

Circadian Rhythms and Shift Work *Policy Resource and Education Paper (PREP)*

This policy resource and education paper (PREP) is an explication of the policy statement
“Emergency Physician Shift Work”

Introduction

Emergency medicine is known as a high stress specialty. The adverse effect of constantly rotating shifts is the single most important reason given for premature attrition from the field. The problems of rotating shifts stem mainly from working in opposition to the body's normal circadian rhythms. The major circadian rhythm involved is the sleep/wake cycle. Social isolation of those who must work while others sleep is also a major problem.

There are many biological and social problems associated with rotating shifts. Physical problems include an incidence of peptic ulcer disease eight times that of the normal population. Cardiovascular mortality has also been noted to be increased among shift workers.¹ Other physical problems include chronic fatigue, excessive sleepiness, and difficulty sleeping. Part of the social toll on those who must work rotating shifts is reflected in an increased divorce rate. Shift workers are also known to have higher rates of substance abuse and depression. Shift workers are much more likely to view their jobs as extremely stressful. Accidents are increased as a result of working night shifts. Many of the major disasters attributed to human error (Exxon Valdez oil spill, Three Mile Island, Bhopal chemical plant explosion, Chernobyl), occurred on the night shift, when alertness is at its lowest point.

Emergency medicine prides itself on adhering to “any patient, any time, 7 days a week”² However noble this motto seems at 0900 on a random Tuesday morning meeting, it must be fulfilled by real (and usually other) people at 0300 Saturday morning. These early Saturday morning health care workers may be held to the same expectations as their Tuesday bright morning colleagues. This paper will explore the science of sleep, some of the emerging science explaining performance degradation in the setting of disordered sleep, present suggestions for mitigating some of the damage of sleep disharmony, and suggest certain strategies in caring for workers subjected to these non-physiologic conditions. Finally, several intriguing questions and goals will be posed.

Circadian Rhythms

Circadian comes from two Latin words *circa*: about and *dia*: day. It refers to the bodily rhythms that vary throughout the day in a periodic fashion. These rhythms have been recognized since the times of Aristotle and Hippocrates. Many bodily functions exhibit circadian rhythms, from the best-known sleep/wake cycle to all of the vital signs. As we become capable of more precise measurements, more and more circadian cycles are being recognized. Even bone length has been found to exhibit a circadian periodicity.

Most circadian rhythms have both an endogenous component (regulated by an internal clock located in the supra-chiasmatic nucleus of the hypothalamus) and an exogenous component.³ The exogenous

component is composed of various time clues called *zeitgebers*. (German: “time giver” (synchronizer)⁴.) One of the most powerful *zeitgebers* is the light/dark cycle.

Temperature is one of the best studied of the circadian rhythms and exemplifies the effect of both endogenous and exogenous factors. People with a diurnal (work during day, sleep at night) orientation have a peak temperature about 4:00 pm and a trough about 4:00 am. During the day, people are up using muscles, generating heat, and eating, which produces heat as food is metabolized. During the night, not only is muscle use decreased, but one doesn't eat. Subjects kept in a so-called steady state, forced to remain in bed but awake and fed the same amount of calories each hour, continue to exhibit the same temperature curve, but not with as much periodicity (peaks and troughs do not differ by as much). In normal individuals, the endogenous and exogenous components of the circadian rhythms tend to complement each other and work in harmony.⁴ Those who must work at night and sleep during the day pit the endogenous and exogenous components against each other and suffer the consequences.

One important finding about the internal “clock” is that it runs on a 25-hour day, not the expected 24-hour day. Subjects who are isolated and removed from all *zeitgebers* will predictably go to bed an hour later each “day” and sleep an hour longer into the next day. Why this is so is unknown. It is postulated that this allows the body to adjust depending on the season and other external considerations. This 25-hour day explains why it is so easy to stay up later during holidays but so hard to get back on a work schedule where one is rising earlier. It is also why traveling from east to west is much easier (where one adapts by staying up later and sleeping in) than vice versa. This is the basis for recommending a clockwise shift rotation; it takes advantage of the natural tendency to stay up later.

Different circadian rhythms change at different rates and with greater difficulty. This accounts for the out-of-sorts, jet-lagged feeling as one attempts to change to a nocturnal schedule and vice versa. This jet-lagged feeling while different circadian rhythms adjust at differing rates is the inevitable result of attempting to reset one's bodily clock to a nocturnal schedule. It is referred to as circadian disharmony.

Sleep

To understand the effects of shift work and how to best schedule any 24-hour operation, some understanding of sleep is necessary. Little enough is known about normal sleep taken at night, but even less is known about the sleep of those who must attempt to sleep during the day and work during the night. It is not clear how much sleep is actually necessary for optimal health. There is evidence that very long natural sleepers and very short sleepers have increased mortality.⁵

Sleep makeup and duration are under current debate. It appears fairly settled that adolescents need more sleep later into the morning hours than other ages.⁶ The American Academy of Sleep Medicine released a Consensus Statement: “Recommended Amount of Sleep for a Healthy Adult.”⁷ In brief, the panel concluded that 7.5 hours of solid, good quality sleep is needed for optimal health. The adverse consequences of more or less sleep are reviewed.

Sleep is divided into several stages based on electroencephalogram (EEG) criteria. Stage I is the initial part of any sleep episode lasting 10 to 15 minutes. Most subjects when awakened from stage I will deny being asleep at all. Stage II accounts for the largest percent of sleep (50%), yet it is the least understood of all sleep stages, because it is the matrix from which all the other stages proceed. Sleep stages are typically studied by selectively depriving a subject of that particular stage and observing the results. Attempts to selectively deprive a subject of stage II sleep results in total sleep loss because it is impossible to enter other stages without going through stage II. Stage II is the stage least likely to be made up after a period of sleep deprivation, and the most likely to be increased with the use of sedative hypnotics. Stage III and IV are now collectively termed slow wave sleep or (SWS) (the only difference between the two is the

absolute number of delta waves recorded on the EEG). In contrast to stage II, this stage is most constant from individual to individual and most consistently made up after a period of sleep deprivation. SWS is felt to be important for bodily repair. It is the stage during which growth hormone is secreted during normal sleep. The single most important determinant of SWS is the length of time since the last sleep episode, and as such, it is not as subject to circadian factors. Rapid eye movement (REM) sleep is the most well-known sleep stage. During this time, the body is completely paralyzed, and in fact loses its thermoregulatory properties. This is the main time when dreaming occurs, which is thought to be important for psychological adjustment and development. Unlike SWS, REM is highly influenced by circadian periodicity.

Normally these stages cycle throughout the night in periods of about twenty minutes, with relatively more SWS alternating with stage II in the earlier part of the night, while REM sleep dominates during the latter part of a sleep episode. Many things can alter this sleep architecture. Drugs are an important cause of altered sleep patterns; caffeine causes a more rapid than normal cycling between stages, while alcohol suppresses REM sleep.⁸ Sedative hypnotics (with the possible exception of zolpidem) will result in greater total sleep time but almost exclusively increase stage II sleep (which may not be particularly restorative). Noise, even if it doesn't awaken one, will alter sleep cycles. Circadian placement of sleep is also very important.

Daytime sleep is typically one and one-half to two hours shorter than a nocturnal sleep period. REM and to a lesser extent stage II are the most shortened. This compounds the problems of alertness on the night shift. The night worker must contend not only with the expected circadian trough of energy and alertness, but also with sleep deprivation from the poor quality of daytime sleep. Many shift workers develop a near obsession with sleep.

Social/Domestic Factors

The social effects of rotating shifts on the worker and the family are also important. Society seems to actively subvert the shift worker. Neighbors insist on mowing their lawns while a night worker is sleeping. People who would never telephone at 2:00 am routinely do so at 2:00 pm when the night worker is attempting to sleep. Education of the worker and his family is one of the most important strategies for coping with shift work. Everyone in the family must understand that shift work is a lifestyle. Most of society realizes that sometimes one must work during important social functions, but they are not so forgiving if one is "only sleeping." One of the most important things any shift worker can do is to acknowledge the negative impact of shift work and attribute more importance to circadian principles. Other industries have demonstrated greater productivity and increased job satisfaction by applying circadian principles to scheduling.⁹

Commuting

The risk of "drowsy driving" is increasingly recognized. Sleep deprivation has been equated to driving while intoxicated and over 1000 fatal motor vehicle crashes yearly are attributable to falling asleep behind the wheel.¹⁰ Commuting home after a night shift is recognized as being a major risk factor for motor vehicle crashes. Providing a place for a post shift nap before driving home is recommended.

Scheduling Strategies and Shift Length

How best to schedule a department is one of the most important issues for adaptation to shift work. Unfortunately, there is no one best schedule. Many factors must be considered including the census and acuity of the department, individual group member's preferences, group size, part time help, etc. Two of the biggest issues are number of night shifts in a row and shift length. In general people find it more

tolerable to have a schedule based on a forward rotating circadian rhythm, rather than backward, as in, working several day shifts, then evening, shifts, then night shifts if needed.

Another major decision for any group is how many hours in a row to work. It is well known amongst practicing physicians that there are additive effects of fatigue from working multiple days in a row. The effects of this are surely real, though they have not been explored rigorously in the literature, and no standard has been established as to how many shifts in a row is safe to work.

There are myriad shift arrangements possible. Some departments utilize 12-hour long shifts, and some departments use a mix of shorter shifts to stagger physician coverage. The major advantage to 12-hour shifts is having more days off completely free of hospital responsibilities. As physicians age or as patient census and acuity increase, most find shorter shifts more appealing. There is evidence that physician productivity does not stay stable over the course of the shift; rather, physician productivity decreases steadily over the course of a shift.¹¹ Presumably, the quality of care the physician provides also decreases over the course of a shift, though this has not been demonstrated empirically.

Most departments have seemed to settle on an industry standard of morning, (e.g. 7am to 3pm), evening (e.g. 12pm to 8pm, 3pm to 11pm), and overnight shifts (e.g. 11pm to 7am). But the exact configuration of scheduled shifts in the department is almost as numerous as there are departments, though most departments stagger shifts to increase coverage during busy afternoon and evening hours, with lighter coverage during the night and morning.

Night Shift Scheduling

There are two diametrically opposed approaches to scheduling night shifts. From a circadian perspective, the gold standard is never to rotate shifts. A group lucky enough to find someone who will work permanent nights should work hard to retain him or her and make sure they are appropriately compensated.

Lacking a permanent night member, one strategy is to have each member do “block nights,” ie, do nights for two months solid. During this time, other members will do only occasional nights. This block night rotation (with a hypothetical group of six) would come around but one time a year.

The other strategy is to work as few nights in a row as possible, ideally one. The idea is to never reset your circadian rhythms but to maintain a constant diurnal orientation. Which strategy a group uses depends on whether one finds circadian disharmony, that jet-lagged feeling as one adjusts to a stretch of nights and then back again to days, or inappropriate phasing, being awake and alert at night when one is used to being asleep, to be most distasteful. Working 4-7-night shifts in a row is universally condemned. One suffers from inappropriate phasing during each night shift and then, just when the body starts to adapt to nights, switches back again, experiencing the worst of both systems.

The major benefit of working many night shifts in a row is that once adjusted to nights one will be alert, well rested, and provide optimal patient care, rather than struggling to stay awake for every single night shift. With the use of bright lights and possibly melatonin, rapidly adjusting circadian rhythms has become possible. Many individuals oppose this strategy for social reasons. They fear never seeing their families during night shifts. This is a key place where education and recognition of the tolls of traditional shift work can come into play. This strategy assumes that one will work a certain number of nights each year. While one may not see as much of their family during their time on nights they can spend proportionately more time during the remaining 10 to 11 months and be well rested and fun to be around.

Night shift performance

There is a common belief that one “adapts” to night shift work. Research indicates this is a myth. Night workers demonstrate consistent degradation in work performance when experiencing chronic sleep loss. This adverse effect on performance appeared to be most pronounced in the morning.¹² Acute/one-off losses do not appear to create the same effect.¹³ The good news here: performance appeared to return to baseline acutely with extended good quality rest. However, this restorative sleep did not appear to mitigate the long-term adverse health consequences of chronic sleep loss.¹³ The self-declared perception of adaptation may have its origins in the Dunning-Kruger effect.

Shift Length

Another major decision for any group is how many hours in a row to work.¹⁴ Traditionally most groups have worked two primary shifts of 12 hours each, with additional double coverage shifts of varying lengths as needed. There is a trend to shortening the primary shift. Patient care is thought to be improved with a better rested, more alert physician. There is also the ability to enjoy recreational pursuits even on workdays with shorter shifts. Circadian principles are much more easily applied with 8-hour shifts. If a group adopts a system of many nights in a row, shorter shifts are an advantage.

The major advantage to 12-hour shifts is having one-third more days off completely free of hospital responsibilities. Those with a long commute are likely to favor longer shifts as well as those lucky enough to reliably get 2 to 3 hours sleep on each night shift. As physicians age or as patient census and acuity increase, most find shorter shifts more appealing. Patient care is probably improved with shorter shifts.

Other scheduling strategies for groups to consider are to change shifts at different times. Some groups work from 2 am to 10 am, 10 am to 6 pm, and 6 pm to 2 am. With this system, each person gets some sleep during the normal sleep time. Many groups also vary shift length, typically making the night shift shorter, i.e., 10-hour day shifts, 8-hour evening shifts, and 6-hour night shifts. It is also possible to shorten the night shift by overlapping shifts, i.e., 7 am to 3 pm, 3 pm to 12 pm, 1 am to 7 am with an overlap shift from 6 pm to 2 am. The department will have single coverage for one hour from 12 pm to 1 am but when the night person arrives there will be double-coverage again until the bulk of patients have been seen.

Shift Differentials

Just like in other industries, emergency departments often provide supplemental bonus pay to individuals who work unfavorable hours, particularly overnight shifts, if such shifts are not equally distributed amongst all physicians. Although there is scant research on the topic, it is widely accepted that working night shifts becomes more difficult as one ages and increases the potential for errors. Older members who don't tolerate nights well often gladly “pay” extra to those younger members who are more tolerant of nights and less secure financially. It is relatively easy to devise a reimbursement system whereby the night shift pays relatively more and other shifts proportionately less. In other industries, this helps retain valuable workers who would otherwise prematurely retire as night shifts become increasingly burdensome. Some groups reward night shifts in other ways such as fewer total shifts and/or fewer weekend and holiday shifts. Non-monetary incentives for working nights should also be considered such as decreased administrative duties.

Individual Strategies

There are also many individual strategies to help adapt to shift work. One of the most important is education of family and friends. Many studies have shown that those who are most successful at shift work don't try to live in two different worlds. Friends and family should be educated about the importance

of uninterrupted daytime sleep. A dark, cool, quiet sleeping place increases both total sleep time and sleep quality. Blackout curtains are a worthwhile investment for all who must sleep during the day.

The American Academy of Sleep Medicine's definition of Shift Work Disorder (SWD) may apply to many emergency physicians who routinely work a rotating mix of day, evening, and night shifts.^{15,16} In the appropriate circumstance, the American Academy of Sleep Medicine recommends planned napping before a night shift to enhance performance, as well as environmental light exposure during the night shift, and environmental light-restriction after the night shift. Under the counsel of an individual's personal physicians, melatonin and hypnotic medications to enhance daytime sleep can be used to promote daytime sleep, or more restful sleep, though these medications may cause residual sleepiness during the shift which is obviously detrimental. Stimulants such as caffeine are widely used by individuals, though prescription stimulants, such as modafinil, should only be used under careful physician oversight.

There are also individual sleeping strategies that can be used. A split sleep period is a technique where one sleeps for 3 to 4 hours immediately before and 3 to 4 hours immediately after a night shift. The rationale is that at least part of each sleep episode is during the circadian period when sleep is expected. Anchor sleep is a technique used following one's shift during a series of nights. It is basically a compromise to switching to a diurnal orientation. One would stay up until 3 am or 4 am and then sleep until 10 am or 11 am. That way one gets some time to socialize but doesn't completely lose a nocturnal orientation. Naps are problematic.¹⁷ Regularly scheduled naps can be effective and some industries with multiple workers on night shifts include them in their shift design. In general, however, random unscheduled naps serve to hinder adaptation (making it harder to get proper sleep during the planned sleep period) and do not increase alertness or improve mood.

Pharmacology must also be considered. Sedative hypnotics should not be routinely used by night workers. They are very addictive and, while they do increase total sleep time during the day, they do not hasten resetting of rhythms to night shifts or improve alertness during the night.¹⁸ Shift workers nearly universally use caffeine. It can increase alertness but can alter sleep architecture when used within 4 hours of a planned sleep period. Another alerting agent of proven benefit is modafinil, and more recently its isomer armodafinil.¹⁹ They are in the broad family of amphetamines but are felt to have very low abuse potential. They are not proven to be significantly more alerting than higher doses of caffeine (500-600 mg) but may have fewer side effects. Alcohol induces sleep, but the sleep is markedly distorted with decreased REM sleep, which is already diminished during daytime sleep periods. Another pharmacological agent which holds promise is melatonin. It is a hormone secreted nightly by the pineal gland in response to darkness. Melatonin is a sedative but more importantly has been shown to hasten resetting of circadian rhythms. Ramelatonin, a selective melatonin receptor agonist, has proven to be a useful long-term hypnotic agent, although its use for daytime sleep is untested.²⁰ Several studies of jet lag have shown significant improvement with melatonin. Careful timing of melatonin has also been shown to be helpful for shift workers. Bright light of greater than 3,000 lux can also hasten resetting of circadian rhythms.²¹ Bright lights during the nights will increase alertness on the night shift and rapidly convert circadian rhythms. Bright light in the early morning (5 am to 7 am) can hasten adaptation back to days by phase advancing one's rhythms and allowing earlier night sleep. Exercise is a useful strategy to adapt to shift work. Not only does it improve general mood but also promotes alertness on night shifts (if not too strenuous). It has been shown to increase circadian adaptation also. Aerobic exercise immediately after awakening, no matter which shift one is working, is most effective.

Conclusions

Shift work is a necessary fact of life for emergency physicians. Emergency physicians must attribute more importance to well-being and acknowledge adverse effects of shift work. This includes making rational

schedules from a circadian perspective. Individual strategies should also be employed, particularly good sleep hygiene and decreasing potential interruptions.

Future goals and research

Emergency medicine has accepted the mantle of care at any time for any person. There are areas that need discussion and action:

Personal wellness, caring for the caretaker in the fashion we want the caretaker to care for the patient. This means discussing whether giving money to physicians who give up years of life by working nights (shift differentials) is morally just and sufficient versus finding ways to lift some of life's exigencies. Stanford model may be a lead.²²

Emergency medicine has agreed, by its ethics, to care for all who come to the same level. In return, society should provide some protection from liability. Our current system is built on arrangements that are voluntary on both sides, using 49-51% (preponderance of evidence, "more likely than not") standards to adjudicate the routine of care. Using EMTALA, ACEP is advocating for protection under FTCA (Federal Tort Claims Act, H.R. 548/S. 527.) Various states have enacted higher standard for negligence, 85-15% (clear and convincing) EMTALA-related medical care. Regardless of "how," in return for 24/7/365 coverage, emergency physicians are owed protection from the society we protect.

Finally, we desperately need research into physician well-being and coping mechanisms. What gets a physician into 3+ decades of active practice? How do we create leadership that can support the newest members of our specialty? Given that coverage is needed 24/7/365, what are the best strategies? What, among the topics above and discussed in our conferences, is Eminence Based Medicine?

Revised by the Well-being Committee under the direction of Thomas E. Benzoni, DO, FACEP - June 2017

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Resources

Sleep, An Essential Coin of the Realm in Emergency Medicine

Emergency Medical Abstracts, Volume 39, Number 2, February 2015. Available at: Ccme.org.

Written by Billy Mallon, MD and Michele Lin, MD, published by Rick Bukata, MD's EMA, this article summarizes the field succinctly with a good visual.

Association Between Rotating Night Shift Work and Risk of Coronary Heart Disease Among Women

Vetter C, Devore EE, Wegrzyn LR, et al. Association between rotating night shift work and risk of coronary heart disease among women. *JAMA*. 2016;315:1726-1734.

Part of the Nurses' Health Study, this group is watching nearly 200,000 nurses as they work; this is a robust source of longitudinal morbidity and mortality data. It appears to show an increased risk of heart disease proportional to night shift attendance and a reduction with getting off nights.