Effects of Health Care Provider Work Hours and Sleep Deprivation on Safety and Performance

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During the past three years, a series of studies have demonstrated the risks to patients and providers of long work hours in health care. Compared with nurses working shorter hours, nurses working greater than 12.5–13 consecutive hours report (1): a 1.9- to 3.3-fold increased odds of making an error in patient care[1,2]; (2) a significantly increased risk of suffering a needlestick injury, exposing them to an increased risk of acquiring hepatitis, HIV, or other bloodborne illnesses[3]; and (3) significant decrease in vigilance on the job.[2]

Likewise, physicians-in-training working long hours have been found to be at greatly increased risk of injuring their patients or themselves. Recent research has demonstrated that physicians-in-training working traditional schedules with recurrent 24-hour shifts:

- Make 36% more serious medical errors than those whose scheduled work is limited to 16 consecutive hours[4]
- Make five times as many serious diagnostic errors[4]
- Have twice as many on-the-job attentional failures at night[5]
- Suffer 61% more needlestick and other sharp injuries after their 20th consecutive hour of work[6]
- Double their risk of a motor vehicle crash when driving home after 24 hours of work[7]
- Experience a 1.5 to 2 standard deviation (S.D.) deterioration in performance relative to baseline rested performance on both clinical and nonclinical tasks[8]
- Suffer decrements in performance commensurate with those induced by a blood alcohol level of 0.05 to 0.10%[9,10]

Article-at-a-Glance

Background: There has been increasing interest in the impact of resident-physician and nurse work hours on patient safety. The evidence demonstrates that work schedules have a profound effect on providers' sleep and performance, as well as on their safety and that of their patients. Nurses working shifts greater than 12.5 hours are at significantly increased risk of experiencing decreased vigilance on the job, suffering an occupational injury, or making a medical error. Physicians-in-training working traditional > 24-hour on-call shifts are at greatly increased risk of experiencing an occupational sharps injury or a motor vehicle crash on the drive home from work and of making a serious or even fatal medical error. As compared to when working 16-hours shifts, on-call residents have twice as many attentional failures when working overnight and commit 36% more serious medical errors. They also report making 300% more fatigue-related medical errors that lead to a patient's death.

Conclusion: The weight of evidence strongly suggests that extended-duration work shifts significantly increase fatigue and impair performance and safety. From the standpoint of both providers and patients, the hours routinely worked by health care providers in the United States are unsafe. To reduce the unacceptably high rate of preventable fatigue-related medical error and injuries among health care workers, the United States must establish and enforce safe work-hour limits.

■ Report making 300% more fatigue-related medical errors that lead to a patient's death[11]

In this article, we review these studies in detail and place these findings in the context of the biologic mechanisms known to underlie the development of fatigue. In the companion article by Landrigan et al.,[12] the manner in which these data have informed policy will be discussed, as will the need for evidence-based changes in current work-hour regulations.

Background: Sleep Deprivation and Circadian Misalignment

As the science of sleep and circadian medicine has advanced, the neurobiologic pathways that drive human performance and alertness have become better understood (Figure 1, page 9). We briefly discuss the state of the science regarding sleep and performance as it relates to health care workers and then discuss recent clinical studies that have directly assessed the effects of long work hours and sleep deprivation on physicians and nurses.

Circadian Rhythms

Health care providers regularly work during the biological night, when the endogenous drive for alertness is lowest. The endogenous circadian pacemaker, situated in the suprachiastmatic nuclei (SCN) of the hypothalamus, controls the intrinsic rhythms of sleep, alertness, and performance, among many other physiological and behavioral parameters, with the maximal drive for alertness emanating from the pacemaker during the biologic day, and maximal drive for sleepiness during the biologic night (Figure 1a).[13–15] Changes in work schedules from days to nights or from days off to nights are often too rapid to allow the circadian system to adapt to the scheduled wakefulness at night, placing many providers in a permanent state of "jet lag" as they attempt to remain awake and work, and subsequently sleep, at the incorrect internal circadian phase.[16,17] Such circadian misalignment is responsible for the higher rates of accidents by night-shift workers[18] and by drivers at night.[19]

Acute Sleep Deprivation

Nurses or physicians working nights after they have been awake during the day also suffer deterioration in performance because of long episodes of continuous wakefulness; residents working extended 24- to 30-hour on-duty shifts invariably experience these effects. Independent of the circadian system, acute continuous sleep deprivation has a profound impact on fatigue: After about 16–18 hours of wakefulness, alertness and performance decline rapidly (Figure 1b).[20,21] When prolonged wakefulness is coincident with being awake at an adverse circadian phase, for example, in the latter half of an extended-duration on-call shift, these two factors interact nonlinearly such that their combined effects exceed their individual decrements, making this a particularly critical and vulnerable time for the risk of a fatigue-related error or accident,[22,23] as we have demonstrated repeatedly in medical residents[4–7,11](see studies described in later sections).

Chronic Partial Sleep Deprivation

Residents and nurses are also frequently exposed to chronic partial sleep deprivation, often for many months at a time, as they repeatedly fail to gain adequate sleep on a daily basis. Young adults would spontaneously sleep an average of approximately 8.5 hours per night if given sufficient opportunity, even following several nights of longer sleep.[24,25] Young adult residents working extended-duration shifts, however, sleep about 2 hours less than this amount on average per day,[5,26,27] guaranteeing a chronic buildup of sleep pressure. Nurses, particularly those who regularly work nights, also typically fail to achieve their average daily sleep requirements.[28] Repeated failure to gain sufficient sleep to fully recover from the previous wake episode has a cumulative detrimental effect on waking function that rapidly builds to significantly impair performance.[29,30] For example, after less than two weeks with only 6 hours time in bed per night, performance levels are equivalent to those observed after 24 hours of acute sleep deprivation, and after one week of only 4 hours in bed per night, performance is equivalent to that following 48 hours without sleep (Figure 1c).[30] Even more concerning for health care provider scheduling, however, is the disassociation between self-ratings of alertness and objective performance under such conditions.[30] Although performance continues to decline during several weeks of chronic partial sleep deprivation, subjective ratings level off, making self-assessment of fatigue and performance unreliable, much in the same way that occurs following alcohol consumption. Institution-level protections to ensure adequate alertness

Examples from Experimental Data Sets of the Four Major Physiologic Determinants of Fatigue

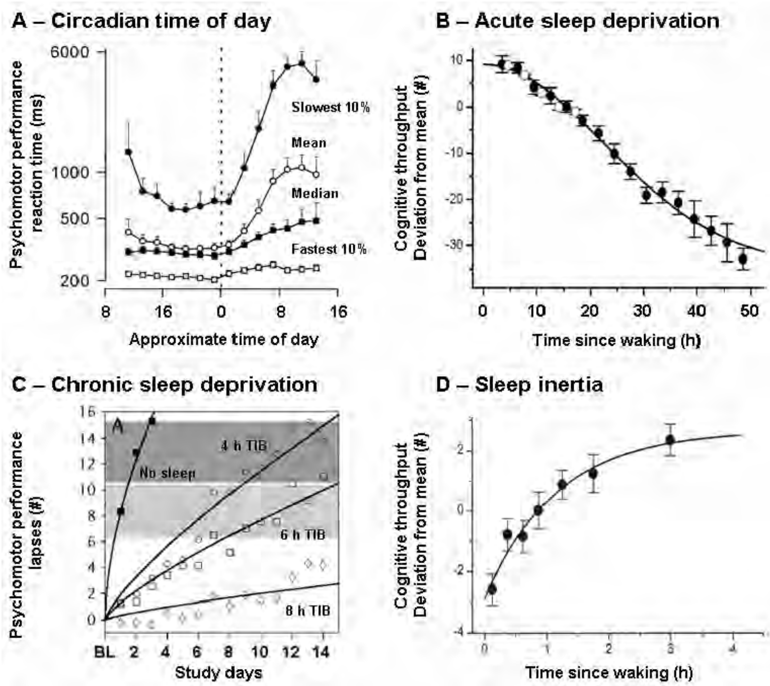

Figure 1. *The figure shows examples from experimental data sets of the four major physiologic determinants of fatigue.*

*Figure 1a illustrates the endogenous circadian rhythm in visual psychomotor performance (mean, median, 10% slowest, and 10% fastest responses) during a 32-hour vigil under constant conditions (*n *= 10). Performance is poorest towards the end of the biologic night but then improves again slightly, even in subjects remaining continually awake (although not equivalent to the same clock time 24 hours earlier because of the prolonged acute sleep deprivation) because of the drive for alertness emanating from the endogenous circadian pacemaker. Although average reaction times may slow to ~1 second, there is more than a 10-fold increase in the slowest 10% of responses, which average nearly 6 seconds at the circadian nadir before the subject reacts to a visual stimulus, which would represent a significant lapse of attention under real-world conditions. Reproduced with permission from Cajochen C., et al.: EEG and ocular correlates of circadian melatonin phase and human performance decrements during sleep loss.* Am J Physiol Regul Integr Comp Physiol *277:R640–R649, Sep. 1999.*

Figure 1b shows the effects of 48 hours of continual wakefulness on mean (± standard error of the mean[sem]) cognitive throughput, as measured by a simple 4-minute addition test in subjects measured under constant routine (●, n *= 147) or forced desynchrony (○,* n *= 11) conditions. Cognition declines sigmoidally with increasing time awake. The line represents a model prediction of cognition under these conditions. Reproduced with permission from Jewett M.E., et al.: Sigmoidal decline of homeostatic component in subjective alertness and cognitive throughput.* Sleep *22(suppl.):S94–S95, Jun. 1999.*

Figure 1c shows how different amounts of chronic partial sleep deprivation affect psychomotor performance and compares the time course of average daily lapses in attention (based on 2-hourly tests from 7:30 A.M.–11:30 P.M.) during two weeks in subjects with an 8-hour (◇, n *= 9), 6-hour (□,* n *= 13) and 4-hour (○,* n *= 13) time-in-bed (TIB) sleep opportunity each day, and 88-hours of continuous sleep deprivation (■,* n *=13). Performance deteriorated in both the 6- and 4-hour sleep groups such that after 14 days, the 6-hour sleep group performed at an equivalent level to those kept awake for 24 hours continuously, and the 4-hour group was performing at the same level as someone kept awake for 3 whole days. Reproduced with permission from Dongen H.P., et al.: The cumulative cost of additional wakefulness: Dose-response effects on neurobehavioral functions and sleep physiology from chronic sleep restriction and total sleep deprivation.* Sleep *26:117–126, Mar. 2003. Erratum in:* Sleep *27:600, Jun. 15, 2004.*

Figure 1d shows the time course of sleep inertia in cognitive throughput during the first 4 hours of wakefulness after a normal 8-hour sleep for 3 days. Although there is an exponential improvement in performance over time, it takes at least 2 hours to reach maximal performance and there is a highest risk of a fatigue-related error in the first 30 minutes after waking. Reproduced with permission from Jewett M.E., et al.: Time course of sleep inertia dissipation in human performance and alertness. J Sleep Res *8:1–8, Mar. 1999.*

Relative Impact of Sleep Inertia and Acute Sleep Deprivation on Cognitive Performance

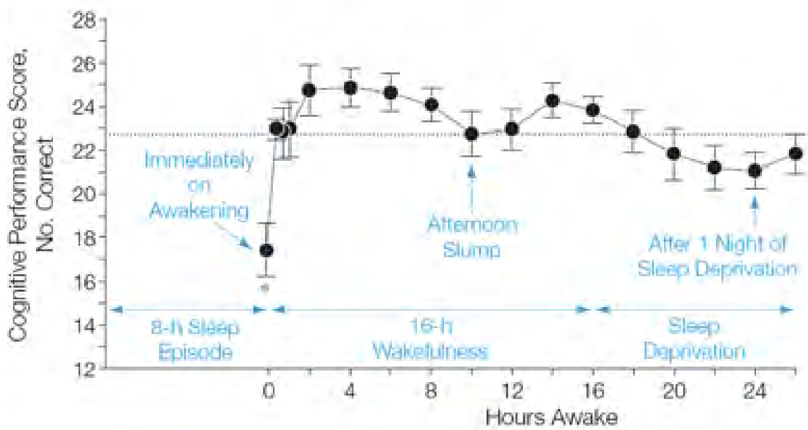

Figure 2. *The figure shows the relative impact of sleep inertia and acute sleep deprivation on cognitive performance (*n *= 9: 8 men, 1 woman, 20–41 years of age). After 6 days with an 8-hour sleep opportunity at the same time each night, subjects remained awake for 26 hours under constant conditions and completed a simple addition task at ~1, 21, 41, and 61 minutes after awakening, and then every 2 hours. Cognitive performance was worst immediately after waking and more impaired than following 24 hours of continuous wakefulness. These data highlight the particular risk of residents committing a fatigue-related error when woken from sleep on duty by a page. Reproduced with permission from Wertz A.T., et al.: Effects of sleep inertia on cognition.* JAMA *295:163–164, Jan. 11, 2006. Copyright ©2006 American Medical Association.*

on duty are required, therefore, rather than relying on individual self-policing of fatigue.

Sleep Inertia

A fourth factor that can affect performance is the phenomenon of sleep inertia, the impairment present immediately on awakening from sleep. Naps during residents' on-duty shifts have been tested as a countermeasure to chronic and acute sleep deprivation.[31,32] Although these may be beneficial in ameliorating performance decrements following a period of recovery, such naps, which are often taken under very high levels of sleep pressure, can induce postnap impairment. Alertness and performance are not maximal immediately on waking, and it takes several hours to realize a fully alert state (Figure 1d).[33] Sleep inertia dissipates exponentially, but the first 15–30 minutes after waking are a particularly vulnerable period. Performance decrements at this time can exceed those experiences after 24 hours of continuous wakefulness (Figure 2, above).[34] Requiring residents and nurses to make vital decisions shortly after being woken on duty therefore presents a very high risk of fatigue-related error.

Sleep Deprivation and Learning

In addition to the immediate effects on clinicians' alertness and performance (discussed in the section, "Recent Clinical Studies"), long-term adverse effects of sleep deprivation are increasingly being recognized. Particularly relevant both to medical trainees and junior nurses is the impact of sleep and sleep deprivation on learning and memory.[35–37] Many tasks, including visual discrimination, motor learning, and insight are dependent on adequate sleep following the initial learning opportunity,[37–40] and failure to sleep the night after learning a task may impair providers' ability to consolidate this learning.[40,41]

Sleep Deprivation and Health

There are also longer-term health detriments due to shift work and chronic sleep deprivation. Sleep deprivation and the circadian system affect metabolic processes,[42–44] which may result in increased risk of cardiovascular disease, insulin resistance, and diabetes.[45] Regular night-shift workers also have a increased risk of certain cancers, particularly breast cancer, as compared with non-shift workers.[46,47] Resident schedules are among the most extreme of any profession and may present even greater risks than standard night-shift work.

Recent Clinical Studies: Health Care Provider Sleep Deprivation, Performance, and Safety

Although an extensive literature on sleep deprivation, circadian misalignment, and human performance has accrued during the past three decades, debate on the effects of these factors on physicians and nurses has persisted. The notion that providers' long work hours might have an adverse effect on their performance and safety is not new. More than 35 years ago, it was recognized that extended work hours adversely affect medical[48,49] and surgical[50] performance. Subsequent studies have also documented additional adverse effects on provider health and well-being.[51–54] The importance of these effects in clinical (as opposed to simulated or laboratory) settings, however, was previously somewhat unclear. Consequently, we and others initiated a series of studies during the past several years on the effects of sleep deprivation on provider performance and patient and provider safety.

Effect of the Extended Work Hours of Physicians-in-Training on Physician-in-Training Safety: The HWHHS National Cohort Study

In 2001, concerned with the potential risks of residents' extended duty hours on the safety of patients and providers, we formed the Harvard Work Hours, Health, and Safety (HWHHS) Group, an interdisciplinary collaboration between investigators interested in rigorously evaluating the effects of provider sleep deprivation on safety. With the support of the Agency for Healthcare Research and Quality (AHRQ) and the National Institute of Occupational Safety and Health (NIOSH), we began a prospective nationwide Web-based survey of 2,737 postgraduate year (PGY)-1 residents (53% female, mean age ± S.D. = 28.0 ± 3.9 yrs) in 2002 (a year before publication of the Accreditation Council for Graduate Medical Education (ACGME) guidelines on duty hours) to examine the impact of extended-duration work hours on resident health and patient safety.

Methods. Most participants were medical residents (79%), with 11% from surgical programs and 10% in other or nonspecified specialties; 85% were graduates of medical schools in the United States. Volunteers completed a total of 17,003 monthly reports between June 2002 and May 2003 that included questions about their work hours, sleep, motor vehicle crashes, occupational injuries and self-reported medical errors among approximately 60 questions.[6,7,11] Monthly sleep and work hour reports were validated by daily diaries for three to four weeks in 7% of the cohort using the same methods that we have shown to be highly correlated ($r \geq 0.98$) with continuous observation and polysomnographically determined sleep, respectively.[5] The number of work hours reported on the survey per month (mean ± S.D. = 249.8 ± 75.3 h) correlated with the daily work hour diaries (244.0 ± 69.3 h; $r = 0.76$, $p < .001$, $n = 192$), and the number of extended shifts reported by the two methods (3.6 ± 3.3 and 3.5 ± 2.8, respectively; $r = 0.94$, $p < .001$, $n = 40$).[7]

Additional information was requested in support of the reported motor vehicle accidents and percutaneous injuries. A police report, insurance claim, repair record or photograph of the damaged vehicle, medical record, or written description of the crash was obtained for 82% of all reported motor vehicle crashes. Respondents reporting occupational exposure to body fluids were asked about the type of exposure, the location and time of exposure, whether it was formally reported, the number of hours worked prior to the exposure, and the cause(s) of the exposure. Only percutaneous injuries due to a needlestick or cut with another sharp instrument for which the location and time of the incident were provided were included in analysis. Similar follow-up details were requested for self-reported medical errors.

PGY-1 residents reported completing extended-duration work shifts (> 24 h) an average (± S.D.) of 3.9 ± 3.4 times per month, with a mean duration of each extended-duration work shift of 32.0 ± 0.7 hours. Sleep was minimal on these shifts, averaging 3.2 (± 1.6) and 2.6 (± 1.7) hours for those with and without night-float coverage, respectively. The mean maximal hours of continuous wakefulness reported on these shifts was 25.3 ± 8.3 hours.[7]

Residents' Motor Vehicle Crashes, Near-Miss Motor Vehicle Accidents, and Percutaneous Injuries Reported Relative to the Duration of Work Shifts

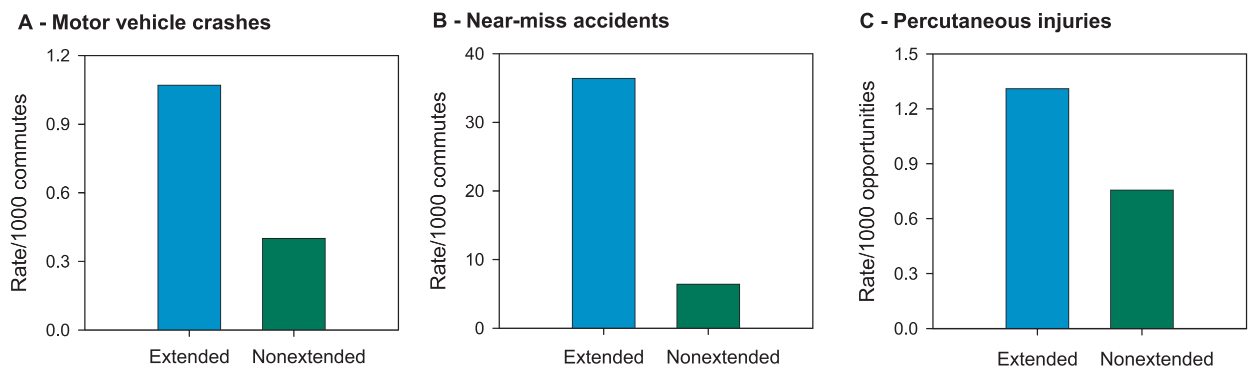

Figure 3. *This figure shows the rate of* (A) *motor vehicle crashes,* (B) *near-miss motor vehicle accidents and* (C) *percutaneous injuries reported by postgraduate year (PGY)-1 residents nationwide* (n *= 2,737) in 17,007 monthly reports between June 2002 and May 2003 relative to the duration of work shifts. Residents reported a significantly higher rate of motor vehicle crashes and near misses on the commute following an extended-duration work shift (> 24 hours; Figures A and B, ■) as compared with the same residents' commute following a nonextended shift (< 24 hours, ■). The Mantel–Haenszel odds ratios (OR ± 95% confidence interval) for having an accident or near miss on the commute home were 2.3 (1.6–3.3) and 5.9 (5.4–6.3), respectively (see text). Residents also reported a significantly higher rate of percutaneous injuries when on duty during the day after being on-call overnight (6:30-17:30; Figure C, ■) as compared with the day before on-call (■; OR 1.61, 1.46–1.78).*

Figures A and B: Data replotted from Barger L.K., et al.: Extended work shifts and the risk of motor vehicle crashes among interns. N Engl J Med *352:125–134, Jan. 13, 2005.*

Figure C: Data replotted with permission from Ayas N.T., et al.: Extended work duration and the risk of self-reported percutaneous injuries in interns. JAMA *296:1055–1062, Sep. 6, 2006. Copyright ©2006 American Medical Association.*

Using a within-person case-crossover design, we assessed the number and proportion of motor vehicle crashes and near-miss incidents that occurred following an extended-duration work shift, compared with those following a nonextended shift for each subject.[7] We also calculated the rate of percutaneous injuries that occurred during the day following an on-call overnight extended shift with the same clock time (6:30 A.M.–5:30 A.M.) the day before for each subject, and separately compared daytime (7:30 A.M.–3:30 P.M.) and night-time (11:30 P.M.–7:30 A.M.) injury rates.[6] Finally, the rate of self-reported medical errors and attentional failures was similarly calculated for months with one to four or five or more extended-duration work shifts and compared within-subjects to months without such shifts.[11]

Results. Figure 3 (above) shows the rate of motor vehicle crashes, near-misses accidents, and percutanous injuries in relation to extended-duration work shifts. The associated Mantel-Haenszel odds ratios (odds ratio [OR] ± 95% confidence limit) for a crash on the commute after an extended shift was 2.3 (1.6–3.3; p < .001) and 5.9 (5.4–6.3) for a near miss (p < .001), as compared with the commute after a nonextended shift (OR = 1.0). There was a linear relationship between the number of extended shifts per month and the subsequent occurrence of crashes such that each extended-duration work shift increased (1) the rate of any crash by an additional 9.1% (3.4%–14.7%) over baseline and (2) the risk of a crash on the commute from work by 16.2% (7.8%–24.7%).[7]

The odds of suffering a percutaneous injury between

6:30–17:30 after working overnight was 1.61 (1.46–1.78), as compared with the same times on the previous day.[6] The primary reasons attributed to the injury by the residents were a lapse in concentration (64%), fatigue (31%), leaving a sharp exposed (18%), patient movement (17%), and inadequate lighting (7%). Of note, only 58% of the injuries were reported to the residents' occupational health services. There was also a significant difference between injury rates by time of day; the odds of suffering a percutaneous injury at night were twice that during the day (OR 2.04, 1.98–2.11).

Effect of Nurses' Extended Work Hours on Nurses' Safety

In a similar evaluation of the association between nurses' working conditions and needlestick injuries, Trinkoff and colleagues conducted a longitudinal survey of 2,273 nurses between November 2002 and April 2004.[3] Overall, 16.3% of respondents reported having suffered a needlestick injury. The number of needles nurses estimated using each day was significantly associated with the odds of injury. In addition, hours worked per day, weekends worked per month, working evening and night shifts, and working 13 or more hours per day at least once per week were each significantly associated with needlestick injuries. The authors concluded that nurses' extended work schedules increased the incidence of needlestick injuries and that work hour reductions could reduce needlestick injuries.

Effect of Resident-Physicians' Extended Work Hours on Patient Safety: The HWHHS National Cohort Study

In the HWHHS study, the rate of self-reported fatigue-related medical errors, including those that resulted in a preventable adverse patient outcome or patient fatality, also increased with the increasing number of extended-duration work shifts per month (Figure 4, page 15). Conversely, medical errors reported not to be fatigue related were not dependent on the number of extended-duration shifts. The odd ratios of reporting a medical error were 3.5 (3.3–3.7) and 7.5 (7.2–7.8) when working one to four or more than five extended-duration shifts per month, respectively, as compared with those months without extended work shifts. For adverse events, the odds were 8.7 (3.4–22) and 7.0 (4.3–11), respectively. The odds ratio of reporting a fatigue-related fatality was only significantly higher when working five or more extended shifts per month (4.1, 1.4–12). These rates were not affected by age or gender. Similar relationships between errors and the number of extended shifts were observed in residents who completed all monthly surveys and when analyses were limited to hospital wards only, suggesting no major effects of reporting bias or patient acuity.[11]

The probability of reporting an attentional failure while on duty or during educational activities was also related to the number of extended shifts worked. The odds of reporting falling asleep during surgery were 2.1 (1.7–2.7) and 1.4 (1.3–1.6) for one to four or five or more extended shifts, respectively, and 1.5 (1.3–1.7) and 2.1 (2.0–2.2) for falling asleep during a patient examination. Higher rates of falling asleep during attending rounds and during lectures were also reported, with ORs of 5.5 (5.4–5.7) and 4.3 (4.3–4.4), respectively, when working five or more extended shifts per month. Consistent with these results, the reported sleep duration decreased with increasing numbers of extended shifts worked per month. Residents reported sleeping on average (± S.D.) 179.3 (± 54.3) hours per month when not working extended shifts, 176.6 (± 45.1) hours when working one to four extended shifts per month, and 165.3 (± 39.2) when working five or more per month.[11]

Effect of Nurses' Extended Work Hours on Patient Safety

In two separate studies, Rogers, Scott, and colleagues have demonstrated that nurses working greater than 12.5 consecutive hours are at significantly increased risk of making a medical error. In the first study, 393 randomly selected members of the American Nurses Association logged their work hours daily and reported all medical errors in which they were involved; data were collected on a total of 5,317 work shifts.[1] Thirty-nine percent of all shifts exceeded 12.5 hours, and working ≥ 12.5 hours was associated with a threefold increased risk (OR = 3.29, p = .001) of making an error.

In the second study, Scott et al. conducted a similar evaluation of a random sample of nurses drawn from the membership of the American Association of Critical-Care Nurses.[2] In this study of 502 nurses and 6,017 work shifts, it was found that 67% of critical care nurses' work shifts exceeded 12 hours and that working 16-hour shifts was common. Nurses working more than 12.5 hours had twice the risk of making a medical error (OR = 1.94, $p = .03$).

Effect of Resident-Physicians' Extended Work Hours on Resident Alertness and Patient Safety: The Intern Sleep and Patient Safety Study

At the same time that the HWHHS National Cohort Study was launched, we initiated a prospective, randomized trial to test the effect of eliminating extended-duration work shifts in two critical care units on resident sleep and fatigue and the rate of serious medical errors. Because this was designed principally as a randomized intervention trial, it is discussed in detail in the companion article by Landrigan et al.[12] regarding implementation of work-hour limits. With respect to the current review of the effects of long work hours on safety, however, it is relevant to mention here that in addition to demonstrating the effectiveness of reducing interns' work hours as a means of improving patient safety, this study demonstrated in a clinical setting that provider sleep deprivation leads to significantly impaired alertness and increased rates of medical errors. Interns working a traditional schedule with frequent 24–30 hour shifts had twice the rate of electrooculogram-derived attentional failures[5] (traditional: 0.69 ± 0.13/hour; intervention: 0.33 ± 0.09/hour; $p < .02$) than they had when working an intervention schedule that limited their scheduled work to 16 consecutive hours. In addition, they made 35.9% more serious medical errors than when the same residents worked the intervention schedule (traditional: 136.0/1000 patient days; intervention: 100.1/1000 patient days; $p < 0.001$), including more than five times more serious diagnostic errors during the traditional as compared with the intervention schedule.[4]

Physician Sleep Deprivation and Impairment: Comparison of the Effects of a Traditional On-Call Schedule and Alcohol

During the past decade, several studies have compared the level of cognitive impairment due to sleep deprivation with that caused by alcohol and have shown that performance after being awake for 24 hours or more is equivalent to that of someone who is legally drunk.[9] In a recent study that specifically tested 34 PGY1–PGY3 residents, psychomotor performance reaction, commission errors, and lane and speed variability on a driving simulator and subjective alertness were as impaired following four weeks of "heavy" call rotation (~90 hours per week, including 34–36 hours continuous duty every fourth or fifth night, during which residents obtained an average of 3 hours of sleep per night when on duty) as following a month of "light" call (~44 hours/week and night-call only under emergency circumstances) plus moderate alcohol intake 20 minutes before the testing sessions (~0.05 g% blood alcohol concentration).[10]

Physician Impairment and Clinical Tasks: A Meta-Analysis

In an effort to pull together all the studies conducted during the past three decades on physician and nonphysician performance and sleep deprivation, Philibert conducted a recent meta-review on behalf of ACGME.[8] In this analysis, 60 studies of the effects of sleep deprivation and fatigue on both physicians and nonphysicians were reviewed. On meta-analysis, it was found that continuous duty of 24–30 hours reduced overall performance by nearly one S.D. and reduced physicians' clinical performance by more than 1.5 S.D. (Figure 5, page 16).

Conclusion

Collectively, the weight of current evidence strongly suggests that extended-duration work shifts significantly increase fatigue and impair performance. Residents' traditional work shifts of 24–30 consecutive hours unquestionably increase the risk of serious medical errors and diagnostic mistakes and have been shown in a national cohort study to increase the risk of harmful and fatal medical errors. Nursing shifts of more than 12.5 hours are common and similarly appear to greatly increase the risk of medical error. Likewise, long work hours increase the risk that nurses and doctors will suffer an occupational injury with potentially devastating long-term consequences and increase the risk of motor vehicle crashes, a leading cause of mortality among young adults. Thus, both from the standpoint of providers and patients, the hours routinely worked by health care providers in the United States are unsafe.

As Landrigan et al.[12] discuss, governments abroad have

Medical Errors Reported by Residents Relative to the Number of Extended-Duration Work Shifts (> 24 hours) per Month

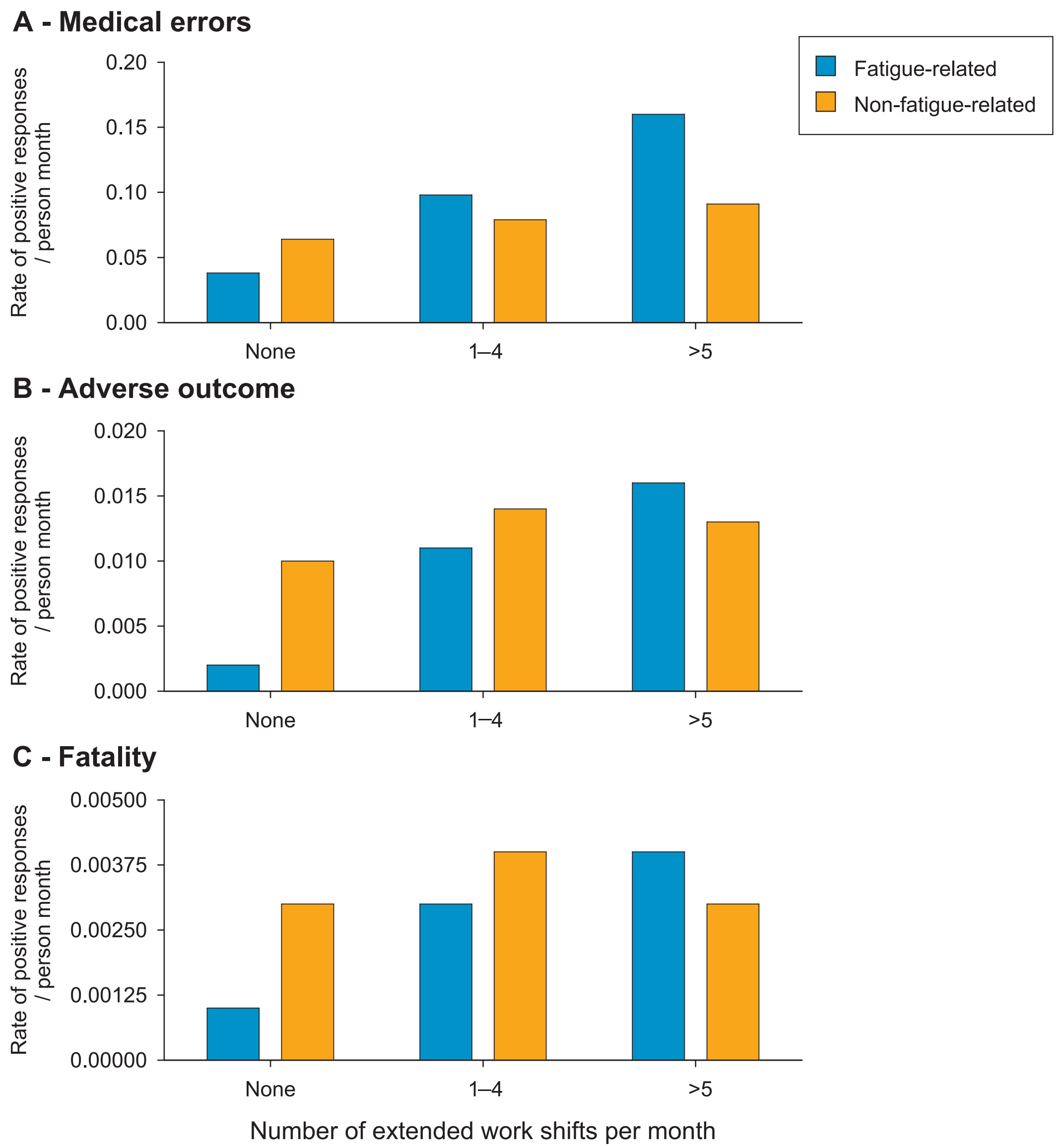

Figure 4. *This figure shows the rate of (A) medical errors, (B) medical errors resulting in an adverse patient outcome and (C) medical errors resulting in a patient fatality reported by postgraduate year (PGY)-1 residents relative to the number of extended-duration work shifts (> 24 hours) worked per month and whether the resident ascribed the error as fatigue-related (■) or non-fatigue-related (■). The rate of self-reported fatigue-related errors increased with increasing number of extended-duration shifts. The odds ratios (OR ± 95% confidence interval) for medical errors, adverse outcomes, and fatalities in months when residents worked five or more extended-duration shifts were 7.5 (7.2–7.8), 7.0 (4.3–11), and 4.1 (1.4–12), respectively, as compared with months in which no extended-duration shifts were reported (see text). The rate of self-reported errors not categorized as due to fatigue did not increase significantly with the number of extended-duration shifts. Data replotted from Barger L.K., et al.: Impact of extended-duration shifts on medical errors, adverse events, and attentional failures.* PLoS Med *3:e487, Dec. 2006.*

Effect of 24–30 Hours of Acute Sleep Loss on Various Types of Performance Based on a Meta-Analysis of 60 Sleep-Deprivation Studies of Physicians and Nonphysicians

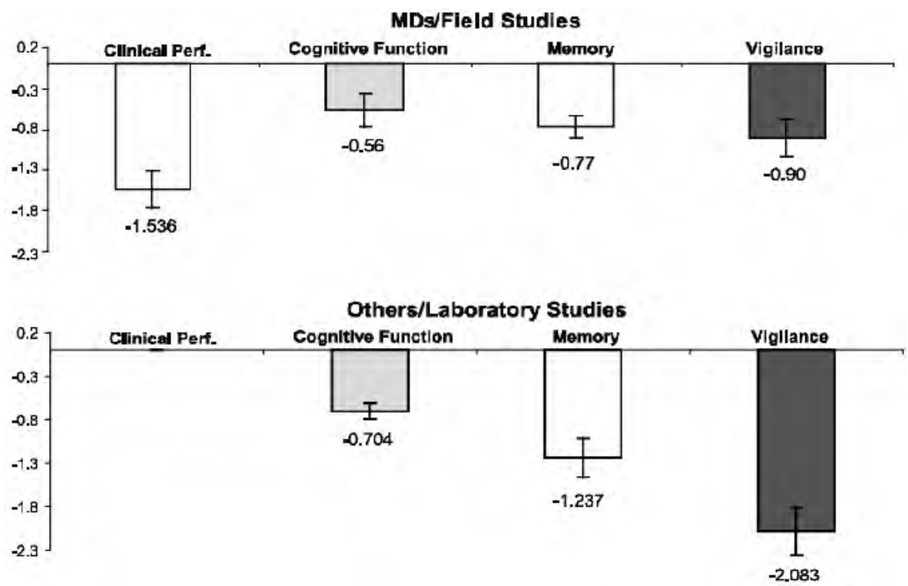

Figure 5. *The figure shows the effect of 24–30 hours of acute sleep loss on various types of performance based on a meta-analysis of 60 sleep-deprivation studies of physicians (top panel) and nonphysicians (bottom panel). The average effect sizes are shown for each performance type and are corrected for measurement error and standard error of the corrected effect sizes. Following 24–30 hours on duty, physicians' clinical performance deteriorated by ~1.5 standard deviations as compared to when 'rested' (top panel). As most of these data were collected under 'field' conditions, however, physicians in the 'rested' condition were unlikely to be non-fatigued, which may explain the greater effect of sleep deprivation observed under more highly controlled laboratory conditions (bottom panel). Reproduced with permission from Philibert I.: Sleep loss and performance in residents and nonphysicians: A meta-analytic examination.* Sleep *28(11):1392–1402, Nov. 1, 2005.*

taken an active stance to address this problem. To reduce the unacceptably high rate of preventable fatigue-related medical error and injury among health care workers, the United States must establish and enforce safe work-hour limits for health care providers. J

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