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The impact of sleep deprivation in resident physicians on physician and patient safety: Is it time for a wake-up call?

Sleep-deprived residents are at increased risk for motor vehicle collisions and hospital-related injuries, while their patients are at higher risk for adverse outcomes resulting from medical errors.

ABSTRACT: Long work hours are a tradition in the medical profession, and work schedules are especially intense among postgraduate resident physicians. However, because of the sleep loss and fatigue that result, these intense work schedules may pose threats to both physician and patient safety. Understanding the potential impacts of fatigue on resident physician performance and safety and using this knowledge to optimize shift schedules may reduce risks to both staff and patients.

Sleep deprivation is a logical consequence of excessive work hours and poses potentially significant problems for physicians and patients. Inadequate sleep may lead to poor health and could adversely affect the medical care physicians deliver. Medical residents typically work shifts between 24 and 36 hours in duration on minimal sleep, and are at heightened risk for motor vehicle collisions, hospital-related injury and infection,[1] and compromised mental health. Indeed, procedural, administrative, and evaluation errors may be linked to physician sleep deprivation, and reducing these could lead to improved patient safety and mortality.

Determinants of alertness

Alertness in a normal subject affects performance and is determined by quantity of sleep, circadian effects, and sleep inertia.

Quantity of sleep

Typically, an appropriate quantity of sleep makes a person feel refreshed and capable of functioning well without effort, even in monotonous situations. Easy alertness is important and should be differentiated from the pressured alertness of people who sleep little.

Quantitative sleep loss can be due to acute continuous loss or chronic partial loss.[1] Acute sleep loss occurs when a person does not sleep for an extended period of time. Erosion of performance has been shown by a number of studies. For example, Dawson and colleagues studied 40 subjects and found that the decline in hand-eye coordination after 28 hours of wakefulness was similar to that resulting from a blood alcohol concentration of 0.10%.[2] In British Columbia, this constitutes a level of impairment above the legal driving limit. Similarly, in a prospective two-session within-subject study of 34 pediatric residents, subjects assessed after a shift on-call had sustained attention, vigilance, and driving abilities comparable to those resulting from a blood alcohol level between 0.04% and 0.05%.[3]

Chronic partial sleep loss occurs when a person consistently obtains less sleep than that person would if given sufficient opportunity. Chronic sleep deficits lead to a dose-dependent decrease in cognitive performance

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comparable to acute deprivation. For example, in a randomized study of 48 healthy adults aged 21 to 38 with varying degrees of sleep deprivation over 14 days, lapses in behavioral alertness were related to a cumulative duration of wakefulness in excess of 15.84 hours. Subjects who slept less than 6 hours per night for 2 weeks had cognitive abilities similar to individuals with 1 night of total sleep deprivation. Subjects who slept less than 4 hours per night for 2 weeks had cognitive abilities similar to individuals who had 2 nights of total sleep deprivation. Subjects' ratings of their sleepiness did not change in accordance with increased sleep deprivation and objectively measured performance deficits, suggesting that individuals who are chronically sleep deprived may not be completely aware of their impairment.[4]

Circadian effects

A group of neurons in the hypothalamus form the circadian pacemaker, which regulates sleep-wake cycles. The fluctuating activity of these neurons enables maximal drive for cognitive performance and alertness in the day, and maximal drive for sleepiness at night, thereby consolidating nocturnal sleep. These circadian effects mean that a performance peak occurs during the day and a performance nadir occurs in the early morning hours (3 a.m. to 5 a.m.).[5] Not surprisingly, an increased potential for error has been demonstrated among nightshift workers across a range of occupations.[6,7]

Sleep inertia

Cognitive performance is typically submaximal immediately upon awakening because of a phenomenon termed sleep inertia.[8] Sleep inertia's effects are most apparent during the initial 10 to 15 minutes after awakening, but they may take hours to dissipate.[9] These effects are more pronounced with sleep deprivation and particularly when awakenings occur during performance nadirs such as during the early morning hours.[10] In a study of nine healthy volunteers by Wertz and colleagues, cognitive performance measured upon awakening was worse than performance measured at all times with 26 hours of sleep deprivation.[11]

The impact of sleep inertia is particularly relevant to residents since they are frequently required to complete complex processes immediately after waking at night. Patient assessment involves a significant degree of evaluative thinking and often necessitates quick, high-impact decision making. A physician must accurately order medications and tests, and may be called upon to quickly perform invasive procedures that require considerable concentration and skill. The cognitive impairment attributed to sleep inertia negatively affects the ability to complete these tasks and poses a serious barrier to effective care. The impact of sleep inertia may be compounded by the likelihood that a resident has been sleeping lightly in an attempt to diminish the effects of sleep inertia upon waking, only to be worse off at work the following day because of suboptimal rest overnight.

Resident physician safety

Sleep deprivation presents many potential risks to physician safety.

Motor vehicle collisions

Sleep deprivation is the second leading cause of car and truck accidents.[12] Many studies have found an increased risk of accidents among residents working long hours. In a prospective cohort study of 2737 medical interns followed for 1 year, the rates of motor vehicle collisions after working an extended shift (> 24 h) were compared to rates after working a nonextended shift. The odds ratio for having a collision after working an extended shift rather than a non-extended shift was 2.3 (95% CI, 5.4–6.3). Residents who worked more than five extended shifts in 1 month had an odds ratio of 2.39 (95% CI, 2.31–2.46) for falling asleep while driving, or 3.69 (95% CI, 3.60–3.77) for falling asleep while stopped in traffic.[13] A study by Kowalenko and colleagues reviewed surveys from 697 emergency medicine residents and found that before these residents started their residency, only 4.1% reported being involved in a motor vehicle collision caused by falling asleep, compared with 19.3% who reported being involved in the same type of accident during their residency years ($P < .001$).[14]

Percutaneous injuries

Percutaneous injuries with exposure to potentially contaminated blood or body fluids through a needlestick or laceration are also more common among sleep-deprived physicians. In a cohort of 2737 interns studied between July 2002 and May 2003, Ayas and colleagues evaluated the risk factors for percutaneous injury and found that fatigue was a contributing factor in 31% of incidents. Furthermore, injuries were more likely on a day after working the previous night than on a day after not being on call, with an odds ratio of 1.61 (95% CI, 1.46–1.78).[15]

Mental health and stress

Many studies suggest that prolonged fatigue adversely affects physician mental health. In 2005, Fletcher and colleagues undertook a systematic review of publications assessing the impact of work hour legislation on residents. Four of the 50 studies reviewed showed that symptoms of stress or depression decreased when work hours were reduced, but two of the 50 stud-

ies showed no significant change in depressive symptoms.[16] After working 30-hour shifts, residents have been found to have significantly elevated serum levels of cytokines and inflammatory markers such as IL-6 and CRP,[17] suggesting that repeated sleep deprivation episodes associated with elevated inflammatory markers may lead to vascular injury and atherosclerosis.

Patient safety

Sleep deprivation also presents many potential risks to patient safety.

Medical errors

In US hospitals, 50 000 to 100 000 patients die annually from medical errors, and inadequate sleep among physicians may be a factor.[18] Many studies have shown that sleep deprivation is associated with poorer patient outcomes. In a recent web-based survey, Barger and colleagues showed that interns committed significantly more fatigue-related medical errors resulting in adverse patient outcomes during months with five or more overnight call shifts, compared with months with no extended shifts (OR 7.0).[19] A separate study evaluated surgical task performance before and after a sleepless night. Surgical residents who had been awake the previous night made 20% more errors and took 14% longer to complete a simulated laparoscopic task than their colleagues who had slept well the previous night.[20] In an earlier study, Shanafelt and colleagues found that internal medicine residents meeting the criteria for burnout were more likely than their colleagues to have self-reported suboptimal patient care practices.[21] Burned-out residents were more likely than their colleagues to report inadequate sleep and frequent extended shifts as major stressors.

There have also been studies suggesting that sleep deprivation has little effect on patient care. Ellman and colleagues reviewed 6751 cardiac surgeries, and found that mortality and surgical complication rates were no higher in surgeries completed by surgeons who had been awake the previous night than those completed by surgeons who had slept the previous night.[22] In explaining these results, the authors postulated that certain procedural tasks have an incentive for good performance, and that these tasks are less susceptible to retardation with fatigue.

Lockley and colleagues assessed the attentiveness of 20 interns working in critical care units in a randomized crossover controlled trial, with interns working both a traditional schedule (e.g., one in three nights on call) and an intervention schedule with a maximum shift length of 16 hours. Under the new schedule, residents worked 61 hours per week rather than the traditional 77 to 81 hours per week. Residents slept more with the intervention schedule (7.4 hours per day vs 6.6 hours per day, $P<.001$). Furthermore, with the intervention schedule, residents were significantly less likely to have attentional failures during working hours.[23]

Landrigan and colleagues evaluated the same cohort of residents working under the two call schedules, and assessed the incidence of medical errors identified by independent observers. Residents working under the traditional rather than the intervention schedule committed 35.9% more serious medical errors (136 vs 100 per 1000 patient days, $P<.001$), 57% more non-intercepted serious errors (45 vs 29 per 1000 patient days, $P<.001$), and 5.6 times as many serious diagnostic errors (18.6 vs 3.3. per 1000 patient days, $P<.001$).[24]

Handover errors

Despite the evidence supporting shorter work hours for physician and patient safety, most institutions have not enforced shorter working hours. Concerns about discontinuity of care with patient handover has impeded changes in workshift duration.[25] In a review of staff physicians' opinions at the Mayo Clinic, Keating and colleagues noted that staff physicians felt discontinuity of care presented a greater threat to patient safety than physician fatigue. However, when asked whether they would want a family member cared for under a traditional call schedule or a shift schedule, staff physicians preferred the shift schedule.[26] Many authors, including Landrigan, have emphasized the importance of formal evening rounds and practical electronic signover systems for enhancing patient care and avoiding problems that arise when the covering team is less familiar with patient details.

Government policy on physician work hours

Sleep deprivation and fatigue are often blamed for human error. Major disasters such as the Three Mile Island and Chernobyl nuclear power plant meltdowns and the *Exxon-Valdez* oil spill have been attributed to the poor judgment of sleep-deprived workers.[27] As a result, maximum working hours have been defined in many jurisdictions for pilots,[28] marine operators,[29] and truck drivers.[30] For example, under the US Code of Federal Regulations, pilots who have flown more than 8 consecutive hours must be given at least 16 hours of rest before being assigned any further duties, and may not exceed 100 hours per month or 1000 hours per year when working for domestic air carriers. Similarly, truck drivers may drive a maximum of 10 hours per day and 60 hours per week. Drivers must additionally have at least 8 consecutive hours off after a 10-hour day, and marine operators

must have at least 10 hours of rest in 24 hours.

In some jurisdictions, governments have passed legislation on physician hours to improve quality of care. For example, the 1989 death of 18-year-old Libby Zion in New York was partially attributed to poor supervision and heavy patient loads for sleep-deprived house staff; thereafter, the state passed legislation that limited physicians' shifts to 24 consecutive hours, or 80 hours per week.[31] New York State has been the only jurisdiction in North America to enact legally binding legislation concerning work hours; while there are similar recommendations in many other states and provinces, they may be disregarded with impunity. In Europe, doctors follow the European Working Time Directive, which currently limits their work to a maximum of 56 hours per week. In its final phase, the directive will enforce a reduction to 48 hours per week. While this directive was initially introduced in 1993, it excluded health care systems until 2004 and its gradual application is targeted for completion in 2009. These restrictions include time spent on call and are enforceable laws, not just recommendations.[32]

Work hours and patient mortality

In July 2003 the US Accreditation Council for Graduate Medical Education (ACGME) issued a set of standards to limit resident work hours. In order to maintain accreditation status, residency programs must not exceed 80-hour work weeks, with a maximum of 24 hours per shift (this is excepted when more time is needed to adequately fulfill patient handover responsibilities). Additionally, programs must allow residents 1 day off out of every 7, a minimum 10 hours off between daily work activities, and may not schedule in-house call more than 1 in every 3 nights.[33]

A recent study by Shetty and Bhattacharya used hospital mortality as a robust outcome to assess the utility of US resident work-hour regulations in enhancing patient care. With a before and after comparison based on administrative survey data, work-hour legislation was associated with a 0.25% decrease in absolute mortality rate ($P = .043$), and a 3.75% reduction in relative risk of death. Although large improvements in mortality were noted in patients admitted for infectious disease (change -0.66%, $P = .007$) and in medical patients over 80 years of age (change -0.71%, $P = .005$), this change (0.13%, $P = .54$) was not significant for surgical patients, which comprised one-fifth (or 243 207) of the patients studied. The authors suggested that differences might be attributed to the smaller number of surgical patients in the sample, fewer surgical residents working at a given time as a result of the new schedule, handover errors, and poor compliance of surgical programs with the new legislation.[34] Indeed, Landrigan and colleagues show that interns widely reported noncompliance with ACGME guidelines in the first year of their implementation.[35]

In a similar study, Volpp and colleagues studied mortality outcomes before and after ACGME regulations were set in place, using nonteaching hospitals as a control group. While no significant results were found in the first year after these regulations, during the second post-reform year the odds of mortality significantly decreased in teaching hospitals for medical patients only. The odds of mortality were reduced for patients with myocardial infarction, congestive heart failure, gastrointestinal bleeding, or stroke with the work-hours legislation (OR 0.74, 95% CI 0.61-0.89). As in the study by Shetty and colleagues, no significant changes were observed in surgical patients.[36]

Conclusions

To function well, physicians require adequate sleep. Sleep deprivation leads to cognitive decline, altered mood, and impaired motor skills. There is mounting evidence that sleep deprivation has long-term health consequences such as premature death, cardiovascular death, obesity, and diabetes. Sleep-deprived residents are at increased risk for motor vehicle collisions and percutaneous injuries, and their patients are at higher risk for medical error. In other parts of the world, shorter work hours for physicians are becoming the norm and these have often been enacted through legislation. Physicians in British Columbia govern themselves through the College of Physicians and Surgeons. Rather than waiting for a government body to direct our actions through legislation, we believe physicians should address this problem and adequately limit resident work hours to protect both our patients and our trainees.

Competing interests

None declared.

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