



Original Article

Characterizing pediatric inpatient sleep duration and disruptions

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ABSTRACT

Objective: To contextualize inpatient sleep duration and disruptions in a general pediatric hospital ward by comparing in-hospital and at-home sleep durations to recommended guidelines and to objectively measure nighttime room entries.

Methods: Caregivers of patients four weeks – 18 years of age reported patient sleep duration and disruptions in anonymous surveys. Average at-home and in-hospital sleep durations were compared to National Sleep Foundation recommendations. Objective nighttime traffic was evaluated as the average number of room entries between 11:00pm and 7:00am using GOJO brand hand-hygiene room entry data. **Results:** Among 246 patients, patients slept less in the hospital than at home with newborn and infant cohorts experiencing 7- and 4-h sleep deficits respectively (Newborn: 787 ± 318 min at home vs. 354 ± 211 min in hospital, $p < 0.001$; Infants: 703 ± 203 min at home vs. 412 ± 152 min in hospital, $p < 0.01$). Newborn children also experienced >2 h sleep deficits at home when compared to NSF recommendations (Newborns: 787 ± 318 min at home vs. 930 min recommended, $p < 0.05$). Objective nighttime traffic measures revealed that hospitalized children experienced 7.3 room entries/night (7.3 ± 0.25 entries). Nighttime traffic was significantly correlated with caregiver-reported nighttime awakenings (Spearman Rank Correlation Coefficient: 0.83, $p < 0.001$).

Conclusion: Hospitalization is a missed opportunity to improve sleep both in the hospital and at home.

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1. Introduction

Adequate sleep plays a crucial role in the optimal growth and development of children and adolescents [1]. Studies have also shown that getting an appropriate amount of sleep as a child is associated with a decreased risk of developing chronic conditions such as obesity or Type II diabetes later in life [2,3]. The numerous benefits afforded by adequate sleep have prompted organizations like the National Sleep Foundation (NSF) to release recommended ranges for sleep durations for newborns, infants, toddlers, school-aged children, teenagers, and young adults [4] (Appendix 1). Sufficient sleep is particularly important for ill children as it can

facilitate the recovery process by promoting protein synthesis, cell-division and tissue repair mechanisms [5].

Unfortunately, in spite of the many benefits of adequate sleep for growth, development, and recovery from illness, periods of hospitalization are often associated with complaints of poor sleep quality among pediatric inpatients [5,6]. Studies of sleep quality among hospitalized children could provide useful information needed to develop interventions that improve sleep in the hospital inpatient setting. However, in order to develop targeted interventions, researchers must recognize that sleep in the hospital does not occur within a vacuum and is, instead, influenced by the hospital environment and pre-established sleep hygiene behaviors that affect baseline sleep. Though many studies investigating hospitalized sleep in children admitted to general pediatric wards compare home and hospital sleep durations, few compare sleep durations in the hospital and at home to recommended sleep

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guidelines to assess whether sleep deficits are occurring at baseline. Further, few studies utilize objective measures of sleep disruptions to assess the true impact of the hospital environment on patient sleep [5,7–9].

We hypothesized that the overall duration of sleep would be reduced in the inpatient setting among hospitalized children and that sleep disruptions in the form of nighttime room entries are frequent within the hospital setting. Therefore, this study aimed to characterize inpatient pediatric sleep by comparing subjective measures of home and hospital sleep durations to recommended pediatric sleep guidelines, and to quantify hospitalized sleep disruptions using objective measures.

2. Methods

2.1. Study population

This study was reviewed and approved by the Institutional Review Board of the University of Chicago Medicine and verbal consent was obtained from all study participants. A convenience sample of patients was recruited in the general pediatric inpatient ward of Comer Children's Hospital. Eligible patients included all children between the ages of four weeks and 18 years admitted to the ward which also includes the neurology or gastroenterology inpatient specialty services. All the caregivers approached in this study had spent the night in the hospital room with their child and all the patients included in the study slept in single rooms. Children recovering from recent surgeries are not admitted to the general pediatric ward and, therefore, were not included in the study. Further exclusions were made to identify a study population that represents a general population of healthy children without known chronic diseases that may impact sleep at baseline. Therefore, we excluded patients with established diagnoses or recent medical procedures that are known disruptors of sleep. This included patients with a known diagnosis of cerebral palsy, tracheostomy, nasogastric or gastrostomy tube dependence, sleep apnea or altered mental status. Patients were also excluded if they were on bed rest or were undergoing long term monitoring for epilepsy.

2.2. Data collection

2.2.1. Survey instruments

Caregivers were asked to complete a Pediatric Sleep Assessment upon recruitment. This survey contained several validated instruments including the Karolinska Sleep Log and the Pediatric Sleep Questionnaire (PSQ) [10]. The PSQ is a tool that screens for pediatric sleep-disordered breathing (SDB) in children 2–18 years of age based on the presence of symptoms such as snoring, daytime sleepiness, and behavioral problems. Thus, the PSQ was used in this study to further characterize our study population [11]. Data from survey responses were stored using the REDCap Database Version 6.14.0 (Vanderbilt University, 2016, Nashville, TN) [12].

2.2.2. Caregiver-reported sleep duration & disruptions

Caregivers reported patient sleep duration and sleep disruptions at home and in the hospital by completing the Karolinska Sleep Log. This tool has been validated against EEG variables and includes questions regarding the total number of hours a patient slept and the total number of awakenings experienced during nighttime sleep [10]. Recruited caregivers were asked to provide these values for a typical night of sleep at home within the past month when their child was not ill and for the previous night of sleep within the hospital. Caregivers were also asked to report daytime sleep duration within this survey.

2.2.3. Objectively measured sleep disruptions: nighttime traffic

Objective data on nighttime traffic in and out of patient rooms were collected using data from Activity Counters provided by the GOJO SMARTLINK Hand-Hygiene system (GOJO Industries Inc., 2017, Akron, OH). These activity counters employ heat sensors to track all patient room entries and exits. This information is used by the hospital as a denominator for potential hand hygiene opportunities. For the purpose of this study, data from these devices were obtained from the hospital to measure nighttime room entries (Supplemental Fig. 1).

2.3. Data analysis

Descriptive statistics were used to summarize data. Subjective data were separated into newborn, infant, toddler, preschooler, school-aged, teenager and young adult cohorts to mirror National Sleep Foundation recommendations [4]. The average durations for sleep in the hospital and at home within the two age groups were compared using paired t-tests. In addition, the observed values for sleep duration in the hospital and at home for each cohort were compared to age-appropriate sleep guidelines set by the National Sleep Foundation using t-tests.

2.3.1. Objectively measured sleep disruptions: nighttime traffic

To analyze our objective room entry data, we first defined “nighttime traffic” as all room-exits occurring between 11:00pm and 7:00am. We chose this definition to exclude nighttime room entries by patient family members that were not paired with a subsequent exit. A single room entry was defined as the total number of room exits that occurred within a 3-min window [13]. The average number of room entries within a single night was then calculated.

Caregiver responses for the number of nighttime hospital sleep awakenings (collected from the Karolinska Sleep Log) were averaged by month and variation was compared to monthly changes in objectively measured nighttime room entries by calculating the Spearman rank correlation coefficient. All data were analyzed using STATA 15.0 [14]. Statistical significance was set as a p-value <0.05.

3. Results

3.1. Study population

From February 2017 to April 2018, a total of 246 patients were recruited and completed the Pediatric Sleep Assessment. Of the recruited patients, 42% were female and 59% were two years and older (Table 1). Almost half of the participating children were the youngest children in their family (48%), and the majority of the caregivers surveyed in this study were mothers (77%). Patients recruited for this study were also diverse in racial and ethnic backgrounds with 72% of respondents identifying as African American, and 10% of respondents identifying as Hispanic. The most common admitting diagnoses in our study population were upper or lower respiratory tract infections (21%), asthma exacerbations (14%), acute conditions pertaining to the GI tract (7%) and skin and soft tissue infections (6%). Use of the PSQ revealed that 24% of patients ≥ 2 years screened positive for high risk of sleep-disordered breathing.

3.2. Caregiver-reported subjective sleep duration

On average, patients slept less in the hospital than at home with the newborn and infant cohort experiencing 7- and 4-h sleep deficits respectively (Newborn: 787 ± 318 min at home vs. 354 ± 211 min in hospital, $p < 0.001$; Infants: 703 ± 203 min at

Table 1
Study population demographics.

	n	%
Age		
Newborns (0–3 mos)	22	9%
Infants (4–11 mos)	35	14%
Toddlers (1–2 yrs)	62	25%
Preschoolers (3–5 yrs)	49	20%
School-Aged Children (6–13 yrs)	62	25%
Teenagers (14–17 yrs)	14	6%
Young Adults (18–21 yrs)	2	1%
Female		
	104	42%
Identity of caretaker		
Mother	190	77%
Father	36	15%
Grandparent	12	5%
Other	8	3%
Race/ethnicity		
Black/African-American	177	72%
Hispanic	24	10%
White/Caucasian	38	15%
Asian/Pacific Islander	3	1%
Native American	0	0%
Other	4	2%
Birth order		
Oldest	26	11%
Middle	41	17%
Youngest	117	48%
Only	61	25%
Other	1	0%

A convenience sample of patients on a general pediatric inpatient floor of Comer Children's Hospital in Chicago, Illinois, was recruited for surveys pertaining to sleep at home and within the hospital.

home vs. 412 ± 152 min in hospital, $p < 0.01$). Additionally, study participants had at-home and in-hospital sleep durations that were below the age-related NSF recommendations [4] (Fig. 1) with newborn and infant children experiencing the greatest deficits. For infant children, the average reported sleep duration at home fell shy of recommendations by approximately 1.5 h (Infants:

703 ± 203 min at home vs. 810 min recommended, $p = 0.09$). Newborn children exhibited an average sleep debt of >2 h when comparing at-home sleep duration to recommended sleep guidelines (Newborns: 787 ± 318 min at home vs. 930 min recommended, $p < 0.05$). For the whole cohort, only 23% of caregivers reported at-home sleep durations that met NSF standards.

3.3. Objectively measured sleep disruptions: nighttime traffic

Hospitalized children with inpatient stays between February 1, 2017 and February 1, 2018 experienced an average of 7.3 room entries within a single night in the hospital (7.3 ± 0.25 nighttime room entries). Further, monthly averages of objectively measured nighttime room entries (between February 2017 and February 2018) were significantly correlated with monthly variation in the average number of caregiver-reported nighttime awakenings (Spearman Rank Correlation Coefficient: 0.83, $p < 0.001$) (Fig. 2).

4. Discussion

In this study, we found that, regardless of age, caregivers reported less sleep in the hospital when compared to the duration of sleep reported for their children at home. These results are consistent with prior studies that focus on patients admitted to general pediatric units, and suggest that acutely ill pediatric inpatients are at increased risk of experiencing sleep deficits while in the hospital [5,7,8]. Moreover, most of the caregivers in this study reported sleep durations for their children in the hospital and at home that were below the recommended guidelines set by the NSF [4] with newborn patients experiencing the greatest deficits, suggesting that sleep deficits are pervasively present among newborn children independent of their health status.

Previous studies have suggested that poor sleep in the week prior to hospital admission was the strongest predictor of poor sleep within the hospital, prompting the assumption that the poor sleep observed during hospitalization could be related to the

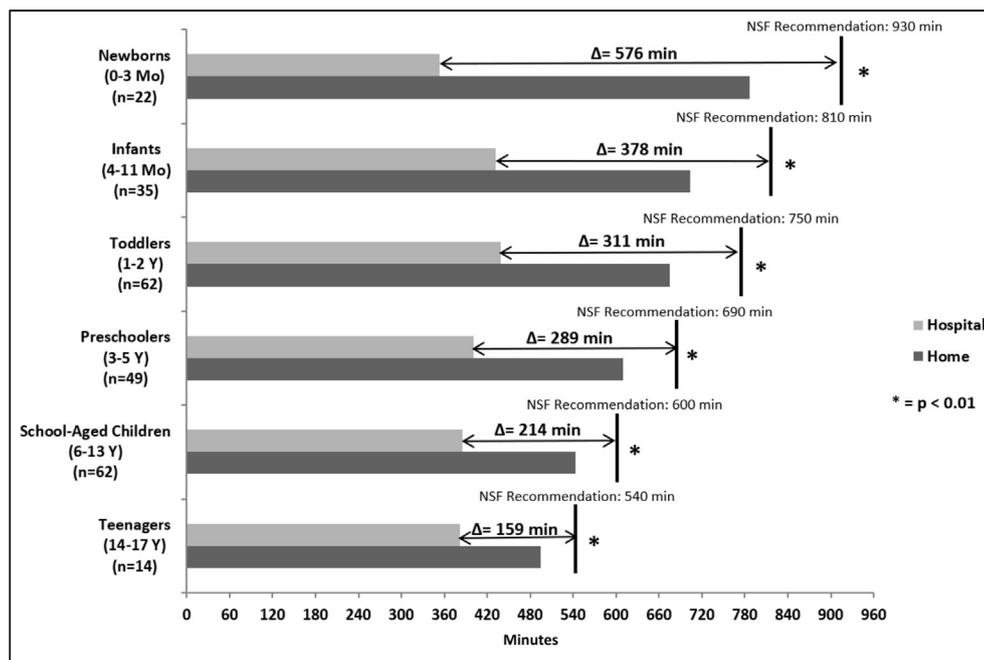


Fig. 1. Comparing at home and in-hospital sleep duration to recommended pediatric patient guidelines for nighttime sleep. Sleep duration was reported by caregivers using the Karolinska Sleep Log within a Pediatric Sleep Assessment [10]. Recommended sleep duration values for children are averages of age-specific ranges published by the National Sleep Foundation (NSF) [4].

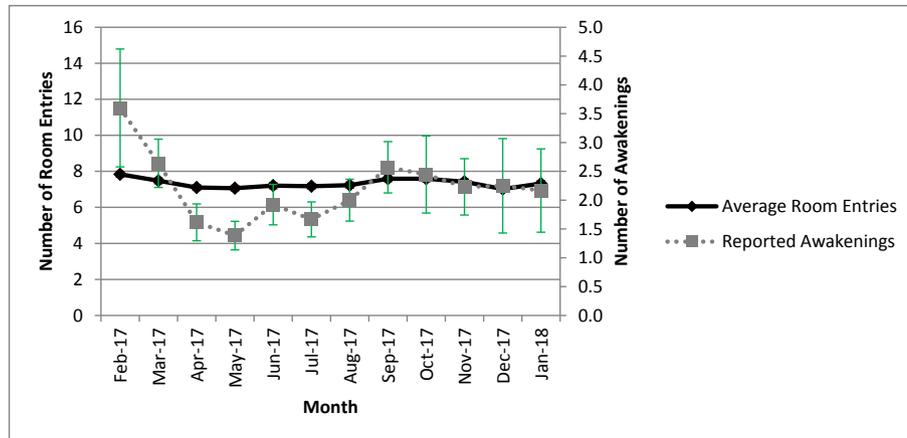


Fig. 2. Monthly average of objectively measured nighttime room entries and number of caregiver-reported of nighttime awakenings in the hospital. Data from activity counters within hand-hygiene heat sensors inside of each patient room in the general pediatric ward were obtained to objectively measure nighttime room entries. Caregiver reports regarding number of nighttime awakenings were drawn from responses to the Karolinska Sleep Log [10]. Monthly variation in the average number of objectively measured nighttime room entries varied in a similar manner as monthly changes in the average number of caregiver-reported nighttime awakenings within the hospital (Spearman Rank Correlation Coefficient: 0.83, $p < 0.001$).

pathology causing the study participant's admission to the hospital [7]. Although our study also demonstrated sleep deficits at home and in the hospital, the assessment of typical home sleep duration, presumably when the child is not acutely ill, suggests that the sleep deficits observed at home could also be the result of chronic poor sleep hygiene, rather than be ascribable to the acute illness that prompted their admission. These findings illustrate that within this predominantly minority urban patient population, periods of hospitalization may be missed opportunities for patient and caregiver education surrounding overall sleep habits, and that educational efforts addressing sleep may need to be more holistic in nature, and include initiatives that reinforce the importance of sleep at home.

This study is the first to incorporate objective measures of hospital sleep disruptions to characterize pediatric inpatient sleep [5,7,8,15]. We found that pediatric patients hospitalized between February 2017 and February 2018 experienced an average of 7.3 nighttime room entries. These results provide a better insight to sleep in the hospital by objectively illustrating the magnitude of sleep disruptors that can be attributed to the hospital environment. The fact that the monthly variation recorded by the sensors is significantly correlated with monthly changes in parallel caregiver reports of nighttime awakenings suggests that hospital-based factors are likely impacting the ability of hospitalized children to achieve optimal sleep during their inpatient stays. This finding also aligns with prior studies that have exclusively used subjective caregiver reports to illustrate that nurse or physician interruptions lead to increased nighttime awakenings for hospitalized children [5,7,8]. Thus, there is a clear need for targeted interventions that decrease nighttime sleep interruptions in hospital settings. One example of such an intervention would involve changing the electronic medical record order sets, such that medication administration and blood draws are conducted at times that are not disruptive to the patient's sleep. Other options could allow nurses to forego overnight vital sign checks on patients when they are not critically indicated, ultimately resulting in anticipated decreases in the number of sleep interruptions that these patients will experience.

We also found that there was no seasonal variation in the number of nighttime room entries observed with the number of room entries nearly identical in the winter months. This is surprising due to the increased number of acutely ill children admitted to the hospital with diagnoses such as influenza or upper

respiratory infections that may require increased monitoring by nursing staff.

Notably, we found that 24% of our patients screened positive for high-risk of sleep-disordered breathing—a figure that is markedly higher than the reported prevalence in the general population [16,17]. Although we did not use polysomnography to confirm the putative SDB diagnosis, the PSQ's positive predictive value suggests that ~85% of the hospitalized patients screening positive for high-risk of SDB would de facto be confirmed as suffering from SDB via polysomnography. This high prevalence in hospitalized patients may be explained by the fact that SDB often presents with conditions commonly seen in acutely ill hospitalized children such as severe asthma or lower respiratory tract infections [18–20]. The high prevalence could also be explained by studies that have clearly documented that patients with sleep disorders such as sleep apnea are high-utilizers of healthcare services with elevated rates of emergency room visits and hospital admissions [19].

An important limitation of our analysis of hospitalized sleep duration is the exclusive reliance on subjective reports from caregivers which may be susceptible to recall bias. In future studies, we plan on utilizing objective measures of sleep duration and quality such as actigraphy to address this potential issue. In addition, this study was conducted at a single institution with an underserved patient population, thus, limiting its generalizability. Another limitation of the study is the fact that we did not assess whether our objective room entry data correlated with caregiver responses for nighttime awakenings at the room level. The absence of this analysis can be explained by the fact that we did not include protected health information (eg, patient room numbers) in our survey data. Furthermore, our use of the Karolinska Sleep Log is another limitation as this instrument has not been validated in pediatric populations. Finally, the lack of data on daytime sleep and parent sleep at home and in the hospital further limits the ability to develop a more holistic understanding of sleep debt incurred within the hospital.

5. Conclusions

Notwithstanding the recognized fact that sufficient sleep is crucial for overall health and wellness, development, and recovery from illness, hospitalized children and their families report sleep durations and disruptions indicative of poor sleep quality, both in the hospital

and at home, but particularly in the hospital. The large differences between recommended sleep duration and the sleep duration reported in the hospital and at home suggest that the hospital sleep deficits observed in newborn and infant patients could be related, at least in part, to underlying poor sleep hygiene at baseline. Moreover, our objective analysis of nighttime traffic in the patient rooms suggests that the fewer hours of sleep that children attain in the hospital are plagued with frequent sleep interruptions—often in the form of numerous room entries over the course of the night.

This study adds to the extant literature by suggesting that poor sleep quality in a pediatric inpatient population may be due to pre-admission poor sleep hygiene behaviors, a disruptive hospital environment, and/or underlying clinical diagnoses negatively impacting sleep. Finally, our study highlights that periods of hospitalization constitute missed opportunities to address some of these issues through more targeted interventions that improve education of caregivers around proper sleep hygiene for their children; as well as initiatives that promote better sleep in hospital environments.

Contributors' statement

Amarachi Erondu aided in data collection, conducted the statistical analysis of the data, drafted the initial manuscript and reviewed and edited the final submission.

Leah Peirce and Michael Chamberlain aided in data collection and reviewed the final submission.

Kelsey Hopkins aided in data collection, statistical analysis, and reviewed the final submission.

Samantha Anderson developed the databases for data collection, aided in survey administration and reviewed the final submission.

Christopher Lyttle aided in the statistical analysis of the data and reviewed the final submission.

Dr. David Gozal conceptualized and designed the study and reviewed the final submission.

Dr. Nicola Orlov and Dr. Vineet Arora conceptualized and designed the study, conducted the statistical analysis of the data, aided in drafting the initial manuscript and reviewed and edited the final submission.

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Conflict of interest

None.

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.sleep.2019.01.030>.

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