

*Sleep, Alertness, and Fatigue Education in Residency  
(SAFER) Program*

**Speaker's Guide  
2006 Revision**

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## **Introduction**

Acute and chronic sleep loss, whether partial or complete, substantially impairs physical, cognitive, and emotional functioning in human beings. In addition, the influence of circadian physiology dictates both that wakefulness and alertness are for the most part at optimal levels during daylight hours, and that sleepiness is maximized during the night. Failure to adhere to this need for both appropriately-timed and adequate amounts of sleep results in an increase in sleepiness and fatigue levels and a decline in waking function that are likely to be particularly relevant to performance of daily tasks in the context of occupational settings.

Modern society expects performance and productivity on a 24-hour basis. This need for round-the-clock operations in many spheres, including healthcare, often assumes precedence over the basic physiologic principles governing sleep and wakefulness. In particular, the long continuous shifts, reduced opportunities for sleep, and minimal recuperation time traditionally experienced by medical students and house staff during training, and frequently by physicians in practice as well, impact their work, their health and well-being, and the quality of their educational experience.

In response to such concerns, the ACGME in 2001 charged its Work Group on Resident Duty Hours and the Learning Environment with developing a set of recommendations regarding common requirements for resident duty hours across accredited programs in all medical specialties. These recommendations include an 80-hour work week, continuous duty hours limited to 24 hours, and one day in seven free of patient duties. Every residency program in the United States was required to implement these recommendations by July 1, 2003. The overriding goal of these recommendations was to create the opportunity for medical trainees to experience adequate rest, and enable them to perform and learn at their optimal level on a consistent basis.

## **The Need for Education**

Work hour regulations are necessary but not sufficient to achieve this goal. Education regarding the antecedents and consequences of sleep loss and fatigue and alertness management strategies forms the necessary foundation for any sleep loss and fatigue management strategies, including work hour regulations, and must be part of any comprehensive and integrated approach to this issue:

- Education is necessary to effect any substantial and sustained behavioral change on the individual level (i.e., the individual needs to understand the rationale for the changes in order to “buy into” them, and also to accept personal responsibility for instituting them).
- Education is often the only vehicle for producing changes in lifestyle or personal behaviors that impact fatigue and alertness, as these behaviors are not likely to be amenable to external regulation (like amounts of baseline and recovery sleep obtained by residents on non-call nights, and moonlighting practices).

- Education is a critical part of causing change at the social dynamic level, where one of the most powerful identified barriers to adherence to work hour regulations is the “culture” of the medical workplace. This culture implies that physicians need to “learn” how to manage without sleep.
- Education is necessary at the pragmatic level, where system-wide changes need to support and complement the changes in individuals (i.e., the hospital should provide adequate call room space for napping).

The ACGME work hour guidelines call for “education of faculty and residents in recognizing the signs of fatigue” and “applying operational countermeasures,” and mandate the inclusion of sleep education in all residency programs. Unfortunately, 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. Furthermore, the guidelines clearly state that monitoring of work hours within institutions must not be the only outcome measured, and refers to the need to monitor such parameters as “the physical and emotional well-being of residents,” “the effects of sleep loss and fatigue,” and “effect on performance.” Many residency programs and program directors do not have expertise in sleep medicine or access to extensive educational resources, and are likely to need assistance on employing these parameters operationally, evaluating or monitoring them, and making “adjustments” or interventions to achieve the required goals. This perceived educational need provided the impetus for the development of the SAFER sleep education curriculum program.

### **SAFER Educational Goals**

The goal of the SAFER program is to increase knowledge and awareness about sleep and fatigue among medical students and residents, and to help create a learning environment that maintains optimal performance and alertness. The first specific objective in achieving that goal was to develop the following educational curriculum module for medical professionals on sleep, fatigue, and alertness management, and to make it available to every residency program in the country. The module was designed to be easily adaptable to a variety of target audiences, including medical students, residents, residency directors, hospital administrators, and support staff such as allied health care professionals. The SAFER curriculum was developed by a task force of individuals with diverse backgrounds and expertise in sleep medicine, medical education, curriculum development, and residency training programs. The task force was headed by members of the AASM Board and AASM Medical School Education Committee, as well as resident representatives, and representatives from ACGME and the AMA. The SAFER program stresses the importance of supporting balanced, evidence-based, and socially responsible policies regarding sleep, sleep loss and fatigue in medical education settings. The SAFER program also provides standardized and empirically-based information, including strategies that have already been developed in other industries facing similar needs (e.g., transportation and aeronautics).

### **SAFER Curriculum Content**

The basic content areas of the SAFER curriculum include:

- Principles of sleep and chronobiology
- The impact of sleep loss and fatigue on medical trainees (mood, health and safety, work performance, medical education, medical errors)
- Myths and misconceptions about sleep loss and fatigue
- A framework for developing strategies at the systems levels and at the individual level for addressing and managing sleep loss and fatigue

The 50-minute PowerPoint presentation is designed to be given by non-sleep as well as sleep medicine faculty to a variety of target audiences, and to present an educational overview of the issues that are accessible and pragmatic. Most of the key educational points are contained in the content of the slides themselves; this accompanying Speaker's Guide was developed to provide users with the empirical basis for the slide presentation content, and to supplement the information contained therein. The syllabus also contains a pre- and post-test evaluation tool for assessment of educational goals and objectives.

The 2006 version includes several new studies that were published since the original SAFER. These studies reinforce the importance of sleep education for residents and include the results of initial assessments of the effects of resident work hour restrictions. Further modifications of SAFER were made in response to feedback from users and sleep specialists in order to clarify confusing slides and focus the message in the Speaker's Guide.

Slides are designated as Level I or Level 2. Level I slides identify key topics and provide information appropriate for a one-hour presentation to health care professionals. Level 2 slides (identified in these notes) include greater detail -- study outcomes, illustrations, graphs or areas of controversy -- and are intended for a more advanced audience.

## Slide Presentation

### SLIDE 1: Contact Information

The SAFER program was developed by a task force of the American Academy of Sleep Medicine, Address: One Westbrook Corporate Center, Ste. 920, Westchester, IL 60154. Telephone: (708) 492-0930; Fax: (708) 492-0943; Web site: [www.aasmnet.org](http://www.aasmnet.org). Please direct comments and questions to Richard S. Rosenberg, PhD, Director of Professional Education and Training at [rosenberg@aasmnet.org](mailto:rosenberg@aasmnet.org).

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### SLIDE 2: Learning Objectives

At the conclusion of the presentation, participants should be able to:

- 1) List specific factors relevant to the medical setting that put physicians at risk for sleepiness and fatigue
  - 2) Describe the impact of sleep loss on residents' personal and professional lives, including performance of work-related tasks, health and safety of medical trainees, medical education, and medical errors
  - 3) Recognize the common (and frequently overlooked) signs of sleepiness and fatigue in themselves and others
  - 4) Recognize and challenge the most common misconceptions among physicians about sleep and sleep loss, and understand the empirical basis for the counter arguments to these misconceptions
  - 5) Use and adapt the information presented in the curriculum including fatigue countermeasures such as napping and strategic caffeine use, optimal sleep health behaviors and other information to develop individualized alertness management strategies
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### SLIDE 3: The Scope of the Problem

The scope of the problem of sleep loss and fatigue in residency training is illustrated in this and other quotes throughout the presentation from a national focus group study of residents' perspectives on sleep deprivation.<sup>1</sup> The study was conducted at five medical schools across the country, and included 149 residents at all levels of training and from a number of specialties (internal medicine, pediatrics, surgery, emergency medicine, family practice, and obstetrics and gynecology) speaking about their own and colleagues' experiences with sleep loss and the impact of sleepiness and fatigue on themselves, their work, and their patients.

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### SLIDE 4: Sleepiness in Residents

Residents report sleepiness tendencies that are equivalent to those found in some clinical populations of patients with sleep apnea or narcolepsy. Shown are data representing mean values for the Epworth Sleepiness Scale (ESS) for normal subjects and patients with a variety of sleep disorders (insomnia, sleep apnea, and narcolepsy) studied at the Louis Stokes DVA Medical Center<sup>2</sup>, compared with data reporting ESS values obtained in a multi-center survey of medical residents.<sup>1</sup>

The Epworth Sleepiness Scale is an eight-item self report that asks respondents to rate their likelihood of “dozing” under several specified conditions. The individual rates each situation from 0 - 3, with 3 indicating the highest likelihood. The highest possible score is 24. The generally accepted value for the upper limit of “normal” is 11. Values between 11 and 13 are considered mild sleepiness, 14 and 17 moderate sleepiness and over 17 severe sleepiness.<sup>3,4</sup>

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## **SLIDE 5: Sleep Loss and Fatigue – Addressing the Issue**

There is considerable empirical evidence to support the conclusion that experimental sleep deprivation has negative effects on neurobehavioral performance (sustained attention, reaction time, vigilance, etc) and cognitive performance (memory, reasoning, etc) in humans.<sup>5</sup> Although other occupations (transportation, aviation, military operations) have moved forward in developing and implementing strategies to address work-related fatigue<sup>6, 7</sup>, the health care profession has been slow to acknowledge and address the substantial impact of sleep loss and fatigue on safety and quality of health care delivery. There are a number of reasons for this relative lack of response, which include concerns about quality of patient care<sup>8, 9</sup>, professionalism, and medical education, as well as political and financial considerations.<sup>10, 11</sup>

There is no drug test for sleepiness. Despite ongoing investigations regarding the development of practical measures of physiologic sleepiness (analogous to the "breathalyzer" test to assess blood alcohol concentration), the current gold standard remains the Multiple Sleep Latency Test (MSLT), a series of five 20 minute nap opportunities in which the time to onset of EEG-documented sleep is measured.

Most programs do not recognize or address the problem of resident sleepiness. The "culture" of medicine often equates the number of hours on the job and without sleep with professionalism and dedication to patient care.<sup>12</sup>

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## **SLIDE 6: Cultural Norms and Sleep Need**

The "culture" of medicine often equates professionalism, or "service above self," with long work hours. Further, the perception is that those who sleep on call or go home in a timely manner to sleep must have an easy workload; those who stay awake must have the harder tasks and be more dedicated residents.<sup>12</sup> Rarely is it mentioned that having rested, alert physicians may allow for better patient care, improved resident education, and more efficient accomplishment of tasks.

Empirical data from both survey and clinical outcome studies strongly suggest that, in general, physician education regarding basic sleep and circadian biology as well as the recognition, diagnosis, management, and prevention of clinical sleep disorders is inadequate. Substantial knowledge deficits exist at the medical school level, as well as at the post-graduate training and continuing medical education levels.<sup>13, 14</sup> The presence of large gaps between scientific knowledge and clinical teaching and practice has important public health implications. For example, it is known that physicians outside of sleep medicine significantly under-diagnose or misdiagnose sleep disorders — despite the high prevalence of these disorders — leading to increased morbidity and decreased quality of life.

Modifying the culture of training and medicine as a whole to include healthy sleep habits requires good role modeling by attendings, a supportive environment and schedule, reinforcement of positive behaviors, and recognition that reshaping notions of dedication that are deeply ingrained throughout a 24/7, on-the-go society will take time and effort.

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## **SLIDE 7: What Causes Sleepiness?**

One explanation of sleepiness is the "two process" model, which incorporates sleepiness as the result of prolonged wakefulness (homeostatic process) and circadian rhythms.<sup>15</sup>

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## **SLIDE 8: Physiologic Factors that Cause Sleepiness – Myths and Facts**

Wakefulness and sleep are highly regulated states. They are primarily governed by a balance of homeostatic drive for sleep and circadian influences on alertness, and influenced to a degree by the interaction of external and internal stimuli.<sup>16</sup> Optimal mental performance requires a combination of adequate sleep and circadian wakefulness.<sup>17</sup> When adults obtain less than five hours of sleep per night, the homeostatic drive to sleep raises sharply, which results in an increased propensity to sleep<sup>18</sup> and a decline in cognitive performance. This may be manifested as falling asleep in inappropriate places, such as in noon conference. In other words, it is lack of sleep (not room temperature, a large lunch, a boring lecture, dim light, etc) that causes sleepiness.

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## SLIDE 9: Conceptual Framework

Excessive daytime sleepiness (EDS) may be due to a variety of factors that may occur independently or in combination. These include insufficient sleep, fragmented sleep, underlying circadian rhythm abnormalities, and primary sleep disorders. An insufficient *quantity* of sleep results from an individual getting less sleep than is needed to be optimally rested, which in most cases is about eight hours a night. This is probably the most common reason for sleepiness in medical training. Sleep may be of adequate duration, but still result in daytime sleepiness if disrupted or poor *quality* sleep; fragmented sleep in residents during call nights may be caused by interruptions from repeated phone calls, pagers going off, attending to patients on the floor, and emergency room consultations, as well as even the *anticipation* of being interrupted during opportunities to sleep. Circadian rhythm disruptions result from a mismatch between environmental demands on the individual and endogenous circadian sleep wake rhythms (working night shifts). Finally, primary sleep disorders such as obstructive sleep apnea, narcolepsy, and insomnia are an important cause of excessive daytime sleepiness.

Like all adults, both residents and physicians in practice may experience a variety of primary sleep disorders, which may compound the effects of work-related inadequate and/or fragmented sleep. These disorders include obstructive sleep apnea, restless legs syndrome, periodic limb movement disorder, learned or “conditioned” insomnia and medication-induced insomnia.<sup>19</sup>

- **Obstructive Sleep Apnea (OSA)**

OSA is a common condition in which the upper airway closes repeatedly during sleep. Affected patients typically stop breathing for 10 to 30 seconds, and sometimes longer, until a brief arousal allows them to open their airway, resume breathing, and fall back asleep, only to repeat the same cycle. The most important risk factors for OSA in adults are obesity and male gender. Untreated, obstructive sleep apnea may lead to high blood pressure, stroke, heart attack, and shorter life span. However, one of the most common shorter-term effects is excessive daytime sleepiness. Once identified, OSA can be successfully treated in most instances. The most common form of treatment in adults is continuous positive airway pressure, or CPAP.

- **Restless legs syndrome (RLS) and periodic limb movement disorder (PLMD)**

Restless leg syndrome has four cardinal symptoms: uncomfortable sensations in the legs; motor restlessness; worsening episodes during the night; and improvement of the symptoms with leg movements. These symptoms may cause sleep onset insomnia as well as frequent arousals during the night, leading to significant daytime sleepiness. About 10% of the adult population is thought to have RLS, but most go undiagnosed. Risk factors include pregnancy, iron deficiency anemia and low ferritin levels. Periodic limb movements (PLMs) are continuous and repetitive leg jerks lasting a few seconds, typically occurring every 20 to 40 seconds and sometimes resulting in arousals or awakenings. Most patients with RLS also have PLMs. Bed partners of patients with restless leg syndrome and periodic limb movements frequently bring this problem to the attention of the clinician.

- **Insomnia (primary and medication-induced)**

Although most residents complain that they fall asleep *too* easily and at inopportune times, insomnia can also be a problem. Insomnia, which is a symptom and not a diagnosis, is defined as difficulty initiating sleep, difficulty maintaining sleep (frequent awakenings during the night), awakening too early, and/or unsatisfactory sleep quality. The duration and time course of insomnia can range from transient (a few days) and situational (stress-related) to continuous and chronic (weeks to months to years). Some of the wide ranges of causal factors that may be involved include poor sleep hygiene, stress, anxiety, depression, and use of certain medications. Effective treatment strategies may include addressing any underlying psychiatric or medical problems, sleep hygiene measures (good sleep habits; see Slides 56 and 57), cognitive-behavioral therapy, psychotherapy, and short-term or intermittent use of short-acting hypnotic medications.

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## **SLIDE 10: Sleep Needed vs. Sleep Obtained**

Individuals may have differences in their optimal sleep requirements. Most sleep experts agree that the adult sleep requirement is typically between six to 10 hours of sleep per 24-hour period, with the majority of individuals requiring approximately eight hours of sleep per day. When adults get less than five hours of sleep over a 24-hour period, peak mental abilities begin to decline. Although in experimental settings adults who get four hours of sleep can function reasonably well for short periods of time (two to three days), performance of tasks requiring sustained attention is still clearly sub-optimal, even in the short run.

If an individual experiences restricted sleep for just a few days, the result is significantly slower response times. After one night of missed sleep, cognitive performance may decrease as much as 25% from baseline; after the second night of missed sleep, cognitive performance can fall to nearly 40% of baseline. Furthermore, any discrepancy between the amount of sleep needed by an individual and the amount of sleep actually obtained, even for one night, begins to build up a “sleep debt.” This sleep debt continues to accumulate over time until adequate recovery sleep is obtained. Sleep debt leads to slower response times, altered mood and motivation, and reduced morale and initiative.<sup>20-22</sup> Sleep need is under genetic control<sup>23</sup> and therefore cannot be adjusted or reduced without consequences.

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## **SLIDE 11: Sleep Deprivation Decreases Attention**

With decreased sleep, higher-order cognitive tasks are affected early and disproportionately. Tests requiring both speed and accuracy demonstrate considerably slowed speed before accuracy begins to fail. A dose response experiment measuring waking neurobehavioral and sleep physiological functions during chronic sleep restriction is very revealing.<sup>22</sup> The results demonstrate that chronic restriction of sleep to six hours or less per night produced cognitive deficits equivalent to up to two nights of total sleep deprivation.<sup>22</sup> The experiment further reveals that even relatively moderate sleep restriction can have detrimental affects on waking neurobehavioral functions in healthy adults.

The data shown in this slide clearly demonstrates that sleep deprivation decreases attention. Four different neurobehavioral assays served to measure cognitive performance capability and subjective sleepiness. Each panel displays group averages for subjects in the eight hour (black line), six hour (light blue line) four hour (red line), and total sleep deprivation (yellow line) groups. Chronic sleep period conditions are shown at baseline (BL) and across 14 days. Data shows that chronic restriction of the nocturnal sleep period to either six hours or four hours per day for 14 days resulted in significant cumulative degradation of attention (more lapses) relative to the eight hour sleep period condition.

Decreased behavioral alertness, as measured by lapses of attention, is a dose-dependent, near-linear function of the number of days of sleep restriction.<sup>22</sup> This finding may indicate that the development of neurocognitive deficits over days of sleep restriction may be accounted for solely by cumulative sleep loss. This may further suggest that sleep debt is perhaps best understood as resulting in additional wakefulness that has a neurobiological “cost” that accumulates over time.

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## **SLIDE 12: Reducing the Impact of Sleep Loss**

Sleeping less than seven hours per day can result in a sleep deficit. It has been shown that chronic partial restriction of sleep of six hours or less per night produces cognitive performance deficits similar to that seen following total sleep deprivation.<sup>22</sup> Chronic loss of sleep has also been shown to have adverse effects on metabolic and endocrine function.<sup>24</sup> Therefore, it is important to get an adequate amount of sleep (seven to nine hours) per night for several days prior to anticipated sleep loss.<sup>25</sup>

However, a recent study of medical residents published in JAMA<sup>26</sup> suggested that even when residents are on “light” or no night call rotations and thus have more opportunity to sleep, they still report getting less than optimal sleep amounts (average 6.38 hours per night).

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### SLIDE 13: Adaptation to Sleep Loss

Many studies, including those cited above<sup>5, 18, 22</sup> and below<sup>27, 28</sup>, have clearly demonstrated that human beings do not simply adapt to a state of chronic sleep loss by "learning to function" on less than adequate amounts of sleep. For example, a recent study of medical residents found that post-call performance on a battery of neurocognitive tasks, including a driving simulator, was not significantly better in more senior residents compared to more junior ones.<sup>25</sup> The need for sleep is a biological imperative that must be obeyed at the risk of compromising cognitive functioning, memory, and efficiency and accuracy in performing tasks. Performance can be maintained under certain conditions of sleep loss but only for short periods of time and at sub-optimal levels, on certain types of tasks (shorter, less complex), and under the right circumstances (high level of motivation, powerful reinforcement).

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### SLIDE 14: Sleep Fragmentation Affects Sleep Quality

Slide 14 shows two hypnograms, which are graphic representations of sleep stages as a function of time of night.

The framework or architecture of sleep is based upon recognition of two distinct sleep stages: *REM sleep* (rapid eye movement sleep) and *non-REM sleep* (75 - 80% of sleep in healthy young adults). These stages are defined by distinct polysomnographic features of EEG patterns, eye movements, and muscle tone.

- **Non-REM sleep** may be viewed as a period of relatively low brain activity during which the regulatory capacity of the brain is actively ongoing and in which body movements are preserved. Non-REM sleep is further divided into:
  - *Stage 1* sleep (2 - 5% of total sleep time) occurs at the sleep-wake transition and is often referred to as "light sleep"
  - *Stage 2* sleep (45 - 55%) is characterized by bursts of rhythmic rapid EEG activity called sleep spindles (fluctuating episodes of fast activity) and high amplitude slow wave activity called K-complexes
  - *Stages 3 and 4* sleep (3 - 23%) is known as "deep" sleep, slow wave sleep, or delta sleep. The highest arousal threshold (most difficult to awaken) occurs during Stages 3 and 4 sleep. Delta sleep is generally considered the most restorative stage of sleep, and one which tends to be preserved if the total amount of sleep is restricted. The relative percentage of delta sleep is also increased during the recovery sleep that follows a period of sleep loss.
- **REM sleep** (20 - 25%; four to six episodes per night) is characterized by paralysis or nearly absent muscle tone (except for control of breathing), high levels of cortical activity (low-voltage, mixed-frequency EEG) that are associated with dreaming, irregular respiration and heart rate, and episodic bursts of phasic eye movements that are the hallmark of REM sleep.

Non-REM and REM sleep alternate throughout the night in cycles of about 90 to 110 minutes. Brief arousals normally followed by a rapid return to sleep often occur at the end of each sleep cycle (four to six times per night). The relative proportion of REM and non-REM sleep per cycle changes across the night, such that slow wave sleep predominates in the first third of the night and REM sleep in the last third.

The top panel shows the sleep hypnogram of a normal sleeper. The Y axis depicts stages of sleep as the individual falls into deeper sleep proceeding from Wake into Stage 1 and 2 (light sleep), and Stage 3 and 4 (deep/slow wave sleep). The lower panel shows the sleep hypnogram of a typical resident on call. Sleep is very fragmented by frequent interruptions during the night. As a result, the resident does not obtain an adequate period of consolidated sleep, spends very little time in the restorative stages of sleep (Stages 3 and 4 and REM), and wakes up very sleepy just in time for morning rounds.

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## SLIDE 15: How the Circadian Clock Impacts You

Circadian rhythms, including the sleep wake rhythm, are intrinsic physiologic processes with a "free-running" cycle length of a little over 24 hours. In normal circumstances, circadian rhythms in the human organism are synchronized with and supported by the external environment, which makes it possible for the organism to better adapt to environmental demands.<sup>29</sup>

During some rotations in residency training and in individuals on a shift-work schedule, the sleep wake rhythm is inverted; thus, the individual has to be alert and functional during the period of intrinsic low circadian alertness, and needs to sleep during the day, when she is usually active and alert. In order to perform adequately, the shift worker has to adapt to such disruptions of the sleep wake pattern.

Because the internal periodicity of the human circadian clock is slightly longer than 24 hours, it is easier to stay up later (delay sleep) than to try to fall asleep earlier (advance sleep time). For the same reason, it is also easier to adapt to shifts that rotate in a forward (clockwise) direction (day/evening/night), just as it is easier to adjust to travel across time zones flying west than flying east.<sup>30</sup> "Night owls," who normally have a tendency to fall asleep and wake later ("eveningness"), may also find it easier to adapt to night shifts<sup>31</sup>, although most sleep experts agree that human beings in general never fully adjust to working night shifts.

A study which looked at the day-night pattern of occurrence of accidental blood-borne pathogen exposure incidents in medical students and residents found that reported exposures were 50% greater at night (60 incidents per 1000 trainees), indirectly suggesting additional potential effects of circadian rhythms on occupational safety.<sup>32</sup>

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## SLIDE 16: Physiologic Determinants of Sleepiness

Sleep and wakefulness are regulated by two basic, highly coupled processes operating simultaneously (the "two process" model). These are the *homeostatic process*<sup>15</sup>, which primarily regulates the length and depth of sleep, and endogenous *circadian rhythms* ("biological time clocks"), which influence the internal organization of sleep and timing and duration of daily sleep/wake cycles.<sup>29</sup>

The *circadian sleep rhythm* is modulated by the hypothalamus, in particular the suprachiasmatic nucleus (SCN). The SCN sets the biologic body clock to approximately 24 hours, with both light exposure and environmental and scheduling cues entraining or coupling this clock to the 24-hour cycle. Body temperature cycles are also under this circadian hypothalamic control. An increase in body temperature is seen during the course of the day and a decrease is observed during the night. People who are alert late in the evening (i.e., evening types or "night owls") have body temperature peaks late in the evening, while those who find themselves most alert early in the morning (i.e., morning types or "larks") have body temperature peaks early in the evening.

Melatonin has been implicated as a modulator of the effects of light exposure on the circadian sleep-wake cycle. Melatonin is secreted maximally during the night by the pineal gland. Prolactin, testosterone, and growth hormone also demonstrate circadian rhythms, with maximal secretion during the night. Many other physiologic functions, such as urine production and changes in blood pressure, are under circadian control and synchronized with the sleep-wake cycle.

Sleep *homeostatic drive* (sleep load) builds up during wake, reaching a maximum in the late evening (near usual sleep time). The circadian system facilitates awakening and through the day usually acts as a counterbalance to the progressive accumulation of sleep load. This model explains the ability to maintain wakefulness during the day and sleep during the night. Thus, the relative level of sleepiness or alertness existing at any given time during a 24 hour period is determined by the duration and quality of previous sleep, as well as time awake since the last sleep period, interacting with the 24 hour cyclic pattern or rhythm characterized by clock-dependent periods of maximum sleepiness ("*circadian troughs*") and maximum alertness ("*circadian peaks*").

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## **SLIDE 17: Consequences of Sleep Deprivation**

The consequences related to sleep loss and shift work in physicians in training, like those in any occupational setting, are potentially broad in scope and are likely to occur in a number of domains. They include:

- Personal and family consequences (mood disturbances, increased stress, adverse health consequences, negative effects on personal relationships, increased potential for alcohol and substance abuse, and increased risk of motor vehicle crashes)
- Negative effects on cognitive and neurobehavioral functioning (attention, reaction time, vigilance, memory, as well as motivation)
- Impact on the performance of professional duties (including procedures such as intravenous insertion, cognitive tasks such as electrocardiogram interpretation, and patient-related behavior such as communication skills)
- Implications for the quality of medical education (decreased retention of information, impaired information processing, and decreased motivation to learn)
- Impact on the quality of patient care and on commission of errors in the hospital setting, a particular concern in this era of increasing accountability in health care.

To date, there are over 50 studies in the literature on sleep loss and fatigue in medical training, including about 30 performance studies that have examined specific effects on a variety of different performance and performance-related measures. Outcome variables in these studies include: effects on neuro-cognitive and psychomotor functioning in the laboratory setting, effects on performance of simulated work-related tasks and of occupational tasks in actual work settings, and effects on mood and psychological state.

However, there are methodologic flaws in many of the studies, including small sample size, lack of objective or reliable recording of actual sleep amounts, and use of performance outcome measures which may not be sensitive enough or may not be of adequate duration to detect more subtle levels of impairment. Furthermore, the design of most of these studies involves comparisons between pre-call (“rested”) and post-call performance in groups of residents. Because the “rested” comparison residents were often in reality chronically sleep deprived, this can obscure an actual difference between baseline and post-call performance. Although it is difficult to compare studies because of the wide variation in methodology, several reviews have attempted to summarize the available data.<sup>33-37</sup> The following slides will illustrate some specific findings in various fields and across tasks.

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## **SLIDE 18: Impact on Professionalism**

In the focus group study cited above<sup>1</sup>, a surprising number of residents identified professionalism and task performance as problems related to sleep loss and fatigue. Professionalism included residents’ attitudes toward and interactions with patients and their families, objectification of patients, interactions with staff, loss of empathy, role resistance, and negative attitudes towards the profession. In the focus group study, residents described themselves as inattentive and emotionally unavailable in their relationships with patients, having difficulty listening to patients, and being much more ‘directed’ in their discussions with patients when sleep-deprived, as well as having less patience with families. Residents also noted that their compassion level decreased during post call clinic, when they were seeing less acutely ill but nevertheless demanding patients. Sleep loss appeared to contribute significantly to residents’ resentment of and disenchantment with the profession of medicine.

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## **SLIDE 19: Residents Averaging Less Than Five Hours of Sleep per Night**

In a national, random, multi-specialty survey conducted in 1999, 3,604 PGY1 and PGY2 residents (64.2% response rate) reported working an average of 79.4 hours per week and sleeping 41.1 hours per week, or slightly less than six hours per night. PGY1 residents averaged only 5.7 hours of nightly sleep. Work hours and sleep hours were negatively correlated ( $r = -.39$ ;  $p < 0.0001$ ). Nearly a quarter of the entire sample (22.2%) reported sleeping five hours or less per night, while over 66% of the residents averaged six hours or less.<sup>38, 39</sup>

Slide 19 shows that residents averaging five hours or less per night had elevated odds-ratios for a number of important variables affecting patient care and safety, as well as personal health. These included being named in a malpractice case, making a serious medical error, personally experiencing serious accidents or injuries, increased alcohol intake, notable weight change, taking medications to stay awake and to cope with the residency, having serious conflict with other residents, attendings, and nursing staff, and working while in an impaired condition.

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## **SLIDE 20: Average Hours of Sleep per Night Impacts Residency Experience**

### **LEVEL 2 SLIDE**

In the large, national multi-specialty survey referenced in Slide 19<sup>38</sup>, there was a dose response relationship between average hours of sleep per night and a number of other variables. Reported satisfaction with overall residency experience increased with increasing hours of sleep, whereas ratings of personal stress, reports of working while personally impaired, and experiences of being “belittled and humiliated” at work decreased with greater hours of sleep.

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## **SLIDE 21: Impact on Patient and Personal Health and Safety**

Sleep loss and fatigue not only have a profound effect on factors related to medical errors and patient safety, but also impact on the health and well-being of medical trainees. Medical errors may occur at any of multiple different steps in the diagnostic and treatment process, and often involve human factors in their genesis, such as inattention, poor communication, and fatigue. Given the fact that most of the studies cited above show some adverse effects of sleep loss and fatigue in medical trainees on neuro-cognitive 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.

There is also considerable evidence to support the link between acute and chronic, partial and complete sleep deprivation and a host of devastating consequences, ranging from effects on the cardiovascular and immune systems, to impairment in neurobehavioral domains, to functional impairment on the job and behind the wheel.<sup>24, 40, 41</sup>

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## **SLIDE 22: Resident Performance and Fatigue**

In 2005, a meta analysis was conducted to explore the effect of sleep loss on cognitive function, memory, and vigilance in resident physicians and non-physicians and on residents’ clinical performance.<sup>42</sup> The analysis included 60 studies on the effect of sleep deprivation, with a total sample of 959 physicians and over 1,028 non-physicians and 5,295 individual effect indexes.<sup>42</sup> The authors measured cognitive performance and performance on clinical tasks under acute and partial chronic sleep deprivation.

Data revealed that sleep deprivation of less than 30 hours reduced physicians’ overall performance by nearly one standard deviation and clinical performance by more than 1.5 standard deviations. Subjects demonstrated a decline in vigilance, memory and cognitive as well as clinical performance.<sup>42</sup> The results showed that the work schedule and continuous wakefulness permitted under national minimum standards for residents may not be sufficient to protect against the detrimental effects of sleep loss on cognitive and clinical performance.

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## **SLIDE 23: Resident Self-reported Errors by Average Daily Hours of Sleep**

In the national multi-specialty survey referenced previously<sup>38</sup>, the reported average work and sleep hour figures varied greatly by specialty. In general, residents in surgery and the surgical subspecialties reported the fewest hours of nightly sleep, with those in surgery averaging nearly two hours less per night than those in pathology. There was a significant correlation ( $p = 0.0001$ ) between residents’ reported sleep hours and their ratings of the frequency of personal experiences of prolonged sleep deprivation

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## **SLIDE 24: Sleep Deprivation and Errors in Detection of Cardiac Arrhythmias on ECG**

### **LEVEL 2 SLIDE**

Interns in this New England Journal of Medicine study<sup>43</sup> had significantly more errors in electrocardiogram reading after being sleep deprived. Of note, the “rested” interns still had an average of five errors. This could be attributed in part to the concept that in earlier studies of resident physicians, “rested” residents were in fact chronically sleep deprived and “sleep deprived” residents had an additional acute sleep deprivation (e.g. call). Some of the more recent sleep studies have made an effort to allow residents successive nights of adequate sleep to avoid this ‘chronic’ vs. ‘acute on chronic’ sleep deprivation comparison. Regardless, the study highlights that lack of sleep has a significant negative impact on performance.

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## **SLIDE 25: Impaired Speed and Errors in Performance: Laparoscopic Surgical Simulator**

### **LEVEL 2 SLIDE**

This prospective study<sup>44</sup> conducted in a gastroenterology unit assessed surgeons’ performance in laparoscopic skills after one night on call. The average amount of sleep the preceding night was 1.5 hours. Speed decreased and errors and unnecessary movements increased across various virtual laparoscopic tasks. Although the absolute differences were small (e.g., a few seconds or a few extra movements), they were significant and could amount to clinically important differences over the length of an entire surgery. Of note, the task with the most notable differences represents a combination of several virtual tasks and has been correlated with surgical performance *in vivo*.

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## **SLIDE 26: Residency Specific Data**

### **Results**

A number of studies have included outcome variables with “real world” medical task components, either simulated or actual work performance measures. The following studies illustrate that impairment in performance in residents occurs across specialties, settings, and tasks.

- **Surgery**

For example, two recent simulated laparoscopy studies found significantly more errors and more time to perform procedures such as tissue electrocoagulation with increasing sleep loss and on mornings post-call, even in experienced surgeons. There were 20% more errors and 14% more time was required to perform a simulated laparoscopy post-call<sup>45</sup>; Grantcharov’s group found a two-fold increase in errors, and a 38% increase in time required.<sup>44</sup>

- **Internal Medicine**

In another study that looked at the effect of training experience (first/second year residents vs. third/fourth), Lingenfelter examined the performance on a number of psychomotor tasks of residents in the “off-duty” state (at least six hours of sleep the previous night) and after 24 hours on call.<sup>46</sup> Efficiency and accuracy of performance on a simulated ECG task deteriorated post-call; there was no significant difference in performance between junior and senior residents, suggesting a lack of “adaptation” over time to the sleep-deprived state.

- **Pediatrics**

In a study of pediatric residents that included measurement of performance on both board-type questions and several simulated tasks including intubation, vein catheterization, and arterial catheterization, significant differences were found after 24 and 36 hours of continued wakefulness on efficiency of task performance.<sup>47</sup>

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## SLIDE 27: Residency Specific Data

- **Emergency Medicine**

Residents in emergency medicine are particularly vulnerable to the additional effects on performance of circadian rhythm disruption. For example, one study of ten randomly selected second-year residents demonstrated significant reductions in comprehensiveness of the clinical encounter as measured by the number of items documented on history and physical exam.<sup>48</sup>

- **Family Medicine**

A retrospective study of 353 family medicine residents found that scores achieved on the ABFM practice in-training exam were significantly negatively correlated with pre-test sleep amounts.<sup>49</sup>

In summary, similar to what has been found with performance on neurobehavioral tasks in the laboratory setting, simulated tasks dependent upon high and/or sustained levels of vigilance, those of longer duration, and those which involve newly learned procedural skills appear to be more vulnerable to the effects of short-term sleep loss in medical trainees. In addition, efficiency of performance on "real world" tasks is often sacrificed in favor of preserving accuracy, a factor which could have significant impact in situations that require both speed and precision (intubation of a critically-ill patient, for example). There is little evidence in these studies to support "adaptation" to or the development of increased tolerance for the effects of sleep loss over time in medical trainees.

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## SLIDE 28: Intern Sleep and Patient Safety Study

### LEVEL 2 SLIDE

Lockley and colleagues<sup>50</sup> studied a group of 20 interns under two conditions: a *traditional* schedule with 30 hour shifts scheduled every other shift and an *intervention* schedule in which shifts were limited to 16 hours. Sleep times were collected from sleep logs and, during ICU shifts, the logs were supplemented by continuous ambulatory polysomnographic recordings. Attentional failures were defined as periods of slow rolling eye movements intruding during wakefulness. Failures were documented in a subgroup of recordings from between 11 p.m. and 7 a.m. The number of attentional failures during the night in the traditional condition was more than twice the number of attentional failures in the intervention condition.

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## SLIDE 29: Intern Sleep and Patient Safety Study

Landrigan and colleagues<sup>51</sup> measured medical errors under the same two conditions as in the previous slide. Medical errors were determined by direct observation of interns and chart review, voluntary reports and computerized event-detection monitoring. Errors were categorized as including procedural, medication and diagnostic errors. The study included 2203 patient days, 634 admissions and 5888 hours of direct observation. Interns made 35.9% more serious errors during the traditional schedule than during the intervention schedule. The rate of diagnostic errors was 5.6 times higher in the traditional schedule than the intervention schedule.

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## SLIDE 30: Specialties Most Likely to Report Experiences of Sleep Deprivation

In the national, multi-specialty survey referenced previously<sup>38</sup>, an inverse dose response relationship ( $p > 0.0001$ ) was found between average hours of sleep per night and the percentages of residents reporting having made a significant medical error, as well as one which resulted in an adverse patient outcome. Figures for residents reporting averages of 4 hours or less sleep per night were over twice as high (45% for medical errors and 10.7% for adverse patient outcomes) as were those for residents who averaged 6 or more hours of sleep per night (22.4% and 3.85% respectively).

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### **SLIDE 31: Drowsy Driving: Effects of Sleep Deprivation on Physician Safety**

Sleep deprivation not only places patients at risk. Significant effects of prolonged shifts and sleep deprivation on automobile accident rates in physicians have been reported in several studies.<sup>52-56</sup>

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### **SLIDES 32 - 33: Harvard Work Hours, Health, and Safety Study**

One of the more dangerous consequences of sleep loss is a significant decrement in attention and reaction time that has been shown to have a measurable impact on operating a motor vehicle. Fall-asleep car crashes are a predictable consequence of sleep loss. Compared to sleeping eight hours or more, sleeping less than five hours increases the risk of involvement in a sleep-related versus a non sleep-related crash by 4.5 times. Furthermore, such crashes are more likely to result in serious injury or death than alcohol-related crashes, perhaps because there are fewer behavioral attempts made by the driver to avoid the imminent event.<sup>40, 54</sup>

Several retrospective self-report studies have examined the relationship between sleep loss and fatigue and traffic citations, motor vehicle crashes (MVC), and “near-miss” driving accidents. Studies which have looked at the issue have found prevalence rates for collisions as high as 8% and near-crashes up to 58% in emergency room physicians.<sup>56</sup> In this 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 found a significantly increased prevalence compared to faculty of falling asleep at the wheel either while driving or 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 accidents), with the vast majority of these incidents occurring post-call.<sup>55</sup> 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 as compared to prior to residency; furthermore, these collisions were associated with rotations with more frequent call and during which less sleep was routinely obtained.<sup>53</sup>

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### **SLIDES 34: Harvard Work Hours, Health, and Safety Study**

#### **LEVEL 2 SLIDE**

The Harvard Work Hours, Health and Safety Study report provides estimates of the increased risk of incidents as a result of prolonged work shifts. Using a web-based survey, Barger and colleagues<sup>52</sup> collected data from 2737 interns on documented motor vehicle crashes, near miss incidents and incidents involving involuntary sleeping. The frequency of incidents following extended shifts (more than 24 hours) was compared to the frequency of incidents following non-extended shifts (less than 24 hours). The odds ratio for reporting either type of incident after extended shifts was 2.3 compared to non-extended shifts (95% confidence interval 1.6 to 3.3). The risk of actual crashes was 9.1% higher after extended shifts (95% confidence interval 3.4 to 24.7%). In addition, the risk of falling asleep at the wheel or while stopped in traffic was significantly higher in months when interns worked five or more extended shifts.

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### **SLIDE 35: Driving Simulator**

The level of impairment seen with sleep deprivation may be compared to that seen with an easily-appreciated impaired state, i.e., alcohol intoxication. A recent study of medical residents compared their performance on a driving simulator under four conditions: a “rested” baseline (at the end of a light or no night call rotation), a sleep deprived condition (post-call day at the end of a heavy night call rotation) an “alcohol” condition (rested with a blood alcohol of .04 - .06) and a sleep deprived with alcohol placebo condition. Results for variability in performance in regards to deviation from the posted speed limit (speed variability) and deviation from the middle of the road (tracking variability) are shown here. In the sleep deprived conditions, residents’ performance was comparable to or worse than it was in the alcohol condition.<sup>25</sup>

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**SLIDE 36: Potential Legal Implications for House Staff and Hospitals****LEVEL 2 SLIDE**

Several states have either passed legislation or are considering legislation to criminalize driving while sleepy. In most cases proof of drowsiness consists of documentation of more than 24 hours of continuous wakefulness. Although this may be difficult to prove in many occupations, hospital documents might provide a convenient paper trail for prosecutors to follow. Interns and residents may not be the only group at risk when accidents occur after prolonged shifts. Several cases have held employers responsible for causing sleepiness as well, raising the possibility that hospitals will be held liable for resident's accidents. To this point, however, "vicarious liability" of hospitals has not been extended beyond errors committed by residents during the course of their work in the hospital.<sup>57</sup>

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**SLIDE 37: Recognize Signs of Driving While Drowsy**

There are a number of warning signs that indicate an increased risk for a drowsy driving accident. By the time these behaviors occur, however, the individual may have already been experiencing "microsleeps", the brief intrusions of the sleep state into wakefulness. These microsleeps, which often occur without any subjective awareness of the individual experiencing them, can have tragic consequences under certain circumstances, like driving or monitoring anesthesia (see Slides 42 – 44 for more information).

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**SLIDE 38: Risk Factors for Drowsy Driving**

Typically, drowsy driving crashes involve a single occupant driving off the road. The highest risk group for drowsy driving crashes is young (less than 25 years old) males. The risk of a drowsy driving crash is also significantly higher under conditions that increase drowsiness (medication, alcohol), or minimize environmental stimuli (highway driving for long periods). The relationship among circadian rhythms, homeostatic drive related to sleep loss, and driving performance also impact the timing of drowsy driving crashes; the graph on Slide 36 demonstrates that the most common times of day for fall asleep crashes are in the morning and in the mid afternoon, times when residents are most likely to be driving home post-call.<sup>40</sup>

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**SLIDE 39: Drowsy Driving: What Does and Does Not Work**

Specific countermeasure to mitigate (not eliminate!) the risks of driving home after a period of sleep loss are listed on Slide 37, as well as those that have not been shown to be effective but which are common behavioral reactions. The best countermeasure for sleep loss remains sleep. Many of these strategies require a cooperative effort among residents, program directors, and hospital administrators. For example, napping before driving home post-call can be greatly facilitated by both a stated endorsement from the residency director, and the provision of appropriate sleeping quarters by the hospital. Some programs have instituted operational measures such as an optional taxi service for residents who feel unsafe to drive home after work.

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**SLIDE 40: Impact on Medical Education**

This quote is from the focus group study cited in Slide 4.<sup>1</sup> An argument that has been traditionally 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 resulting in enhanced learning. Thus, the results of those few studies which have examined the impact of sleep loss on outcomes potentially related to medical education (decreased retention of information, impaired information processing, and decreased motivation to learn) are important to consider.

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#### **SLIDE 41: Increasing Sleep Time Improves Learning during Residency**

In the large, national multi-specialty survey referenced in Slide 19<sup>38</sup>, there was a dose response relationship between average hours of sleep per night and a number of variables related to learning during residency. Reported satisfaction with learning, amount of time with attending physicians, and rating of quality of time with attending physicians increased with increasing hours of sleep. By contrast, ratings of time working without adequate supervision declined as nightly sleep hours increased.

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#### **SLIDE 42: Impact on Medical Education: Myths and Facts**

Both medical students<sup>58</sup> and residents<sup>59</sup> have reported a negative correlation between long work hours and effective learning and use of skills. In those studies that have examined trainees' actual performance on educational tasks, the results are mixed in terms of finding differences in factual knowledge test scores pre- and post-call.

In a study of 34 surgery residents using sleep logs and monthly surveys of operative participation, every other night call was associated not only with increased levels of fatigue and stress and decreased overall satisfaction, but also with participation in *fewer* operative cases per month, compared to every third and every fourth night call schedules.<sup>60</sup>

In summary, studies suggest that residents may be able to compensate on tests of factual knowledge for the negative effects of sleep loss and fatigue and that they are appropriately confident about their performance. However, trainees' motivation to learn appears to be significantly impacted by inadequate sleep.

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#### **SLIDE 43: Bottom Line**

Self-perceived negative effects on mood, motivation, and life satisfaction as a result of chronic sleep loss are almost universally reported in medical trainees. Negative effects of sleep loss on mood in medical trainees is one of the most consistent findings in the literature on this topic, paralleling what is known about the effects of sleep deprivation in general. In one study of six emergency physicians which assessed sleep amounts (sleep logs and ambulatory EEG), mood states, and performance on two 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.<sup>61</sup> Residents also report that the negative psychological effects of sleep loss frequently take a toll on family life, and on their professional and personal relationships.

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#### **SLIDE 44: Recognizing Sleepiness in Yourself and Others**

What are the recognizable signs of sleepiness and fatigue? (Warning: this question is harder than you think!)

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#### **SLIDE 45: Estimating Sleepiness**

To put this very simply, there are two major influences on the physiologic tendencies towards sleepiness- time from last sleep period and the time of day. Circadian variations occur in the levels of alertness (see Slide 16), but both sleep deprivation and sleep restriction contribute towards sleepiness and alertness at any given time of the day. Partial sleep loss results in a cumulative increase in sleepiness by *objective* measurements. Ironically, *subjective* perception of sleepiness correlates much less reliably with these objective measures. Thus, over time, a mismatch develops between the increasing degree of sleepiness and the individual's perception of being sleepy, resulting in a tendency to underestimate subjective sleepiness. Furthermore, not only is subjective self-evaluation of sleepiness in general poor, but the ability to detect actual sleep onset in sleep-deprived individuals is often compromised.

These principles are illustrated by a recent study of anesthesia residents<sup>11</sup>, in which daytime sleepiness was measured using the Multiple Sleep Latency Test (MSLT) in three conditions. The MSLT is a standardized, validated physiological measure of sleepiness that assesses the time to fall asleep while lying in a quiet, dark bedroom at repeated

two hour intervals throughout the day. In the baseline condition subjects had no call period with 48 hours and were rotating on general operating room rotations. In the post-call condition, the subjects were working on difficult rotations (ICU or obstetric anesthesia) and were studied the day after call. In the sleep extended condition, subjects had four consecutive days off and reported to work at 10:00 a.m. Subjects in the sleep extended condition averaged two hours more sleep per day than they did in the baseline condition.

Sleepiness levels (measured by the MSLT) in the baseline and post-call conditions were not statistically different and were at the level of pathologic daytime sleepiness seen in patients with sleep apnea or narcolepsy. Allowing for four days of sleep extension normalized levels of daytime sleepiness – supporting sleep as the ultimate countermeasure. When the residents in this study were asked whether or not they had fallen asleep or remained awake during formal testing in a sleep laboratory, self perception of whether they had remained awake or had fallen asleep was no better than chance. This is important in considering the operational consequences of "feeling fit for duty" (or driving home) when the opposite might be true.

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#### **SLIDE 46: Microsleeps**

Microsleeps (also known as “lapses,” “blocks,” “gaps” or “delayed actions”) are unintentional episodes of loss of attention and are used to define very short periods of sleep, typically between 5-to-14 seconds in duration.<sup>62</sup> Microsleeps are associated with a marked reduction in behavioral responsiveness following prolonged loss of sleep.<sup>63</sup> The underlying pathophysiology of microsleeps is believed to be due to phasic interruption of the capacity of the brainstem, and possibly other cortical structures to which they are allied, to maintain arousal.<sup>64</sup> The electrographic hallmark of this inattention is the appearance of bursts of high voltage slow wave activity (more characteristic of deep sleep) in cortical areas.<sup>64</sup> The term microsleep has been used in the transportation industry to characterize short sleep episodes which can impact driving performance and lead to accidents. They are good indicators of excessive daytime sleepiness and have been associated with poor simulated driving performance.<sup>65</sup>

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#### **SLIDE 47: The Effects of Sleep Loss are Cumulative**

Dinges and colleagues<sup>28</sup> studied the effects of sleep restriction to five hours per night on mood and performance variables, including measures of alertness, fatigue, mood disturbance and stress. Lapses on a psychomotor vigilance task (presumed to be associated with microsleeps) showed an immediate and persistent increase with sleep deprivation and continued to worsen over the seven days of the study. A single recovery night was not sufficient to restore baseline performance.

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#### **SLIDE 48: Impact of Continued Wakefulness**

Studies of sleep-restricted healthy adults have shown that deficits in attention and vigilance begin to occur after 15 to 16 hours of continued wakefulness. The interaction of the homeostatic drive to sleep after being awake for a prolonged period and the normal circadian dip in alertness that occurs in the early morning hours conspire to make the morning after a night on call a particularly vulnerable period for the effects of sleepiness (i.e., medical errors or automobile accidents).

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#### **SLIDE 49: Recognize the Warning Signs of Sleepiness**

As noted above (Slide 8), sleepiness is physiologically dependent upon previous quantity or quality of sleep and the circadian rhythm of sleep, but may be unmasked by reductions in environmental noise, light, and social engagement. A person with a moderate to severe sleep debt may fall asleep even while rating themselves quite alert. Other neurophysiologic phenomena accompanying sleep loss includes microsleeps (brief intrusions of EEG indications of sleep into the awake state) and inattention, resulting in forgetfulness and difficulty in staying on-task. These events may not be perceived by the individual as being asleep or recognized as resulting from sleepiness.<sup>66</sup>

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## SLIDE 50: Alertness Management Strategies

Given the inevitability of some degree of sleep loss and fatigue in the course of medical training, work hour regulations notwithstanding, developing strategies to combat the effects of sleepiness is paramount. There is both anecdotal and empirical evidence to suggest that operational or system changes such as limits on work hours in and of themselves do not guarantee well-rested and optimally-functioning residents. There are likely to be a number of reasons for this observation.<sup>67</sup> First, it is clear from the experience with instituting work hour regulations in New York State that system changes may be very difficult to implement and maintain. Second, work hour regulations and other system changes cannot by definition govern residents' behavior outside of the workplace (e.g., "moonlighting" activities) or establish their personal priorities regarding adequate sleep, and thus cannot ensure that residents are adequately rested. Finally, it should be pointed out that many of the proposed operational changes themselves have limited or no empirical support. For example, there are no studies in any occupational settings which suggest that an 80-hour work week provides adequate opportunity for rest and recovery; furthermore, this number is well above that stipulated in federal regulations for the aviation and trucking industries where much of the research on work hours and fatigue has been conducted.<sup>68</sup>

In summary, operational changes such as limitations on resident work hours, scheduling adjustments, and provision of "protected time" for sleep are necessary but unlikely to be sufficient to assure optimal levels of alertness in medical trainees, partially because of difficulties in implementation of and adherence to systems-based measures.

The use of personal strategies or countermeasures (such as napping and strategic caffeine consumption) to address sleep loss and fatigue has been extensively studied in other occupational settings, although only a handful of studies have addressed the issue of countermeasure strategies in medical trainees. One review article<sup>69</sup> examined the impact of shift work in emergency medicine and proposed the use of both operational and personal strategies to optimize alertness, including rotation schedule designs based on chronobiologic principles, use of regular exercise, exposure to light on and off the job, and sleep strategies such as anchor sleep, split sleep periods and planned napping.

There are several key concepts to keep in mind regarding the development of individual strategies to manage fatigue in the medical setting. All strategies should be evidence-based and include a range of options as outlined in the next slides; there is neither a "one-size-fits-all" approach nor a single "magic bullet" solution that works for everyone. Because sleep needs, tolerance to sleep loss, and non work-related demands vary across individuals, residents need to develop a sense both of their own personal vulnerability to fatigue (with the caveat that self-assessment of that vulnerability is not always accurate!) and the approaches that work best for them and their lifestyle.

There is also clearly a 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 for the problem of sleep loss and fatigue in medical training. Ongoing mechanisms must be developed to insure accountability from residency program and hospital administrators in implementing and assessing the efficacy of given interventions. Because of the unique nature of the combined student and physician role of trainees, working conditions must be structured not only to ensure the safety of both patients and of trainees, but they should also provide an optimal learning environment that allows residents to learn in a well-rested state.

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## SLIDE 51: Napping Strategies

The strategic use of naps has been shown in a number of occupational settings (aviation, trucking, etc.) to provide temporary relief from the effects of sleep loss and fatigue. In all of these situations, however, consideration must be given to the timing and duration of naps in order to minimize the effects of *sleep inertia* on performance. Sleep inertia is defined as a clouded sensorium or incomplete arousal from sleep.<sup>70</sup> Behaviorally, sleep inertia manifests as slowed speech, substantial performance deficits, poor memory and impaired decision making.<sup>71</sup> Sleep inertia is most likely to occur upon an elicited arousal from deep sleep; therefore, brief naps should be timed to end before the first period of deep sleep is likely to occur. With either time or sufficient stimulation, e.g., physical activity or caffeine, sleep inertia is reversed. Although sleep inertia may result in profound impairments, very little is known about the effects of sleep inertia in residents answering pages in the middle of the night.

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## **SLIDE 52: Sleep Inertia**

Sleep inertia (also known as “sleep drunkenness”) refers to a period of impaired performance, altered vigilance, and disrupted behavior during transition between sleep and wakefulness.<sup>72</sup> It reflects a struggle to move from sleep toward full alertness. The impairment noted during sleep inertia may be mild or severe, lasting minutes to hours, and at times associated with microsleep (see Slide 43) episodes.<sup>70</sup> One of the most crucial factors in the presentation of sleep inertia is the sleep stage prior to the awakening: Abrupt awakening from slow wave sleep (SWS) produces more sleep inertia than awakening from other stages of sleep.<sup>73</sup> Prior sleep debt, therefore, promotes greater sleep inertia since it is associated with increased SWS.<sup>73</sup>

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## **SLIDE 53: Cognitive Performance on Awakening from Sleep Compared with Subsequent Sleep Deprivation**

Occupations that require individuals to perform immediately on awakening are adversely affected by individuals likely to suffer from sleep deprivation. The following experiment compared the effects of sleep inertia and sleep deprivation on cognition measured by a standardized addition test that presented a series of randomly generated pairs of two digit numbers.

Participants subjected to 26 hours of sleep deprivation and evaluated immediately upon awakening were found to have poor cognitive performance.<sup>74</sup> In fact, severe impairments were seen within the first three minutes of awakening, and some reported severe impairments lasting for as long as 10 minutes following awakening, with effects on performance detectable for at least two hours.<sup>74</sup> Error bars indicate standard error of the mean; the asterisks indicate difference from all subsequent time points at  $p \leq 0.01$ .

This study has important implications for occupations in which sleep-deprived personnel are expected to perform immediately upon awakening from SWS.

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## **SLIDE 54: Napping**

Since the most effective countermeasure for sleepiness is clearly sleep, the efficacy of napping in combating the effects of fatigue has been an active area of research in the laboratory as well as in other occupational settings.<sup>75</sup> For example, "prophylactic" brief naps prior to 24 hours of sleep loss have been shown to improve alertness during 24 hours of sustained wakefulness<sup>76</sup>, and frequent (every two to three hours), brief (15-minute) "therapeutic" naps can significantly mitigate performance decrements during periods of prolonged sleep deprivation.<sup>77</sup> "Maintenance" or on the job naps may also improve performance in shift workers.<sup>78</sup> A two to eight hour nap prior to 24 hours of sleep loss improves vigilance and minimizes sleepiness for 24 hours.<sup>79</sup> According to research, naps as short as 15 minutes can significantly ameliorate the performance decrements of residents if they are provided at two to three hour intervals during 24 hours of sleep deprivation.<sup>80</sup> The time of the day most refractory to counter-measures is the circadian nadir, 2 to 9 a.m.<sup>81</sup>

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## **SLIDE 55: Recovery from Sleep Loss**

There is substantial evidence that getting less than six hours of sleep on a chronic basis leads to decreased neuropsychological performance. Following sleep loss, such as night on call, five to six hours of sleep is not enough to pay back the sleep debt. In a recent National Sleep Foundation poll, of those interviewed who slept seven hours or less on weekdays, most reporting having to sleep longer on weekends and about half slept eight or more hours during the two weekend days to recover their sleep.<sup>82</sup> Following sleep deprivation, recovery sleep is characterized by an increase in the amount of slow wave sleep or deep sleep.<sup>15</sup>

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## **SLIDE 56: Recovery Sleep and Attention**

In this study by Belenky and coworkers<sup>83</sup>, 66 volunteers spent 14 days in a sleep lab. Baseline (B) records their performance after three nights of at least eight hours in bed. Subjects were then divided into four groups with time in bed varying from nine to three hours per night for seven nights (E). They then were tested for an additional three nights of “recovery” time with eight hours in bed per night (R). Decreasing the amount of time in bed was associated with more lapses. Further, even after several nights of recovery sleep, only the group with nine hours in bed was at baseline. Although the three hour in bed group had the most dramatic increase in lapses during the study, both the three hour and five hour groups had similar high lapse rates in the recovery period. Even the seven hour group, considered perhaps to be a minimal difference in amount of sleep per night, was not at baseline after three nights of recovery sleep, although the performance appeared unchanged compared to the previous few nights. This illustrates how a person may feel that less sleep has no impact, when in fact s/he is not at optimal performance.

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## **SLIDE 57: Caffeine** **LEVEL 2 SLIDE**

A number of studies have shown that caffeine, a central nervous stimulant commonly used to counteract the effects of sleep deprivation, does have alertness-enhancing effects in relatively high doses. Caffeine takes effect within 15 to 45 minutes after consumption and remains active for three to five hours, thus *strategically timing* consumption is critical. Caffeine effects also depend on body mass, previous usage, and food intake; regular use tends to produce relative tolerance to its stimulatory effects. Caffeine use may also result in more fragmented sleep and decreased total sleep time.<sup>84, 85</sup>

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## **SLIDE 58: Caffeine Content**

This slide shows the caffeine content of some commonly-consumed beverages. It should be noted that the caffeine content of coffee drinks can vary significantly according to the method of preparation and amount of ground coffee used. For example, a large serving of some “gourmet” coffee brands can contain almost as much caffeine as four tablets (twice the recommended dose) of an over-the-counter stimulant.

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## **SLIDE 59: Healthy Sleep Habits – Strategies**

### **SLIDE 60: Healthy Sleep Habits (LEVEL 2 SLIDE)**

Conditions that disrupt the normal sleep wake rhythm and behaviors that increase physiologic and cognitive arousal may weaken the circadian sleep rhythm and decrease sleep quality. Good sleep habits to improve the strength of the circadian rhythm, relaxing pre-sleep rituals and a comfortable sleep environment will lead to improved sleep quality and quantity. Some simple good sleep habits include: 1) regular bed time and wake times; 2) relaxation before sleep, 3) a comfortable sleeping environment (cooler temperature, darkness and minimizing noises); 4) avoiding eating large meals; 5) avoiding strenuous physical and mental activities within three hours of sleep.<sup>86</sup>

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## **SLIDE 61: Residents Report Using:**

### **LEVEL 2 SLIDE**

Although oral administration of exogenous melatonin has been investigated in other occupational settings as a means of mitigating the effects of circadian disruption (shift work), several studies which have examined the effectiveness of oral melatonin use in emergency medicine physicians working night shifts have failed to document a significant effect.<sup>87-89</sup>

Central nervous system stimulants have been tested for effectiveness in improving performance following sleep loss. High-dose caffeine, modafinil and d-amphetamine are effective in reducing sleepiness as measured with polysomnography and enhancing vigilance performance in individuals following short-term (reduced sleep for less than

two days) sleep loss.<sup>86, 90</sup> However, potential health risks with regular use of any of these drugs, including the risk of abuse, cardiovascular effects, and disrupted subsequent nocturnal sleep should prompt caution in considering them as counter-measures for chronic sleep loss in physicians in training.

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## **SLIDE 62: Operational Measures to Reduce Fatigue**

### **LEVEL 2 SLIDE**

Managing resident fatigue is both a program and personal responsibility. Programs must be designed to allow residents adequate support to get the sleep they need. Residents must also take the initiative to use their time wisely in order to get the sleep they need when they need it. Attendings and other role models must also do their part to foster healthy sleep habits.

Some argue that physicians and the work they do is unique, especially in training. However, many programs have successfully merged high quality patient care, education, and resident well-being. Adequate sleep may in fact contribute to better care rather than hinder it.

This section provides an overview of resident work hours and other industry duty hour limitations, scheduling principles including details on shift work, rebuttals to some common concerns about redesigning programs, and tips about maintaining high quality patient care, resident education, and resident well-being.

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## **SLIDE 63: ACGME Common Standards for Resident Duty Hours (2003)**

### **LEVEL 2 SLIDE**

The combination of data from sleep research and recognition that the intensity of training had increased led the ACGME to adopt new work hour standards for all residents in 2003. The ACGME has input from a variety of stakeholders, including residents and program directors. The ACGME has also been active in providing resources for programs that need redesign, in citing programs that are not in compliance, and in looking critically at any need to revise the standards.

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## **SLIDE 64: Work Hour Limits for Physicians in Other Countries**

### **LEVEL 2 SLIDE**

The European Parliament published a directive that was expanded to include resident doctors in 2000. The directive mandates a work week of no longer than 58 hours (reduced to 56 hours in August, 2007 and to 48 hours in August 2009), a minimum of 11 hours of rest per 24 hours and at least 24 hours out of work per week.<sup>91</sup> Sweden has had a 40 hour work week for doctors for many years, but, unlike many other countries, does not face a physician shortage. Since 1985, New Zealand has required residents be limited to 72 hours per seven consecutive days, no more than 16 hours per day and a limit of two shifts longer than 10 hours per seven days.<sup>92</sup>

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## **SLIDE 65: Work Hour Limits for Other Occupations in the U.S.**

### **LEVEL 2 SLIDE**

A press release from the American Medical Student Association in 2000 read: “Trucker hours are capped at 10 but doctors work 36 hours or more: is this safe?”<sup>93</sup> This helped turn attention to the problem of sleepiness in physicians.

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## **SLIDES 66 - 67: Shift Work – Myths, Facts and Strategies**

### **LEVEL 2 SLIDES**

Because different physiologic systems in the body adjust at different rates, the disruption in endogenous circadian rhythms associated with adaptation to night shift work may result in a whole host of psychological (i.e., cognitive dullness, irritability) and somatic complaints (e.g., gastrointestinal symptoms), similar to those experienced in jet lag. Adjustment to working night shift, although probably never complete in most individuals, generally takes at least a week. Due to the intrinsic periodicity of the human circadian clock of slightly longer than 24 hours described earlier (Slide 16), it is easier to adapt to shifts that rotate in a forward (clockwise) direction (day/evening/night) and "night owls" may be more successful "night floats."

Strategies to assist in adapting to working the night shift include assuring adequate sleep during off-work hours.<sup>6,7</sup> Studies suggest that workers tend to lose one to four hours of sleep each night for approximately three days after a rotation to a new shift.<sup>94</sup> Shift workers are also more vulnerable to sleep interruptions from family, social pressures, and other responsibilities. Thus, enlisting the cooperation of others is a key factor in ensuring adequate sleep. Napping strategies include "prophylactic" naps before work. If it is not possible to obtain adequate sleep on work days (equivalent to a normal night's sleep on non-work days) in a single sleep period, splitting sleep into two periods may be a viable alternative for some. Sleep periods should be timed, if possible, to take advantage of those times in the circadian cycle that are most sleep-conducive ("sleep when you are sleepy"). Finally, because light has such a powerful influence on circadian rhythms of alertness and sleepiness, light exposure should be maximized when alertness is desired (i.e., at work) and minimized when a sleep period is planned (driving home after the night shift).

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## **SLIDE 68: Morning Shifts**

### **LEVEL 2 SLIDE**

Work shifts that start early in the morning (before 7 a.m.) also pose potential risks in terms of sleep loss and fatigue. Individuals working these shifts typically get less than adequate sleep due to the early rise time, and in addition may have disrupted sleep due to the phenomenon of "anticipatory awakenings" in which the deeper stages of sleep (slow wave sleep) may be reduced. Early rise times often also require the individual to become awake and alert at a time when they are physiologically most prone (circadian trough of alertness between 3 and 5 a.m.) to sleepiness.

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## **SLIDE 69: Aviation Standards to Reduce Shift Work Fatigue**

Other occupations which require long work hours and involve shift work have developed strategies to reduce associated fatigue which may be modifiable for the medical setting. For example, the aviation industry has set standards which require adequate time for recovery between shifts and allow for planned nap time to counteract fatigue associated with adapting to nightshifts. A "clockwise" shift rotation and limiting the number of days spent on each shift to minimize circadian disruption are other strategies which can help facilitate adaptation to rotating shifts in settings such as the emergency ward.<sup>95</sup>

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## **SLIDE 70: "The Best Laid Plans ..."**

### **LEVEL 2 SLIDE**

There have been a handful of studies which have examined the effects of other operational changes in medical settings. In one example of the use of operational strategies, institution of a team day/night shift on-call system resulted anecdotally in improved morale and resident learning in one obstetrics and gynecology residency program.<sup>96</sup> A more recent study which examined the impact of a "night stalker" (night float) radiology resident in the emergency room on quality of care reported fewer "missed" radiologic findings and less clinically significant discordant findings in the post-intervention cases reviewed.<sup>97</sup>

However, in the striking illustration of the complexity and challenges involved in implementing system changes to address sleep and fatigue outlined in this slide, one study which examined the impact of a "night float" on-call coverage system on resident performance found that, counter to expectations, the "covered" residents who had protected time for

sleep actually obtained *less* sleep overall than the residents who were relieved by the night float.<sup>98</sup> The authors concluded that the covered residents used their protected time to catch up on work, not sleep.

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## **SLIDE 71: Schedule Design Principles**

### **LEVEL 2 SLIDE**

There are three elements to designing a successful residency schedule -- maintaining high quality patient care, excellent resident education, and resident well-being. Research indicates there is a performance decline after 16 hours of being awake, so containing work within those hours or creating strategic naps, etc. is ideal. Additionally, for patient care, any situations made risky because of fatigue should be minimized. Education need not be sacrificed when designing better work environments, and programs are only truly successful if residents are satisfied with their schedules overall. Residency training is still a long, intense process, but it is a better one if there is a supportive culture. Finding the balance between patient care responsibilities, education, and resident well-being can be challenging but doable if the focus is on creating working sustainable solutions.

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## **SLIDE 72: Reducing Hours or Workload – Examples**

### **LEVEL 2 SLIDE**

Programs have been very creative in redefining traditional resident roles and care structure. For example, floats are not limited to nighttime, patients are not limited to one provider, and teams can be fluid in their start/stop times. When redesigning schedules, the “old way” can be questioned. At the same time, however, new schedules should allow as many good sleep practices as possible.

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## **SLIDE 73: Some Potential Pitfalls Regarding Mistakes, Education, and Morale**

### **LEVEL 2 SLIDE**

For every pitfall that is commonly cited, there is a solution, often one which provides better patient care, education, and/or resident well-being. Oftentimes, something that was not done well before, such as hand-offs (transfer of care), is cited as the reason that scheduling cannot be changed. Improving hand-offs and the associated communication skills, regardless of schedule changes, are better for patients. Applying basic principles of medicine, such as treat the underlying problem (often poor communication), will address many common complaints.

Other issues, such as complaints about float experiences, can be resolved by redefining what is “float.” Traditionally night float has one resident working from approximately 11 p.m. to 8 a.m. every night who has minimal interaction with other physicians, not to mention family or friends, and no formal education. A new approach might have two night floats, one working every other night, but starting at 6 p.m. and going home at noon, allowing interaction with more day team members, including attending time and conferences. Such systems need to be balanced against a more erratic sleep schedule.

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## **SLIDE 74: Minimizing Risk-prone Situations**

### **LEVEL 2 SLIDE**

These are just two examples of risk-prone situations that can be minimized with simple interventions. The more complex task for the residency program is infiltrating use of the interventions into the culture. For example, post-call residents may not want to “give-up” doing procedures either because of the desire for experience or the perception of weakness. This is when the true meaning of professionalism comes into play: residents should put the patient first and allow the rested team to provide care.

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**SLIDE 75: Maintaining Opportunities for Education****LEVEL 2 SLIDE**

Education should remain a priority. Well-rested residents report that they are able to perform better on cognitive tasks.<sup>1</sup> Residents who fall asleep during conferences have neither mastered the material nor gotten good sleep. Capitalize on technology to provide conferences at different times (e.g. videotaping; putting PowerPoint slides with notes online). Think creatively about how to structure the curriculum so that material is reinforced in different venues; if residents miss one format, they can pick up the information in another. Protect resident education time whenever possible; residents should be called out of conferences for true emergencies only, not routine work. Treat attendings as a valuable resource: their time is limited by work demands but their contact with residents, as teachers, mentors, and advisors is critical to residents' success.

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**SLIDE 76: Supporting Resident Well-being**

The rates of burn-out and depression among residents are alarmingly high<sup>99, 100</sup>, and are now shown to grow as the academic year progresses, in part due to the increasing burden of chronic sleep deprivation. The nature of the work can itself be stressful; ensure that residents have the time and resources to maintain connections with friends, family, one another, and advisors/mentors. Check in with residents as individuals and as a whole program to determine if interventions are needed. And, of course, emphasize the role of healthy sleep habits in supporting positive resident well-being.

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**SLIDE 77: In Summary**

It should be evident from this presentation that the problem of sleep loss and fatigue in medical training is one that impacts significantly on the professional and personal lives of residents and of their patients. Because health care delivery in teaching hospitals must operate 24 hours a day, seven days a week, *management* rather than *elimination* of fatigue should be the driving concept. Alertness management strategies should be informed by the growing body of research and policy experience from other occupational settings; however, because there are fundamental differences in the nature of the tasks which medical personnel are required to perform in the course of their workday, fatigue management strategies that have been successful in other occupational settings may not be uniformly applicable to medical training; therefore, strategies which are unique to the hospital setting and which incorporate the process of medical education and patient care needs must continue to be developed and tested. Recognition that work hour regulations alone are unlikely to be sufficient to ensure residents who are functioning at an optimal level should prompt ongoing evaluation of the effects of sleep loss and fatigue on key outcomes such as patient health and safety, education effectiveness, resident health and professionalism, and health care economics.

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**SLIDE 78: Statement of the American College of Surgeons****SLIDE 79: For Additional Information**

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