# Sleep Deprivation and Clinical Performance

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PHYSICIANS' ABILITY TO PROVIDE high-quality care can be adversely affected by many factors,[1] including sleep deprivation. Concerns about the danger of physicians who are sleep deprived and providing care have led state legislatures and academic institutions to try to constrain the work hours of physicians in training (house staff).[2] Unlike commercial aviation, for example, medicine is an industry in which public safety is directly at risk but does not have mandatory restrictions on work hours. Legislation before the US Congress[3] calls for limiting resident work hours to 80 hours per week and no more than 24 hours of continuous work. Shifts of residents working in the emergency department would be limited to 12 hours. The proposed legislation, which includes public disclosure and civil penalties for hospitals that violate the work hour restrictions, does not address extended duty shifts of attending or private practice physicians.

There is still substantial controversy within the medical community about the magnitude and significance of the clinical impairment resulting from work schedules that aggravate sleep deprivation. There is extensive literature on the adverse effects of sleep deprivation in laboratory and nonmedical settings. However, studies on sleep deprivation of physicians performing clinically relevant tasks have been less conclusive. Opinions have been further influenced by the potential adverse impact of reduced work schedules on the economics of health care, on continuity of care, and on quality of care.[2,4,5] This review focuses on the consequences of sleep loss both in controlled laboratory environments and in clinical studies involving medical personnel.

## What Is Sleep Deprivation?

Sleep is a homeostatic process with the amount of previous sleep contributing to or diminishing the subsequent level of alertness. The homeostatic process interacts with circadian processes (24-hour rhythms that control our sleep/wake cycles). A person who is sleep deprived will have difficulty staying awake at the point of the circadian cycle where sleep is normally induced, while a well-rested individual may be more able to fight the urge to sleep. In the early stages of sleep deprivation, activity, bright light, noise, temperature, posture, stress, and stimulating drugs reverse sleep loss decrements, but only temporarily.[6]

Altered sleep schedules can lead to either partial or total sleep deprivation. Total sleep deprivation, where the individual gets no sleep, is more likely to occur in acute situations (eg, studying all night). Partial sleep deprivation refers to a night of reduced or interrupted sleep, which may be due to sleep disorders (sleep apnea), medical conditions (insomnia-promoting disorders), medications (caffeine, stimulating drugs), work schedules (shift work or call schedules), or lifestyle (a new baby). Recurrent episodes of partial sleep deprivation, therefore, are most likely to be of relevance to clinical practitioners.

## Effects of Sleep Deprivation: Laboratory Studies

Most studies of recurrent partial sleep deprivation have suggested that sleeping only 5 to 6 hours a night can lead to impairment.[6] These decrements in performance accumulate with continued partial sleep deprivation[7] as may be seen in individuals with chronic insomnia (defined as difficulty sleeping on a frequent basis) or in physicians working regularly recurring call or night shifts. In the early morning hours, after nearly 24 hours without sleep (eg, at the end of a difficult night on call), psychomotor performance can be impaired to an extent equivalent to or greater than is currently acceptable for alcohol intoxication (FIGURE).[8]

Two meta-analyses conducted in the last decade summarize the cognitive performance effects of one or more nights of reduced sleep.[9,10] Although these meta-analyses do not address the shortcomings of individual studies, they do provide a succinct review of available research. In general, the studies suggest that sleep-deprived subjects performed 1.4 SDs below that of controls. Sleep deprivation had the greatest impact on mood and cognitive tasks and less, but still significant, impact on motor tasks.

## Effects of Sleep Deprivation: Physicians' Clinical Performance

The issue of impaired clinical performance of sleep-deprived physicians first gained attention in the 1980s.[11] Several dozen studies were published between 1985 and 1992.[12,13] Although the data were inconclusive, state legislatures, national organizations, such as the Accreditation Council for Graduate Medical Education, and academic institutions have attempted to regulate house staff work schedules. Nev-

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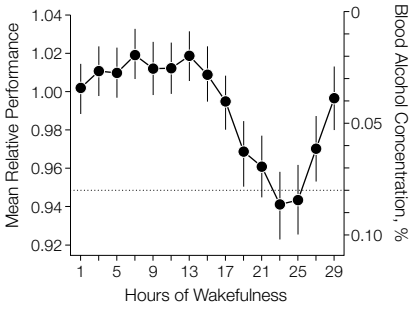
**Figure.** Effect of Sleep Deprivation on Psychomotor Performance Compared With Blood Alcohol Concentration




The legal limit for blood alcohol concentration while driving a motor vehicle is as low as 0.08% (dotted line) in some states. Mean relative performance is expressed as percentage of performance at the start of the session. The effects of sleep deprivation on psychomotor performance become equivalent to the effects of acute alcohol intoxication in the early morning after nearly 24 hours without sleep. Reproduced with permission from *Nature* (http://www.nature.com/).[8]

ertheless, many residents still work in excess of 80 hours per week and have call obligations of at least 24 continuous hours at least once each week.[2] Many physicians in practice have similarly rigorous clinical work schedules.

One of the earliest studies[14] showed that sleep-deprived medical interns detected fewer cardiac arrhythmias and complained of feeling sad, fatigued, and unsure of themselves when compared with rested interns. However, many of the pre-1990 studies[12,13] had methodological limitations, reflecting the difficulties inherent in studying physician sleep deprivation. These flaws included inadequate controls, no randomization, inadequate consideration of training effects over time, or failure to control for circadian effects. Many early studies used tests of insufficient duration or tests involving factual knowledge, which is relatively insensitive to the effects of sleep deprivation. Others included acute inducements to perform under the sleep-deprived condition, a situation in which even highly sleep-deprived subjects can rise to baseline levels of performance.[15] Studies also failed to control adequately for subjects' actual sleep schedules under the different test conditions. This is critical since many resident physicians are chronically sleep deprived. For example, anesthesiology residents, even when not on call for 2 full days, have pathological daytime sleep latencies comparable with those of narcoleptic patients.[16]

Fewer than a dozen studies on sleep deprivation have been published in the last decade.[17-23] Although all involved relatively small numbers of subjects, they were generally more carefully controlled. Results of these studies suggest that clinical performance is adversely affected by sleep deprivation.

In a laboratory study, Taffinder et al[21] examined the effects of sleep deprivation on surgical skills. Tests were administered in the evening and again the following morning under well-rested, sham on call (sleep interruptions at midnight, 3 AM, and 6 AM), and sleepless night conditions. With increasing sleep loss, surgical residents made more errors and were slower to complete electrocoagulation of bleeding tissue in a virtual reality simulation of laparoscopic surgery. These results were corroborated in a recent study in which surgical residents were less efficient and made more errors on a laparoscopic simulator in the morning after a night on call (<3 hours of sleep during a 17-hour shift) compared with performance during normal daytime work hours.[24] Leonard et al[17] studied psychological state and cognitive performance of 16 medical residents during a 32-hour clinical shift using a randomized balanced within-subjects design. The residents, who averaged 4.5 hours of sleep per shift, showed impaired performance at the end (compared with the beginning) of their shift on 4 out of 5 tests of mood state and 2 out of 5 tests of alertness or concentration. In a small controlled study of anesthesiology residents, Nelson et al[18] demonstrated that those completing a 24-hour call shift (with <30 minutes of actual sleep) performed significantly worse on a standardized test of creative thought processes than the same residents at the same testing time after a normal night's sleep. Similarly, Wesnes et al[23] found that surgical residents' cognitive performance on a standardized computerized test battery was impaired on the Monday morning after a weekend on call when compared with a noncall weekend.

In the only study our literature search located that has examined the effects of sleep disturbances on the performance of experienced physicians, Smith-Coggins et al[20] performed a prospective double-blind placebo-controlled trial of a fatigue countermeasure program with 6 attending physicians in an emergency department. Performance on a psychomotor vigilance task and mood were impaired, and the time required to intubate a mannequin was significantly slower during the night shift when compared with the same physician's performance on a day shift. There were no differences in performance on a test of electrocardiogram analysis and interpretation and no apparent effect of the countermeasures, which included a more regular work schedule and 31 specific strategies to promote sleep at home and alertness at work, based on a National Aeronautics and Space Administration program for commercial airline pilots. In an earlier study by the same group, an increase in errors in a simulated clinical triage test occurred at the end of a 24-hour work shift.[25]

In preliminary work at the Veterans Affairs San Diego and Palo Alto Healthcare Systems, we have begun to study the effects of sleep deprivation on anesthesiologists' performance during actual patient care and in a realistic patient simulator. In a recently completed study, the task performance and workload of 15 anesthesiology residents performing actual operating room cases were measured under 2 conditions: once at night while fatigued (average case start time about 2 AM; awake for 18 [SD, 2] hours) and a second time during a regular workday (average start time, 10:30 AM).[26] At night, residents had more negative moods, reported higher clinical workload, and allocated significantly more time to their primary physiologic monitors to ex-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tract essential clinical data. This suggests that sleep-deprived anesthesiologists may need to allocate greater cognitive resources to accomplish routine clinical tasks.

In a complementary study using a realistic patient simulator, anesthesiology residents performed 2 comparable 4-hour simulated anesthetics for laparoscopic surgery in a darkened, simulated operating room environment with trained actors playing the surgeon and nurses.[22,27] The residents were studied on 2 separate days under either acute sleep deprivation (awake for at least 25 hours) or in a well-rested condition (2 extra hours of sleep on average for 4 consecutive nights before the study). Trained observers, blinded to the subjects' condition, reviewed and analyzed videotapes of all of the cases. During these long, tedious, simulated anesthetics, subjects used, with variable success, a number of sleepiness-reducing strategies, especially nonpatient care activities like conversation, personal care activities, and calisthenics. Nevertheless, there was strong behavioral evidence of significant sleepiness in the sleep deprivation condition with some subjects actually falling asleep while administering anesthesia.

## Conclusions

Sleep deprivation can affect clinical performance and may be an important factor in patient safety. The complexity of modern health care makes the conduct of high-quality prospective controlled research on the effects of physician work and sleep schedules extremely difficult. Naturalistic studies, which are likely to be the most generalizable, are especially difficult due to the tremendous variability in physician and practice attributes (eg, work schedule, workload, case mix). Nevertheless, it is time to undertake large prospective studies that examine the actual clinical performance of both physicians in training and experienced physicians, measuring patient outcomes in both routine and nonroutine clinical situations.

We conclude that the current body of evidence supports the assertion that physicians' sleep schedules are important factors in determining their performance in specific clinical situations. In particular, patient care may be compromised if a fatigued, sleep-deprived clinician is allowed to operate, administer an anesthetic, manage a medical crisis, or deal with an unusual or cognitively demanding clinical presentation. The effects of acute sleep deprivation on clinical performance will depend on many salient contextual factors, including chronic sleep deprivation, time of day (circadian effects), clinical experience, task demands, and clinical workload. Individual work and sleep schedules, under specific but hard to anticipate circumstances, will be an important factor affecting the occurrence of medical error. Physicians must recognize that it is neither unprofessional nor weak to admit sleepiness or fatigue when on the job and make efforts to mitigate the potential consequences to patient care.

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