

Sleep Deprivation and Fatigue in Residency Training: Results of a National Survey of First- and Second-Year Residents

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Study Objectives: To examine the relationship between residents' self-reported sleep hours, work hours, and other empirical correlates.

Design: Using the American Medical Association's Graduate Medical Education database, a national, random sample of PGY (postgraduate year) 1 and PGY2 residents in the 1998-1999 training year was surveyed by mail.

Measurements and Results: Residents completed a 5-page survey with 44 questions requiring 144 separate responses about their residency experience. Completed surveys were received from 3,604 of 5,616 residents contacted, a 64.2% response rate. Although work hours and sleep hours were significantly correlated ($r = -.39$), this relationship was less robust than is generally assumed. Total average sleep hours varied across specialties but also within specialties. Just over 20% of all residents reported sleeping an average of 5 hours or less per night, with 66%

averaging 6 hours or less per night. Residents averaging 5 or fewer hours of sleep per night were more likely to report serious accidents or injuries, conflict with other professional staff, use of alcohol, use of medications to stay awake, noticeable weight change, working in an "impaired condition," and having made significant medical errors.

Conclusions: Reduced sleep hours were significantly related to a number of work-related, learning, and personal health variables. Capping residents' work hours is unlikely to fully address the sleep deficits and resulting impairments reported by residents.

Key Words: Internship and residency, sleep deprivation, fatigue, work, stress, learning, medical error, impairment

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INTRODUCTION

MOST RESIDENTS REPORT SLEEP DEPRIVATION AND CHRONIC FATIGUE AS A FREQUENT CONSEQUENCE OF THE EXTENDED WORK SCHEDULES EXPECTED IN THEIR TRAINING PROGRAMS.¹⁻⁵ This sleep deprivation is different from that experienced by most people during occasional stressful periods of work and life. As several recent reviews have demonstrated, the loss of sleep for residents is cumulative and prolonged, extends over many months, and leaves them in a nearly continuous state of chronic partial sleep deprivation.⁵⁻⁹ Acute sleep loss, brought on by a busy night on call, simply overlays this baseline.⁶ Not only is the quantity of sleep significantly reduced below that required for maintenance of good health and effective performance, resulting in a cumulative "sleep debt," but the quality of that sleep is also compromised.¹⁰⁻¹⁴ Interruptions of sleep during night call not only reduce the total amount of sleep, but result in "sleep inertia," which can impair performance for up to 30 minutes after waking.¹⁵⁻¹⁸ Fragmented and impaired sleep also produces significant disturbances of electroencephalographic sleep patterns and normal circadian sleep-wake rhythms.^{10,11,13,14} Even where residents deny sleepiness, objective observation has established that such persons frequently exhibit momentary "microsleeps" that impair attention and performance on tasks requiring vigilance.^{10,19-22}

The extended work hours and sleep loss experienced by residents are well documented. A recent survey of 4,510 residents in obstetrics and gynecology found that 3 out of 4 reported working between 61 and 100 hours each week, and more than 70% claimed to have slept less than 3 hours per night when on call.¹ In another study, 20% of interns reported

having gone without sleep for longer than 48 hours.³ Our own recent national multispecialty survey of 3,604 residents found that half of PGY (postgraduate year) 1 and 35% of PGY2 residents reported working an average of more than 80 hours per week.²

Studies of workers in transportation occupations have confirmed consistent impairments in performance after work schedules of more than 12 hours per day.²³ Two recent studies illustrate this by demonstrating that a single episode of 17 hours of continuous sleeplessness can cause performance deficits comparable to those of persons with a blood alcohol level of 0.05%, while 24 hours of sustained wakefulness was associated with a level of 0.1%, enough to be legally drunk.²⁴⁻²⁵ Performance deficits, medical errors, and other impairments of patient care due to fatigue and sleep deprivation have also been widely documented in the medical community.^{2,4-7,26} Sixty-one percent of practicing anesthesiologists in the United States and 86% of their colleagues in New Zealand have reported making fatigue-related errors.^{27,28} A 1991 report on 254 residents in internal medicine revealed that 45% of the respondents admitted making mistakes and that 41% of these claimed that fatigue had caused them to make their most significant medical mistake.²⁹ In another study of 225 residents from various specialties, "tiredness" was listed as the most important factor in impaired patient care.³⁰ The toll that fatigue and sleep impairment take on residents' mood, physical health, obstetrical complications, mental health, traffic accidents, substance use and abuse, and impaired relationships with coworkers and family members has been thoroughly reviewed by others.^{5,6,23} A number of studies have found an increased risk of automobile accidents and violations for residents following call.³¹⁻³³ In a survey of 697 emergency medicine residents, fall-asleep motor vehicle crashes were 6.7 times more frequent than before residency.³³ A recent report has shown that chronic sleep deprivation is associated with a marked decrease in glucose tolerance and alterations in the cortisol profile, which can have long-term effects on health.³⁴⁻³⁵ Perhaps the most devastating finding of all is that sleep-deprived residents appear to lose the capacity to recognize their own possible impairment.^{10,19-20,36-38}

As the nation's residency programs scramble to achieve compliance with the duty-hour requirements established by the Accreditation Council for Graduate Medical Education,³⁹ there seems to be an implicit assumption that the 80-hour limit will result in increased rest for sleep-

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deprived residents. It is not clear that this will be the case. Within the constraints of their physiologic needs for sleep, residents can, and apparently do, make distinctly individual choices concerning what they want to do with their unscheduled work time. At the extremes, work hours may well control the amount of sleep that residents get, but it is not at all clear how robust this relationship is overall. In spite of burgeoning interest in these issues, there are no recent, large-scale, national, multispecialty studies examining sleep hours, work hours, and correlates of sleep deprivation among residents training in the United States. We focus here on the self-reported sleep hours and ratings of sleep deprivation by a national random sample of 1,629 PGY1 and 1,863 PGY2 residents in a variety of specialties and hospitals. Our report includes analyses of the associations between these reported sleep hours and a number of work-related, learning, personal health, and satisfaction variables.

METHODS

The study sample was identified using the Graduate Medical Education database, which is secured as part of the annual Survey of Graduate Medical Education Programs by the American Medical Association.^{2,4,40} A 15% sample was drawn, using the random selection feature of SPSS-PC (SPSS, Inc. Chicago, Ill), from residents who were reported to be in PGY1 and PGY2 positions, had had no prior training, and were scheduled to complete their current year of training in the summer of 1999. There was no attempt at over-sampling or stratification. The final target sample consisted of 6,106 residents (14.8%).

Survey Instrument

The questionnaire was based on an earlier national survey conducted by the authors during 1989, as well as on similar surveys conducted by the American Medical Association in 1979, 1983, and 1987.^{2,4,41} Questions were derived primarily from our previous surveys and focused on the broad residency experience, including work hours, sleep, supervision, stress, learning, behavioral change, and impairment, as well as on reported incidents of humiliation, sexual and racial harassment or discrimination, and observations of unethical or unprofessional behavior. The resulting survey was revised after pilot testing for clarity and cognitive testing with residents in different specialties. The final instrument consisted of a 5-page questionnaire, with 44 questions requiring 144 separate responses.

Survey Procedure

The questionnaire was mailed out in late April 1999, along with a cover letter, a prestamped return envelope, and a postcard with the resident's name and address. Residents were asked to return the postcard and the completed questionnaire separately, thus enabling the investigators to identify whether subjects had responded to the survey, while maintaining respondents' anonymity. Residents were also instructed to return the postcard if they declined to participate or were not enrolled in either their PGY1 or PGY2 year. Subjects who did not return the postcard were mailed a follow-up survey package on 3 subsequent occasions. Additional efforts were made to contact nonresponders through their program directors. Surveys were accepted until September of 1999. They were numbered and coded in the order in which they were received. Correlations were calculated between identification numbers and reported variables. None were outside the range of $r = \pm .03$.

Survey Questions

The index questions relating to sleep were as follows: "How often, if ever, did you experience periods of prolonged sleep deprivation during your current year of residency?" Five response categories were supplied: "Never," "A few times a month," "Weekly," "More than once a week," and "Almost daily." A second question queried, "In an average week, during your current year of residency, about how many hours of sleep did you get? (8 hours of sleep per night = 56 hours per week)." A third

question then asked, "During your current year of residency, what was the longest number of hours you went without sleep? (Provide an estimate)." Survey questions of this type have been shown by a number of investigators to have strong convergent validity with both sleep diaries and actigraphy.⁴²⁻⁴³ Residents were also asked to rate the degree to which they agreed or disagreed with the following 5 statements about the effects of sleep deprivation, using a scale of 1 (strongly disagree) to 7 (strongly agree): (1) "I feel that doing without sleep has sometimes impaired my capacity to care for patients." (2) "When I have to do without sleep, I am moodier and more short-tempered." (3) "The number of hours I was required to put in each week was too long." (4) "Sleep deprivation has led me to make misjudgments in patient care." (5) "During periods of sleep deprivation, I got into more conflicts with the professional staff." These items were drawn from previous national surveys conducted by the authors and highlight the possible negative effects of sleep deprivation in keeping with residents' own commentary about the impacts of sleep deprivation.^{3,4}

Statistical Analyses

All statistical analyses were conducted using SPSS-PC (SPSS, Inc., Chicago, Ill). Sleep hours and ratings of sleep deprivation are reported as both averages and percentages of respondents reporting 5 or fewer and 6 or fewer hours of sleep per night. Differences in reported sleep hours, ratings of sleep deprivation, and longest number of hours without sleep were assessed by means of 1-way analyses of variance. The relationship between patient care, personal health and behavior variables, and residency satisfaction ratings were also assessed by means of 1-way analyses of variance, with each resident classified into 1 of 5 categories of average daily amount of sleep (< 4 hours, 4-5 hours, 5-6 hours, 6-7 hours, > 7 hours). This method of analysis permits visual inspection of the empirical relationships in a way that abstract regression coefficients do not. Odds ratios were used to assess any increased risk incurred by very low amounts of sleep (≤ 5 hours per night vs > 5 hours per night) on reports of medical errors, negative life events, changes in personal health habits, and working in an impaired condition. The relationship between sleep hours and work hours was examined both graphically and by analyses of variance.

RESULTS

Of the 6,106 surveys mailed, 295 were found to be undeliverable, and 145 respondents replied that they were not in either the PGY1 or PGY2 training year. An additional 39 were identified as having left their programs before the date of the survey, usually for cause. Two additional residents had died, and there was no record of 9 others ever having been in the identified program. The total denominator for responding residents, then, was 5,616. Completed surveys were received from 3,604 residents, a 64.2% response rate. The response rate for PGY1 residents was 59% ($n = 1665$), and for PGY2 residents it was 68.7% ($n = 1912$). Less than 1% ($n = 27$) of the respondents did not indicate their graduate year. Response rates were relatively consistent across specialties, with only 2 surgical specialties registering below 50%. Distribution across specialties approximated national figures for comparable years.⁴⁰ The demographic composition of the sample closely paralleled national figures and is described in detail elsewhere.^{2,40}

Sleep Hours

Residents reported sleeping an average of 40.3 (SD = 6.3) hours per week, or 5.7 (SD = .90) hours per night during PGY1, and 41.9 (SD = 6.8) hours of sleep a week and 5.98 (SD = .97) hours per night during PGY2. This difference was statistically significant, with PGY2 residents recording 1.6 more hours of sleep per week, or 13.8 more minutes per night than PGY1 residents ($t = 7.30$, unequal variances, $df = 3524.49$, $P < .0001$). PGY1 residents also reported that they had experienced significantly more "prolonged sleep deprivation," as well as longer single

periods without sleep than their PGY2 colleagues ($t = 5.80$, equal variances, $df = 3543$, $P < .0001$). There were significant differences in reported average weekly sleep hours between specialties ($F = 28.21$, $df = 3543$, $\eta^2 = .138$, $P = .0001$); with PGY1 residents in pathology averaging 48.6 (SD = 6.2) hours of sleep per week, while those in general surgery reported 35.4 (SD=6.0) hours per week, nearly 2 hours less per night. This same pattern was reflected in PGY2, with the exception of more sleep reported in emergency medicine, family practice, and psychiatry residents and less sleep in surgery residents. Differences between PGY1 and PGY2 residents were not of sufficient magnitude, however, to overcome the advantages of combining the 2 groups for most subsequent analyses, except where otherwise noted. For the total sample, reported sleep hours closely approximated a bell-shaped distribution (skewness coefficient = .003, SE = .041). Slightly less than 4% ($n = 131$) of respondents claimed to have averaged 4 hours or less per night, while 22.2% ($n = 788$) reported averaging 5 hours or less per night. Just over 10% ($n = 382$) stated that they had averaged 7 hours or more of sleep per night, and 0.4% ($n = 15$) averaged 8 hours or more per night. There was a high degree of variability in the sleep hours reported by residents within different specialties. Although visual inspection shows slight shifts from the normal distribution for selected specialties, in every case skewness coefficients demonstrated that the distribution of reported sleep hours within each specialty approximated the normal.

Table 1 summarizes sleep deprivation ratings, average weekly sleep hours, and percentages of residents who reported an average of 5 hours or fewer and 6 hours or fewer hours of sleep per night for each specialty. Significant differences across specialties (details in Table 1) were found for all 4 of these measures. Figure 1 portrays the correlation between the self-reported weekly sleep hours and the residents' own ratings of their perceived levels of sleep deprivation ($r = -.41$, $n = 3,532$, $P = .0001$).

Work Hours and Sleep Hours

The relationship between reported work and sleep hours merits careful examination. As expected, reported work hours were significantly

correlated with sleep hours ($r = -.39$, $n = 3,476$, $P = .0001$). However, this correlation indicates that reported average work hours account for just over 10% of the variance in reported sleep hours. Figure 2 presents a scatterplot of the relationship between average sleep hours and work hours for the entire sample. The wide variations in both sleep hours and work hours, as well as the limits to the covariation between reported sleep and work hours, are immediately apparent. A step-wise multiple regression analysis (forward inclusion) was performed to predict sleep hours, using all of the variables in our data set. The model with the largest R^2 included 7 other variables (stress rating; not taking time off for illness; US medical graduate vs International medical graduate; time teaching medical students; the occurrence of life events, such as death in the family; working without adequate supervision; residency year) in addition to work hours but only increased the prediction of sleep variation by an additional 6% ($R^2 = .21$). Even if one assumes high rates of respondent error in reporting both sleep and work hours, other nonspecified factors are required to account for the lion's share of the variation in reported sleep hours.

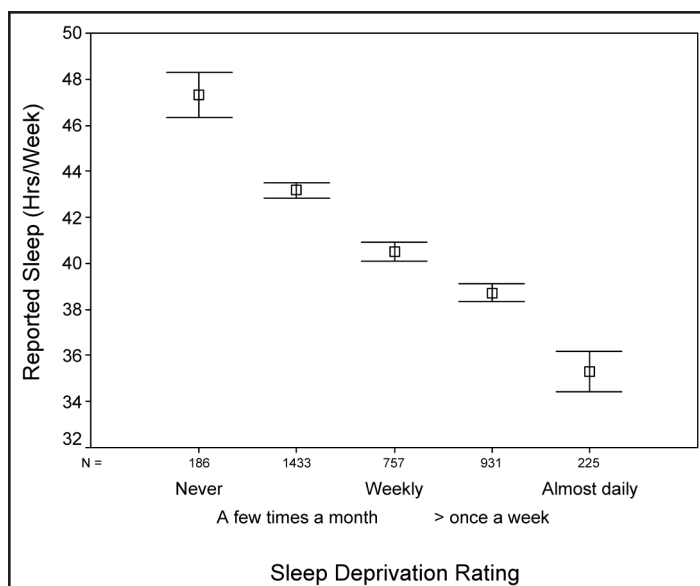


Figure 1—Residents' reports of average weekly hours of sleep by ratings of how often they experienced "prolonged sleep deprivation" with 95% confidence intervals indicated. SDs for the presented confidence intervals are as follows: Never = 6.6; A few times a week = 6.0; Weekly = 5.7; More than once a week = 6.0; Almost daily = 6.7.

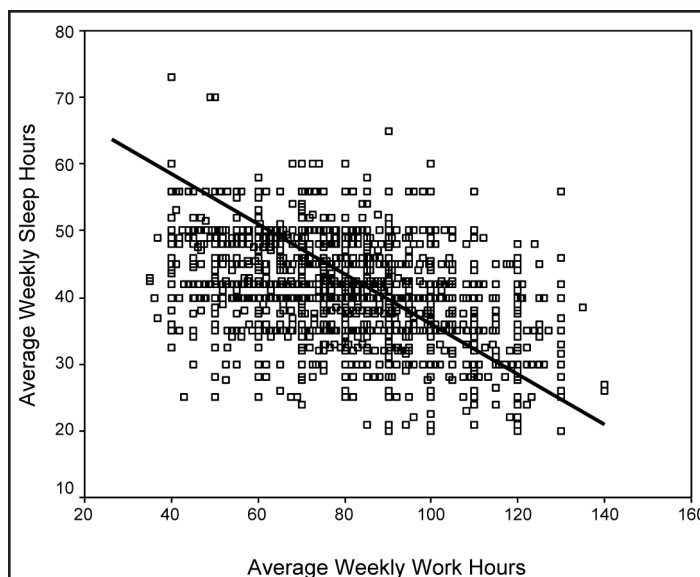


Figure 2—Scatterplot of reported average weekly work hours of sleep with reported average weekly work hours, PGY (postgraduate year) 1 and PGY2 combined (regression line plotted, $r = -.39$).

Table 1—Average Hours of Sleep per Week and Percentage of Residents Reporting 5 or Fewer and 6 or Fewer Hours of Sleep per Night by Specialty (PGY [postgraduate year]1 and PGY2 Combined).

Specialty	No.	Sleep Deprivation Index*	Weekly Sleep, h†	5 or fewer h/night, %	6 or fewer h/night, %
Anesthesiology	106	2.67(1.06)	42.6 (6.0)	15.0	58.9
Dermatology	29	1.79 (1.11)	45.3 (7.0)	17.2	31.0
Emergency Medicine	155	2.82 (1.06)	42.2 (6.9)	19.7	63.1
Family Practice	570	2.76 (.93)	42.0 (6.1)	17.2	61.8
Internal Medicine	1,051	2.93 (1.05)	41.3 (6.1)	18.3	68.5
IM/Pediatrics	99	2.77(.87)	41.0 (4.9)	15.8	70.5
Neurological Surgery	18	4.06 (1.09)	33.5 (6.7)	66.7	94.4
Neurology	37	3.16 (1.09)	43.2 (5.5)	10.8	45.9
Obstetrics/Gynecology	186	3.10 (1.04)	39.1 (6.7)	32.1	73.8
Ophthalmology	39	2.21 (.73)	44.5 (5.7)	5.1	46.2
Orthopedic Surgery	70	3.17 (1.17)	37.9 (5.3)	40.0	84.3
Otolaryngology	28	2.46 (.88)	41.4 (5.3)	10.7	64.3
Pathology	77	1.71 (.86)	48.1 (6.2)	3.9	24.7
Pediatrics	444	3.01 (.93)	40.4 (5.9)	22.6	70.9
Physical Med/Rehab	22	2.09 (.92)	43.8 (8.8)	22.7	59.1
Psychiatry	211	2.55 (.96)	44.0 (7.0)	13.3	49.8
Radiation Oncology	11	2.18 (.41)	41.8 (3.3)	0.0	81.8
Radiology	50	2.30 (.95)	44.2 (6.5)	12.0	40.0
Surgery (General)	252	3.65 (1.06)	34.6 (6.0)	62.3	94.0
Transitional	89	2.88 (1.03)	41.9 (5.9)	21.6	64.8
Urology	6	3.17 (.98)	36.5 (7.4)	50.0	66.7
TOTALS	3,547	2.88(1.06)	41.1(6.6)	22.2	66.4
		F=21.84 n=3,546	F=28.21 n=3,543	$\chi^2=309.83$ df=20	$\chi^2=278.89$ df=20

*Mean (SD) response to "How often, if ever, did you experience periods of prolonged sleep deprivation during your current year of residency?" (Never=1, Almost Daily =5)
†Report of mean (SD) average hours of sleep per week (8 hours/night = 56 hours per week).

Demographic and Other Variables

Table 2 lists residents' reports of sleep deprivation, average hours of sleep per week, and longest number of hours without sleep by selected demographic and other variables. Both PGY1 residents and US medical graduates reported significantly higher levels of prolonged sleep deprivation, fewer average weekly hours of sleep, and longer periods without sleep than did their PGY2 and international medical graduate counterparts. Residents who moonlighted reported significantly less prolonged sleep deprivation and more sleep per week than did nonmoonlighters, primarily because they also reported shorter residency work hours and less-intensive residency experiences.^{2,44} Residents reporting more instances of inadequate supervision and occasions of working while impaired, as well as those who believed that they should have taken time off for illness but did not, also reported less sleep time and more sleep deprivation.

Reported Effects of Sleep Deprivation

Using a 7-point scale (1 = strongly disagree, 7 = strongly agree), residents generally agreed with statements that sleep deprivation and fatigue made them moodier (5.74, SD = 1.53) and impaired their capacity for patient care (5.03, SD = 1.71) and that their work hours were too long (4.64, SD = 1.70). They were split on whether that sleep deprivation

caused more conflict with professional staff (3.80, SD = 1.94) or caused misjudgments in patient care (3.59, SD = 1.80). Along with these averages, residents' ratings of the effects of sleep deprivation showed inverse dose-response relationships with average reported hours of sleep (Figure 3). Residents who reported getting less sleep were more likely to agree that a lack of sleep produced negative consequences for both personal relationships and patient care.

Sleep-Hour Correlates

Sleep hours showed an inverse, dose-response relationship with residents' ratings of their work environment, learning, satisfaction, personal health, and lifestyle (Table 3). Fewer hours of sleep were associated with longer work hours; being named in a malpractice suit; making a significant medical error; more conflicts with attending faculty, other residents, and nursing staff; working while personally impaired; and working without adequate supervision. Similar negative dose-response relationships were found between sleep hours and observations of others working while in an impaired condition, falsifying medical records, and mistreating patients. The number 1 and 2 reasons cited for both self and others working while impaired were lack of sleep and overwork (followed by, in order, emotional problems, incompetence, alcohol problems, and drug problems). The number of sleep hours was also negatively correlated with increased levels of stress, working while ill, reporting a serious personal accident or injury, increased alcohol use, significant weight change, and taking medications to stay awake and to cope with the residency. In contrast, residents' ratings of satisfaction with their overall residency experience, learning, contact and quality of time with attendings all increased with rising levels of average daily sleep. Figure 4 portrays an illustrative set of these relationships. Because weekly sleep and weekly work hours are correlated ($r = -.39$), we reran each of these analyses using work hours as a covariate. The magnitude of the variance account-

Table 2—Residents' Reports of Sleep Deprivation, Average Weekly Hours of Sleep, and Longest Number of Hours Without Sleep by Selected Demographic and Other Variables (PGY [postgraduate year] 1 and PGY2 Combined).

	No.	Sleep Deprivation Index Mean (SD)	Average Hours of Sleep per Week Mean (SD)	Longest no. of Hours Without Sleep Mean (SD)
PGY1	1,650	3.03 (1.05)‡	40.29 (6.29)‡	37.2 (6.95)‡
PGY2	1,895	2.76 (1.05)	41.89 (6.78)	35.7 (8.43)
USMG	2,566	2.92 (1.05)‡	40.74 (6.56)‡	37.4 (7.45)‡
IMG	843	2.88 (1.07)	41.15 (6.62)	32.9 (8.00)
Male	2,007	2.91 (1.05)	41.05 (6.80)	36.0 (8.23)*
Female	1,548	2.85 (1.06)	41.20 (6.36)	36.7 (7.21)
Single	1,431	2.94 (1.06)*	40.78 (6.52)*	37.0 (7.59)‡
Married	2,013	2.83 (1.05)	41.38 (6.61)	35.9 (7.83)
Divorced	104	2.87 (1.06)	41.67 (6.62)	37.1 (9.67)
Children in home	887	2.83 (1.08)	41.31 (6.82)	35.4 (8.55)‡
No children in home	2,651	2.89 (1.05)	41.08 (6.55)	36.7 (7.51)
Moonlighting	340	2.70 (0.97)†	42.22 (6.12)‡	37.1 (8.24)
No Moonlighting	3,212	2.90 (1.06)	41.03 (6.65)	36.3 (7.76)
Worked while ill				
Never	1,206	2.58 (1.01)‡	42.52 (6.60)‡	35.1 (7.91)‡
Once	1,044	2.75 (0.98)	41.29 (6.43)	36.1 (7.17)
More than Once	1,238	3.26 (1.05)	39.74 (6.51)	37.7 (7.97)
Inadequate Supervision				
Never	1,092	2.62 (1.03)‡	42.05 (6.53)‡	35.1 (7.99)‡
Less than once a month	1,130	2.87 (1.03)	41.21 (6.27)	36.8 (7.37)
At least once a month	551	2.91 (0.99)	40.66 (6.46)	36.7 (7.61)
At least once a week	345	3.11 (1.05)	40.53 (6.93)	36.8 (7.74)
More than once a week	229	3.28 (1.04)	40.05 (6.78)	37.8 (7.73)
Almost daily	157	3.57 (1.08)	38.57 (7.17)	38.4 (8.74)
Worked in "impaired condition"				
Never	1,731	2.58 (1.00)‡	42.06 (6.69)‡	35.1 (8.18)‡
1 to 2 times	746	2.79 (0.98)	41.12 (6.03)	36.2 (7.53)
3 to 4 times	361	3.11 (0.99)	41.05 (6.03)	37.6 (6.02)
5 or more times	680	3.62 (0.93)	38.85 (6.50)	39.2 (7.21)

* $P > .05$, computed by ANOVA; † $P > .001$, computed by ANOVA; ‡ $P > .0001$, computed by ANOVA
PGY refers to postgraduate year; USMG, United States medical-school graduate; IMG, international medical-school graduate.

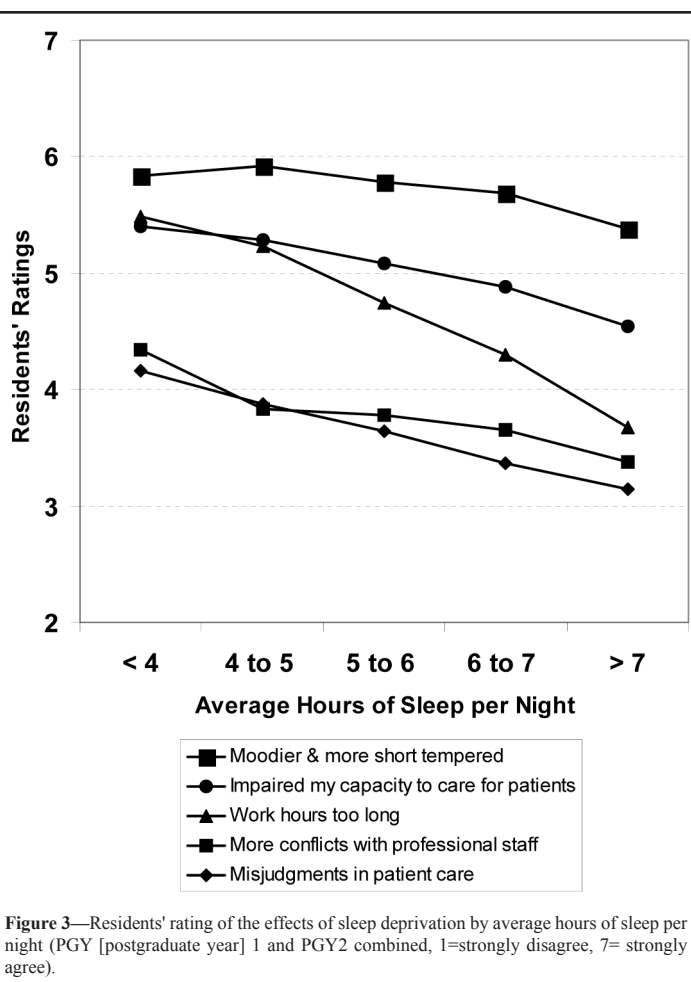


Figure 3—Residents' rating of the effects of sleep deprivation by average hours of sleep per night (PGY [postgraduate year] 1 and PGY2 combined, 1=strongly disagree, 7=strongly agree).

ed for by reported sleep hours and each of the variables presented here was decreased by roughly one third. However, even when using the residual left for sleep hours, all relationships reported in Table 3 remained significant at the level of $P \leq .01$.

Odds Ratios

To focus on the consequences of more extreme sleep deprivation, odds ratios were computed comparing the 22.2% of residents who reported averaging 5 hours or less of sleep per night ($n = 788$) with the remainder of respondents ($n = 2,764$) (Table 4). Residents who slept 5 or fewer hours per night were 1.74 times more likely than those who slept longer to report having made a significant medical error and 2.02 times more likely to have been named in a malpractice suit. They were also 1.84 times more likely to be involved in a “serious accident or injury”; in serious conflict with other residents (1.86), attendings (1.41), or nursing staff (1.47); and to have worked 5 or more times while in a personally impaired condition (2.19). Similarly, they were more likely to have increased their alcohol intake (1.52), to have taken “medications to stay awake” (1.91), and to have experienced a “significant weight change” (1.59).

DISCUSSION

There is always some concern over the validity of self-report data, especially when it is retrospective. Short of expensive and time-consuming observations, however, it remains the best method to acquire a broad range of information from a large random group of subjects. Several investigators have recently demonstrated support for the validity of retrospective sleep reports.^{42,43} In addition, we believe that the design and sampling frame, the experience of the investigators with this

instrument, the good response rate from a large number of busy residents to a mailed survey, and the close correspondence between existing demographic data and the characteristics of our sample all strengthen the validity and the representativeness of the residents’ reports.^{4,40} Further support is found in the close parallel between our findings and those in the literature we cited in our introduction.^{1-3,4,30,40,45} This study is also limited by our choice to ask respondents to report their experiences primarily as averages. There are enormous variations in the quantity and quality of sleep associated with differing service assignments, call schedules, and clinical responsibilities.

The residents in our study reported averaging between 5 and 6 hours of sleep per night, although reported sleep time varied across and within specialties and by residency year. Reduced hours of sleep were significantly associated with impairments in a number of work-related, health, learning, and life-style variables. The number of reported sleep hours was negatively correlated with increased levels of significant medical errors; conflicts with attending faculty, other residents, and nursing staff; being named in a malpractice suit; working in an impaired condition; increased levels of stress, illness, personal accidents or injuries, and alcohol use; significant weight change; and taking medications to stay awake and to cope with the residency. Van Dongen and his colleagues have recently documented significant, cumulative, dose-dependant deficits in cognitive performance and neurobehavioral functions with chronic restriction of sleep to 6 hours or less per night.¹¹ Nearly a quarter of our responding residents reported sleeping an average of 5 hours or less per night, and two-thirds reported sleeping 6 hours or less per night, not just occasionally, but regularly throughout the entire year. These figures rose to over 50% and 90%, respectively, for selected specialties. As striking as these averages are, they do not begin to account for the regular overlay of acute sleep loss experienced during night call, when many residents report sleeping as little as 2 or 3 hours a night.^{1,26} The weight of the data suggests that many PGY1 and PGY2 residents may be performing at less than their best much of the time.

Although work hours were significantly related to sleep hours, this relationship was less robust than might be expected. A number of possibilities can be cited to account for the relatively low magnitude of the relationship ($r = -.39$) between reported weekly sleep and work hours. First, both sleep and work were assessed as self-reported retrospective averages. Distortions are possible from both recall bias and the inefficiency of reports based on averages. A second possibility is that the nature and pattern of the work hours, not simply the number of work hours, determines resulting sleep time.^{1,5,14,26} Being on call every other night has effects different from those resulting from being on call every third night.^{1,26} Third, differences in specialty or workload within specialties determine the amount of sleep residents are able to squeeze into their work hours. Some residents are able to sleep during their duty hours, while others are not.^{19,46} Fourth, individuals have different needs for sleep.⁴⁷⁻⁴⁹ Because of this, individuals with the same work schedules may sleep different amounts during their nonworking time. Finally, individuals also have different personal demands, such as family obligations, outside of work hours, and these other demands may cause the residents to forgo even much-needed sleep to attend to their personal lives.¹

It is important to note that the negative correlates of reduced sleep time are not simply the results of extended work hours in disguise. Secondary analyses showed that even with work hours as a covariate, all of the reported relationships still attained commonly accepted standards of statistical significance. We chose to present the data about the correlates of sleep deprivation directly rather than filtered by the covariate analyses for 2 rea-

Table 3—Residents’ Self-Reported Average Daily Hours of Sleep by Selected Variables (PGY1 and PGY2 Combined)

Variable	Average Daily Hours of Sleep					P value*
	<4 (n = 131)	4-5 (n=656)	5-6 (n=1,560)	6-7 (n = 808)	>7 (n = 380)	
Patient Care						
Work Hours	98.2	88.2	79.5	73.7	68.5	<.0001
Medical Errors, %	45.0	34.6	26.7	22.4	20.9	<.0001
Adverse patient outcomes, %	10.7	5.7	4.8	3.8	3.8	.003
Malpractice suit, %	6.2	1.8	1.4	1.2	1.3	.011
Serious Conflict, residents, %	20.2	13.9	9.4	7.9	6.3	<.0001
Serious Conflict, nurses, %	15.5	10.7	9.5	6.6	5.5	<.0001
Serious Conflict, attending, %	10.9	10.4	8.6	6.7	6.1	.002
Impairment, Others†	1.68	1.42	1.17	1.13	.98	<.0001
Impairment, Self‡	2.32	2.26	2.01	1.86	1.63	<.0001
Falsifying records, Others†	.99	.91	.77	.68	.56	<.0001
Mistreating pts, Others†	2.01	1.70	1.58	1.41	1.24	<.0001
Program class size	13.2	15.6	17.0	16.7	14.7	NS
W/out adequate supervision	3.05	2.56	2.44	2.24	2.19	<.0001
Personal Health and Behaviors						
Sleep deprivation index	3.87	3.38	2.93	2.52	2.22	<.0001
Overall stress, current year	5.56	5.20	4.85	4.57	4.12	<.0001
Worked while ill	2.34	2.17	2.06	1.89	1.77	<.0001
Took medication to stay awake, %	14.7	6.6	6.2	2.0	1.6	<.0001
Took medication to cope, %	8.5	6.4	7.0	4.4	4.2	NS
Increased alcohol use	10.9	7.3	6.2	4.5	3.9	<.0001
Significant weight change	52.7	40.5	35.8	27.8	23.2	<.0001
Serious accident/injury	10.9	3.7	3.0	2.5	2.1	<.0001
Belittled or humiliated	2.53	2.31	2.03	1.81	1.61	<.0001
Slap, kicked or hit	.38	.24	.20	.17	.12	<.0001
Satisfaction Ratings						
Overall Rating	4.68	5.05	5.17	5.32	5.30	<.0001
Learning rating	4.55	4.95	5.03	5.20	5.17	<.0001
Contact with attending	4.92	5.35	5.47	5.53	5.53	<.0001
Quality of time w/ attending	4.31	4.81	4.96	5.07	5.09	<.0001
Medical school preparation	5.58	5.60	5.55	5.60	5.57	NS

* Statistical comparisons based on 1-way analysis of variance; P values were generated by a test for linear trend.

† “How often, if ever, have you observed others...” (Never=1, 5 or more times =4)

‡ “How often, if ever, have you worked in an impaired condition?” (Never=1, 5 or more times =4)

PGY refers to postgraduate year.

sions. First, and foremost, the data are easier to interpret, and communication about the important relationships can occur in a more straightforward manner. Second, there is no clear reason to place work hours ahead of sleep hours, or the converse, as an explanatory variable. As might be expected from the magnitude of their correlation, both work and sleep hours contribute to explaining the reasons for the reports of negative experiences during residency training. More detailed analyses of the correlates of work hours have been reported elsewhere.²

The fact that some level of sleep deprivation and fatigue is widespread during residency training does not legitimize its existence, especially when it is related to patient safety and to negative personal and professional outcomes. The finding that satisfaction with learning declines as the average number of hours of sleep declines, suggests that sleep deprivation also interferes with learning, the primary purpose of residency training.⁵⁰⁻⁵¹ This result is antithetical to the argument that learning compensates for lack of sleep and long work hours.

We must continue to examine the structure and intent of resident training and to find ways of limiting these risks. Mandated limits to work hours, while well intentioned, will not necessarily ensure that residents get the optimal sleep they need. The average number of hours of sleep achieved by residents is, in the final analysis, the result of an interaction between individual choices, both personal and professional, and institutional demands. Only at the upper level of work hour demands are the opportunities for sleep likely to be so constrained that residents have little or no choice in allocating their priorities. But as these demands lessen, both variation in biologic needs and each individual's choices may move to the foreground in determining total sleep time.⁴⁶⁻⁴⁹

In other publications, we have advanced the idea that conceptualizing the residency experience based on convergent characteristics, such as work hours, sleep, stress, etc., might be more useful than discussions based merely on specialty.^{2,44} Utilizing cluster analysis, we identified 4 distinct types of residency experience: High Intensity, characterized by

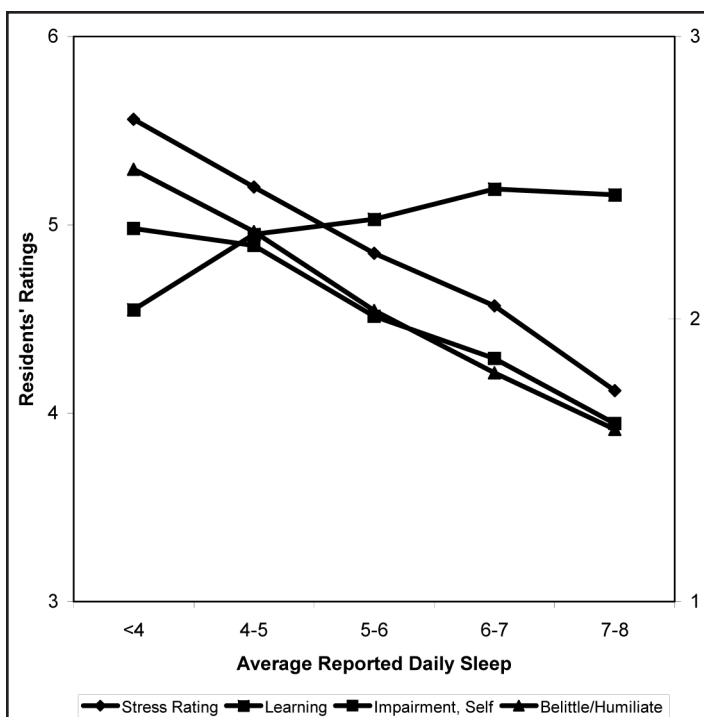


Figure 4—Residents' ratings of level of stress, how often they worked in an impaired condition, how often they experienced belittlement or humiliation and ratings of satisfaction with learning by reported average hours of sleep per night. "In general, how stressful was your current year of residency?": (1="not at all stressful", 7="very stressful"); "How often, if ever, have you worked in an impaired condition?": (1="never", 4="5 or more times"); "How often, if ever, did any of the following persons belittle or humiliate you during your current year of residency?": (0="never", 3="5 or more times"); "Please rate your current year of graduate medical education" in terms of "learning": (1="poor", 7="excellent"). Level of stress and satisfaction with learning are plotted on the left-hand axis. Working in an impaired condition and experience of belittlement or humiliation are plotted on the right-hand axis.

excessively long work hours, fewer sleep hours, high stress, and low satisfaction; Moderate Intensity, with fewer work hours, longer sleep, greater satisfaction, and lower stress; Low Intensity, with even fewer work hours and less stress and greater satisfaction and sleep; and Moonlighters, a subset of the low-intensity group who account for most of the reported moonlighting hours. Thinking about sleep as just one component of a particular residency experience makes more sense to us than a focus on the simple inverse linear relationship between work hours and sleep time.

Much of the current debate about residency work hours seems to assume that limiting residents' work hours will translate directly into residents getting a greater amount of sleep and, thereby, providing better patient care. Sleep hours are determined not only by work hours, but also by physiologic needs for sleep,⁴⁷⁻⁴⁹ personal motivation (including the desire for education),^{1,52} and the demands of or desire for a personal life outside of residency.^{1,45} Residents' lives are composed of work hours, sleep hours, and the remaining other or personal hours.² Much remains to be learned, however, about how residents choose to allocate their time among these conflicting demands. It seems clear from our data that sleep deprivation and resulting fatigue are pervasive and inevitable consequences of the high demands of a substantial number, although not all, residency training programs.² The benefits of capping resident work hours will be found, we believe, in providing residents not only an opportunity to increase sleep time, but also the ability to better manage their lives. Sleep deprivation impacts all areas of the residents' lives: patient care, learning, professional relationships, and even their personal lives.⁴⁵ No one wants to see residents sleep deprived or stressed beyond their ability to care for either their patients or themselves.

Residents and program directors alike need to better inform them-

Table 4—Variables Associated with Residents Averaging 5 or Fewer Hours of Sleep per Night* (PGY1 and PGY2 Combined).

Variable	Odds Ratio	95% CI	Comment
Reported Errors			
Medical Error	1.74	(1.47 – 2.06)	More errors
Adverse patient outcome	1.51	(1.08 – 2.13)	More adverse outcomes
Named in malpractice suit	2.02	(1.17 – 3.47)	More malpractice suits
Life events			
Serious accident or injury	1.84	(1.23 – 2.74)	More accidents or injuries
Serious conflict:			
With another resident	1.86	(1.47 – 2.36)	More conflict
With attending physician	1.41	(1.08 – 1.84)	More conflict
With nursing staff	1.47	(1.14 – 1.91)	More conflict
Health Habits			
Increased alcohol use	1.52	(1.12 – 2.07)	Increased use
Noticeable weight change	1.59	(1.35 – 1.87)	Weight change
Took medications:			
To stay awake	1.91	(1.39 – 2.62)	Took medications
To sleep	.99	(.76 – 1.28)	
To cope with residency	1.18	(.86 – 1.63)	
Worked in an Impaired Condition			
Never	NA	NA	
1 - 2- times	1.21	(.98 – 1.50)	
3 - 4 times	1.20	(.91 – 1.58)	
> 5 times	2.19	(1.79 – 2.68)	More often impaired
Reasons for Impairment			
Alcohol consumption	1.17	(.49 – 2.77)	
Emotional problems	1.02	(.73 – 1.42)	
Incompetence	1.04	(.59 – 1.82)	
Lack of sleep	1.59	(1.35 – 1.86)	More sleep loss
Overwork	1.52	(1.29 – 1.80)	More overwork

*22.2% of residents reported averaging 5 hours or less of sleep per night (n = 788), leaving 77.8% of residents who reported averaging more than 5 hours of sleep per night (n = 2,764). PGY refers to postgraduate year.

selves concerning the impact of sleep deprivation on professional performance.⁵⁻⁷ The current SAFER education program for residents is an initial step in the right direction.⁵³ But education, by itself, will not solve the problem.⁵⁴ Increased efforts need to be made to examine the details of the work schedules that set the boundaries of the residents' existence. We hope that, in the future, these examinations and supporting research can help to establish work and sleep schedules that are more physiologically, psychologically, and professionally sound.

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DISCLAIMERS

The opinions expressed in this paper are the authors' own and do not reflect any official position or policy of the Accreditation Council for Graduate Medical Education or any other institutional body.

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