

Sleep and Alertness Among Interns in Intensive Care Compared to General Medicine Rotations: A Secondary Analysis of the iCOMPARE Trial

Makayla Cordoza, PhD, RN, CCRN-K
 Mathias Basner, MD, PhD, MSc
 David A. Asch, MD, MBA
 Judy A. Shea, PhD
 Lisa M. Bellini, MD
 Michele Carlin
 Adrian J. Ecker
 Susan K. Malone, PhD, RN
 Sanjay V. Desai, MD

Joel T. Katz, MD
 David W. Bates, MD, MSc
 Dylan S. Small, PhD
 Kevin G. Volpp, MD, PhD
 Christopher G. Mott, MASc
 Sara Coats, BS
 Daniel J. Mollicone, PhD
 David F. Dinges, PhD

ABSTRACT

Background Medical interns are at risk for sleep deprivation from long and often rotating work schedules. However, the effects of specific rotations on sleep are less clear.

Objective To examine differences in sleep duration and alertness among internal medicine interns during inpatient intensive care unit (ICU) compared to general medicine (GM) rotations.

Methods This secondary analysis compared interns during a GM or ICU rotation from a randomized trial (2015–2016) of 12 internal medicine residency programs assigned to different work hour limit policies (standard 16-hour shifts or no shift-length limits). The primary outcome was sleep duration/24-hour using continuous wrist actigraphy over a 13-day period. Secondary outcomes assessed each morning during the concomitant actigraphy period were sleepiness (Karolinska Sleepiness Scale [KSS]), alertness (number of Brief Psychomotor Vigilance Test [PVT-B] lapses), and self-report of excessive sleepiness over past 24 hours. Linear mixed-effect models with random program intercept determined associations between each outcome by rotation, controlling for age, sex, and work hour policy followed.

Results Of 398 interns, 386 were included ($n = 261$ GM, $n = 125$ ICU). Average sleep duration was 7.00 ± 0.08 h and 6.84 ± 0.10 h, and number of PVT lapses were 5.5 ± 0.5 and 5.7 ± 0.7 for GM and ICU, respectively (all $P > .05$). KSS was 4.8 ± 0.1 for both rotations. Compared to GM, ICU interns reported more days of excessive sleepiness from 12^{AM}–6^{AM} (2.6 vs 1.7, $P < .001$) and 6^{AM}–12^{PM} (2.6 vs 1.9, $P = .013$) and had higher percent of days with sleep duration < 6 hours (27.6% vs 23.4%, $P < .001$). GM interns reported more days with no excessive sleepiness (5.3 vs 3.7, $P < .001$).

Conclusions Despite ICU interns reporting more excessive sleepiness in morning hours and more days of insufficient sleep (< 6 hours), overall sleep duration and alertness did not significantly differ between rotations.

Introduction

High-quality sleep of sufficient duration is essential for optimal daytime functioning.¹ Recommended sleep duration is 7 to 9 hours per night; however, shift workers, including medical residents, regularly fail to achieve sufficient sleep, which may impair neurobehavioral function and attention.^{2–12} Despite long hours with often inconsistent schedules, residents are expected to maintain a high level of alertness in order to make critical clinical decisions and maintain patient safety.^{2,9,13,14}

While medical residents' sleep is recognized as habitually insufficient, few studies have investigated the impact of different hospital rotations on sleep.¹⁵ Inpatient rotations have differing workloads, call schedules, and patient acuity that may influence residents' sleep and subsequent alertness. Given that first-year residents (interns) have the unique challenge of adjusting to life as residents, are often scheduled for more hospital-based rotations than upper-level residents, and are nearly always called first, interns may be at particular risk for insufficient sleep.^{3,15–19} Understanding the effect different rotations have on sleep would allow for implementation of targeted sleep-promoting strategies on rotations where interns are at highest risk for sleep deprivation, which may in turn protect neurobehavioral function.

DOI: <http://dx.doi.org/10.4300/JGME-D-21-00045.1>

Editor's Note: The online version of this article contains the mean sleep duration, sleepiness, and alertness comparing intensive care unit to general medicine interns, stratified by shift type.

We aimed to examine differences in objectively measured sleep duration and alertness among internal medicine resident interns during inpatient intensive care unit (ICU) compared to inpatient general medicine (GM) rotations.

Methods

This was a secondary analysis of the iCOMPARE trial that, in academic year 2015–2016, randomized 63 US internal medicine residency programs to either standard work hour (16-hour shift limits) or flexible (no shift length limit) policies. Within that trial, 12 medium-to-large programs were selected to assess sleep and alertness (6 programs from each arm).^{20–23} Interns were observed for 2 weeks during GM, cardiology, or ICU rotations.

Sleep/wake was continually assessed using wrist actigraphy, which has been used to study sleep in medical residents.² Each morning (generally between 6 and 9 AM) interns completed a brief (5-part) self-report survey on a trial-issued smartphone, which included the type of shift they were working that day (day, night, continuing extended overnight, finishing extended overnight, day off, other), a sleep log (self-reported sleep periods during past 24 hours, used to aid in determination of sleep timing from actigraphy), and a rating of sleep quality (on a 5-point scale from 1=bad to 5=good). They also reported any excessive sleepiness during a past period of 24 hours (options were presented from midnight to midnight in 6-hour intervals, and interns were asked to select all applicable intervals where they experienced excessive sleepiness, or to select no intervals), and current level of sleepiness using the Karolinska Sleepiness Scale²⁴ (KSS; a 9-point scale from 1 = extremely alert to 9 = extremely sleepy–fighting sleep). A 3-minute Psychomotor Vigilance Test (PVT-B),^{4,6} a measure of the stability of vigilant attention that is sensitive to the neurobehavioral effects of acute and chronic sleep loss with some validity evidence for use in medical residents,² was then completed on the issued smartphone. Full study methods, including copies of survey tools, smartphone interface, and participant selection details can be found elsewhere.^{20,23}

For this secondary analysis, only interns in GM (wards, GM) or ICU (medical, cardiovascular, or combined medical/cardiac ICU) rotations were included. The primary outcome was mean sleep duration per 24 hours from actigraphy recordings. Secondary outcomes were mean sleepiness (KSS) and alertness (number of PVT-B lapses where reaction time was ≥ 355 msec, with higher number of lapses indicating lower levels of alertness).

For each outcome, data were averaged across the study period (thirteen 24-hour periods). Separate linear mixed-effect models with random program intercepts were used to determine associations between each outcome (sleep duration, sleepiness, and alertness) by rotation, adjusting for age, sex, and work hour policy followed (standard 16-hour or no shift length limit). To evaluate differences in each outcome during workdays compared to days off, outcomes were also stratified by shift type (work shift or day off). Statistical analysis was performed using Stata version 14 (StataCorp LP, College Station, TX). All analyses were 2-sided, with a significance level of $\alpha < .05$. This study was approved by the institutional review board at the University of Pennsylvania.

Results

Of a potential 398 interns from the iCOMPARE trial, 12 were excluded for being on cardiology rotations, and 386 were included ($n = 261$ [67.6%] GM, and $n = 125$ [32.4%] ICU). Mean age \pm SD was 27.9 ± 2.1 years, with 194 (50.3%) men (TABLE 1). Mean sleep duration \pm standard error (SE) was 7.0 ± 0.1 hours, and 6.8 ± 0.1 hours for GM and ICU, respectively ($P = .09$; 95% CI -0.02, 0.33 hours; TABLE 2). ICU interns had a higher percentage of days with sleep duration < 6 h (27.6% vs 23.4%, respectively). Mean frequency of days with self-report of excessive sleepiness was higher for ICU from 12AM–6AM (ICU: 2.6; GM: 1.7; $P < .001$; 95% CI -1.41, -0.43) and 6AM–12PM (ICU: 2.6; GM: 1.9; $P = .013$; 95% CI -1.30, -0.16). GM interns reported more days with no excessive sleepiness (GM: 5.3; ICU: 3.7; $P < .001$; 95% CI 0.82, 2.46). Mean (\pm SE) KSS was 4.8 ± 0.1 for both rotations. Mean (\pm SE) number of PVT-B lapses were 5.5 ± 0.5 and 5.7 ± 0.7 for GM and ICU, respectively ($P = .83$; 95% CI -1.48, 1.18 lapses). When stratified by shift type (day shift, night shift, extended overnight shift [> 16 -hour shift], day off, or other), ICU interns slept less going into an extended overnight and reported a higher proportion of extended overnight shifts compared to GM (see online supplementary data).

Discussion

This is one of few studies that have compared objective sleep and alertness between different intern rotations. In this secondary analysis from 12 internal medicine residency programs, sleep duration measured by actigraphy over a 2-week period did not differ between GM compared to ICU rotations. Despite ICU interns having a slight deficit of 12 minutes per day on average, and having more

TABLE 1
Intern Characteristics Comparing Intensive Care Unit to General Medicine Rotations

Characteristic	Total (n = 386)	ICU (n = 125)	GM (n = 261)	P Value
Age, mean (SD)	27.9 (2.1)	28.0 (2.1)	27.8 (2.1)	.49
Male, n (%)	194 (50.3)	65 (52)	129 (49.4)	.64
Race, n (%)				.14
White	218 (56.5)	69 (55.2)	149 (57.1)	
Black/African	13 (3.4)	4 (3.2)	9 (3.5)	
Asian	125 (32.4)	47 (37.6)	78 (29.9)	
More than 1	16 (4.2)	2 (1.6)	14 (5.4)	
Other or unknown	14 (3.6)	3 (2.4)	11 (4.2)	
Ethnicity, n (%)				.23
Hispanic/Latino	23 (6.0)	10 (8.0)	13 (5.0)	
Not Hispanic/Latino	348 (90.2)	108 (86.4)	240 (92.0)	
Unknown	15 (3.9)	7 (5.6)	8 (3.1)	
Program, n (%)				.18
Flexible	205 (53.1)	73 (58.4)	132 (50.6)	
Standard	181 (46.9)	52 (41.6)	129 (49.4)	

extended overnight shifts, there were no differences in sleepiness or alertness between rotations.

ICU interns reported being more excessively sleepy in morning hours (12AM to 12PM) and had a higher percentage of days with insufficient sleep (< 6 hours). This is likely because ICU interns had a higher proportion of extended overnight shifts compared to GM interns, resulting in less opportunity for sleep and more opportunity to report excessive sleepiness early in the morning. Regardless, ICU intern alertness remained similar to GM interns, suggesting that they

were able to overcome the slight reduction in sleep duration.

Regardless of rotation, interns showed similar patterns of sleep duration, sleepiness, and alertness (number of PVT-B lapses), except ICU interns beginning an overnight shift (likely because ICU interns had a higher proportion of overnight shifts overall). Interns finishing an overnight shift had the least amount of sleep (~5 hours) and lowest alertness (highest number of PVT-B lapses) compared to all other shift types. Sleep duration among residents has

TABLE 2
Sleep and Alertness Outcomes Comparing Intensive Care Unit to General Medicine Rotations

	Total (n = 386), Outcome Mean (SE)	Intensive Care Unit (n = 125), Outcome Mean (SE)	General Medicine (n = 261), Outcome Mean (SE)	P Value
Sleep duration (in hours) per 24 hours	6.9 (0.8)	6.8 (0.1)	7.0 (0.1)	.09
Karolinska Sleepiness Scale Score	4.8 (0.1)	4.8 (0.1)	4.8 (0.1)	.60
Brief Psychomotor Vigilance Test ^a				
Lapses	5.6 (0.5)	5.7 (0.6)	5.5 (0.5)	.83
Response speed	3.9 (0.04)	3.9 (0.1)	3.9 (0.05)	.96
False starts	1.7 (0.1)	1.8 (0.1)	1.7 (0.1)	.79
Excessive sleepiness in past 24 hours ^b				
12AM to 6AM	2.0 (0.1)	2.6 (0.2)	1.7 (0.2)	< .001
6AM to 12PM	2.1 (0.2)	2.6 (0.3)	1.9 (0.2)	.013
12PM to 6PM	2.0 (0.2)	2.2 (0.3)	1.9 (0.2)	.29
6PM to 12AM	2.8 (0.2)	3.1 (0.3)	2.6 (0.2)	.17
No excessive sleepiness in past 24 hours ^b	4.8 (0.4)	3.7 (0.5)	5.3 (0.4)	< .001

^a Lapses: reaction time to stimulus > 355 ms; Response speed: mean reciprocal reaction time (1/s); False starts: response prior to stimulus being presented.

^b Response from daily survey question, "Please indicate when you experienced excessive sleepiness in the past 24 hours." Options were presented from midnight to midnight in 6-hour intervals, with an option to select "Did not experience of excessive sleepiness in the past 24 hours."²⁰

been shown to vary by shift type and length, with extended overnight shifts having the most prominent effect on neurobehavioral function.^{2,10,12,19} Further, extended-duration shifts are known to impair performance and safety.⁹ As residents must maintain a high level of alertness in order to make critical clinical decisions, residency programs should consider promoting strategies that offer opportunities for more sleep, such as protected sleep periods, during extended overnight shifts.^{13,25}

This study included internal medicine interns from 12 residency programs. Given the heterogeneity of call schedules and workloads across internal medicine residency programs, findings from this study may not be generalizable across programs. We also collapsed all categories of GM and ICU rotations together. There may be unique demands for different types of rotations that differentially impact sleep and thus were not captured. Finally, data were collected for a single 2-week period from 2015 to 2016. Given the rapidly changing clinical landscape, findings may not reflect the current training environment.

In future research on the effects of resident work hours on sleep, it may be valuable to consider how sleep patterns change over time in longer longitudinal studies, include a wider range of specialties, and include outpatient experiences with variable call patterns.

Conclusions

Although ICU interns experienced more excessive sleepiness in morning hours and a higher percentage of days with insufficient sleep (< 6 hours per day), objectively measured sleep duration and alertness did not differ between ICU and GM rotations.

References

1. Consensus Conference Panel, Watson NF, Badr MS, et al. Joint consensus statement of the American Academy of Sleep Medicine and Sleep Research Society on the recommended amount of sleep for a healthy adult: methodology and discussion. *Sleep*. 2015;38(8):1161–1183. doi:10.5665/sleep.4886
2. Basner M, Dinges DF, Shea JA, et al. Sleep and alertness in medical interns and residents: an observational study on the role of extended shifts. *Sleep*. 2017;40(4):zsx027. doi:10.1093/sleep/zsx027
3. Zebrowski JP, Pulliam SJ, Denninger JW, Berkowitz LR. So tired: predictive utility of baseline sleep screening in a longitudinal observational survey cohort of first-year residents. *J Gen Intern Med*. 2018;33(6):825–830. doi:10.1007/s11606-018-4348-3
4. Van Dongen HP, Maislin G, Mullington JM, Dinges DF. The cumulative cost of additional wakefulness: dose-response effects on neurobehavioral functions and sleep physiology from chronic sleep restriction and total sleep deprivation. *Sleep*. 2003;26(2):117–126. doi:10.1093/sleep/26.2.117
5. Cavallo A, Jaskiewicz J, Ris MD. Impact of night-float rotation on sleep, mood, and alertness: the resident's perception. *Chronobiol Int*. 2002;19(5):893–902. doi:10.1081/cbi-120014106
6. Basner M, Dinges DF. Maximizing sensitivity of the psychomotor vigilance test (PVT) to sleep loss. *Sleep*. 2011;34(5):581–591. doi:10.1093/sleep/34.5.581
7. Durmer JS, Dinges DF. Neurocognitive consequences of sleep deprivation. *Semin Neurol*. 2009;29(4):320–339. doi:10.1055/s-2005-867080
8. Caruso CC. Negative impacts of shiftwork and long work hours. *Rehabil Nurs*. 2014;39(1):16–25. doi:10.1002/rnj.107
9. Lockley SW, Barger LK, Ayas NT, et al. Effects of health care provider work hours and sleep deprivation on safety and performance. *Jt Comm J Qual Patient Saf*. 2007;33(suppl 11):7–18. doi:10.1016/s1553-7250(07)33109-7
10. Anderson C, Sullivan JP, Flynn-Evans EE, et al. Deterioration of neurobehavioral performance in resident physicians during repeated exposure to extended duration work shifts. *Sleep*. 2012;35(8):1137–1146. doi:10.5665/sleep.2004
11. Rose M, Manser T, Ware JC. Effects of call on sleep and mood in internal medicine residents. *Behav Sleep Med*. 2008;6(2):75–88. doi:10.1080/15402000801952914
12. Weiss P, Kryger M, Knauer M. Impact of extended duty hours on medical trainees. *Sleep Health*. 2016;2(4):309–315. doi:10.1016/j.sleh.2016.08.003
13. Shea JA, Bellini LM, Dinges DF, et al. Impact of protected sleep period for internal medicine interns on overnight call on depression, burnout, and empathy. *J Grad Med Educ*. 2014;6(2):256–263. doi:10.4300/JGME-D-13-00241.1
14. Landrigan CP, Rahman SA, Sullivan JP, et al. Effect on patient safety of a resident physician schedule without 24-hour shifts. *N Engl J Med*. 2020;382(26):2514–2523. doi:10.1056/NEJMoa1900669
15. Baldwin DC Jr, Daugherty SR. Sleep deprivation and fatigue in residency training: results of a national survey of first- and second-year residents. *Sleep*. 2004;27(2):217–223. doi:10.1093/sleep/27.2.217
16. Kalmbach DA, Fang Y, Arnedt JT, et al. Effects of sleep, physical activity, and shift work on daily mood: a prospective mobile monitoring study of medical interns. *J Gen Intern Med*. 2018;33(6):914–920. doi:10.1007/s11606-018-4373-2

17. Sen S, Kranzler HR, Krystal JH, et al. A prospective cohort study investigating factors associated with depression during medical internship. *Arch Gen Psychiatry*. 2010;67(6):557–565. doi:10.1001/archgenpsychiatry.2010.41
18. Nasca TJ, Day SH, Amis ES Jr. The new recommendations on duty hours from the ACGME Task Force. *N Engl J Med*. 2010;363(2):e3. doi:10.1056/NEJMs1005800
19. Lin YH, Ho YC, Lin SH, et al. On-call duty effects on sleep-state physiological stability in male medical interns. *PLoS One*. 2013;8(6):e65072. doi:10.1371/journal.pone.0065072
20. Basner M, Asch DA, Shea JA, et al. Sleep and alertness in a duty-hour flexibility trial in internal medicine. *N Engl J Med*. 2019;380(10):915–923. doi:10.1056/NEJMoa1810641
21. Silber JH, Bellini LM, Shea JA, et al. Patient safety outcomes under flexible and standard resident duty-hour rules. *N Engl J Med*. 2019;380(10):905–914. doi:10.1056/NEJMoa1810642
22. Desai SV, Asch DA, Bellini LM, et al. Education outcomes in a duty-hour flexibility trial in internal medicine. *N Engl J Med*. 2018;378(16):1494–1508. doi:10.1056/NEJMoa1800965
23. Shea JA, Silber JH, Desai SV, et al. Development of the individualised comparative effectiveness of models optimizing patient safety and resident education (iCOMPARE) trial: a protocol summary of a national cluster-randomised trial of resident duty hour policies in internal medicine. *BMJ Open*. 2018;8(9):e021711. doi:10.1136/bmjopen-2018-021711
24. Akerstedt T, Gillberg M. Subjective and objective sleepiness in the active individual. *Int J Neurosci*. 1990;52(1-2):29–37. doi:10.3109/00207459008994241
25. Volpp KG, Shea JA, Small DS, et al. Effect of a protected sleep period on hours slept during extended

overnight in-hospital duty hours among medical interns: a randomized trial. *JAMA*. 2012;308(21):2208–2217. doi:10.1001/jama.2012.34490



Makayla Cordoza, PhD, RN, CCRN-K*, is a Lecturer, University of Pennsylvania; **Mathias Basner, MD, PhD, MSc***, is a Professor, University of Pennsylvania; **David A. Asch, MD, MBA**, is a Professor, University of Pennsylvania, and Practicing Physician, Corporal Michael J. Crescenz Veterans Affairs Medical Center; **Judy A. Shea, PhD**, is a Professor, University of Pennsylvania; **Lisa M. Bellini, MD**, is a Professor, University of Pennsylvania; **Michele Carlin** is a Project Manager, University of Pennsylvania; **Adrian J. Ecker** is a Senior IT Project Leader, University of Pennsylvania; **Susan K. Malone, PhD, RN**, is an Assistant Professor, New York University; **Sanjay V. Desai, MD**, is a Professor, Johns Hopkins University; **Joel T. Katz, MD**, is Vice Chair for Education, Brigham and Women's Hospital; **David W. Bates, MD, MSc**, is Division of General Internal Medicine Chief, Brigham and Women's Hospital; **Dylan S. Small, PhD**, is a Professor, University of Pennsylvania; **Kevin G. Volpp, MD, PhD**, is a Professor, University of Pennsylvania, and Practicing Physician, Corporal Michael J. Crescenz Veterans Affairs Medical Center; **Christopher G. Mott, MASc**, is Chief Technology Officer, Pulsar Informatics; **Sara Coats, BS**, is Lead Project Coordinator, Pulsar Informatics; **Daniel J. Mollicone, PhD**, is Chief Executive Officer, Pulsar Informatics; **David F. Dinges, PhD**, is a Professor, University of Pennsylvania; and iCOMPARE Research Group.

* Denotes co-first authors.

Funding: Makayla Cordoza, PhD, RN, CCRN-K, is supported by NIH/NINR (K99 NR019862). This study was funded by the National Heart, Lung, and Blood Institute and the Accreditation Council for Graduate Medical Education.

Conflict of interest: The authors declare they have no competing interests.

This work was previously presented at the American Association of Sleep Medicine Virtual Meeting, August 27–30, 2020.

Corresponding author: Makayla Cordoza, PhD, RN, CCRN-K, University of Pennsylvania, mcordoza@penmedicine.upenn.edu, Twitter @makaylacordoza

Received January 12, 2021; revisions received July 8, 2021; accepted July 22, 2021.