Sleep loss and fatigue in medical training

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The effects of sleep loss and fatigue in the context of medical training is a topic that has generated considerable interest, as well as controversy, over the past two decades. The sleep deprived state in medical trainees potentially impacts on a variety of domains relevant to medical care, including performance on neurobehavioral and work-related tasks, mood and affect, learning, risk for and commission of medical errors, and the health and well-being of medical students and residents. The following review provides a summary of research conducted on this topic in the past decade, including the relation of sleep loss and fatigue to medical errors and the quality of patient care. Those few studies that have analyzed the use of operational alertness management strategies, countermeasures, and educational interventions to address and mitigate the effects of sleep loss and fatigue are also reviewed. There is clearly a need for additional research to further explore the complex interaction between sleep and fatigue and medical care, and to support the development and implementation of regulatory policies based on sound science. Curr Opin Pulm Med 2001, 7:411–418

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Healthcare delivery is necessarily a 24-hour per day process, and healthcare providers, including physicians, medical students, and resident physicians, frequently are required to function in the occupational setting under conditions of chronic sleep deprivation and fatigue. Over the past several decades, concern has grown that sleep loss and fatigue in medical trainees has significant potential to compromise both the quality of patient care and the quality of life of medical trainees [1]. In 1989, the Bell Commission Report cited sleep deprivation in medical house officers as a major contributor to the death of a young woman in New York, Libby Zion [2], and, in response, the New York State Legislature reduced total work hours for house staff from 100 or more per week, to 80 hours maximum. More recently, the Institute of Medicine report "To Err Is Human", which estimated an annual error-related patient death rate of 44,000 to 98,000, generated considerable concern about the high prevalence of adverse clinical outcomes resulting from medical errors [3]. There is a renewed interest in identifying and addressing modifiable provider-related risk factors, such as sleepiness and fatigue, in those types of errors deemed preventable.

Previous reviews of the literature

To date, there are at least 40 studies in the English literature examining specific effects of sleep loss and fatigue in medical interns and residents. Several excellent review articles [4–6], the most recent of which was published in 1992, summarized the empirical evidence regarding the association between sleep loss and fatigue and a number of outcome measures, including mood, neurocognitive testing, and work performance of trainees. The conclusions reached by the authors of these reviews suggested that the evidence linking sleep loss to performance deficits and adverse outcomes in the medical setting, although in some cases quite compelling, was neither consistent nor conclusive. Furthermore, they concluded that, given the wide variation in the methodology, study designs, and subject characteristics employed in the studies, this result was not surprising.

It is also important to note that many of the studies that have been done in this area, partially owing to the inherent difficulties in conducting this type of research, have substantial methodological weaknesses or design flaws. These include small sample sizes, lack of objective or reliable recording of actual sleep amounts, and use of potentially inappropriate performance outcome mea-

sures, which lack the sensitivity or are of inadequate duration to detect more subtle levels of impairment. Perhaps even more importantly, most of these studies have not considered the confounding variable of chronic partial sleep deprivation in the research design, and, therefore, the validity of any comparisons of performance under conditions of acute sleep restriction ("post-call") versus a "rested baseline" is likely to be compromised by the fact that most resident physicians are routinely functioning under the burden of a considerable chronic sleep debt. Moreover, the different types of outcome measures that have been used to assess the effects of sleep loss and fatigue in these studies, which have ranged from performance on psychometric tests of vigilance and reaction time, to the ability to correctly answer national board-type questions, to performance on simulated tasks, raise concerns about the potential relevance of some of these measures to actual work performance ("ecological validity"). Alternatively, outcome measures of many potentially significant domains of impact, such as the quality of physician-patient communication and complex problem-solving skills, have not been adequately assessed in the literature. Because many of these outcome measures are also based on self-report, they are vulnerable to the frequently found discrepancy between self-assessment of sleepiness/alertness levels and actual physiologic levels of sleepiness; therefore, results may represent either an underestimation or overestimation of impairment. Finally, very few studies to date have systematically evaluated strategies for fatigue/alertness management, such as "counter-measures" (napping, use of caffeine, etc) or alternative work hour schedules.

With these limitations in mind, and accepting the assumption that more research is clearly needed to more fully understand the relation between sleep loss and fatigue and performance in physicians-in-training, the questions become: what new information exists? And, what conclusions may reasonably be drawn from the body of research that has been done on this topic in the past decade?

Documentation of sleep loss and sleepiness in medical trainees

A number of studies have attempted as either a primary or secondary focus to document the quality and quantity of sleep that medical trainees obtain, both during on-call and non-call nights. It may be concluded from these studies that interns and residents are frequently functioning in a state of chronic partial sleep deprivation. For example, a number of survey studies have included retrospective self-report data regarding typical amounts of sleep (or hours of continuous wakefulness) obtained by trainees in various specialties. Results range from 37.6 (SD 9.88) hours as the longest period of time without sleep in a random sample of 1773 second year residents [7], to 45.5 (SD 9.3) hours without sleep reported by surgical residents in a survey of interns from a variety of specialties [8]. In the latter study, more than 20% of the residents surveyed also reported having gone without sleep for more than 48 hours on at least one occasion.

Several studies have used more objective measures, including polysomnography and actigraphy, a wristwatch-like device that monitors sleep-wake cycles, to assess sleep amounts. One recent study of 26 internal medicine residents in a major teaching hospital documented that interns spent an average of less than 5 hours per call night in bed, and obtained an average of 3.7 hours of sleep, as measured by ambulatory EEG recording [9•]. Another study, which also used continuous ambulatory EEG monitoring of sleep [10] in 6 house officers, found that they obtained 3.9 hours (SD 0.4) of sleep on call, and had significantly increased slow wave sleep (23%, SD 4%) and significantly decreased REM (18%, SD3%) compared with sleep on non-call days. Tov *et al.* [11] used actigraphy in combination with sleep diaries to compare sleep amounts during "heavy" (HWL) vs "light" (LWL) workload rotations (based upon numbers of patients, admissions, and discharges) in 27 Israeli residents. Residents doing emergency room rotations obtained the least sleep (3.06 hours, SD1) although the average for all HWL residents was only 4.49 hours (SD 1.34); sleep onset in the HWL group was delayed 3 hours later than their usual bedtime.

In order to place these sleep amounts in some context, it should be noted that many studies in the sleep literature have documented significant performance impairments when sleep is restricted to four hours or less under experimental conditions. One recent study documented that restricting sleep to 5 hours of sleep per night during a one week period results in a level of cognitive impairment equivalent to 2 nights of total sleep deprivation [12]. Furthermore, in addition to sleep loss, medical trainees are subject to multiple other factors that increase sleepiness and fatigue and decrease alertness. These include frequent interruptions on-call leading to fragmented and poor quality sleep [10], and shift work-related interruption of normal circadian sleep-wake rhythms. The latter is particularly apparent in studies of emergency medicine residents, for many of whom shift rotations are both frequent and often occur in a circadian-disruptive pattern. In one study of 6 emergency physicians, [13] which assessed sleep amounts (sleep logs and ambulatory EEG), mood states, and performance on 2 simulated tasks (patient triage and intubation) as a function of day and night shift work, night-shift physicians rated themselves as more sleepy, less happy, and less clear-thinking. They also were consistently slower and made more errors performing intubations, and were less efficient at triaging patients than day-shift workers. Finally, inadequate post-call or "recovery sleep" may further compromise mood and performance in trainees. In

Tov's study [11], residents in both workload groups obtained similar post-call amounts of sleep, which also were not significantly higher than either group's baseline sleep amounts, implying incomplete compensation for sleep loss in the heavy workload group; compensatory napping occurred in only 50% of the sleep-deprived residents. In the aforementioned emergency room study, night-shift physicians who slept during the day slept significantly less (496.6 min SD 46.2 vs 328.5 SD 96.3) and had less REM sleep than day-shift workers, similar to what has been documented in other shift-work groups.

Impact of sleep loss and fatigue on trainees' personal lives

The consequences related to sleep loss and shift work in physicians in training, like those in any occupational setting, are potentially considerable in scope and are likely to occur in a number of domains that directly affect the health and well-being of trainees themselves. These include mental health consequences (mood changes, depression, increased stress, increased potential for alcohol and substance abuse), repercussions on social and family life (negative effects on personal relationships, decreased time and energy for spouse and children), a negative impact on physical health (somatic complaints, increased adverse pregnancy outcomes, an increased risk of motor vehicle crashes), and potential impediments to learning. One caveat in interpreting the results of these studies, however, is that many of them do not distinguish the impact of sleep loss, *per se*, from that of long work hours and other job-related stressors.

One of the more consistent findings in the literature on this topic, paralleling what is known about the effects of sleep deprivation in general, has been the almost universal reports of negative effects of sleep loss on mood in medical trainees. For example, a study of 40 junior and senior house staff in Germany documented a clear deterioration in "emotional condition" (increased negative mood) post-call [14]. In another study, total and subscale (Tension-Anxiety, Confusion, Fatigue, and Vigor) scores on the Profile of Mood States (POMS), a self-report measure of affective state which has been used in many of these studies, deteriorated significantly after a 32 hour shift in 16 house officers [15]. At least one study also has suggested that these negative mood effects persist for several days post-call [16]. It should be noted, however, that in another survey study, 1785 surgical residents [17], despite multiple complaints of exhaustion and sleep loss, infrequently reported feelings of anger, hostility, or discouragement and reported less substance use and fewer physical complaints than residents from other specialties. As might be expected, residents report that the negative psychological effects of sleep loss frequently take a toll on family life and on their professional and personal relationships [8]. For example, one study, which examined the complex interaction between work and home-related demands (termed "work-home interference") in medical residents [18], found that residents' perception of increased tension between their work and home roles strongly affected their perception of how sleep deprived they were.

Residents also report negative effects of sleep loss on their physical health. In one study of house officers in Scotland [19], both the number of hours worked and the number of hours slept while on call was positively correlated with the number of somatic symptoms they reported experiencing over the previous year. A number of studies have specifically analyzed the effects of occupational stress and work hours on pregnancy outcomes in female residents [20–23], although it should be kept in mind that many of these studies are based on retrospective self-report data, and none of them have specifically analyzed the effects of sleep loss as a risk factor. Although the overall results are somewhat mixed, an increase in a number of pregnancy-related complications (pregnancy-induced hypertension [23], abruptio placenta, and preterm labor [20]) and adverse fetal outcomes (low birth weight and intrauterine growth retardation) [20] have been reported in residents. Even one larger study, which failed to find any significant overall increase in adverse pregnancy outcomes [24] in comparison to a demographically similar control group, did find an association between >100 hours worked per week and preterm delivery.

Several recent retrospective self-report studies also have analyzed the relation between sleep loss and fatigue and traffic citations, motor vehicle crashes (MVC), and "near-miss" driving accidents. Although one study of 27 anesthesiology residents in the United Kindom failed to find an increase in motor vehicle crashes compared with the general population [25], other studies that have looked at the issue in more detail have found prevalence rates for collisions as high as 8% and near-crashes up to 58% in emergency room physicians [26]. In the latter study, 74% and 80% of the collisions and near-miss crashes, respectively, occurred on the drive home following the night shift. Furthermore, driving incidents were correlated with both the number of night shifts worked, and residents' self-reported tolerance of shift work and adaptation to drowsiness. Marcus and Loughlin's survey of pediatric house officers [27] found a significantly increased prevalence compared with faculty of falling asleep at the wheel either while driving or while stopped at a traffic light (49% of the residents vs 13% of the faculty), traffic citations (25% vs 18%), and motor vehicle accidents (20 vs 11 MVA's), with the vast majority of these incidents occurring post-call. Finally, a recent retrospective survey of 697 emergency medicine residents found that they were 6.7 times more likely to have a fall-asleep MVC during residency compared with the period before residency; furthermore, these collisions were associated with

rotations having more frequent calls and during which less sleep was routinely obtained [28].

Impact of sleep loss and fatigue on performance

Previous reviews summarized the studies conducted before 1990 that analyzed the effects of sleep loss and fatigue on residents' performance on cognitive and neuropsychological tests (psychometric tests of attention and concentration, vigilance, reaction time, memory, reasoning) and on simulated patient tasks (intubation, EKG and radiographic interpretation, arterial catheterization, anesthesia monitoring). The design of most of these studies involved comparisons between precall ("rested") and postcall performance in a group of residents. Despite the aforementioned methodological concerns, the results of these studies do support a number of general conclusions: 1. tasks dependent on high or sustained levels of vigilance, tasks of longer duration, or those which represent newly learned procedural skills seem to be more vulnerable to the effects of short-term sleep loss; 2. efficiency of task performance is often sacrificed in favor of preserving accuracy, a factor which may have significant impact in situations that require both efficiency and accuracy (*eg*, intubation of a critically-ill patient); 3. most of the studies examining performance in surgical residents have failed to show significant performance decrements postcall, suggesting the importance of considering the underlying effects of chronic partial sleep deprivation. There also is a possibility that some degree of self-selection results in a larger percentage of individuals who have a relatively high tolerance for sleep loss being more likely to opt for a career in surgery, a factor that has not been well-studied; 4. the role of such performance-related variables as motivation, reinforcement, feedback during the testing sessions, circadian timing of the testing sessions, and the intrinsic interest and perceived importance of the task itself have largely not been considered in these studies.

Table 1 presents an overview of the more recent studies (1991–2001) on the impact of sleep loss on performance, which, although subject to some of the previously mentioned methodological concerns, largely support the general conclusions outlined above.

Impact of sleep loss and fatigue on medical education

A traditional argument made in defense of the long hours of continuous duty demanded by the current system of medical training is that increased exposure to patients and disease states results in enhanced learning. Thus, the results of those few studies that have analyzed the impact of sleep loss on outcomes potentially related to medical education (decreased retention of information, impaired information processing, decreased motivation to learn) are important to consider. Medical students [8] and residents have reported a negative correlation between long work hours and effective learning and use of skills [19]. One study of 34 surgery residents used sleep logs and monthly surveys of operative participation. Every other night call was associated not only with in-

Table 1. Summary of recent studies on sleep loss and fatigue in medical trainees: effects on performance

Study/Subjects	Methods	Outcome measure(s)	Results	Comments
Rubin, et al. 1991[64] 63 Internal medicine and pediatric residents	3 conditions: 1) morning of pre-call, 2) evening of post-call, 3) post "regular" (10 hr) work day	Neurobehavioral Evaluation System: (includes tests of vigilance, dexterity, speed and coding ability, mental manipulation)	Worse performance post call on vigilance, coding dexterity, mental manipulation improved; return to baseline performance on most tests in condition 3	Similar deficits 2< and >2 hrs of on-call sleep
Lingenfelser, et al. 1994 40 house officers- (Germany) Group A ("Learning"): 1st & 2nd yr residents Group B ("Experienced"): 3rd & 4th yr residents	2 conditions: 1) off duty 2) post call (1 night of ≥ 6 hours uninterrupted sleep) Tested at 8 am	– tests of reaction time, selective attention, memory recall, vigilance – EKG interpretation, mood	Performance decrements and mood deterioration post-call; few group differences	Baseline nightly sleep Averages 6.3–6.7 hours
Leonard et al. 1998 [15] 16 house officers– (Ireland)	1 condition: random assignment to testing pre vs. post-call (32 hr shift)	5 neurocognitive tests: alertness/ concentration, memory/reasoning	Worse performance attention tasks only	Averages 4.5 hours sleep on call
Taffinder, et al. 1998 [63] 6 surgical residents– (Great Britain)	3 conditions: 1) "undisturbed night" 2) "sham" on call (disturbed at 0000, 0300, 0600) 3) "no sleep" call night tested in evening pre-call and morning post-call	Performance on laproscopic surgery simulator, Stress/arousal adjective checklist	Significant increase total time, error score across conditions; in condition 3: 20% more errors, 14% longer to complete task; increased stress, decreased arousal across all conditions	Sleep deprivation mediates effects on performance through increased stress rather than decreased arousal?

creased levels of fatigue and stress and decreased overall satisfaction, but also with fewer operative cases participated in per month compared with every third and every fourth night call schedules [29].

In those studies that have analyzed the actual performance of trainees on educational tasks, the results are mixed. One study [30] correlated amount of sleep obtained by a group of medical students and residents the night before the testing session (by sleep diary) with scores on a test on content recall of selected surgical journal articles. "Sleep deprived" (defined as $\leq$ 4 hours of uninterrupted sleep) and "rested" trainees obtained similar scores, despite self-reported increased fatigue and decreased motivation in the sleep-deprived group. Several other recent studies have compared performance on standardized examinations, such as the American Board of Surgery In-Training Exam (ABSITE) [31, 32]. In contrast to previous studies that showed a negative correlation between pretest sleep amounts and test scores for family practice residents [33], these studies failed to show any significant detrimental effect of call status or hours of sleep on test performance. Finally, in one interesting study of 23 medical interns [34], there were no significant differences in medical knowledge test scores between sleep-deprived ($\leq$ 3 hours) and rested residents. In addition, sleep loss did not seem to decrease the appropriateness of a subject's confidence in the accuracy of their answers, a finding that, if replicated, has potential implications for the relative risk of trainees committing medical errors in a sleep-deprived state.

Sleep loss and fatigue and medical errors

A *medical error* is defined as an adverse event which results from the failure of a health care delivery plan to be completed as intended, or the use of an incorrect plan to reach an appropriate patient care objective [35]. Medical errors may occur at any of multiple different steps in the diagnostic and treatment process, and often involve human factors, such as inattention, poor communication, and fatigue, in their genesis [35]. Given the fact that at least half of the studies cited show adverse affects of sleep loss and fatigue on neurocognitive function and performance of occupational tasks, it is logical to postulate that sleep loss in medical trainees has significant potential to compromise the margin of safety in the delivery of patient care. Furthermore, the almost universal effects on affective domains such as mood, motivation, and personal investment in the outcome of one's performance would be expected to have some impact on communication and interaction with patients, and thus affect the quality of the provider-patient relationship.

Attempts to analyze the association between sleep loss and fatigue in medical trainees and adverse clinical outcomes have included both survey studies of provider-identified risk factors for medical errors and studies that have analyzed antecedents of actual reported errors. Recent surveys of health care providers have documented that, for example, 61% of anesthesiologists surveyed in the US [36] and 86% of those in Australia [37] report having made fatigue-related errors. Surveys of trainees' perceptions of risk factors for medical errors have reported an association between prolonged work hours, fatigue, and lack of sleep and self-reported decreased efficiency in performance of work-related tasks [38], commission of medical errors while on call [30], and overall compromised quality of patient care [39]. In one of these studies [40], "tiredness" in a group of 225 residents from a variety of specialties was the single most important attribution for the lack of quality patient care. It was cited as a contributing factor in 48.8% of incidents of lowered standards of care and 45.5% of incidents involving increased irritability and anger towards patients. In a recent survey of 254 internal medicine residents, 41% of the respondents cited fatigue as a cause of their most significant medical mistake [41]. The fatigued residents in this study were also less likely to seek out additional information after the incident, thereby potentially reducing the opportunity to avoid similar errors in the future.

There have been few studies to date that have analyzed the specific contribution of sleep deprivation to actual medical errors. In previous reviews, "real world" occupational tasks, such as monitoring anesthesia [42], performing surgical operations [43], ordering medications, and documenting medical histories [44], have all been shown to be impaired in sleep-deprived medical students or physicians. Several more recent studies also have looked at this relationship, using a number of different methodologies to assess prevalence, type, and risk factors for medical errors. For example, in one recent study of anesthetic incidents in Australia, fatigue-related events constituted 2.7% of the 5600 reported errors that occurred during a 10-year period [45•]. In another Australian study, fatigue was considered a contributing factor in 10% of medication errors [46]. Another study of 70 serious anesthesia incidents found that one half were related to factors potentially correlated with fatigue, such as decreased vigilance [47]. Another study [48], however, which looked at surgical complications in relation to call status (determined by correlation with a database of call schedules) of the operating surgical resident, failed to find any significant differences in postoperative complication rates (as reported by senior residents/attendings to a weekly morbidity and mortality conference). More indirect evidence of an association between resident fatigue and medical errors was reported in a retrospective cohort analysis of over 19,000 patients admitted to the internal medicine service of a county teaching hospital. This study found that patients admitted after midnight had a significantly higher mortality rate, which did not

seem to be a result of a systematically different case mix (ie, patients admitted after midnight being sicker) [49].

Fatigue management strategies

To date, attempts to address the problem of sleep loss and fatigue during medical training have been largely regulatory. For example, in addition to the New York State regulations resulting from the Bell commission limiting duty hours, the Accreditation Council for Graduate Medical Education (ACGME), has also implemented work hour limits through changes to the Program Requirements (accreditation standards) in some, but not all, specialties. A recent petition to the Occupational Safety and Health Administration (OSHA) by Public Citizen, the Committee of Interns and Residents, and the American Medical Student Association asks OSHA to limit resident work hours and duty shift schedules in the interests of trainee safety.

There have been very few outcome-based studies which have systematically assessed the impact of regulations that limit work hours for physicians in training. One study, which examined the quality of patient care delivered before and after implementation of Code 405 regulations in New York (including an 80 hour work week maximum), found an increased number of delays in ordering diagnostic tests and an increase in the number of patients suffering at least one medical complication post-regulations. This persisted after accounting for a number of patient-related variables [50•]. However, in another study that assessed the impact of instituting similar continuous work hours and on call limitations in a VA hospital, not only did sleep hours on call significantly increase, but there was a 15% reduction in mean length of stay, a 19% reduction in median length of stay, a decrease in the number of laboratory tests ordered, and a reduction in the number of medication errors committed [51].

However, evidence from a number of sources suggests that specific regulatory strategies, such as limitations on work hours for residents, although most likely necessary, may not be sufficient to optimally impact on sleepiness and fatigue management in medical trainees or on related medical errors. From the standpoint of individual factors that could potentially impact on the success of any given fatigue management strategy, such as work hour limitations, a number of studies have addressed the issue of what residents actually do on call and how factors other than work hours, such as variability in efficiency and perception of work load may impact on sleep amounts [52, 53]. A particularly striking example of the importance of confounding individual factors is found in a recent study of the institution of a night float system in an internal medicine residency program that was designed to provide residents with protected time for sleep [54]. Contrary to the authors' hypothesis, the results showed that the "covered" residents actually obtained less sleep than the residents who were relieved by the night float, because the covered residents used protected time to catch up on work, not sleep. Finally, on a pragmatic level, resident physicians are frequently under financial pressures to engage in moonlighting that would not be covered under residency program work hour limitations but would be likely to further compound the negative impact of training-related sleep loss and fatigue.

In contrast to other professions that have high potential for human error (*eg*, aeronautics, transportation) and that have more actively developed and implemented measures to mitigate the effects of sleep and fatigue on worker performance [55•, 56•], only a handful of studies have addressed the issue of countermeasure strategies in medical trainees. One recent review article, which analyzed the impact of shift work in emergency medicine [57•], proposed the use of operational and personal strategies to optimize alertness, including rotation schedule designs based on chronobiologic principles, use of regular exercise and exposure to light on and off the job, and sleep strategies, such as anchor sleep, split sleep periods, and planned napping. In one example of the use of operational or systems-wide strategies, institution of a team day/night shift on-call system resulted anecdotally in improved morale and resident learning in an obstetrics and gynecology residency program[58]. A more recent study, which examined the impact of a "night stalker" radiology resident on quality of care in the emergency room, reported fewer "missed' radiologic findings and less clinically significant discordant findings in the post-intervention cases reviewed [59].

Smith-Coggins [13] studied the impact of a comprehensive sleep and fatigue management program on a number of sleep and performance-based outcome variables in six emergency medicine attendings. The program included an educational component on sleep physiology, circadian rhythms, and sleep hygiene that was based on a fatigue countermeasure program developed for commercial airline pilots by NASA; institution of a shift rotation schedule that adhered to accepted chronobiologic principles (*ie*, rotating shifts in a clockwise direction, limiting consecutive night shifts, etc); and use of a variety of countermeasure strategies by the physicians (use of caffeine, napping, etc). Outcome measures included sleep quality and quantity (measured by sleep logs and ambulatory PSG), psychomotor performance tests of vigilance/sustained attention, and simulated tasks (EKG interpretation and intubation). Despite a high rate of self-reported compliance with the countermeasure strategies and subjective reports of "quality of life" improvements resulting from the intervention, there was no significant improvement overall compared with the active placebo condition ("jet lag diet") on most of the outcome variables. However, the pervasiveness of the negative

effects (less sleep, more negative mood, impaired vigilance performance, etc associated with night shifts) resulting from circadian disruption found in this study under all of the experimental conditions may have masked actual differences.

Conclusions

Several recent reviews and commentaries have summarized the complex ethical, political, and economic factors that must be considered in addressing the issue of sleep loss and fatigue in medical training, including the implications that any policies have for "professionalism" and the physician-patient relation [1, 60–62]. Ultimately, however, all changes in policy and procedures should be evidence-based and linked to results of specific studies. A primary goal must be to develop a scientifically sound and comprehensive body of evidence regarding the effects of sleep loss and fatigue on physicians in training and on the quality of health care that they deliver. To achieve this aim, the research questions need to be clearly defined and optimal research strategies identified. New research methods and data collection techniques will likely be needed for this purpose. Because lack of funding has clearly hampered efforts to develop a coordinated research program in this area, additional funding will need to be allocated to achieve these goals.

In addition, educational interventions with providers regarding the antecedents and consequences of sleep loss and fatigue and alert management strategies are a necessary foundation for all sleep loss and fatigue management strategies, including work hour regulations, and must be a component of any comprehensive and integrated approach to this issue. The development of such educational interventions will then allow the creation of the infrastructure for additional interventions, such as work hour limitations. The next decade promises to provide an opportunity to integrate sleep science, principles of medical education, and healthcare outcomes research into a comprehensive, balanced, and ethical approach to the issue of sleep loss and fatigue in medical training.

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