Sleep quality during an overnight on-call program

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Purpose. Many institutions deploy pharmacy residents to expand clinical pharmacy services, often in the form of overnight, in-house on-call programs. There is little published evidence regarding pharmacy resident sleep and sleepiness after a night of overnight, in-house on-call activity. A prospective observational cohort study was conducted to determine the relationship between overnight, in-house on-call programs and pharmacy resident sleep and sleep quality.

Methods. The cohort study included both postgraduate year 1 and postgraduate year 2 pharmacy residents. Each resident participated in 10 to 15 overnight on-call shifts. Sleep and sleep quality were assessed using devices worn on residents' wrists on the nights prior to, during, and after on-call shifts. Resident sleepiness was assessed via the Epworth Sleepiness Scale (ESS) during specified baseline and postcall periods. Univariate and multivariate analysis were used to assess the relationship between measurements of sleep, sleep quality, and sleepiness.

Results. We enrolled a total of 23 residents in the study and recorded data on 269 on-call shifts. Frequently (42.6% of shifts) residents had no time to sleep during overnight on-call shifts. Among those who did have sleep time, the mean sleep time during an overnight, in-house on-call shift was 1.22 (SD, 1.56) hours. Additionally, ESS scores indicated a 2.4-fold increase in sleepiness on the morning after vs the morning before on-call shifts.

Conclusion. Residents often did not sleep while on call. Sleep periods overnight were short and of poor quality. Predictably, residents reported increased sleepiness after an overnight on-call shift. Residents received an average of approximately 10 clinical consultation calls per overnight shift.

Keywords: duty hours, fatigue, on-call, pharmacy, residents, sleep

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The American Society of Health-System Pharmacists (ASHP) has emphasized the importance of patient safety and resident well-being through the enforcement of duty-hour requirements. The 2012 ASHP duty-hour requirements limit continuous duty periods of pharmacy residents to 16 hours, with a maximum allowable duty assignment of 24 hours, allotting 2 additional hours for transitions of care or educational activities.¹ Pharmacy departments across the country deploy residents to enhance the provision of patient care by extending clinical coverage. Specifically, weekend and weeknight coverage may often be

covered by residents through on-call services, some of which are overnight and in-house.² Residents are responsible for numerous on-call activities, including emergency response, bleeding and/or coagulopathy reversal, therapeutic drug monitoring, drug information questions, antimicrobial dosing, and support of pharmacy operations.³

The presence of an overnight, in-house on-call program leads to increased provision of patient care and a reduction in medication cost—both important priorities of the ASHP Practice Advancement Initiative (PAI).^{2,3} Utilization of pharmacy

residents allows clinical pharmacy services personnel to influence decision making on high-cost, high-risk therapies throughout the day and also at night, when clinical coverage is often not otherwise available, and also serves as a valuable educational opportunity for the residents. However, overnight coverage by pharmacy residents could have a detrimental effect on sleep and sleep quality, potentially leading to decreased awareness and cognitive flexibility, resulting in medication errors and a decrease in patient safety. While some research evaluating the effects of duty-hour requirements and sleep disturbance on medical and surgical resident well-being and patient outcomes has been conducted, there is limited published information on this topic in relation to pharmacy residents.^{4,5}

The primary purpose of the study described here was to determine the influence of overnight, in-house on-call duty on sleep and sleep quality in pharmacy residents, as well as sleepiness following overnight, in-house on-call duty.

Methods

The study was a single-center, prospective observational cohort study of postgraduate year 1 (PGY1) and postgraduate year 2 (PGY2) pharmacy residents designed to determine the impact of an overnight, in-house on-call program on sleep, sleep quality, and sleepiness. Residents participated in approximately 10 to 15 overnight call shifts throughout the study period (September 2016 through June 2017). The on-call schedule was created independent of the study, and the number of overnight on-call shifts was determined before the residency year by individual program directors. Weekday overnight on-call shifts were defined as a 12-hour shift from 1900 to 0700, while weekend and holiday on-call shifts were 24-hour shifts from 0700 to 0700 the next day. Prior to their weekday overnight on-call shifts, all residents were encouraged to nap or rest after completion of their rotation activities;

KEY POINTS

- Resident sleep was minimal and sleep quality poor during overnight on-call shifts.
- On-call residents were typically quite busy performing clinical tasks and activities.
- Poor sleep during on-call shifts led to increased sleepiness relative to baseline levels of sleepiness.

however, this was not strictly monitored, and time between shifts could vary based on resident rotations. The activities of the on-call resident at our institution have been described in part in previous publications.^{3,6-10}

Demographic variables such as age and gender were collected for all participants. Additional variables included the current learning experience, postgraduate year, on-call shift type (weekday vs weekend), and time spent napping prior to call shifts. We also had access to variables related to pharmacy resident on-call shifts, such as the number and types of consultations received throughout each night.

FitBit Flex devices (Fitbit, Inc., San Francisco, CA) were utilized to collect data on resident sleep quality the night prior to, the night of, and the night following on-call shifts. This device reports information such as actual sleep time, frequency of restlessness throughout the night, and overall sleep quality (a measure computed by the device weighing in factors such as length of sleep time, number of times restless, and number of times awake). Previous studies have demonstrated the usefulness of FitBit devices for tracking sleep.¹¹

The Epworth Sleepiness Scale (ESS) was employed to assess resident sleepiness on the morning of and the morning after on-call shift. The ESS consists of an 8-question survey, with responses given on a 4-point

Likert scale, and is often used in sleep disorders such as narcolepsy and obstructive sleep apnea. The ESS is comprised of situational questions reflecting the likelihood of falling asleep in different environments (eg, sitting and reading, seated in a car while stopped for a few minutes in traffic).^{12,13} Residents were also asked to rate their sleepiness on a scale of 1 to 10 (with 10 indicating most sleepy) in order to gain a more subjective measure of their perception of sleepiness. Residents were provided verbal and written instruction on when to wear the FitBit Flex devices and when to complete the surveys.

Data analysis included the use of descriptive statistics to quantify resident sleep, sleep quality, and sleepiness on the night prior to, the night of, and the night following an on-call shift. Simple linear regression was performed to determine the relationships between the number of hours slept and sleep quality and between sleep quality and sleepiness score on the ESS. A mixed-model analysis was used to determine the influence of potential confounding variables on resident sleep during on-call shifts. This model was chosen to control for intra- and interresident variability, as subjects had numerous on-call shifts throughout the study period. Potential confounding variables included learning experience type, postgraduate year, gender, on-call shift type, and napping prior to on-call shift. Data was collected through the use of automated surveys created using Research Electronic Data Capture (REDCap) tools.¹⁴ The data analysis was generated using SAS software version 9.4 (SAS Institute, Cary, NC). The study was approved by the local institutional review board, and informed consent was obtained from each participant prior to enrollment.

Results

A total of 23 residents provided informed consent and were included in the study. The mean resident age was 26.2 (SD, 1.4) years, and the majority of residents (60.9%) were female (Table 1). Each resident completed a mean of 11.7

Table 1. Demographics and Sleep Data Overall and by Year of Residency

Characteristic or Variable	All Participants (n = 23)	PGY1 Residents (n = 8)	PGY2 Residents (n = 15)
Age, mean (SD), y	26.2 (1.4)	26.3 (1.7)	26.1 (1.3)
Gender, No. (%)	14 (60.9)	3 (21.4)	11 (78.6)
On-call shift type, No. (%)			
Weekend	88 (32.7)	32 (36.4)	56 (63.6)
Weekday	181 (67.3)	61 (33.7)	120 (66.3)
Time spent napping prior to on-call shift, No. (%) of shifts (n = 275)			
None	226 (82.2)	75 (33.2)	151 (66.8)
0.5-2 hours	40 (14.5)	11 (27.5)	29 (72.5)
>2 hours	9 (3.3)	7 (77.8)	2 (22.2)
Learning experience type, No. (%) of shifts (n = 272) ^a			
Emergency medicine	28 (10.3)	11 (39.3)	17 (60.7)
ICU early morning	31 (11.4)	7 (22.6)	24 (77.4)
ICU standard morning	44 (16.2)	12 (27.3)	32 (72.7)
Ambulatory care	33 (12.1)	10 (39.3)	23 (69.7)
Acute care	74 (27.2)	29 (39.2)	45 (60.8)
Administration	62 (22.8)	25 (40.3)	37 (59.7)
Sleep time by period, mean (SD), h			
Baseline	6.33 (1.36)	6.15 (1.18)	6.43 (1.45)
On-call	1.22 (1.56)	0.96 (1.46)	1.36 (1.60)
Postcall	7.31 (2.01)	6.82 (1.44)	7.57 (2.23)
Sleep quality score by period, mean (SD), %			
Baseline	93.3 (7.8)	92.9 (7.2)	93.5 (8.2)
On-call	83.6 (20)	86.3 (21.2)	81.8 (19)
Postcall	95.4 (5.4)	95.6 (5.8)	95.2 (5.1)
ESS score by period, mean (SD)			
Baseline	6.0 (4.6)	7.2 (5.8)	5.2 (3.5)
On-call	14.4 (6.4)	15.0 (7.1)	13.9 (5.9)
Sleepy time during on-call shifts (n = 263)			
Resident had some sleep	150 (57.4)	43 (28.7)	107 (71.3)
Resident had no sleep	113 (42.6)	47 (41.6)	66 (58.4)

Abbreviation: ESS, Epworth Sleepiness Scale; PGY1, postgraduate year 1; PGY2, postgraduate year 2.

^aLearning experience description or focus areas: emergency medicine = any emergency medicine rotation (first, second, or third shift) or rotation in pediatric emergency department; ICU early morning = neurosurgery, cardiothoracic surgery, surgical intensive care, and trauma; ICU standard morning = cardiac intensive care, medical intensive care, bone marrow transplant, hematology; ambulatory care = any clinic rotation (cardiology, transplant, oncology, oncology sub-specialty, primary care); acute care = heart failure, internal medicine, pediatrics, neurology, nutrition, solid organ transplant, infectious diseases, and medical oncology; administration = administration, academia, research.

overnight on-call shifts from September 2016 through June 2017. The majority (67.3%) were 12-hour call shifts occurring on weeknights (Table 1). Most of the on-call shifts occurred

during acute care (27.2%) and administrative (22.8%) learning experiences; residents were least likely to serve overnight on-call shifts during emergency medicine (10.3%), intensive care unit

early morning (11.4%), and ambulatory care (12.1%) learning experiences.

Residents did not sleep at all during 42.6% of overnight on-call shifts (Table 1). For those who did sleep, the

mean resident sleep time was 1.22 (SD, 1.56) hours, with a mean sleep quality of 83.6% (SD, 20%). The mean resident sleep time did not differ significantly by residency year, with PGY1 residents averaging 0.96 (SD, 1.46) hours of sleep per call shift and PGY2 residents averaging 1.36 (SD, 1.6) hours. PGY2 residents had decreased sleep quality when compared with PGY1 residents (81.8% vs 86.3%) (Table 1). On the day of an on-call shift, residents frequently (82.2% of instances) did not nap.

In order to better understand resident sleep duration and quality on a typical night, the night prior to on-call duty (the baseline period) and the night after on-call duty (the postcall period) were evaluated. On nights before on-call duty, residents slept a mean of 6.33 (SD, 1.36) hours, with a mean sleep quality of 93.3% (SD, 7.8%). We believe those values provided an approximation of baseline pharmacy resident sleep. On postcall nights, residents slept a mean of 7.31 (SD, 2.01) hours. The mean sleep quality was 95.4% (SD, 5.4%) on these nights. Residents scored an average of 6 out of 24 on the ESS the morning prior to overnight on-call shifts, compared to an average of 14.4 the morning after on-call shifts. These figures represented a 2.4-fold increase

in sleepiness and qualitatively suggest that the residents were sleepier after an overnight on-call shift, with the likelihood of dozing increasing from “slight” to “moderate” (Table 1).

There was a statistically significant ($P < 0.0001$) relationship between sleep and sleep quality for both baseline and postcall nights; this suggested that the more sleep a resident had on nights before and after on-call duty, the better their sleep quality (ie, more sleep at home meant better-quality sleep). This relationship was not observed during on-call shifts ($P = 0.5708$). The analysis identified a possible inverse relationship between the amount of sleep obtained during an overnight on-call shift and sleep quality (ie, during an on-call shift, more sleep did not mean better quality sleep). There was a statistically significant relationship between sleep quality and baseline ESS score ($P = 0.0023$). This finding indicated that an increase in sleep quality led to a decrease in sleepiness. A statistically significant association between sleep quality and on-call ESS score was not observed ($P = 0.6888$), likely due to the high percentage of residents who did not sleep during on-call shifts.

The mixed-model analysis controlled for resident gender, resident

program year, time spent napping prior to call, call-shift type, and learning experience type. No variables significantly impacted the amount of sleep residents got during on-call shift, suggesting that there were no significant predictors of resident sleep during an on-call shift. Resident sleepiness did not seem to be affected by consult volume, although the nature of and time spent on each consultation were not quantified.

The overall activity by residents during the overnight on-call period was extensive. The mean number of consultation requests received during overnight on-call shifts (from 1900 to 0700) was 10, though the frequency varied considerably from day to day (data not shown). Consultations were evenly distributed throughout the nighttime hours (Figure 1), with an average of nearly 1 (0.93) consultation per hour. Consultation topics or content included the following: rapid diagnostic test results (28% of consults), stroke alerts (13%), anticoagulation (12%), antimicrobial dosing (9%), supratherapeutic drug concentrations (8%), emergency response (7%), nonantimicrobial drug dosing (6%), drug information and high-risk medication histories (5%), administrative and miscellaneous (5%), sepsis bundle

Figure 1. Hourly numbers of calls (requests for consultation) during overnight on-call shifts at the study site. Calls were more frequent in the late evening and in the mid-morning hours, with a lull in calls typically occurring from 1 to 3 AM.

(4%), antimicrobial selection (2%), and bleeding reversal (1%). A large proportion of these consultations (at least 25%) required the resident to be at the bedside with the patient and other caregivers during high-acuity events (eg, emergency response, bleeding reversal, stroke alert).

Discussion

The study results add to the literature by describing sleep and sleep quality during typical nights at home and during overnight, in-house on-call shifts among pharmacy residents. While there is information in the literature related to medical and surgical resident on-call activities, sleep, and fatigue,^{4,15,16} little published data pertinent to pharmacy is available.⁵ It may be that the nature of some of the tasks that pharmacists engage in during an on-call shift differ from those performed by surgical or medical residents (eg, pharmacy residents do not perform emergency surgery in the middle of the night), but pharmacy residents may be counted on to apply complex critical thinking skills in providing guidance on dosing of life-saving medications in an ICU patient with multiorgan failure or in verifying and/or checking prescription orders with minute details. Numerous pharmacy residency programs employ on-call programs to some degree, so this information is likely to be impactful for many programs, including those contemplating starting a similar overnight on-call service.²

Knauss et al⁵ recently published a study evaluating alertness after an on-call shift in the pharmacy residency program at Grady Health System in Atlanta, GA. Their study differed from our analysis in that those investigators had a smaller sample size (10 residents were evaluated over the course of 31 on-call shifts during one month) and used a different device to track sleep data. Knauss and colleagues used a psychomotor vigilance test to evaluate attentiveness and the Karolinska sleepiness scale to evaluate sleepiness. Overall, their analysis demonstrated that, on average, a resident was not

significantly sleepier after an on-call shift relative to baseline levels of sleepiness; mean attentiveness scores at baseline and while on call were similar as well. Important differences between the findings of Knauss et al and our findings with regard to number of sleep disruptions (1.7 “interruptions” per night vs 0.93 consult requests per hour) and the mean amount of sleep per night (approximately 6 hours vs 1.22 hours) make it difficult to compare the study results. However, the study of Knauss and colleagues was an excellent preliminary evaluation of the impact of sleep and overnight activity on attentiveness.

The topic of adequate sleep and cognitive performance has been studied across the medical profession; the results thus far have been conflicting. While the effects of an overnight on-call shift on attention, vigilance, and driving performance have been equated to those of low levels of alcohol exposure, other studies have not demonstrated major performance problems.¹⁷ Numerous studies using different measurements and in different physician populations have yielded conflicting results regarding the impact of overnight duty and shift length on patient care, resident wellness, and residents’ participation in educational activities.⁴ Across medical training, the optimal approach to resident work hours and overnight duty is yet to be defined.

Many of the consultations and tasks that residents in our sample performed while on call require bedside response to acute, high-stakes clinical scenarios. Some responsibilities of an on-call resident are focused on distribution of specific medications, such as recombinant factor VIIa and coagulation reversal agents. An on-call resident is also a standard member of institutional response teams for events such as cardiac arrest (adult and pediatric), pulmonary embolism, stroke, status epilepticus, and acute sepsis. In addition, after normal first-shift hours, the clinical laboratory calls the on-call resident in the event of any supratherapeutic

serum drug concentration or positive rapid diagnostic test results for blood cultures. Other drug information consultations, time-sensitive handoffs from daytime pharmacists, and various other random consultations are also common activities for the on-call resident. Based on the frequency and nature of the consultations residents handle while on call, more studies on resident alertness and attentiveness may be necessary to better describe the result of sleep disruption on executive function.

Our analysis found that residents typically slept less during on-call shifts and reported increased sleepiness following overnight, in-house on-call duty. Interestingly, we found that the amount of sleep residents get while on call does not affect their sleep quality; this was consistent for all residents, regardless of postgraduate year, with PGY2 residents averaging slightly more sleep per on-call shift and slightly lower sleep quality than PGY1 residents. One explanation for this finding could be the increased comfort level and decreased anxiety veteran residents may have; alternative, it may have been due to the fact that we only analyzed 1 year’s worth of resident data.

Our findings related to both baseline and postcall sleepy time may represent underestimates, as we evaluated sleep during a time period that included an anticipated night on call (ie, a stressful event), potentially impacting sleep and sleep quality ratings. Baseline sleep may vary throughout the year given that residents may experience work or personal issues that lead to increased stress, depression, increased fatigue, and other life issues that may affect sleep patterns. We did not evaluate these factors in the current study. However, it is plausible that actual baseline, on-call, and postcall sleep quality may be different than our study shows.

One potential study limitation was the potential for the device to not capture sleep time appropriately. We attempted to control for this possibility through use of only FitBit Flex devices.

Another study limitation was the potential for missed survey entries and uncaptured FitBit data for various reasons (eg, device battery was discharged, device failed to record sleep, resident forgot to wear the device); in the event residents reported such occurrences, associated data were censored in our analysis. These incidents were infrequent and occurred randomly across the spectrum of participants. The use of the ESS in the specific context evaluated has not been well studied. However, the practical nature of the scenarios posed in the survey are reflective of some of the concerns about lack of sleep among pharmacy residents, and the ESS is similar to other sleepiness scales that have been used in that context.⁵ Furthermore, the ESS questionnaire is a reliable means of measuring sleepiness, even when used for retesting, and has been demonstrated to have a high level of internal consistency.^{12,13} Survey fatigue could have impacted our ability to accurately assess resident sleepiness throughout the year, as residents participated in multiple overnight on-call shifts and completed numerous surveys over the study period. We also did not regulate or collect information on resident consumption of caffeine or other substances that may affect sleep and sleep quality. We recognize that variability amongst other residency programs related to program design, resident responsibilities, and the structure of rest and/or duty-free time may limit the generalizability of our results; however, we feel the study findings will help raise awareness of important questions related to pharmacy resident well-being.

Conclusion

Residents often did not sleep during on-call shifts. Sleep periods overnight were short and of poor quality. Predictably, residents reported increased sleepiness after an overnight on-call shift. Residents

received an average of approximately 10 clinical consultations or calls per overnight shift.

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At the time of the study, Dr. Cannon was affiliated with UKHealthcare, Lexington, KY.

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