

Brief Communication

A prospective observational study of sleep patterns and work-related communications during home call for a pediatric surgery fellow

Steven L. Raymond, MD^{a,*}, Edward Tagge, MD, MS^b^a Division of Pediatric Surgery, Department of Surgery, University of Florida, Gainesville, FL, USA^b Division of Pediatric Surgery, Department of Surgery, Loma Linda University Health, Loma Linda, CA, USA

HIGHLIGHTS

- A pediatric surgery fellow frequently experiences insufficient sleep.
- Sleep patterns during call nights are significantly different than non-call nights.
- Overnight work-related communications often disrupt sleep.
- Need for further research to help protect the health of medical professionals.

ARTICLE INFO

Keywords:

On-call
Fellowship
Surgical training
Surgical education
Hours of sleep
Sleep duration
Night call
Heart rate
Sleep deprivation
Paging
Coverage

ABSTRACT

Objective: A pediatric surgery fellow is often regarded as a cornerstone of an academic children's hospital due to the need for their clinical services with overnight coverage being an important aspect of the care provided. There is little known about the objective sleep patterns and work-related communications of a pediatric surgery fellow during overnight home call. The aim of this study is to better understand the sleep patterns and interruptions of an on-call pediatric surgery fellow.

Design: A prospective observational study of 60 call nights and 60 non-call nights of a pediatric surgery senior fellow was performed from September 2022 to February 2023.

Setting: An academic Children's Hospital.

Participant: An ACGME-accredited clinical pediatric surgery fellow.

Results: On average, the pediatric surgery fellow spent 6.9 and 5.8 total hours in bed and asleep each night, respectively. The total sleep time was less for call nights compared to non-call nights (5.4 versus 6.3 h, $p < 0.0001$). The mean number of work-related communications per 12-hour night shift was four. The majority of communications were regarding new consults (63.8%). The pediatric surgery fellow spent an average of 5.9 min per communication and approximately 23.8 min total during each 12-hour night shift. Approximately half of these communications occurred during sleep hours.

Conclusions: This study reveals overall sleep duration was below recommended levels. There were significant alterations in sleep patterns during call nights. Work-related communications further compounded sleep disturbances. Further research and interventions in this area are warranted.

Introduction

The pediatric surgery fellow plays a vital role in an academic children's hospital, assessing new consultations, evaluating and managing perioperative patients, and assisting in operations. Overnight coverage is an important aspect of the patient care provided. Despite the frequent use of home call, little is known about the objective sleep patterns and

overnight work-related communications of a pediatric surgery fellow.

While ideal sleep varies among individuals, most need 7–9 h of sleep per night to maintain optimal performance and overall health. Concerning trends have emerged in recent years. Between 2008 and 2018, the percentage of employed adults in United States reporting 6 h of sleep or less per night increased from 28% to 33% [1]. This rise has significant health consequences. A meta-analysis of 153 studies with 5.1

* Corresponding author at: Division of Pediatric Surgery, Department of Surgery, University of Florida, 1600 SW Archer Rd, Gainesville, FL, USA.

E-mail address: steven.raymond@surgery.ufl.edu (S.L. Raymond).

<https://doi.org/10.1016/j.sopen.2024.04.006>

Received 28 November 2023; Received in revised form 9 April 2024; Accepted 28 April 2024

Available online 4 May 2024

2589-8450/© 2024 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

million participants demonstrated that short sleep, typically defined as <5–6 h per night, was associated with increased risk of mortality, diabetes mellitus, hypertension, cardiovascular disease, coronary heart disease, and obesity [2].

A historical survey of 3604 first- and second-year resident physicians found that 66 % averaged 6 h of sleep or less [3]. More recent studies regarding the sleep duration of surgical residents and fellows is lacking.

Previous studies have shed light on communication challenges faced by trainees during in-house call, with reports of trainees receiving 13–55 pages per night [4–8]. Despite a tenfold rise in home call usage from 1998 to 2009 [9], there is a paucity of literature on the volume of overnight communications received by residents and fellows on home call.

The aim of this study is to better understand the sleep patterns and work-related communications of an on-call pediatric surgery fellow at an academic Children's Hospital.

Methods

Setting

The study was conducted at a 364-bed university-based Children's Hospital with Accreditation Council for Graduate Medical Education (ACGME) pediatric surgery fellowship program sponsoring one pediatric surgery fellow for a two-year duration. Night coverage consists of an in-house junior surgery resident (postgraduate year 2), a senior surgery resident (postgraduate year 3) or pediatric surgery fellow (postgraduate year 9) on home call, and a board-certified pediatric surgeon also on home call. The in-house resident manages the pediatric surgery service and consult pagers. The senior resident or pediatric surgery fellow provides clinical coverage, responding to communications such as pages, texts, and phone calls. They are available to return to the hospital as needed to evaluate patients and assist in the operating room. Night call coverage is 12 h from 17:30 to 05:30.

Study design

For 60 call nights and 60 non-call nights from September 2022 to February 2023, a third generation Oura™ Ring was worn by the pediatric surgery fellow between bedtime and wake-up. Oura™ Ring is a wearable device that senses and monitors body temperature, respiration, heart rate (HR), heart rate variability (HRV), and sleep patterns. Oura™ Ring is 99.6 % accurate for nighttime resting HR and 98 % accurate for HRV, compared to medical-grade electrocardiograms [10]. Oura™ Ring achieves a 79 % agreement in observed sleep patterns compared to polysomnography laboratory sleep tests.

During call nights, work-related communications to the pediatric surgery fellow were recorded, noting the time received, duration spent addressing the communication in minutes, the source of the communication, and the nature of each communication. This information was compiled from review of the communication systems the following morning.

Variables

Sleep data included total time in bed, sleep latency, total sleep time, light sleep, deep sleep, rapid eye movement (REM) sleep, awake time, and sleep efficiency. Total time in bed is the duration from bedtime to wake-up. Sleep latency is the time it takes to fall asleep. Total sleep time is the cumulative duration of all sleep stages. Light sleep is characterized by low-intensity brain activity and marks the initial stage of sleep. Deep sleep features profound relaxation, minimal brain activity, and reduced responsiveness to stimuli. REM sleep is characterized by rapid eye movements and increased brain activity. Awake time measures nighttime wakefulness after initial sleep onset.

Cardiovascular parameters included resting heart rate and heart rate

variability. Resting HR is the number of heartbeats per minute at rest. HRV is a measure of the changes in time intervals between successive heartbeats, reflecting the autonomic nervous system's influence on HR. Higher HRV is considered to be associated with better cardiovascular health and adaptive stress response.

Analysis

Data were collected prospectively using a standardized form and analyzed at the completion of the study using Microsoft Excel™ Version 16.16.27. Continuous variables are presented as average and range, and analyzed using *t*-tests. All significance tests were two-sided, with *p*-values <0.05 considered significant.

Results

Sleep patterns

On average, the pediatric surgery fellow spent 416.7 and 350.7 total minutes in bed and asleep each night, respectively (Table 1). The mean sleep latency was 8.1 min. About 16 % of time in bed was spent awake, averaging 66.4 min awake per night.

The total time in bed was less for call nights compared to non-call nights (390.3 min versus 443.0 min, *p* = 0.0002); total sleep time was less for call nights compared to non-call nights (321.2 min versus 380.1 min, *p* < 0.0001). Likewise, percentage of awake time was greater for call nights compared to non-call nights (18 % versus 14 %, *p* = 0.0002). The fellow was awake in bed for an average of 69.5 min per call night and 63.2 min per non-call night (*p* = 0.1545). The average on-call night consisted of 56 % light, 22 % REM, and 22 % deep sleep. The average non-call night consisted of 58 % light, 25 % REM, and 18 % deep sleep. There was a decrease in percent of REM sleep during call nights compared to non-call nights (*p* < 0.0001). There was an increase in percent of deep sleep during call nights compared to non-call nights (*p* = 0.0191). There was no difference in percentage of light sleep between call and non-call nights (*p* = 0.4086).

The average resting heart rate and heart rate variability during sleep were 60 beats per minute (bpm) and 40 milliseconds (ms), respectively. The lowest resting HR was 47 bpm with a mean lowest resting HR of 54 bpm. The maximum HRV was 137 ms with a mean maximum HRV of 79 ms. There was a difference in average resting HR and HRV between call and non-call nights (call average resting HR 59 bpm, non-call average resting HR 61 bpm; *p* = 0.0203) (call average HRV 42 ms, non-call

Table 1
Sleep patterns for call and non-call nights.

	Overall (n = 120)	Call nights (n = 60)	Non-call nights (n = 60)	p-Value
Total time in bed (min)	417	390	443	0.0002
Latency (min)	8	7	9	0.274
Awake time (min)	66	70	63	0.1545
Sleep time (min)	351	321	380	<0.0001
REM sleep (min)	83	72	94	<0.0001
Deep sleep (min)	66	66	67	0.6695
Light sleep (min)	201	184	219	<0.0001
Awake time (%)	16	18	14	0.0002
Sleep time (%)	84	83	86	0.0002
REM sleep (%)	23	22	25	<0.0001
Deep sleep (%)	20	22	18	0.0191
Light sleep (%)	57	56	58	0.4086
Resting HR (bpm)	60	59	61	0.0203
Resting HRV (bpm)	40	42	38	0.0039

average HRV 38 ms; $p = 0.0039$).

On-call communications

The pediatric surgery fellow was on overnight call an average of 2.9 times per week (range 1–5). The mean number of work-related communications per 12-h shift was 4.0 (range 1–11). Communications occurred at a variety of times (Fig. 1). The most of communications were from the in-house junior general surgery resident (94.2 %) (Table 2). The majority of communications were regarding new consults (63.8 %) with most of the consults for patients in the emergency department (85.1 %). Half of communications (50.2 %) occurred while the fellow was in bed. Monday-Thursday nights had a similar number of communications compared to Friday-Sunday nights (4.03 versus 4.06, $p = 0.9598$). The fellow spent a mean time of 5.9 min per communication and approximately 23.8 min total during each 12-h night shift.

Discussion

Partial sleep deprivation, characterized by reduced or interrupted sleep, is common in night shift work. Recurrent partial sleep deprivation, or cumulative sleep deprivation, can impair alertness and performance, increase errors, and lead to accidents [11–13]. The pediatric surgery fellow averaged 5 h 51 min of sleep per night. Specifically, the fellow averaged 5 h 21 min and 6 h 20 min of sleep on call nights and non-call nights, respectively. This is a 15.5 % reduction in sleep during call nights. These averages are below the recommended 7 or more hours recommended by the Centers for Disease Control and Prevention, American Academy of Sleep Medicine, and Sleep Research Society [13,14]. Cumulative sleep deprivation is linked to adverse outcomes such as obesity, diabetes, increased pain, impaired immune function, and higher mortality rates [13].

While prior studies have investigated the sleep duration of surgical residents, there is a notable gap in the literature regarding surgical fellows. A 2021 study of 26 general surgery residents reported an average of 4 h 44 min of sleep on home call nights, compared to 6 h 22 min on post-call nights [15]. Meanwhile, a 2017 study tracked ten urology residents and demonstrated an average of 2 h 45 min of sleep on home call nights, compared to 4 h on post-call nights [16]. A similar study of four urology residents demonstrated sleep duration correlated with the number of pages received, with each page reducing sleep by 4.7 min [17].

Following night call with sleep interruptions, surgical residents make

Table 2
Summary of on-call communications.

	On-call communications (n = 243)
Person contacting, n (%)	
Emergency department physician	0 (0)
Junior surgery resident	229 (94)
Neonatal intensivist	6 (2)
Pediatric intensivist	0 (0)
Pediatric surgery attending	6 (2)
Other	2 (1)
Nature of communication, n (%)	
Change in clinical status	14 (6)
Clinical question	30 (12)
Emergency department consult	132 (54)
Floor consult	9 (4)
Intraoperative consult	1 (0)
Neonatal intensive care unit consult	12 (5)
Notification of results	38 (16)
Pediatric intensive care unit consult	1 (0)
Other	6 (2)
Occurred during sleep, n (%)	
Yes	122 (50)
No	121 (50)
Time spent in minutes, average (range)	6 (1–60)

more errors and perform slower in virtual laparoscopic tasks [18,19]. Likewise, surgical residents have impairments in attention, working memory, and long-term memory after a weekend on-call, compared to a weekend off [20]. Conversely, a study of 40 surgical residents reported the acquisition of laparoscopic skills was not affected by the amount of sleep the previous night [21]. In that study, residents averaged <4 h of sleep on call nights compared to over 6 h on non-call nights. Using virtual surgery simulator and psychometric tests, Lehmann et al. found no impairments in performance after a night with <3 h of sleep [22]. The impact of call frequency and differences between in-house and home-call on performance remains unclear. Cumulative sleep deprivation may significantly impair cognition and technical skills more than short-term sleep deprivation.

Using Holter monitoring of 28 general surgery residents, Tendulkar et al. demonstrated in-house call increased mean HR. [23] In the study herein, average resting HR was lower and average HRV was higher during call nights. These favorable indicators during call nights suggest a complex relationship between sleep, call frequency, and physiological responses. Considering the findings of Tendulkar et al., this may indicate reduced physiologic stress during home call compared to in-house call. It is important to note resting HR and HRV are highly

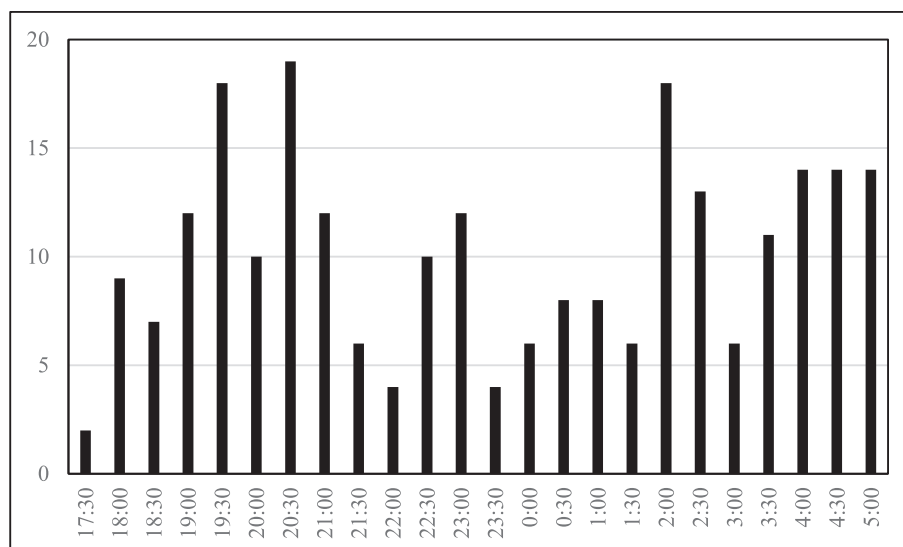


Fig. 1. Total communications received per half-hour time interval for all 60 call shifts.

individualized and impacted by cardiac conditioning and activity level. High cardiovascular conditioning may mitigate the adverse effects of sleep disruptions on resting HR. Although not analyzed in the current study, the frequency and duration of aerobic activities were more common on non-call days and may impact the findings.

The fellow averaged four work-related communications per call night, each lasting about 6 min. This is consistent with a 2018 study where senior urology residents averaged five pages per call night [17]. Over 60 call nights, the pediatric surgery fellow returned to the hospital overnight on nine occasions. This excludes times when the fellow stayed past typical workday hours to evaluate patients and complete operations on both call and non-call nights. A 2022 study found no link between surgeons performing overnight surgeries and worse patient outcomes for operations performed the following day [24]. While this offers reassurance about patient care quality, it does not address a genuine concern for the surgeon's well-being.

This study has notable limitations. Personal obligations were not analyzed and could have impacted the fellow's ability to achieve a full night of sleep. Additionally, the impact of alcohol consumption and intensity of daily activities on sleep and heart rate data were not analyzed. This study did not examine effects of limited sleep and overnight interruptions on cognitive and motor skills. Finally, this study was focused on a single pediatric surgery fellow at a single institution.

To our knowledge, this is the first study to objectively track sleep patterns and overnight work-related communications for a pediatric surgery fellow on home call. Future multi-institutional studies involving multiple trainees could provide additional insights.

Conclusions

The study highlights the challenging nature of a pediatric surgery fellow, particularly the impact of home call on sleep. It underlines the need for effective strategies to mitigate sleep disruptions without compromising patient care. Work hour and call frequency restrictions may not guarantee adequate sleep, as this a multifactorial process involving the physiological need for sleep, personal motivation, desire for personal life outside of training, personal/family obligations, professional/educational aspirations, and institutional demands [3]. Trainees must navigate these competing demands to best allocate their time.

Abbreviations

ACGME	Accreditation Council for Graduate Medical Education
BPM	beats per minutes
HR	heart rate
HRV	heart rate variability
MS	milliseconds
REM	rapid eye movement

Funding source

No external funding was received for this study and manuscript.

Ethics approval

Not applicable.

CRedit authorship contribution statement

Steven L. Raymond: Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Edward Tagge:** Writing – review & editing, Writing – original draft, Supervision, Investigation, Conceptualization.

Declaration of competing interest

The authors have indicated they have no potential conflicts of interest to disclose.

References

- [1] QuickStats: percentage of currently employed adults aged ≥ 18 years who reported an average of ≤ 6 hours of sleep per 24-hour period, by employment category — National Health Interview Survey, United States, 2008–2009 and 2017–2018. *MMWR Morb Mortal Wkly Rep* 2020;69:504.
- [2] Itani O, Nike M, Watanabe N, Kaneita Y. Short sleep duration and health outcomes: a systematic review, meta-analysis, and meta-regression. *Sleep Med* 2017 Apr;32: 246–56.
- [3] Baldwin DC, Daugherty SR. Sleep deprivation and fatigue in residency training: results of a national survey of first- and second-year residents. *Sleep* 2004 March; 27(2):217–23.
- [4] Loew M, Niel K, Burlison JD, Russell KM, Karol SE, Talleur AC, et al. A quality improvement project to improve pediatric medical provider sleep and communication during night shifts. *International J Qual Health Care* 2019 Oct;31 (8):633–8.
- [5] Fargen KM, O'Connor T, Raymond S, Sporrer JM, Friedman WA. An observational study of hospital paging practices and workflow interruption among on-call junior neurological surgery residents. *J Grad Med Educ* 2012 Dec;4(4):467–71.
- [6] Storino A, Polanco-Santana JC, Allar BG, Falker MN, Wong D, Whyte R, et al. Paging patterns among junior surgery residents in a tertiary care center. *J Surg Educ* 2021 Sep–Oct;78(5):1483–91.
- [7] Smith AD, de Vos MS, Smink DS, Nguyen LL, Ashley SW. Text paging of surgery residents: efficacy, work intensity, and quality improvement. *Surgery* 2016 Mar; 159(3):930–7.
- [8] Parrado RH, Notrica DM, Molitor MS. Nighttime calls, pages, and interruptions to the on-call surgery resident. *Am Surg* 2022 Jun;88(6):1181–6.
- [9] Donini-Lenhoff F, Brotherton SE, Rocky PH. Out of sight, but not out of mind: at-home call for residents and fellows. *Acad Med* 2010 May;85(5):742.
- [10] Kinnunen H, Rantanen A, Kentta T, Koskimaki H. Feasible assessment of recovery and cardiovascular health: accuracy of nocturnal HR and HRV assessed via right PPG in comparison to medical grade ECG. *Physiol Meas* 2020 May;41(4):04NT01.
- [11] Weinger MB, Anocoli-Israel S. Sleep deprivation and clinical performance. *JAMA* 2002 Feb;287(8):955–7.
- [12] Dinges DF, Pack F, Williams K, Gillen KA, PowellJW, Ott GE, Aptowicz C, Pack AI. Cumulative sleepiness, mood disturbance, and psychomotor vigilance performance decrements during a week of sleep restricted to 4-5 hours per night. *Sleep* 1997 Apr;20(4):267–77.
- [13] Watson NF, Badr MS, Belenky G, Bilwise DL, Buxton OM, Buysse D, et al. Recommended amount of sleep for a healthy adult: a joint consensus statement of the American Academy of Sleep Medicine and Sleep Research Society. *Sleep* 2015 Jun;38(6):843–4.
- [14] Centers for Disease Control and Prevention. How much sleep do I need? CDC; 2023. https://www.cdc.gov/sleep/about_sleep/how_much_sleep.html.
- [15] Kelly-Schuette K, Shaker T, Carroll J, Davis AT, Wright GP, Chung M. A prospective observational study comparing effects of call schedules on surgical resident sleep and physical activity using the Fitbit. *J Grad Med Educ* 2021 Feb;13(2):113–8.
- [16] Morhardt DR, Luckenbaugh A, Goldstein C, Faerber GJ. Determining resident sleep during and after call with commercial sleep monitoring devices. *Urology* 2017 Aug; 106:39–44.
- [17] Ludvigson AE, Ryan ST, Gentile CR, Mills GJ, VerLee GT, Hansen MH. Impact of volume and type of overnight pages on resident sleep during home call. *J Grad Med Educ* 2018 Oct;10(5):591–5.
- [18] Taffinder NJ, McManus IC, Gul Y, Russell RCG, Darzi A. Effect of sleep deprivation on surgeons' dexterity on laparoscopy simulator. *Lancet* 1998 Oct;352(9135): 1191.
- [19] Grantcharov TP, Bardam L, Funch-Jensen P, Rosenberg J. Laparoscopic performance after one night on call in a surgical department: prospective study. *BMJ* 2001 Nov;323(7323):1222–3.
- [20] Wesnes KA, Walker MB, Walker LG, Heys SD, White L, Warren R, et al. Cognitive performance, and mood after a weekend on call in a surgical unit. *Br J Surg* 1997 Apr;84(4):493–5.
- [21] Jensen A, Milner R, Fisher C, Gaughan J, Rolandelli R, Grewal H. Short-term sleep deficits do not adversely affect acquisition of laparoscopic skills in a laboratory setting. *Surg Endosc* 2004 Jun;18(6):948–53.
- [22] Lehmann KS, Martus P, Little-Elk S, Maass H, Holmer C, Zurbuchen U, et al. Impact of sleep deprivation on medium-term psychomotor and cognitive performance of surgeons: prospective cross-over study with a virtual surgery simulator and psychometric tests. *Surgery* 2010 Feb;147(2):246–54.
- [23] Tendulkar AP, Victorino GP, Chong TJ, Bullard MK, Liu TH, Harken AH. Quantification of surgical resident stress "on call". *J Am Coll Surg* 2005 Oct;2014 (4):560–4.
- [24] Sun EC, Mello MM, Vaughn MT, Kheterpal S, Hawn MT, Dimick JB, et al. Assessment of perioperative outcomes among surgeons who operated the night before. *JAMA Intern Med* 2022 Jul;182(7):720–8.