

WORK SCHEDULES AND SLEEP PATTERNS OF U.S. RAILROAD SIGNALMEN

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LIST OF FIGURES

FIGURE 1. Duration of Nighttime Sleep on Workdays for Signalmen versus U.S. Adults 16

LIST OF TABLES

TABLE 1. Work Schedule by Job Type	11
TABLE 2. Workday Schedule by Job Type (median times)	12
TABLE 3. Typical, Nominal, and Actual Work for 2-Week Period (hr:min).....	13
TABLE 4. Nighttime Sleep Duration versus U.S. Adult Norms by Type of Day (hr:min)	15
TABLE 5. Sleep Ratings and Duration by Sleep Disorder Status.....	18

ABSTRACT

Objectives

The project objectives were 1) to document and characterize work/rest schedules and sleep patterns of U.S. railroad signalmen and 2) to examine the relationship between these schedules and level of alertness/fatigue.

Approach or Methods

A random sample of actively working U.S. railroad signalmen was selected for participation in the study. Each participant completed a brief background survey and kept a 2-week daily log. The background survey collected demographic information, job characteristics and health status data, including diagnosis of a sleep disorder. Using the daily log, the signalmen reported daily sleep and work times and provided subjective assessments of sleep quality and alertness.

Results

A total of 409 signalmen, with a median age of 46, participated in the study. The majority work non-construction jobs, which are subject to emergency call. Six percent reported having a diagnosed sleep disorder. Construction jobs have consistent schedules, but non-construction jobs are subject to start time variability. The probability of an unscheduled work period for non-construction jobs was .09 on a workday and .18 on a planned day off. Non-construction signalmen averaged 1.9 unscheduled work periods in 2 weeks. Both groups had the same amount of nighttime sleep, but non-construction signalmen had lower sleep quality ratings and reported lower levels of alertness.

Conclusion

Unscheduled work periods impact next day alertness, but the effect size is small, so reducing emergency call will not have a substantial impact. Lower alertness of non-construction signalmen is likely due to start time variability as well as unscheduled work periods.

INTRODUCTION

Because railroading is a round-the-clock, 7-days-a-week operation, many of the crafts involved in operating and maintaining the nation's railroads are subject to fatigue. The Federal Railroad Administration (FRA) and the railroad industry, through the North American Rail Alertness Partnership (NARAP), have focused on the issue of fatigue among train and engine crew personnel. In 2001, the FRA suggested and NARAP concurred on the need to study the fatigue issues of the non-operating crafts, which include locomotive and car repair, right-of-way construction and maintenance, signal system construction and maintenance, and telecommunications. For the non-operating craft groups, staff shortages, seasonal work, expanding territories, and response to emergency situations can result in long work hours leading to fatigue. The FRA decided to focus initially on signalmen.

Nature of the Signalman's Job

Signalmen work two fundamental types of jobs: maintenance and construction. Signal maintainers are responsible for inspecting and certifying the functioning of the signal and communication equipment on a specific track territory. The maintainer is also responsible for making minor repairs as he/she inspects. Depending upon the railroad, a separate gang of maintainers may be responsible for repairs that cannot be done in the course of the routine inspection. The nominal schedule of a maintainer is regular, but the maintainer is also subject to call for emergencies at night and on weekends. Major yards also have maintainers permanently assigned to maintain the signal system in the yard. These individuals work on a shift work schedule to cover the yard around the clock. Most signalmen work on wayside signal equipment, but a limited number work on communications equipment, such as radios and antenna systems.

In contrast to the maintainer, a signalman who works on a construction gang will usually work a compressed schedule of, for example, 8 workdays followed by 6 days (d) off, and is rarely called for an emergency. Maintainers work in a defined geographic area. In contrast, signalmen on a construction gang can work anywhere on the railroad's system and likely travel long distances, on their own time, to reach the construction sites.

Since 1976 the Hours of Service Law for railroad workers and the associated FRA regulations (49 C.F.R. § 228) have applied to a railroad employee “engaged in installing, repairing or maintaining signal systems.” This Law provides that, after working 12 consecutive hours (hr) in a 24-hr period, a signalman must have at least 10 consecutive hr off before being permitted to return to work. If the employee works less than 12 hr in a 24-hr period, then he/she must have at least 8 hr off before returning to duty. However, if an employee works up to 12 non-consecutive hr during a 24-hr period, the employee must have at least 8 consecutive hr of rest before returning to duty. The Law includes an emergency provision that permits employees to stay on duty up to 16 hr if extraordinary circumstances necessitate continued service. The carrier must report such instances to the FRA, and the burden of proof rests with the carrier to establish that excess service could not have been avoided.

Signal maintainers are responsible for responding to emergencies at night and on weekends. Depending upon the nature of the territory, signal maintainers may have an “on call” schedule, but more commonly they are responsible for all emergencies in their territory. When an emergency call comes, if the signalman has not worked 12 hr, he/she may report back to work to handle the emergency.

While the intent of the Hours of Service Law is to reduce fatigue and ensure that signal employees are rested when performing their safety sensitive duties, situations arise where the provisions of the Hours of Service Law are extremely deficient. For example, a signal maintainer goes to bed at 10 p.m. on a Sunday night and gets up at 5 a.m. to report to duty on Monday morning. He/she works the regular shift from 7 a.m. until 4 p.m. The mandatory rest period begins at 4 p.m. and ends at 12 a.m. Tuesday morning. Under the Hours of Service Law, he/she is considered fully rested at this time. At 12:30 a.m. he/she is called for duty. Being fully rested at 12 a.m., according to the regulations, a new 24-hr work period begins at 12:30 a.m., the time of the trouble call. The signalman can now work 12 consecutive hr, possibly up to 16 consecutive hr if it is an emergency. While under the law he/she is considered fully rested, the reality is that after being released from work at 12:30 p.m., on Tuesday, or 4:30 p.m. in the case of working 16 consecutive hr, the employee likely has slept for not more than 2 or 3 hr over the past 31.5 hr or 35.5 hr. In either case this individual will be suffering from sleep deprivation and is more likely to make a mistake in performing his/her duties.

Objectives

The objectives of this study were:

- To document and characterize the work/rest schedules and sleep patterns of U.S. railroad signalmen.
- To examine the relationship between these schedules and level of alertness/fatigue for the individuals who work the schedules.

Scope

The goal was to characterize U.S. signalmen as a group, not to characterize signalmen on a specific railroad. Making specific recommendations regarding fatigue countermeasures was beyond the scope of this study.

STUDY DESIGN

Characterizing the work and sleep patterns of U.S. signalmen required a nationwide survey. The only practical means of reaching these individuals was through their union, the Brotherhood of Railroad Signalmen (BRS).

Survey Instruments

The study used two survey instruments: a background survey and a daily log. The background survey was designed to gather demographic information, descriptive data for the signalman's job type and work schedule, and a self-assessment of overall health. The purpose for collecting this data was twofold. First, it provided data for characterizing the U.S. signalman population. Second, it provided identifying data that was used in conjunction with the daily logs to characterize the work/sleep patterns of the two major categories of signal jobs, maintenance and construction. Completion of the survey required less than 15 minutes (min).

A daily log was developed for recording sleep and work periods on both regular workdays and planned days off. Signalmen recorded not only the starting and ending times for each sleep and work period but also a self-assessment of alertness at five times during the day and sleep quality upon arising. These subjective assessments used a Likert scale. The daily log included space to record "Comments on today's sleep experience" and "Comments on today's work experience." The instructions for the log encouraged participants to use this space to

explain anything unusual about the day's sleep or work. These comments proved useful in understanding an irregular work or sleep pattern. The work log portion of the daily log included space to record "unscheduled work periods." This section was designed to capture response to emergency calls beyond the normal workday and work periods on a planned day off.

Data Collection Period

Examination of the relationship between work schedules and fatigue requires data that includes a full work cycle. Fatigue is cumulative and its effects on the individual are not readily identified from 1 or 2 days (d) of data. Also, adequate data must exist to compare sleep periods from both work and rest days. The length of the typical signalman's work cycle was also a consideration in determining the length of the data collection period. Signal maintainers tend to work a regular work week of 4 or 5 d followed by 2 or 3 d off. In contrast, those working construction jobs tend to have a 14-d compressed work cycle. To capture the work cycle of the construction jobs, it was necessary to collect 14 d of work and sleep data. Since it was not possible *a priori* to identify those signalmen who work a construction job, all participants provided 2 weeks of data.

Sampling Plan

The BRS maintains a database with the names, mailing addresses, and dates of birth for all of its members. Because signalmen frequently change from working one type of job to another, this information is not in the BRS database. Only actively working BRS members living in the U.S. were included in the sampling frame. Retirees, full-time union officials, and anyone currently holding a railroad management position were specifically excluded. The BRS membership includes a small number of telecommunications workers. Since the Hours of Service Law does not apply to these people, it was preferable to exclude them from the sampling frame. Unfortunately, no way existed to identify them *a priori*. The effective sampling frame was 8,241 after the exclusions were made.

The FRA felt that 95 percent confidence was adequate for this study and that estimates of work hours and sleep time should be within 15 percent (± 7.5 percent) of the true value. Using the BRS estimate that 60 percent of their members worked maintenance jobs and the remainder construction jobs, the survey required 327 participants. Assuming a 40 percent response rate, a

total of 819 signalmen were selected randomly without replacement from the sampling frame described above.

Survey Procedure

In accordance with government regulations, the FRA sought and received approval for this collection of information under Office of Management and Budget (OMB) control number 2130-0558 on October 2, 2003. The survey materials were mailed to a simple random sample of 819 signalmen on October 16, 2003. One month (mo) after the survey materials were mailed, every survey recipient received a reminder postcard encouraging them to participate in the study. Respondents who completed both the background survey and daily log received a gift certificate to a national retail chain as compensation for their participation in the survey.

RESULTS

This study used a confidence interval of 95 percent. SPSS 11.5 was used for statistical analysis of the data.

Survey Response Rate

The survey materials were mailed to 819 signalmen. A total of 409 people returned both the background survey and the daily log, yielding an overall response rate of 49.9 percent. Of the 409 complete responses, 20 were not usable, leaving a total of 389 responses that were analyzed.

OMB requires that a non-response bias study be conducted if the survey response rate is below 75 percent. The purpose of the non-response bias study is to assure that there is no difference in the characteristics of the survey respondents versus the non-respondents. Both the respondent and non-respondents groups were divided into two age groups: 1) age 43 and younger and 2) age 44 and older. This age breakdown corresponds to that used in a recent study that examined age-related changes in sleep of healthy men (1). Analysis of the mean age for each of the two age subgroups found no significant difference between the respondents and the non-respondents, for 43 and under, $t(351) = -.808, p = .420$ and for 44 and over, $t(450) = .098, p = .922$.

Signalmen Demographic Characteristics

The median age of a signalman is 46, with the construction signalmen being on average 4 years (yr) younger than their maintenance counterparts. Construction signalmen have a median of 8.9 yr of experience as a signalman with nearly all of it being with their current employer. In contrast, maintenance signalmen have 24 yr of experience with 18.7 yr of it with their current employer. Railroad signalmen are a predominantly male population. Less than 1 percent of the survey participants were women, so segregation of results by sex was not meaningful.

A majority of signalmen, 65 percent, worked maintenance jobs, while 28.5 percent worked construction jobs. “Yard maintenance” (5.7 percent) and “other” (0.8 percent) accounted for the remainder. Because construction jobs tend to have different work schedules and are rarely subject to emergency call, all further analyses by job type compare construction jobs with all “non-construction” jobs. Non-construction includes “maintenance,” “yard maintenance,” and “other.”

At the time of the study, 85.3 percent of participants were married, 7.7 percent were divorced, 5.7 percent single, 0.5 percent widowed, and 0.8 percent fell into the “other” category (these people were likely “separated” or “living together”). The most recent U.S. Census data indicates that 56.6 percent of the U.S. population 18 and over and 58.9 percent of the U.S. male population in this age group are married (2). Since many railroaders report that their work schedule strains marital relationships, finding such a high proportion of signalmen to be married was surprising. However, this data does not indicate whether or not the married individuals were in an initial marriage or one subsequent to a divorce.

Nearly 25 percent of the signalmen rated their health as excellent, and 62 percent rated it as good. Taken together, over 86 percent rated themselves in good or excellent health. These ratings are reflected in the relatively small number of workdays missed due to illness in the last 6 mo. Only 16 percent of participants lost a workday due to illness. The low number of workdays lost due to illness may be due in part to the fact that signalmen must use vacation or personal days for these absences.

Although the signalmen appear to be a relatively healthy group, 22 signalmen (5.7 percent) reported having a diagnosed sleep disorder. Fifteen of those people (68.2 percent) reported being treated for the disorder, with seven reporting no treatment (31.8 percent). The background survey which solicited this information inquired about *diagnosed sleep disorders*,

not sleep apnea specifically. Because of the wording of the question, it is not possible to determine whether or not signalmen have a higher rate of sleep apnea than the U.S. adult male population. The Wisconsin Sleep Cohort Study, a longitudinal study of cardiopulmonary sleep disorders among middle-aged working adults, estimated that 2 percent of women and 4 percent of men have sleep apnea (3).

Job Characteristics

The study explored several aspects of the signalman’s job. The following sections discuss these aspects.

Work Schedule

Signalmen work one of three basic types of schedule: 4-d week, 5-d week, or 8-on 6-off. Half of those holding construction jobs worked a 4-d week, with the other half divided between a 5-d week and an 8-on 6-off schedule. Nearly all of the non-construction signalmen worked a 5-d week, with only a small number working a 4-d week. TABLE 1 presents the distribution of signalmen by job type across the various schedules.

TABLE 1. Work Schedule by Job Type

Work Schedule	Construction	Non-construction
4-d week	50.5 %	3.2 %
5-d week	22.5 %	95.7 %
8-on 6-off	26.1 %	0 %
Other	0.9 %	0 %
Not reported	0 %	1.1 %

Signalmen reported their “nominal” workday (as defined by their labor agreement) in the background survey. They reported “actual” workday start and end times in the daily logs. TABLE 2 contains the median times for each group’s workday. The median start time for both groups is 7 a.m., but because the construction group tends to work 4 10-hr days, their workday ends later.

TABLE 2. Workday Schedule by Job Type (median times)

	Construction	Non- construction
Start time (nominal)	7 a.m.	7 a.m.
Start time (actual)	7 a.m.	7 a.m.
End time (nominal)	5 p.m.	3:30 p.m.
End time (actual)	5 p.m.	4 p.m.
Meal break (nominal)	30 min	30 min

Start time variability can lead to fatigue if it disrupts the worker's normal sleep pattern. Backward rotation of the start time (i.e., when one starts work earlier than the prior day) can be especially problematic. To assess work schedule variability, start time variation was investigated. A variation in start time was defined as a change in start time of more than 1 hr from the previous day. In the 2-week timeframe of the study, 10 percent of construction signalmen and 37 percent of non-construction signalmen experienced start time variation at least once. This relationship between start time variability and job type is statistically significant, $X^2(4, N=389) = 26.93, p < .05$. The higher level of variability in the non-construction signalmen's schedules likely results from their need to respond to emergencies.

Number of Hours Worked

The study collected data on a "typical" work week, "nominal" work week, and "actual" hours worked. On average, construction signalmen reported (in the background survey) a "typical" work week to be 43:34, and non-construction, 46:13. In a 2-week period, this equates to 87:08 for construction signalmen and 92:26 for non-construction (see TABLE 3). "Nominal work" was calculated based on the employee's job characteristics as reported in the background survey. "Actual work" for 2 weeks was computed from the daily logs.

For both job types the average "actual work" for the 2-week period was less than "typical work" but was greater than "nominal work." (Daily work period was defined as the elapsed time between start and end times minus the lunch break.) In other words, participants worked less than they said they typically do, but more than their normal, or nominal, schedules dictate. The difference between "nominal" and "actual" work schedules is likely due to any overtime extension of the nominal daily work period or a callback to respond to an emergency at night or on a planned day off.

Although the nominal schedules for both groups of signalman require 80 hr of work in 2 weeks, the “typical” and “actual” work hours for the non-construction group were larger than that of the construction group. This result is likely due to the emergency calls that non-construction signalmen must handle. During the 2-week survey period, a quarter of the construction signalmen worked at least 8 hr of overtime, and a quarter of the non-construction signalmen worked 12 hr or more of overtime.

TABLE 3. Typical, Nominal, and Actual Work for 2-Week Period (hr:min)

	Mean	Median	Std. Dev.	25 th %	75 th %
Construction					
Typical work	87:08	80:00	15:42	80:00	88:00
Nominal work	80:37	80:00	8:00	77:20	80:00
Actual work	83:16	80:00	16:07	73:58	88:19
Non-construction					
Typical work	92:26	90:00	12:14	80:00	100:00
Nominal work	79:18	80:00	2:31	80:00	80:00
Actual work	87:32	85:25	14:01	79:07	92:50

Unscheduled Work Periods

This study defined unscheduled work periods as any work period that was not in the employee’s nominal work schedule and that occurred on a planned day off or after the employee began the trip home at the end of the workday. Overtime that was an extension of the nominal work schedule was not considered an unscheduled work period. Callbacks, a subset of unscheduled work periods, are unscheduled work periods that occur on a regular workday. Because construction signalmen are rarely called out to work beyond regular work hours, all calculations for unscheduled work periods and callbacks included only non-construction signalmen.

Nearly two-thirds of signalmen (63.9 percent) had at least one unscheduled work period in the 2-week period of the study. A signalman was twice as likely to get called in for an unscheduled work period on a planned day off as on a regular workday (.18 and .09 percent, respectively). Based on the study period, signalmen averaged 1.9 unscheduled work periods per worker per 2-week period. Overall, the probability of getting called in to work an unscheduled work period on any given day was .12. If a signalman worked an unscheduled work period, the probability of that person being called back a second time was .14, and a third time, .04.

The time between the end of shift (on a workday) and the time called back to work (for an unscheduled work period) averaged 5:12. First and second callbacks (after regular work) lasted just over 2:20. It appears that the Hours of Service Law limited the length of the callback work periods because the average rest period was approximately 5 hr. (If a signalman works 10 hr in a day, then he/she can only work another 2 hr and then must have 8 hr off.)

Work Schedules and Alertness

Data from participants' daily logs revealed a statistically significant difference between the two groups in alertness assessments. The daily log data indicate that construction signalmen had higher alertness ratings than non-construction signalmen throughout the day. A series of *t*-tests validated this difference. Generally, peak alertness for both groups was just after arriving at work, which is around 7 a.m., after which, alertness levels declined throughout the rest of the day.

The study explored the relationship between several aspects of the signalmen's work schedules and alertness. One issue was the relationship between consecutive workday and morning alertness. No significant correlation existed between consecutive workday and mean morning alertness rating, $r = .010$, $r^2 = .0001$, $p = .540$, and no significant differences existed in morning alertness by consecutive workday, $F(4,3605) = .299$, $p = .879$.

Unscheduled work periods appear to affect morning alertness ratings. Alertness levels the morning following an unscheduled work period were significantly lower than on mornings not following an unscheduled work period, $t(5012) = 5.204$, $p < .05$. However, the effect size for this relationship was .25, a relatively small effect size. Cohen (4, p. 23) suggests that the effect size (ES) can be converted to r and r^2 using the following relationship:

$$r = \frac{ES}{\sqrt{ES^2 + 4}}$$

Using this formula, $r = .1228$ and $r^2 = .015$ which means that unscheduled work periods only explain 1.5 percent of the variance in morning alertness.

On those days with a start time variance from the previous day, alertness levels were significantly lower than on those days with no start time variance, $t(5376) = -6.579$, $p < .05$. The effect size for this relationship was .49, a medium effect size, but $r^2 = .056$ indicating that schedule variability explains only 5.6 percent of the variance in morning alertness.

The relationship between commute time, number of hours worked and time without a break, and alertness were also explored. Commute time did not affect alertness levels. Although statistically significant relationships existed between commute times (to and from work) and alertness, the correlations were very weak.

The number of hours worked in a day (not including unscheduled work periods after arriving home) did not affect alertness upon arriving at home from work. Although the correlation between the two variables was statistically significant, the strength of the relationship was very weak, $r = -.126$, $r^2 = .016$, $p < .05$.

A statistically significant relationship existed between “time without break” and “alertness upon arriving home,” but once again the correlation was very weak, $r = -.179$, $r^2 = .032$, $p < .05$.

Sleep Patterns

The study examined nighttime sleep as well as supplementary naps. The duration and quality of sleep were considered for both workdays and planned days off.

Nighttime Sleep

TABLE 4 presents nighttime sleep duration for the two groups of signalmen and U.S. adults. The National Sleep Foundation (NSF) 2002 “Sleep in America” Poll is the source of the data for U.S. adult norms (5). In terms of mean nighttime sleep, signalmen are averaging less sleep on regular workdays than U.S. adults, but on planned days off they are averaging more. However, in terms of median nighttime sleep, signalmen get less regardless of type of day. A statistically significant difference existed between average signalmen’s sleep and that of U.S. adults.

TABLE 4. Nighttime Sleep Duration versus U.S. Adult Norms by Type of Day (hr:min)

Day	Group	Mean	Median	Std. Dev.	25%	75%
Regular Workday	Construction	6:43	6:41	0:47	6:15	7:12
	Non-construction	6:45	6:47	0:46	6:21	7:13
	U.S. adults	6:54	7:00	NR	NR	NR
Planned Day Off	Construction	7:52	7:56	1:10	7:10	8:36
	Non-construction	7:42	7:40	1:07	7:02	8:21
	U.S. adults	7:30	8:00	NR	NR	NR

NR=not reported

No significant differences existed between the nighttime sleep durations of construction and non-construction signalmen for both workdays and planned days off. However, both construction and non-construction signalmen averaged significantly longer sleep durations on planned days off compared to regular workdays, $t(108)= 15.33, p<.05$ and $t(278)= 20.73, p<.05$, respectively.

Signalmen recorded subjective ratings for sleep on both workdays and planned days off. With the exception of “ease of falling asleep” where the average ratings were the same, construction signalmen recorded higher/better sleep ratings than non-construction signalmen, and in all cases both groups reported higher/better sleep ratings on planned days off than on regular workdays.

FIGURE 1 presents a frequency distribution of nighttime sleep on workdays for all signalmen in comparison with the data from the NSF survey mentioned above. Almost two thirds of signalmen are getting less than 7 hr sleep on work nights in contrast with 39 percent of U.S. adults. The proportion of signalmen getting less than 6 hr of sleep is similar to that for U.S. adults.

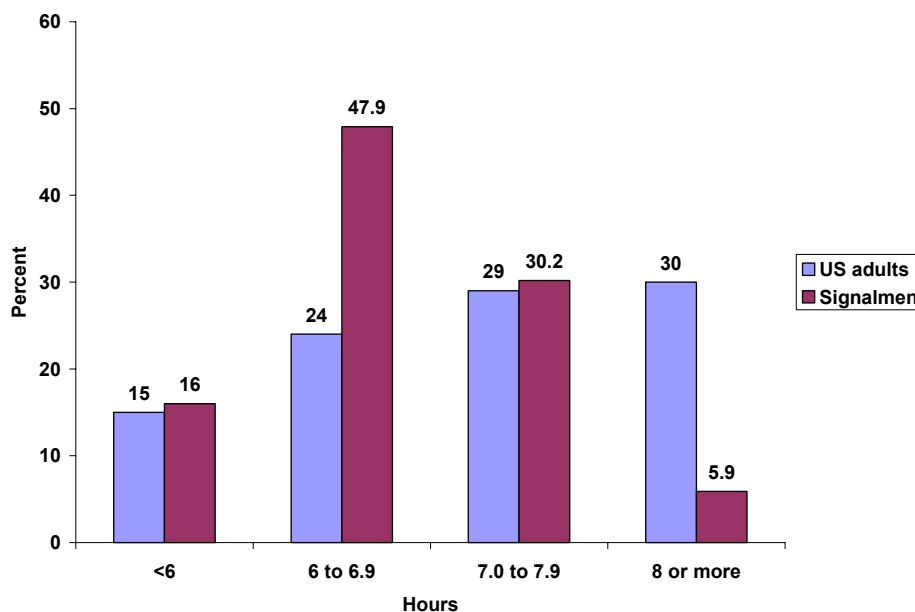


FIGURE 1. Duration of Nighttime Sleep on Workdays for Signalmen versus U.S. Adults

The affect of sleep location on nighttime sleep duration was investigated for construction signalmen. Because construction signalmen may work significant distances from their primary

residence, they may often sleep away from their home, in a hotel or other arrangement, closer to the worksite. This analysis examined nighttime sleep on workdays only since nighttime sleep is influenced by type of day. The survey data indicate that sleep location influences nighttime sleep duration. Signalmen averaged 6:31 of nighttime sleep when at home and 6:50 when away from home. This difference was statistically significant, $t(908) = -4.11, p < .05$ and may be due to the lack of personal and family distractions when away from home. While construction signalmen slept longer when away from home, their ratings for sleep quality were higher for sleep at home.

The study also investigated the relationship between job schedule and nighttime sleep duration. All job schedules averaged similar amounts of nighttime sleep on workdays; 4-d weeks, 6:43; 5-d weeks, 6:45; and 8-on 6-off, 6:40. These slight differences were not statistically significant, $F(2,381) = .157, p > .05$.

As might be expected, a positive correlation existed between nighttime sleep duration and morning alertness ratings, $r = .317, r^2 = .100, p < .05$. Those getting more sleep at night tended to feel more alert in the morning, and those getting less sleep at night tended to feel less alert. The r^2 value indicates that nighttime sleep accounts for 10 percent of the variance in morning alertness.

Naps

Some signalmen supplement nighttime sleep with naps. The non-construction group napped more frequently than the construction group and averaged 1.8 naps during the 2-week study period. The construction signalmen averaged 1.1 naps, a statistically significant difference, $t(387) = -2.338, p < .05$.

Most naps occurred in the afternoon in the after work hours with nearly half beginning between 2 and 6 p.m. Comments in the daily logs indicate that some signalmen take a brief nap during their lunch break.

Sleep Disorders

There were 22 (5.7 percent) survey respondents who reported having a diagnosed sleep disorder, and seven of these reported that their problem was untreated. Sleep ratings and alertness levels were compared across three groups: 1) the untreated sleep disorder group (n=7), 2) the treated sleep disorder group (n=15) and 3) those with no diagnosed sleep disorder or the

“normal” group (n=367). For every sleep rating category other than nighttime sleep duration, those with untreated sleep disorders reported poorer sleep ratings than the other two groups (see TABLE 5). Differences in “ease of arising” were not statistically significant. Interestingly, those with treated sleep disorders reported equal or better sleep ratings than the “normal” group, although these differences were not statistically significant.

Similar to their sleep ratings, those with untreated sleep disorders also reported being less alert. At every point throughout the day that alertness was rated, those with untreated sleep disorders had lower alertness scores than the other two groups. Again similar to the sleep ratings, those with treated sleep disorders generally had equal or higher alertness ratings than the “normal” group, although these differences were not statistically significant.

TABLE 5. Sleep Ratings and Duration by Sleep Disorder Status

	Untreated sleep disorder	Treated sleep disorder	“Normal”
Ease of falling asleep	3.3	4.0	3.9
Ease of arising	2.9	3.5	3.3
Length of sleep	2.7	3.5	3.5
Quality of sleep	2.8	3.6	3.6
“How feel” in morning (alertness)	2.8	3.6	3.6
Nighttime sleep duration (hr:min)	7:10	6:59	7:05

Note: Sleep rated on scale of 1-5, with 1 being lowest rating and 5 the highest.

CONCLUSIONS

The nominal work schedule for U.S. railroad signalmen allows adequate time for sleep. The survey indicates that the length of nighttime sleep is independent of the number of work days in the work cycle. However, the non-construction signalman’s schedule is subject to start-time variability due to the need to respond to emergency calls at night and on planned days off. This schedule variability, and the resulting sleep disruption, appear to contribute to the group’s lower alertness levels throughout the work day. Although morning alertness following an unscheduled work period is significantly lower than when no unscheduled work occurs, the effect size and corresponding r^2 are small. This factor alone does not determine the level of alertness, and reducing emergency call will not have a substantial impact on morning alertness.

On average, signalmen get 15 min less sleep than U.S. adults on workdays. While the difference in average sleep for this group of railroad workers is modest in comparison with U.S.

adult norms, the percentage of signalmen getting less than 7 hr of sleep on weeknights far exceeds the U.S. adult norms. Research has shown that performance declines even with mild sleep restriction. Belenky et al. (6) have shown that performance declines initially with mild to moderate sleep restriction of 7 and 5 hr, and after a few days stabilizes at a less than fully rested level. Van Dongen, Maislin, Mullington and Dinges (7, p. 117) concluded the following:

Since chronic restriction of sleep to 6 hr or less per night produced cognitive performance deficits equivalent to up to 2 nights of total sleep deprivation, it appears that even relatively moderate sleep restriction can seriously impair waking neurobehavioral functions in healthy adults. Alertness ratings suggest that subjects were largely unaware of these increasing cognitive deficits, which may explain why the impact of chronic sleep restriction on waking cognitive functions is often assumed to be benign.

Based on the survey results, the 16 percent of signalmen getting less than 6 hr of nighttime sleep on workdays may be performing significantly below that of a well rested signalman. The 48 percent getting 6 to 6.9 hr of sleep are also likely performing at less than optimal alertness. More disconcerting, based on the Van Dongen study, is that these individuals, who perform a safety critical job, are probably unaware of the extent of their performance degradation. These survey findings underscore the need for fatigue education programs for signalmen that emphasize the relationship between inadequate sleep and performance.

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