnaire scores. One-way analysis of variance procedures were considered for categorical factors. Statistically significant predictors and controlling factors (race, insurance, and CCT) were used for adjusted analyses, with multivariable linear regression models for sleep, arousal, and bedtimes, and the number of awakenings was modeled with segmented Poisson regression with dispersion correction. Ordinal logistic regression was used to model clock time asleep.

Statistical analysis was performed by using SAS 9.4 (SAS Institute, Inc, Cary, NC) for Windows. Data and documents in this study were identified by subject study number and securely stored. The Institutional Review Board and Office of Human Research Ethics at the University of North Carolina at Chapel Hill (Biomedical Institutional Review Board: 117927) approved this study.

RESULTS

A total of 156 patients were eligible for the study; 89 of those enrolled were included, although some of those included had incomplete data collection. No parents withdrew consent in the morning after the recording had been completed. In Fig 1, we detail subjects randomly assigned to be approached, enrollment, and data collection, and subject characteristics are included in Table 1.

The average age of enrolled subjects was 10 years (range: 2–17 years), and average length of stay before recording was 2 days (range: 1–14 days). The majority of subjects was girls, white, and insured by Medicaid (Table 1). Based on video confirmation, 74% of subjects had a parent or guardian confirmed in the room during sleep, 2% did not, and 23% could not be determined as a result of no adult appearing in the recording, the camera being focused on the child and bed, or an adult other than the consenting guardian visible during recording. The most common admitting diagnoses were neurologic, gastrointestinal, or infectious problems, and participants had a mean CCT score of 8.6 (3–22). The mean bedtime was 22:35 (range: 20:00–02:47), with a mean total sleep time of 475 minutes (89–719 minutes). The average number of awakenings during the night was 2.2 (0–7), with an average total time awake of 56 minutes (2–352 minutes) during those awakenings. The majority of awakenings (53%) with a clear cause were related to a staff member entering the room to provide care or interact with equipment such as monitors and intravenous pumps. After multivariate regression, children who went to sleep in the latest quartile (after 23:00) had fewer awakenings after they went to sleep (0.62 times the rate of awakening, $P = .039$).

Almost half of children (41%) were observed eating after 21:00. Of those who ate, 36% had a late-night meal. On survey, 21% of the sample reported drinking caffeine-containing beverages on the day of the observation.

Demographic Characteristics, Sleep at Home, and Hospital Sleep Outcomes

In bivariate analysis, some demographic variables were strongly associated with sleep outcomes in the hospital (Table 2).

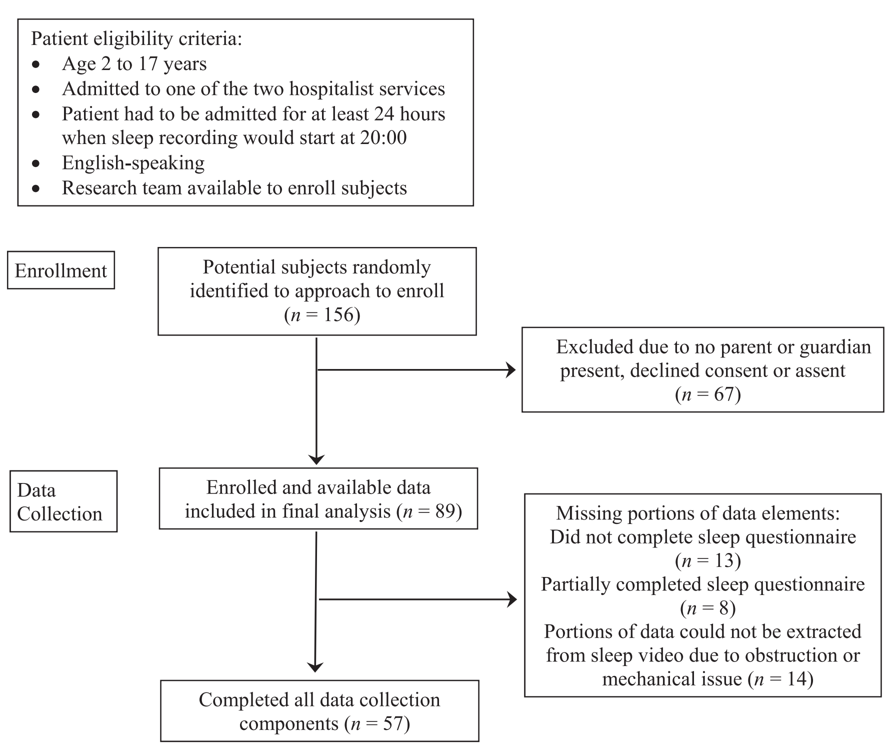

FIGURE 1 Flow diagram of subject enrollment and completion.

TABLE 1 Baseline Demographic, Sleep, and Oral Intake Information for Included Subjects

Characteristic	Grouping	Subjects, *n* (%)
Sex	Girls	53 (59.6)
	Boys	35 (39.3)
	Missing	1 (1.1)
Self-identified race	AA	20 (22.5)
	White	57 (64)
	Other or not designated	11 (12.4)
	Missing	1 (1.1)
Insurance	Medicaid	41 (46.1)
	Private	36 (40.5)
	Tricare	10 (11.2)
	Other	1 (1.1)
	Missing	1 (1.1)
Sleep difficulties at home	No	50 (56.2)
	Yes	20 (22.5)
	Missing	19 (21.4)
Clock time asleep	Before 21:59	24 (27)
	22:00–22:59	22 (24.7)
	After 23:00	24 (27)
	Missing	19 (21.4)
Wt status	Normal wt	69 (77.5)
	Overweight or obese	19 (21.4)
	Missing	1 (1.1)
Eating after 21:00	No	52 (58.4)
	Yes	37 (41.6)
Type of food	None	53 (59.6)
	Snack	23 (25.8)
	Meal	13 (14.6)
Caffeine intake at home	No	30 (33.7)
	Yes	45 (50.6)
	Missing	14 (15.7)
Caffeine intake d of filming	No	57 (64)
	Yes	19 (21.4)
	Missing	13 (14.6)

African American (AA) subjects had less total sleep (399 minutes for AA subjects versus 515 minutes for white subjects, $P <$ .001) and more time awake during the night (106 minutes for AA subjects versus 36 minutes for white subjects, $P =$ .006). Similarly, children insured by Medicaid had less total sleep time (Medicaid: 437 minutes; private: 502 minutes; Tricare: 553 minutes; $P =$ .014), more awakenings, and more time awake (Medicaid: 78 minutes; private: 33 minutes; Tricare: 17 minutes; $P =$ .058). Age was not associated with any sleep outcomes, including time to bed, sleep time, or awakenings. Similarly, home sleep characteristics per TCSQ were not associated with sleep in the hospital, including bedtime, total sleep time, awakenings, or time awake.

In multivariate analysis including race, insurance, CCT score, and bedtime, race was no longer associated with total sleep time or time awake during the night (Table 2). However, insurance status continued to be associated with less total sleep time. Children with Medicaid had 52 less minutes of sleep than those with private insurance ($P =$ .046). This estimate corresponds to the regression coefficient for the linear model for the total sleep time outcome.

Chronic Complexity and Hospital Sleep Outcomes

In unadjusted analysis, CCT score was positively associated with the number of awakenings ($r =$ 0.30, $P =$ .01) and also total time awake during the night ($r =$ 0.39, $P =$ .04) but was not associated with total sleep time. Specific diagnoses were not significantly associated with sleep outcomes. A Poisson regression was fit to account for this distribution, and a Wald test in which we used the fitted model for the CCT score effect demonstrated that a 1-U increment on the CCT score is expected to increase the rate of awakenings by 1.10 (confidence interval [CI] 1.02 to 1.19) for scores lower than 12.5. After the 12.5 threshold, each unit increase on the score decreased the rate of awakenings by 0.83 (CI: 0.67 to 1.03). This interaction was statistically significant at the overall $P =$ .04 level.

Food and Beverage Intake and Hospital Sleep Outcomes

Reported caffeine intake on the day of observation was not associated with sleep outcomes in either bivariate or multivariate models. Subjects who ate a snack after 21:00 were more likely to have a later bedtime than children who did not (odds ratio: 9.5; CI 2.6 to 34.9). In bivariate analysis, children who ate after 21:00 had less total sleep time (436 vs 517 minutes, $P =$ .03). In multivariate analysis, those that ate after 21:00 continued to trend toward less sleep time (45 minutes less, $P =$ .10) and spent less time in bed than subjects that did not eat (Wald statistic for ordinal logistic regressor, $P =$ .007). Late-night eating was not associated with subject BMI percentile.

DISCUSSION

Children in the hospital have late bedtimes, experience multiple awakenings during the night, and average <8 hours of sleep. Sleep duration in our study was not associated with patient age, although average sleep duration in our cohort was less than that recommended by clinical guidelines for all included ages. Our cohort's inadequate sleep disproportionately impacts younger children because they generally need more sleep. Additionally, we found that hospitalized children go to sleep on average at 22:35, which is markedly later than would be expected for children at home. Late bedtime has implications for early-morning medical activities, such as team-based rounds in patient rooms.

Sleep awakenings in the hospital can be caused by symptoms, necessary medical care, hospital logistics, families sleeping in the same room, and numerous other

TABLE 2 Results of Multivariate Models for Primary Sleep Outcomes

Sleep Outcome	Variable	Level or Type	Reference	Effect	95% CI	*P*
Total No. awakenings	Insurance	Private	Medicaid	0.92	0.64 to 1.32	.65
		Tricare	Medicaid	0.85	0.37 to 1.95	.70
	CCT[a]	Score (≤12.5)	Unit increment	1.1	1.02 to 1.19	.01
		Score (>12.5)	Unit increment	0.83	0.67 to 1.03	.10
	Race	AA	All other	1.31	0.88 to 1.93	.18
		White	All other	0.96	0.67 to 1.38	.83
	Clock time asleep	Before 22:00	Other times	0.87	0.58 to 1.31	.51
		After 23:00	Other times	0.62	0.4 to 0.98	.039
Total arousal time (min)	Insurance	Private	Medicaid	0.69	0.31 to 1.51	.34
		Tricare	Medicaid	0.26	0.07 to 0.92	.038
	CCT[b]	Score	Unit increment	1.08	0.99 to 1.19	.09
	Race	AA	All other	2.07	0.55 to 7.75	.27
		White	All other	1.36	0.4 to 4.68	.62
	Type of food	Snack	None	0.41	0.15 to 1.11	.08
		Meal	None	1.17	0.42 to 3.24	.76
	Caffeine d of enrollment	Yes	No	0.38	0.14 to 0.99	.047
	Clock time asleep	Before 22:00	Other times	1.00	0.38 to 2.62	.99
		After 23:00	Other times	0.96	0.34 to 2.73	.94
Total sleep time (min)	Insurance	Private	Medicaid	51.70	1.1 to 103.4	.046
		Tricare	Medicaid	51.70	−35.2 to 137.5	.24
	CCT[b]	Score	Unit increment	−0.59	−6.31 to 5.13	.84
	Race	AA	All other	−40.70	−117.7 to 36.3	.30
		White	All other	27.50	−44 to 97.9	.45
	Eat after 21:00	Yes	No	−37.40	−90.2 to 14.3	.15
	Clock time asleep	Before 22:00	Other times	11.00	−49.5 to 72.6	.71
		After 23:00	Other times	−78.10	−140.8 to −15.4	.02
Total bedtime (min)	Insurance	Private	Medicaid	35.20	−20.9 to 90.2	.21
		Tricare	Medicaid	−8.32	−105.27 to 88.63	.86
	CCT[b]	Score	Unit increment	1.02	−5.34 to 7.39	.75
	Race	AA	All other	16.50	−71.5 to 104.5	.71
		White	All other	−7.57	−95.15 to 80.02	.86
	Eat after 21:00	Yes	No	−45.10	−100.1 to 9.9	.11
	Sleep difficulties at home	Yes	No	48.40	−12.1 to 107.8	.12
	Clock time asleep	Before 22:00	Other times	−9.45	−78.8 to 59.91	.78
		After 23:00	Other times	−138.00	−205 to −71	.0002

CI, confidence interval.
[a] Estimated relative risk for a 1-U change in patients with a CCT score ≤12.5 and >12.5.
[b] Estimated change on the sleep outcome mean for a 1-U change in patients with CCT score.

factors. In our sample, children averaged just over 2 awakenings per night, much fewer than the 14 awakenings per night previously reported in pediatric oncology patients, who may require increased monitoring or lengthy infusions compared with patients on a general pediatrics service.[12] Although our patients had fewer awakenings, they also had a late bedtime and short total sleep duration. Sleep awakenings, bedtime, and sleep duration are related. Children who go to bed early and sleep longer would predictably have more opportunity for awakenings. Likely neither going to bed early and having more awakenings or going to bed late and having fewer awakenings is helpful for achieving high-quality sleep. As reported elsewhere in the literature, the most common cause for awakening after sleep initiation in our observations was a staff member entering or exiting the room.[12–16]

In contrast with previous studies, children's sleep at home as estimated by the TCSQ score did not correlate with sleep in the hospital.[20,21] That is, even children who were "good sleepers" by this validated measure slept relatively poorly while hospitalized. Age was also not significantly associated with total sleep time.

AA children tend to have later bedtimes and sleep less than their white counterparts.[21–24] In our study, hospitalized AA children had less total sleep time and were awake more during the night. However, these differences diminished when adjusting for other factors, including insurance type, which can be a surrogate for socioeconomic status. It has been shown in previous research that children from low-resource families have less total sleep time and later bedtimes than children living in families with higher socioeconomic status, consistent with our findings that children with Medicaid insurance averaged almost an hour less sleep than children with private insurance.[24] Authors of future research should explore why this inequity would exist in a hospital setting and identify ways to mitigate it.

In unadjusted analysis, increasing CCT score, used in this study as a marker for baseline medical complexity, was associated with more awakenings and more total time awake during the night. However, the relationship between CCT score and sleep in the hospital was complex. We found that as a group of children go from having minimal baseline chronic illness to moderate levels on the scale used, their sleep is increasingly more fragmented with awakenings during the night. These awakenings are likely due to more nighttime interventions, such as intravenous medication and procedures, as well as increased vigilance by nursing and other staff. However, as the CCT score increases from moderate to severe, the number of awakenings incrementally decreased. It is likely that once children reach a certain level of complexity and chronicity, such as with severe neurologic impairment, observable physical awakening as well as oral feeding decrease. Similarly, in children with severe baseline impairment, typical indicators of sleep quality and rest may not be applicable. Further research should be done on important qualities of sleep for children with severe chronic illnesses and how those vary with illness and hospitalization.

We had an additional interest in exploring nighttime food consumption and the relationship to sleep with the hypothesis that eating late may be associated with delayed and worsened sleep. Despite previous reports of the relationship between BMI and home sleep habits, late-night eating in our cohort of hospitalized children was not associated with increased BMI.[9,10,25,26] Daytime disruptions, medical testing, and illness could result in eating later at night while hospitalized. However, our hospital also allows children or parents to order food late at night, which may be easier to do than when the family is at home. We found that hospitalized children frequently consume late-night food, many having full meals after 21:00. Late-night consumption was associated with later bedtime and, accordingly, less overall sleep and time in bed.

The results of our study should be interpreted in the context of some limitations. First, this study is a relatively small sample of hospitalized children. Enrollment was limited to families willing to participate in video recording during hospitalization during the study period, and incomplete data for some subjects limit our power to detect differences in some outcomes. Further, this was a convenience sample of children selected on the basis of the undergraduate research staff schedules. Study enrollment opportunities for families were spread across weekdays and weekends and at all times of the year, and we do not believe that this introduced an important systematic bias in the study interpretation. On available days, the enrollment methodology was strengthened through use of a random-number generator to determine the order that eligible patients were approached for enrollment. Additionally, we only observed sleep behavior from 20:00 until 08:00 the subsequent day. Particularly for younger subjects, there may have been important nap times during the day, which could partially compensate for shortened or fragmented sleep at night. It is important to note that we did not have direct EEG measurements to confirm cognitive sleep and instead documented sleep when eyes were shut and purposeful movements stopped. This surrogate measure certainly confirms "restful" time but may have overestimated actual time asleep and numbers of awakenings. Third, using CCT score to capture disease and illness chronicity has some limitations and was validated for use in the measure of intervention needed in a complex care program.[18] This score was not a measure of the acuity or severity of hospitalization, which has been difficult to quantify within a group of hospitalized children outside of ICUs. Finally, placement of the "Recording in Progress" sign and presence of a video camera may have impacted staff and family behavior to deviate from typical patterns during hospitalization.

CONCLUSIONS

This observational study of hospitalized children expands previous research to demonstrate that general hospitalized children have poor sleep outcomes including late bedtimes, frequent awakenings, and shortened total sleep time. The methodological strength of direct observation of sleep and activity over a full nighttime 12-hour period helped to identify a variety of sociodemographic, chronic complexity of illness and hospital factors, such as when food is eaten, that are associated with these sleep outcomes. Authors of future research should focus on identifying ways to improve sleep quality in hospitalized children. Ideas might include establishing bedtimes or quiet times and decreasing awakenings by adjusting medication administration times, discontinuing intravenous fluids at nighttime, discontinuing unnecessary cardiorespiratory monitoring, and clustering staff visits into the room when possible. Additionally, the relationship of therapeutic sleep goals for hospitalized children and medical outcomes should also be investigated.

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Ellen L. Cowherd, Ashley G. Sutton, Jennifer O. Vincent, Michael S. Humphries, Victor Ritter, Jason Fine and Michael J. Steiner

Hospital Pediatrics 2019;9;333
DOI: 10.1542/hpeds.2018-0236 originally published online April 8, 2019;