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Work Schedules and Sleep Patterns of Railroad Maintenance of Way Workers

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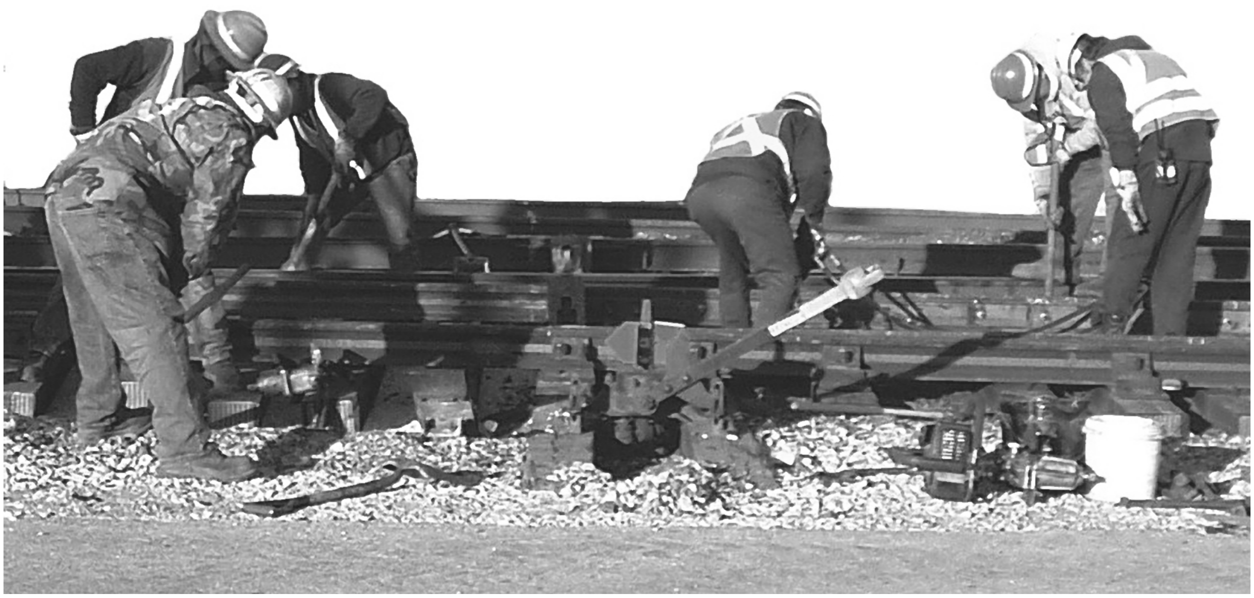

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13. ABSTRACT (Maximum 200 words)
This report presents the results of a study designed to characterize the work/rest schedules and sleep patterns of U.S. railroad maintenance of way (MOW) employees and to examine the relationship between these schedules and levels of alertness of the individuals working the schedules. The study methodology was a survey of a random sample of currently working U.S. MOW employees who completed a background survey and kept a daily log for 2 weeks. MOW workers are a predominantly healthy middle-aged male population. They work either production (construction) or non-production (maintenance) jobs and focus on either track or bridge and building infrastructure. A majority of non-production jobs have a 5-day work week, but nearly half of production jobs work a 4-day week and 20 percent work 8-on 6-off. Overall, 24 percent of MOW workers traveled on their own time to an out-of-town worksite during the study's 2-week period. Both groups get the same amount of sleep, but it is significantly less than U.S. adult norms. Several work schedule characteristics, including time without a break, total hours worked, weeknight emergency calls, and commute time, were related to daytime alertness, but their relationship was weak.

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1 mile (mi)	=	1.6 kilometers (km)	1 meter (m)	=	1.1 yards (yd)
			1 kilometer (km)	=	0.6 mile (mi)
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				=	1.1 short tons
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1 fluid ounce (fl oz)	=	30 milliliters (ml)	1 liter (l)	=	1.06 quarts (qt)
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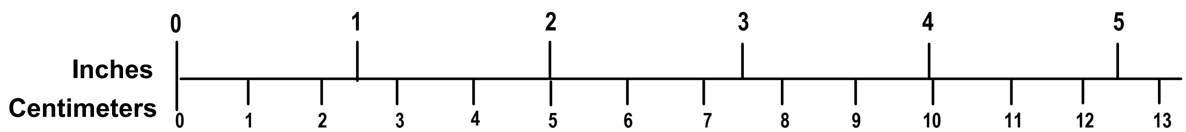

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°F	-40°	-22°	-4°	14°	32°	50°	68°	86°	104°	122°	140°	158°	176°	194°	212°
°C	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°

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Contents

Illustrations

Tables

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This report presents the results of a research study designed to characterize the work schedules and sleep patterns of U.S. railroad maintenance of way employees and to examine the relationship between these schedules and level of alertness for the individuals working the schedules. Foster-Miller, Inc. conducted the work for the Federal Railroad Administration (FRA) under contract DTFR53-01-D-00029 with guidance from Dr. Thomas Raslear, Office of Research and Development, Human Factors Program. The authors worked closely with the Brotherhood of Maintenance of Way Employes Division (BMWED) of the International Brotherhood of Teamsters. Special thanks are due to Mr. Richard Inclima and Mr. James Superfisky, BMWED, who provided invaluable insight on the job of a maintenance of way employee and facilitated the distribution of the survey materials to their members. Their participation was a key element in the successful conduct of the study. The authors are especially appreciative of the efforts of Mr. Robert Brogan, FRA Office of Safety, who facilitated the Office of Management and Budget approval process for this study.

The authors also wish to thank several individuals at Foster-Miller for their significant contributions to this survey. Ms. Susan McDonough designed and managed the database for tracking and compensating the survey participants. Ms. Sarah Acton answered questions from survey participants and helped to review the log books before the data was coded. Ms. Gayle Staffiere from Foster-Miller's Publications Department designed the layout of the log books and oversaw printing and mailing of the survey documents. Ms. Jeanne Seaquist designed the database for the survey data, and Ms. Deidra Bradley entered data from the background survey and log books into the database.

Executive Summary

In a continuing effort to improve rail safety and to reduce the number of injuries and fatalities to railroad workers, 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. Because railroading is a round-the-clock, 7-days-a-week operation, and because a wide array of workers are needed to operate and to maintain the Nation's railroads, other crafts besides train and engine crews may also be subject to fatigue. The non-operating crafts, which include locomotive and car repair, right-of-way production and maintenance, signal system production and maintenance, and telecommunications, fall into this category. With all of 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. In 2001, FRA suggested, and NARAP concurred, on the need to study the fatigue issues of the non-operating crafts. An initial study focused on signalmen. This study investigated the fatigue issues of maintenance of way (MOW) workers.

This study had two primary objectives:

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

MOW jobs fall into two categories, production (construction) and non-production (maintenance). Within each of these categories, some jobs work on track infrastructure, and a smaller portion work on bridges and buildings. The goal was to characterize U.S. MOW workers as a group, not to characterize MOW workers on a specific railroad.

The research described in this report had three phases: preparation, field data collection, and data analysis. Since no existing data source would provide answers to the study's research questions, a survey of MOW workers was the only means to obtain the necessary data. The preparation phase included securing approval from the Office of Management and Budget (OMB) for the survey. Representatives from the Brotherhood of Maintenance of Way Employes Division of the International Brotherhood of Teamsters (BMWED) worked closely with the researchers throughout the study.

Survey Design

The study used two survey instruments, a background survey and a daily log. Survey participants used the background survey to provide demographic information, descriptive data for the MOW worker's job type and work schedule, and a self-assessment of overall health. The daily log provided a place for recording sleep and work periods on both regular workdays and planned days off. MOW workers recorded not only the starting and ending times for each sleep and work period, but also a subjective assessment of alertness at different times during the day. Capturing the work cycle of production MOW workers required collecting 14 days (d) of work and sleep data.

Researchers drew a random sample of 845 MOW workers from the BMWED database of actively working U.S. MOW workers. Retirees, full-time union officials, and anyone currently holding a railroad management position were specifically excluded from the sampling frame. Determination of the sample size assumed a 95 percent confidence interval on the estimates for mean sleep time, an error tolerance of 15 percent and a 40 percent response rate. OMB approved this collection of information under OMB control number 2130-0561 on May 14, 2004.

Mailing of the survey materials took place on June 29, 2004. One month (mo) later, every survey recipient received a reminder postcard encouraging him/her to participate and to call the researchers if he/she needed additional materials. In October, because the response rate was not at the desired level, anyone who had not either returned the completed survey materials or indicated a lack of interest in participating in the study received a second reminder postcard.

Survey Response Rate

The overall response rate for the survey was 31 percent. Table 1 provides a breakdown of the survey responses.

Table 1. Breakdown of survey responses

	Number	Percent
Returned both background survey and daily log	262	31
Returned only one survey instrument	30	4
Materials undeliverable due to invalid address or deceased	4	0
No response	549	65
Total number of surveys mailed	845	

Of the 262 complete responses, 8 were not usable due to failure to follow the instructions.

The non-response bias study based on age found no difference between respondents and non-respondents.

MOW Worker Demographics

The survey respondents held primarily track non-production (maintenance) jobs (52 percent) and track production (construction) jobs (34 percent). The remainder worked bridge and building (B&B) jobs, either non-production or production. Average MOW worker experience was approximately 23 years (yr), with those working production and non-production having nearly the same level of experience. The majority of MOW workers are middle-aged with nearly half being 50 yr and older. As with years of experience, the average age for production and non-production MOW workers was nearly identical. All but two participants were male so segregation of the survey results by sex was not meaningful.

Nearly all MOW workers (81 percent) were married with no children under the age of 2 yr. In contrast, 59 percent of the U.S. male population 18 and older is married. Since many railroaders report that their work schedule strains marital relationships, finding such a high proportion of MOW workers to be married was surprising. The lack of young children is consistent with the average age of this population.

Nearly 80 percent of the MOW workers reported their health as good or excellent. The vast majority, 89 percent, had not taken a day off due to illness in the last 6 mo. The low number of workdays lost due to illness may be due in part to the fact that MOW labor agreements do not provide compensation for sick days.

Approximately 7 percent of this population of railroad workers reported having a diagnosed sleep disorder, and one third of those have gone without treatment. Since the survey asked about a diagnosed sleep disorder and not sleep apnea specifically, this result is not readily comparable with the estimate of the prevalence of sleep apnea in the U.S. adult male working population. The true rate of sleep disorders may be higher, as some may have an undiagnosed sleep disorder.

Job Characteristics

The work schedules of production and non-production MOW workers differ in several respects. While labor agreements define both types of jobs to work 80 hours (h) in a 2-week period, a majority of non-production jobs (74 percent) have a 5-d work week, but less than a third of the production jobs have this schedule. Nearly half of all production jobs work a 4-d week and 20 percent work 8-on 6-off. B&B MOW workers work either a 4-d or 5-d week.

During the 2-week survey period, non-production MOW workers worked 87:01 (hours:minutes) and the production MOW workers 89:28. For both groups of MOW workers, this was about what they reported typically working but more than their nominal schedules dictate. The small difference between the two groups was likely due to the extra hours required of production gangs on major construction projects.

Nearly a quarter of non-production MOW workers experienced start time variability at least once during the survey period, most likely as a result of an emergency call or unscheduled work. (Start time variability was defined as a change in start time of more than 1 h from the previous day.) In contrast, 84 percent of the production MOW workers experienced no start time variability.

On any given day, the probability of an unscheduled work period was .045. Once called for an unscheduled work period, an MOW worker had less than a 1 percent chance of being called back a second time. Callbacks, defined as an unscheduled work period that began on a workday after the individual arrived home, affected next day morning alertness; however, the effect size was somewhat small.

Many MOW jobs require the worker to travel, usually on his/her own time, to an out-of-town lodging or rally point. Overall, 24 percent of the MOW workers reported this type of travel during the 2-week study period. Half of these individuals made more than one trip. Production MOW workers traveled more than the non-production people, 41 percent of production versus 12 percent of non-production. This type of travel compromises personal time that would otherwise be available to spend with family members and to attend to personal business. It may also compromise the worker’s sleep time.

The study examined the relationship between characteristics of the MOW workers’ work schedules and alertness. The characteristics examined included time without a break, total hours worked, and commute time. While the correlations between alertness and these factors were statistically significant, the strengths of the relationships were weak. For example, the correlation coefficient between number of hours worked and alertness upon arriving home was -.214, but $r^2 = .046$ so number of hours worked explained only 4.6 percent of the variance. Sources of work-related stress were different for the two groups of MOW workers. Only in the case of travel to work and lodging at the worksite did production MOW workers report a statistically different and higher level of stress than their non-production counterparts. The greatest sources of stress for non-production MOW workers were inadequate staff, management policies, and ambiguous work rules.

Sleep Characteristics

MOW workers get less nighttime sleep than U.S. adults on workdays, but on planned days off they are getting more sleep. In terms of median nighttime sleep, however, MOW workers get less sleep regardless of type of day. While 39 percent of U.S. adults get less than 7 h of sleep on workdays, 66 percent of MOW workers have this amount of sleep. Total daily sleep, which includes naps as well as nighttime sleep for production and non-production MOW workers, is at least 1 h longer on planned days off than on workdays. MOW workers tend not to nap. For those who do, nearly half of all naps on workdays begin between 2 and 6 p.m., which corresponds with the circadian afternoon nadir, making it a convenient time for naps. This time period also follows the end of the workday for many MOW workers.

Both production and non-production MOW workers gave higher ratings to their sleep on planned days off than on regular workdays. Only one statistically significant difference existed in sleep quality by sleep location (home versus away). Production workers slept approximately 40 minutes (min) longer when away from home. Nearly two-thirds reported that their employer provides sleeping accommodations when the work location requires sleeping away from home. No statistically significant differences existed in sleep ratings by type of sleeping arrangement.

Textual Analysis of Log Book Comments

A systematic qualitative analysis of the textual comments in the daily logs provided greater insight into the concerns of MOW workers and, in many cases, added further insight to the quantitative survey results. Over 1000 comments were in the log books. The most frequently mentioned topics were weather, fatigue/alertness, and travel.

Findings and Recommendations

The following lists the key findings with respect to the MOW worker's nominal work periods, unscheduled work periods, and sleep patterns:

- The overall nominal length of the MOW workday, including commuting and lunch breaks, allows adequate time for nighttime sleep. In addition to overtime work, other aspects of the job, such as emergency call and travel to a lodging/rally point, place demands on the MOW worker's time that may compromise his/her ability to get adequate rest.
- While the average hours worked during the study period do not indicate excessive overtime, one quarter of the production MOW workers worked at least 8 h of overtime per week, and one quarter of the non-production MOW workers worked at least 6.5 h of overtime. This level of overtime, if done on a regular basis, may prevent the employee from achieving full rest and recovery.
- Callbacks (work periods that occurred on workdays after the employee arrived home) were related, to a limited degree, to lower alertness the following morning.
- Both groups of MOW workers get less nighttime sleep during the work week than the norm for U.S. adults. Not only is weeknight sleep significantly different than the U.S.

norms, but the percentage of MOW workers getting less than 7 h of sleep is also significantly greater than the norm for U.S. adults. A total of 15 percent are getting less than 6 h of nighttime, and 1.8 percent are getting less than 5 h. Research has shown that this level of sleep deprivation leads to performance degradation. Railroad industry and labor organizations' fatigue education programs should emphasize the performance consequences of inadequate sleep.

- Seven percent of the study population reported having diagnosed sleep disorders, but only two-thirds reported being treated for the sleep disorder. To encourage these individuals to seek treatment, railroads and unions should continue their education programs, pointing out the possible performance consequences of untreated sleep disorders.

Based on the experience of this study, several methodological changes should be a part of any future studies of this nature. The following lists the recommended changes:

- *Avoid data collection over holiday period.* Because mailing of the survey materials for this study occurred at the end of June, some participants recorded data over the Fourth of July weekend. As a result, reporting of a full 2-week cycle was not possible with the holiday.
- *If the study population includes workers who must travel long distances on their own time to reach a rally point or lodging site, the daily log should have a better way to record travel to rally point/lodging.* This study included a place for recording such travel; however, participants experienced some confusion over the difference between travel to lodging/rally point and commute to worksite.
- *The background survey should inquire whether or not the participant has been diagnosed with sleep apnea, as well as a sleep disorder, so that the results can be compared with U.S. adult norms for sleep apnea from the Wisconsin Cohort Study.* A question on sleep disorders is also necessary to be certain that poor sleep due to a sleep disorder does not confound the survey data.
- *The instructions should state that when an employee works on a planned day off, he/she should record this work period in the same section of the log that is used for regular workdays, rather than in the unscheduled work period section.* Participants had some confusion over where to record unscheduled work on a planned day off.

Further analysis and use of this survey data is possible. Fatigue modelers may want to refine their models using the data and predict how the typical MOW work schedule may be affecting on-the-job alertness and related performance. Separately, further statistical analysis of the data could identify additional explanatory factors for the reported alertness levels and sleep quality.

1. Introduction

In a continuing effort to improve railroad safety and to reduce the number of injuries and fatalities to railroad workers, FRA and the railroad industry, through NARAP, have focused on the issue of fatigue among train and engine crew personnel. Because railroading is a round-the-clock, 7-days-a-week operation, and because a wide array of workers are needed to operate and to maintain the Nation's railroads, other crafts besides train and engine crews can also be subject to fatigue. The non-operating crafts, which include locomotive and car repair, right-of-way construction and maintenance, signal system construction and maintenance, and telecommunications, fall into this category. With all of 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. In 2001, FRA suggested and NARAP concurred on the need to study the fatigue issues of the non-operating crafts.

In 2001 FRA decided to focus initially on signalmen in exploring fatigue of non-operating craft workers. A separate report presents the results of the signalmen study (Gertler & Viale, 2006). The study described in this report, which is similar in scope and methodology to the signalmen study, concerns MOW workers. Obtaining insight into the schedule-related fatigue issues of any population of workers requires data on their work and sleep patterns. FRA undertook the study described in this report to collect the necessary data and to develop an understanding of the potential work schedule-related fatigue issues for MOW workers.

1.1 Nature of the MOW Worker's Job

Over the past decade, the volume of shipments of goods by rail increased significantly while the railroad work force declined. In 1990, the volume of goods transported by railroads amounted to 1.1 trillion ton-miles. By the year 2000, the volume of goods carried by railroads totaled 1.5 trillion ton-miles. Meanwhile, the number of railroad MOW employees working for U.S. railroads decreased from 44,282 to 37,744 or 15 percent, during the 10-yr period 1990 to 2000. Increasing traffic combined with the shrinking work force intensified the demands on MOW employees who must maintain the track. At the same time, the decision of Presidential Emergency Board 219 in 1991 allowed railroads to utilize track construction crews systemwide. Railroads had previously assigned construction crews to a specific geographic region. The impact of this ruling is that MOW employees who work production (construction) jobs many times travel distances of up to 1000 miles (mi), on their own time, to reach the worksite.

MOW employees work outside year round in all types of weather conditions and over varying terrain. The work is heavy and physically demanding and often involves personnel and heavy equipment working in close proximity. There is no question that this work exposes railroad MOW employees to an extremely hazardous environment because of the nature of the work and the operation of trains and other on-track equipment within the MOW work environment. The introduction of Roadway Worker Protection regulations in 1997 has helped to reduce the risk to this group of railroad workers of being struck by trains and other on-track equipment. Nevertheless, because of the hazardous work environment of the MOW worker, maintaining alertness on the job is critical.

MOW workers build and maintain the tracks, bridges, buildings, and other structures on the railroad. MOW work has two fundamental job classifications, production and non-production. Production jobs involve either track or B&B construction while non-production jobs are responsible for inspection, maintenance, and repair of the same infrastructure. The non-production MOW worker is responsible for inspecting and certifying the condition of the right-of-way in a specific territory and initiating repairs or other remedial action when he/she finds defects. Non-production workers typically work either a 4-d or 5-d week, and they often support the work of production crews when on their territory. Non-production workers are also subject to call to handle emergency problems at night and on rest days. Railroads typically assign non-production workers to a specific geographic area, which may encompass several hundred miles end-to-end.

In contrast to the non-production jobs, an MOW worker on a production gang will frequently work a compressed schedule of, for example, 8 workdays followed by 6 or 7 d off, and is rarely called for an emergency. The industry frequently refers to this type of schedule as compressed halves. The railroad may assign its production workers anywhere on the railroad's system, and, as such, these workers must often travel long distances on their own time to reach the lodging site or rally point for the construction project.

Most construction work occurs during months of good weather, especially in the colder climate areas of the country, while non-production inspection and maintenance is done year round. Cold weather and snow lead to increased track maintenance problems during the winter months. This increased winter workload can result in long workdays and emergency call at night and on rest days.

Unlike the operating crafts (i.e., train and engine crews) and signalmen, no statutory limits exist on the number of hours that MOW workers may work. A few railroads have taken voluntary steps to reduce fatigue by limiting work hours, but this is the exception rather than the norm.

Labor agreements with individual railroads address company provisions for meal allowances and sleeping accommodations. Some agreements provide for at least a shared motel room or shared housing in railroad camp cars, but some offer only a fixed per diem, which the MOW worker may use to offset a portion of the costs associated with his/her meals and overnight accommodations. If this is the arrangement, the MOW worker may chose to sleep in a personal vehicle or tent because the daily per diem does not adequately cover the actual expense of purchasing meals and/or lodging. In some instances, the railroad provides a camper allowance in lieu of other housing and meal provisions. The purpose of the camper allowance is to offset some of the production employee's costs for maintaining a personal camper, which the employee uses when assigned to work away from home over extended periods.

1.2 Objectives

This study had two primary objectives:

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

The goal was to characterize U.S. railroad MOW workers as a group, not to characterize MOW workers on a specific railroad.

Specific research issues that the study sought to answer include the following:

- What is the distribution of MOW employees among different types of jobs?
- What is the average number of hours worked per day? per week? per work cycle[1]?
- How does average hours worked vary by type of job? type of schedule?
- What is the average number of hours of sleep on workdays? on non-workdays? at home? away from home?
- Does the quality of sleep differ between home and away from home?
- What is the relationship between quality of sleep when away from home and type of sleeping arrangement?
- Does alertness upon arising deteriorate with each successive workday?
- What is the relationship between time worked before a break in work period and end of day fatigue?
- What is the average number of hours that each MOW employee spends traveling to and from work? to and from the rally or lodging point? Is travel time related to level of sleepiness?
- How frequently are MOW employees called back to respond to emergencies?

1.3 Overall Approach

Since no existing data sources could provide answers to the above issues, a survey of MOW workers was the only means to obtain the necessary work schedule and sleep data. The research project consisted of three phases: preparation, field data collection, and data analysis (see Figure 1). The preparation phase involved designing the survey methodology and procedures, conducting a pilot survey to refine the survey instruments and data collection procedure, securing approval from OMB, and preparing the final survey instruments. (Because this survey involved more than nine participants, Federal regulations required that OMB approve the overall study design.) Activities during this phase included discussions with BMWED to assure that the survey instruments were suitably worded and would collect the data necessary to address the research issues. A pilot survey, conducted in parallel with the OMB review process, assured that the survey would capture the data needed to meet the survey objectives.

The second phase of the research consisted of distributing the survey materials and collecting the survey data. Analysis of the survey data was the final phase. A non-response bias study validated that no difference existed between the survey participants and the non-respondents. The data analysis methods for the survey data included descriptive statistics, analysis of variance (ANOVA), and correlation analysis.

[1] A work cycle refers to several workdays followed by planned days off.

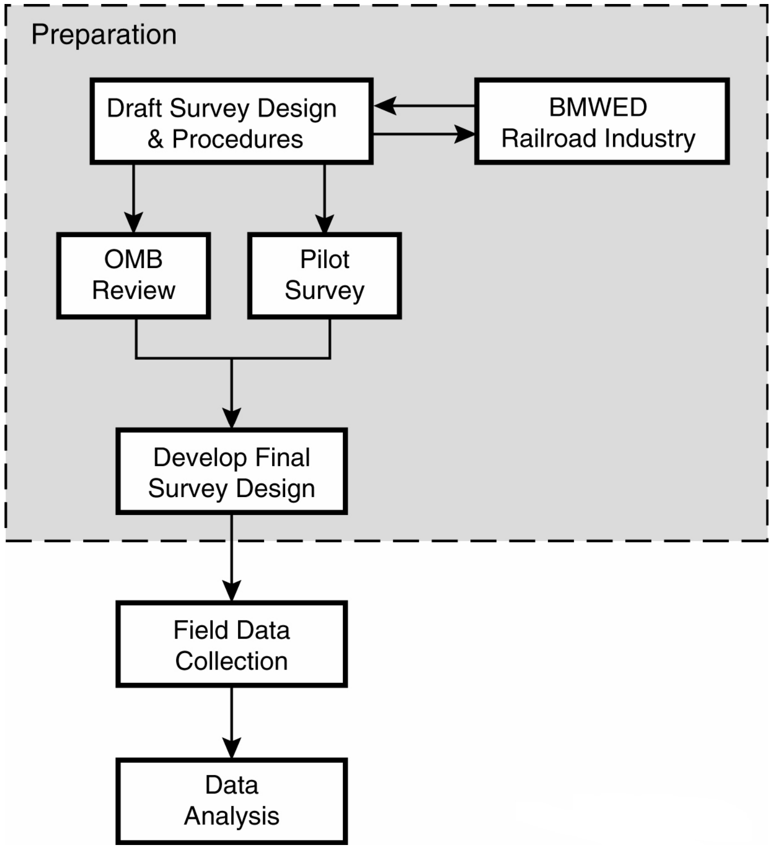

Figure 1. Overall approach

1.4 Scope

This survey involved railroad MOW workers working in the United States. It was designed to characterize these workers as a group. The study did not attempt to characterize MOW workers employed by specific railroads. Making recommendations regarding fatigue countermeasures was beyond the scope of the study.

1.5 Organization of the Report

Section 2 describes the overall survey design and procedures. Section 3 provides analysis of the survey results, and Section 4 contains the findings and recommendations. Appendix A contains copies of the survey materials, and Appendix B describes adjustments that were made to the data as part of the analysis process. Appendix C provides detailed data summaries that support the technical analysis. A list of the abbreviations and acronyms used in the report follows the appendices.

2. Survey Design

One of the objectives of this study was to characterize the work schedules and sleep patterns of U.S. railroad MOW workers. Achieving this objective required a nationwide survey. The only practical means of reaching these individuals was through their union, the BMWED. This section describes the survey instruments, sampling plan, and procedures that the researchers developed to survey this population. This methodology is similar to that used in an earlier study of railroad signalmen.

2.1 Survey Instruments

The study used two survey instruments, a background survey and a daily log. (Copies of both instruments appear in Appendix A.) The background survey gatherered demographic information, descriptive data for the MOW worker'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. MOW worker population. Second, it provided identifying data that the researchers used in conjunction with the daily logs to characterize the work/sleep patterns of the two major categories of MOW jobs, production, or construction, and non-production, or maintenance. If the respondent's job required that he/she be away from home overnight, he/she provided information on the type of sleeping accommodation provided by the employer. This instrument also asked participants to rate, using a Likert scale of 1 to 4, potential sources of stress at work. The background survey also included a list of life stress events. In the event that a participant's daily log indicated frequent nighttime awakenings or excessive fatigue, survey researchers could use the individual's response to this section of the background to assure that no non-work circumstances were confounding the survey data. Completion of the survey required less than 15 min.

A daily log provided a place for recording sleep and work periods on regular workdays and planned days off. The log also included a place to record travel time to a lodging or rally point.[2] MOW workers recorded not only the starting and ending times for each sleep and work period, but also a self-assessment of alertness at different times during the day. These subjective assessments used a five-point 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. The purpose of this section was to capture response to emergency calls beyond the normal workday. Completion of the daily log required less than a total of 10 min daily.

2.2 Data Collection Period

Examination of the relationship between work schedules and fatigue requires data that encompasses a full work cycle. Fatigue is cumulative, and its effects on the individual are not

[2] Production jobs frequently require the employee to assemble at a location referred to as the rally point. From this location, the workers travel to the worksite in the employer's vehicle.

readily identified from 1 or 2 d of data. In addition, adequate data must be available to compare sleep periods from both work and rest days. The length of the typical MOW worker's work cycle was also a consideration in determining the length of the data collection period. Non-production workers tend to work a regular work week of 4 or 5 d followed by 2 or 3 d off. In contrast, those working production jobs tend to have a 14-d or 15-d compressed work cycle. To capture the work cycle of the production jobs, it was necessary to collect 14 d of work and sleep data. Since it was not possible *a priori* to identify those individuals who work a production job, all participants provided 2 weeks of data.

2.3 Sampling Plan

BMWED maintains a database with the names, mailing addresses, and dates of birth for all of its members. Because MOW workers frequently change from working one type of job to another, this information is not in the BMWED database. Only actively working BMWED members living in the United States could be in the sampling frame. Retirees, full-time union officials, and anyone currently holding a railroad management position were specifically excluded. The effective sampling frame was 30,800 after the exclusions. The researchers drew a random sample from these individuals.

One of the most important issues in conducting this study was determining how large a sample was necessary for the estimates obtained in the sample survey to be reliable enough to meet the study's objectives. In general, the larger the sample the greater the reliability of the resulting estimates, but this must be traded off against the expense of a larger sample. The first step in this process is to specify the level of reliability needed for the resulting estimates.

Since the study design includes examining characteristics of two subgroups of MOW workers (production versus non-production), the study design must assure that the subgroups have adequate numbers within the overall sample to support reliable estimates of their characteristics. One statistic of interest is the mean number of hours of sleep per day for each subgroup. Using the BMWED estimate of the workforce breakdown, approximately 16,940 (55 percent) non-production and 13,860 (45 percent) production MOW workers are in the sampling frame. According to Levy and Lemeshow (1999), the appropriate sample size, *n*, for estimating the mean daily sleep time can be computed from the following:

$$n \geq \frac{(z^2 N V_x^2)}{z^2 V_x^2 + (N-1)\varepsilon^2}$$

where z = reliability coefficient (1.96 for 95 percent confidence level)

N = population size (non-production = 16,940, production = 13,860)

V_x = unknown population variance (1)

ε = error tolerance (.15)

Webb (1992) estimates the standard deviation for daily sleep for the general population is 1 h (Webb, p. 72). Applying this estimate of standard deviation (and hence V_x, variance) to the two MOW worker subpopulations and using an error tolerance of ± 7.5 percent (ε = .15), 169 production workers must be in the sample, as well as 169 non-production MOW workers, for a total of 338 participants. These methods for estimating sample size also apply to other mean values, such as work and commute time that the study seeks to estimate.

Since not every BMWED member who is selected to participate in this study would choose to do so, over sampling was necessary. The extent of over sampling was a function of the anticipated response rate. A recent member survey by another railroad labor organization had a 40 percent response rate (personal communication with labor representative). BMWED representatives felt their membership was similar and would likely have a similar response rate. The study design reflected the conservative assumption that the planned study could likely achieve at least this response rate. Based on experience with other FRA research efforts that sought participation from railroad workers, FRA researchers have found that many are suspicious of any efforts to collect data, even if the effort has the endorsement of their labor union and the researchers assure the information's confidentiality. Moreover, this survey differed significantly from most mail surveys in that it required responses every day for a 14-d period. For these reasons, a goal of 40 percent response rate appeared reasonable and realistic. If 40 percent of the selected individuals in fact participate in the study, then the random sample must be 845 (338/.4) to yield 338 participants.

2.4 Procedure

In accordance with government regulation, FRA sought approval for the proposed survey from OMB. OMB approved this collection of information under OMB control number 2130-0561 on May 14, 2004.

Concurrent with submittal of the OMB application, the researchers conducted a 1-week pilot survey with six participants. The purpose of the pilot study was to refine the data collection procedures and instruments. (Eight individuals volunteered to participate, but one returned only the log, and the eighth individual never returned the survey materials.) In addition to completing the Railroad Maintenance of Way Worker Background Survey and Maintenance of Way Worker's Daily Log, pilot participants also completed a brief Post-Survey Form to provide feedback on the survey instruments and procedures. Similar to the full survey, pilot participants received a $75 gift certificate to a national retail establishment. Based on the experience with the pilot survey, the researchers added several additional sources of stress to the Background Survey, and they modified the instructions for reporting travel to/from the rally point and home. Following the pilot survey, during the spring of 2004, BMWED publicized the survey through an article in its publication, *BMWED Journal,* and on its Web site.

The researchers drew a simple random sample of 845 MOW workers, without replacement, from the sampling frame derived from the BMWED membership list. The package mailed to each participant on June 29, 2004, consisted of the following items:

- *Railroad Maintenance of Way Worker Background Survey* in booklet form. Each page was 5.5 x 8.5 inches (in), printed on white paper with no questions on the cover page.
- *Railroad Maintenance of Way Worker's Daily Log* in spiral notebook form. Each page was 5.0 x 3.25 in. The log included 14 sections, one for each day of the data collection period. One of the introductory pages contained brief instructions on completing the log.

- *Cover letter* signed by the President, BMWED. This letter explained the purpose of the study and encouraged BMWED members to participate.
- *Instructions* explaining the survey procedures and how to complete the daily log.
- *Return envelope,* postage paid.
- *$5 bill.*

Copies of the cover letter and instructions appear in Appendix A along with the survey instruments.

All materials were printed on high quality paper, and each letter was individually addressed to the recipient. The mailing envelope had the BMWED return address, rather than Foster-Miller, because it would be familiar to recipients. The purpose of the $5 was to encourage participation. Those who returned both the background survey and daily log also received a $75 gift certificate to a national retail establishment.

The instructions emphasized that (a) a total of 14 consecutive d of data should be provided, (b) data collection should begin on the first day of the next work cycle, and (c) data should not be reported during vacation periods. Both the instructions and the log included contact information for two Foster-Miller researchers who were available to answer questions regarding the survey instruments and procedures. Because capturing the time for production workers to travel to the assigned lodging or rally point was of particular interest and proved problematic in the pilot survey, a portion of the instructions addressed how to record this information.

One mo after the materials were mailed, every survey recipient received a reminder postcard encouraging him/her to participate and to call Foster-Miller if he/she needed additional materials. In October, because the response rate was not at the desired level, anyone who had either not returned the completed survey materials or indicated a lack of interest in participating in the study received a second reminder postcard.

3. Analysis of Survey Data

This chapter presents the survey findings based on data provided in respondent background surveys and daily logs. The quantitative results are organized into five subtopic headings:

- Survey response rate
- Non-response bias study
- MOW worker demographic characteristics
- Job characteristics
- Sleep patterns

A separate subsection contains the results of a textual analysis of the log books. This study used a confidence interval of 95 percent. The researchers used SPSS 13.0 to analyze the data.

3.1 Survey Response Rate

The survey materials were mailed to 845 MOW employees. A total of 262 people returned both the background survey and the daily log. Thirty individuals returned only one of the survey items, four mailings failed to reach the addressees due to bad addresses, one individual on the mailing list was deceased, and three individuals could not participate due to injuries. If a log contained at least one work cycle of data for both workdays and planned days off, then the researchers included the data in the analysis. Eight responses were disqualified because either they did not provide 14 consecutive days of data or their data was erroneous. The overall response rate was 31.0 percent. The final analysis used data from 254 of those individuals who returned both data collection instruments.

3.2 Non-Response Bias Study

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 no difference exists in the characteristics of the survey respondents versus the non-respondents.

Information about non-respondents was limited to information available from the BMWED membership database. In addition to each member's address, this database includes birth date. Birth date (or age) is an appropriate variable to use for determining non-response bias. For a number of reasons, age is an important characteristic for assessing potential bias in this study. First, human sleep patterns change with age (Van Cauter, Leproult, & Plat, 2000). In addition, age is highly correlated with years of work experience and seniority. Seniority allows an MOW employee more opportunity to select work schedules that meet his/her personal needs.

All 262 individuals who returned both the background survey and the daily log were respondents, and the remaining 583 were non-respondents. Analysis of mean age for each of the groups found no significant difference between the respondents and the non-respondents, $t(843) = -.041$, $p = .968$.

3.3 MOW Worker Demographic Characteristics

This section provides demographics, as well as basic job-, family-, and health-related information based on responses in the background survey. Where appropriate, there are comparisons of the study results with national norms.

Characterization of MOW employees considered a number of factors. These factors are job type, work experience, sex and age, marital and family status, overall health, incidence of sleep disorders, and consumption of caffeinated beverages. Each of these elements is discussed below, followed by a brief summary of this information.

3.3.1 Job Type

Respondents reported the type of MOW job they worked. The background survey offered the following five choices:

- Construction/Production Crew
- Track Maintenance (non-production)
- B&B (production)
- B&B (non-production)
- Other

Fifty-nine individuals selected Other as their job type and provided a description of their jobs. Based on information provided by the participant, as well as assistance from BMWED representatives, re-categorization of all but two of these individuals into one of the other four job type categories was possible.[3]

Figure 2 displays the distribution of MOW job types from the survey. Approximately half of MOW employees (52 percent) worked Track Maintenance (non-production) jobs, while about a third (34 percent) worked Construction/Production jobs. The remaining 14 percent were split among B&B (non-production)–8 percent, B&B (production)–5 percent, and Other–1 percent.

Because those working construction/production jobs tend to have different work schedules and are rarely subject to emergency call, all further analyses by job type compares construction/production jobs with all non-construction/non-production jobs. The non-production group includes track maintenance, B&B (non-production), and other job types, while the production group consists of construction/production jobs, as well as B&B (production) jobs.

[3] One reported an Electrical Technician Lineman position, and the other was a Safety Assistant Trainer and Coordinator.

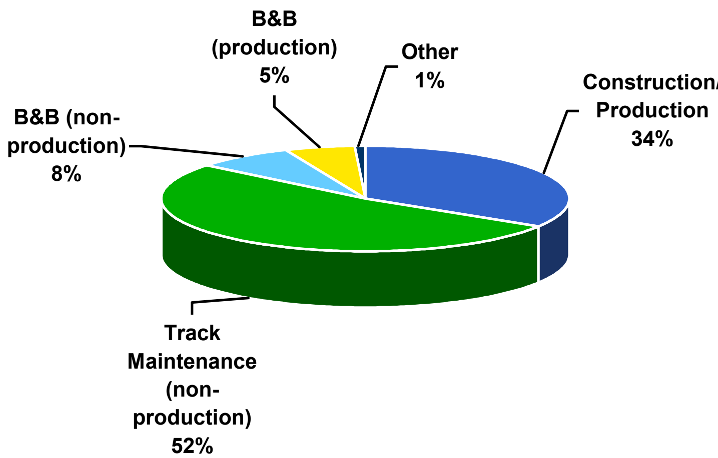

Figure 2. Distribution of respondents by type of MOW job

3.3.2 Experience

The average MOW employee had 22.8 yr experience. No statistically significant difference existed in the level of experience between production and non-production jobs, $t(251) = .220$, $p = .826$. The median level of experience was 27.1 yr. The higher median value indicates that individuals with years of experience in excess of the mean dominate the group.

Both production and non-production jobs had nearly all of their experience with their current employer. Table 2 and Table 3 provide further details on experience.

Table 2. Experience as an MOW employee (yr)

	Mean	Median	Standard Deviation
All MOW Jobs	22.8	27.1	10.7
Production	23.0	27.6	10.6
Non-Production	22.7	26.1	10.7

Table 3. Experience with current employer (yr)

	Mean	Median	Standard Deviation
All MOW Jobs	19.7	24.9	11.2
Production	19.8	25.1	11.3
Non-Production	19.7	23.8	11.2

3.3.3 Sex and Age

Railroad MOW employees are a predominantly male population. Of the 254 total usable responses, 252 (99.2 percent) were from male participants and only 2 (0.8 percent) were from females. Because of the limited number of females, segregation of results by sex was not meaningful.

The overall age for this group was 47.3. Just as experience levels between production and non-production job types were similar, age comparisons between production and non-production job types were similar as well–production (46.9) and non-production (47.5). Table 4 contains the age statistics.

Table 4. MOW worker age (yr)

	Mean	Median	Standard Deviation
All MOW Jobs	47.3	49.0	8.9
Production	46.9	49.0	9.5
Non-Production	47.5	50.0	8.5

Figure 3 displays the age distribution for MOW workers, based on the survey results. As is typical for other railroad crafts, this is an aging work force. Half of all MOW workers are 50 yr and older, and 83 percent are 40 yr and older.

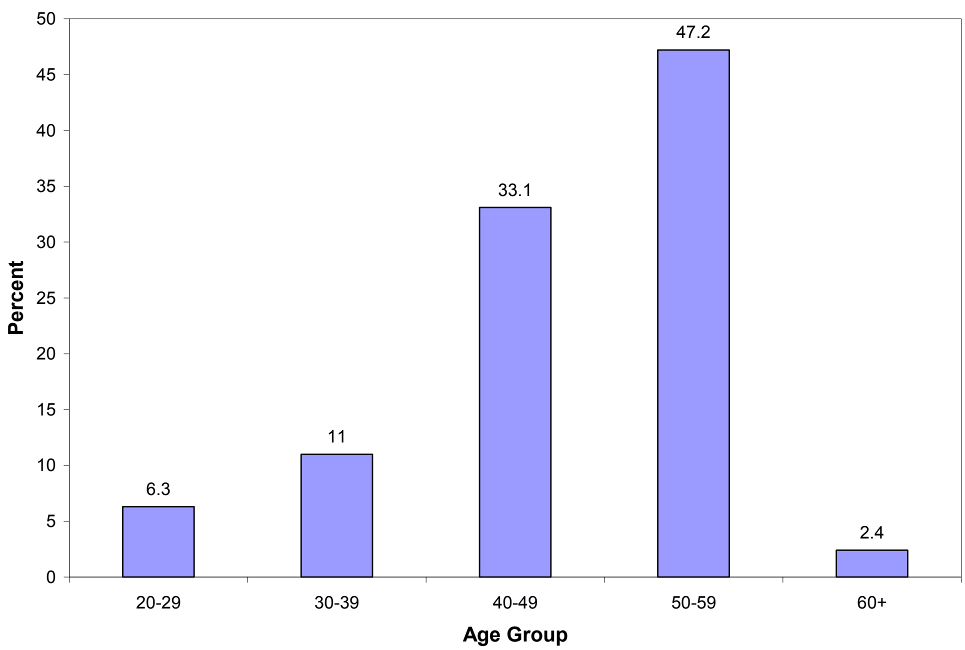

Figure 3. Distribution of MOW workers by age group

Research has found that a higher perceived age, relative to chronological age, can be an indicator of chronic stress and poor psychological well-being (Barnes-Farrell & Petrowski, 1989, 1991). Overall MOW workers reported a lower perceived age (44.8 yr) in comparison with their average chronological age (47.3 yr). As shown in Table 5, the MOW population tends to feel younger as they age. This is the same pattern that Barnes-Farrell and Petrowski found with permanent day shift workers in a manufacturing plant. Barnes-Farrell and Petrowski point out that younger people tend to report feeling older to reflect perceived maturity.

Table 5. Discrepancies between chronological and perceived age by age group (percent)

Age Perception	MOW Worker Age (yr)			
	18-29	**30-39**	**40-49**	**50+**
Younger	28.6	30.8	50.6	55.4
Same age	50.0	38.5	33.8	28.9
Older	21.4	30.8	15.6	15.7

The researchers also investigated the difference between actual age and perceived age by job type. Both groups reported feeling approximately 3 yr younger than their chronological age.

3.3.4 Marital and Family Status

Most recent statistical data from the U.S. Census indicates that 56.6 percent of the U.S. population age 18 and older and 58.9 percent of the U.S. male population 18 and older are married (U.S. Census Bureau, 2003). At the time of the study, 80.6 percent of participants were married, 10.3 were single, 7.5 divorced, 0.8 widowed, and 0.8 fell into the other category (these people were likely separated or living together). Since many railroaders report that their work schedule strains marital relationships, finding such a high proportion of MOW workers who are married was surprising. This data, however, does not indicate whether or not the married individuals were in an initial marriage or one subsequent to a divorce.

The survey asked participants whether or not their family included young children, a factor that can lead to disrupted sleep. While a large percentage of MOW workers are married, very few have children under the age of two (3.5 percent). No participants reported more than one child under the age of 2 yr. This finding is not surprising given the average age of an MOW worker.

3.3.5 Health

Participants rated their health as excellent, good, fair, or poor. Nearly 80 percent of MOW workers rated themselves in good (63.6 percent) or excellent (15.8 percent) health (see Figure 4). These ratings are reflected in the relatively small number of workdays missed due to sickness in the last 6 mo. Almost 90 percent of MOW workers had not taken a day off due to illness in the last 6 mo. Only 6.7 percent took 1 d off, 2.8 percent took 2 d, and 2 percent took 3 d or more in the previous 6 mo (see Figure 5). The low number of workdays lost due to illness may be due in part to the fact that MOW workers must use vacation or personal days for these absences. (MOW labor agreements do not provide for sick days.)

Perceived health was not linearly correlated with self-assessment of how often the individual reported feeling well rested and alert over the course of his/her work period. Although perceived health did have a statistically significant positive linear correlation with how often the individual reported feeling drained after work, $r = .172$, $r^2 = .026$, $p = .005$, the strength of this correlation is very weak, with perceived health explaining only 2.6 percent of the variability in ratings of feeling drained after work.

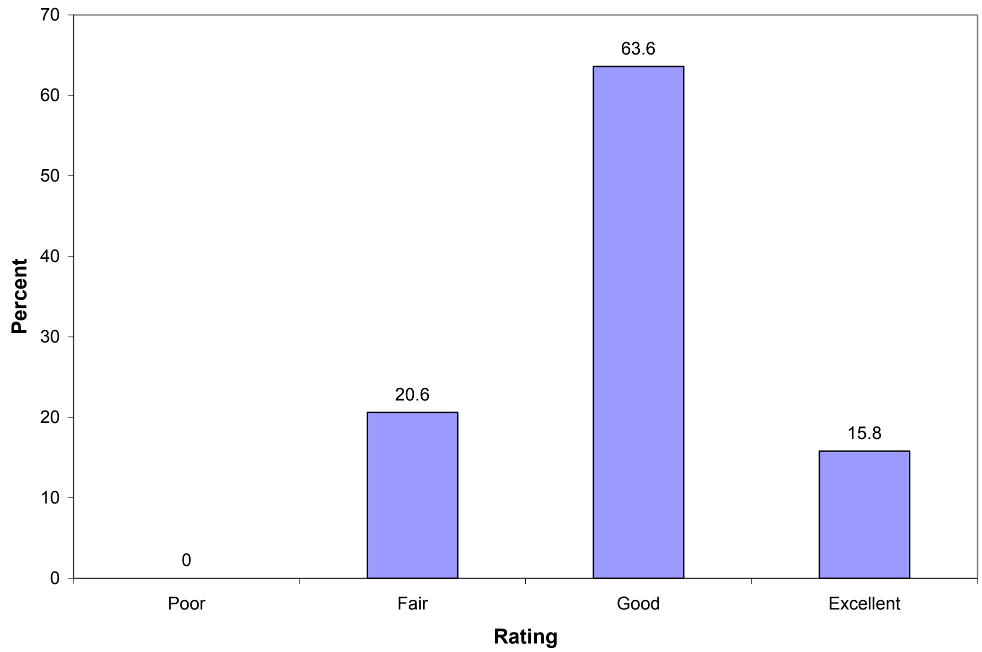

Figure 4. Self-assessment of overall health

3.3.6 Incidence of Sleep Disorders

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 (Young, et al., 1993). (The definition of sleep apnea for this study was an apnea-hypopnea score of 5 or higher and daytime hypersomnolence.) The National Sleep Foundation (NSF) and the National Institutes of Health report the numbers from the Wisconsin study as an estimate of the prevalence of sleep apnea among U.S. adults. Some sleep researchers hypothesize that the prevalence of sleep apnea may in fact be higher because many remain to be diagnosed. According to the Wisconsin study, 9 percent of women and 24 percent of men have undiagnosed sleep-disordered breathing, a condition that in some people results in excessive daytime sleepiness.

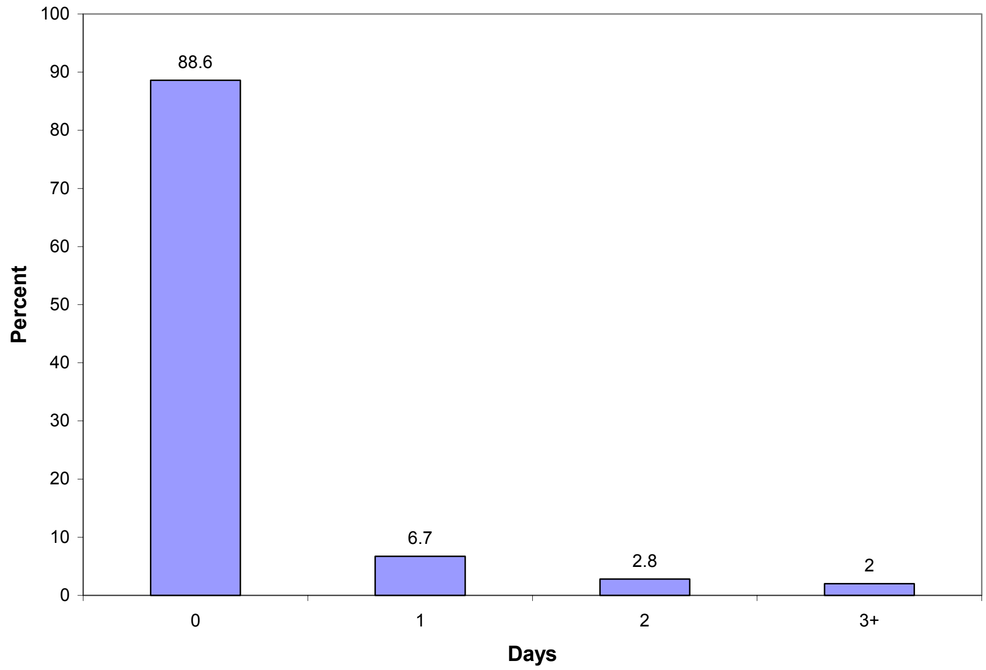

Figure 5. Workdays lost due to illness in the last 6 mo

Of the 254 participants in the MOW study, 17, or 6.7 percent, reported having a diagnosed sleep disorder. Eleven of those people (65 percent) reported being treated for the sleep disorder, with six reporting no treatment (35 percent). The six individuals with a diagnosed but untreated sleep disorder account for 2.4 percent of the total group of MOW employees. The background survey that solicited this information inquired about diagnosed sleep disorders, not sleep apnea specifically. It is possible that some of the people reporting a diagnosed sleep disorder have sleep-disordered breathing and not sleep apnea. (Sleep-disordered breathing does not necessarily lead to excessive daytime sleepiness and, as such, is a less problematic sleep disorder than sleep apnea.) For this reason it is not possible to conclude with certainty that railroad MOW workers have a higher rate of sleep apnea than the U.S. adult male population. The fact that MOW workers do report a higher rate of sleep apnea and/or sleep disorders may be due to increased awareness of the condition among this group of railroad employees. In recent years the media have publicized the symptoms of sleep disorders and their associated risks. Some railroads have also conducted educational campaigns on the subject and encouraged employees with symptoms of a sleep disorder to seek evaluation and treatment.

3.3.7 Consumption of Caffeinated Beverages

NSF reports that 250 mg of caffeine a day, the equivalent of a soda and a couple of coffees, generally poses no harm. Almost all participants reported consuming caffeinated beverages on a daily basis (93.3 percent), and those who did averaged 3.2 beverages a day. Based on this level of caffeine consumption, MOW workers are within normal healthy limits, and their sleep, in general, is not likely disrupted due to caffeine unless caffeine consumption occurs close to bedtime (NSF, 2002).

3.3.8 Summary of MOW Worker Demographic Characteristics

At the time of the study, half of the MOW workers held track maintenance–non-production jobs and one-third worked construction/production jobs. The remainder of the group was split among B&B–non-production (8 percent), B&B–production (5 percent), and other (1 percent). Average experience for production and non-production workers was 22.8 yr. All but two participants were male. The majority of MOW workers are middle-aged but reported feeling 2.5 yr younger than their chronological age. Approximately 80 percent of participants were married, and few had young children. Eighty percent of participants reported being in good or excellent health, which is supported by 89 percent of them reporting no workdays lost due to illness in the last 6 mo. Seven percent of respondents reported having a diagnosed sleep disorder, with one-third of those not undergoing treatment. The true number of sleep disorders may be higher, as some may have an undiagnosed sleep disorder. Participants averaged 3.2 caffeinated beverages daily, a level which poses no harm or health risks.

3.4 Job Characteristics

This section explores several aspects of the MOW worker's job, including work schedule, number of hours worked, unscheduled work periods, travel to the lodging/rally point, commute time, and sources of stress. A separate subsection addresses the relationship between alertness and work schedule. Selected participant comments illustrate MOW workers' concerns regarding their jobs.

3.4.1 Work Schedule

Weekly work schedules fell into three basic categories: 4-d week, 5-d week, and 8-on 6-off (8 straight days of work followed by 6 straight days off). Almost half of those holding production jobs worked a 4-d week, one-third worked a 5-d week, and 20 percent worked 8-on 6-off. Nearly 75 percent of the non-production people worked a 5-d week, nearly a quarter worked a 4-d week, and a small number worked 8-on 6-off (see Table 6).

Table 6. Work schedule by job type (percent)

	Job Type	
Work Schedule	**Production**	**Non-Production**
4-d week	46.5	23.4
5-d week	32.5	74.0
8-on 6-off	20.0	2.6
Other	1.0	0.0

Comparison of the work schedules for B&B jobs with those of the track jobs revealed some differences between the two groups (see Table 7). B&B people do not work compressed work schedules (8-on 6-off), and nearly all of the production B&B jobs require a 4-d week while only 39 percent of track jobs work a 4-d week. With regard to non-production, more than half of B&B jobs work a 4-d week in contrast with 18 percent of track jobs.

Table 7. Length of work week for track versus B&B jobs (percent)

Work Schedule	Track		B&B	
	Production (n = 86)	Non-Production (n = 134)	Production (n = 14)	Non-Production (n = 20)
4-d week	39.0	17.9	92.9	60.0
5-d week	36.6	79.1	7.1	40.0
8-on 6-off	23.3	3.0	0	0
Other	1.2	0	0	0

Note: "n" refers to the number of survey respondents holding this type of job.

MOW workers provided information about their nominal workday (as defined by their labor agreement), in terms of start and end times of the workday, in the background survey. They reported their actual start and end times in the daily logs. The computation for actual work includes only those individuals who reported a full 2 weeks of data, although these individuals may not have worked a full 2 weeks. That is, their logs contained complete records for each workday.

Table 8 presents both the mean and median values for nominal and actual workday start and end times by job type. Median values provide the most meaningful comparison for this information. The median start time for both production and non-production jobs is 7 a.m. Production jobs tend to work a 10-h day so the end time for these jobs is later than for the non-production jobs. All MOW workers have a 30-min lunch break. Nearly all MOW people work during the day. Of the 254 study participants, three non-production MOW workers worked third shift, and two production workers worked second shift.

Appendix C contains the workday information for track versus B&B jobs. Two primary differences exist between the two groups. The track production jobs have a median start time of 6:45 a.m., while the B&B production jobs start at 7 a.m. In addition, because more of the B&B non-production jobs work a 4-d week, their workday ends later than their track counterparts. Due to the small number of B&B people in the survey and the similarity of their work schedules to those of the larger track group, all subsequent analysis does not differentiate between B&B and track MOW workers.

Table 8. Workday by job type

	Production		Non-Production	
	Mean	Median	Mean	Median
Start time (nominal)	6:50 a.m.	7 a.m.	7:14 a.m.	7 a.m.
Start time (actual)	6:55 a.m.	6:35 a.m.	7:11 a.m.	6:50 a.m.
End time (nominal)	4:42 p.m.	5 p.m.	3:48 p.m.	3:30 p.m.
End time (actual)	4:38 p.m.	5 p.m.	4:10 p.m.	4 p.m.
Length of meal break (nominal)	27 min	30 min	28 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. Investigation of start time variation provided a means to estimate work schedule variability. This study defined a variation in start time as a change in start time of more than 1 h from the previous day. During the 2-week timeframe of the study, 16 percent of the production MOW workers and 22 percent of the non-production MOW workers experienced start time variation at least once (see Table 9). This difference between job types is not statistically significant, X^2 (4, n = 254) = 5.21, p = 0.267.

Table 9. Start time variability by job type (percent)

Number of Start Time Variations (in 2-Week Period)	Job Type	
	Production	Non-Production
0	84.0	77.9
1	10.0	15.6
2	3.0	5.8
3	2.0	0.6
4+	1.0	0

In the daily log, production and non-production workers reported that the longest amount of time that they worked without a break is approximately 4 h (see Table 10). This result is reasonably consistent with the contractual provision for a meal break after 4 h on the job.

Table 10. Longest time working without a break by job type (h:min)

Job Type	Mean	Median
Production	4:17	4:00
Non-Production	3:56	3:40

3.4.2 Number of Hours Worked

The study collected data on a typical work week, nominal work week, and actual hours worked. On average, production workers reported (in the background survey) a typical work week to be 44:39, and non-production workers reported 43:58. For a 2-week period, this is equivalent to 89:18 and 87:56, respectively (see Table 11). The employee's job characteristics, as reported in the background survey, determined the employee's nominal work. The researchers computed actual work for 2 weeks using data from the daily logs. Based on the actual work data, half of each group worked about 4 h or more of overtime during the 2-week period. One quarter of the production group worked 95:58 or more (see 75^{th} percentile column in Table 11.) This is equivalent to one additional 8-h day per week. Similarly, a quarter of the non-production group worked 93:12 or more during the same period. These values are nearly the same as the 75^{th} percentile values for typical work and indicate that the data collection period was probably a truly typical work week, in terms of overtime hours, for a quarter of non-production MOW workers.

For production jobs, both the median nominal work and actual work were less than typical for the survey period. For non-production jobs, the median actual work exceeded both the typical and nominal work. Actual work exceeds nominal work due to any overtime extension of the regular workday or, in some circumstances, work on a planned day off or response to an emergency call.

The production group worked on average 2½ h more in the 2-week period than their non-production counterparts. This data collection occurred during the summer months when most production work occurs so it is not surprising that this group worked a slightly longer work week.

Table 11. Typical, nominal, and actual work for 2-week period (h:min)

	Production					Non-Production				
	Mean	Median	Std. Dev.	25th %	75th %	Mean	Median	Std. Dev.	25th %	75th %
Typical work	89:18	88:00	10:36	80:00	95:30	87:56	80:00	11:22	80:00	94:00
Nominal work	82:58	80:00	6:46	80:00	85:20	80:24	80:00	4:51	80:00	80:00
Actual work	89:28	84:30	18:50	76:35	95:58	87:01	83:39	16:35	76:10	93:12

3.4.3 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 after the employee began the trip home at the end of the workday or on a planned day off. Overtime that was an extension of the nominal work schedule was not an unscheduled work period. Callbacks, a subset of unscheduled work periods, were unscheduled work periods that occurred on a regular workday.

One-third of participants had an unscheduled work period at least once in the 2-week period. An MOW worker was 10 times more likely to be called for an unscheduled work period on a planned day off than on a regular workday (.10 and .01, respectively). Overall, the probability of an MOW worker being called for an unscheduled work period was .045, production employees .03, and non-production .05. Based on the study period, MOW workers averaged .62 unscheduled work periods per worker per 2-week period. If an MOW employee worked an unscheduled work period, less than a 1 percent chance existed of being called back a second time on that day.

The time between the end of shift (on a workday) and the time called back to work averaged 3:24. At this point, the MOW worker was home, on average, 2:52. Callbacks lasted an average of 4:24. Unscheduled work periods on planned days off lasted 9:07, an indication that these work periods were probably a planned additional workday rather than response to an emergency.

If data collection had taken place during the winter months, more callbacks to handle weather-related problems would likely have occurred.

3.4.4 Travel to Lodging/Rally Point

Many MOW jobs, both production and non-production, require the worker to travel, usually on his/her own time, to a meeting point. This meeting point may be the lodging site for out-of-town work or merely a location from which the employees are transported to the worksite (referred to as a rally point). The requirement for this type of travel is more common with production jobs. Regardless of the type of job, however, the travel is usually done on a planned day off because it requires substantial time that cannot be accommodated on a workday.

Overall, 23.6 percent of the MOW workers reported travel to a lodging/rally point at some point during the 2-week study. Half of these individuals made more than one trip. Production MOW workers traveled more than the non-production MOW jobs, with 41 percent of the production MOW workers making at least 1 trip to a lodging/rally point over the 2 weeks of the study, and only 12 percent of the non-production MOW jobs having to travel to a lodging/rally point. As shown in Table 12, approximately one-third of the production workers traveled on a planned day off, and 8 percent made the trip on a regular workday. Non-production workers traveled less frequently. Seven percent made trips on planned days off and on workdays. Travel that occurs on a workday may be either travel from home at the beginning of the work cycle or travel midweek to move to a new worksite. Only two instances of relocation travel midweek occurred. Because this is paid travel while on the job, further analyses involving travel to a lodging/rally point excluded these two cases.

Travel on planned days off compromises personal time that would otherwise be available to spend with family members and to attend to personal business. It may also compromise the worker's sleep time. The average trip for production workers who traveled on planned days off was 5:36; non-production averaged 6:36. In contrast, travel to the lodging/rally point that occurred on workdays averaged 2:25 for production jobs and 2:09 for non-production. Table 12 summarizes the travel time to the lodging/rally point by job type and type of day. Table 13 displays the percentiles for travel time to a lodging/rally point by job type and type of day. Both groups had significantly longer travel on planned days off.

Table 12. Travel time to lodging/rally point by job type and type of day (h:min)

	Production			Non-Production			All		
Type of Day	**Percent of Workers**	**Mean**	**Median**	**Percent of Workers**	**Mean**	**Median**	**Percent of Workers**	**Mean**	**Median**
Regular Workday	8.1%	2:25	2:13	6.5%	2:09	2:00	7.1%	2:16	2:05
Planned Day Off	35.7%	5:36	4:45	6.7%	6:36	7:15	18.1%	5:48	5:00

Table 13. Percentiles for travel time to lodging/rally point by job type and type of day (h:min)

Type of Day	Production 25th Percentile	Production 75th Percentile	Non-Production 25th Percentile	Non-Production 75th Percentile	All 25th Percentile	All 75th Percentile
Regular Workday	1:56	3:01	1:20	2:33	1:30	2:38
Planned Day Off	3:45	6:30	3:30	8:30	3:41	7:34

Overall for both groups of MOW workers who traveled, the median travel to the lodging/rally point was 2:05 on regular workdays and 5:00 on planned days off. A quarter of the group traveling on a planned day off traveled 7:34 or longer. A total of 24 trips occurred on a regular workday, and 70 happened on a planned day off.

Table 14 presents this same travel data by work week and job type. This data indicates that those working 8-on 6-off have significantly longer trips to the lodging/rally point. The reason for the 8-on 6-off schedule is usually because the work location is far from the workers' homes, and staying onsite for the extended period avoids an extra round trip to the site. This situation supports this finding.

Table 14. Travel time to lodging/rally point by job type and work week (h:min)

Work Week	Production Mean	Production Median	Non-Production Mean	Non-Production Median
4-d week	4:50	4:10	4:05	3:30
5-d week	4:57	4:45	3:59	2:40
8-on 6-off	6:21	7:15	8:00*	10:30*
All schedules	5:06	4:20	4:27	3:00

* Only three trips existed for this category.

The survey materials did not collect data for the return trip home from the lodging/rally point separately. Study participants reported it in the commute home on the last day of the work week. It is reasonable to assume that, on average, the return trip is of the same duration.

3.4.5 Commute Time

For the purposes of this study, commute time refers to local travel from home to the daily reporting point. This type of travel is most common with non-production jobs. If the individual slept away from home, in lodging or otherwise, commute time reflects the trip from the lodging to the worksite. This type of travel applies primarily to production workers. It may include travel from the lodging to a rally point, as well as travel from the rally point to the day's worksite. Because the survey included travel back home from a lodging or rally point in the commute home reported at the end of the work week, commute home is somewhat of an overestimate for both groups. Figure 6 depicts the average workday, including commute and lunch break, for production and non-production workers. Figure 7 shows the average workday by job schedule.

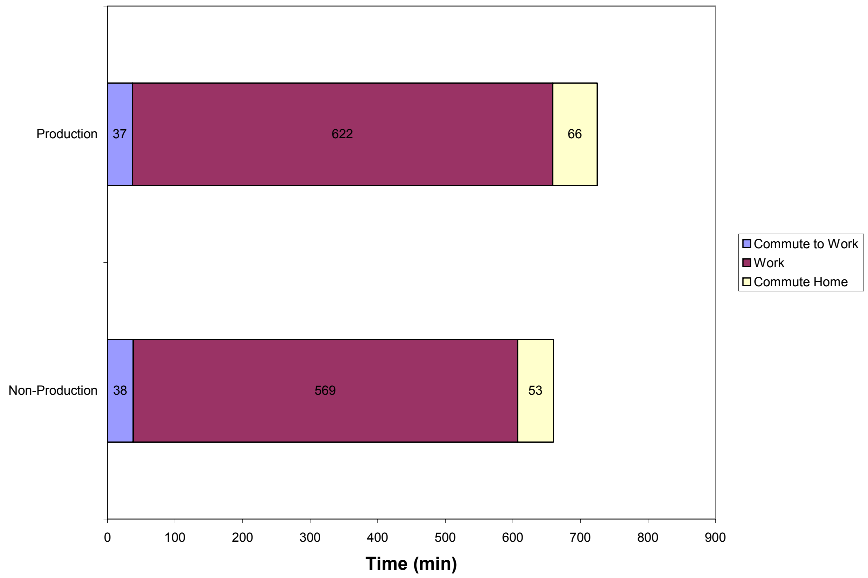

Figure 6. Commute time and workday by job type

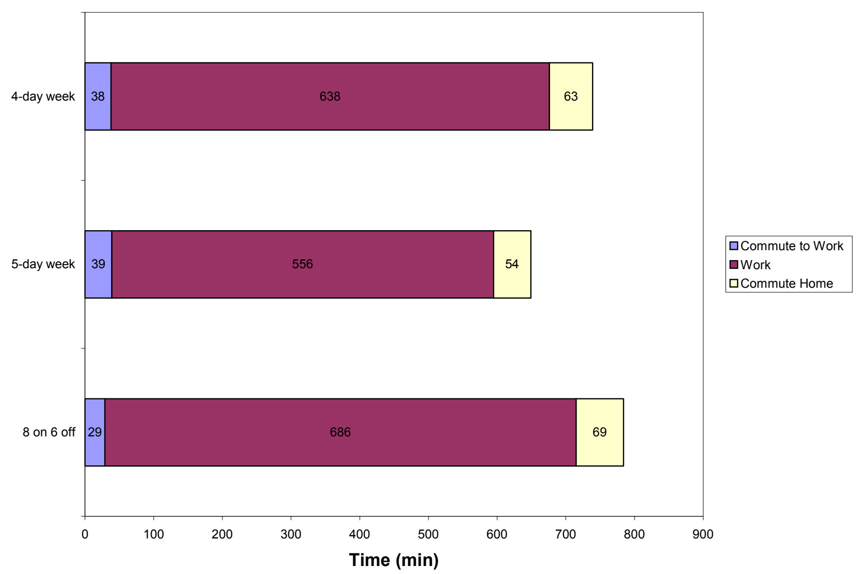

Figure 7. Commute time and workday by job schedule

3.4.6 Work Schedules and Alertness

Through questions on the background survey, MOW workers rated their overall alertness at work and after work. Approximately 60 percent of each group reported that they always or frequently feel alert at work (see Table 15). With regard to the end of the workday, 65 percent of the production workers and 56 percent of the non-production group reported that they occasionally or never felt drained after work (see Table 16). No statistically significant difference existed between the two groups on either of these self-assessments, X^2 (3, n = 254) = 1.13, p = 0.77 and X^2 (3, n = 254) = 2.49, p = 0.48.

Table 15. Alertness at work by job type (percent)

Alert at Work?	Production	Non-Production
Always	11.0	8.4
Frequently	49.0	55.2
Occasionally	39.0	35.7
Never	1.0	0.6

Data from participants' daily logs provided real-time assessments of their alertness. These data did not reveal a statistically significant difference between the two groups in their daily alertness assessments (see Table 17). Peak alertness for both groups occurred after the commute to work about 7 a.m., after which alertness levels declined throughout the day.

The study explored the relationship between several aspects of the MOW workers' 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, $r = -.024$, $r^2 = .0006$, $p = .263$.

Table 16. Drained after work by job type (percent)

Drained After Work?	Production	Non-Production
Always	4.0	4.5
Frequently	31.0	39.0
Occasionally	62.0	55.2
Never	3.0	1.3

Table 17. Alertness throughout the day by job type

	Job Type		
Time of Rating	**Production**	**Non-Production**	**Significance Test**
Upon awakening	3.39	3.47	$t(2226) = -1.90, p = .058$
After commute to work	3.55	3.61	$t(2170) = -1.25, p = .211$
After lunch	3.52	3.55	$t(2045) = -0.70, p = .487$
After arriving home	3.06	3.11	$t(1824) = -1.17, p = .241$
At bedtime	2.48	2.47	$t(1531) = 0.14, p = .892$
After callback	2.50	2.32	$t(28) = 0.22, p = .828$

Callbacks appear to affect morning alertness ratings, although to a limited degree (see Table 18). Alertness levels the morning following a callback were significantly lower than on mornings not following a callback, $t(2140) = -3.38$, $p < .05$. The effect size for this relationship is 0.34. (The *t*-test is an indication of the strength of the relationship while effect size is a measure of the degree to which a relationship exists between callback and morning alertness.) According to Cohen (1988), this is a small to medium effect size. Cohen (1988, p. 24) also suggests that effect size (*ES*) can be converted to r and r^2 using the following relationship:

$$r = \frac{ES}{\sqrt{ES^2 + (1/pq)}}$$

where p = proportion with callback on the prior night and $q = 1\text{-}p$. Using this formula, $r = .074$ and $r^2 = .0055$, which means that callbacks only explain .55 percent of the variance in morning alertness. A X^2 test investigating callbacks and morning alertness supports the hypothesis that alertness ratings are not independent of callbacks (i.e., a relationship exists between callbacks and morning alertness ratings, X^2 $(4, n = 2142) = 31.69$, $p < .05$).

Table 18. Alertness and callbacks

	Morning Alertness Rating	
	Mean	**Median**
Following callback	2.85	3.0
No callback	3.50	4.0

This effort also explored alertness and its relationship to commute time, number of hours worked, and time without a break. 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. For commute to work and alertness level upon arriving at work, $r = -.129$, $r^2 = .017$, $p < .05$, and for commute home and alertness when arriving home, $r = -.204$, $r^2 = .042$, $p < .05$. A statistically significant correlation existed between time without a break and alertness upon arriving home; however, this correlation was very weak, $r = -.052$, $r^2 = .003$, $p < .05$. Length of workday had the strongest relationship with alertness when arriving home, although even this correlation is considered weak, $r = -.214$, $r^2 = .046$, $p < .05$.

3.4.7 Sources of Stress

In the background survey, participants rated job-related sources of stress. They rated stress using a Likert scale with values from 1 to 4, with 1–no stress, 2–a little stress, 3–stressful, and 4–very stressful. The sources and levels of stress differed by job type. Overall, participants gave higher stress ratings to sources arising from organizational and management issues than those related to the work schedule and associated travel. The three greatest sources of stress for production MOW workers were management policies, job pressure, and inadequate staff. For non-production workers, the three greatest sources of stress were inadequate staff, management policies and ambiguous rules (see Figure 8). As shown in Table 19, for 9 of the 17 sources of stress, there were statistically different ratings from the two groups of MOW workers. Only in the case of travel to work and lodging at the worksite did production MOW workers report a statistically different and higher level of stress than their non-production counterparts.

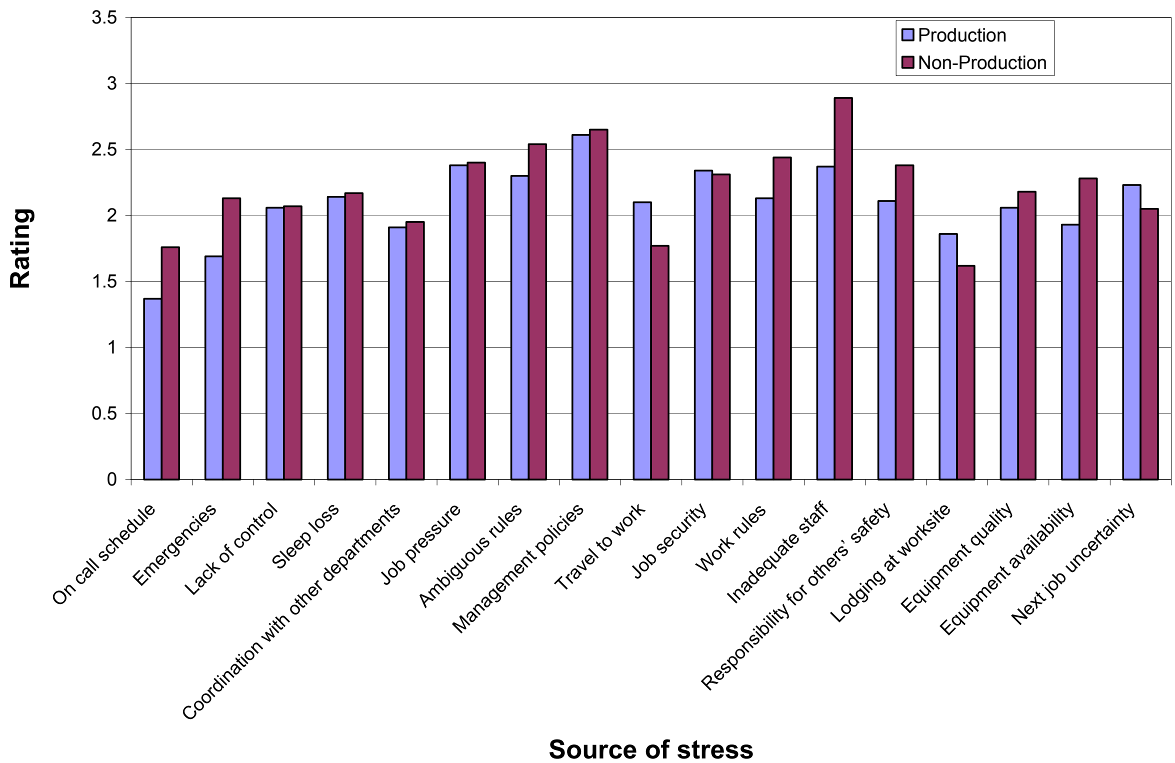

Figure 8. Sources and levels of stress

3.4.8 Job Characteristics Summary

The work schedules of production and non-production employees differ in several respects. Nearly half of those holding production jobs work 4-d weeks, one-third work 5-d weeks, and 20 percent work 8-on 6-off. In contrast, nearly 75 percent of those holding non-production jobs work 5-d weeks, approximately one-quarter work 4-d weeks, and only a small number work 8-on 6-off. In addition, because production jobs work primarily a 4-d week, they tend to work a 10-h day, while non-production crews generally work 8½ h a day.

Similarities between production and non-production workdays include a similar amount of start-time variability, a 40-min commute to work, 30-min lunch break, generally no more than 4 h of work without a break, and approximately a 1-h commute home. Again, the commute home may be artificially high due to some participants recording their entire travel back home at the end of a work week.

Both production and non-production workers traveled to a lodging or rally point during the study period. Forty-one percent of production workers but only 12 percent of non-production workers had this type of travel. Average travel time on planned days off was more than double that on workdays. This type of travel on planned days off compromises personal time and may affect a worker's sleep.

Table 19. Stress ratings by job type

Sources of Stress	Production	Non-Production	Significance Test
On call schedule	1.37	1.76	$t(245) = -3.95, p < .05^*$
Emergencies	1.69	2.13	$t(247) = -3.92, p < .05^*$
Lack of control	2.06	2.07	$t(249) = -0.09, p = .925$
Sleep loss	2.14	2.17	$t(248) = -0.22, p = .828$
Coordination with other departments	1.91	1.95	$t(248) = -0.38, p = .704$
Job pressure	2.38	2.40	$t(249) = -0.14, p = .887$
Ambiguous rules	2.30	2.54	$t(248) = -2.02, p < .05^*$
Management policies	2.61	2.65	$t(249) = -0.36, p = .717$
Travel to work	2.10	1.77	$t(250) = 2.97, p < .05^*$
Job security	2.34	2.31	$t(249) = 0.24, p = .808$
Work rules	2.13	2.44	$t(249) = -2.53, p < .05^*$
Inadequate staff	2.37	2.89	$t(249) = -3.88, p < .05^*$
Responsibility for others' safety	2.11	2.38	$t(249) = -2.21, p < .05^*$
Lodging at worksite	1.86	1.62	$t(245) = 2.03, p < .05^*$
Equipment quality	2.06	2.18	$t(249) = -0.98, p = .329$
Equipment availability	1.93	2.28	$t(249) = -2.88, p < .05^*$
Next job uncertainty	2.23	2.05	$t(246) = 1.36, p = .177$

Note: 1 = no stress, 2 = a little stress, 3 = stressful, 4 = very stressful
*statistically significant at $\alpha = .05$

Both production and non-production MOW workers tend to work more than their nominal schedules require, most likely due to overtime and unscheduled work periods. Although results did not indicate excessive overtime, approximately one-quarter of both MOW groups worked nearly 2 d or more of overtime in the 2-week period.

One-third of participants had at least one unscheduled work period in the 2-week period, with a .045 probability of being called for an unscheduled work period on any given day. An MOW worker was 10 times more likely to have an unscheduled work period on a planned day off than on a workday, with callbacks lasting approximately 4½ h on workdays and 9 h on planned days off. There likely would have been more frequent unscheduled work periods had this data collection occurred during the winter months, when weather can cause track problems. Callbacks affected morning alertness ratings; alertness levels the morning following a callback were significantly lower than on mornings not following a callback. This relationship, however, was considered weak.

For all MOW workers, level of alertness generally increased upon arriving at work and deteriorated throughout the day. The study examined several factors contributing to self-assessed alertness. Of the job-related factors, length of workday had the largest impact, although this relationship was weak.

3.5 Sleep Characteristics

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

Analysis of the sleep and nap data required a way to distinguish between naps and split nighttime sleep. For workday entries, if the nap began after the person went to sleep, but before he/she began the commute to work, then it was considered split nighttime sleep and added to nighttime sleep duration. No adjustment was necessary for those who worked night shift (defined as a start time between 6 p.m. and 1 a.m.) since these individuals could potentially have a legitimate nap after bedtime but before the commute to work. For nap entries on planned days off, if the nap began between 12 a.m. and 7 a.m., then the researchers added nap duration to nighttime sleep duration. The nap analysis did not include naps that were part of split nighttime sleep and, as a result, were combined with nighttime sleep duration.

3.5.1 Nighttime Sleep

Table 20 presents nighttime sleep duration for the two groups of MOW workers and U.S. adults. The NSF *2002 "Sleep in America" Poll* is the source of the data for U.S. adult norms. MOW workers are averaging less nighttime sleep on regular workdays than U.S. adults, but on planned days off they are averaging more. In terms of median nighttime sleep, however, MOW workers get less sleep regardless of type of day. As shown in Table 21, a statistically significant difference existed between MOW workers' sleep and that of U.S. adults on workdays. On planned days off, however, only non-production MOW workers differed from U.S. adults. Both production and non-production groups get significantly more sleep on planned days off than on workdays, production: $t(95) = -8.87$, $p < .05$, and non-production: $t(145) = -11.92$, $p < .05$.

Figure 9 presents a frequency distribution of nighttime sleep on workdays for all MOW workers and U.S. adults. Two-thirds of MOW workers get less than 7 h sleep on work nights in contrast with 39 percent of U.S. adults. The proportion getting less than 6 h is the same as that for U.S. adults. Only 3.2 percent of MOW workers averaged less than 5½ h sleep on workdays, and only 1 MOW worker (less than 1 percent) averaged less than 5 h of sleep.

Table 20. Nighttime sleep duration versus U.S. adult norms by type of day (h:min)

Day	Group	Mean	Median	Std. Dev.	25%	75%
Regular Workday	Production	6:41	6:45	0:39	6:16	7:08
	Non-Production	6:43	6:42	0:45	6:13	7:08
	U.S. Adults	6:54	7:00	--	--	--
Planned Day Off	Production	7:41	7:38	1:00	6:52	8:24
	Non-Production	7:52	7:43	1:13	7:04	8:36
	U.S. Adults	7:30	8:00	--	--	--

Table 21. Mean nighttime sleep duration–tests for significance

Type of Day	Comparison	Significance Test
Regular Workday	Production vs. U.S.*	$t(99) = -3.33, p < .05$
	Non-Production vs. U.S.*	$t(151) = -3.01, p < .05$
	Production vs. Non-Production	$t(250) = -0.22, p > .05$
Planned Day Off	Production vs. U.S.	$t(96) = 1.81, p > .05$
	Non-Production vs. U.S.*	$t(144) = 3.63, p < .05$
	Production vs. Non-Production	$t(240) = -1.25, p > .05$

* Statistically significant at $\alpha = .05$

Research has shown that performance declines even with mild sleep restriction. Belenky et al. (2003) have shown that performance declines initially with the mild to moderate sleep restriction of 7 and 5 h, and after a few days stabilizes at a less than fully rested level. Van Dongen, Maislin, Mullington, and Dinges (2003, p. 117) concluded that:

> Since chronic restriction of sleep to 6 h or less per night produced cognitive performance deficits equivalent to up to two 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 15 percent of MOW workers who are getting less than 6 h of nighttime sleep on workdays may be performing significantly below that of a well rested MOW worker. More disconcerting, based on the Van Dongen study, is that these individuals are probably unaware of the extent of their performance degradation.

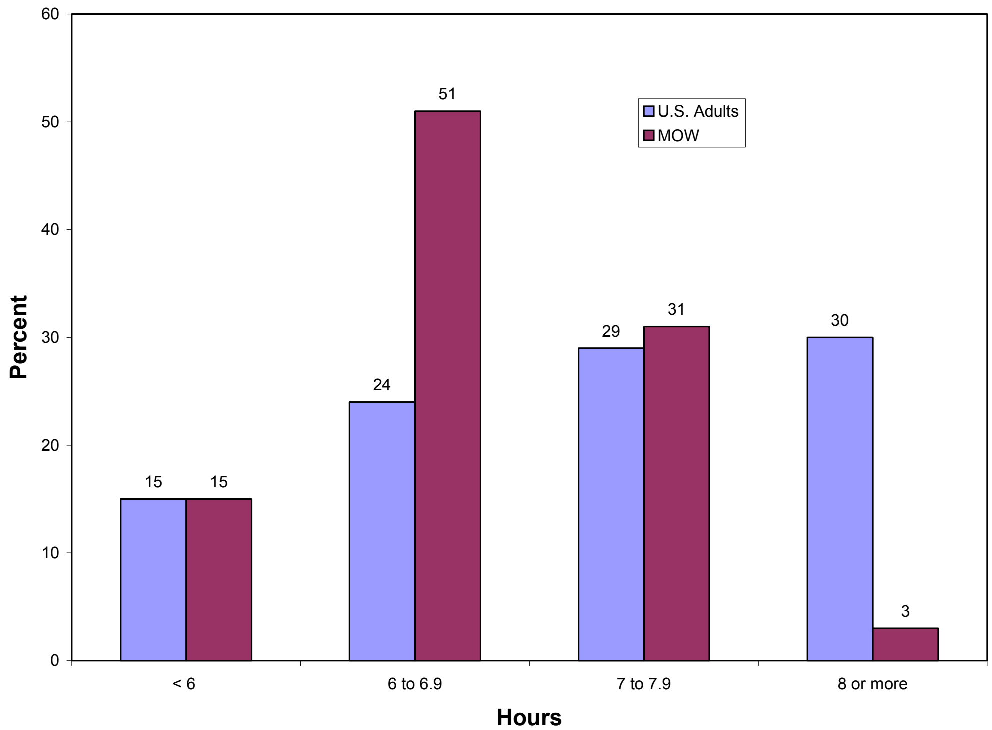

Figure 9. Duration of nighttime sleep on workdays for MOW workers versus U.S. adults

ANOVA showed no significant effect of job schedule on nighttime sleep duration (on workdays), $F(2, 247) = 2.78$, $p = .064$.

As might be expected, a positive correlation existed between nighttime sleep duration and morning alertness ratings, $r = .290$, $r^2 = .084$, $p < .05$. Those getting more sleep at night tended to feel more alert in the morning, and those getting less sleep tended to feel less alert. The r^2 value indicates that nighttime sleep accounts for 8.4 percent of the variance in morning alertness.

Total daily sleep is the combined sleep from nighttime sleep and naps. Because MOW workers in general tend not to nap (see Section 3.5.3 for further information on naps), total sleep was not a great deal more than nighttime sleep (see Table 22).

Table 22. Total sleep by type of day and job type (h:min)

Day	Job Type	Mean	Median
Regular Workday	Production	6:44	6:48
	Non-Production	6:46	6:43
Planned Day Off	Production	7:50	7:49
	Non-Production	8:00	7:52

3.5.2 Sleep Ratings

Participants recorded subjective ratings for sleep on both workdays and planned days off. Participants also rated their ease of falling asleep, ease of arising, length of sleep, quality of sleep, and alertness upon arising. The ratings shown in Table 23 used a Likert scale ranging from 1 to 5, with 1 being the lowest or worst rating, while 5 indicated the highest or best. While no significant differences existed between the two groups on either workdays or planned days off, both groups rated their sleep significantly higher on planned days off than on workdays.

Table 23. Sleep ratings by job type and type of day

	Production			**Non-Production**		
	Regular Workday	**Planned Day Off**	**Significance Test**	**Regular Workday**	**Planned Day Off**	**Significance Test**
Ease of Falling Asleep	3.71	4.00	$t(95) = -4.69, p < .05$	3.78	4.03	$t(147) = -5.75, p < .05$
Ease of Arising	3.30	3.66	$t(95) = -5.82, p < .05$	3.25	3.51	$t(147) = -4.52, p < .05$
Length of Sleep	3.19	3.68	$t(95) = -7.49, p < .05$	3.32	3.72	$t(147) = -8.58, p < .05$
Quality of Sleep	3.45	3.88	$t(95) = -6.31, p < .05$	3.49	3.82	$t(147) = -6.79, p < .05$
Alertness Upon Arising	3.39	3.77	$t(95) = -6.34, p < .05$	3.42	3.75	$t(147) = -6.21, p < .05$

The researchers investigated sleep location as a possible influential factor on sleep ratings. This analysis examined nighttime sleep on workdays only. As previously mentioned, MOW employees may work significant distances from their primary residence and therefore sleep away from home during their work cycle in a hotel or other arrangement closer to the worksite. Production crews, because they travel considerable distances to various locations for work, sleep away from home more often than non-production crews. Production crews spent less than half (48.1 percent) of their work nights at home, while non-production crews slept at home more than 80 percent (83.6 percent) of the time.

Comparisons of sleep ratings for sleeping at home versus away from home revealed few differences. Dependent measures *t*-tests indicated no significant differences between home and away ratings, except that production crews got 40 min less sleep at home than away from home and found it easier to fall asleep at home (see Table 24). Two possible reasons exist for the difference in sleep duration. An absence of distractions when away from home may allow the MOW employee more opportunity for sleep. Another possible explanation is that the trip from the lodging to the worksite is shorter than from home to a worksite, so the reduced commute time allows for more nighttime sleep. Interestingly, although their actual sleep was statistically longer when away from home, no statistical difference existed in their ratings of length of sleep. Although non-production crews gave higher ratings to their at-home sleep, no statistically significant differences existed by sleep location (see Table 25).

When sleeping away from home, both production and non-production crews may have various sleeping arrangements, often dependent on company provisions, and may range from sleeping in an individual room (not shared), to sharing a hotel room or camp car with other workers, to sleeping in a vehicle, camper, or tent. For two-thirds of MOW workers, the company generally provides accommodations when away from home. One-third receives a per diem and spends it as desired. Only 1 percent reported receiving no provision (see Figure 10).

Table 24. Sleep ratings by location on workdays (production jobs)

	Home	Away	Significance Test
Ease of Falling Asleep	3.86	3.43	$t(19) = 2.08, p = .05$*
Ease of Arising	3.23	3.03	$t(19) = 1.15, p = .26$
Length of Sleep	2.93	3.05	$t(19) = -0.54, p = .59$
Quality of Sleep	3.67	3.34	$t(18) = 1.81, p = .08$
Alertness Upon Arising	3.14	3.31	$t(19) = -1.15, p = .27$
Nighttime Sleep Duration	5:51	6:30	$t(19) = -2.14, p < .05$*

* Statistically significant at $\alpha = .05$

Table 25. Sleep ratings by location on workdays (non-production jobs)

	Home	Away	Significance Test
Ease of Falling Asleep	3.65	3.46	$t(26) = 1.15, p = .26$
Ease of Arising	3.36	3.42	$t(26) = -0.42, p = .68$
Length of Sleep	3.31	3.14	$t(26) = 1.21, p = .24$
Quality of Sleep	3.54	3.25	$t(26) = 1.90, p = .07$
Alertness Upon Arising	3.28	3.23	$t(27) = 0.29, p = .77$
Nighttime Sleep Duration	6:22	6:47	$t(25) = -1.78, p = .09$

Since sleeping arrangements may affect away from home quality of sleep, a separate analysis compared sleep at home to sleep away from home based on sleeping arrangements. Dependent measures *t*-tests indicated only one statistically significant difference between sleeping home and sleeping away from home by sleeping arrangement. Those sharing a room with others when away from home actually slept longer than when they sleep at home. While those sleeping in an individual room and those sleeping in a vehicle, camper, or tent also had longer nighttime sleep duration when away from home, those differences were not statistically significant. Table 26 contains the data for these comparisons. Table C-2 in Appendix C contains the results of the significance tests related to the comparisons in Table 26. A total of 48 survey participants reported sleeping both at home and away from home during the survey, and 43 of these people reported their typical sleeping arrangement on the background survey. The information was missing for the remaining five people.

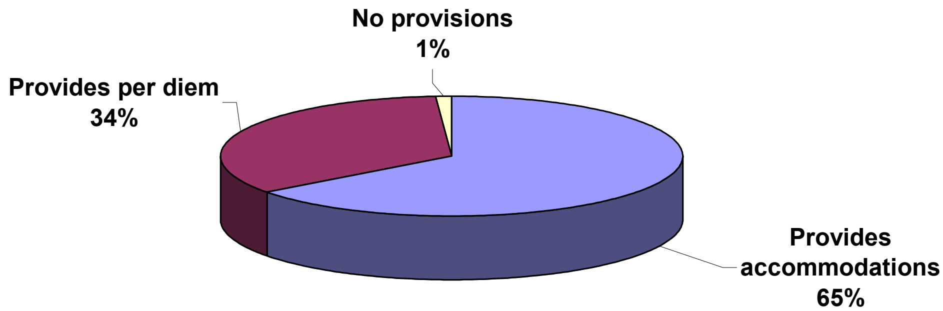

Figure 10. Company provisions for nights away from home

The effect of age on sleep quality was also of interest. Research by Ohayon et al. (2004) suggests that the durations of Stage 1 and Stage 2 sleep increase with age, while rapid eye movement sleep and slow wave sleep decreases. No significant relationship existed between age and sleep quality ratings for this MOW population, $r = .020$, $r^2 = .0004$.

3.5.3 Naps

Data from participants' daily logs indicate that MOW employees, in general, do not nap a great deal. Participants averaged 1.3 naps in 2 weeks. Approximately 60 percent of the MOW employees took no naps during the 2 weeks of the study, and 11 percent took only one nap over the 2-week period. The average nap duration was 00:56, and the median was 00:45.

The production group napped slightly more often than the non-production group, 1.4 naps in a 2-week period, compared with 1.2 naps, respectively. This is not a statistically significant difference, $t(252) = 0.38$, $p = .702$.

MOW workers nap more frequently and longer on planned days off. They averaged .14 naps/d on planned days off and .06 naps/d on workdays. The average nap length was 1:02 on planned days off and 0:50 on workdays. MOW workers may be making up for a weeknight sleep deficit with longer naps on their days off.

Nap frequency did not vary greatly by work schedule. Those working 4-d weeks averaged 1.5 naps in 2 weeks, those working 5-d weeks averaged 1.1 naps in 2 weeks, and those working 8-on 6-off averaged 1.6 naps over the 2-week period. A one-way ANOVA showed no statistically significant difference between groups, $F(2,249) = 0.66$, $p = .518$.

Table 26. Sleep ratings at home versus away from home by sleeping arrangement

	Sleeping Arrangement					
	Share with Others (n = 20)		Individual Room (n = 20)		Vehicle, Camper, or Tent (n = 3; Inadequate for Statistical Comparisons)	
	Home	Away	Home	Away	Home	Away
Nighttime Sleep Duration	5:51*	6:36*	6:15	6:44	6:28	6:52
Ease of Falling Asleep	3.76	3.36	3.57	3.44	4.83	4.71
Ease of Arising	3.50	3.32	2.97	2.99	4.10	3.72
Length of Sleep	3.28	3.06	2.95	3.08	3.55	3.75
Quality of Sleep	3.53	3.18	3.55	3.29	4.33	4.05
Alertness Upon Awakening	3.24	3.23	3.06	3.24	3.90	4.33

* Statistically significant at $\alpha = .05$

Naps occur at various times throughout the workday. As illustrated in Figure 11, most first naps occurred after work, between 4 p.m. and 6 p.m. (35.7 percent). The second most popular naptime was between 6 p.m. and 8 p.m. (16.8 percent), followed by 10 a.m. to 12 p.m., and 12 p.m. to 2 p.m. (14.7 percent each). Individuals napping on the way to work while someone else drove and those napping during an early lunch account for the early morning nap times and pre-noon naptimes.

Sixteen MOW employees reported more than one nap on a given day. This group reported 28 occurrences of a second nap (of the day) during the 2 weeks of the survey. Of those taking 2 naps in a day, over 80 percent were older than the average age of 47.3 yr, and over 50 percent were 58 yr or older. In addition, over 60 percent of this group rated their health as fair, while in the overall sample only 20 percent rated themselves as being in fair health. It is possible that overall health and/or age may be related to the frequency of naps.

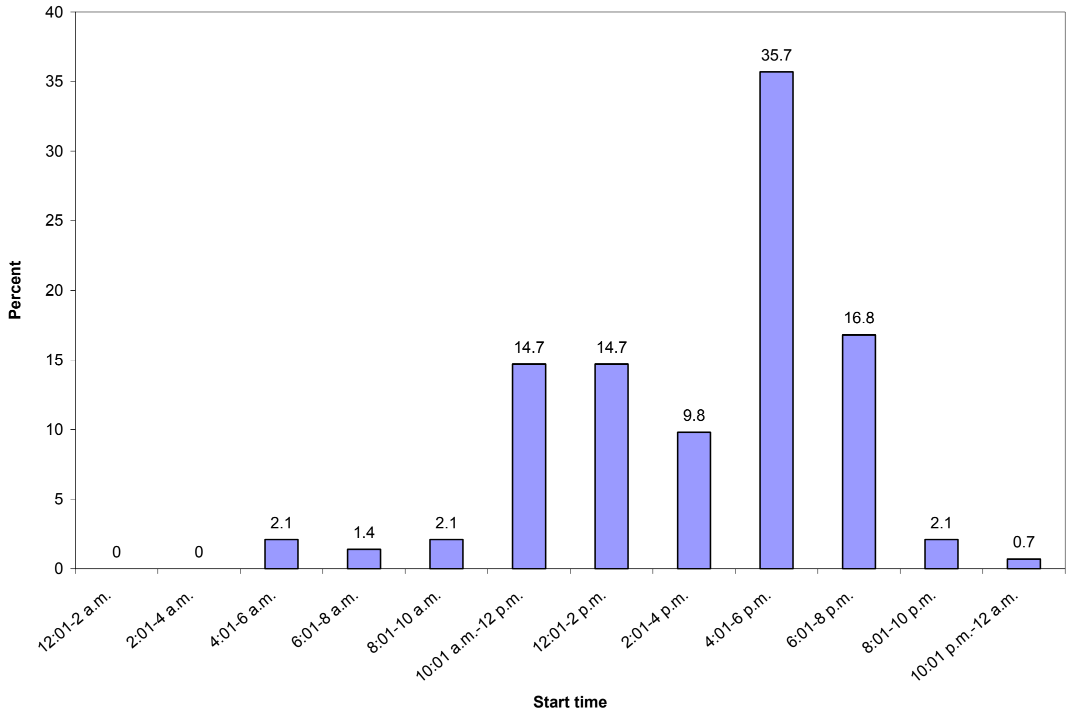

Figure 11. Nap 1 start times for workdays

3.5.4 Sleep Disorders–Alertness and Sleep Ratings

Seventeen MOW employees (6.7 percent) of 254 total survey respondents reported having a diagnosed sleep disorder. Eleven of those individuals (65 percent) reported receiving treatment for their disorder. Six of those with a diagnosed sleep disorder (35 percent) reported that their problem was untreated.

A separate analysis compared sleep ratings and alertness levels across three groups: (1) the untreated sleep disorder group (n = 6), (2) the treated sleep disorder group (n = 11), and (3) those with no diagnosed sleep disorder, or the normal group (n = 237).

For most sleep rating categories, those with untreated sleep disorders reported poorer sleep ratings than the other two groups (see Table 27). The only statistically significant difference between those with untreated sleep disorders and those with treated sleep disorders, however, was the difference in quality of sleep. Interestingly, in the majority of categories, those with treated sleep disorders reported equal or better mean value sleep ratings than the normal group, although again these differences were not statistically significant. Table C-3 in Appendix C provides the significance tests for these comparisons.

Table 27. Sleep ratings and duration by sleep disorder status (all days)

	Untreated Sleep Disorder (n = 6)	Treated Sleep Disorder (n = 11)	Normal (n = 237)
Ease of Falling Asleep	3.75	3.92	3.86
Ease of Arising	3.38	3.34	3.40
Length of Sleep	3.24	3.57	3.44
Quality of Sleep	3.10	3.72	3.63
"How Feel" in Morning (Alertness)	3.34	3.76	3.56
Nighttime Sleep Duration	7:09	7:00	7:06

Similar to their sleep ratings, those with untreated sleep disorders also reported lower mean alertness levels throughout the workday (see Table 28). At every point throughout the day that alertness was rated, those with untreated sleep disorders had lower alertness scores than the other two groups. These differences, however, were not statistically significant. Also similar to the sleep ratings, those with treated sleep disorders generally had equal or higher alertness ratings than the normal group, although again these differences were not statistically significant (see Table C-4 in Appendix C).

Table 28. Alertness and sleep disorders (workdays only)

	Untreated Sleep Disorder (n = 6)	Treated Sleep Disorder (n = 11)	Normal (n = 237)
Upon Awakening	3.40	3.62	3.42
After Commute to Work	3.45	3.62	3.58
After Lunch	2.99	3.68	3.53
After Arriving Home	2.84	2.90	3.06
At Bedtime	2.37	2.68	2.49

3.5.5 Sleep Characteristics Summary

During the study period MOW workers averaged less nighttime sleep than U.S. adults on workdays. A much larger percentage of MOW workers got less than 7 h of sleep on weeknights (66 percent) compared to U.S. adults (39 percent). Fifteen percent of MOW workers are getting less than 6 h of sleep on workdays and may be performing below that of a well-rested MOW worker.

Conversely, on planned days off, MOW workers averaged more nighttime sleep than U.S. adults. Both groups of MOW workers got approximately 1 h more sleep and reported better sleep ratings on planned days off than on workdays.

Production and non-production workers differed in the percentage of time spent sleeping home versus away from home on workdays. Those working production jobs slept away from home on half of their workdays, while non-production crews slept away from home on only 20 percent of their workdays. Very few differences existed in sleep ratings comparing sleep at home and sleep away from home, or by sleeping arrangement. MOW workers did, however, sleep longer when away from home, although only for those sharing a room with others was this a statistically significant difference.

Neither group of MOW workers napped a great deal. Those who did nap more frequently tended to be older, and a much greater percentage of them assessed their overall health as fair.

Almost 7 percent of MOW workers in the sample reported having a diagnosed sleep disorder. Almost two-thirds of those individuals reported having received treatment for their condition, while 35 percent reported no treatment. Data generally show lower sleep quality ratings and alertness throughout the day for those with untreated sleep disorders compared to those with treated sleep disorders and those without a sleep disorder, but only the quality of sleep rating had a statistically significant difference.

3.6 Textual Analysis of Work and Sleep Comments

The MOW worker's daily log included two separate spaces for participants to record any comments regarding their sleep and work periods each day. This section presents an overview of participants' comments on their sleep and work experiences throughout the 2 weeks of the study.

Commenting on sleep or work experiences in the daily log book was not a requirement of participation. Rather, individuals had an opportunity to qualify part of their day. As such, some participants chose not to comment, while others commented frequently. For this reason, a statistical analysis of these comments was not possible. Researchers, however, scanned a number of participant log books to determine common themes presented in the comments, and performed a simple tabulation of the frequency of topics mentioned. The following themes emerged from this review:

1. Fatigue (physical fatigue, being sleepy, worn down, sore, etc.)
2. Sleep location (related to sleeping home or away from home)
3. Alertness (mental alertness, vigilance)
4. Unscheduled work (asked to work early, stay late, work off days, overtime, etc.)
5. Stress
6. Travel (related to commuting to/from work or lodging)
7. Personal issues (family, etc.)
8. Management
9. Job security
10. Responsibility
11. Territory
12. Weather

13. Dispatcher, track gang, track crew, track department
14. Safety

ATLAS.ti® software V5.0 was used to autocode comments based on keyword searches and tally the number of comments made under each topic area. Table 29 lists the keywords that were the basis for each topic area search.

The most frequently mentioned topics in the sleep comments were fatigue, sleep location, and travel. Comments on weather, fatigue, and travel dominated the work experience section. The comments complement the quantitative survey results by providing personal examples of the effect of work or sleep patterns present in the survey data. Perhaps more important is that the survey did not explicitly address the most frequently mentioned topic, weather. In this way, the comments provide a more complete picture of MOW workers' fatigue-related concerns.

Table 30 presents more detailed results of keyword searches. Topics of fatigue and alertness were combined in the table due to relatively few comments on alertness.

The selected comments that appear following the tables illustrate the consequences of the work and sleep patterns in the survey data. For example:

- The comments with regard to *Weather* illustrate that the survey participants frequently felt that weather affected their perceived level of fatigue and the overall quality of the workday experience.
- The *Travel* comments illustrate how travel to a distant worksite compromises personal and sleep time.
- Most of the *Fatigue* comments relate to fatigue resulting from travel and long workdays.
- Comments with respect to *Sleep Location* address difficulties encountered when sleeping away from home.
- Some survey participants described *Personal Situations* that affected their sleep.
- While the survey participants did not report much *Unscheduled or Emergency Work*, some MOW workers who did have unplanned work reported sleep disruption as a result.

The limited comments relating to "dispatcher, track gang, track crew, track department" and "responsibility" were not meaningful, and therefore they are not presented below. No comments were made on the topic of job security.

Table 29. Keywords used for each topic area search

Topic	Keywords
Alertness (mental)	Alert*, aware*, awake, attentive*, watchful, vigilant, prepared
Dispatcher, track gang, track crew, track department	Dispatcher, track gang, track crew, track department
Fatigue (physical)	Fatigue*, tired, sleepy, exhaust*, spent, weary, energy, weak*
Job security	Job security, secure*
Management	Manage*, boss, supervis*, company, policy, organization, administration
Personal issues (family, etc.)	Personal, private, family, domestic, son, daughter, wife, kid*, baby, father, mother, grand*, relative*, child*
Responsibility	Responsib*, duty, blame, reliab*, accountab*
Safety	Safe*, accident, incident, injury, casualty, error, protection
Sleep location	Bed, hotel, motel, away, camp*, camp car, noise*, room*, lodging, accommodation*, quarters
Stress	Stress*, workload, work load, pressure, too much, strain, anxious, anxiety, worry, tense
Territory	Territory, coverage, area, region
Travel	Travel, commute, driv*, drove, worksite, trip, car, truck, camper
Unscheduled work	Schedule, overtime, call*, night call, weekend call, emergency, unscheduled, shift work, respond, crisis, trouble,
Weather	Weather, heat, hot, degrees, temperature cold, freezing, wet, rain, snow, sleet, light*, dark, sun, ice, climate, condition*

Note: ATLAS.ti search logic uses the symbol "*" as a wildcard. For example, searching for "stress*" would result in all words starting with s-t-r-e-s-s and would include any ending (such as stress<u>ful</u>, stress<u>or</u>, etc.).

Table 30. Frequency of comments by topic area and source

Topic	Sleep Log	Work Log	Total
	Source of Comments		
Weather	29	252	**281**
Fatigue/Alertness	122	134	**275**
Travel	40	141	**181**
Sleep Location	58	9	**67**
Personal Issues	20	38	**58**
Unscheduled Work	9	45	**54**
Stress	15	35	**50**
Safety	3	26	**29**
Management	1	6	**7**
Territory	0	3	**3**
Dispatcher, Track Gang, Track Crew, Track Department	0	2	**2**
Responsibility	0	1	**1**
Job Security	0	0	**0**
Total	**302**	**706**	**1008**

Selected comments by topic follow.

Weather

- "In the winter we have snow removal detail. It is nothing to get a call at 3:00 a.m. to come in and start removing snow…the snow removal in the winter is an everyday thing if it snows. There are no days off."
- "The weather is a big factor here. Sometimes it's very cold or very hot. That alone wears you out by the end of the day and week!"
- "Heat index around 110 degrees for today. Men on gangs having difficulty coping with heat and humidity. Almost lost one to the heat today."
- "Hot weather. Crews starting to hurry up to get things done. Some rules not being followed completely."
- "Long day. Had a lot of work to do. The heat continues to be a big factor; we're not used to it. Need to keep drinking a lot of water."
- "Very hot and humid weather combined with very physical work made me more tired than usual during and after work."

Fatigue/Alertness

- "I'm so tired that I could not work in a safe manner if I had to because just not enough sleep and too many hours changed. Worked so many hours that I cannot remember what day it is."
- "Sleep was only 5 hours but very sound. Felt kind of tired most of the day but that's the way Monday's are when you work 5 days a week on the road far from home and try to have some kind of home life on a 2 day weekend."
- "It was a typical Monday after traveling. It was 9 hours to the motel and between that and getting up between 2-3 a.m. I am very tired. On this job we are working early Monday hours because that is the only time that we can get the track."
- "The jobs at work are getting more numerous and we have not got enough help. I am tired most of the time because we work like dogs trying to keep up."
- "The reason I and the 2 people that I work with are so tired most of the time is that we are getting into our fifties. Lack of help is probably a big factor. There is only three of us to cover the whole … terminal. That is not enough people to keep up with the workload that is put on us."
- "30 minute nap helped me to be more alert."
- "I am mentally exhausted after today's work day. I worked a 12 hour day on my scheduled off day. Very tired!"

Travel

- "Normal [sleep] for Saturday night before leaving Sunday afternoon for work location. Have to use 8 and a half to 9 hours of planned off day to travel to lodging/rally point. Leave at 1530, arrive 0030-0100 on work day."
- "It seems Monday's I am usually more tired than any other day of the week. It takes me 8 hours to drive from home to my lodging motel."
- "I left home at 0400. How do you expect me to keep my family together? My mother is also in the hospital. Drove 900 miles just to get to work."
- "Another work schedule change. Move motel 30 miles. I'm taking the next 2 days off to take care of many things. Drove 287 miles home. The home front is falling apart because I'm never home. Situation critical."
- "I always try to drive to work the night before work. I need some sleep before I go in on a Monday or I am totally off-center all day. If I drive at night and start work with some sleep, I am OK. If I drive all night without sleep Monday's are too long."
- "My drive home was 1,000 miles which is a 14 hour drive."

Sleep Location

- "Always staying in a motel on these production gangs is difficult. Newness of motel and cleanliness conditions of mattresses and bedding, AC and heat, all these things account for the type of rest at night."

- “Did not sleep good at camp. There were passing trains that woke me up 2 times. And a co-worker woke up and opened the door and it woke me up.”
- “Employees opening and closing the camp door as they come in. Employee snoring very loudly after being out late.”
- “I have difficulty sleeping at times due to noise in the motel.”
- “I have to settle down and get used to surroundings after getting to hotel.”

Personal Issues

- “Due to infant son that was sick and home from daycare, the day started early. Unable to catch a nap. Scheduled to be on the job by 1630.”
- “Slept on couch as wife too upset with me for having to leave so early.”
- “Had grandchildren stay overnight. Sleep was poor.”
- “After working in that damn heat all day, now I have to look at a 3 hour drive ahead of me. After being away from home all week now I have to mow the lawn and other jobs that await me. I only have one day and a half to get everything done as well as be a husband and father plus a grandfather. Plus a 3 hour drive from home to lodging.”

Unscheduled Work

- “Did not sleep too well. Expecting to get called out again.”
- “Difficulty falling asleep. Called out to report to work at 0530. Difficulty going back to sleep knowing I had to get up early.”
- “Very tired. 28 hours overtime in last 11 days. Have to take tomorrow off, too tired and personal business.”
- “... And as far as being recalled to work outside our assigned work hours, during the summer it is very rare. In the winter we have snow removal detail. It is nothing to get a call at 3:00 am to come in and start removing snow. I myself live 60 miles [away] and it is a long day when you start at 3:00 am and don’t get home until 4:00 pm. The snow removal in the winter is an everyday thing if it snows. There are no days off. My foreman and I are the only two that showed up to do the removal on the weekends last winter. Nobody else would come in….”
- “Logged over 26 hours of overtime this week. But I really need my overtime to support my family, so when I get a chance to work, I take it. I only wish I didn’t have to worry about making a mistake and getting suspended without pay or worse. Nobody seems to worry about getting hurt or killed. All of us young guys worry about getting in trouble for making mistakes. Young/new guys will make mistakes, its human nature and part of the learning process.”
- “Called on vacation to repair broken rail at 0400…”
- “Get called about 1400 to 1430 every day to add work. They want you to work till dark every day.”

- "Today is Saturday, a rest day. Got called at 2100, left home at 2130. Had to inspect track. Done at 0000. Back home at 0030."

Stress

- "Busy day at work. A little stressed out mentally and physically. Too much to do and not enough people to do the work. … Have another busy day tomorrow. Hopefully I will get a good night's rest."
- "…I was with the rail detector which is pretty stressful. I had a crew behind me to change out rail and I think I had about 20 phone calls today relating to work. Drove me nuts. We have a lot of new hires working now and they just don't get it…. By the end of the day I am tired from stress. Don't like my job…."
- "Deleting a bunch of rules would relieve a lot of stress. A lot of rules the FRA implemented with the pressure from the union made our job a lot harder."
- "Most stressful part of working is trying to follow all the rules. It is almost impossible to do and accomplish any work."

Safety

- "I'm so tired that I could not work in a safe manner if I had to because just not enough sleep and too many hours changed. Worked so many hours that I cannot remember what day it is. Damn!"
- "My opinion on sleep and safety. The day I am most concerned about for my men's safety and mine is Monday. Some of my men, about half of surfacing gang, travel at night to early morning to make 0700 job briefing. During the day they are sleepy, short-tempered and not as alert as normal. Especially late in the day. This is a very poor day to have major projects, switch cutovers or railroad projects that require overtime. All my men are always very tired and ready to quit at 1530 on Mondays. The rest of the workdays are always much better. Just my observation over the years …."
- "When the union pushed for all the new rules on track safety it did no good on safety but made it a lot harder to do the job and a lot more stressful."

Management

- "The company claims that we (employees) can take power naps no longer than 20 minutes yet we get a lot of flack whenever we do! What's up with this?!?"

Territory

- "Had to drive 70 miles to and from job site. Have too much territory!"

4. Findings and Recommendations

Analysis of the data from this study provides some insights into the demographics of the MOW worker population, as well as how their work schedules and sleep patterns affect their alertness on the job. Because a random sample of the U.S. MOW population provided the data, the results are representative of the Nation's MOW worker population at the time of the survey. Conducting the survey during the summer months when major track construction occurs assured that an adequate number of production workers would participate. Had the survey taken place during the winter, the results likely would have been different, particularly in terms of emergency calls due to weather-related track problems.

This section presents the key findings of the study, as well as some recommendations for methodological changes for future field studies of this nature. This section concludes with some suggestions for additional uses of this data.

4.1 Key Study Findings

The following subsections highlight the key findings with respect to the MOW worker's nominal work periods, unscheduled work periods, and sleep patterns.

4.1.1 Work Periods

The nominal schedules for both production and non-production MOW workers have 80 h of work in a 2-week period. The typical workday is 7 a.m. to 5 p.m. for production jobs and 7 a.m. to 3:30 p.m. for non-production jobs.

Nearly a quarter of MOW workers reported travel to a lodging/rally point during the study. Travel occurred on both workdays and planned days off but was more frequent and of significantly longer duration on planned days off. Travel on planned days off compromises personal time that would otherwise be available to spend with family and to attend to personal business. It may also compromise the worker's sleep time.

The weekly work schedules for production and non-production jobs differ. Almost half of those with production jobs worked 4 d per week, one-third worked a 5-d week, and 20 percent worked 8-on 6-off. Nearly 75 percent of the non-production people worked a 5-d week, nearly a quarter worked a 4-d week, and only a small number worked 8-on 6-off.

The overall length of the workday, including commuting and lunch breaks, was 11 h for non-production jobs and 12 h for production jobs. Both workdays allow for adequate time for nighttime sleep; however, both production and non-production MOW workers tend to work more than their nominal schedules require. This is likely due to overtime and unscheduled work periods. The mean number of hours worked by production crews in the 2-week period was 89:28, while non-production crews worked 87:01. These results do not indicate excessive overtime. However, 25 percent of those with production jobs worked more than 95:58, and 25 percent of the non-production group reported working more than 93:12. This means that a quarter of both production and non-production MOW crews worked nearly 2 d or more of overtime in the 2-week period. This level of overtime, if done on a regular basis, may prevent the employee from achieving full rest and recovery.

4.1.2 Unscheduled Work Periods

Overall, the probability of an MOW worker being called for an unscheduled work period was .045, production employees .03, and non-production .05. One-third of participants had an unscheduled work period at least once in the 2-week period. An MOW worker was 10 times more likely to be called for an unscheduled work period on a planned day off than on a regular workday (.10 and .01, respectively).

The length of an unscheduled work period on a workday was significantly shorter than one on a planned day off. Callbacks lasted on average 4:24. Unscheduled work periods on planned days off lasted 9:07, an indication that these work periods were probably a planned additional workday rather than response to an emergency. If data collection had occurred during the winter months, there probably would have been more callbacks to handle emergency weather-related problems.

Morning alertness following a callback was significantly lower in comparison to mornings when no callback had occurred the prior night. While the difference was statistically significant, the effect size was small. This result implies that other factors contribute to morning alertness and that eliminating callbacks would not substantially improve morning alertness ratings.

4.1.3 Sleep Patterns and Alertness

On planned days off, both production and non-production groups get the same amount of sleep, with both groups averaging more than the U.S. adult norm. On workdays, again, both groups of MOW workers get the same amount of nighttime sleep, but this amount is significantly less than the norm for U.S. adults. Not only is weeknight sleep significantly less than U.S. adult norms, but the percentage of MOW workers getting less than 7 h of sleep is also significantly greater. This is a concern since research has shown that performance decrements occur with less than 7 h of sleep, particularly if it is consistently at this level. Even more disconcerting is that 15 percent of MOW workers are getting less than 6 h of nighttime sleep on workdays and that these individuals, who perform safety critical jobs, are probably unaware of the extent of their performance degradation.

While no significant differences existed in sleep ratings between the two groups on either workdays or planned days off, both production and non-production workers had significantly higher sleep ratings on planned days off than on workdays.

The incidence of reported sleep disorders among MOW workers exceeds the U.S. adult norm for sleep apnea. Because of the wording of the question on the background survey, it is not possible to determine if all of these MOW workers have sleep apnea. For this reason, it is not certain that the incidence of sleep apnea in this population exceeds U.S. norms. Railroads and union sponsored fatigue education programs should point out the possible performance consequences of untreated sleep disorders. These education programs should encourage those with untreated sleep disorders to seek treatment.

4.2 Recommendations for Improvements in Study Procedures

Based on the experience of this study, several methodological improvements should be a part of any future studies to collect work schedule and sleep pattern data. The recommended changes are the following:

- *The data collection period should avoid a holiday period.* Because mailing of the survey materials for this study occurred at the end of June, some participants recorded data over the Fourth of July weekend. As a result, some participants did not work their normal work schedule during the data collection period so data for a full 2-week work cycle was not reported.
- *If the study population includes workers who must travel long distances on their own time to reach a rally point or lodging site, the daily log should have a better way to record travel to the rally point/lodging site.* The daily log for this study included a place for recording such travel, and the instructions described how to record this travel. Nevertheless, some participants did not understand the difference between travel to lodging/rally point and commute to worksite, and they entered the information in the incorrect place.
- *The background survey should inquire whether or not the participant has been diagnosed with sleep apnea, as well as a sleep disorder, so that the results can be compared with U.S. norms for sleep apnea from the Wisconsin Cohort Study.* A question on sleep disorders in general is necessary to be certain that poor sleep due to any sleep disorder does not confound the survey data.
- *The instructions should state that when an employee works on a planned day off, he/she should record this work period in the same section of the log that is used for regular workdays, rather than in the unscheduled work period section.* Participants were not sure whether to record this information in the regular workday section or in the unscheduled work period section.

4.3 Recommendations for Additional Research

A number of mathematical models exist for predicting human fatigue and alertness. Development of the majority of these models used laboratory data on the human sleep cycle. A need exists for data on both work schedules and sleep patterns for further refinement of these models. In particular, the only data for railroad workers available to date is from locomotive engineers. The availability of the MOW employee data will allow the modelers to refine their models and predict how the typical MOW worker work schedule may be affecting on-the-job alertness.

Finally, the analysis presented in this report characterizes the work schedules and sleep patterns of MOW employees. Further analysis of the data could identify explanatory factors for the reported alertness levels. For example, the data indicates that a difference exists in morning alertness following an unscheduled work period, but statistically, the occurrence of the unscheduled work period only accounts for a small portion of variance in alertness. Other factors, such as length of the prior days' sleep periods and the time of awakening, also merit investigation.

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Appendix A.
Survey Materials

This appendix includes copies of the following survey materials:

- Cover letter to BMWE members from BMWE International President
- Instructions to participants on making entries in the Daily Log
- Railroad Maintenance of Way Worker Background Survey
- Railroad Maintenance of Way Worker Daily Log (1 day)

Freddie N. Simpson
Acting President

Perry K. Geller, Sr.
Acting Secretary-Treasurer

Brotherhood of Maintenance of Way Employes

Affiliated with the AFL-CIO and C.L.C.

<<Enter date here>>

«Whole_Name»
«Address_1»
«Address_2»
«Location»

Subject: **FRA Sponsored Fatigue Study**

Dear Sister or Brother:

Fatigue is a major concern in our industry. The expansion of territories, the erratic on-call status of BMWE members, workweek variations, and away from home lodging and meal provisions contribute to an environment where fatigue can easily result.

As you may have read in *the BMWE Journal,* the Federal Railroad Administration (FRA) and the Brotherhood of Maintenance of Way Employes are conducting a fatigue study that focuses on maintenance of way workers. You have been randomly selected to participate in this very important scientific study. The results of the study will provide the FRA and the BMWE with a clearer picture of work schedules and sleep patterns of maintenance of way workers. The study will also provide the statistical basis necessary to identify areas for improvements.

You are among a small group of randomly selected BMWE union members nationwide that are being asked to fill out work/sleep diaries for a two-week period.

Your participation in this study involves:

1) completing a brief background survey; and
2) keeping a daily log for 14 consecutive days of your sleep and work times along with self-assessments of your level of alertness five times per day.

To insure that your personal information is completely confidential, the FRA has engaged the services of Foster-Miller for executing the study. The names and personal information of the participants from the sample group will be completely confidential, and the data gathered will only be used to compile the information as a group. After the study's conclusion, all the personal data gathered will be destroyed and only the compiled information will be distributed.

Completing the background survey should take less than 15 minutes; making entries in the daily log should require no more than a total of 10 minutes per day. As a reward for your participation in this study, you will receive a $75 gift certification to either Home Depot or Sears. *You must provide 14 consecutive days of data and a completed background survey to receive the gift certificate.*

The overall purpose of the study is to develop a better understanding of the work/rest schedules and sleep patterns of maintenance of way workers and to evaluate the relationship between these schedules and fatigue. Your participation is critical to the success of this study. The data will allow us to identify any fatigue-related problems specific to our craft. Once we have the data, we will be able to work toward reducing the risk of fatigue-related accidents and incidents and improving the quality of life for our members. A report concerning this study will be published next year in the *Journal.*

Please read the enclosed instructions carefully before beginning your data collection. Thank you for your participation in this important research study.

In Solidarity,

Acting President

20300 Civic Center Drive, Suite 320
Southfield, MI 48076-4169
Telephone: 248-948-1010 FAX: 248-948-7150

Survey of Work Schedules and Sleep Patterns of Railroad Maintenance of Way Employees

Important: Please Read Before Making Entries in Daily Log

Using the Daily Log	The log is divided into 14 sections, one for each day that you will be recording data. Each section contains both a Sleep and Nap Log, and a Work Log. Start a new section for each new day. On the section divider page, write the date and indicate whether or not this is a regular workday or a planned day off. Please start with Day 1. Begin your log on the **first day of your next work cycle**. It is important that you provide data for 14 **consecutive** days. Do not record data during a vacation period. Complete the Sleep and Nap Log for every day of the study, not just your workdays. **We need a record of your sleep for all 14 days.** Complete the Work Log for those days that you work. If for any reason you do not record data at the appointed time, fill out your log as soon as possible to the best of your ability. The study results will not be meaningful without complete diary entries from you. Record times in the log using the 2400 clock system. For example, 4:30 p.m. is 1630.
Sleep and Nap Log (complete daily)	Make entries on this log **upon awakening** and **at bedtime** every day. In addition, if you took any naps, enter this information in the log. If your nighttime sleep is disrupted due to emergency call or other circumstances, record the first segment of your sleep in the "Upon Awakening" section of the Sleep and Nap Log. Use the "Nap 1" section to record subsequent sleep. Explain anything unusual about your sleep in the Comments section.
Work Log (complete only for workdays)	Make entries on the work log **at the start of your workday when you arrive at your workplace, during your lunch break and at the end of the workday when you arrive home/at lodging.** You should use the **unscheduled work period** section of the log if 1) you were called back to work on a weekend or other day that is a planned day off, 2) there was a break between the end of your regular workday and the start of your overtime or 3) there was a break between the end of your overtime and the start of your regular workday. If you did not work an unscheduled work period or there was no break between your regular work period and the overtime, then leave this section blank.

Please turn over →

Recording Travel to/from Lodging or Rally Point

Please record any traveling to lodging/rally point on the day you begin your travel. For example, assume you travel to your lodging/rally point on Sunday night for work on Monday. Record this travel in the work log for Sunday. On the day that you return home, be sure to record "Time you arrived home or at lodging."

Recording Unscheduled Work Periods

Each day's log begins when you get up for the day. **If you were called back to work after midnight, enter this work period on the prior day's section of the log.** For example, assume you went to bed at 10 p.m. Monday night but were called back at 1 a.m. You returned home at 4 a.m. and went back to sleep from 4:15 until 6 a.m. You would 1) record the emergency call as an unscheduled work period for Monday, 2) record the sleep period from 10 p.m. to 1 a.m. in the Sleep and Nap Log for Tuesday and 3) record the second sleep period from 4:15 to 6 a.m. as Nap 1 for Tuesday.

Study Compensation

You must return a completed background survey and 14 days of sleep and work schedule information to receive the compensation. You will receive a $75 gift certificate to a retail establishment as compensation for your participation in this study. Complete the last page of the log book to indicate your preference for the study compensation. You should receive your gift certificate within 4 weeks of returning your materials.

Returning Study Materials

Return your Background Survey and Daily Log in the postage paid envelope.

Questions or Problems?

If you have questions on any aspect of these instructions, are not sure how to report specific work or sleep information, or need additional survey materials, please contact us:

Alex Viale	Sarah Acton
781-684-8444	781-684-4281
aviale@foster-miller.com	sacton@foster-miller.com

ID Number:________

Railroad Maintenance of Way Employee Background Survey

Confidential

This collection of information is voluntary, and will be used for research purposes only, specifically to study work-related fatigue among railroad employees. Public reporting burden is estimated to average 15 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Please note that an agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. The OMB control number for this collection is 2130-0561.

Form FRA F6180.114 (12/03)

About Yourself

1. Age: ____ years
2. Sex: ____ male ____ female
3. How long have you been a maintenance of way employee?
   _____ years and ____ months
4. How long have you been a maintenance of way employee at your current railroad?
   _____ years and ____ months
5. What type of maintenance of way employee job do you currently work?
   ____ construction/production crew
   ____ track maintenance (non-production)
   ____ bridge and building (non-production)
   ____ bridge and building (production)
   ____ other (please explain) __________________
   ____
6. What is your marital status?
   ____ single ____ divorced ____ other
   ____ married ____ widowed
7. How many children or other dependents do you have (not including your spouse)? _______
8. How many of your dependents are under the age of 2 years?_____
9. a) Do you drink caffeinated beverages?
   _____ yes _____ no
   b) On average, how many cups and cans of these beverages do you drink per day?_____

Your Health

1. How many times have you called in sick in the last 6 months? ___ days
2. In general, how would you rate your health? Circle One:

   Excellent Good Fair Poor
3. Some people feel younger or older than their biological age. How old do you feel? ____ years
4. Have you been diagnosed as having a sleep disorder?

   ____ Yes ____ No (skip question 5)
5. Are you receiving medical treatment for this condition?

   ____ Yes ____ No

Your Work Schedule

1. Please describe your job characteristics.
   a) Circle the days you are scheduled to work over a two-week period:

      S M T W Th F S S M T W Th F S
   b) Start time _____
   c) End time _____
   d) Length of meal break _____ minutes
2. On average, how many hours do you work per week? ____
3. How often do you feel well rested and alert over the course of your work period? Circle one:

   Never Occasionally Frequently Always
4. How often do you feel physically drained at the end of your work period? Circle one:

   Never Occasionally Frequently Always

Stress at Work

Use the following scale to rate how much each factor below contributes to your stress at work:

No Stress	A Little Stress	Stressful	Very Stressful
1	2	3	4

Please assign a rating to *each* of the following items:

___ On call schedule
___ Responding to emergencies
___ Lack of control over work schedule
___ Loss of sleep
___ Coordination with other departments
___ Pressure to finish a job
___ Ambiguous operating rules or procedures
___ Management policies and decisions
___ Travel to work site
___ Job security
___ Work rules
___ Inadequate staffing
___ Responsibility for safety of others
___ Lodging at work site
___ Equipment quality
___ Equipment availability
___ Uncertainty of next job location and/or project duration
___ Other (please specify) ________________________
____

Sleeping Arrangements

Please complete this section only if your job requires you to travel.

1. When held away from home on company business, most times:

   ___I share a hotel room or camp car with one or more other workers.

   ___I sleep in an individual room, not shared with anyone.

   ___I sleep in my vehicle, camper, or tent.

2. When held away from home on company business, the company:

   ___Provides me with sleeping accommodations.

   ___Provides a daily per diem and I must find my own overnight accommodations.

   ___Does not provide either sleeping accommodations or daily per diem.

Life Events

Please indicate with a ✓ whether any of the events listed below has occurred to you in the last 6 months:

__ Personal illness or injury

__ Marital difficulties

__ Birth of a child

__ Death of a spouse

__ Change in sleeping habits

__ Difficulty with the law

__ Illness/injury of family member or friend

__ Financial difficulties

__ Change in living conditions

__ Change in social activities

__ Death of a close family member


Maintenance of
Way Employee's
Daily Log

ID Number________________________________

If you have questions, you can contact:

Alex Viale
781-684-8444
aviale@foster-miller.com

Sarah Acton
781-684-4281
sacton@foster-miller.com

This collection of information is voluntary, and will be used for research purposes only, specifically to study work-related fatigue among railroad employees. Public reporting burden is estimated to average 10 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Please note that an agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. The OMB control number for this collection is 2130-0561.

FRA F6180.115 (12/03)

Welcome...
and thank you for participating in this project. The purpose of this study is to assemble data on both work and sleep patterns of maintenance of way employees. The data that you record will serve as a history of your work and sleep patterns and how you feel throughout the day. The study will examine the relationship between maintenance of way employees' work schedules and their level of alertness/fatigue.

Your participation is appreciated. Please contact us if you have any questions or comments.

Instructions

This log is divided into 14 sections, one for each day that you will be recording data. Each section contains both a Sleep and Nap Log and a Work Log.

Start a new section for each new day. On the section divider page, write the date and indicate whether or not this is a regular workday or a planned day off. Please start with Day 1. It is important that you provide data for 14 *consecutive* days.

When recording time, use the 2400 clock system. For example, 4:30 p.m. is 1630.

Complete the Sleep and Nap Log for *every* day of the study. Complete the Work Log for those days that you work.

If for any reason you do not record data at the appointed time, fill out your log as soon as possible to the best of your ability.

Sleep and Nap Log
Make entries on this log *upon awakening* and *at bedtime* ***every day***. In addition, if you took any naps, enter this information in the log.

Work Log
Make entries on the work log at the *start of your workday* when you arrive at your workplace, *during your lunch break* and at the *end of the workday* when you arrive home.

You should use the *unscheduled work period* section of the log *only* if you were called back to work on a weekend or other day that is a planned day off, or on a regular workday after you left your workplace. If you did not work an unscheduled work period, then leave this section blank.

Study Compensation
Complete the last page of this log book to indicate your preference for the study compensation.

Day 1

Date ______/_______/2004

Today is: ❑ regular workday
❑ planned day off

Sleep and Nap Log

Upon Awakening

Sleep Location

Home ☐ Away from home ☐

Time you went to bed	
Time you fell asleep	
Time you woke up	
Time you got up	
Number of awakenings during the night	

Rate your sleep

Ease of falling asleep

1 2 3 4 5

Very difficult — Very easy

Ease of getting up

1 2 3 4 5

Very difficult — Very easy

Length of sleep

1 2 3 4 5

Wholly insufficient — More than sufficient

Quality of sleep

1 2 3 4 5

Very poor — Very good

Indicate how you feel now

1 2 3 4 5

Very sleepy — Very alert

Complete if you took any naps, or had subsequent sleep after unscheduled work period or other nighttime interruption

Nap 1

Time fell asleep	
Time awoke	

Nap 2

Time fell asleep	
Time awoke	

At Bedtime

Indicate how you feel now

1 2 3 4 5

Very sleepy — Very alert

Comments on today's sleep experience: ____________

Work Log

Start of workday

Construction/production jobs only if applicable

Time you began travel to lodging/rally point	
Time you arrived at lodging/rally point	

All maintenance of way employees

Time you began commute to worksite	
Time you reported to worksite	

Indicate how you feel now

1 2 3 4 5

Very sleepy Very alert

During lunch break

Time at start of lunch break______________

Indicate how you feel now

1 2 3 4 5

Very sleepy Very alert

End of workday when you arrive home or at lodging

Longest time period you worked today without a break (A break is considered a minimum of 15 minutes of rest from work)	hr	min
Time you completed today's work period (Include unscheduled hours if there was *no break* between regular and extra work)		
Time you arrived home or at lodging		

Indicate how you feel now

1 2 3 4 5

Very sleepy Very alert

After unscheduled work period(s), if any

Period 1

Time you were called to report back to work	
Time you reported back to work	
Time you completed unscheduled work period	
Time you arrived home or at lodging	

Indicate how you feel now

1 2 3 4 5

Very sleepy Very alert

Period 2

Time you were called to report back to work	
Time you reported back to work	
Time you completed unscheduled work period	
Time you arrived home or at lodging	

Indicate how you feel now

1 2 3 4 5

Very sleepy Very alert

Comments on today's work experience:

Appendix B.
Adjustments to Data

Travel to the lodging/rally point

Travel to the lodging/rally point was intended to capture the long distance trip from home to the lodging/rally point, not daily commutes. Survey participants did not always correctly report Travel to the lodging/rally point in this way. Often, participants incorrectly recorded short daily trips from a motel or home to the worksite in the Travel to lodging/rally point field. When this occurred, researchers moved the entry from the Travel to lodging/rally point field to the Commute to worksite field.

In other instances, participants incorrectly coded daily travel from a motel or home to a rally point (a meeting place for further travel by company vehicle) as Travel to lodging/rally point. Researchers again corrected these cases by moving the entry from the Travel to lodging/rally point field to the Commute to worksite field.

In some cases, individuals drove a long distance from home directly to work on the first day of a work week, and incorrectly entered this in the Commute to worksite field, rather than the Travel to lodging/rally point field. As mentioned earlier, long distance traveling to a work location was intended for the Travel to lodging/rally point field, whereas the shorter daily commutes were intended for the Commute to work field. Researchers made the proper adjustments in these cases.

Finally, if the first day of the log was a workday and did not capture travel to a lodging/rally point the prior night, an extra field was added to the database to properly record this travel.

Total nighttime sleep versus naps

The survey instructions asked participants to record their nighttime sleep in the Upon Awakening section of the Sleep and Nap Log. If their nighttime sleep was disrupted due to emergency call or other circumstances, they were to use the Nap 1 section to record any subsequent sleep.

Some of the entries in the Nap section of the daily log that were in fact split nighttime sleep rather than naps required an adjustment to nighttime sleep. For workday entries, any nap that began after Time Feel Asleep but before Time You Began Commute To Work was added to nighttime sleep duration. The researchers did not make this adjustment for those who worked night shift (defined as a start time between 6 p.m. and 1 a.m.) since these individuals could potentially have a legitimate nap after bedtime but before the commute to work. For nap entries on planned days off, if the nap began between 12 a.m. and 7 a.m., the nap duration was added to nighttime sleep duration.

Naps that were combined with nighttime sleep duration were not a part of the nap analysis.

Unscheduled work periods

If an individual worked on a planned day off, the researchers treated the work period as an unscheduled work period. Hence, unscheduled work periods were counted not only for people who were called back to work after returning from their regular work period, but also for those who worked on a planned day off.

The researchers did not treat work hours that were an extension of the regular work period as an unscheduled work period because the individual had not yet gone home.

Population means versus mean of individual means

For some analyses of the daily log data, a mean was calculated for each survey participant and then the analysis was done with the individual means. The following measures were analyzed in this manner: actual hours worked (for 2 weeks); nighttime sleep by job type, type of day and job schedule; total sleep by job type; nap duration for everyone and by job type; sleep latency for all, by job type, and by type of day; and all data used in sleep disorder comparisons. For all other analysis of the data from the daily logs, data from all participants was used without computing a mean for each individual. For example, the analysis of commute time was based on the mean of the data for all workdays in the survey data. This latter approach was used where it was desirable to characterize a typical day rather than the individual MOW worker's experience.

Data from vacation periods

Some survey participants collected sleep data during a vacation period. These data were not a part of the analysis of MOW worker's sleep.

Appendix C.
Supporting Data

This appendix contains detailed data summaries that support the technical analysis in the main sections of this report.

Table C-1. Comparison of Track Maintenance and B&B daily work schedules

	Track				**B&B**			
	Production (n = 85)		**Non-Production (n = 134)**		**Production (n = 14)**		**Non-Production (n = 20)**	
	Mean	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**
Start Time (Nominal)	6:51 a.m.	6:45 a.m.	7:11 a.m.	7 a.m.	6:41 a.m.	7 a.m.	7:30 a.m.	7 a.m.
End Time (Nominal)	4:40 p.m.	5 p.m.	3:46 p.m.	3:30 p.m.	4:58 p.m.	5 p.m.	4 p.m.	5 p.m.
Length of Meal Break (Nominal)	27 min	30 min	28 min	30 min	29 min	30 min	25 min	30 min
Length of Workday (Nominal) h:min	9:40	10:00	8:29	8:00	9:49	10:00	9:08	9:35
2 Weeks of Work (Nominal) h:min	83:32	80:00	80:33	80:00	79:28	80:00	79:25	80:00

Table C-2. Significance tests for sleep ratings at home versus away from home by sleeping arrangement

	Sleeping Arrangement	
	Share with Others	**Individual Room**
Nighttime Sleep Duration	$t(19) = -2.39, p < .05$*	$t(18) = -1.82, p = .086$
Ease of Falling Asleep	$t(19) = 2.00, p = .060$	$t(19) = 0.65, p = .521$
Ease of Arising	$t(19) = 1.17, p = .257$	$t(19) = -0.13, p = .901$
Length of Sleep	$t(19) = 1.37, p = .186$	$t(19) = -0.64, p = .529$
Quality of Sleep	$t(18) = 1.71, p = .105$	$t(19) = 1.77, p = .093$
Alertness Upon Awakening	$t(19) = 0.10, p = .919$	$t(19) = -1.26, p = .222$

* Statistically significant at $\alpha = .05$

Table C-3. Significance tests for sleep ratings by sleep disorder status (all days)

	Untreated versus Treated	Untreated versus Normal	Treated versus Normal
Ease of Falling Asleep	*t*(15) = -0.44, *p* = .667	*t*(241) = -0.40, *p* = .688	*t*(246) = 0.30, *p* = .764
Ease of Arising	*t*(15) = 0.09, *p* = .933	*t*(241) = -0.07, *p* = .941	*t*(246) = -0.25, *p* = .803
Length of Sleep	*t*(15) = -1.02, *p* = .324	*t*(241) = -0.82, *p* = .416	*t*(246) = 0.72, *p* = .471
Quality of Sleep	*t*(15) = -2.17, *p* < .05*	*t*(241) = -1.88, *p* = .062	*t*(246) = 0.43, *p* = .665
"How Feel" in Morning (Alertness)	*t*(15) = -1.27, *p* = .225	*t*(241) = -0.77, *p* = .441	*t*(246) = 0.98, *p* = .330
Nighttime Sleep Duration	*t*(15) = 0.47, *p* = .647	*t*(239) = 0.19, *p* = .441	*t*(244) = -0.46, *p* = .643

*Statistically significant at $\alpha = .05$

Table C-4. Statistical tests for alertness and sleep disorders (workdays only)

	Untreated versus Treated	Untreated versus Normal	Treated versus Normal
Upon Awakening	*t*(15) = -0.63, *p* = .536	*t*(241) = -0.07, *p* = .943	*t*(246) = 0.89, *p* = .373
After Commute to Work	*t*(15) = -0.44, *p* = .670	*t*(241) = -0.44, *p* = .663	*t*(246) = 0.19, *p* = .852
After Lunch	*t*(15) = -1.98, *p* = .066	*t*(239) = -1.82, *p* = .070	*t*(244) = 0.67, *p* = .501
After Arriving Home	*t*(15) = -0.17, *p* = .867	*t*(240) = -0.69, *p* = .488	*t*(245) = -0.68 *p* = .500
At Bedtime	*t*(14) = -0.95, *p* = .357	*t*(224) = -0.39, *p* = .700	*t*(228) = 0.81, *p* = .420

Abbreviations and Acronyms

ANOVA	analysis of variance
BMWED	Brotherhood of Maintenance of Way Employes Division, International Union of Teamsters
B&B	bridge and building
d	day
FRA	Federal Railroad Administration
h	hour
in	inches
mi	miles
min	minutes
mo	month
MOW	maintenance of way
NARAP	North American Rail Alertness Partnership
NSF	National Sleep Foundation
OMB	Office of Management and Budget
yr	year