Sleep, Fatigue, and Medical Training: Setting an Agenda for Optimal Learning and Patient Care

A Report from the Conference "Sleep, Fatigue, and Medical Training: Optimizing Learning and the Patient Care Environment" Held on October 28 and 29, 2001, Alexandria, Virginia

Sponsoring Organizations: American Academy of Sleep Medicine, Sleep Research Society, American Medical Association, National Center on Sleep Disorders Research of the National Heart, Lung, and Blood Institute, National Institutes of Health

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INTRODUCTION

A SUBSTANTIAL BODY OF BIOMEDICAL RESEARCH DEMONSTRATES THAT PHYSIOLOGIC AND COGNITIVE FUNCTIONS IN HUMAN BEINGS VARY WITH 24-HOUR, OR CIRCADIAN, RHYTHMS. The most obvious circadian rhythm is that of sleep and wakefulness; more subtle examples include those expressed in alertness and performance levels. Although such circadian rhythms are endogenous, their expression and timing are strongly influenced by the environment. Alertness and ability to function also vary as functions of homeostatic factors such as sleep duration, sleep quality, and time awake. Acute and chronic sleep loss, whether partial or complete, substantially impairs our physical, cognitive, and emotional functioning.

However, healthcare professionals have been slow to acknowledge the substantial impact of these fundamental physiological processes on safety and quality of healthcare delivery. Traditionally, medical students and house staff work long hours with continuous shifts and minimal recuperation time. In light of recent advances in circadian and sleep biology, these traditional practices raise important questions: What are the effects of sleep loss and fatigue on learning, patient safety and medical errors, and trainees’ lives? What impact do these practices have on healthcare systems and healthcare financing? What empirical data exist regarding work hours and fatigue management programs in other industries, and how might these be applicable to medical education? What interventions could ensure that residents are well rested and functioning at optimal levels? Finally, what are the major barriers against and opportunities for change?

To begin addressing these issues, the sponsoring organizations held a national conference bringing together major stakeholders in this issue on October 28-29, 2001, in Alexandria, Virginia. The original concept for this working conference was developed by four groups: The Sleep Academic Award program of the National Center on Sleep Disorders Research (NCSDR) of the National Heart, Lung, and Blood Institute; the American Academy of Sleep Medicine (AASM) Medical School Education Committee; the Sleep Research Society (SRS); and the Council on Medical Education (CME) of the American Medical Association (AMA). The conference was supported by grant from the Agency for Healthcare Research and Quality (AHRQ). Additional organizations invited to attend the conference included representatives from the Accreditation Council on Graduate Medical Education (ACGME), the Association of American Medical Colleges (AAMC), the Resident and Fellow Section (RFS) of the AMA, the American Medical Student Association (AMSA) and the Committee on Interns and Residents (CIR), the American Hospital Association (AHA), and representatives of individual Residency Review Committees (RRCs).

The specific objectives of the conference were:
- To discuss how sleep deprivation and fatigue affect performance
- To evaluate the effectiveness of countermeasures and other strategies designed to overcome the effects of fatigue
- To discuss how data from other industries may be applicable to the medical setting
- To identify gaps in knowledge that must be filled before establishing any new meaningful policies regarding sleep, fatigue, and medical training
- To set an agenda for future activities addressing the role of sleep and fatigue in medical education

The conference addressed these objectives by convening four data-review panels followed by four work groups. The data-review panels provided overviews on sleep, fatigue, and performance; sleep loss and fatigue in medical education; evaluation and management of fatigue in nonmedical settings; and input from stakeholders, including trainees, hospital administrators, and RRC representatives. Following these presentations, participants broke into four work groups to address research issues, education issues, medical-trainee issues, and patient-safety issues. The work groups were charged with identifying key issues related to each area from the earlier presentations; establishing a set of goals, priorities, and recommendations for addressing unresolved issues; identifying key organizations and individuals to address these issues; and creating a timeline for implementing recommendations. A writing group summarized and integrated information from the conference into the current report, which was approved by each of the sponsoring organizations. This report provides a brief historical overview, followed by a summary of the conference data-review presentations. Because several published reviews are available elsewhere, these sections are summarized briefly, and general references are organized by topic at the end of this paper. The summary of critical issues, general goals, and specific recommendations from the work groups constitute the major focus of this report.

HISTORICAL BACKGROUND

The issue of sleep and fatigue in medical training has evolved within specific historical, political, and scientific contexts. In particular, three

Fatigue in laboratory studies of animals and humans and in field studies of circadian biology. Research data regarding the effects of sleep loss and fatigue in medical training without a third converging element, of medical errors.

Additional federal dollars have been allocated to address the prevention of medical errors" by designing optimal working conditions for medical personnel. As a result of the report, a committee appointed by the Institute of Medicine was established a “Work Group on Residents Duty Hours and the Learning Environment” to address what aspects of the work-hours issue were in its purview. In June 2002, the ACGME set forth new recommendations for work-hour limitations to be included in its Common Program and Institution Requirements. These recommendations include limitation of duty to an average of 80 hours per week, a maximum of 24 consecutive hours on call, 10 hours off between shifts, and maximum on-call frequency of every third night. Other medical-education organizations have also promulgated policy on resident work hours. Both the AMA and AAMC, for example, have specified that resident physicians should be scheduled for no more than 80 duty hours per week and no more than 24 consecutive duty hours. Despite the limits included in these policies, the optimal number of resident work hours to balance educational experience and adequate rest is simply not known.

Legislative actions to limit medical trainees’ work hours have been attempted in several states, but New York is the only state that has actually enacted such legislation. This action resulted from the 1989 recommendations of the Bell Commission, which was established by the New York State Commissioner of Health to investigate the death of a young woman named Libby Zion at a New York City teaching hospital. The Bell Commission concluded that trainee fatigue, as well as inadequate supervision, contributed to the adverse outcome in the Zion case and subsequently recommended limiting trainees to 80 hours on duty per week (averaged over a four-week period) and 24 consecutive hospital-duty hours. Reports of widespread violations of the New York regulations and concern about the ability of medical education and professional organizations to enforce compliance with ACGME work-hour standards eventually helped to prompt the filing of a petition with the Occupational Health and Safety Administration (OSHA) by several trainee groups in the spring of 2001. The petition alleged that excessive work hours were harmful to resident-physician health and requested that OSHA limit work hours to 80 per week and limit work shifts to a maximum of 24 hours. Similar requirements were subsequently incorporated into bills introduced in the House of Representatives (H.R. 3236) by Representative John Conyers and in the Senate (S. 2614) by Senator Jon Corzine. This legislation would require hospitals, as a condition for participation in Medicare, to limit resident work hours to 80 per week and shifts to 24 hours.

The second converging development is public interest in the issue of sleep loss and fatigue in medical training, galvanized by the National Academy of Sciences Institute of Medicine report, “To Err is Human” in the spring of 2000. This report estimates that as many as 98,000 patients die each year as a result of medical errors occurring in hospitals, and it stresses the need to investigate and address human factors, such as sleep deprivation, that are potentially involved in violations of patient safety. As a result of the report, a committee appointed by the Institute of Medicine recommended the establishment of a federally funded center for patient safety that would include initiatives to develop a “culture of safety” by designing optimal working conditions for medical personnel. Additional federal dollars have been allocated to address the prevention of medical errors.

Political pressure and public concern alone, however, would not have formed the basis for a rational and informed discussion of the issue of sleep and fatigue in medical training without a third converging element, expanding knowledge derived from scientific developments in sleep and circadian biology. Research data regarding the effects of sleep loss and fatigue in laboratory studies of animals and humans and in field studies from other occupations are critical to formulating an empirically based approach to this issue. In addition, there is now a critical mass of literature on the specific effects of sleep loss on medical trainees, summarized below.

In summary, a series of historical, political, and scientific developments have set the stage for a creative and informed dialogue regarding the problem of sleep and fatigue in medical training.

SUMMARY OF CONFERENCE PANELS

Sleep, Fatigue, and Performance: Overview of Research and Scientific Issues

Most physiologic and cognitive processes in living organisms vary with endogenous, self-sustaining, 24-hour rhythms, called circadian rhythms (see reference list for reviews). In humans, sleep-wake activity, cognitive and psychomotor performance, and alertness vary systematically across the circadian cycle. The circadian timing system actively promotes alertness during usual daylight hours; during the nighttime, circadian nadir, alertness is markedly reduced and sleep tendency increases. These circadian rhythms exist independently of the duration of prior sleep.

While the circadian system promotes wakefulness and increased vigilance, the homeostatic drive for sleep increases in a linear fashion with time spent awake. These influences may be so powerful that despite external stimuli, wakefulness across time becomes an extremely unstable behavior, and involuntary sleep may occur. Contrary to the popular notion that healthy adults can acclimate to sleep loss, the effects of chronic partial sleep loss are cumulative. Specifically, sleepiness increases and psychomotor performance deteriorates in direct proportion to the degree of sleep loss. Notably, the perception of sleepiness is far less affected than are electrophysiologic measures of sleepiness and objective measures of vigilance, which show incremental effects over a week of partial sleep restriction. Creative thinking, verbal processing, and complex problem solving are significantly impaired with both short-term and chronic partial sleep loss. Substantial interindividual differences have been observed in the cognitive and performance effects of sleep deprivation.

An equally important influence on sleep/wake behavior and cognitive function is sleep inertia. Sleep inertia can be defined as an incomplete arousal following a period of 3 or more hours of sleep. Sleep inertia is characterized by confusion, poor judgment, inappropriate decision making, and impaired recall of events occurring during the awakening period.

Thus, across the 24-hour cycle of a young adult with a typical light-dark schedule, alertness is lowest in the early morning hours because of the circadian nadir and, potentially, sleep inertia. Later in the morning, the circadian wake-promoting signal increases, sleep inertia resolves, and homeostatic sleep drive is still low (under baseline conditions of adequate sleep). In the afternoon hours, a second lesser circadian nadir results in a slight reduction of performance and alertness. Later in the evening, despite an increased homeostatic drive for sleep, the circadian alerting signal increases substantially, again resulting in greater alertness. Understanding the complex interplay between circadian, homeostatic, and sleep-inertia influences is crucial for determining the optimal work and learning schedules for medical trainees.

Various countermeasures have been shown to be effective in reducing sleepiness and fatigue effects on performance in controlled laboratory trials. The most effective countermeasure for sleepiness is sleep. Brief naps prior to 24 hours of sleep loss improve alertness. Fifteen-minute naps every 2 to 3 hours can significantly ameliorate the performance decrements during 48 hours of total sleep deprivation, and 2-hour naps every 12 hours help sustain performance over 80 hours of sleep deprivation. Central nervous system stimulants have also been tested for effectiveness in improving performance following sleep loss. As with all pharmacologic therapies, these countermeasures have potential health risks associated with their use. Bright-light therapy at the circadian nadir (early morning) may be effective in improving performance.
In addition to acute total sleep loss from a night on call, many residents and medical students suffer from chronic sleep reduction. Unfortunately, the effectiveness of countermeasures for chronic (i.e., greater than several days) partial sleep loss has not been sufficiently addressed.

In summary, several physiologic regulatory systems influence sleep-wake behavior and cognitive performance. In testing and designing work schedules and other countermeasures, careful consideration should be given to circadian, homeostatic, and sleep-inertia effects on performance and alertness.

**Sleep Loss and Fatigue in Medical Education Settings**

Several comprehensive review articles (see reference list) have evaluated empiric evidence regarding the effects of sleep loss and fatigue on learning and performance in medical trainees. Approximately 50 studies have been reported, most of which have design or methodologic problems of various types. Many studies on the effects of sleep loss on performance have utilized standardized psychomotor tasks, which may be measured precisely but have less face validity than do tasks more directly related to job performance. Empiric studies examining the relationship between sleep deprivation and medical errors are also confounded by a number of intervening variables, including the level of training and experience of the practitioner, the inherent relative risk of a given procedure, the magnitude of both the acute and chronic sleep deprivation, the conditions of testing, and the chosen outcome measures. Few data exist to either support or refute the effectiveness of work-hour regulations, or to address potential concerns with these types of regulations, such as discontinuity of care and compromises in the quality of medical education.

Given these caveats, a number of studies have been conducted on the effects of sleep deprivation on neurobehavior test performance in medical trainees. Reaction time, manual dexterity, and memory recall are among the parameters typically impacted by sleep loss in these studies. Another common finding in these studies is that the speed or efficiency of task completion is more likely to be affected by restricted sleep than are the quality or accuracy of performance. In terms of subjective self-report, however, many residents feel that they were not able to perform at optimal levels when they had not received sufficient sleep. Tests that involve longer periods of sustained vigilance and tasks that are newly learned are more sensitive to effects of sleep deprivation, although increased mental effort can mitigate these effects in the short term.

One of the most consistent effects of sleep loss in medical trainees is a detrimental impact on mood. In addition to psychologic complaints, residents who have been deprived of sleep may also experience physical problems, including reports of adverse pregnancy outcomes. Another risk to physical health that has been explored is that of motor vehicle accidents experienced by residents as a result of sleep deprivation, although increased mental effort can mitigate these effects in the short term.

In summary, a growing body of research and policy experience from other occupational settings can be applied to fatigue-related issues in healthcare. Evaluation and Management of Fatigue in Nonmedical Occupations

Experience from other occupations, such as the military, aviation and space, and commercial driving, are relevant to understanding sleep and fatigue effects in healthcare settings and in evaluating optimal alertness strategies. Studies from the military, for example, show that performance of complex mental operations declines more than 60% compared to baseline levels following 72 hours of sleep loss. Furthermore, postion emission tomography (PET) studies in military personnel show progressive changes in the prefrontal cortex, thalamus, and multimodal association cortex, substantiating functional neuroanatomic changes consequent to sleep loss.

Fatigue in aviation and space operations has similarly been examined using a broad range of research designs and methodologies (e.g., labora-
tory-based studies, surveys, full-fidelity flight-simulator studies, and field research conducted during actual flight operations). For example, NASA examined the effects of a planned in-flight cockpit nap for pilots flying long-haul trans-Pacific journeys. A 40-minute nap opportunity was provided in the pilot’s cockpit seat for one crewmember while the other two pilots maintained flight operations. Compared to a control group, cockpit naps were associated with a 34% improvement in performance and a 54% increase in physiologic alertness.

Based on these studies, NASA has developed an education and training program entitled, “Alertness Management in Flight Operations.” This program has been associated with significant changes in work performance in one study. Policy changes have also been implemented, as evidenced by the NASA Technical Memorandum on “Principles and Guidelines for Duty and Rest Scheduling in Commercial Aviation.” This document was used by the Federal Aviation Administration to establish guidelines for flight schedules and duty-time limitations for pilots.

Sleep and fatigue effects in motor vehicle operations and commercial driving have also been examined, particularly in regard to fatal or near-fatal accidents. The overwhelming majority of fall-asleep crashes across different age groups occur during nighttime hours. Other significant risk factors include night-shift work, sleep duration less than 5 hours, self-reported sleepiness, and hours awake before the crash. Fatigue countermeasures for driving include road surface changes, driving regulations, behavior interventions (e.g., napping), pharmacologic interventions (e.g., caffeine), and fatigue management programs. One study showed that introduction of one passive countermeasure, continuous shoulder rumble strips, reduced drift-off accidents 11% to 89%. Technologic approaches to fatigue management involve both predriving assessment (i.e., fitness for duty) and on-line detection of drowsiness.

House staff may be particularly at risk for drowsy driving accidents. In one study of pediatric house staff, 23% reported having fallen asleep while driving (81% while driving home after call), 44% had fallen asleep while stopped at a red light (100% after call), and 25% reported crashes. Another study examined accident risk in emergency department residents using a national survey with 957 respondents. A total of 96 crashes were reported in 76 residents (8%) and near-crashes were reported by 553 residents (53%). Notably, 74% of the crashes and 80% of the near-crashes occurred following night shifts.

In summary, a growing body of research and policy experience from other occupational settings can be applied to fatigue-related issues in healthcare. Education, alertness strategies, technologic innovations, and scheduling activities under the context of an alertness or fatigue management program have been keys to success in these other industries. In addition, real-world barriers to change must be explicitly acknowledged, including the importance of individual and organizational attitudes.
Stakeholder Issues and Concerns

Critical stakeholders in the issue of sleep and fatigue in medical education include student and resident organizations, graduate medical accreditation organizations (e.g., ACGME and its RRCs), the medical education council of the AMA, the AAMC, hospital staff and administrators, and professional organizations involved in sleep and circadian rhythms (e.g., AASM and SRS). Although medical student and resident organizations are clearly concerned about duty hours, a competing concern for many residents is that restriction of work hours could negatively affect the quality of educational programs and training. As work hours are restricted, educational activities, rather than service or administrative obligations of the residents, may be limited. In addition, issues related to sleep and fatigue extend beyond work hours to include the full scope of lifestyle conditions for residents, including family constraints and responsibilities, moonlighting, and quality of life.

As noted above, the ACGME has taken a major step forward in the development of new guidelines for duty hours and fatigue management in medical residents. Implementation of these guidelines and compliance monitoring are major concerns at present. According to ACGME records, up to 30% of surveyed programs were in violation of the previous guidelines regarding work hours and related requirements. This percentage may increase with the introduction of more restrictive guidelines.

Financial and staffing considerations also need to be considered in relation to regulatory or legislative actions on work hours. From the perspective of hospital administration, educational programs, schedule changes, or proposals to limit work hours for residents should be considered in a budget-neutral environment. Moreover, changes designed to optimize medical resident alertness and performance must be considered within the overall hospital workforce environment. The shortage of nursing and ancillary personnel, in particular, may need to be addressed before major changes can be implemented in trainee programs. Federal and state funding support for graduate medical education does not adequately cover the cost of residency training. Analyses of potential savings accrued by a more efficient resident staff must be balanced against increased costs for other healthcare providers. As viewed by hospital administration, the problem of resident work hours may be best addressed by the physician community, rather than by administrative means.

SUMMARY OF WORK GROUP REPORTS

The Work Groups included individuals representing sleep medicine and circadian biology, medical students and residents, medical educators, professional medical organizations, and hospital administrators. Below, a summary of findings from each Work Group is followed by a set of general goals, specific recommendations, and key constituencies.

Research Issues

The goals of ensuring quality patient care, maintaining the health and safety of resident physicians, and optimizing graduate medical education and training effectiveness should be amenable to an evidenced-based research approach. Many stakeholders suspect that acute and chronic sleep loss and fatigue contribute to medical errors. However, establishing evidence regarding the extent of this contribution and ways to mitigate it will require new research initiatives.

Research on the relationship between work hours and resident performance has often been inadequately informed by the large body of data on the effects of sleep loss in humans. Negative findings have occasionally been interpreted as proving the absence of a relationship between prolonged work hours and resident performance. In addition to other methodologic limitations, the studies making this claim have not been statistically powered to test for a true finding of no difference. It is important to define the relationship between sleep, work hours, and resident performance. If evidence emerges to substantiate the view that sleep loss contributes to medical errors, reduced educational performance, and/or adverse health and reduced safety for resident physicians, then research priorities must shift to studies that evaluate sleep loss and fatigue management programs.

Research is often overlooked in the midst of competing arguments on the value of regulating and legislating work hours. Yet research, particularly research to mitigate the risks of fatigue, is essential for designing any workable solution to the problem. Management of fatigue is the fundamental concept to be developed from evidence, since healthcare delivery in teaching hospitals must operate 24 hours a day, 7 days a week. This means that, regardless of whether work-hour limits are imposed externally by legislation or internally by regulation, the potential for reduced sleep time, fatigue, and their consequences will remain. This point is illustrated by current proposals to limit weekly work to 80 duty hours. There is currently no evidence that an 80-hour work week will reduce fatigue and its adverse consequences. Moreover, this number is well above federally imposed limits on regulated transportation, where much of the research on work hours and fatigue has been conducted. Similarly, on-call duty limits of 24 hours go well beyond research data showing that the risk of human error goes up markedly when wakefulness exceeds 16 to 18 hours. These observations are not arguments for longer or shorter work hours but, rather, acknowledgments that sleep loss and fatigue are likely to be present during medical training even in the presence of work-hour regulations. Thus, effective management strategies are crucially important. Best practices for successful management of fatigue will need to be informed by evidence-based outcome data that all stakeholders view as valid and relevant.

Education Issues

Two types of education issues are relevant to the question of sleep and fatigue in medical trainees: education regarding sleep as a biologic phenomenon and the effects of sleep loss on learning and education. Medical students and house officers typically receive little or no education about normal sleep and circadian rhythms, or the essential role of sleep in maintaining adequate health and performance. Moreover, long work hours in residency training have often been justified by the notion that physicians need to “learn” how to manage without sleep. This traditional belief not only lacks empiric evidence, it also conveys the implicit message that sleep is a nonessential activity. Based upon accumulating evidence to the contrary, training programs should be strongly encouraged to educate trainees about the vital need for sleep and the potential risks and consequences of sleep deprivation.

Similarly, there is a pressing need for education of residency program directors, attending physicians, and medical school and hospital administrators regarding the importance of adequate sleep for maintaining optimal learning and performance among medical trainees. Education programs in this area also need to address negative cultural attitudes towards sleep, as well as the widespread belief that extended periods of sleep deprivation contribute positively to medical education and patient care. Education programs need to take into account the learning environment and potential structural barriers, such as lack of “on-call” facilities for ensuring adequate sleep. Finally, suitable education materials and resources on the role of sleep loss and fatigue in medical education need to be developed. Thus, the overall goal of education is to increase knowledge and awareness about sleep and fatigue among medical students and residents and to create a learning environment that maintains optimal performance and alertness.

Medical Trainee Issues

The trainee perspective regarding sleep loss and fatigue encompasses three critical issues: 1) The nature of the work and learning environment in which trainees are required to function; 2) the conditions necessary to effect positive, substantial, and long-lasting changes in the system; and 3) the role of regulation and economic issues.

Trainees’ work and learning environments are influenced by the competing priorities of service and education, as well as quality of life for
residential physicians. Two basic components of the work environment must be considered. The first is the actual working conditions and the contribution of the physical working environment to sleep loss and fatigue. This includes issues such as scheduling policies, work hours, patient load, and availability of ancillary personnel to perform essential duties (e.g., phlebotomy, nursing, etc.). The second basic component of the work environment is the culture of medicine in which trainees function, which often serves as a more subtle but very real barrier to change in the current system. In this culture, ignoring the need and even the desire for adequate rest is frequently considered to be a “badge of honor.” Although such a culture will be difficult to change, it is a key factor in ensuring the success of any intervention.

Several other elements are also necessary to implement and maintain effective interventions for managing sleep loss and fatigue. Chief among these is the need for shared responsibility among trainees, medical school faculty and administration, hospital administration, and medical education regulatory bodies for developing and incorporating effective and creative solutions. In order to foster this sense of collective responsibility, it is critical to include all groups with a vested interest in this issue.

The role of regulation of work hours and working conditions for residents, and the economic realities that both drive current policies and present barriers to implementing change, are also vitally important issues. A number of potentially nonexclusive pathways for regulation exist, including regulation by educational-governing bodies; legislative and judicial regulation at national and state levels; and punitive measures, such as fines and sanctions by accrediting bodies. However, as indicated above, regulatory actions do not mitigate the need for effective sleep loss and fatigue management solutions.

**Patient Safety Issues**

Sleep loss and fatigue affect individual performance and performance in the healthcare system. The effect of sleep loss and fatigue on patient safety has been more difficult to document. Evidence from the existing literature is equivocal because there is great variability in how researchers have addressed the question. We do not have comprehensive data relating the amount of sleep to the occurrence of adverse events and medical errors by medical trainees. Many of the existing data are based on self-reports. Since systems for reporting various types of adverse events and errors do not typically exist, the ability to relate sleep loss and fatigue to these outcomes is limited. Consequently, improved information systems for reporting adverse patient outcomes will be essential to assess potential relationships between such outcomes and trainee sleep and fatigue.

**AN AGENDA FOR CHANGE: GENERAL GOALS**

Each of the Work Groups identified general goals and specific recommendations to address the issues of sleep and fatigue in medical education. Because most of these were remarkably consistent, the following set of goals incorporates the items identified by each of the Work Groups.

1. Create learning environments that promote optimal performance and alertness among medical trainees. Accomplishing this goal will depend on education, research, and changes in the culture and structure of medical training.
2. Educate healthcare professionals, including physicians and physician trainees, to recognize the essential need for sleep in maintaining optimal health and performance. Additionally, the medical profession must increase awareness regarding the potential role of sleep loss as a source of stress, fatigue, and adverse health outcomes among trainees and as a potential cause of medical errors and adverse patient outcomes. Concurrently, it is important to increase awareness of sleep disorders among healthcare professionals.
3. Establish operational metrics to assess the effects of sleep loss and fatigue on key outcomes such as patient health and safety, education effectiveness, resident health and professionalism, and healthcare economics. Examples of such metrics are shown in Table 1.
4. Using these metrics, define the scope and consequences of problems related to resident work hours. Methodologies may include cross-sectional and longitudinal observational studies; surveys of trainees, attending physicians, patients, and other healthcare personnel; examination of trainees’ education records; medical chart reviews of patients and trainees; and qualitative studies on the working conditions and the care environment.
5. Identify testable linkages in the presumed line of causality between work schedules, sleep histories, resident performance, effectiveness of resident education programs, and health and safety outcomes for both patients and trainees. These studies would be designed to identify causal relationships and potential strategies for intervention.
6. Identify fatigue management interventions or countermeasures based on strategies proven to be effective in laboratory experiments and other industries. Until experimental intervention studies can be conducted, incentives should be provided for fatigue management initiatives within training programs. Barriers to the implementation of such programs should be identified.
7. Establish support to conduct research and to implement and enforce regulations regarding sleep and fatigue in medical training. This support would include funding for research studies, intervention programs, and enforcement of regulations, as well as infrastructure and systems-level support.
8. Work to change the culture of medicine to value sleep and appropriate work schedules through education and dissemination of empirical data.

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<th>Table 1—Important Metrics for Studying Sleep and Fatigue in Medical Education</th>
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<td><strong>Domain</strong></td>
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| **Standard definition of trainee work hours** | • Actual duty hours  
• Sleep and awake time  
• Work intensity  
• Moonlighting hours |
| **Patient outcomes** | • Length of stay  
• Medical errors  
• Medication errors  
• Complications  
• Iatrogenic disease  
• Satisfaction with care |
| **Education outcomes** | • Resident in-training exam scores  
• Board scores  
• Number of medical procedures performed  
• Education performance in relation to on-call schedules (e.g., post-call vs. no call) |
| **Trainee health outcomes** | • National registry of resident motor vehicle crashes and relevant covariates (e.g., work schedules, distance driven, time of day, work-related and non-work-related exposure measures)  
• Longitudinal database of resident health outcomes relative to an appropriate control group (e.g., dentist trainees)  
• Health outcomes from a variety of domains including mental health and substance use disorders, pregnancy, endocrine, cardiovascular, and neurologic diagnoses |
| **Trainee professional outcomes** | • Measures of doctor-patient relationships  
• Patient satisfaction surveys  
• Incidences of falling asleep on the job |
| **Economic outcomes** | • Costs associated with sleep loss and fatigue (e.g., fatigue-related medical errors)  
• Cost-benefit analyses of fatigue management programs  
• Hospital costs  
• Patient care costs  
• Direct and indirect costs |

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SPECIFIC RECOMMENDATIONS

Most of the specific recommendations generated by the work groups can be broadly conceptualized as either gathering additional data to evaluate the scope of the problem or educating various constituencies about this data. Specific short-term recommendations over the next 6 to 12 months focus on gathering additional information, disseminating this information, and refining research and education priorities (Table 2). Data regarding the general relationships between sleep, sleep loss, circadian rhythms, and performance are sufficiently robust to warrant immediate dissemination to medical trainees and training directors. These data, together with the specific recommendations in Table 2, would lay the groundwork for subsequent more definitive actions.

Intermediate-term recommendations for the subsequent 12 to 24 months include gathering more rigorous empirical data and developing targeted intervention programs to mitigate the effects of sleep loss and fatigue. These steps will depend on continued cooperation between groups and organizations representing different stakeholders in medical education. Specific intermediate steps are described in Table 3.

Long-term recommendations for the next 2 to 5 years are intended to consolidate information collected in the short and intermediate term, help to develop evidence-based strategies for managing sleep loss and fatigue, and integrate new information regarding sleep and fatigue into the culture of medicine. Specific recommendations are described in Table 4.

KEY STAKEHOLDERS

Developing strategies to address sleep and fatigue in medical education will require the shared responsibility and coordinated efforts of numerous stakeholders, including individuals and groups involved in research, education, healthcare delivery, and policy making. Such a broad range of issues will involve academic medical centers, hospital management, federal and state governmental agencies, and private and professional organizations. Organizations that are likely to play key roles in developing a plan for change are listed in Table 5.

SUMMARY

The difficult issues surrounding discussions of sleep, fatigue, and medical education stem from an ironic biologic truth: physicians share a common physiology with their patients, a physiology that includes an absolute need for sleep and endogenous circadian rhythms governing alertness and performance. We cannot ignore the fact that patients become ill and require medical care at all times of the day and night, but we also cannot escape the fact that providing such care requires that medical professionals, including medical trainees, be awake and func-

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Table 2—Short-Term Recommendations (6 to 12 Months)

1. Convene an expert panel to comprehensively summarize what is known and what is not known regarding sleep and fatigue in medical training. This panel would include diverse groups and would focus exclusively on medical training issues. It would also identify critical gaps in research data and potential high-impact studies. This panel would focus more exclusively on empirical data than did the conference of October, 2001.
2. Obtain cross-sectional data on actual resident work schedules using objective techniques and common definitions. This information would provide baseline data and permit cross-sectional analyses relating work schedules to education and health outcomes.
3. Perform a retrospective study of department of motor vehicles data bases on crash rates in house officers and a relevant control group.
4. Hold local and national meetings for medical trainees to focus on awareness and education regarding sleep and fatigue in the work and learning environment. In collaboration with sleep researchers, develop education strategies to enhance learning in this area.
5. Disseminate existing information about the relationships between sleep loss, fatigue, performance, and their implications for patient safety to medical trainees, physicians, residency training directors, medical school administrators, other healthcare professionals, hospitals and hospital administrators, and patient groups.
6. Establish common definitions and refine research and education priorities related to the potential patient safety consequences of sleep loss and fatigue in medical trainees.

Table 3—Intermediate-Term Recommendations (12 to 24 Months)

1. Develop a research plan to systematically examine the relationships between sleep, sleep loss, and fatigue in medical trainees and patient outcomes and trainee health outcomes. Initial investigations of the efficacy of countermeasure strategies might be part of this plan.
2. Establish a prospective national database registry of motor vehicle crashes by medical trainees.
3. Begin to incorporate fatigue management requirements and guidelines into ACGME general competencies (systems, professionalism, practice-based learning and improvement).
4. Develop an effective and valuable fatigue management education program for residency training. This program should be broadly applicable across specialties and should emphasize the essential role of sleep in maintaining health and performance. Potential resources could include educational videotapes, printed or electronic materials, educational interventions for individuals involved in medical training, and assessment of the physical environment related to sleep (e.g., on-call facilities).
5. Foster local institutional initiatives in “best practices in fatigue management” and a computerized regularly updated database of “best practices” regarding alertness management strategies.
6. Create mechanisms for public disclosure of residency programs not in compliance with RRC regulations.

Table 4—Long-Term Recommendations (2 to 5 Years)

1. Disseminate the results of early and intermediate intervention studies via publications, workshops, and training programs.
2. Develop and implement intervention and countermeasure studies to manage fatigue and sleep loss in medical trainees.
3. Assess the common features and generalizability of fatigue management programs with demonstrated positive short-term outcomes in medical training.
4. Evaluate the long-term outcomes of specific education programs and interventions on sleep and fatigue management.
5. Modify education programs for medical trainees to reflect knowledge about the relationship of sleep loss and fatigue to performance. Trainees should be taught appropriate use of countermeasures to fatigue and the limits of these strategies. Enhance learning on sleep and fatigue issues through the effective use of educational technology, timing of interventions, and outcomes research.
6. Develop strategies to raise general public awareness regarding the role of medical students and residents in the healthcare delivery system and the potential impact of sleep loss and fatigue.
7. Develop collaborative, multigroup advocacy to ensure the financial health of institutions that provide medical education. Such efforts may be needed to offset potential increases in the cost of medical training that could result from work-hour regulations.
8. Develop a culture of mutual responsibility for reducing errors and improving patient safety in training institutions, recognizing the potential role of fatigue and sleep loss. Quality improvement and reporting of medical errors should be based on standard definitions and should focus on bringing about positive change, rather than assigning blame.

Table 5—Key Organizations for Addressing Sleep and Fatigue in Medical Education and Promoting Change

- Department of Health and Human Services (DHHS), encompassing the National Institutes of Health (NIH), including the National Center on Sleep Disorders Research (NCSDR) within the National Heart, Lung, and Blood Institute; the Agency for Healthcare Research and Quality (AHRQ); and the Centers for Disease Control (CDC), including the National Institute for Occupational Safety and Health (NIOSH).
- Professional organizations with specific interests in sleep research, including the American Academy of Sleep Medicine (AASM) and the Sleep Research Society (SRS).
- The Accreditation Council on Graduate Medical Education (ACGME) and its Residency Review Committees (RRCs).
- Association of American Medical Colleges (AAMC), the American Medical Association (AMA), and their joint Liaison Committee on Medical Education (LCME).
- Specialty boards, such as those comprising the American Board of Medical Specialties (ABMS).
- Residency training program directors and their professional organizations.
- Medical student, resident, and faculty organizations, including the American Medical Student Association (AMSA) and the Committee on Interns and Residents (CIR).
- Hospital administrators and their professional organizations, such as the American Hospital Association (AHA) and the Association of AcademicHealth Centers.
- Medical insurance companies and risk management organizations.
- Patient and patient safety advocacy groups.
- Federal and state governments, including legislatures and other agencies such as the Occupational Safety and Health Administration (OSHA), Department of Labor.
tioning at times that are in conflict with their endogenous sleep and circadian physiology. Finally, we cannot avoid the reality that medical education requires long hours in a constrained number of years.

Solutions to the problem of sleep and fatigue in medical education will require the active involvement of numerous parties, ranging from trainees themselves to training program directors, hospital administrators, sleep and circadian scientists, and government funding and regulatory agencies. Each of these parties can be informed by previous laboratory and field studies in a variety of operational settings, including medical environments. Education regarding the known effects of sleep, circadian rhythms, and sleep deprivation can help to elevate the general level of discourse and point to potential solutions. Empiric research addressing the effects of sleep loss on patient safety, education outcomes, and resident health is urgently needed; equally important are the development and assessment of innovative countermeasures to maximize performance and learning. Addressing the economic realities of any changes in resident work hours is an essential component of any discussion of these issues. Finally, work-hour regulations may serve as one component of improved sleep and circadian health for medical trainees, but they should not be seen as substitutes for more original solutions that rely less on enforcement and more on collaboration.

By working together to address the problems of sleep and fatigue in its own trainees, the medical field can provide a valuable legacy to patients and to future generations of healthcare providers—a legacy of optimal medical education, healthy doctors, and healthy patients.

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