EFFECTS OF A FATIGUE MANAGEMENT PROGRAM ON FATIGUE IN THE COMMERCIAL MOTOR CARRIER INDUSTRY

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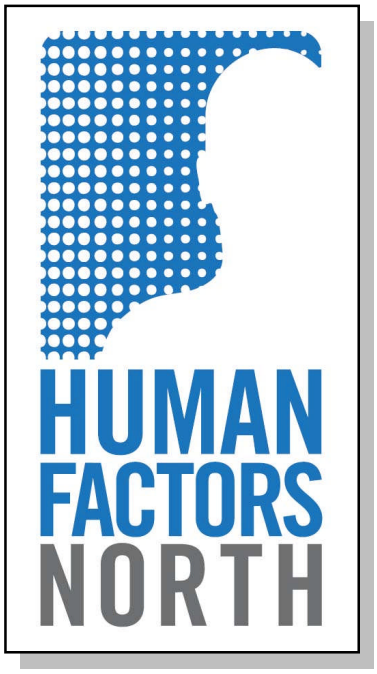

by
Human Factors North Inc.

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EFFECTS OF A FATIGUE MANAGEMENT PROGRAM ON FATIGUE IN THE COMMERCIAL MOTOR CARRIER INDUSTRY

FINAL REPORT

by

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EXECUTIVE SUMMARY

INTRODUCTION

Fatigue Management Programs (FMPs) are interventions intended to assist trucking companies in reducing driver fatigue. This report describes a field study of a comprehensive FMP involving 1) educational sessions at all levels of the trucking company, 2) sleep disorder diagnosis and treatment, and 3) interaction with dispatchers and management with the aim of improving dispatch practice with regard to fatigue. The goal of this study was to assess the feasibility of a company-wide approach to fatigue management and its impact on drivers' fatigue, performance, sleep duration and mood, as well as on company performance measures, scheduling policies and practices.

EXPERIMENTAL DESIGN AND METHODS

The study design involved: 1) providing a fatigue management program, and 2) data collection using a PDA (personal digital assistant) and an actigraph before and after FMP implementation. All drivers participating in the study, as well as a number of managers, trainers and dispatchers, received education on fatigue and sleep disorders. All drivers participating in the study underwent an in-home diagnostic evaluation for sleep disordered breathing. Sleep recorder results were provided to the physician who carried out a clinical evaluation, diagnosis and treatment.

Pre-FMP data collection was conducted over an eight to ten-day period to establish driver baseline levels of fatigue, sleep and performance. Post-FMP data collection was started after the following two criteria were met: 1) at least one month had passed after the drivers diagnosed with sleep apnea had started their treatment, and 2) two weeks had passed after the driver had attended the last education session.

Data were collected at the beginning and end of each duty or rest day except as noted. Drivers used a PDA device to record data on sleep, mood, workload and performance (psychomotor vigilance task [PVT] and critical incidents) and an actigraphic recorder to objectively document the number and duration of activity and rest bouts by wrist activity monitoring.

Corporate measures which reflect a range of safety, health, and operational variables were obtained from each company during the pre-FMP and post-FMP periods. The specific measures were dependent on those that were available from the company. Corporate approaches to fatigue management were determined by means of the Alertness Management Strategies Evaluation (AMSE) questionnaire. Focus groups or individual interviews were used to obtain information about dispatcher scheduling practices and challenges.

Company Sample

The sponsors, in co-operation with various stakeholders, assisted in identifying a company willing to participate in the FMP in each jurisdiction. In Québec, the company recruited was Robert Transport, in Alberta, ECL Group, and in California, J.B. Hunt Transport.

Driver Sample

At each company, drivers were recruited according to a number of inclusion and exclusion criteria. Amongst other requirements, drivers were 24 to 64 years old and held a full driver's licence for at least three years and a commercial driver's licence for at least one year. A total of 77 drivers completed all phases of the study.

ANALYSIS

Drivers' results with respect to sleep disorder screening and treatment and with respect to PDA data collection were analyzed with respect to three parameters relevant to sleep apnea:

1. Respiratory disturbance index (RDI)
2. Epworth sleepiness score (ESS)
3. Adherence to continuous positive airway pressure treatment (CPAP)

CONCLUSIONS

At the outset of this study our hypotheses were as follows:

1. A comprehensive FMP will:
    a. Improve drivers' awareness of good sleep practices
    b. Result in increased sleep time during work days as measured by sleep-wake logs and actigraphy as well as improved sleep quality as measured by post-sleep questionnaires
    c. Improve psychomotor performance during work days and reduce the number of close calls (near accidents) experienced while driving
2. Sleep disorder screening and treatment is feasible as part of an integrated, comprehensive FMP and will result in substantial reduction of fatigue levels at work and improvement of sleep duration and quality in affected drivers.
3. Ongoing consultations with company representatives as part of an integrated FMP will improve fatigue management practices in the company as measured by an assessment of fatigue management policies before and after implementation of the FMP and as measured by improvements in corporate indicators.

With respect to the first hypothesis, there were sleep-related improvements post vs. pre-FMP in subjective sleep quality with the greatest effect on duty days and in sleep achieved during the main sleep period post vs. pre-FMP for duty days. The changes that occurred in sleep efficiency indicated a better balance between rest and duty days.

In association with these improvements in sleep length and quality, there was a trend towards drivers reporting less fatigue post-FMP as compared to pre-FMP. There was a significant reduction in the number of drivers reporting one or more critical events (i.e., nod off or close call) from pre-FMP to post-FMP and a significant reduction in critical events per kilometre driven for the two sites with available distance data.

With respect to the second hypothesis, post-FMP vs. pre-FMP changes in PVT data related to drivers affected by sleep apnea were only found for rest days. Changes

during the rest days were in the expected direction – improvement in the CPAP adherent group and deterioration in the CPAP non-adherent group.

Results observed in these groups during duty days with respect to reported sleep in the prior 24 hours and minor lapses are more difficult to reconcile with this second hypothesis. At the start of duty and rest days, drivers unaffected by sleep apnea (RDI No Abnormality and No CPAP) reported having slept significantly more in the prior 24 hours in the post-FMP vs. pre-FMP condition. The number of minor lapses increased during duty days in the post-FMP vs. pre-FMP condition. This difference was significant at the end but not at the start of duty days. Confounding factors such as change in the temporal organization of duty days might have complicated the analyses of performance data in the study group. It is worth mentioning that more drivers defined themselves as "night drivers" during the post-FMP vs. pre-FMP condition. This database thus calls for further and more refined analyses in order to better account for factors such as the variability observed across and within subjects in work scheduling, the organization of their sleep-wake cycle, and changes in their clinical status.

With respect to the third hypothesis, a survey of fatigue management practices post as compared to pre-FMP showed significant increases/improvements in reported and perceived fatigue management activities. Specifically, there were significant increases reported for education, alertness strategies, healthy sleep, and organizational elements. The one element that did not show a significant improvement was scheduling. Night driving remained the same post-FMP in that number of hours driven at night did not change. However more night drivers were observed post-FMP. In addition, those drivers so classified drove more hours at night post as compared to pre-FMP. Given that there were no FMP activities focused specifically on changing scheduling policies and practices, this appears to accurately reflect actual implementation.

Corporate measures over a three-month period indicated an improvement in company performance with significantly fewer road infractions and accidents and a trend for reduction of absent days per kilometre travelled in Québec. Changes at the Alberta and California sites were not significant.

Overall, the present study demonstrates the feasibility of implementing a comprehensive FMP program, using a company-based approach within the CMV industry. This approach has beneficial impacts on individual drivers' well-being and safe behaviour. Drivers benefit from sleep disorder screening and treatment and receive education on sleep and fatigue highly relevant to their work. The present study shows the positive impact that an FMP program had on drivers' sleep-wake behaviour and performance. In addition, it demonstrated a beneficial effect on corporate health and safety measures of absenteeism and crash rate.

The results of this study lead to a number of suggested areas of future research that might be explored in Phase 4. The FMP examined in this study comprised education and screening of drivers and broader corporate interaction elements. Other elements such as scheduling software, in-vehicle technology and dispatching practice changes might also have been considered. Research is needed to determine the optimal combination. This study has also identified the need for better sleep apnea screening tools and an improved understanding of how adherence to CPAP therapy can be

improved, contributing to the safe treatment of apneic drivers in the challenging environment of commercial trucking.

A comprehensive FMP approach at the company and industry level is a promising approach for an efficient and long-term reduction in the experience of fatigue. Only such systematic interventions can have a real influence and lead to desirable cultural changes that will allow all players, especially individual drivers, to have the potential to put in place effective fatigue countermeasures when needed. Moreover, such an approach is important to identify the obstacles and solutions to a fundamental change of behaviour towards safe scheduling and sleep-wake behaviours within the industry.

OVERVIEW

INTRODUCTION

Fatigue Management Programs (FMPs) are interventions intended to assist trucking companies in reducing driver fatigue. The goal of this study was to assess the feasibility of a company-wide approach to fatigue management and its impact on drivers' fatigue, performance, sleep duration, and mood, as well as on company performance measures, scheduling policies, and practices.

This report describes a field study of a comprehensive FMP involving 1) educational sessions at all levels of the drivers' company, the drivers and their families, 2) sleep disorder diagnosis and treatment and 3) interaction with dispatchers and management with the aim of improving dispatch practice with regard to fatigue.

The primary rationale for this study was to demonstrate that a comprehensive FMP will reduce commercial driver fatigue and have a positive impact on company operations compared to baseline. More specifically, the following hypotheses were tested:

- An integrated, comprehensive education and training program will:
  - Improve drivers' awareness of good sleep practices
  - Result in increased sleep time during work days as measured by sleep-wake logs and actigraphy as well as improved sleep quality as measured by post sleep questionnaires
  - Improve psychomotor performance during work days and reduce the number of close calls (near accidents) experienced while driving
- Sleep disorder screening and treatment is feasible as part of an integrated, comprehensive FMP and will result in substantial reduction of fatigue levels at work and improvement of sleep duration and quality in affected drivers
- Ongoing consultations with company representatives as part of an integrated FMP will improve fatigue management practices in the company as measured by an assessment of fatigue management policies before and after implementation of the FMP and as measured by improvements in corporate indicators.

EXPERIMENTAL DESIGN AND METHODS

The study design involved: 1) providing a fatigue management program and 2) data collection using a PDA (personal digital assistant) and an actigraph before and after FMP implementation. Each of these elements is described below.

Fatigue Management Program

The FMP was designed as a comprehensive intervention that included education, discussion about dispatch/scheduling activities, sleep disorder diagnosis and treatment, and examining corporate culture. The implementation was tailored to the specific setting and circumstances of the participating company. Dispatch/scheduling policies and practices were significantly different between sites and attempting to impose standardized interventions in this area was impractical and beyond the scope of the present project. The two intervention elements that were standardized and

implemented as consistently as possible across all three sites were: 1) fatigue management education and 2) sleep disorder testing, diagnosis and treatment.

Fatigue Management Education Program

The original plan was to offer four 90-minute sessions and to use a train-the-trainer approach for delivery. The four sessions included a core education module and supplementary modules on Trip Planning, Wellness and Lifestyle and Sleep and Sleep Disorders. Due to time constraints and challenges relating to drivers' schedules, each site had to adapt the material, offering fewer sessions, shortened sessions, combined sessions and, at the California site, some web-based interactive training. At each site all drivers participating in the study were trained, as well as a number of managers, trainers and dispatchers (with the exception of California where dispatchers were out of state). Following each training session, short quizzes on educational content were administered. Three two-page newsletters were developed on issues related to fatigue and were provided to the participating companies and circulated to the drivers.

A train-the-trainer approach for delivering the educational sessions was initially planned. However, as there was a lack of trainer availability and some concerns on the trainers' part about their ability to present the material in the supplementary modules, this approach was followed fully at only one of the three sites.

Sleep Disorder Screening and Treatment

At each site, sleep disorder physicians other than the site investigator and external to the research group were identified. All drivers participating in the study underwent an in-home diagnostic evaluation for sleep disordered breathing. Sleep recorder results were provided to the physician who carried out a clinical evaluation. This included assessment of sleep hygiene, daytime somnolence (Epworth Sleepiness Scale (ESS)) and sleep apnea-related quality of life (SAQLI). In addition, the physician reviewed symptoms and signs related to sleep apnea as well as other disorders such as narcolepsy and periodic limb movements. In order to evaluate a pre-test probability of sleep apnea, the adjusted neck circumference (ANC) was calculated. Also, to evaluate sleep symptoms, the Multivariate Apnea Predictor (MAP) sleep symptom-frequency questionnaire was used. An appropriate physical exam was carried out.

Data Collection Period

Pre-FMP data collection was conducted over an eight to ten-day period to establish driver baseline levels of fatigue, sleep and performance. Post-FMP data collection was started after the following two criteria were met: 1) at least one month had passed after the drivers diagnosed with sleep apnea had started their treatment, and 2) two weeks had passed after the driver had attended the last education session.

Driver Pre and Post-FMP Measures

Table OV-1 indicates measures collected pre and post FMP. Data were collected at the beginning and end of each duty or rest day except as noted. Drivers used a PDA device to record data on sleep, mood, workload and performance (psychomotor vigilance task (PVT) and critical incidents) and an actigraphic recorder to objectively document the number and duration of activity and rest bouts by wrist activity monitoring. The 10-minute psychomotor vigilance test (PVT) was the primary objective performance task used in the project. The PVT is a simple, visual reaction time (RT)

task that is not dependent on aptitude or skill level and does not have a learning curve. It is sensitive to even small amounts of sleep loss and yields informative metrics on the capacity for sustained attention and vigilance The PVT provides an objective measure of vigilance and sustained attention that is sensitive to sleep loss and a fundamental performance metric that underlies higher order cognitive functioning. Critical events provided a subjective measure of safety. The gold standard measure of safety is crashes, but these, fortunately, are too few and far between to serve as indicators of safety over the short test period. Critical events occur much more frequently than crashes. Although they seldom result in crashes, because they occur in forgiving circumstances, they are precursors to crashes, and are useful indicators of the level of safety pre versus post FMP.

Table OV-1 Field Data Collection Procedure

2 rest days	4 – 6 duty days	2 rest days
• Sleep-wake log • Actigraphy • Mood/fatigue assessment • PVT	• Sleep-wake log • Actigraphy • Mood/fatigue assessment • Workload assessment (end of day) • Critical incidents (end of day) • Factors contributing to fatigue (end of day) • PVT	• Sleep-wake log • Actigraphy • Mood/fatigue assessment • PVT

Corporate Measures

Corporate measures which reflect a range of safety, health, and operational variables were obtained from each company during the pre-FMP and post-FMP periods. The specific measures were dependent on those that were available from the company. Corporate approaches to fatigue management were determined by means of the Alertness Management Strategies Evaluation (AMSE) questionnaire. This survey was completed in the three month pre-FMP period, and again in the post-FMP period. The AMSE was administered to all participating drivers as well as to small groups of managers/dispatchers at each site.

Dispatcher Interactions

Focus groups or individual interviews were used to obtain information about dispatcher scheduling practices and challenges.

Company Sample

The sponsors, in co-operation with various stakeholders, assisted in identifying a company willing to participate in the FMP in each jurisdiction. In Québec, the company recruited was Robert Transport, in Alberta, ECL Group, operating out of Calgary and Edmonton, and in California, J.B. Hunt Transport, whose headquarters are based in Arkansas, operating out of several locations in northern and southern California.

To ensure that companies understood the extent of the commitment expected, a high-level presentation was prepared and given to senior management by the senior investigator at each site. A letter of agreement was signed. An implementation committee was set up at each company including managers in health and safety and human resources among others. For further support, a stakeholder committee including members of industry associations, government and the research team also was set up in each jurisdiction.

Driver Sample

At each company, drivers were recruited according to a number of inclusion and exclusion criteria. Amongst other requirements, drivers were 24 to 64 years old and held a full driver's licence for at least three years and a commercial driver's licence for at least one year. Drivers agreed to undertake the educational components of the FMP and to participate in data collection before and after the implementation of the FMP. Drivers agreed to be tested for sleep disorders, and comply with treatment if they were diagnosed with a sleep disorder. To the degree possible, "night drivers", defined as having at least 25 percent of driving hours during the period 00:00 to 06:00 during the four to six days of the on-road study period, were selected. Team drivers, drivers who reported an "at fault" involvement in a fatal accident in the past three years and drivers with a prior conviction for logbook falsification, or any history of unsafe driving were excluded.

Recruiting methods varied from one jurisdiction to another. Access to drivers was impacted by availability and use of a central company meeting facility, as well as shift predictability and variability. Recruiting methods included group, one on one, in person meetings, company newsletter and mailouts with pay stubs. A total of 121 drivers completed the pre-FMP data collection; of these, 92 completed the clinical screening, and, of these, 77 completed the post-FMP data collection.

Prior to recruiting drivers, the Scientific Protocol was submitted to an Institutional Review Board (IRB Services, Aurora, Ontario, Canada) and to independent ethics committees at the University of Calgary and in the Province of Québec (ethica Clinical Research Inc., Dorval, Québec, Canada).

ANALYSIS

Drivers' results with respect to sleep disorder screening and treatment and with respect to PDA data collection were analyzed with respect to three parameters relevant to sleep apnea:

1. Respiratory disturbance index (RDI)
2. Epworth sleepiness score (ESS)
3. Adherence to continuous positive airway pressure treatment (CPAP)

RDI score is an objective indicator of sleep apnea severity. Categories were: No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15). CPAP Adherence is expected to predict which drivers would demonstrate the greatest change from pre to post-FMP. Subgroups were: No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time) ESS is a measure of subjective sleepiness, not well-correlated with RDI. ESS score subgroups were: No Abnormality (score 0 to 10),

Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24). For data collected using the PDA device, an ANOVA was carried out for each of the three subgroupings (RDI, ESS, CPAP).

RESULTS

The sleep disorder screening and treatment results, the effects of the FMP on driver schedules, work demands, factors contributing to fatigue, sleep variables, mood, psychomotor vigilance task performance, reported close calls, dispatcher interactions and corporate measures are summarized and discussed below.

Sleep Disorder Screening and Treatment Results

A number of portable monitors for in-home assessment of sleep apnea are available. Many of these provide adequate diagnostic accuracy for clinical purposes. The present study examined the feasibility of two different methods of applying the recorder clinically (one face-to-face instructions and one mailed to drivers) and using two different types of oximeters (one reflective and one transmittance). Both methods and both diagnostic devices appear to be feasible and have an acceptable high success rate (86 percent).

The severity of sleep apnea, treatment and adherence to nasal continuous positive airway pressure (CPAP) is presented in Table OV-2. The N value includes all drivers who saw a physician. If the driver saw a physician and was subsequently lost to follow-up, the driver is assumed to be non-adherent to the treatment. Other drivers were determined to be adherent based on the data card indicating CPAP use greater than four hours for 70 percent of nights.

Table OV-2 Sleep Apnea Severity, Treatment and Adherence to CPAP

Sleep Apnea	N (%)	No CPAP (%)	CPAP (%)	Adherent [§] (%)	Non-adherent (%)	Lost to follow-up (%)
None (RDI < 5)	27 (28.7)	26 (96.3)	1 (3.7)	0 (0)	1 (100)	0 (0)
Mild (RDI 5 – 14.9)	37 (39.4)	16 (43.2)	21 (56.8)	7 (33.3)	13 (61.9)	1 (4.8)
Moderate (RDI 15 – 19.9)	21 (22.8)	3 [‡] (14.3)	18 (81.8)	9 (50.0)	5 (27.8)	4 (22.2)
Severe (RDI ≥ 30)	7 (7.6)	0 (0)	7 (100)	3 (42.9)	2 (28.6)	2 (28.6)
Total	92 (100)	45 (48.9)	47 (51.1)	19 (40.4)	21 (44.7)	7 (14.9)

[§] adherence: CPAP use > 4 hours / 70 percent of nights
[‡] one driver prescribed oral appliance therapy

Using an RDI of less than 5 $hr.^{-1}$ (Fleetham, Ayas, Gradley, Ferguson, Fitzpatrick, & George, 2006) as the upper limit of normal, the in-home sleep studies revealed that 71.3 percent of drivers had sleep apnea. These drivers with sleep apnea were distributed into three categories as follows: mild (RDI 5 – 14.9 $hr.^{-1}$): 39.4 percent; moderate (RDI 15 – 29.9 $hr.^{-1}$): 23.4 percent; and severe (RDI ≥30 $hr.^{-1}$): 8.5 percent.

Stratifying drivers (n = 92) by severity, CPAP was prescribed for one driver (four percent) with no sleep apnea, 21 drivers (57 percent) with mild sleep apnea, 18 drivers (82 percent) with moderate sleep apnea, and seven drivers (100%) with severe sleep apnea. Adherence ranged from 33.3 percent in mild apneics to 50 percent in moderate

apneics and 42.9 percent in severe apneics with an overall average of 40.4 percent adherence. Approximately 24 percent of drivers with moderate or severe apnea, who were started on therapy, were lost to follow-up. Reasons for this are varied and include dropping out from the study, no longer being employed by the participating trucking company, and failing to return for follow-up clinical appointments.

Drivers with sleep apnea, as indicated by RDI greater than five, had a highly elevated mean ANC score indicative of high probability of sleep apnea. By contrast, neither ESS nor SAQLI correlated with RDI, and drivers with severe sleep apnea displayed near normal values. The mean values for SAQLI were normal in Québec and California drivers but modestly depressed in the Alberta drivers.

Reason for Participation

Drivers were asked to rate the importance of eight factors in regards to their decision to participate in the FMP. Overall, the incentives that were rated as the most important were:

1. Possibility of being treated by a sleep disorder specialist
2. To take part in the fatigue management training given by scientific team
3. Free access to CPAP

PDA Data Collection

For continuous data, repeated-measures ANOVA was used to analyze the effect of study phase (pre vs. post-FMP), and depending on the variable, type of day (work vs. rest days), or start vs. end of day, or first vs. fifth day. In addition, for each variable, drivers were divided into three subgroups based on their RDI score, their level of CPAP Adherence, or their ESS Score. There is likely a difference in performance and sleep between those with moderate and those with severe sleep apnea. However, our sample of drivers with severe sleep apnea (n=7) was too small to consider separately, and thus the data for drivers with severe and moderate sleep apnea were combined.

Effects on Schedule

Overall Study Period

The study protocol called for en-route data to be collected. A pre and post-FMP period of data collection of about ten days each was planned. Each period of data collection comprised about one to two rest days, followed by three to six duty days and then another one to two rest days. On average, the study period length was 9.26 days pre-FMP and 8.55 days post-FMP. A t-test showed that the duration of data collection significantly decreased by 0.71 days from pre to post-FMP. This was mainly due to a decrease in data collection on rest days.

Start and End Times

Compliance with requested times for completing questionnaire data entry was defined as an elapsed time of less than two hours from the self reported “Shift End Time” to the timestamp recorded for the “End of work” questionnaire. Overall, out of 410 duty days, one-third (33 percent) were non-compliant. Data from drivers were included in the analyses if there were sufficient data to create a complete data file.

Compliance with requested times for completing the PVT at the start and end of shift was defined as an elapsed time of less than two hours between the PVT test and the

PDA questionnaire data entry time. Overall, the PVT compliance rate was 91.3 percent.

No significant changes between pre and post FMP were found in shift start times and end times, or in the proportion of shifts that ended between 00:00 and 05:59 (to assess night driving avoidance), or in drive or duty times.

NIGHT DRIVING

One possible outcome of implementing an FMP would be scheduling less night driving post compared to pre FMP. While there were significantly more "night drivers" post-FMP as compared to pre-FMP (18.2 percent vs. 7.8 percent), there was no difference in the number of duty hours classified as 'night driving'. Further examination of the data showed that not only were more drivers classified as "night drivers" post-FMP as compared to pre-FMP, but those drivers so classified drove more at night than they had pre-FMP. In contrast those drivers who were not classified as "night drivers" because they did too little night driving, drove fewer hours at night post-FMP as compared to pre-FMP.

Work Demands

With respect to work demands, at the end of each shift, drivers scored mental demands, physical demands, stress of duty period and intensity of duty period on a scale of 1 to 100, with 1 being not at all demanding and 100 being extremely demanding. Demands (mental, stress of duty period) decreased in the severe ESS group post as compared to pre-FMP but increased by a smaller degree for the other two groups. When data were analyzed by CPAP, demands (physical, stress of duty period) were higher in the CPAP Non-Adherent group, both pre and post FMP as compared to the other CPAP groups.

Factors Contributing to Fatigue

At the end of each duty period, three factors potentially contributing to fatigue were assessed: loading and/or unloading, driving conditions and time spent waiting, on a scale of 1 (not at all) to 100 (extremely). The only factor affected was driving conditions. The mean ratings of the ESS No Abnormality group increased from pre-FMP to post-FMP whereas they decreased for the Moderate Abnormality and Severe Abnormality groups. When driving conditions were analyzed by CPAP adherence, the CPAP Non-Adherent group reported that driving conditions had a much greater contribution to fatigue compared to the CPAP Adherent and No CPAP group both pre and post FMP.

Sleep Variables

Subjective sleep variables were calculated based on PDA responses. These were: reported duration and subjective sleep quality of main sleep period and reported total sleep time in the last 24 hours. Objective sleep variables were calculated based on actigraphy data. These were: sleep latency, time spent in bed for main sleep period, duration of main sleep period, sleep achieved during the main sleep period, and sleep efficiency during the time in bed.

Drivers reported a 5.5 percent significant improvement in subjective sleep quality post- vs. pre-FMP; this improvement was especially pronounced for duty days (10.1 percent).

During the pre-FMP condition, sleep efficiency during time in bed (actigraphy) was poorer by 2.2 percent on duty days as compared to rest days. No such difference was observed during the post FMP condition. This lack of difference between duty and rest days during post FMP was mainly due to an improvement of sleep efficiency during duty days (+1.1 percent).

Drivers achieved 20 minutes (5.9 percent) longer sleep during the main sleep period (actigraphy) during duty days in the post-FMP compared to the pre-FMP condition. Subgroup differences in duration of main sleep period (actigraphy) were also observed. Namely, drivers in the No Abnormality RDI and in the No CPAP groups had more sleep in the last 24 hours in the post as compared to the pre-FMP phase, whereas those in the other sub-groups showed no significant difference.

Apart from study phase effects, drivers slept about an hour less during duty as compared to rest days.

The lowest sleep latency (actigraphy) was observed in drivers with no CPAP, followed by drivers adherent to CPAP, and then by drivers non-adherent to CPAP.

Mood Ratings

At the start and end of each duty period, drivers were asked to rate subjective mood factors on a scale of 1 to 100. With respect to aches and pains, feeling happy or sad, feeling calm and excited there was no main effect for study phase. There was a trend towards a main effect of CPAP Adherence, with those in the No CPAP Required group reporting greater happiness than the other two groups. With respect to level of fatigue, there was a trend towards drivers reporting less fatigue post-FMP as compared to pre-FMP. Drivers reported being significantly less fatigued at the start of their duty day, as compared to the end of their duty day. On duty days, there was no main effect of RDI or CPAP Adherence. There was a main effect of ESS Score, with the No Abnormality group reporting less fatigue than the Moderate and Severe Abnormality groups.

Psychomotor Vigilance Test

REST DAYS

Reaction time and minor lapses were increased at the end as compared to the start of day on rest days. Drivers in the severe ESS group had longer reaction times and more minor lapses compared to the No Abnormality ESS group. There also was a significant interaction (study phase x time of day x ESS group) for reaction time. More specifically, at the start of day during the pre-FMP condition, drivers in the Severe ESS group performed significantly more poorly than drivers in other ESS groups. However, no significant group difference was observed in the post-FMP condition because of a significant improvement in reaction time in the post as compared to the pre-FMP condition for the Severe ESS group at the start of day. Drivers in the No Abnormality ESS group had a slight increase in reaction times during post as compared to pre-FMP. No differences between pre- and post-FMP were observed at the end of day in any group

Drivers from the CPAP adherent group had a trend for shorter reaction times in the post as compared to pre-FMP condition for rest days only. There were significantly more minor lapses in the CPAP non-adherent group post as compared to the pre-FMP.

DUTY DAYS

Drivers had significantly (CPAP and RDI analysis) more minor lapses during the post as compared to the pre-FMP study phase. Reaction time was increased at the end of day as compared to the start of day on duty days for all subgroup analyses.

Critical Events

Overall, the proportion of drivers reporting at least one critical event (i.e., nod off or close call) decreased from pre to post FMP (45.5 percent to 28.6 percent). When the number of critical events was controlled for exposure by dividing by kilometres driven (Québec and Alberta only, California exposure not available), there was a 40 percent decrease in the rate of critical events reported (1 critical event per 24,064 km driven pre-FMP to 1 critical event per 33,722 km driven post-FMP).

Linear regression was used to determine the effect of RDI raw scores on the number of critical events, pre- vs. post-FMP. A high RDI score was associated with significantly more pre-FMP critical events. The same was not true for post-FMP critical events (of which there were fewer: 22 vs. 35). The drop in critical events, pre-FMP minus post-FMP, was also significantly correlated with RDI score in that the Mild Abnormality group had a significant reduction in drivers reporting critical events. The post versus pre-FMP reduction for the Moderate and Severe group was similar in size to that in the Mild Abnormality group, but there were fewer drivers in these groups, which likely contributed to the lack of a significant effect for this group. All three ESS score subgroups had fewer drivers with critical events post-FMP as compared to pre-FMP. The reduction in critical events for drivers with No ESS Abnormality was found to be significant. There also was an effect of CPAP Adherence, with a trend towards fewer critical events for the No CPAP Required (37.8 percent to 21.6 percent, $p = .109$) groups.

Dispatcher Interactions

At all sites, dispatchers indicated there were numerous factors to be considered in scheduling to prevent fatigue. These included availability of drivers and equipment, HOS rules, driver family needs, driver requirements for time off due to fatigue, the collective bargaining agreements with respect to seniority, customs switchovers and customer needs. Software tools to assist in scheduling were used in Québec but not in Alberta or California.

Exchanges of opinion among various dispatchers in Québec regarding their involvement in drivers' fatigue indicated a range of opinion with some considering that it was the drivers' own responsibility to manage their life around their driving schedule which they self-selected. Other dispatchers were more open to offering flexibility in the drivers' work schedule in order to maximize their chance to rest and improve their alertness at work. This resulted in peer interactions, a situation that was considered beneficial for the advancement of cultural changes concerning fatigue management within the company.

In California, one dispatcher noted that drivers who operate during the day are assigned different hours compared to ones who operate at night, in an apparent effort to reduce night time driving when possible. It was not specified whether these "different" hours were longer or shorter and a brief examination of drivers' schedules did not show day as compared to night differences. This was apparently intended to acknowledge circadian influences but it was not an explicit policy or practice based on scientific resources.

Corporate Results

The AMSE results from drivers regarding their perception of fatigue management practices within the company showed statistically significant increases/improvements in four (education, alertness strategies, healthy sleep, organization) of the five FMP elements.

Overall corporate measures indicated a significant improvement in company performance with significantly fewer road infractions and accidents and a trend for reduction of absent days per kilometre travelled in Québec. Statistical analysis indicated changes in corporate measures in Alberta and California were not significant.

DISCUSSION

The discussion section is organized as follows. The first section deals with clinical findings and concerns related to predictors of sleep apnea, feasibility of home recorder screening, confidentiality issues, costs and implications, prevalence of sleep apnea in the study population and adherence to treatment. The second section deals with experience related to the implementation of the educational program. The third section deals with the pre vs. post-FMP comparisons based on PDA and Actigraph data. This section considers whether the data support each of the three hypotheses proposed at the outset of the study with respect to the effects of an FMP. The fourth and fifth sections deal with differences in measures between duty as compared to rest days and the start vs. the end of the day. The sixth section deals with the interaction between the study team and the dispatchers, and the seventh, with cultural change indications. The last section concerns implementation and data collection challenges.

Clinical Findings

Prevalence of Sleep Apnea

Perhaps the most significant sleep disorders finding is that 71.3 percent of drivers were found to have sleep apnea, with 31.9 percent being moderate to severe sleep apnea. These values are higher than previously reported, using the same criteria, in a large study of randomly selected commercial drivers (Pack, Dinges, & Maislin, 2002) where the prevalence of sleep apnea determined by PSG was found to be approximately 30 percent. Differences in subject selection (random versus volunteer) may have contributed to the higher prevalence of sleep apnea in the current study. Portable monitoring in the home tends to yield a lower value of RDI than PSG probably because of greater time spent supine in the PSG. Thus, the method of evaluating RDI in the current study seems unlikely to explain the difference. Using a portable monitor, Stoohs et al. (1995) reported a prevalence of sleep apnea in volunteer long haul drivers which is comparable to that observed in the current study (Stoohs, Bingham, Itoi, Guilleminault, & Dement, 1995). Importantly this study, like the present one, used

volunteer subjects whereas Pack et al. studied randomly selected drivers. Drivers were asked for their reasons for volunteering for the study. The possibility of being treated by a sleep disorder specialist and free treatment for sleep apnea, were two of the top three reasons given for participation. This may account for a selection bias and the observed high number of drivers with sleep apnea in the present study (Access to fatigue education was the third reason for participation.)

California drivers had significantly higher prevalence of sleep apnea than those in Québec or Alberta. The reason for this is not apparent as the predictors of sleep apnea (ANC and MAP) were comparable in all three sites. The index of oxygen status during sleep (fraction of night below 90 percent O_2 Sat) in California drivers was comparable to Québec and lower than that reported in Alberta. The California site used a different portable monitor for assessment of respiratory status during sleep than Québec and Alberta and accordingly, technical differences in detecting respiratory disturbances may have been one factor that contributed to the apparent higher prevalence of sleep apnea in the California group.

Pre-Test Questionnaires

ANC and, to some extent, MAP proved to be reasonable predictors of sleep apnea. ANC for the entire population of drivers indicated a moderate probability for sleep apnea. Drivers with sleep apnea, as indicated by RDI greater than five, had a highly elevated mean ANC score indicative of high probability of sleep apnea. Overall, this corresponds with previous data from the literature and indicates that ANC might serve as a reasonable predictor of severe sleep apnea (Flemons & Reimer, 2002). Based on these findings, the ANC may have utility as a screening instrument for sleep apnea in commercial drivers. Using a predictive cut off of 43, the ANC has a sensitivity of 82.8 percent and a specificity of 64 percent. In addition, it correctly identified all drivers in our sample with severe sleep apnea. However, it should be noted that the sensitivity of the ANC may be artificially elevated by the high prevalence of sleep apnea in our volunteer population compared to the entire population of drivers. The sensitivity of the ANC will be lower in a population having a lower prevalence of OSA.

By contrast, neither ESS nor SAQLI correlated with RDI, and drivers with severe sleep apnea displayed near normal values. This lack of correlation between symptoms (ESS and SAQLI) and severity of sleep apnea, as defined by RDI, agrees with published reports (Pack, Dinges, & Maislin, 2002). The mean values for SAQLI were normal in Québec and California drivers but modestly depressed in the Alberta drivers. Overall, though, approximately 25 percent of drivers had moderate or severe sleepiness and a comparable amount had moderate or severe impairment of quality of life, even though these indices were not correlated with severity of sleep apnea.

Feasibility of Screening for Sleep Apnea using Portable Monitor Testing

A number of portable monitors for in-home assessment of sleep apnea are available. Many of these provide adequate diagnostic accuracy for clinical purposes. The present study examined the feasibility of two different methods of applying the recorder clinically (one face-to-face instructions and one mailed to drivers) and using two different types of oximeters (one reflective and one transmittance). Both methods and both diagnostic devices appear to be practical and have an acceptable high success rate (86 percent).

Confidentiality and Sleep Apnea Diagnosis

One major concern regarding screening for sleep apnea in the context of commercial drivers is maintenance of confidentiality. Also, issues such as a required non-driving period after initiation of CPAP or non-compliance with CPAP therapy may force the treating physician to take actions regarding vehicular safety. For example, in a single instance in Alberta, a well-intentioned physician inappropriately breached confidentiality over concern regarding a no-driving period after initiation of CPAP. In the process of resolving this situation, it became clear that specific policies regarding these issues are critical for clarity among all participants (i.e., drivers, companies, treating physicians). Subsequent to the initiation of this project in 2005, a consensus statement from a joint task force recommended a two-week no-drive period (Hartenbaum, Collop, Rosen, Philips, George, & Rowley, 2006).

Sleep Apnea Treatment: Cost and Implications

Difficulties also were encountered in California and Québec in getting the financial support of the insurance companies necessary to support a comprehensive therapeutic approach with continuing access to advice regarding CPAP use and adjustment. It may be important to involve this industry along with the commercial vehicle industry, and governmental representatives in order to secure funds for the adequate screening, diagnosis, and treatment of commercial drivers.

Adherence to Therapy

There were large differences between California and the other two sites in adherence. For Québec and Alberta, the 42 percent of drivers with sleep apnea were treated with CPAP, whereas, this figure is higher in California (68 percent) (see Table OV-3). Adherence data was collected for the vast majority (85 percent) of the drivers who were prescribed CPAP. The severity and driver symptoms did not differ for those drivers started on CPAP between the three sites as there were no differences in mean RDI or mean ESS amongst the three sites (see Table OV-3). The fairly low ESS value and fraction of the night below 90 percent oxygen saturation would be negative predictors for adherence to therapy. However, the drivers in Alberta were significantly more hypoxic on average than those drivers at the other two sites which may lead to higher adherence in this group.

Table OV-3 Data on Drivers for whom CPAP was Prescribed

	Québec	Alberta	California
CPAP prescribed (N and %)	15 (45%)	13 (39%)	19 (68%)
CPAP prescribed and adherence data (N)	12	11	17
RDI for CPAP prescribed and adherence data (mean)	19 $hr.^{-1}$	16.2 $hr.^{-1}$	19.9 $hr.^{-1}$
ESS for CPAP prescribed and adherence data (mean)	8.2	10	8
Time <90% for CPAP prescribed and adherence data (mean)	4.2%	11.3%	3.8%
Adherence rate N (%)	7 (60%)	8 (69%)	1 (5%)
Nightly CPAP usage (mean)	4.4 hr	4.4 hr	1.2 hr
Number of drivers having at least one face-to face post-CPAP initiation visit N (%)	10 (83%)	11 (100%)	6 (35%)
TOTAL	33	33	28

Adherence to therapy of CPAP treated drivers in Québec was 60 percent and in Alberta was 69 percent and this is comparable to, or exceeds, most of the reports in the literature (e.g., Weaver & Grunstein, 2008). By contrast, the CPAP adherence rate for California drivers was 5 percent, much lower than expected and much lower than observed in Québec and Alberta. Interestingly, another report of CPAP adherence in commercial motor vehicle drivers diagnosed with sleep apnea indicates that the adherence rates are much lower (5 percent) than those described for undifferentiated populations of apneics and comparable to that observed in California (Parks, Durand, Tsismenakis, Vela-Bueno, & Kales, 2009). Perhaps country-specific economic or cultural factors may influence CPAP adherence. Identifying these and ameliorating their influence would be important in improving the compliance outcome of drivers with sleep apnea. Whatever factors influence adherence in commercial drivers, the methods used in Alberta and Québec yielded adherence comparable to that observed in the general sleep medicine community.

All drivers with obstructive sleep apnea were seen by a sleep physician. All sites used similar CPAP units, with a mixture of auto and fixed pressure limits. The observed site differences in adherence rate may have been affected by differences between face-to-face interactions between the drivers and the clinical staff. Québec and Alberta used a diagnostic method which employed a pre-treatment face-to-face visit prior to CPAP initiation, whereas, California employed a method that involved no face-to-face diagnostic interaction. Also, while all drivers were seen in face-to-face visits to initiate CPAP treatment, the drivers in Québec and Alberta were more likely to have a face-to-face visit with a member of the clinical staff after CPAP initiation. In Alberta, 100 percent of drivers were seen in a face-to-face clinical visit post treatment initiation. This compares to 83 percent in Québec and 35 percent in California. The difference in the number of face-to-face visits between Alberta/Québec and California was significant.

The literature suggests that certain methods are more effective than others for promoting therapeutic adherence (Weaver & Grunstein, 2008). For example, phone follow-up after treatment initiation is reported to be ineffective (Fletcher & Luckett, 1991). Face-to-face follow-up clinical visits, such as used in Alberta and Québec, are known to promote a higher compliance rate (Hoy, Vennelle, Kingshott, Engleman, & Douglas, 1999). Our results agree with these reports in that the adherence rates at the three sites correlates with post-treatment face-to-face follow-up rates. The role of drivers' schedules, distance to treatment sites, and time/travel costs need further examination to understand their effects on adherence after treatment has been initiated. While there is no report in the literature evaluating the influence of a face-to-face visit in diagnostic testing (i.e., pre-treatment face-to-face visit), the use of a testing method requiring a face-to-face visit in Québec and Alberta may have contributed to a higher adherence rate in these two centres.

Although the 60 to 70 percent compliance rate achieved in Québec and Alberta is in agreement with the adherence rate reported for general clinical experience, this may not be sufficient from a safety point of view and is not a question addressed by this study. However, the compliance level in commercial drivers might be improved using additional techniques. For example, treatment educational programs directed at CPAP adherence and self-management techniques were not used in this study but could be used to improve adherence. These involve substantial interaction and peer leadership and may have a considerable role in improving compliance amongst commercial drivers (Stepnowsky, Palau, Gifford, & Ancoli-Israel, 2007).

The safety implications of CPAP adherence rate is not well established in the literature; hence, the importance of our findings regarding compliance is uncertain. The findings do, however, raise many important questions for discussion and potentially further research that would delineate the role and meaning of compliance rates in safety and future FMP efforts.

This project breaks new ground through implementation of a program that involves sleep disorders diagnosis, treatment, and compliance evaluation. Our results demonstrate that reasonable compliance rates (60 to 70 percent) can be achieved in a population of commercial drivers with sleep apnea. Whether or not these rates can be improved is uncertain, but promising methods for achieving this end are now available. Two Level 1 evidence clinical trials demonstrated CPAP treatment improved quality of life and decreased sleepiness (Jenkinson, Davies, Mullins, & Stradling, 1999; Gay, Weaver, Loube, & Iber, 2006). Minimal results in this one project, especially given the many differences and confounding factors, can not appropriately be used to question the effectiveness of CPAP treatment. Rather, the findings highlight the need for further investigation into the factors influencing effective treatment and successful outcomes in commercial drivers.

Education Program Challenges

The initial challenge in implementing the education program was to condense the educational sessions to accommodate drivers' diverse schedules and geographic distribution. A train-the-trainer approach was planned but too difficult to implement at two of the sites (Québec and California); instead training was mainly done by members of the research team. In California, due to the wide geographic dispersion of drivers,

web-based training also was used. Debriefing the trainers revealed that most felt some concerns regarding their level of knowledge – which they judged insufficient – to provide good training sessions.

Family members were invited to training sessions but time constraints related to the drivers' schedules made it difficult for many family members to attend. Drivers were, however, encouraged to share the course material they received with their families.

Although there are no formal data to demonstrate the effectiveness of family involvement to facilitate change related to an FMP, there are data in a variety of other arenas that show behavioural change can be encouraged by support (Renjilian, Perri, Nezu, McKelvey, Shermer, & Anton, 2001) Therefore, educating family members about fatigue issues and their potential role in obtaining effective FMP outcomes is recommended as a component of a comprehensive FMP.

There are several lessons learned that emerge from the educational activities that can be useful in future FMP efforts. First, it appears that multiple mechanisms will be needed to address the differences among operational settings and drivers. Second, there is perhaps core information that can be identified for incorporation into an FMP and "additional" content that can be made available although not required. These issues are especially relevant given time and schedule constraints. Third, FMP activities should use adult learning principles and some level of interaction with scientific experts to develop this FMP element.

Pre vs. Post Effects of FMP

At the outset of this study a number of hypotheses were identified concerning the impacts of a comprehensive FMP involving 1) educational sessions at all levels of the drivers' company, the drivers and their families, 2) sleep disorder diagnosis and treatment and 3) interaction with dispatchers and management with the aim of improving dispatch practice with regard to fatigue. Each of these hypotheses is considered below, with respect to whether it was supported or not by the pre versus post-FMP findings.

<u>Hypothesis 1a: A comprehensive FMP will improve drivers' awareness of good sleep practices.</u>

This hypothesis was supported by the following findings:

- At the one site with a pre/post comparison of knowledge, there was an average improved score by 4.5 percent (based on 16 questions) gained in the education on sleep practices.

<u>Hypothesis 1b: A comprehensive FMP will result in increased sleep time during work days as measured by sleep-wake logs and actigraphy as well as improved sleep quality as measured by post sleep questionnaires</u>

This hypothesis was supported by the following findings:

- Drivers reported significantly better subjective sleep quality post-FMP vs. pre-FMP (when analyzed by RDI; trend when analyzed by ESS). The improvement was 7.6 percent post vs. pre-FMP; this improvement was especially pronounced for duty days (9.1 percent).
- Drivers had longer main sleep periods based on actigraphy during rest days as compared to duty days (significant when analyzed by RDI, CPAP; trend when analyzed by ESS), for both pre and post-FMP. Pre-FMP sleep was longer on rest days compared to duty days, whereas post-FMP, there was no longer a significant difference. The result was a better balance in that post-FMP, main sleep periods for rest and duty days were more similar than they had been pre-FMP.
- During the pre-FMP condition, sleep efficiency, based on actigraphy, during time in bed was 2.2 percent less on duty days as compared to rest days. No such difference was observed during the post-FMP condition. This lack of difference between duty and rest days during post-FMP was mainly due to a significant improvement of sleep efficiency during duty days. This again indicates a better balance between sleep on duty days and sleep on rest days.
- Drivers achieved 20 minutes (5.9 percent) greater sleep duration during the main sleep period based on actigraphy during duty days in the post-FMP condition, a significant improvement compared to the pre-FMP condition.
- There was a significant increase in the percentage of drivers who reported obtaining more than six hours of sleep before their shift. Pre-FMP, 31.2 percent of all shifts were preceded by main sleep periods that were less than six hours in length as compared to 24.4 percent post-FMP.

Hypothesis 1c: A comprehensive FMP will improve psychomotor performance during work days and reduce the number of close calls (near accidents) experienced while driving.

This hypothesis was supported by the following findings:

- There was a trend towards drivers reporting less fatigue post-FMP as compared to pre-FMP, when analyzed by RDI subgroup, although not when analyzed by CPAP or ESS subgroup.
- There was a significant reduction in reported critical events from pre- to post-FMP. Overall, the number of drivers with at least one critical event (i.e., nod off or close call) decreased from pre- to post-FMP (45.5 percent to 28.6 percent).
- When the number of critical events was controlled for exposure by dividing by kilometres driven (Québec and Alberta only, California exposure not available), there was a 40 percent decrease in the rate of critical events reported (1 critical event per 24,064 km driven pre-FMP to 1 critical event per 33,722 km driven post-FMP)

The reduction in critical events reported from pre to post-FMP was substantial. This is a subjective measure, dependent on driver reporting, rather than an objective measure. However, evidence for its validity comes from several sources. First, post-FMP data

provided evidence linking the duration of the sleep period to the occurrence of critical events. On average, post-FMP drivers had a significantly shorter sleep period before having a critical event while driving (mean = 6.08 hours) as compared to shifts where they did not have a critical event (mean = 6.69 hours). Second, when linear regression was used to determine the effect of RDI and Epworth Sleepiness Scale scores on the number of critical events, pre- vs. post-FMP, High RDI and High ESS scores were associated with more pre-FMP critical events.

The hypothesis was partially supported by the following finding:

- During rest days but not during duty days, drivers in the CPAP adherent group had a trend for shorter reaction time and significantly greater reaction speed post-FMP vs. pre-FMP.
- During rest days, but not during duty days, drivers in the CPAP adherent group displayed a non-significant reduction in the number of minor lapses. This observation contrasted with the significant increase in minor lapses in the post vs. pre-FMP condition for drivers in the CPAP non-adherent group.

The hypothesis was not supported by the following finding:

- For duty days, drivers had significantly more minor lapses during the post-FMP as compared to the pre-FMP study phase when analyzed by RDI Subgroup and a trend when analyzed by CPAP Adherence Subgroup

Despite the limited number of positive PVT findings, drivers did report more sleep per 24 hours in the post- vs. pre-FMP condition for all duty and rest days and about 20 minutes more sleep achieved during the main sleep period on duty days. These observations are relevant since extra sleep, through either sleep extension or short, discrete naps is an extremely effective strategy for improving alertness and performance. For example, chronically sleep deprived individuals in a work setting showed a Multiple Sleep Latency Test (MSLT) score in the pathological sleepy range and were then allowed to obtain extra sleep through sleep extension. The extra sleep increased their MSLT score to within a “normal” range (Howard, Gaba, Rosekind, & Zarcone, 2003). Also, a 26-minute nap has been shown to increase performance by 34 percent and alertness by 54 percent. This has been demonstrated in high-performance, safety-sensitive operational environments such as commercial airline pilots while in-flight, with similar finding in physicians and nurses working in an emergency medicine department (Rosekind, Graeber, Dinges, Connell, Rountree, Spinweber, & Gillin, 1994; Smith-Coggins, Howard, Mac, Wang, Kwan, Rosekind, Sowb, Balise, Levis, & Gaba, 2006). This hypothesis would appear to have been too restrictive as it does not reference possible changes on rest days. FMP effect on PVT parameters were observed on rest days and these may have significance for daytime performance on duty days.

Hypothesis 2: Sleep disorder screening and treatment is feasible as part of a comprehensive FMP and will result in substantial reduction of fatigue levels at work and improvement of sleep duration and quality in affected drivers.

This hypothesis was supported by the following findings:

- Two portable, home monitors (Remmers Sleep Recorder and ARES Unicorder) were used to screen for sleep apnea in participating drivers. These sleep studies proved to be convenient, inexpensive, well accepted, and have a high success rate (86 percent). (The success rate measures the fraction of total studies that are technically satisfactory.) For the Remmers Sleep Recorder (used in Québec and Alberta), a face-to-face instructional session with a technician was employed. For the ARES (used in California) the device was mailed to the drivers with hard copy instructions enclosed.
- The RDI values indicated that 71.3 percent of the drivers have sleep apnea and 31.9 percent of them are moderate-to-severe cases. This prevalence is higher than reported in a randomized sample of commercial drivers and may reflect a sampling bias due to the free access to sleep diagnosis and treatment offered to participating drivers in this study.
- Adherence to therapy of CPAP treated drivers in Québec and Alberta was 60 percent and 69 percent respectively and this is comparable to, or exceeds, most of the reports in the literature which concern undifferentiated populations of apneics. The adherence rate for the California drivers treated with CPAP was lower (5 percent) than expected from those reported for undifferentiated population studies (Weaver and Grunstein 2008), but comparable to that reported in a recent study of CPAP adherence in CMV sleep apneics (Parks et al. 2009)
- The observed site difference may be related to the difference in the percent of drivers with face-to-face interactions with the clinical staff. As noted above, Québec and Alberta used a diagnostic method which employed a face-to-face instructional visit in contrast to California which employed a method that did not. Probably more significant, the drivers in Québec and Alberta were more likely to have a face-to-face visit with a member of the clinical staff after CPAP initiation (Alberta, 100 percent; Québec, 83 percent; California, 35 percent). The observed differences may also be related to other unidentified country-related factors.
- Overall, drivers – regardless of whether they had been diagnosed with a sleep disorder (primarily sleep apnea) – showed a significant increase in total sleep achieved in the main sleep period (actigraphically documented)
- There was a trend for a reduction from pre- to post-FMP in reported critical events for drivers with RDI Mild Abnormality. There was a significant reduction from pre- to post-FMP in reported critical events for drivers with No ESS Abnormality and for ESS Mild Abnormality.
- Based on linear regression analysis, there were more reported critical events for those with higher RDI and higher ESS raw scores. The reduction in critical events from pre- to post-FMP, also was significantly correlated with RDI scores with greater reductions for those with higher RDI scores.

- There were significantly more minor lapses post-FMP compared to pre-FMP in the CPAP Non-Adherent group during rest days
- Drivers in the CPAP adherent group demonstrated a trend for a shorter reaction time in the post- vs. pre-FMP for rest days although not for duty days.

The hypothesis was partially supported by the following findings:

- Drivers reported longer total sleep in the last 24 hours post-FMP as compared to pre-FMP but only for the RDI No Abnormality group (by 1 hour and 18 minutes) and the No CPAP group (by 1 hour and 20 minutes)
- The 20 minutes greater sleep duration during the main sleep period (actigraphy) is even more pronounced if only drivers in the No CPAP and the No RDI Abnormality subgroups are considered. The drivers in the No CPAP group reported sleeping 28 minutes more, and in the No RDI Abnormality group, 47 minutes more during the post- vs. pre-FMP.

Hypothesis 3: Ongoing consultations with company representatives as part of a comprehensive FMP will improve fatigue management practices in the company as measured by an assessment of fatigue management policies before and after implementation of the FMP and as measured by improvements in corporate indicators.

This hypothesis was supported by the following findings:

- The AMSE results from drivers showed statistically significant increases/improvements in four (education, alertness strategies, healthy sleep, organization) of the five FMP elements.

- Overall corporate measures indicated an improvement in company performance with significantly fewer road infractions and accidents and a trend for reduction of absent days per kilometre travelled in Québec. Statistical analysis indicated changes in corporate measures in Alberta and California were not significant.

The hypothesis is not supported by the following:

- More night drivers were observed post-FMP. In addition, those drivers so classified drove more hours at night post as compared to pre-FMP.

It should be noted that the period of observation in the present project is rather limited for the purpose of adequately quantifying corporate cultural changes regarding fatigue management. It was not the purpose of the present study to systematically quantify corporate and cultural changes towards fatigue-related issues. Nevertheless, an effort to standardize assessment of corporate changes at each site was made by administering the AMSE questionnaire to various participants (drivers, managers, dispatchers) during the pre- and post-FMP data collection. Across the three sites, a substantial improvement from pre- to post-FMP was observed in the percentage of responders who reported that there was corporate support of education during the post- vs. pre-FMP condition. A moderate increase in the percentage of respondents

who considered positive company involvement with regards to alertness strategies, scheduling and healthy sleep was observed. Answers to these questions reflect the respondents' perception of company support of these key aspects of fatigue management.

In addition to the AMSE questionnaire, corporate data were collected at each site depending on their availability. There is thus some site variability in the capacity to evaluate the impact of an FMP program on corporate measures. Moreover, it is recognized that some corporate measures such as number of incidents and accidents require a longer period of observation before meaningful conclusions can be drawn. Furthermore, data were collected over different time periods, and there could be important seasonal differences in corporate measures such as crash risk and absenteeism rate that may have confounded the data, making it more difficult to find significant effects. These limitations should be considered when designing the future Phase 4 of the FMP project and developing monitoring tools for corporate change. In that context, corporate measures that are more specific to the participating drivers, such as number of infractions and possibly absenteeism and sick days, could be more sensitive to the period of observation.

While more night drivers were observed post-FMP, it is impossible to know if this difference occurred in response to operational demands.

BEST PRACTICE GUIDELINES

The present study has demonstrated the feasibility of a company-wide FMP that comprises an educational component, offered to drivers, family members, managers, and dispatchers, a data collection component covering corporate measures and driver-based data, and a clinical intervention component designed to test and treat sleep disorders such as sleep apnea.

With regards to education, the present project revealed that the educational sessions should be planned with enough flexibility such that they are sensitive to companies' operational constraints including the drivers' atypical schedules and multiple locations. The educational sessions should be kept to a reasonable duration (e.g., 60 minutes or less) in order to maximise attendance per session, facilitate their integration with the actual operations, and minimize their costs. Some resistance to use a train-the-trainer approach was observed at two sites. Specific efforts could be developed to recruit and train trainers who are comfortable with the science underlying fatigue-management and the operational realities of the CMV industry. Various modes of presentations could be developed such as web conferences, e-teaching, interactive educative CDs, although face-to-face interactions with trainers and experts is suggested at regular intervals in order to improve long-term retention and foster interactive discussions. To support the education sessions, three newsletters were circulated over the course of the FMP intervention to keep drivers and managers informed of relevant news on fatigue-related issues for the CMV industry.

Future efforts should explore strategies to extend educational activities to other sectors of the industry (e.g., receivers, customers), to train more managers and dispatchers within each company, and to better reach out to family members. This last action would be beneficial in improving family-work balance and drivers' self-involvement in adopting fatigue-wise behaviours. In this context, mixed group interactions, led by scientific

experts, are recommended in order to identify obstacles to cultural changes, engage in problem-solving discussions and develop solutions. While an attempt was made in the present project to encourage participants' self-involvement in their fatigue-management education by setting up a website for frequently asked questions (FAQ), participants did not use the site.

With respect to whether an FMP should include sleep apnea screening, the following statistically significant findings relating to apneic drivers on rest days should be considered:

- CPAP adherent apneics displayed a significant improvement post-FMP in reaction speed and non-significant improvement in number of minor lapses by PVT
- CPAP non-adherent apneics displayed a significant worsening post-FMP in the number of minor lapses

In terms of the clinical intervention component, the present study has underlined the feasibility, but yet the difficulties involved in sleep apnea testing and treatment of CMV drivers. Namely, the atypical drivers' work schedules, their geographical dispersion, and regional inequalities in terms of accessibility to clinical teams are obstacles for extending this intervention component to the whole industry. Issues such as financial coverage, involvement of insurers, and development of clinical standards for large scale screening, treatment initiation and follow-up should be addressed. Nonetheless, the results of the present study reinforce the idea that diagnosis and successful treatment of drivers with sleep apnea constitutes an important component of a comprehensive FMP.

Sleep apnea treatment should also be based on a comprehensive clinical assessment and not limited to the simplistic approach of treating an RDI number instead of a patient and only providing a CPAP machine. Initiatives to improve the long-term adherence rate to CPAP should be encouraged. The circumstances surrounding driver support are critical early in CPAP initiation. Face-to-face interaction is far superior to phone contacts. A best practice recommendation would be, at minimum, at least one face-to-face follow-up interaction with a member of a clinical team with each driver started on CPAP. Driver education, problem-solving resources, and support group meetings may be important in relation to CPAP therapy adherence. Finally, peer led self-management sessions for drivers on CPAP might be of considerable positive influence in promoting CPAP adherence within the CMV industry.

The medical/scientific literature very clearly shows that sleep apnea represents a significant health and safety risk and that CPAP is an effective treatment for sleep apnea. Data from a variety of sources indicate that the prevalence of sleep apnea in commercial truck drivers warrants the diagnosis and treatment of sleep apnea in this population. Effective treatment of this group represents a significant opportunity to enhance health and safety factors for these individuals and the trucking industry. The improvement in vigilance performance may be one of the most relevant measures with regards to critical events which were, as discussed early, observed to be less post-FMP.

Finally, it is critical to acknowledge that effectively managing fatigue in commercial trucking is a shared responsibility that cannot be successfully addressed by a single

industry group. Trucking companies, individual drivers, regulatory authorities, safety advocates, company personnel, shippers, and others all play a role in addressing the complex factors that create fatigue-related safety risks in commercial trucking. Successfully managing fatigue will require a shared responsibility that involves each group acknowledging and identifying their role in reducing known fatigue-related risks. A collaborative, shared responsibility approach that involves multiple components (i.e., education and training, sleep disorder diagnosis and treatment, corporate and individual driver efforts, etc.) offers the greatest opportunity to effectively manage fatigue-related safety risks in commercial trucking.

Also, the present project also indicated that the involvement of company top management is essential in supporting the implementation of a comprehensive FMP. Future efforts should include measures of change in corporate culture as it pertains to fatigue management, documentation of how and to which level interventions are integrated within each company, identification of obstacles and solutions for an effective approach, and collection of relevant corporate measures and road safety indicators over a longer period of time. This will help to monitor and more accurately assess the benefits of implementing a comprehensive FMP within the industry.

FUTURE RESEARCH

The “comprehensive” FMP that was implemented and evaluated in this project comprised three elements: 1) education, 2) sleep apnea screening (diagnosis and treatment) and 3) interaction with dispatchers and managers with the aim of helping them consider drivers’ fatigue in their dispatching practice. This FMP did not include formal modifications of scheduling practices, in-vehicle technology, shift scheduling computer models or specific dispatching changes resulting from a fatigue-oriented analysis of current dispatching practice at each company. It is clear that the more multi-faceted the program, the more likely behaviour is to be impacted. Any changes or scientific recommendations should take into account the complexity and sensitivities of real-world operations. More research is needed to determine which versions of each of these elements as well as which combination of elements is most effective in improving behaviour. Of equal importance to commercial interests, evaluation of which combination of elements provides the best return on investment is also needed.

As noted above, adherence to treatment is very much affected by the circumstances surrounding driver support early in CPAP initiation. Face-to-face interaction is far superior to telephone contact and is recommended. Education about CPAP use and what the driver’s diagnosis entails appears critical and needs to be evaluated. Support group meetings may be important in relation to CPAP therapy adherence, and peer led self-management sessions may be the best format. Further study to determine the effectiveness and utility of such approaches is recommended to improve diagnosis management. The present project has identified the need for the field of sleep medicine to develop standards for the safe treatment and follow-up of apneic drivers.

The data from this project support the idea that identifying and successfully treating drivers with sleep apnea promotes an improvement in psychomotor vigilance. However, more research will be required, examining longer treatment periods and compliance issues, to determine how to best extend the known beneficial effects of CPAP treatment to the challenging environment of commercial trucking.

Diagnosis of drivers with a high probability of sleep apnea and subsequent treatment is an important goal for a FMP. However, strategies, cost effectiveness and operational feasibility need to be determined with further research. Thus, tools to adequately and reliably pre-test or screen for drivers at the greatest risk for sleep apnea and for ensuring rapid, proper clinical care, follow-up and adherence should be developed. Moreover, more corporate measures should be gathered to better document the economic and road safety implication of such major initiatives. While screening CMV drivers at risk for severe sleep apnea may be one useful strategy, the diagnostic utility of screening procedures such as ANC as an industry approach is unknown, although promising. Given the accuracy and convenience of portable monitoring, the comprehensive use of such monitoring is recommended. While the ANC may be useful as a pre-test assessment, it is no substitute for direct cardio-respiratory investigation during sleep.

Overall, our results show that on rest days psychomotor performance is improved in apneic drivers who adhere to CPAP treatment compared to those who do not adhere to treatment. The only cautionary note here is that these findings are based on a small number of drivers, in highly variable field conditions, and, therefore, need to be confirmed in a larger study. That these analyses indicate improved psychomotor performance limited to rest days may seem counter-intuitive or even disappointing. Nevertheless, it is important to underline that duty days are linked to a significant sleep-wake disruption due to irregular working schedules that can limit our ability to detect more subtle between-group differences associated with CPAP adherence. Thus, the specific clinical benefits of detecting and treating sleep apnea should be based also on a critical review of other relevant clinical studies. Furthermore, confounding factors such as change in the temporal organization of duty days were observed in the post vs. pre-FMP condition and might have further complicated the analyses of performance data in the study group. Indeed, more drivers defined themselves as “night drivers” during the post-FMP vs. pre-FMP condition. Despite these operational limitations, the overall effects of CPAP adherence on performance were in the expected direction.

CONCLUSIONS

At the outset of this study our hypotheses concerning a comprehensive FMP, involving 1) educational sessions at all levels of the drivers’ company, the drivers and their families, 2) sleep disorder diagnosis and treatment and 3) interaction with dispatchers and management with the aim of improving dispatch practice with regard to fatigue, were as follows:

4. A comprehensive FMP will:
    a. Improve drivers’ awareness of good sleep practices
    b. Result in increased sleep time during work days as measured by sleep-wake logs and actigraphy as well as improved sleep quality as measured by post sleep questionnaires
    c. Improve psychomotor performance during work days and reduce the number of close calls (near accidents) experienced while driving
5. Sleep disorder screening and treatment is feasible as part of an integrated, comprehensive FMP and will result in substantial reduction of fatigue levels at work and improvement of sleep duration and quality in affected drivers

6. Ongoing consultations with company representatives as part of an integrated FMP will improve fatigue management practices in the company as measured by an assessment of fatigue management policies before and after implementation of the FMP and as measured by improvements in corporate indicators.

With respect to the first hypothesis, there were sleep-related improvements post vs. pre-FMP in subjective sleep quality with the greatest effect on duty days and in sleep achieved during the main sleep period post vs. pre-FMP for duty days. The changes that occurred in sleep efficiency indicated a better balance between rest and duty days.

In association with these improvements in sleep length and quality, there was a trend towards drivers reporting less fatigue post-FMP as compared to pre-FMP.. There was a significant reduction in the number of drivers reporting one or more critical events (i.e., nod off or close call) from pre- to post- FMP and a significant reduction in critical events per kilometre driven for the two sites with available distance data.

With respect to the second hypothesis, post- versus pre-FMP changes in PVT data related to drivers affected by sleep apnea were only found for rest days. Changes during the rest days were in the expected direction: improvement in the CPAP adherent group and deterioration in the CPAP non-adherent group.

Results observed in these groups during duty days with respect to reported sleep in the prior 24 hours and minor lapses are more difficult to reconcile with this second hypotheses. At the start of duty and rest days, drivers unaffected by sleep apnea (RDI No Abnormality and No CPAP) reported having slept significantly more in the prior 24 hours in the post- vs. pre-FMP condition. The number of minor lapses increased during duty days in the post- vs. pre-FMP condition. This difference was significant at the end but not at the start of duty days. Confounding factors such as change in the temporal organization of duty days might have complicated the analyses of performance data in the study group. It is worth mentioning that more drivers defined themselves as “night drivers” during the post-FMP vs. pre-FMP condition. This database thus calls for further and more refined analyses in order to better account for factors such as the variability observed across and within subjects in work scheduling, the organization of their sleep-wake cycle, and changes in their clinical status.

With respect to the third hypothesis, a survey of fatigue management practices post as compared to pre-FMP showed significant increases/improvements in reported and perceived fatigue management activities. Specifically, there were significant increases reported for education, alertness strategies, healthy sleep, and organizational elements. The one element that did not show a significant improvement was scheduling. Night driving remained the same post-FMP in that number of hours driven at night did not change. However more night drivers were observed post-FMP. In addition, those drivers so classified drove more hours at night post as compared to pre-FMP. Given that there were no FMP activities focused specifically on changing scheduling policies and practices, this appears to accurately reflect actual implementation.

Corporate measures over a three-month period indicated an improvement in company performance with significantly fewer road infractions and accidents and a trend for

reduction of absent days per kilometre travelled in Québec. Changes at the Alberta and California sites were not significant.

Given the complexity of defining and measuring corporate measures and corporate culture relevant to fatigue management, these significant findings demonstrate that the FMP had important and beneficial effects beyond the individual drivers that were reflected more broadly within the organization.

Overall, the present study demonstrates the feasibility of implementing a comprehensive FMP program, using a company-based approach within the CMV industry. This approach has beneficial impacts on individual drivers' well-being and safe behaviour. Drivers benefit from sleep disorder screening and treatment and receive education on sleep and fatigue highly relevant to their work. The present study shows the positive impact that an FMP program had on drivers' sleep-wake behaviour and performance. In addition, it demonstrated a beneficial effect on corporate health and safety measures of absenteeism and crash rate.

The results of this study lead to a number of suggested areas of future research that might be explored in Phase 4. The FMP examined in this study comprised education and screening of drivers and broader corporate interaction elements. Other elements such as scheduling software, in-vehicle technology and dispatching practice changes might also have been considered. Research is needed to determine the optimal combination. This study has also identified the need for better sleep apnea screening tools and an improved understanding of how adherence to CPAP therapy can be improved, contributing to the safe treatment of apneic drivers in the challenging environment of commercial trucking.

A comprehensive FMP approach at the company and industry level is a promising approach for an efficient and long-term reduction in the experience of fatigue. Only such systematic interventions can have a real influence and lead to desirable cultural changes that will allow all players, especially individual drivers, to have the potential to put in place effective fatigue countermeasures when needed. Moreover, such an approach is important to identify the obstacles and solutions to a fundamental change of behaviour towards safe scheduling and sleep-wake behaviours within the industry.

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GLOSSARY

AMSE	Alertness Management Safety Evaluation
ARES	Apnea Risk Evaluation System
ANC	Adjusted Neck Circumference
CMC	Commercial Motor Carrier
CMV	Commercial Motor Vehicle
CPAP	Continuous Positive Airway Pressure
ESS	Epworth Sleepiness Scale
FMA	Fatigue Management Assessment
FMP	Fatigue Management Program
HOS	Hours of Service
HM	Home Monitor
HUAR	High Upper Airway Resistance
IRB	Institutional Review Board
MAP	Multivariable Apnea Prediction
MSS	Medical Sleep Specialist
OSA	Obstructive Sleep Apnea
PDA	Personal Digital Assistant
PSG	Polysomnogram
PVT	Psychomotor Vigilance Task
RDI	Respiratory Disturbance Index
SAS	Sleep Apnea Syndrome
SAQLI	Sleep Apnea Quality of Life Index
SDB	Sleep Disordered Breathing
SSS	Stanford Sleepiness Scale
VAS	Visual Analogue Scales

Implementation Team: An internal FMP Coordinating Group referred to as the Implementation Team was formed to provide guidance and support for implementation of the FMP. This group may include representatives from management, safety, operations, drivers, health/medical, HR, labour groups, and other important elements from the company.

Investigators: Alertness Solutions headed by Dr. Mark Rosekind, Alpha Logik, Inc. headed by Dr. Diane Boivin and SagaTech Electronics Inc. headed by Dr. John Remmers.

Research Team: All Investigators and Dr. Alison Smiley of Human Factors North Inc.

Sponsors:

- Alberta Transportation (TRANS)
- Alberta Workers' Compensation Board (WCB)
- Commission de la santé et de la sécurité du travail du Québec (CSST)
- Société de l'assurance automobile du Québec (SAAQ)
- Transport Canada (TC), including both the Road Safety Directorate and the Transportation Development Centre (TDC)
- U.S. Department of Transportation (DOT), acting through the Federal Motor Carrier Safety Administration (FMCSA)

In-kind, operational, and other financial support to the project is also provided by the motor carrier industry through the participation of:

- Alberta Motor Transport Association (AMTA)
- American Transportation Research Institute (ATRI)
- Canadian Trucking Alliance (CTA)
- Association du camionnage du Québec (ACQ)
- Respironics Inc.

1 INTRODUCTION

Fatigue Management Programs are interventions intended to assist trucking companies in reducing driver fatigue. The goal of this study was to assess the feasibility of a company-wide approach to fatigue management and its impact on drivers' fatigue, performance, sleep duration, and mood, as well as on company performance measures, scheduling policies, and practices.

This report describes a field study, conducted by Human Factors North Inc. (HFN), in conjunction with Alpha Logik Inc. (Québec), SagaTech Electronics Inc. (Alberta), and Alertness Solutions (California), of the impacts of a comprehensive fatigue management program (FMP) involving 1) educational sessions at all levels of the drivers' company, the drivers and their families, and 2) sleep disorder diagnosis and treatment and 3) assessment of changes in corporate culture. This FMP was implemented at three companies: Robert Transport in Montréal, Québec, ECL Transportation operating out of Calgary and Edmonton, Alberta and J.B. Hunt, headquartered in Arkansas, and operating out of various sites in Southern and Northern California. It was expected that education on proper fatigue management and sleep awareness, along with sleep disorder treatment, would result in enhanced sleep duration, reduced fatigue levels, improved mood, improved psycho-motor performance, and road safety, along with improvements in corporate performance measures such as worker's compensation costs and absenteeism. It was also expected that FMP education and involvement of company management in FMP implementation would result in changes in company scheduling guidelines, policies, and practices. Based on the findings, "recommended practice" guidelines for industry implementation of a comprehensive, practical and effective FMP were produced.

The overall research initiative was undertaken as a collaborative effort funded and sponsored by:

- Alberta Transportation (TRANS)
- Alberta Workers' Compensation Board (WCB)
- Commission de la santé et de la sécurité du travail du Québec (CSST)
- Société de l'assurance automobile du Québec (SAAQ)
- Association du camionnage du Québec (ACQ)
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Section 2 of this report describes the hypotheses of the field study; Section 3 describes the inclusion criteria for companies and drivers, as well as the regional recruiting efforts. Section 4 describes the fatigue management program, including education and the intended sleep disorder diagnosis and treatment. Section 5 describes the experimental design and methods and, Section 6, the implementation of and experience with the FMP at each site. Section 7 describes the results of driver testing with respect to pre vs. post FMP comparisons of subjective and objective measures including work demands, factors contributing to fatigue, sleep amount and quality, mood ratings, critical events and performance of the psychomotor vigilance task. Section 8 presents the discussion of the results, and Section 9 the conclusions. Section 10 presents recommended guidelines for implementation of FMPs.

2 HYPOTHESES

The primary rationale for this study was to demonstrate that a comprehensive FMP will reduce commercial driver fatigue and have a positive impact on company operations compared to baseline. More specifically, the following hypotheses were tested:

- An integrated, comprehensive education and training program will:
  - Improve drivers' awareness of good sleep practices
  - Result in increased sleep time during work days as measured by sleep-wake logs and actigraphy as well as improved sleep quality as measured by post sleep questionnaires
  - Improve psychomotor performance during work days and reduce the number of close calls (near accidents) experienced while driving
- Sleep disorder screening and treatment is feasible as part of an integrated, comprehensive FMP and will result in substantial reduction of fatigue levels at work and improvement of sleep duration and quality in affected drivers
- Ongoing consultations with company representatives as part of an integrated FMP will improve fatigue management practices in the company as measured by an assessment of fatigue management policies before and after implementation of the FMP and as measured by improvements in corporate indicators.

3 COMPANY AND DRIVER SAMPLES

3.1 Company Sample

The sponsors (see Glossary for complete list), in co-operation with various stakeholders, assisted in identifying a company willing to co-operate in the FMP in each jurisdiction (Québec, Alberta and California). In Québec, the company recruited was Robert Transport; in Alberta, the company recruited was ECL Group. Two sites were required, one in Calgary and one in Edmonton, to facilitate recruitment. In California, the recruited company was J.B. Hunt Transport whose headquarters are based in Arkansas. To access a group of drivers sufficiently large enough to recruit forty participants, several locations in northern and southern California were used including Fresno, Ontario, and Tracy.

The selected companies met the following criteria:

- Committed to the full implementation of the FMP at all levels (corporate executive, human resources, managers, dispatchers and drivers)
- Agreed to engage in a high-involvement consultative change process including working on a regular basis with an external consultant to implement and monitor policy and process implementation
- Of sufficient size to provide approximately 30 to 60 volunteer drivers to participate in data collection, education, and sleep apnea diagnostic testing and treatment aspects of the research
- Agreed to protocol requirements in terms of protection of individual driver confidentiality
- Lawfully licensed to operate within the jurisdictions where the revenue generating routes occur
- Company senior management agreed to: (a) meet all the requirements of the study, including scheduling U.S. and Canadian hours-of-service-compliant revenue-generating routes and (b) permit drivers to choose to volunteer (or not) without prejudice or repercussion

To ensure that companies understood the commitment expected, a high-level presentation was prepared and given to senior management by the senior investigator at each site. A letter of agreement (see Appendix A) was signed.

An implementation committee was set up at each company. In Québec, two committees were in charge of implementation. The company implementation committee included the Vice President, Quality/Security, Director of Human Resources, Training Supervisor, Ontario Operation Director and Safety Trainer. The Québec stakeholder committee included one representative from each of the following organizations: Société de l'assurance automobile du Québec (SAAQ), Association du camionnage du Québec (ACQ), Commission de la santé et de la sécurité du travail du Québec (CSST), and Transportation Development Centre (TDC). Also, it included two representatives from the drivers' company and finally, two representatives from Alpha Logik.

In Alberta, the implementation committee included the Director of Quality, Health, Safety, and Environment, the Vice-President of Transportation Services, and three Driver Supervisors: two from Edmonton and one from Calgary. The Alberta stakeholder

committee included representatives from Alberta Transportation, Alberta Motor Transport Association, ECL executives and representatives from Sagatech Electronics. In California, this committee included J.B. Hunt's Director of Safety, the Regional Operations Manager for Northern/Central California and Southern Oregon, and the Director of Benefits. The California stakeholder committee included members of the American Transportation Research Institute, American Trucking Associations, J.B. Hunt executives and representatives from Alertness Solutions.

3.2 Driver Sample

At each company, drivers were recruited according to the following inclusion and exclusion criteria. These criteria were used to allow comparison of individual driver data with the results from the Fatigue Management Technologies study (Brewster, Dinges, Kruegar, Grace, Belenky, Redmond, Goodhart, Howard, Chester, & Jochem, 2001), and to ensure a representative cross-section of licensed commercial drivers. Driver inclusion criteria were as follows:

- 24 to 64 years old
- Male or female
- Currently hold a valid licence to drive a commercial vehicle in one of the jurisdictions in which the study is being conducted (confirmed with documentation)
- Volunteers
- Passed any physical examination required by law (confirmed by medical records)
- Worked for at least three years as a Class 1 (Canada), or equivalent, commercial vehicle driver and at least one year with the company (original criteria – see change below). Drivers recruited for the study in California were required to hold a valid California driver's licence for a minimum of three years and a valid Class I commercial driver's licence for a minimum of one year.
- Operated within the relevant hours-of-service regulations, and drive fatiguing schedules as defined by the drivers and by company dispatchers/managers
- Agreed to undertake the educational components of the FMP and to participate in data collection before and after the implementation of the FMP
- Agreed to be tested for sleep disorders, and comply with treatment alternatives if they were diagnosed with a sleep disorder

Initial recruiting efforts using the three year criterion for holding a commercial driver's licence and working with the company proved to be overly restrictive, affecting the ability to recruit the requisite number of drivers. After consulting with the research team and the contract monitor, the recruiting criteria was changed from three years holding a commercial driver's licence in the original protocol, to holding a full driver's licence for three years and a commercial driver's licence for at least one year, allowing less experienced drivers to participate.

Driver ages for drivers who completed all phases of the study are shown in Table 3-1.

Table 3-1 Driver Ages

	N (Male/Female)	Mean	Sd	Min	Max
Québec	29 (28/1)	45.6	10.5	25	61
Alberta	23 (23)	48.2	8.2	32	60
California	25(24/1)	47.2	9.1	33	64

3.3 Driver Exclusion Criteria

Certain drivers or categories of drivers were excluded from the study in order to ensure, to the degree possible, the homogeneity of the sample and to reduce the possible occurrence of adverse events or non-compliance with government regulations that would alter the results. More specifically, drivers were excluded if they were:

1. Team drivers, since they reflect a significantly different working situation than solo drivers.
2. Drivers who had an "at fault" involvement in a fatal accident (involving either a work-related or personal vehicle) in the past three years (confirmed by drivers for three years and the company for at least one year). Such drivers were considered to be at risk for further occurrence. In Québec, participating drivers signed a form confirming that they had not been convicted of road safety infractions in the past three years. In Alberta, the driver supervisors confirmed this for each driver. In California, this question was included in the pre-screening questionnaire and if the prospective participant answered "yes", then the driver was not recruited.
3. Drivers with a prior conviction for logbook falsification, or any history of unsafe driving (confirmed by drivers for three years – no other mechanism was used, in order to preserve confidentiality).

The investigators reserved the right to terminate a driver's participation in the study if at any time they felt it was necessary for the participant's physical or psychological welfare, or for research purposes. No drivers were dropped from the study at the instigation of the investigators.

3.4 Route Inclusion Criteria

The Scientific Protocol describing the study envisioned that to the extent possible, standard revenue-generating routes would be selected so there would be a strong likelihood that drivers would be assessed on the same routes after the implementation of the FMP (Smiley, Boivin, Remmers, & Rosekind, 2006). In addition, routes flagged by dispatchers and/or drivers as particularly fatigue-inducing were to be selected. In the Scientific Protocol, night driving was defined as driving during the period of 22:00 to 06:00. The intention was that routes with night driving would comprise at least 50 percent of the selected routes for the study.

Once the study was initiated, it became clear that drivers rather than routes were the focus of the selection process. Suitable drivers would be those who reported driving at night. It also became clear that the criteria of 50 percent of routes being driven at night

was unrealistically high. For example, the first company recruited in Alberta did almost no night driving and therefore was excluded from participation in this study. An informal assessment was made by Roger Clarke of Alberta Transportation of typical night driving practices in various companies. As a result a revised definition for a night driver was developed and accepted by the Steering Committee. The revised definition for a night driver to be included in the study was the following: a driver, who drove at least 25 percent of hours during the period 00:00 to 06:00 during the four to six days of the on-road study period. Various recruiting practices were used to attract and identify night drivers as discussed in the following section.

3.5 Regional Recruiting Methods and Sample Size

Recruiting methods varied from one jurisdiction to another. Access to drivers was impacted by availability and use of a central company meeting facility, as well as shift predictability and variability. Group, one on one, in person, company newsletter and mailouts with pay stubs recruiting methods were used.

A total of 121 drivers were recruited and completed the pre-FMP data collection; of these, 94 completed the clinical screening, and of these 77 completed the post-FMP data collection.

3.5.1 Québec

In Québec, a total of seven recruitment sessions were organized by the trucking company at the request of the investigator. With the help of the company implementation team, sessions were arranged at times that were likely to attract drivers working night or mixed shifts. Six out of seven sessions were early in the morning, and one was planned prior to a night shift.

At these sessions, potential drivers were given an explanation of the protocols, research methodology, requirements, risks and benefits. Interested drivers were asked to remain in the room at the end of the presentation and were provided with the Drivers' Pre-Screening Form and Consent Form (Appendices B and C). Drivers then underwent the formal informed consent procedure and were invited to ask questions. Drivers were also invited to contact the research team for any additional questions. Drivers' eligibility, based on the Pre-Screening Form, was later reviewed by the research team and drivers were then contacted by phone. A question on the pre-screening questionnaire asked, "Approximately what percentage of your driving occurs between 10 p.m. and 6 a.m.?" and was used to identify drivers likely to drive at night. A confidential study list linking drivers' personal information and their confidential study code was developed. This study code was used to identify all documents and data.

By mail, drivers received an envelope containing an instruction letter and the following documents: 1) a copy of their signed consent form, 2) a form confirming that they had not had an at-fault accident while driving in the past three years 3) the 12-page Driver General History Questionnaire, 4) the partner consent form, and 5) the three-page Partner Satisfaction Survey (see Appendices D and E for the questionnaire and survey). Drivers kept a copy of the consent form, and returned a second, signed copy in a pre-stamped envelope to the research team. Drivers also filled out the questionnaire, identified by the confidential study code only and returned it in another sealed envelope to the research team. Partners signed the partner consent form and returned it in a pre-stamped envelope to the research team. Partners also filled out

their questionnaire, identified by the confidential study code only, and returned it in another sealed envelope to the research team.

FMP data collection was then planned on drivers' usual driving routes and schedule. This ensured study requirements would be met without increased demand for driving nights (thus potential increased risk of accidents) for any driver participating in this study compared to his/her usual schedule.

The Alertness Management Safety Evaluation (AMSE) was used to assess perception of company fatigue management practices and policies (see Appendix F). The AMSE was mailed at a later stage to each individual driver after the pre-FMP data collection had begun. All questionnaires were handled in a confidential manner using only the driver's study code. Forty drivers completed questionnaires. Photocopies of all returned forms were sent to Human Factors North (HFN). A total of 40 driver questionnaires, 45 AMSEs (39 drivers and 6 managers), and 21 partner questionnaires were completed at this site.

The first 10 drivers received consent forms before the inclusion of the Psychomotor Vigilance Task (PVT) was requested by the Steering Committee and approved by the Institutional Review Board (IRB). Once the PVT was approved, revised consent forms were mailed to drivers to include the collection of objective performance measures by the PVT.

A total of 40 drivers in Québec completed the pre-FMP data collection. Following the end of data collection, eleven Québec drivers dropped out of the study, four before, four during and three after the sleep disorder testing process. Of these eleven drivers, three left the company, one was expelled from the company and the other seven were no longer interested in participating. Two of the drivers who left during the clinical portion of the program left because technical problems required that they repeat the sleep apnea recording procedures, which they considered too demanding. A total of 29 drivers completed the post-FMP data collection. Out of those drivers, 22 did the PVT.

3.5.2 Alberta

In Alberta, drivers were recruited through six presentations at scheduled weekly morning meetings and at two monthly safety meetings as well as in one-to-one meetings. Articles were written for the company newsletter and flyers were included with the driver's pay stub outlining the program. Driver supervisors were also encouraged to recruit drivers. The most successful method of recruitment involved having a member of the research team available in the company's coffee room for one-on-one discussion of the program. All but one of the drivers were recruited in these face-to-face meetings, although they likely had heard of the program through the formal presentations and articles. At the face-to-face meeting, the program was explained to the driver and the informed consent was reviewed. Many of the drivers took the consent form home to consult with their partner before returning it to SagaTech. The only driver not recruited in person contacted SagaTech by phone and the consent form was reviewed at this time. In Alberta, drivers were selected based on their willingness to participate and meeting specified criteria, regardless of their route schedule. Nonetheless, the revised night driving criteria (25 percent of drivers being night drivers) were met with the recruited participants.

Questionnaires were mailed to the drivers after verifying they were qualified to participate and after receiving their signed informed consent. A cover letter was attached explaining the process. Each driver received a business card indicating their subject code for future reference. All questionnaires had this code on the subject line. SagaTech's contact information was included to answer questions or concerns. The cover letter also stated a “return by” date. Follow-up calls were made after this date to remind individuals to return their questionnaires. To preserve confidentiality, returned packages were opened by a SagaTech employee not directly involved in the research project. Photocopies of all returned forms were sent to HFN. A total of 39 driver questionnaires, 38 AMSE, and 30 partner questionnaires were completed at this site. All subjects completed the PVT.

In Alberta, 33 drivers completed the clinical component of the program. Ten dropped out before completing the post-FMP data collection. Information was not gathered regarding specific reasons drivers dropped out of the study because the consent form stated in the Participation Section: “If you choose to withdraw from the study, you do not have to provide a reason for that decision.” The remaining 23 participants completed the post-FMP data collection.

3.5.3 California

In California, drivers were recruited through a variety of methods that included driver meetings, a one-page flyer and information provided by managers at the different sites. During the initial phone contact from potential participants, Alertness Solutions screened drivers for the minimum participation requirements before the consent form package was mailed to them, which included a cover letter, the consent form, the Driver Pre-Screening document, and a self-addressed, stamped envelope.

As for Québec, the Pre-Screener question concerning night driving was used to help identify potential night drivers. Among the recruited driver participants, 24 percent did only daytime driving, 17 percent did only night-time driving, and 59 percent did a combination of day and night driving. These route determinations were verified by scheduling personnel, the internal J.B. Hunt project co-ordinator, and the driver participants themselves.

The first 18 drivers received consent forms before the inclusion of the Psychomotor Vigilance Task (PVT) was approved by the IRB. After approval by the IRB, 11 of those 18 drivers, as well as the remaining 24 drivers, were given revised consent forms including the PVT.

Upon receipt of the consent form package, drivers contacted Alertness Solutions by phone to review the consent form and to address any concerns. The drivers then signed the consent forms and completed the Driver Pre-Screening document before returning them via the self-addressed, stamped envelope. Follow-up calls were made after two weeks if the drivers did not call or return their paperwork.

Next, Alertness Solutions mailed a package containing a cover letter, the General History Questionnaire, the Partner Satisfaction Survey for Family Members, and the Alertness Management Safety Evaluation (AMSE), to each driver with the driver’s unique identification number written on each form. Photocopies of all returned forms

were sent to HFN. A total of 42 General History Questionnaires, 38 Partner Satisfaction Surveys, and 37 AMSEs were completed at this site.

An initial group of 42 driver participants completed the pre-FMP data collection. Subsequently, 17 California drivers dropped out of the study (14 no longer worked for J.B. Hunt – three dropouts related to the sleep apnea assessment). A total of 25 drivers completed the post-FMP data collection, with 23 drivers completing the PVT.

3.6 Institutional Review Board

Prior to recruiting drivers, the Scientific Protocol was submitted to an Institutional Review Board (IRB Services, Aurora, Ontario, Canada). Once approved, recruiting began in California. The same protocol was submitted to ethics committees at the University of Calgary and at Université de Montréal. Once these committees approved the protocol, recruiting began in Alberta and Québec.

4 FATIGUE MANAGEMENT PROGRAM

The FMP was designed as a comprehensive intervention that included: education, dispatch/scheduling activities, sleep disorders diagnosis and treatment, and examining corporate culture. The intervention elements that were standardized and implemented as consistently as possible across all three sites were: 1) fatigue management education, 2) sleep disorder testing, diagnosis and treatment, and 3) assessment of changes in corporate culture. Since dispatch/scheduling policies and practices were significantly different between sites, so that attempting to impose standardized interventions in this area was impractical, these were discussed from a general perspective.

Education on fatigue management was offered to drivers participating in the study, their family members, managers and dispatchers. During these sessions, participants were taught how to recognize fatigue, its effect on their work and its contributors. They were provided with advice on good sleep hygiene.

The sleep disorder diagnosis and treatment portion of the FMP comprised ambulatory testing for respiratory disorders during sleep, assessment and treatment by a sleep disorder specialist and review of sleep hygiene principles with the clinical team. The education and sleep disorder diagnosis and treatment components of the FMP are described more fully below.

4.1 Fatigue Management Education

Educational materials developed in a previous contract were provided by Transport Canada (Moscovitch, Reimer, Heslegrave, Boivin, Hirshkowitz, Rhodes, & Kealey, 2006). These consisted of a core module and three supplementary modules as outlined in Table 4-1. Each session was expected to last 90 minutes.

Table 4-1 Educational Modules

Educational Modules	
CORE MODULES	Fatigue Alert – Introduction
	Fatigue Alert for Managers and Dispatchers
	Fatigue Alert Family Forum
SUPPLEMENTARY MODULES	Module 1- Trip Planning Supplementary
	Module 2 - Wellness and Lifestyle Supplementary
	Module 3 - Sleep and Sleep Disorders Supplementary

The research team reviewed the educational material and proposed numerous changes. These were made by Transport Canada prior to starting pre-FMP data collection. Short quizzes were developed for each of the four educational modules (see Appendix G.)

A Train-the-Trainer approach was proposed to leverage resources and to increase internal company participation and responsibility for the FMP. This involved the identification of two to three potential trainers within each company (e.g., current trainers, human resources personnel) who would observe the Investigators as they presented the modules, and then would be observed by the Investigators as they initially presented the modules. Following this, the trainers would be responsible for the organization and administration of the educational modules to the remaining drivers, managers, dispatchers, shippers, receivers, and family members. The Investigators would be available to answer trainers' questions on the phone regarding these educational sessions. This approach was proposed since it would offer an opportunity for participants to interact with each other in a constructive manner, and learn to recognize fatigue-related scenarios and avenues for solutions. Participants would be given a copy of the educational module, tailored according to their employment category.

Three two-page newsletters were developed on issues related to fatigue, with each newsletter targeted to the content of one of the three supplementary modules. These were circulated to the drivers.

As will be discussed in Section 6.1, modifications were made to the original plan in order to make the educational program feasible and practical in the various company environments. In particular, the Train-the-Trainer method was not used for two of the three participating companies.

4.2 Sleep Disorder Screening and Treatment

The original plan for sleep-disordered screening is described below. Section 7 describes how the plan was implemented at each site, and presents the results of the clinical evaluations.

At each site, a sleep disorder physician was identified. In order to separate the research role from the role of the treating physician, this individual was not the site investigator. All drivers participating in the study underwent an in-home diagnostic evaluation for sleep disordered breathing. This was a Level III study (portable monitor in the home) the results of which were coded so that the driver would remain anonymous to the investigators. The sleep disorder physician carried out a clinical evaluation. This included assessment of sleep hygiene, daytime somnolence (Epworth Sleepiness Scale (ESS)) and sleep apnea-related quality of life (SAQLI) (see Appendices H and I). In addition, the sleep disorder clinician reviewed symptoms and signs related to sleep apnea as well as other disorders such as narcolepsy and periodic limb movements. An appropriate physical exam was carried out.

In order to evaluate a pre-test probability of sleep apnea, the adjusted neck circumference (ANC) was calculated as the sum of the neck circumference (cm), plus 3 if snoring present, 3 if apneas have been witnessed, and 4 if the patient has hypertension (Flemons, 2002). In order to evaluate sleep symptoms, the Multivariate Apnea Predictor (MAP) sleep symptom-frequency questionnaire was used (see Appendix J). This is a 14 item Likert scale instrument that evaluates symptoms related to sleep apnea, difficulty sleeping, excessive daytime sleepiness, and narcolepsy-like symptoms (Maislin, Pack, Kribbs, Smith, Schwartz, Kline, & et al., 1995). After this complete history and physical evaluation, the sleep physician was to review the results of the in-home respiratory evaluation during sleep with the driver. If further investigation was deemed warranted, a full night polysomnogram was to be carried out. Finally, after discussions with the driver, management approaches were to be instituted. An overall clinical flow chart (see Figure 4-1) was provided to the sleep disorders physician that provided guidance in treating either moderate/severe obstructive sleep apnea or mild obstructive sleep apnea/high upper airway resistance or no sleep disordered breathing.

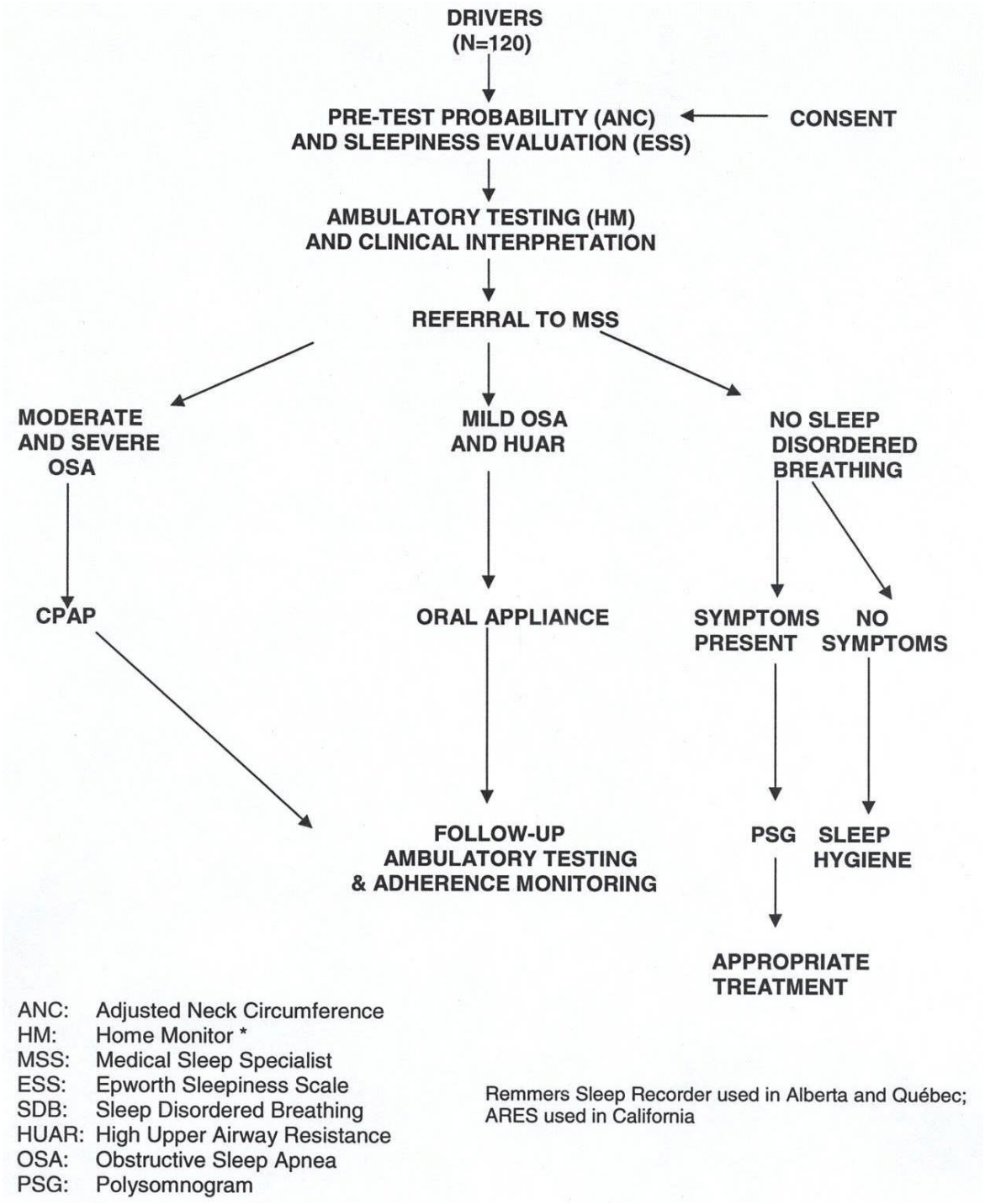


Figure 4-1 Sleep apnea assessment and treatment algorithm

If the patient had moderate-to-severe sleep apnea, CPAP was envisioned to be a likely therapy. Drivers in this category were to be referred to a respiratory home care company for initiation of CPAP treatment free of charge or treated by the sleep physician seen for evaluation. Similarly, if upper airway resistance or mild sleep apnea was encountered, a referral to a dentist for oral appliance therapy was considered the likely therapeutic avenue. (The only feasible surgery for most patients is uvulopalatopharyngoplasty (UPPP) and it has been shown to be substantially less effective than oral appliance therapy in a large randomized trial (Walker-Engström, Tegelberg, Wilhelmsson, & Ringqvist, 2002). Therefore, the only two recommended therapies for OSA are CPAP and oral appliance.) Drivers were to be seen in follow-up capacity by the sleep disorders physician and compliance with CPAP treatment was to be monitored. All data derived from questionnaires, from the home respiratory evaluation during sleep and from therapeutic interventions, were to be gathered and reported anonymously by ID numbers to the site investigators.

SagaTech arranged for the donation of CPAP devices (RemStar Pro M Series) from Respironics Inc. to this project. This enabled drivers requiring CPAP treatment to receive the devices at no cost and represented another benefit of project participation for the drivers. These CPAP devices were distributed to the drivers upon prescription by the sleep physician.

The evaluation and review of sleep hygiene was also conducted by the clinical team for each driver. This included the following:

1. Reviewing time and regularity of going to and getting up from bed and any noticeable changes.
2. Gathering information regarding the driver's response to sleep onset insomnia and sleep maintenance insomnia questions.
3. Questioning if the driver experiences disturbances throughout the night (i.e., leg kicking, gastroesophageal reflex).
4. Providing information regarding the conditions that promote good sleep habits (i.e., noise, light, temperature, pre-sleep rituals).
5. Providing information regarding the use of psychotropic agents (i.e., caffeine, alcohol, nicotine) and other drug use that influences sleep (i.e., hypnotics or central nervous system excitatory agents).
6. Reviewing habits (i.e., diet, eating late, exercise, exposure to light).

5 EXPERIMENTAL DESIGN AND METHODS

5.1 Data Collection Period

Following sample selection, the initial pre-FMP data collection was conducted over an eight to ten day period to establish driver baseline levels of fatigue and sleep. The intention was to collect baseline subjective and objective measures during a minimum four-day driving period (of one or multiple routes).

Post-FMP data collection was started after the following two criteria were met: 1) at least one month had passed since the apneic drivers started their treatment, and 2) two weeks had passed since the driver attended the last education session. En-route testing was conducted on a staggered basis determined by equipment availability.

In Québec the pre-FMP on-road data collection lasted from November 2006 until April 2007 and the post-FMP on-road data collection lasted from February to April 2008. In Alberta, data collection lasted from May to October 2007 and the post-FMP on-road data collection lasted from mid-April to mid-September 2008. In California, the pre-FMP data collection lasted from the end of November 2006 until early November 2007 and the post-FMP on-road data collection lasted from March to July 2008.

In Québec the sleep apnea assessment period lasted from June to December 2007. If the follow-up meeting to assess compliance is added, the period ends in April 2008. The education program began in May 2007 and finished in January 2008. In Alberta the sleep apnea assessment period lasted from March until April 2008. The educational program began in February and was completed by July 2008. In California, the in-home sleep apnea assessment lasted from late November 2007 to January 2008. The educational program lasted from March to April 2008.

Corporate baseline measures (e.g., accidents) were collected during the pre-FMP and post-FMP periods. A survey of corporate approaches to fatigue management was also made in the three month pre-FMP period, using the AMSE questionnaire. These questionnaires were administered again in the post-FMP period.

5.2 Equipment

Prior to the pre-FMP data collection, drivers were provided with a subject code, an instruction booklet (Appendix K: Driver Instruction Booklet), an actigraphic recorder (see Figure 5-1), and a PDA device. In Québec and Alberta, the PDA-Z22 (Palm Inc., Sunnyvale, California) was used, and in California, the Palm Z21 PDA was used for PVT and subjective diary data collection and the AW-64 for actigraphy.

Figure 5-1 Sample actigraphic recorders

All sites used the same solid state, portable data collection device to objectively document the number and duration of activity and rest bouts by wrist activity monitoring (AW-64, Mini-Mitter Co., Inc., Sunriver, Oregon, U.S.A.). Actigraphy monitoring has been used to establish behavioural activity patterns and to assist in characterizing sleep duration and quality (Brooks, Shergold, Angus, Heslegrave, & Redmond, 1988). Subjects wore a wristwatch-type measurement device on their non-dominant wrist during waking periods and sleep to monitor the level of body activity. They pressed an event marker each time they got in and out of bed. This device uses a miniature computerized accelerometer and summarizes the amount of wrist activity every 30 seconds. A computer algorithm then scores this activity to determine the sleep/wake behaviour of the individual.

Actigraphy measures of sleep quantity and quality have been found to be highly correlated (r = .92) to “gold standard” polysomnographic/physiological recordings of sleep (Sadeh, Alster, Urbach, & Lavie, 1989; Sadeh, Hauri, Kripke, & Lavie, 1995), although some limitations have been recently identified comparing polysomnographic recording and actigraphy (Paquet, Kawinska, & Carrier, 2007). The actigraphy was less able to detect wake compared to polysomnographic recording when the sleep episode involved more wakefulness. Thus, objective data related to sleep variables gathered in the present context should be considered less accurate than those which could have been collected by polysomnographic recording.

Nonetheless, actigraphy provides a reliable and valid estimate of sleep quantity and quality and is a critical methodology for collecting objective sleep measures in real-world operational settings. Actigraphy is a non-invasive, non-intrusive method that provides valid objective data over days and weeks from participants in their actual sleep environment and with their usual sleep habits. While polysomnography provides for detailed physiological distinctions related to sleep, it is highly impractical, labour-intensive, intrusive, expensive, and logistically complex when used in field studies. Actigraphy has been used extensively and effectively in a variety of field studies to objectively document the organisation of the sleep-wake cycle, as was the case in this project (Boivin, Caliyurt, James, & Chalk, 2004; Park, Matsumoto, Seo, Cho, & Noh, 2000; Burch, Yost, Johnson, & Allen, 2005; Yoon, Jeong, Kwon, Kang, & Song, 2002; Renjilian et al. 2001; Rosekind, Gregory, & Mallis, 2006; Rosekind et al. 1994).

5.3 Driver Pre and Post-FMP Measures

Data collection periods were dependent, to some degree, on the individual drivers' schedules. Table 5-1 represents a schematic for the intended pre-FMP and post-FMP data collection. Enroute data were to be collected during a four to six-day duty period. In addition, data was to be collected during a two-day period during the rest days preceding and following the en-route data collection.

Table 5-1 Field Data Collection Procedure

2 rest days	4 – 6 duty days	2 rest days
• Sleep-wake log • Actigraphy • Mood/fatigue assessment • PVT	• Sleep-wake log • Actigraphy • Mood/fatigue assessment • Workload assessment • Critical incidents • Factors contributing to fatigue • PVT	• Sleep-wake log • Actigraphy • Mood/fatigue assessment • PVT

Data collected during rest days, before and after the duty days, included information on sleep length and quality, both subjective (sleep diary) and objective (actigraph), an assessment of mood, fatigue levels and a measure of psychomotor performance (PVT). These same data were collected during duty days. In addition, on duty days, data were collected on work demands, both mental and physical, factors contributing to fatigue (i.e., loading/unloading, traffic conditions, waiting) and critical incidents involving nodding off or a close call enroute.

Table 5-2 shows the measures that were collected, and the timing of data collection, during duty days, and Table 5-3, during rest days (see also Appendix K: Driver Instruction Booklet). Figure 5-2 shows the timing of data collection on duty days.

Table 5-2 Schedule of Measures to be Collected during Duty Days

Upon awakening	Before duty period End of duty period	Additional End of duty period	Before Bed	Anytime
- Off duty or on duty **Actigraph Log Sheet** - Bedtime - Wakeup time - Length of last sleep period (actual sleep time) - Quality of last sleep period (VAS) -Total sleep time over last 24 hour	- Off duty or on duty **Enroute Driver Rating** - General physical state (aches and pains, VAS)* - Sleepy/alert (VAS) -Calm/excited (VAS) -Tense/relaxed (VAS) -Happy/sad (VAS) -Attention Task (PVT)	- Total duty time - Total drive time -Critical traffic incidents (#) -Nodding off at the wheel (#) **Workload Assessment** - Mental demand (VAS) - Physical demand (VAS) - Stress level (VAS) **Factors Contributing to Fatigue** -driving conditions (road, traffic, weather) - Monotony to stimulating -Time spent load/unloading -Time spent waiting -Time spent driving -Type of shift (split shift)? -Travel across time zones (yes/no) Attention Task (PVT)	- Naps (number and duration) - Sleepy/alert (VAS)	**Actigraph Event Tracker** - Date - Time - Purpose of removal - Length of time

*Visual Analogue Scale

Table 5-3 Schedule of Measures to be Collected During Rest Days

Upon awakening	Within 2 hours of awakening and within 2 hours of going to bed	Before Bed	Anytime
- Off duty or on duty (box) **Actigraph Log Sheet** - Bedtime - Wakeup time -Length of last sleep period (actual sleep time) -Quality of last sleep period (VAS) -Total sleep time over last 24 hour	- Off duty or on duty -General physical state (aches and pains, VAS) -Sleepy/alert (VAS) -Calm/excited (VAS) -Tense/relaxed (VAS) -Happy/sad (VAS) Attention task (PVT)	- Naps (number and duration) -Sleepy/alert (VAS)	**Actigraph Event Tracker** - Date - Time - Purpose of removal - Length of time

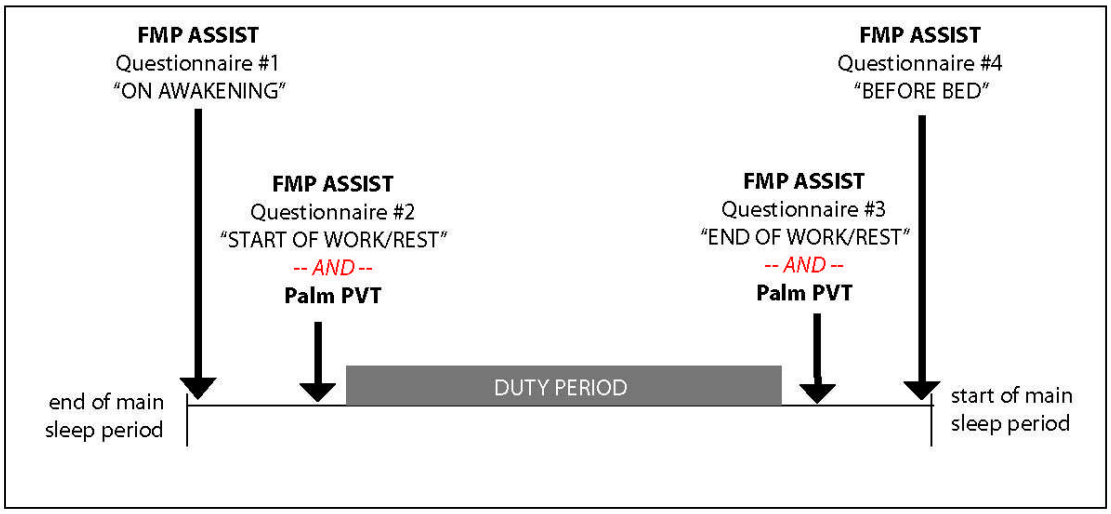


Figure 5-2 Timing of data collection on duty days

The duration of sleep was evaluated by asking drivers to complete a sleep-wake log. The number of rest bouts and duration of activity during rest bouts were objectively documented using the wrist actigraph. Subjects wore this device during wake periods and sleep to monitor the level of body activity. They pressed an event marker each time they got in and out of bed. The use of the actigraphic device (i.e., periods during which it was removed and why, e.g., shower) was documented (see Appendix K: Driver Instruction Booklet).

Upon awakening from their main sleep episode, drivers reported the subjective quality of their prior sleep episode. Visual analogue scales (VAS) were used to assess driver general physical state, fatigue, mood, workload and factors contributing to fatigue during wake periods. The scales were administered by means of the PDA device. VAS

have been extensively used and validated in prior studies and allow the collection of quantitative data in an efficient manner for the participants (Boivin, 1997; Dijk & Czeisler, 1994; Johnson, Duffy, Dijk, Ronda, Dyal, & Czeisler, 1992). The detailed list of VAS used is shown in Appendix K: Driver Instruction Booklet. Before beginning their shift drivers completed a ten-minute PVT on the PDA.

The PVT was the primary objective performance task used in the project. The PVT is a simple, visual reaction time (RT) task that is not dependent on aptitude or skill level and does not have a learning curve. It is sensitive to even small amounts of sleep loss and yields informative metrics on the capacity for sustained attention and vigilance (Belenky, Wesensten, & Thorne, 2003; Dinges & Kribbs, 1991; Dinges & Powell, 1985). PalmPVT software developed at the Walter Reed Army Institute of Research was loaded on the PDA and used to administer the PVT (Thorne, Johnson, & Redmond, 2005). The PVT provides an objective measure of vigilance and sustained attention that is sensitive to sleep loss and a fundamental performance metric that underlies higher order cognitive functioning.

At the end of each duty period, drivers were asked to report if they experienced any falling asleep incidents or close calls of any kind (i.e., critical events). Critical events provided a subjective measure of safety. The gold standard measure of safety is crashes, but these, fortunately, are too few and far between to serve as indicators of safety over the short test period. Critical events occur much more frequently than crashes. Although they seldom result in crashes, because they occur in forgiving circumstances, they are precursors to crashes, and are useful indicators of the level of safety pre vs. post-FMP.

Factors contributing to fatigue such as the amount of time spent waiting and loading/unloading were also reported at the end of each duty day. A workload assessment was completed and finally, drivers completed the ten minute PVT on the PDA.

5.4 PDA Usability and Training Issues

The researchers considered the usability of the user interface on the PDA device an essential component to the successful collection of data. As a result, a menu system with multiple redundant paths was developed to facilitate the input of subjective measures based on the time of day. All entries were made using large touch-screen buttons and sliders (i.e., the use of a keyboard or stylus was not necessary). These approaches made data collection for non-computer users quick and easy.

In Québec, pre-FMP data collection was carried out for six to ten drivers at a time due to equipment availability. The group of drivers met in person just before the pre-FMP data collection and were informed about the data collection procedures and use of equipment. They were asked to complete at least one practice session on the PVT and to carry out two others the same evening. They were also provided with the cellular phone and pager information of a contact person from the research team. Upon completion of the pre-FMP data collection, they were asked to bring back the equipment to the identified member of the company operation committee who would then organize the pick-up of drivers' equipment by the research team. The equipment was given with a protective bag which included a confidential identification code. The same identification code was used as an identifier for the PDA and Actiwatch. The

drivers were asked to bring back the equipment identified by this identification code only to ensure confidentiality. The data were then downloaded under this confidential code.

In California, a training session was conducted by phone with each driver to explain the data collection procedures and to establish communication lines in case of problems. Contact involved a minimum 15 to 30-minute interaction (depending on the individual) and was more than sufficient to effectively introduce driver participants to the equipment used in this project. While the PVT has been shown to have essentially no learning curve, participants were asked to complete one to three practice sessions before initiating actual data collection. An Alertness Solutions contact and toll-free number was provided to deal with any equipment questions or difficulties that occurred during data collection periods.

The same procedure was used in Alberta as in California; about two-thirds of the participants were trained over the phone and one-third were trained in person. Each driver completed one full cycle of the questions and the PVT. Drivers were provided with packaging and instructions to return their equipment and drivers booklet at the end of the data collection period under strict confidentiality, using only their subject code for identification.

5.5 Corporate Measures

5.5.1 Corporate Performance Measures

Corporate measures which reflect a range of safety, health, and operational variables were obtained from each company. The specific measures were determined based on interactions with the participant company, and were dependent on those that were available from the company and could be collected and analyzed in an efficient and informative manner.

In Québec, the following corporate measures were collected during eight months (September 2006 – April 2007) pre-FMP data collection period and during four months (February to May 2008) post-FMP data collection.

- Accidents (count and description)
- Infractions against road regulations (count)
- Absent days (count and reason)
- Total driving time (hours:minutes)
- Total waiting time during duty (hours:minutes)
- Total rest time (hours:minutes)
- Distances travelled (kilometres)
- Panic brake (count)

In Alberta, the following corporate measures were collected during the three month (August – October 2007) pre-FMP data collection period:

- Accident data: Accident type, accident date, preventable costs, weather, accident time, property damage, damage, injuries, fatalities, spills and mixes

- Workers compensation data: Accident date, problem, severity, description, cause detail
- Black box data: Excess speed, hard brake, fuel economy
- Insurance claims: Claim type, patient age, total charge, procedure type, accident
- Sleep apnea claims: Number of drivers over one year period
- Other: Driving code violations, kilometres driven, XATA data (driving time, waiting time)

Accident data (count), violations (count), rapid speed changes (count), and kilometres driven (count) were the corporate measures collected in Alberta during the three month (June – August 2008) post-FMP data collection period. The pre-FMP measures were then limited to these four measures and the data from the drivers that did not complete the program were removed.

In California, the following corporate measures were collected during a three-month pre-FMP period: January 1 to March 31, 2007 and during a three-month post-FMP period: April 1 to June 30, 2008:

- Accident data: Type, date and time, preventable, costs, weather, damage costs, injuries, fatalities
- Workers compensation data: Date, RES($), problem description, severity, description, cause detail

5.5.2 AMSE Assessments

In Québec, the AMSE was administered to all participating drivers before and after the comprehensive FMP program. In addition five managers completed the AMSE pre and post-FMP, respectively in January 2007 and in February 2009. Seven dispatchers completed the AMSEs pre-FMP only and their responses are not reported here. Managers' responses to the post-FMP AMSE were compared to their pre-FMP AMSE to determine if the implementation of FMP activities had affected the company's practices, policies, and procedures with respect to fatigue management.

Similar to Québec, in Alberta the AMSE was administered to all participating drivers pre- and post-FMP. In addition several managers, dispatchers and supervisors completed the AMSE. The results of five individuals who completed the pre-AMSEs were compared with those of four individuals completing the post-AMSEs.

In California, all participating drivers completed the AMSE before and after the implementation of the comprehensive FMP. In addition, five managers completed the AMSE pre-FMP in April – May 2007 and post-FMP in January 2009. The managers' responses to the post-FMP AMSE were compared to their pre-FMP AMSE to determine if the implementation of FMP activities had affected their report and perception of the company's practices, policies, and procedures with respect to fatigue management.

6 FATIGUE MANAGEMENT PROGRAM IMPLEMENTATION

The following sections describe how the FMP was implemented at each of the three company sites. Section 6.1 describes the implementation of the education program, and Section 6.2, the implementation of the sleep disorder screening and treatment program.

6.1 Education Program

6.1.1 Québec Site

6.1.1.1 Outline of the Program

It was originally planned that the principal investigator would train the company trainers, who would be in charge of training their drivers. The company trainers were employees of Transport Robert who had responsibilities in other areas than education. At the beginning of the project, the company identified five trainers, although only two were actively involved with training of drivers. Trainers were asked to read the educational modules prior to each session given by the principal investigator. They had the opportunity to observe the training of drivers by the investigator, and had the opportunity of being observed by the investigators as they trained drivers. During the observation sessions, the investigators assisted when trainers could not answer participants' questions and provided trainers with feed-back regarding their training skills. Trainers were responsible for the organization and administration of the educational sessions, and, following the two initial sessions given by the principal investigator, as well as for the training of the remaining drivers, managers, dispatchers, shippers, receivers, and family members.

At the company's request, the presentation and booklet of the Core Fatigue Alert Module for Managers and Dispatchers was reformatted in order to keep only information relevant for dispatchers' work. All other educational booklets were kept as originally planned. The power point presentations used for the educational sessions were modified in order to limit sessions' duration to about 60 minutes each. This was done for operational reasons, since a large number of drivers attended the core educational module session before or after their habitual run. A special session was planned to provide the three supplementary modules all at once.

6.1.1.2 Mode of Delivery

A half-day session with trainers was given in May 2007 in order to present the core educational module, to answer questions, and to give tips for effective knowledge transfer. The original plan was then followed for the administration of the core educational module, with a first training session given to 25 drivers by the Principal Investigator. The Investigators then observed the training of 10 other drivers by the company trainers. Subsequently, the company trainers trained four additional drivers.

Following each training session, short quizzes on educational content were administered to the drivers participating in the experimental phase of the study. They filled out these forms indicating their confidential participant number. Only drivers who participated in the data collection part of the study were invited to attend these sessions. The company executives made this decision because they wanted to see the

results of the present study before investing more time and money in the FMP program approach.

For the administration of supplementary modules, the Investigators were to organize another half-day session with all trainers in order to cover the presentation of all three supplementary modules. Investigators were to present the most difficult supplementary module, namely the one on sleep and sleep disorders, to a mixed group of participants. The Investigators were then to observe trainers give the supplementary module on sleep and sleep disorders to another mixed group of participants. Due to trainers' perception of insufficient knowledge, it was agreed with the company that the Investigators would train drivers on the three supplementary modules. Half-day training sessions covering all three supplementary modules were given twice by the Investigators during which a total of 27 drivers were trained. Two trainers attended these supplementary training sessions and then trained the few drivers that could not attend these sessions.

A one-hour training session using the revised dispatcher core educational module was given by the Principal Investigator to 11 dispatchers interacting with the drivers participating in the experimental protocol; four managers also attended, as did the trainers. Trainers then trained another 15 dispatchers, and an additional four managers, on the core educational module. A copy of the revised manager core educational module was circulated to managers and the company trainers trained four other managers directly. The time table and number of participants attending each session are detailed in Table 6-1. Alpha Logik sent the three, two-page newsletters, created by HFN for this program, to Transport Robert for distribution to their drivers.

Table 6-1 Québec Training Sessions

Date	Location	Objective	Number of Participants
May, 2007	Montreal	Investigator train the trainer	2 trainers
May, 2007	Montreal	Investigator train the drivers	25 drivers
May, 2007	Montréal	Investigator train the dispatchers, managers and trainers	11 dispatchers, 4 managers, 2 trainers
June, 2007	Montréal	Investigator watch the trainer	10 drivers
June, 2007	Montréal	Trainer train	15 dispatchers
June, 2007	Montréal	Trainer train	4 drivers
June, 2007	Montréal	Trainer train	4 managers

6.1.1.3 ATTENDEES

A total of 39 drivers participated in the educational sessions, as well as eight managers, 26 dispatchers and two company trainers.

6.1.1.4 ORGANIZATIONAL CHALLENGES

The mixed group (drivers, family members and managers) approach was difficult to follow due to time constraints related to the drivers' schedules, and thus few (n=8) managers attended these sessions. In order to meet the experimental timetable, the

company managers decided not to invite family members to the training sessions. Instead the drivers were given printed copies of the four modules and advised to share the information with members of their family and friends. It was also difficult to synchronize the drivers and dispatchers schedules. This represents an organizational challenge that should be addressed in order to organize mixed focus groups on fatigue related issues within the organization.

Due to lack of sufficient knowledge experienced by the trainers, the Investigators, rather than company trainers, trained drivers on the three supplementary modules. Due to time constraints and the difficulty imposed by the drivers' schedule, half-day training sessions were given covering all three supplementary modules.

6.1.1.5 Trainer Feedback

At the debriefing session after the train-the-trainers training session, the trainers expressed their concerns regarding their level of knowledge, which they judged insufficient, to provide good training sessions, especially those on sleep and sleep disorders. A similar situation occurred during Phase 2 of the FMP where drivers had to be trained directly by the project leader in Québec instead of using a train-the-trainer approach. Since only eight drivers participated in Phase 2 in Québec, it was considered more time-efficient to directly train the drivers. The Phase 2 report proposed that the train-the-trainer approach could be better tested during Phase 3 because of a larger sample size (Moscovitch et al. 2006).

6.1.1.6 Lessons Learned

Driver demands and schedules created significant challenges in many program elements, for example, coordinating educational sessions, identifying times that could be attended by family and dispatchers, and general phone contact for coordination (forms completed, appointments, etc.). There was an ongoing challenge to balance program activities with drivers' work and home requirements, in spite of company support and acknowledgement of the importance of managing fatigue.

6.1.2 Alberta Site

6.1.2.1 Outline of the Program

In Alberta, initial discussions about the FMP were held with the ECL implementation committee (made up of the Director of Quality, Health, Safety, and Environment, the VP of Operations, and driver supervisors) to outline the educational program. ECL is a company that conducts its business at two sites, Edmonton and Calgary. The implementation committee decided that educational sessions would have to be duplicated at each site, and that the train-the-trainer approach as described in the protocol, was desirable and feasible also had to be carried out at each site. The original plan was to train three trainers at each site for a total of six trainers. Scheduling difficulties limited the feasibility of this approach and led to the decision that there would be two rather than three trainers at each site.

6.1.2.2 Mode of Delivery

One train-the-trainer session was held in Calgary and one in Edmonton. The Alberta Principal Investigator presented the core and the trip planning modules in a three hour session at each site. Because of the redundancies in these two modules they were revised to form a single module which was used by the trainer at each site. As

described in the research protocol, the Principal Investigator and assistant observed the initial educational sessions by the trainer using the combined module. It was further updated to include some of the information from the remaining supplemental modules. Then the trainer gave subsequent sessions independent of SagaTech personnel. The core and trip planning quizzes were given to the participants at the beginning and then again at the end of the sessions.

The core and dispatcher/manager modules were presented by the Alberta Principal Investigator to mixed group of participants (managers, dispatchers, and driver supervisors) in Edmonton. This session included discussion of dispatching practices at each site.

ECL also distributed the three, two-page newsletters created by HFN for this program to their drivers through their internal mail system.

6.1.2.3 ATTENDEES

A total of 42 drivers participated in the educational sessions, and 25 of these drivers participated in the pre and post-FMP data collection. In addition, six managers/dispatchers/health and safety employees also participated.

The date, the location, the objective of the training, and the number of participants are identified in Table 6-2.

Table 6-2 Alberta Training Sessions

Date	Location	Objective	Number of Participants
February 19, 2008	Calgary	Investigator train the trainer	2 trainers, 1 QHSE, 4 drivers
February 20, 2008 a.m.	Edmonton	Investigator train the trainer	1 trainer, 8 drivers
February 20, 2008 p.m.	Edmonton	Investigator train the trainer and dispatchers	1 trainer, 3 dispatchers
February 21, 2008	Edmonton	Investigator watch the trainer	9 drivers
February 25, 2008	Calgary	Investigator watch the trainer	cancelled – no attendees
March 19, 2008	Edmonton	Trainer train	4 drivers
April 7, 2008	Calgary	Investigator watch the trainer (rescheduled)	3 drivers
April 8, 2008	Edmonton	Trainer train	6 drivers
April 25, 2008	Calgary	Trainer train	5 drivers
May 13, 2008	Calgary	Trainer train	1 driver
July 24, 2008	Edmonton	Trainer train	4 drivers

6.1.2.4 ORGANIZATIONAL CHALLENGES

Because of the disparity in driver start times and time available for education, the major challenge in Alberta was related to attendance at educational sessions. One early morning session was scheduled and was attended by the trainer and the SagaTech employees and no drivers appeared owing to communication difficulties. Other difficulties related to the re-assignment of the trainer (for example safety rotations), vacation time, medical leave, and the general limited availability of the trainer. Family members were invited but none attended the training sessions. Drivers were encouraged to take the handouts home and share them with their families.

6.1.2.5 TRAINER FEEDBACK

The two main trainers at each site were interviewed using prepared questions regarding their experience. The following is a summary from those interviews.

Edmonton: The main trainer in Edmonton reported that the resources provided served well in the class room and that he appreciated the opportunity to get some experience with it while support was in the class. He kept the classes small to around six to eight people. The only negative comments he received was the general “not another training session” variety. He reported that the participants seemed interested enough in the information and a couple of them took it home for their families. He commented that the final version of the presentation was a great improvement.

Calgary: The main Calgary trainer reported that the material was fair to good but needed more details in some areas and so to become more comfortable he did some of his own research (i.e., Google). He found that the participants contributed when they were asked questions and that they seemed reasonably interested in the information. He noted that scheduling education sessions was very difficult and not unique to this program due to driver duty hours (nights and weekends). This trainer felt comfortable asking the individuals about their doctor's appointments and about any therapy that was initiated. He suggested making the presentation more “eye-catching” by including a short movie. While the handouts were used during the course, the trainer suspected that they were thrown away before even leaving the premises which again is usual in his experience. His reported overall comfort level training others on this material was a 6 to 7 out of 10 and his overall rating of the training program was a 7 to 8 out of 10. He further commented that having an external expert come in and make the presentation was beneficial as the drivers recognized the experienced authority.

6.1.2.6 LESSONS LEARNED

The train-the-trainer approach seemed to be an effective and efficient method for educating drivers, managers, and dispatchers. The major limitation related to the limited availability of the trainer due to reassignment to other areas and with internal communication to the drivers (scheduling).

Company communication and involvement seemed to be important. ECL showed their support for this program by including articles about the FMP and fatigue in general in their company newsletter. They also had FMP related information on their internal television system (i.e., the large screen televisions in the driver coffee areas).

6.1.3 California Site

6.1.3.1 Outline of Program

Initial discussions of the planned educational activities with J.B. Hunt personnel quickly determined that changes would be required to successfully implement education training. It was made clear that total educational time could be a maximum of two hours and would have to be conducted in one session. More than two hours or one session would create significant barriers to scheduling and attendance.

To address these issues, first, the original Modules 1 and 2 were integrated into a single module for live presentation to be provided in a 1.5 to 2-hour session. The original Modules 3 and 4 were reviewed, and, where appropriate, some information (e.g., a slide) was included in the integrated live presentation module. Second, a CD was created that contained all four of the original educational modules and was provided to all education session participants. Third, a web-based mode of delivery was developed to accommodate schedules and geographic considerations.

6.1.3.2 Mode of Delivery

The initial plan involved a train-the-trainer approach with Alertness Solutions personnel providing the first educational sessions with several J.B. Hunt safety personnel in attendance. These safety personnel were intended to be trained on the content and then subsequently provide the educational sessions for the remaining driver participants, with Alertness Solutions personnel available for questions and guidance as needed.

After the first educational session, the three J.B. Hunt safety trainers underwent an extended three-hour training session reviewing content, issues, frequently asked questions, and methods to use Alertness Solutions expertise for support. However, for a variety of reasons, the coordinator responsible for scheduling the training sessions, trainers, and driver participants was unable to get any sessions organized or delivered over a nine-month period. In spite of several efforts to initiate actions, revise the approach, and include other trainers, it became clear that alternate modes of delivery would have to be used.

First, a live presentation was planned at a central J.B. Hunt facility in the San Francisco Bay Area with sufficient preparation time to schedule as many possible driver participants as possible. Second, a web-based presentation using the integrated Modules 1 and 2 was created that involved a computer-based presentation of the slides (i.e., WebEx) and a voice interaction with all participants over a call-in phone line. The phone voice interactions allowed for ongoing interactions, including questions and answers. The web-based presentation was provided to all driver participants that were unable to attend the live presentation.

The date, presentation mode, and number of participants are identified in Table 6-3.

Table 6-3 California Training Sessions

Date	Presentation Mode	Number of Participants
April 23, 2007	Live/train-the-trainer	1 driver/3 safety trainers
March 8, 2008	Live	16 drivers/5 managers
March 15, 2008	Web-based	6 drivers
March 21, 2008	Web-based	2 drivers
April 2, 2008	Web-based	1 driver

The Principal Investigator provided presentations for 22 drivers and the five managers. An experienced Alertness Solutions trainer provided the web-based presentation for the last three drivers. These presentations averaged about 1.5 to 2 hours based on the amount of interaction and questions raised. A different Alertness Solutions Ph.D. presented the first training session; however, the one driver participant in this session later dropped out of the project and the safety trainers did not provide any subsequent educational sessions.

These two educational modes were implemented to address the specific challenges encountered with the train-the-trainer approach. The same materials were used, the project Principal Investigator provided the majority of training in both modes, and the same resource material was provided to all participants. No formal evaluation was conducted to examine differences between the live and web-based sessions, as there were insufficient participants to do this and it was not an intended focus of the project.

The three two-page newsletters were provided via email to the participating company's Director of Safety with a request for the newsletters to be distributed to company personnel. It was suggested that the information be distributed through multiple company forums and formats (e.g., via internal company email, hardcopy handouts, etc).

6.1.3.3 ATTENDEES

A total of 26 drivers participated in the educational sessions, as well as three family members, five managers and three safety trainers, for a total of 37 educational session participants. A total of 28 individuals attended the two live sessions and nine individuals participated in web-based presentations. The participating carrier was headquartered in Arkansas and the primary dispatcher/scheduler group was geographically located in Arkansas. Therefore, none of the Arkansas-based dispatchers were able to attend the live training sessions held in California. However, the web-based training sessions provided an opportunity to offer the same training delivered to drivers to the dispatcher/scheduler group. Therefore, dispatchers and schedulers were invited through company channels to participate in one of the three web-based education sessions held in March and April, 2008. No dispatcher or scheduler participated in the web-based education sessions and no information was available about their inability to participate (scheduling conflict, timing, interest, etc.).

6.1.3.4 ORGANIZATIONAL CHALLENGES

The initial challenge was to readjust educational materials to accommodate the time allotted. It was clear that the original project plan to deliver four educational modules, each 1.5 hours, over multiple sessions was not practical given drivers' schedules and geographic distribution. This issue was effectively addressed with the integrated educational module that was presented in about 1.5 to 2 hours, complemented with a CD provided to each participant that included all four original educational modules. During subsequent contacts, informal inquiries were made about whether drivers had accessed the CD material in any way following their education session with perhaps half reporting some use. All of the original four quizzes were used and completed by drivers, even though only the integrated module was presented.

The other significant challenge was the geographic distribution and diverse schedules of the driver participants. J.B. Hunt has headquarters in Arkansas, and California-based drivers located and driving throughout the state. Therefore, the live presentation mode and web-based method provided effective, complementary mechanisms to deliver the required educational sessions to all driver participants. In fact, over a nine-month period, the initial train-the-trainer approach was unable to be implemented or gain traction, in spite of significant efforts. However, the live presentation and web-based training for all of the driver participants that completed the project was accomplished in about one month (with about another month of planning and scheduling).

6.1.3.5 TRAINER FEEDBACK

While initial interactions with the three J.B. Hunt safety trainers were all positive, there was no subsequent feedback given that the trainers did not provide any educational sessions.

6.1.3.6 LESSONS LEARNED

J.B. Hunt represents one type of trucking company in the industry: large number of drivers, operating in 48 states, centralized headquarters, diverse operations (local, long haul, etc.), many different driving schedules, and broad geographic distribution (drivers, operations, clients). Therefore, the challenges raised by their participation reflect issues that can be generalized to other commercial carriers across the trucking industry.

Effectively addressing these challenges required flexibility, i.e., creating an integrated focused educational module/training session that fit allotted time and corporate support. The diverse driver schedules and geographic distribution required offering two modes of delivering the educational training sessions: live training and web-based presentations. Using these two approaches, training was completed in about one month, with another month for preparation and scheduling. There also was the need to make adjustments to the education training after an initial train-the-trainer approach proved ineffective.

The experiences, challenges, and final effective outcomes of the educational activities with J.B. Hunt represent a valuable "lessons learned" that can be generalized to future educational program implementation at other commercial truck companies in the industry.

6.1.4 Driver Education Program Quiz Results

The original protocol described before and after educational session, multiple-choice quizzes to evaluate driver knowledge of the education program. The four quizzes were:

- Core Module
- Trip Planning
- Sleep Disorders
- Wellness and Lifestyle

Due to feasibility concerns, these were employed in Alberta for the Core Module and Trip Planning sessions only. Québec and California did not employ pre-session quizzes.

Each quiz consisted of eight questions. The results are shown in the following sections.

6.1.4.1 CORE MODULE

Overall, for all drivers combined, the average score was 60 percent correct post FMP (see Table 6-4). Drivers were most likely to provide the correct response to the following questions:

- (#5) Driving at night and sleeping during the day can result in … (all of the above, 85 percent correct)
- (#1) Driving what the goals of the fatigue management program … (all of the above, 78 percent correct)
- (#4) The longest sleep period is obtained if you go to bed at … (midnight, 75 percent correct).

Fewer than half of all drivers provided correct responses to the following questions:

- (#3) Which of the following statements is true … (time of day has a bigger effect on fatigue than time on duty, (29 percent correct)
- (#2) The estimated percent of heavy truck accidents involving fatigue is … (37 percent correct)
- (#7) Hours of service regulations … (fail to consider time-of-day effects, (41 percent correct)

A pre versus post FMP comparison in Alberta for the core module showed an increased score (63 percent vs. 56 percent).

Table 6-4 Core Module Quiz Results

		Pre-FMP		Post-FMP			
		Alberta (n=24)		Québec (n=29)	Alberta (n=24)	California (n=24)	Total (n=77)
1	The goals of this fatigue management program	96%		74%	92%	71%	78%
2	The estimated percent of heavy truck accidents involving fatigue is 30 – 40%	32%		24%	44%	50%	37%
3	Time of day has a bigger effect on fatigue than does sleep quality	48%		18%	48%	25%	29%
4	The longest sleep is obtained if you go to bed at midnight	80%		82%	86%	62%	75%
5	Driving at night and sleeping during the day can result in … all of the above	84%		74%	88%	100%	85%
6	Being awake for 20 to 25 hours has been shown to be equal to a blood alcohol level of 0.10%	36%		63%	68%	75%	68%
7	Hours of service regulations fail to consider time-of-day effects	32%		42%	28%	54%	41%
8	Single vehicle accidents are most likely to occur between 2:00 – 4:00 a.m.	40%		82%	48%	62%	67%
	AVERAGE SCORE	**56%**		**57%**	**63%**	**62%**	**60%**

6.1.4.2 TRIP PLANNING

Overall, for all drivers combined, the average score was 66 percent correct (see Table 6-5). Drivers were most likely to provide the correct response to the following questions:

- (#8) Concerning amount of driving … (driving for more than 10 hours can result in drowsiness, short attention span, irritability, decreased concentration and memory, 84 percent correct)
- (#2) Concerning the recovery period … (all of the above, 83 percent correct)
- (#6) Concerning the time-of-day effect … (people generally feel sluggish in the mid-afternoon and after midnight, 79 percent correct)

Drivers were least likely to provide the correct response to the following questions:

- (#3) Concerning your level of alertness … (how much you slept in the prior day affects your level of alertness, 47 percent correct)
- (#4) Concerning your ability to sleep … (all of the above, 52 percent correct)
- (#5) Concerning sleep inertia … (sleep inertia impairs your driving performance after a nap, 53 percent correct)

Table 6-5 Trip Planning Quiz Results

		Pre-FMP		Post-FMP			
		Alberta (n=24		Québec (n=29)	Alberta (n=24	California (n=24	Total (n=77
1	The best times to plan a nap are between 00:00 – 06:00 and between 13:00 – 16:00	72%		63%	52%	58%	58%
2	Concerning the recovery period … all of the above	92%		73%	88%	92%	83%
3	How much you slept in the prior day affects your level of alertness	28%		50%	32%	58%	47%
4	Consider your ability to sleep … all of the above	52%		47%	56%	54%	52%
5	Sleep inertia impairs your driving performance after a nap	48%		53%	60%	46%	53%
6	People generally feel sluggish in the mid-afternoon and after midnight	88%		77%	80%	79%	79%
7	Considering amount of sleep … all of the above	56%		57%	80%	71%	68%
8	Driving for more than 10 hours can result in drowsiness, short attention span, irritability, decreased concentration and memory	92%		83%	92%	75%	84%
	AVERAGE SCORE	**66%**		**63%**	**68%**	**67%**	**66%**

6.1.4.3 SLEEP DISORDERS

Overall, for all drivers combined, the average score was 73 percent correct (see Table 6-6). Drivers were most likely to provide the correct response to the following questions:

- (#5) Which of the following statements is NOT true … (sleep disorders only affect unhealthy middle-aged men, 89 percent correct)
- (#3) Sleep debt … (refers to missed sleep that you needed but did not get, 85 percent correct)

Drivers were least likely to provide the correct response to the following questions:

- (#1) Which of the following statements is true regarding the stages of sleep … (stages NREM 3 and 4 comprise deep sleep, 38 percent correct)
- (#6) Which of the following statements is NOT true … (people with chronic forms of insomnia function normally during daytime, 54 percent correct)

Table 6-6 Sleep Disorders Quiz Results

		Post-FMP			
		Québec (n=29)	**Alberta (n=0)**	**California (n=24)**	**Total (n=53)**
1	Stages NREM 3 and 4 comprise deep sleep	29%	n/a	50%	38%
2	The amount of sleep required during each 24-hour day ranges between 6 and 10 hours for adults	90%	n/a	75%	84%
3	Sleep debt refers to missed sleep that you needed but did not get	84%	n/a	87%	85%
4	Sleep disorders have various physiological or psychological causes	71%	n/a	75%	73%
5	Sleep disorders DO NOT only affect unhealthy middle-aged men	87%	n/a	92%	89%
6	People with chronic forms of insomnia DO NOT function normally during daytime	61%	n/a	46%	54%
7	Sleep apnea describes pauses in breathing during sleep	100%	n/a	62%	84%
8	Medication IS NOT a treatment for sleep apnea	90%	n/a	62%	78%
	AVERAGE SCORE	**77%**		**69%**	**73%**

6.1.4.4 WELLNESS AND LIFESTYLE

Overall, for all drivers combined score was 70 percent correct (see Table 6-7). Drivers were most likely to provide the correct response to the following questions:

- (#2) Regular exercise will improve your … (all of the above, 94 percent correct)
- (#3) Which of the following is an effective strategy for coping with stress … (all of the above, 87 percent correct)

Drivers were least likely to provide the correct response to the following questions:

- (#4) Which of the following is a real road block to exercise … (lack of skills or facilities, 6 percent correct)
- (#6) Exercise offers so many health benefits but for each exercise to be successful and increase well being it … (can be done at short intervals over the course of the day, 41 percent correct)

Table 6-7 Wellness and Lifestyle Quiz Results

		Post-FMP			
		Québec (n=29)	**Alberta (n=0)**	**California (n=24)**	**Total (n=53)**
1	To lose weight you need to have energy intake be less than your energy output	80%	n/a	83%	81%
2	Regular exercise will improve … all of the above	97%	n/a	92%	94%
3	Effective strategy for coping with stress … all of the above	90%	n/a	83%	87%
4	Lack of skills or facilities is a real road block to exercise	0%	n/a	12%	6%
5	Too much stress DOES NOT allow you to get all the sleep you need	87%	n/a	83%	85%
6	For exercise to be successful and increase well being it can be done at short intervals over the course of the day	40%	n/a	42%	41%
7	In order to help reduce the risk of obesity-related diseases … al of the above	87%	n/a	83%	85%
8	A healthy lifestyle is a family affair	80%	n/a	83%	81%
	AVERAGE SCORE	**70%**		**70%**	**70%**

6.2 Sleep Disorder Screening and Treatment Implementation

6.2.1 Overall Experience

6.2.1.1 DIAGNOSTIC DATA: ALL SITES

A total of 94 drivers were evaluated at three sites: Alberta, Québec and California. All 94 drivers had completed the first pre-FMP data collection phase of the study, followed by implementation of the FMP which consisted of fatigue education sessions and sleep disorder screening, diagnosis, and treatment. For each driver at each site, two predictive variables were assessed: Adjusted Neck Circumference (ANC) (Flemons 2002), and Multivariable Apnea Predictor (MAP) (Maislin et al. 1995), two symptom-related questionnaires were completed: Epworth Sleepiness Scale (ESS) (Johns, 1991) and Sleep Apnea Qualify of Life Index (SAQLI) (Flemons and Reimer 2002), and a Level III portable monitor sleep test was administered in the home. The in-home sleep test yielded the Respiratory Disturbance Index (RDI), and three indices of oxygen saturation (mean, fraction of the night below 90 percent O_2 Sat, and fraction of the night below 80 percent O_2 Sat).

Stratifications of data for ANC, MAP, ESS, SAQLI, RDI and fraction of night below 90 percent O_2 Sat are presented in Table 6-8.

Table 6-8 Stratifications of Data

ANC value	N	%
< 43 (low probability)	27	30.3
43 – 48 (intermediate probability)	42	47.2
> 48 (high probability)	20	22.5
MAP value	**N**	**%**
< . 4 (low probability)	29	33.7
.4 - .7 (intermediate probability)	39	45.3
> .7 (high probability)	18	21.0
ESS value	**N**	**%**
0 – 10 (asymptomatic)	70	75.3
11 – 16 (moderate)	18	19.3
17 – 24 (severe)	5	5.4
SAQLI value	**N**	**%**
6 – 7 (normal)	39	41.5
5 – 5.9 (mild)	28	29.8
4 – 4.9 (moderate)	12	12.7
< 4 (severe)	15	16.0
RDI $hr.^{-1}$	**N**	**%**
< 5 (no abnormality)	27	28.7
5 – 14.9 (mild)	37	39.4
15 – 29.9 (moderate)	22	23.4
≥ 30 (severe)	8	8.5
O_2 Sat below 90%	**N**	**%**
0 – 2 (normal)	63	67.0
2 – 5 (mild)	16	17.0
5 – 15 (moderate)	7	7.5
> 15 (severe)	8	8.5

The ANC data predicts that nearly 70 percent of drivers have intermediate or high risk of sleep apnea. Similarly, MAP predicts that 66.3 percent of drivers have intermediate or high risk of sleep apnea. The values for ESS reveal that approximately one third of drivers reported no sleepiness or mild sleepiness, whereas approximately one-quarter reported moderate to severe sleepiness. SAQLI scores reveal a similar distribution with 40 percent lying in the normal range, 30 percent in the mild range and approximately 30 percent in the moderate to severe range.

Using an RDI of less than 5 $hr.^{-1}$ (Fleetham et al. 2006) as the upper limit of normal, the in-home sleep studies revealed that 71.3 percent of drivers had sleep apnea. These drivers with sleep apnea were distributed into three categories as follows: mild (RDI 5 – 14.9 $hr.^{-1}$): 39.4 percent; moderate (RDI 15 – 29.9 $hr.^{-1}$): 23.4 percent; and severe (RDI ≥30 $hr.^{-1}$): 8.5 percent. A comparable distribution was observed for fraction of the night below O_2 Sat 90 percent, with values as follows: normal (0 to 2 percent of night), 67 percent of drivers; mild (2 to 5 percent of night), 17 percent of drivers; moderate

(5 to 15 percent of night), 7.5 percent of drivers; and severe (>15 percent of night), 8.5 percent of drivers.

Table 6-9 shows the results of inter-variable corrections.

Table 6-9 Results of Inter-variable Correlations

		RDI	ANC	MAP	EPWORTH	SAQLI	MeanO_2 Sat	Below 90
RDI	Pearson Correlation	1	.619(**)	.488(**)	-.133	-.114	-.201	.303(**)
	Sig. (2-tailed)		.000	.000	.205	.274	.052	.003
	N	94	89	86	93	94	94	94

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

ANC was significantly correlated with RDI (R^2=.619). Similarly, MAP was significantly correlated with RDI at a somewhat lower level than ANC (R^2=0.488). By contrast, RDI did not correlate with ESS or SAQLI. Finally, a weak but significant correlation was found between RDI and fraction of the night below 90 percent.

The summary data for all four categories of RDI are presented in Table 6-10.

Table 6-10 Summary Data for all Four Categories of RDI

No Sleep Apnea (RDI <5)						
	N	Range	Minimum	Maximum	Mean	Std. Deviation
ANC	25	12.7	34.5	47.2	41.7	3.0
MAP	26	.59	.12	.70	.39	.17
ESS	27	19	0	19	8.8	4.9
SAQLI	27	3.6	3.3	6.9	5.5	1.0
RDI	27	4.2	.6	4.8	2.3	1.3
MeanO2Sat	27	8.3	89.0	97.3	94.6	1.8
Below90	27	26.6	.0	26.6	1.5	5.2
Below80	27	6.5	.0	6.5	.3	1.3
Mild Sleep Apnea (RDI 5 – 14.9)						
	N	Range	Minimum	Maximum	Mean	Std. Deviation
ANC	37	16.5	35.6	52.1	44.3	3.9
MAP	33	.79	.15	.94	.49	.21
ESS	36	14	2	16	8.1	4.0
SAQLI	37	4.5	2.3	6.8	5.5	1.0
RDI	37	9.3	5.3	14.6	9.6	2.9
MeanO2Sat	37	10.6	87.0	97.6	94.4	2.2
Below 90	37	28.4	.0	28.4	2.5	5.8
Below 80	37	1.0	.0	1.0	.0	.2

Moderate Sleep Apnea (RDI 15 – 29.9)						
	N	**Range**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
ANC	19	14.8	40.5	55.3	47.9	3.9
MAP	19	.48	.36	.84	.61	.16
ESS	22	17	2	19	8.1	4.5
SAQLI	22	5.2	1.8	7.0	4.9	1.7
RDI	22	13.6	15.9	29.5	21.6	4.1
MeanO2Sat	22	7.6	88.7	96.3	93.5	2.4
Below90	22	71.2	.0	71.2	10.9	20.6
Below80	22	.6	.0	.6	.1	.2
Severe Sleep Apnea (RDI ≥30)						
	N	**Range**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
ANC	8	22.0	43.0	65.0	51.5	7.0
MAP	8	.42	.49	.91	.67	.15
ESS	8	9	3	12	6.9	3.2
SAQLI	8	3.2	3.2	6.4	5.2	1.1
RDI	8	32.0	31.0	63.0	43.5	10.8
MeanO2Sat	8	5.5	90.2	95.7	93.6	1.8
Below90	8	35.0	1.8	36.8	10.4	11.2
Below80	8	3.8	.0	3.8	.6	1.3

The mean values of all variables were normal for drivers with no sleep apnea (RDI <5 $hr.^{-1}$). Drivers with mild sleep apnea (RDI 5 – 14.9 $hr.^{-1}$) displayed elevations in ANC and MAP, as well as abnormally high fraction of the night below 90 percent O_2 Sat. Drivers with moderate sleep apnea (RDI 15 – 29.9 $hr.^{-1}$) displayed a more striking increase in ANC and MAP. Fraction of the night below 90 percent O_2 Sat was in the moderate category. The mean RDI for the severe (RDI ≥30 $hr.^{-1}$) group was 43.5 $hr.^{-1}$. Both the ANC and MAP were elevated, 51.5 and 0.67 respectively. This group displayed a depressed mean O_2 Sat (90.2 percent) and elevation in the fraction of the night below 90 percent comparable to that observed for moderate sleep apnea. ESS was in the normal range (<10) for drivers with no sleep apnea and was no higher for drivers with sleep apnea. SAQLI was mildly depressed in drivers with no sleep apnea and in drivers with mild sleep apnea. SAQLI was slightly lower in drivers with moderate and severe sleep apnea.

Table 6-11 provides the cross-tabulation for stratified values of ANC and RDI.

Table 6-11 Cross-tabulation for Stratified Values of ANC and RDI

		ANC Values			Total
		< 43 (low probability)	43 - 48 (intermediate probability)	> 48 (high probability)	
RDI	RDI < 5 (no sleep apnea)	16	9	0	25
	RDI 5 – 14.9 (mild sleep apnea)	10	21	6	37
	RDI 15 – 29.9 (moderate sleep apnea)	1	9	9	19
	RDI ≥30 (severe sleep apnea)	0	3	5	8
Total		27	42	20	89

Using an ANC value of 43 as the cutoff for prediction of sleep apnea, the following values are obtained: true positive 53 (59.6 percent); true negative 16 (18 percent); false positive 9 (10 percent); and false negative 11 (12.4 percent). This yields a sensitivity of 82.8 percent (53/64) and a specificity of 64 percent (16/25).

6.2.1.2 THERAPY AND ADHERENCE: ALL SITES

The treatment and adherence to nasal continuous positive airway pressure (CPAP) is presented in Table 6-12.

Table 6-12 Treatment and Adherence to Nasal Continuous Positive Airway Pressure

Sleep Apnea	N (%)	No CPAP (%)	CPAP (%)	Adherent [§] (%)	Non-adherent (%)	Lost to follow-up (%)
None (RDI < 5)	27 (28.7)	26 (96.3)	1 (3.7)	0 (0)	1 (100)	0 (0)
Mild (RDI 5 – 14.9)	37 (39.4)	16 (43.2)	21 (56.8)	7 (33.3)	13 (61.9)	1 (4.8)
Moderate (RDI 15 – 19.9)	21 (22.8)	3 [‡] (14.3)	18 (81.8)	9 (50.0)	5 (27.8)	4 (22.2)
Severe (RDI ≥ 30)	7 (7.6)	0 (0)	7 (100)	3 (42.9)	2 (28.6)	2 (28.6)
Total	92 (100)	45 (48.9)	47 (51.1)	19 (40.4)	21 (44.7)	7 (14.9)

[§] adherence: CPAP use > 4 hours / 70 percent of nights
[‡] one driver prescribed oral appliance therapy

Forty-seven out of 94 drivers (50 percent) were prescribed CPAP. Stratifying by severity, CPAP was prescribed for one driver (four percent) with no sleep apnea, over half (n=21) with mild sleep apnea, over 80% (n=18) with moderate sleep apnea, and nearly all (n=7) with severe sleep apnea.

Adherence ranged from 33.3 percent in mild apneics to 50 percent in moderate apneics with an overall average of 40.4 percent adherence. Of drivers started on therapy, nearly 15 percent were lost to follow-up. Approximately 20 percent of drivers with moderate or severe apnea, who were started on therapy, were lost to follow-up. Reasons for this are varied and include dropping out from the study, no longer employed by the participating trucking company, and failed to return for follow-up clinical appointments.

6.2.2 Québec Experience

The following outlines how the protocol procedures for sleep apnea diagnosis and treatment were translated into implementation for Transport Robert in Québec.

6.2.2.1 SLEEP PHYSICIANS

In Québec, the sleep disorders screening and treatment was sub-contracted to Laboratoire Médical Biron, where the Medical Director is Dr. Pierre Mayer, MD, FRCP(C). Dr. Mayer specializes in pulmonary medicine and has extensive expertise in Sleep Disorders Medicine.

The procedures included the planning of an in-home sleep apnea testing recording, the documentation of daytime somnolence (Epworth Sleepiness Scale (ESS), sleep apnea-related quality of life (SAQLI), and Adjusted Neck Circumference (ANC)). In addition, Dr. Pierre Mayer met with all participating drivers in order to review symptoms and signs related to sleep apnea or other sleep disorders. During this interview, he informed the drivers of the risks associated with driving under the influence of fatigue, their responsibilities as patients to comply with the recommended treatment, and he provided an in-person review of good sleep hygiene principles. The Multivariable Apnea Prediction (MAP) was calculated. As part of his regular practice Dr. Mayer sent a satisfaction questionnaire after one month on CPAP in order to evaluate whether CPAP titration adjustments were required. As part of this research project, participating drivers on CPAP were invited for a follow-up appointment to verify compliance after three months on treatment. It was the responsibility of drivers to attend this follow-up session.

Drs. Boivin and Mayer agreed that this component of the experiment was clinical in nature and should thus follow the standard best practices employed by the clinical team. In this context, it was considered important to involve private insurers so that drivers positive for sleep apnea would have access to round-the-clock advice on CPAP adjustment. As determined by the research team, a screening and treatment algorithm guideline was proposed and discussed with the treating physician at the outset of the study. However, the research team in no way imposed on the treating physician the methods for diagnosing and treating sleep disorders. It was thus made clear that the research team would not become involved in the clinical procedures, that maintenance of confidentiality was necessary, and that drivers' booklets identified by confidential participants' numbers would only be transferred to Alpha Logik when this portion of the experiment was completed.

6.2.2.2 HOME DIAGNOSTIC RECORDER

All drivers were tested at home using the Remmers Sleep Recorder, a home diagnostic recorder. The recorder measures oxygen saturation, nasal air flow, snoring sound, and body position.

The recorder data is downloaded to PC-resident software, Insight, which then provides automated identification of respiratory disturbances and calculates the respiratory disturbance index (RDI), i.e., the number of apneas and hypopneas per hour. The Remmers Sleep Recorder system automatically calculated value of RDI correlates highly with the polysomnographically determined apnea-hypopnea index (r=.97). The recorder provides adequate diagnostic accuracy for clinical use (sensitivity and

specificity greater than 95 percent). The in-home study is both more convenient and less expensive then the polysomnogram. In addition, it may provide data which are more relevant to the driver's usual nightly respiratory status during sleep.

6.2.2.3 HOME DIAGNOSTIC PROCEDURES

In Québec, the sleep disorder diagnostic and follow-up procedures started in July 2007 and ended in May 2008. The steps followed in this phase are summarized as follows:

- Laboratoire Médical Biron contacted participating drivers to schedule an in-home sleep disordered breathing test. To facilitate the scheduling of drivers' appointments, the clinical team was put in contact with Transport Robert by the research team. The clinical team was thus able to obtain the drivers' contact information and adjust to their work schedules. Throughout these screening procedures, the clinical team complied at all times with the confidentiality requirements of the project. For instance, the company was never informed by the clinical team of any results on any particular driver.
- Drivers attended their appointment at Laboratoire Médical Biron to receive the recording device (Remmers Sleep Recorder) and instructions on how to use it. If needed, staff from Laboratoire Médical Biron met the drivers at their homes.
- Each driver underwent an in-home diagnostic evaluation for sleep apnea using the Remmers Sleep Recorder (RSR). This step was repeated if the study was inadequate due to technical difficulties.
- During a second visit to the Laboratoire Médical Biron the sleep recording apparatus was returned and the data were downloaded and sent to Dr. Mayer.
- The sleep disorder physician carried out an in-person medical interview with all drivers who completed the in-home diagnostic evaluation.
- During this interview, the physician screened each driver for excessive wake-time sleepiness and other sleep disorders, and informed the driver of the results of the in-home diagnostic evaluation. He also took this opportunity to provide advice regarding good sleep hygiene. Treatment was discussed and prescribed as needed.
- For the drivers who were treated with CPAP, a satisfaction survey on CPAP use was sent one month after the initiation of CPAP treatment.
- For the drivers who were treated with CPAP, a follow-up visit was offered after three months of treatment in order to download CPAP compliance data.
- Drivers who, in the judgment of the physician, had evidence of another sleep disorder or for whom ambulatory monitoring was questionable (e.g., excessive sleepiness but low RDI) were scheduled for a standard polysomnogram at Laboratoire Médical Biron.

Tables 6-8 to 6-13 summarize the results of the clinical evaluations in Québec. In total, 33 drivers underwent the in-home sleep apnea diagnostic testing evaluation and saw the sleep physician to review the results of the in-home diagnostic evaluation and sleep hygiene practices. Six drivers of this group needed additional in-home recordings due to technical difficulties during the prior recordings (four drivers needed two RSR, one driver needed three RSR, one driver needed four RSR). One driver required a polysomnographic evaluation because the results of the RSR did not agree with his symptomatology.

6.2.2.4 DATA ANALYSIS OF DIAGNOSTIC DATA

Data were downloaded by staff from Laboratoire Médical Biron. The Insight software automatically analyzes the data and provides the RDI and fraction of the night below 90 percent, 85 percent, 80 percent, and 75 percent O_2 Sat. A failure occurs when the data is judged to be technically unsatisfactory due to prior defined criteria (e.g., having less than four hours of valid oximeter data). Drivers were re-tested until adequate data were obtained.

6.2.2.5 RESULTS OF CLINICAL EVALUATION

Sleep apnea was identified in Québec drivers as follows in Table 6-13 and fraction of the night reported below 90 percent oxygen saturation as follows in Table 6-14:

Table 6-13 Sleep Apnea (Québec)

Sleep Apnea	N	%
None (RDI < 5)	15	45.5
Mild (RDI 5 – 14.9)	11	33.3
Moderate (RDI 15 – 29.9)	5	15.2
Severe (RDI ≥ 30)	2	6.0
Total	33	100

Table 6-14 Fraction of the night below 90% O_2 Saturation (Québec)

Time Below 90%	N	%
Normal (0 - 2)	27	81.8
Mild (2 - 5)	2	6.1
Moderate (5 - 15)	3	9.1
Severe (> 15)	1	3.0
Total	33	100

Assessment of sleep apnea related quality of life in Québec drivers was reported as follows in Table 6-15:

Table 6-15 Sleep Apnea on Quality of Life (Québec)

SAQLI Value	N	%
Normal (6 - 7)	17	51.5
Mild (5 – 5.9)	10	30.3
Moderate (4 – 4.9)	5	15.2
Severe (< 4)	1	3.0
Total	33	100

Wake time somnolence was reported in Québec drivers as follows in Table 6-16:

Table 6-16 Day-time Somnolence (Québec)

ESS Value	N	%
Asymptomatic (0 - 6)	24	72.7
Moderate (11 - 16)	8	24.3
Severe (17 - 24)	1	3.0
Total	33	100

Predictive values for probability of having sleep apnea in Québec drivers were reported as follows in Tables 6-17 and 6-18.

Table 6-17 Adjusted Neck Circumference

ANC Value	N	%
Low probability (< 43)	12	36.4
Intermediate probability (43 - 48)	18	54.5
High probability (> 48)	3	9.1
Total	33	100

Table 6-18 Multivariate Apnea Predictor (Québec)

MAP Value	N	%
Low probability (< .4)	14	42.4
Intermediate probability (.4 - .7)	12	36.4
High probability (> .7)	7	21.2
Total	33	100

6.2.2.6 TREATMENT AND ADHERENCE

Respironics provided, at no cost, auto-CPAP (RemStar, Respironics Inc.) along with head gear and interfaces to drivers for whom CPAP was prescribed by the treating physician. The free provision of this equipment reduced the insurance company costs involved in repeated ambulatory screening, polysomnographic investigation, and implementation of a complete treatment with round-the-clock follow-up support.

Table 6-19 shows treatment outcomes. The N value includes all drivers who saw a physician. If the driver saw a physician and was subsequently lost to follow-up, the driver is assumed to be non-adherent to the treatment. Other drivers were determined to be adherent based on the data card indicating CPAP use greater than four hours for 70 percent or more of nights. The percent adherent is based on all drivers who saw the physician and were prescribed CPAP, including those lost to follow-up.

Out of the 33 drivers who were tested, a total of 15 drivers were prescribed CPAP. All of these drivers received a CPAP device when they met the physician. Of the 15 drivers who were put on CPAP, four drivers did not attend the follow-up appointment despite numerous attempts made by the clinical team, two drivers abandoned the FMP project but had seen the physician after three months for follow

up, and one driver stopped using the CPAP after one month. In this case, the sleep apnea was judged mild and a one-month CPAP trial had been suggested during the first appointment with the physician. Out of the 33 drivers initially tested, 18 drivers did not require CPAP. Of these 18 drivers not on CPAP, two abandoned the project.

Table 6-19 Treatment and Adherence (Québec)

Sleep Apnea	N	%	No CPAP		CPAP		Adherent[§]		Non-adherent		Lost to follow-up	
			N	%	N	%	N	%	N	%	N	%
None (RDI <5)	15	45.5	15	100	0	0	n/a	n/a	n/a	n/a	0	0
Mild (RDI 5 - 14.9)	11	33.3	3	27.3	8	72.7	4	50.0	3	37.5	1	12.5
Moderate (RDI 15 - 29.9)	5	15.2	0	0	5	100	3	60.0	0	0	2	40.0
Severe (RDI ≥ 30)	2	6.0	0	0	2	100	2	100	0	0	0	0
Total	33	100	18	54.4	15	45.5	9	64.3	3	23.1	3	20.0

[§] adherence: CPAP use >4 hours – 70 percent of nights

6.2.2.7 LESSONS LEARNED

Operational constraints were important in the scheduling of sleep disorders diagnosis and treatment. Despite the treatment provided to the drivers free of charge and the expected benefits for their well-being and health, some drivers found the repetitive visits too cumbersome. Lack of compliance is suspected since some drivers did not show up for their follow up appointment despite numerous invitations to do so from the clinical team. This situation was observed even though all drivers signed an informed consent form in which they recognized their responsibility to comply with treatment recommendations guidelines. This represents a delicate and challenging element of an FMP effort. A balance must be created between encouragement and incentives for diagnosis, treatment, and compliance and cautious use of policies that would discourage drivers from seeking diagnosis and treatment. Careful consideration of legislative and company policies that will facilitate participation rather than discourage it will be critical. Initiatives should be developed in order to underscore the importance of follow-up and to implement objective measures of treatment compliance for the drivers suffering from a significant sleep disorder.

Difficulties were also encountered in getting the financial support of the insurance company necessary to support a comprehensive therapeutic approach with continuing access to advice regarding CPAP use and adjustment. It is important to involve this industry along with the truck driving industry, and governmental representatives in order to secure funds for the adequate screening, diagnosis, and treatment of CMV drivers.

6.2.3 Alberta Experience

The following outlines how the protocol procedures for sleep apnea diagnosis and treatment were translated into implementation for ECL in Alberta. The analysis presented in this section is based upon the 33 drivers that completed the clinical component of the program.

6.2.3.1 SLEEP PHYSICIANS

Each participating driver was evaluated by a sleep physician and received diagnostic testing in the home. Because ECL has two sites, one in Edmonton and one in Calgary, testing and clinical evaluations were arranged separately in each city. In Calgary, testing was done by RANA Respiratory Care Group and drivers were seen in the Southern Alberta Lung Association Sleep Disorder clinic by Dr. Linda Hames. For Edmonton, testing was carried out by Sleep Medix and drivers were seen by Dr. Neil Skjodt at the Sleep Medix office.

ANC, ESS, SAQLI, and MAP were obtained for each driver from questionnaires administered by RANA or Sleep Medix.

6.2.3.2 HOME DIAGNOSTIC RECORDER

All drivers were tested in the home with a portable monitor (Remmers Sleep Recorder, SagaTech Electronics Inc.) which was provided to the driver by RANA or Sleep Medix.

6.2.3.3 HOME DIAGNOSTIC PROCEDURES

RANA or Sleep Medix met with each driver individually to provide them with the recorder for overnight use. Each driver was instructed on application of sensors and initiation of the study. The recorder was returned the following morning and the data were downloaded into a PC. The initial study was technically adequate in all drivers except for three in whom the test was repeated one time to achieve a technically satisfactory study.

6.2.3.4 DATA ANALYSIS

Data were downloaded to a PC by a technician at RANA or at Sleep Medix. The Insight software automatically analyses the data and provides the RDI, fraction of the night below 90 percent, 85 percent, 80 percent, and 75 percent O_2 Sat.

6.2.3.5 RESULTS OF CLINICAL EVALUATION

Sleep apnea was identified in Alberta drivers as follows in Table 6-20 and fraction of the night reported below 90 percent oxygen saturation as follows in Table 6-21.

Table 6-20 Sleep Apnea (Alberta)

Sleep Apnea	N	%
None (RDI < 5)	9	27.3
Mild (RDI 5-14.9)	13	39.4
Moderate (RDI 15-29.9)	10	30.3
Severe (RDI ≥30)	1	3.0
Total	33	100

Table 6-21 Fraction of the Night below 90% O_2 Saturation (Alberta)

Time Below 90%	N	%
Normal (0 - 2)	16	48.5
Mild (2 – 5)	8	24.2
Moderate (5 - 15)	3	9.1
Severe (> 15)	6	18.2
Total	33	100

Assessment of sleep apnea related quality of life in Alberta drivers was reported as follows in Table 6-22:

Table 6-22 Sleep Apnea on Quality of Life (Alberta)

SAQLI Value	N	%
Normal (6 - 7)	6	18.2
Mild (5 – 5.9)	10	30.3
Moderate (4 – 4.9)	5	15.1
Severe (< 4)	12	36.4
Total	33	100

Day-time somnolence was reported in Alberta drivers as follows in Table 6-23:

Table 6-23 Day-time Somnolence (Alberta)

ESS Value	N	%
Asymptomatic (0 - 6)	23	69.7
Moderate (11 - 16)	7	21.2
Severe (17 - 24)	3	9.1
Total	33	100

Predictive values for probability of having sleep apnea in Alberta drivers were reported as follows in Tables 6-24 and 6-25:

Table 6-24 Adjusted Neck Circumference (Alberta)

ANC Value	N	%
Low probability (< 43)	9	32.2
Intermediate probability (43 - 48)	13	46.4
High probability (> 48)	6	21.4
Total	28	100

Table 6-25 Multivariate Apnea Predictor (Alberta)

MAP Value	N	%
Low probability (< .4)	5	18.5
Intermediate probability (.4 - .7)	17	63.0
High probability (> .7)	5	18.5
Total	27	100

In Alberta, 72.7 percent of drivers who volunteered for the study had sleep apnea and most (69.7 percent) were mild-to-moderately severe. Nearly 68 percent of drivers had a predicted probability by ANC of intermediate or greater. Similarly, MAP reported that a predicted probability of intermediate or greater was present in 81.5 percent of drivers. Most drivers (69.7 percent) did not report excessive daytime sleepiness by the ESS but nearly 82 percent reported impairment in quality of life related to sleep apnea. Oxyhemaglobin desaturation was reduced in over half of the drivers with 24.4 percent being mild, 9.1 percent being moderate, and 18.2 percent being severe.

6.2.3.6 TREATMENT

Respironics provided, at no cost, auto-CPAP (RemStar, Respironics Inc.) along with head gear and interfaces to drivers for whom CPAP was prescribed. Overall, 13 drivers in Alberta received nasal CPAP, four drivers had mild sleep apnea, eight had moderate sleep apnea, and one had severe sleep apnea. None received oral device therapy.

Table 6-26 shows treatment and adherence outcomes.

Table 6-26 Treatment and Adherence (Alberta)

			No CPAP		CPAP		Adherent[§]		Non-adherent		Lost to follow-up	
Sleep Apnea	N	%	N	%	N	%	N	%	N	%	N	%
None (RDI <5)	9	27.3	9	100	0	0	n/a	n/a	n/a	n/a	0	0
Mild (RDI 5 - 14.9)	13	39.4	9	69.2	4	30.8	3	75.0	1	25.0	0	0
Moderate (RDI 15 - 29.9)	10	30.3	2	20.0	8	80.0	6	75.0	1	12.5	1	12.5
Severe (RDI ≥30)	1	3.0	0	0	1	100	0	0	0	0	1	100
Total	33	100	20	60.6	13	39.4	9	69.2	2	15.4	2	15.4

[§] adherence: CPAP use >4 hours – 70 percent of nights

The overall adherence rate was 69.2 percent and two drivers were lost to follow-up. No complications occurred with one major exception, namely: the Edmonton physician violated the confidentiality agreement by contacting ECL in Edmonton to discuss discontinuing driving for one of the drivers while CPAP was initiated. Drivers indicated their concern regarding the repercussions of disclosure of their medical status to their employer. In particular, they were concerned about losing their jobs or having their driving limited. Subsequent to the initiation of this project in 2005, a consensus report of a task force convened by the American College of Chest Physicians, the American College of Occupational and Environmental Medicine, and the National Sleep Foundation recommended that a one to two week interval of no driving after initiation of CPAP therapy might be reasonable (Hartenbaum et al. 2006). Sponsors of the FMP

contract compensated both the company and the driver for losses due to limitation of driving during CPAP initiation.

6.2.3.7 LESSONS LEARNED

It became apparent that the availability of free diagnostic testing and treatment was important for driver participation in the study. The use of the Remmers Sleep Recorder in the clinical aspect of a fatigue management program seems convenient and feasible. Confidentiality of clinical data and therapeutic outcomes seems to be a critical issue for drivers, and loss of employment during initiation of therapy is a concern. No difficulties were encountered in initiation of auto-CPAP in drivers for whom this therapy was prescribed. The overall adherence rate was satisfactory compared to published data but a 30 percent non-adherence rate represents a concern. As well, two drivers being lost to follow-up is a concern.

6.2.4 California Experience

The following outlines how the protocol procedures for sleep apnea diagnosis and treatment were translated into implementation for J.B. Hunt in California.

6.2.4.1 SLEEP PHYSICIANS

Given the geographic distribution of J.B. Hunt drivers in Northern and Southern California, two Board Certified sleep physicians were engaged to meet with drivers and provide diagnosis and treatment; one physician was located in Northern California and the other in Southern California. Dr. Kin Yuen, affiliated with the Bay Sleep Clinic, performed diagnostic and treatment activities in Northern California (centred around the San Francisco Bay Area) and Dr. Del Henninger, Complete Sleep Solutions, performed the same activities in Southern California (Greater Orange County Area).

Based on a driver's geographic location, Advanced Brain Monitoring (ABM) sent the confidential ARES Unicorder data and preliminary review findings from Dr. Westbrook to the appropriately located sleep physician. After seeing each driver, Dr. Yuen and Dr. Henninger made the final diagnosis and placed drivers into their final diagnostic category and initiated treatment if indicated. Drivers without symptoms were contacted with results by phone and received a follow-up letter emphasizing the use of good sleep hygiene. Drivers with symptoms were seen by the physician for treatment initiation. These subsequent sleep physician actions were based on the sleep apnea categories previously identified in the experimental protocol and given to the treating physicians at the start of the study (see Section 4.2).

To maintain confidentiality, the sleep physicians (and their staffs) contacted drivers directly to schedule in-person visits as indicated by diagnostic category and treatments needs. This included follow-up visits planned for one month after treatment initiation, as deemed necessary by the clinician.

6.2.4.2 HOME DIAGNOSTIC RECORDER

The Apnea Risk Evaluation System (ARES) Unicorder is a portable, validated, FDA cleared, wireless physiological recorder that can determine the presence and severity of obstructive sleep apnea. It was developed and is manufactured and implemented in clinical and research activities by Advanced Brain Monitoring (ABM), Inc., a Carlsbad, California company.

The ARES Unicorder can be worn at home, on the forehead and can store up to four nights of nocturnal data. It measures: "blood oxygen saturation (SpO2), pulse rate (reflectance pulse oximetry), airflow (by nasal cannula connected to a pressure transducer), respiratory effort (a combined signal using pressure transducer sensing forehead venous pressure, venous volume by photoplethysmography, and actigraphy), snoring levels (calibrated acoustic microphone), head movement and head position (accelerometers)" (ABM description). Based on these measures, ARES software analysis can determine the presence and severity of obstructive sleep apnea.

6.2.4.3 Home Diagnostic Procedures

The specific procedures to implement the ARES Unicorder were established and coordinated directly with Dan Levendowski, President and Co-Founder, ABM. Alertness Solutions contacted each driver participant by phone to explain the in-home sleep apnea diagnostic procedures and obtain shipping information for sending materials and equipment to each driver. This information was faxed to ABM, who sent materials and equipment to each driver participant.

The materials and equipment sent to each driver included the following:

1. ESS, SAQLI, and MAP questionnaires
2. ABM questionnaires: History and Physical (H&P) – demographic, medical conditions, snoring, choking/gasping, stop breathing (last 3 used for adjusted neck circumference [ANC]) – other subjective questions relating to sleep problems]
3. ARES Unicorder

Drivers completed questionnaires and wore the ARES Unicorder for one full night and then returned all materials and equipment to ABM through a prepaid shipping mechanism. Alertness Solutions followed up over the phone with any issues related to the late return of equipment, incomplete questionnaires, etc.

6.2.4.4 Data Analysis of Diagnostic Data

The ARES Unicorder data were downloaded and technically analyzed by ABM. Dr. Phil Westbrook (ABM Chief Medical Officer; Board Certified in Sleep Medicine) conducted a preliminary review of each driver's data to ensure valid and appropriate outcomes from the device and technical analysis. Driver clinical information was derived from the H&P for ANC, snoring, gasping/choking, apneas, and hypertension. The ARES Unicorder data and presence of sleep apnea symptoms allowed Dr. Westbrook to determine that drivers could be categorized according to the previously identified FMP Project criteria, although he did not provide a diagnosis or place drivers into these categories. This was done after full evaluation by Drs. Yuen and Henninger.

Alertness Solutions scored the ESS, SAQLI, and MAP questionnaires and forwarded the results to HFN for incorporation into the Project database and subsequent analysis.

6.2.4.5 Overall Results

Twenty-eight driver participants completed the in-home ARES diagnostic recordings. Initial office visits with the sleep physicians occurred from January to March 2008. One-

month follow-up visits were scheduled as needed based on diagnosis and treatment requirements, driver schedules, and geographic distribution. The results of the sleep apnea diagnostic evaluations are summarized in Table 6-27.

6.2.4.6 RESULTS OF CLINICAL EVALUATION

Sleep apnea was identified in California drivers as follows in Table 6-27 and fraction of the night reported below 90 percent oxygen saturation as follows in Table 6-28.

Table 6-27 Sleep Apnea (California)

Sleep Apnea	N	%
None (RDI < 5)	3	10.7
Mild (RDI 5 – 14.9)	13	46.4
Moderate (RDI 15 – 29.9)	7	25.0
Severe (RDI ≥ 30)	5	17.9
Total	28	100

Table 6-28 Fraction of the Night below 90% O_2 Saturation (California)

Time Below 90%	N	%
Normal (0 - 2)	20	71.4
Mild (2 - 5)	6	21.4
Moderate (5 - 15)	1	3.6
Severe (> 15)	1	3.6
Total	28	100

Assessment of sleep apnea related quality of life in California drivers was reported as follows in Table 6-29:

Table 6-29 Sleep Apnea on Quality of Life (California)

SAQLI Value	N	%
Normal (6 - 7)	16	57.2
Mild (5 – 5.9)	8	28.6
Moderate (4 – 4.9)	2	7.1
Severe (< 4)	2	7.1
Total	28	100

Day-time somnolence was reported in California drivers as follows in Table 6-30:

Table 6-30 Day-time Somnolence (California)

ESS Value	N	%
Asymptomatic (0 - 6)	23	85.2
Moderate (11 - 16)	3	11.1
Severe (17 - 24)	1	3.7
Total	27	100

Predictive values for probability of having sleep apnea in California drivers were reported as follows in Tables 6-31 and 6-32:

Table 6-31 Adjusted Neck Circumference (California)

ANC Value	N	%
Low probability (< 43)	6	21.4
Intermediate probability (43 - 48)	12	42.9
High probability (> 48)	10	35.7
Total	28	100

Table 6-32 Multivariate Apnea Predictor (California)

MAP Value	N	%
Low probability (< .4)	11	42.3
Intermediate probability (.4 - .7)	9	34.6
High probability (> .7)	6	23.1
Total	26	100

6.2.4.7 TREATMENT AND ADHERENCE

Overall, 19 drivers were treated with CPAP. One driver with moderate sleep apnea refused CPAP treatment and was referred to a personal healthcare professional, who treated him with an oral appliance and behavioural intervention. One was put on CPAP but never used it. One had mild symptoms and no further treatment was recommended. One was initially treated with CPAP and subsequently recommended for a PSG. Based on PSG results the CPAP was continued, although the driver provided poor compliance data. Two drivers with no sleep apnea and no symptoms received letters and were provided sleep hygiene information. The third driver with no sleep apnea but with symptoms (i.e., moderate ESS) was further evaluated with full polysomnography and based on the results no further treatment was recommended. This driver also received a letter and was provided sleep hygiene information. Two drivers dropped from the project before their initial office visit with the sleep physician, although both received a letter with relevant diagnostic and treatment information. These two drivers, one with moderate and one with severe sleep apnea, are not included in the following table. Two drivers dropped from the project after the initial sleep physician visit. The results of the sleep apnea treatment are summarized in Table 6-33.

Table 6-33 Treatment and Adherence (California)

Sleep Apnea	N	%	No CPAP		CPAP		Adherent[§]		Non-adherent		Lost to follow-up[£]	
			N	%	N	%	N	%	N	%	N	%
None (RDI <5)	3	11.5	2	66.7	1	33.3	0	0	1	100	0	0
Mild (RDI 5 - 14.9)	13	50.0	4	30.8	9	69.2	0	0	9	100	0	0
Moderate (RDI 15 - 29.9)	6	23.1	1[‡]	16.7	5	83.3	0	0	4	90.0	1	16.6
Severe (RDI ≥30)	4	15.4	0	0	4	100	1	25.0	2	50.0	1	25.0
Total	26[†]	100	7	26.9	19	73.1	1	5.3	16	84.2	2	7.7

[§] adherence: CPAP use >4 hours / 70 percent of nights
[‡] one driver prescribed oral appliance therapy
[†] two drivers, one moderate and one severe, had no doctor visit and are not included in the table
[£] saw physician but dropped out of the study

6.2.4.8 LESSONS LEARNED

It became obvious that a critical element that encouraged participation and follow-through on the part of the driver participants was that the diagnostic and treatment aspects of the project were conducted in a confidential manner with sleep physicians that were external to the company and the other project activities. A concern voiced frequently by driver participants was that they did not want the company to be informed about a private medical matter, whether they had sleep apnea or not. A major incentive for participation was the opportunity for drivers to have a diagnostic evaluation and treatment (if necessary) for sleep apnea at no cost. Drivers frequently identified the financial benefit of the sleep apnea evaluation and treatment as a significant consideration for volunteering and continuing in the project activities.

The Northern California group included three drivers in Category 3 that required further evaluation with full polysomnography. All of these drivers belonged to the Kaiser healthcare system that has only one Northern California accredited sleep disorders clinic. It was determined that a referral to this Kaiser sleep disorders clinic for the full polysomnographic evaluation would have involved a minimum of several months before the drivers could be scheduled. It also would have involved referral outside the designated project sleep physicians and the potential for inconsistent diagnosis and treatment in relation to the other driver participants. The project sponsors provided supplemental financial support that allowed these three drivers to be referred to the Bay Sleep Clinic, where the diagnostic evaluations were completed within about two weeks. Dr. Yuen's affiliation with the Bay Sleep Clinic provided continuity of care for the drivers and a consistent diagnostic and treatment approach by the participating sleep physician.

Several clear challenges emerged that required flexible solutions to address them successfully. For example, driver schedules and geographic distribution made multiple office visits prohibitive for some drivers. Some basically refused to see the sleep physician more than once due to long drives (e.g., over two hours in each direction) and others requested fuel reimbursements given the high price of gas. Therefore, follow-up visits, CPAP issues, etc. had to be managed within the constraints of driver availability to be seen in the office. Drivers that dropped from the project, either before or after seeing the sleep physician required extra effort to ensure that diagnostic and treatment recommendations were provided. Finally, drivers' schedules created

significant challenges in communication and logistics to complete the sleep apnea diagnostic and treatment component in a timely manner and at the expected level of quality care. This was perhaps most evident in the CPAP compliance data. Although the sleep physicians followed their usual standard of care initiating CPAP treatment, the compliance was clearly affected by a range of driver challenges. Refusal of follow-up visits, inconsistent return of phone contact, and unwillingness to send compliance "smart cards" were related to geographic distances, schedules, and perceived obstacles.

6.3 Dispatcher Interactions

A critical component of the consultative process is the work done to assist dispatchers in their efforts to implement changes in the scheduling process. Dispatchers can make a significant difference in reducing fatigue among drivers. The focus in the consulting process was to provide dispatchers with relevant guidance that could actively support the reduction of driver fatigue and maintain an efficient, effective service that meets customer needs. In that regard, the consultants reviewed the company's existing scheduling policies and practices with the dispatchers in order to assess their inherent fatigue-related risk. During interactions with dispatchers, obstacles to and solutions for effective FMP implementation were discussed.

6.3.1 Québec Site

6.3.1.1 INTERVIEWS

As part of the FMP, a meeting was held at Transport Robert on January 14, 2008 with the Ontario Operations Director to clarify the work of dispatchers. At Transport Robert, dispatchers manage a group of drivers travelling on specific routes. Dispatchers work to manage the drivers' schedules, equipment and order trips to meet the clients' needs. Certain clients are open 24 hours a day so that cargo can be delivered any time, while others are more rigid on delivery times. Failing to meet a deadline can be very costly since fines can amount to more than the trip itself. Benefits are also rather slim for certain routes. Thus, dispatchers attempt to maximize the company's benefits in their work operation. Customer services at Transport Robert usually accept every order placed by their usual client and redirect these orders directly to the dispatchers. The time between the first customer's call and the delivery time can be counted in hours. Due to these practices, dispatchers are constantly under pressure to ensure quality and on-time delivery. They often use partner carriers to satisfy the clients' demands, thus acting as a broker. However, this practice is not used when their own truck drivers are available.

An interactive focus group was held at Transport Robert on January 21, 2008 with the 22 dispatchers responsible for scheduling the FMP participating drivers. The aim of this meeting was to identify dispatchers' scheduling practices, tools to reduce driver fatigue and possible obstacles. We discussed best practices and the measures they took to implement the education received during the FMP in their scheduling practices. Here is a summary of the discussion.

Different factors are taken into account when scheduling drivers. Overall, dispatchers primarily rely on Hours of Service (HOS) regulations. According to the Québec HOS regulations, during a 24-hour duty day, at least eight consecutive hours must be allocated to rest time, following which a maximum of 16 hours can elapse between the

end and start of duty days. However, hours of work are restricted to 14 hours during this 16-hour duty period. These rules require the driver to rest at least 10 hours during any given day; eight hours should be consecutive and two hours should be taken during the 16-hour duty period. Driving time is restricted to 13 hours during the duty period. Also, a 24-hour rest period must be scheduled at least every 14 days.

Another factor taken into account when scheduling drivers is the collective bargaining agreement. It gives the more experienced drivers their choice of trips for the first trip of their week. For any other trip, the "first in, first out" rule applies. Dispatchers also take into account the schedule selected by each driver as their assigned one. Indeed, every year, drivers can ask to be assigned to a different schedule (e.g., starting time). Local drivers are different than interprovincial drivers because the former sleep at home while the latter sleep in their sleeper berths when driving long distances. Longer and more demanding trips are usually given at the beginning of the week, when the drivers are more rested. The driver is responsible for managing his schedule from the departure time until the arrival time, although the arrival time needs to be respected and is given by the dispatcher. The dispatcher will do his best to avoid imposing overtime hours on the driver. Many clients require a rigid delivery time that is subject to severe financial penalties if not respected, while others are more flexible. According to their agreed delivery time, drivers are responsible for giving an estimated time of arrival (ETA) and have to revise it as soon as possible if they know they will not make the delivery on time. Thus, knowing the client is another factor that influences scheduling.

Customs switchovers are also considered in scheduling. The waiting time at the borders was considerably reduced by a new system that sends cargo, equipment and driver information to the customs agency before the driver's arrival at the border. Another important aspect influencing scheduling is the relationship between dispatchers and their assigned drivers. Dispatchers come to know how each of their drivers behaves and how he/she reacts to fatigue. They can thus greatly improve drivers' work scheduling by considering their cumulative fatigue and opportunity to rest and recover. Given the impact dispatchers have on driver schedules, their fatigue management education is essential.

Scientific resources used for scheduling are limited. On this issue, dispatchers explained that they rely on HOS regulations and drivers' physical and mental conditions according to their judgment while scheduling their trips. There was no specific scientific resource cited during the discussion to help scheduling.

The primary tool used by the dispatchers to schedule truck drivers is two software programs, the interfaces of which are displayed on two separate screens. One is named TRIP and is used to view the incoming and in-process trips. The other is named GUI and is used to manage individual driver schedules. Each piece of software communicates with the other to keep track of drivers' duty and driving time. Hours of services regulation and collective bargaining agreements are also tools used to schedule drivers as explained above.

When asked to describe the best practices in their department, dispatchers replied that they primarily rely on the efficiency of their scheduling tools and on teamwork to meet these objectives. Each dispatcher manages a specific territory with the drivers assigned to that territory. Team work is part of their daily work as a means to plan ahead (two meetings a day in some departments, e.g., Ontario and Québec) and to

resolve ordering issues by “sharing” human resources (drivers). Interaction with the sales department is also required to maintain good relationships with the clients and to try to get as much flexibility as possible. Some of the dispatchers were more willing to share resources while others tried to maximize their own resources. According to the dispatchers, knowing the driver helps in their scheduling tasks.

Difficulties can arise from unexpected events such as those related to customer service, road conditions, and weather conditions. When asked about the way they resolve these situations, dispatchers thought of three different options. First, they can share drivers among themselves. They can also give a trip to a partner company. This option is used only if their drivers are not available. Finally, if manpower is still not sufficient to overcome these problems they will check the availability of the office workers in the company who also possess a truck driving licence and have them drive, although this is an extreme situation.

Dispatchers’ attitudes regarding the FMP and their role on drivers’ fatigue varied. Some dispatchers are quite sensitive to the issue of drivers’ fatigue. They consider it is important to communicate with the drivers to get a sense of their fatigue levels and attempt to accommodate them as much as possible. Some dispatchers found that imposing a departure time on their drivers would help them build some margin that would allow them the opportunity to better manage their fatigue on the road. Other dispatchers were quite rigid and argued that fatigue management is mostly the drivers’ responsibility instead of theirs. We generally observed a positive opinion towards good FMP practices within the group of dispatchers.

6.3.1.2 ALERTNESS MANAGEMENT SAFETY EVALUATIONS (AMSE)

In Québec, 5 managers completed the pre-FMP and post-FMP AMSE questionnaire, respectively in January 2007 and in February 2009. In addition, seven dispatchers completed the AMSEs pre-FMP only and their responses are not reported here. Managers’ responses to the post-FMP AMSE were compared to their pre-FMP AMSE to determine if the implementation of FMP activities had affected the company’s practices, policies, and procedures with respect to fatigue management.

Overall, managers reported improvement post-FMP compared to pre-FMP with 24.3 percent more positive answers in the AMSE questionnaire. Responses regarding education and existence of written policies for fatigue management were the most increased post-FMP (+46 percent). Alertness strategies evaluation was generally positive. However, questions about processes for evaluating the scientific validity and effectiveness of the program decreased post-FMP (-22.5 percent).

Generally, responses regarding scheduling were increased which could be an indicator of better sleep management practices at the dispatchers level. With respect to healthy sleep, more managers reported post-FMP that the company does offer information to personnel about sleep disorders. At the organizational level, more managers reported post-FMP that the company offers alertness management strategies. However, no improvement was reported on the AMSE questions on whether these activities were offered to everyone in the company.

6.3.2 Alberta Site

6.3.2.1 INTERVIEWS

Dispatcher interviews were conducted at both Alberta sites in February 2008. The interviews followed structured interview questions and were used to get an understanding of the company's scheduling practices. In Edmonton, the dispatcher interaction occurred after the dispatcher educational session. In Calgary, the time allocated to a failed training session (where no trainees showed up) was modified to interact with the dispatchers, the dispatch supervisor, and the driver development supervisor.

Dispatchers work twelve-hour shifts. At the time of this interaction there were eight Calgary dispatchers, six working day shifts (06:30 to 18:30) and two working night shifts (18:30 to 06:30). Highway dispatchers work four days on followed by four days off. City dispatchers work five days on followed by five days off. In Edmonton there were 10 dispatchers and one order taker. The freight division has one dispatcher that works five, nine-hour days. The propane division has two dispatchers that work four, twelve-hour days followed by four days off then five, twelve-hour days followed by five days off. The four fuel dispatchers work seven, twelve hour days followed by seven days off. There are two graveyard dispatchers that work seven, twelve hour nights followed by seven nights off. The tenth dispatcher's schedule varies as he is a relief dispatcher for holidays and illnesses.

Hours of Service (HOS) was identified as the basis for the company's scheduling practices. The second method identified was consulting with the driver development supervisor to understand the individual driver's particular needs. The dispatchers and driver supervisors are often former drivers themselves and therefore have first hand knowledge of the difficulties involved with the driver lifestyle and schedule. At ECL the driver, the driver supervisor, and the dispatchers work together to make a schedule that "works best" for all involved. Things like preferences to time of day or days of the week, family life, and other jobs are taken into account. ECL also believes in cross-training drivers and dispatchers by having dispatchers go on ride-a-longs and by having drivers work in dispatch while they are on modified duty. Customer needs and equipment availability also dictates scheduling practices

No one involved in the interaction could identify any scientific resources that were used to create the company's scheduling practices. Basically, the dispatchers use what has worked in the past. There is no formal training for this position but these dispatchers believe that most important tool is the verbal passing on of information from managers to dispatchers and driver supervisors to drivers. Training involves one-to-two weeks of sitting at the different desks and observing the process. The essential dispatcher skills identified involve the ability for problem solving by determining the root cause and to be able to say "No" with a reason.

Informal methods for implementing scheduling practices involve consulting the driver supervisor. Most interviewees responded that there were no formal procedures. One dispatcher was able to point to more formal procedures which are documented in the Dispatch Procedures Manual (effective date June 2005 Revision 1.0). This manual included Sections 7.6 Dispatching with subsections entitled: dispatching priorities, dispatching ECL resources, dispatching load assignment, dispatching Bill of Lading

and driver instructions, and dispatching split deliveries. Also, Section 7.7: Delivery Exceptions – delays, diversions, was found in the manual (see Appendix L).

One dispatcher explained that using memory and experience was the top scheduling practice that works well for his department. Another dispatcher identified satellite tracking and after-hours dispatch personnel as essential. Also mentioned was the importance of working with all the people involved, knowing what equipment issues exist or are surfacing, HOS, and "way down the list" would be the customer's needs. This was explained as working with the customer to help him prioritize. The following example was described: the customer wants 30 loads; the dispatcher knows that they only have the ability for 20 loads; the dispatcher works with the customer to determine which 20 loads get done.

Many scheduling challenges were identified. The limited number of available drivers was one that made most dispatchers' top of this list. This was followed by trying to balance the schedules to cover weekends, holidays, and drivers on modified duty. The summer season is particularly busy and often conflicts with the driver's family schedule. The loading facilities at the refineries were identified as a challenge. Routinely there are long line ups and there is very little communication to alert dispatchers or drivers that there may only be one rack available for use. Volumes and peak periods are taken into account as they can greatly affect wait times. Propane on the other hand can often be delivered regardless of the time or day which allows for greater flexibility.

Although management involvement was identified as a challenge it was also identified as a remedy to address the scheduling challenges. By working together, and by trial-and-error, drivers with similar habits can be lined up together (i.e., use the same truck at different times of the day). Other answers included "nothing has been considered to address scheduling challenges" and that the FMP will help address some of these challenges.

6.3.2.2 ALERTNESS MANAGEMENT SAFETY EVALUATIONS (AMSE)

AMSEs were completed by several managers, dispatchers, and supervisors during the pre- and post-FMP data collection. Both pre- and post-AMSEs have twenty yes/no questions. The post-AMSE has an additional seven questions. The results were pooled with five individuals completing the pre-AMSEs and four individuals completing the post-AMSEs.

Overall, this group reported more positive results post-FMP regarding the company's alertness management strategies. Questions that started with a high rate (>75 percent) of positive (i.e., yes) response remained relatively unchanged. Those that started with a low "yes" percent (<60 percent) increased post-FMP with the exception of the question regarding the availability of rest facilities other than a sleeper berth which all responders answered "no" pre- and post-FMP.

Five questions were unanimously (100 percent) reported positively post-FMP: 1) Is there a method to assess the effectiveness of training activities (pre-FMP 20 percent)? 2) Are there explicit written policies regarding on-duty rest opportunities (pre-FMP 20 percent)? 3) Is information offered to drivers and other personnel about sleep disorders, how to recognize sleep disorders, and how to get help if they suspect they

have a sleep disorder (pre-FMP 60 percent)? 4) Is management involved in alertness management activities and policy development (pre-FMP 60 percent)? and 5) Are alertness management activities integrated into the regular practices of the organization, such as safety programs, recurrent training, and standard procedures (pre-FMP 60 percent)? The most significantly changed question (Does your organization have an integrated alertness management program that includes education, alertness strategies, scheduling, and healthy sleep?) went from 0 pre-FMP to 75 percent post-FMP.

No in-truck fatigue management technologies (e.g., lane tracker, on-line drowsiness device, etc.) were reported to be used by ECL. One responder reported using the equipment in this program (i.e., PDA. actigraph, and home sleep recorders). Statements regarding the most effective aspects of the FMP included: receiving training on what fatigue is and how to recognize it, having drivers undergo sleep apnea testing, and the awareness regarding fatigue that the program brought to the company. Other comments outlined the difficulties with maintaining momentum with the program and that testimonials from participants should be communicated throughout the company.

The group rated how the FMP elements affected the company from 1 (extremely negative) to 9 (extremely positive). Diagnosis and treatment of sleep apnea was judged to have the most positive effect. Table 6-34 presents the average and range of ratings (n=4).

Table 6-34 Average and Range of Ratings

FMP Element	Mean	Range
Educational activities	6.75	6 – 8
Scheduling/dispatch guidance	5.75	4 – 7
Diagnosis and treatment of sleep apnea	7.5	7 – 8
Evaluation of corporate and field data	6.25	5 – 7

6.3.3 California Site

6.3.3.1 INTERVIEWS

Dispatcher interviews were conducted over the phone in April and May 2007. The dispatchers included some fleet managers and a regional fleet manager; all had their primary base in Lowell, Arkansas. During the interview, the dispatchers responded to structured interview questions to discuss the company's scheduling practices and fatigue management activities.

All dispatchers identified the Hours of Service (HOS) regulations as the principal basis for the company scheduling practices. Customer pick-up and delivery requirements are entered into a computer system program, which then recommends specific drivers for the loads based in a particular service area. These recommended schedules are then transferred to regional managers, who oversee the pick-up and delivery times and assign the loads based on drivers' eligibility and availability. Once assigned, the driver may opt to accept or deny the load. In standard practice, a driver will perform a load if

there is enough time, and the company attempts to maximize all opportunities for the driver to fill hours without exceeding driver workload and HOS. Drivers who want to exchange schedules with other drivers must consult with the account representatives or fleet managers. In some instances where a driver cannot make a pick-up, especially if the pick-up time is outside of the HOS, an outside carrier will be used instead.

No specific scientific resources were identified as influencing or being incorporated into the scheduling process. However, one dispatcher indicated in an AMSE interview that drivers who operate during the day are assigned different hours compared to ones who operate at night, in an apparent effort to reduce night time driving when possible. The dispatcher did not specify this difference as longer or shorter hours, although it was suggested that this was intended to acknowledge circadian influences but it was not an explicit policy or practice based on scientific resources. A brief review of participant drivers' schedules pre- and post-FMP did not show a notable difference in the average hours driven during day as compared to at night.

The dispatchers indicated that there is no explicit written procedure for implementing exceptions to scheduling policies. However, with safety as a priority, the company supports drivers who call in fatigued. Based on circumstances, a variety of actions might be taken to address the situation (e.g., more time off, change pick-up or delivery times).

When discussing scheduling practices that work well, the dispatchers specifically identified the drivers' availability in terms of hours, location, and load as at the top of their list. One dispatcher mentioned that drivers have "open windows" of time in their schedules, and referred to having success by implementing a "first come, first served" approach (i.e., "first in, first out"). Another positive scheduling practice involves giving drivers sufficient off-duty time so they are usually at home each night. Another dispatcher identified a strategy of matching drivers with loads based on their preferred type of product, type of delivery, delivery location, and/or customer.

The top scheduling challenges discussed by the dispatchers in regards to avoiding fatigue related primarily to night driving. One dispatcher noted that the computer system sometimes books a load outside of the legal HOS, which can become problematic if the schedulers do not catch the error. To address the issue of fatigue, the company does not schedule drivers beyond the HOS and accommodates any driver who judges him or herself as unable to perform a load. If necessary, drivers may reset their scheduled pick-up and/or delivery times in order to complete the loads. One dispatcher refuses to schedule pick-ups between the hours of 1800 and 0800 in order to avoid driver fatigue by minimizing nighttime driving. Any driver who operates beyond the HOS limit "is flagged on a report." Another dispatcher commented that the company should provide fatigue education training at the regional or local account level included with other types of training to further inform the dispatchers/customers about driver fatigue issues.

The dispatchers also discussed other operational challenges they have experienced in managing schedules designed to address fatigue issues. Some have noted the difficulties in balancing the needs of the customers (who are not necessarily concerned with drivers' safety) with keeping the schedules within the HOS limits. One dispatcher remarked that he is not familiar with how to effectively measure fatigue in drivers, especially since the drivers may have very little daily interaction with managers.

Therefore, the company may not be able to adequately convey the risks of driving while fatigued to their customers. It was one dispatcher's opinion that some of the fleet managers create challenges because they are not sufficiently familiar with either the scheduling system or the HOS regulations. The dispatcher stated that some fleet managers came into their position without previous experience in "fatigue-friendly scheduling" of truck routes, so their schedules may not consider the best welfare of the driver.

Although driver fatigue continues to cause complications in scheduling, all dispatchers recognized the company's support in maintaining driver safety and addressing fatigue management issues.

6.3.3.2 ALERTNESS MANAGEMENT SAFETY EVALUATIONS (AMSE)

The same dispatchers who were interviewed also completed pre-FMP AMSEs in May 2007 and post-FMP AMSEs in November 2008. The individuals' responses to the post-FMP AMSE were compared to their pre-FMP AMSE to determine if they reported whether the implementation of FMP activities had affected the company's practices, policies, and procedures with respect to fatigue management.

Overall, the dispatchers reported positive post-FMP improvements in the following areas: 1) that drivers, schedulers, managers, and dispatchers are provided fatigue training, 2) that a scientifically valid mechanism was used to evaluate the training information, 3) drivers and other personnel are trained on alertness strategies, 4) there are clear written policies regarding both the use of these strategies and on-duty rest opportunities, and 5) the existence of rest facilities in the workplace. There was no reported change regarding the scientific validity, effectiveness, and safety of alertness strategies.

Generally, responses regarding Scheduling were unchanged. However, there was a decrease in the number of respondents who believed there was an explicit written procedure for exceptions to scheduling policies.

In terms of Healthy Sleep, more dispatchers reported post-FMP that the company does offer information to personnel about sleep disorders.

At the Organizational level, more dispatchers reported post-FMP that the company uses an integrated alertness management program, with regular, ongoing activities and direct involvement by management.

In the questions unique to the post-FMP AMSE, all dispatchers responded that the company does not use fatigue management technologies as part of an overall FMP. Three individuals acknowledged fatigue education training as the most effective aspect of the FMP because it raises awareness of fatigue and "allows (drivers) to manage their fatigue better." None of the respondents listed a least effective aspect of the FMP or a suggestion for changing the program.

Dispatchers provided ratings of how aspects of the FMP affected the company with responses ranging from 5 ("No effect") to 9 ("Extremely positive"). There was an average rating of 7.4 for the Educational Activities (n = 5), 7 for Scheduling/Dispatch Guidance (n = 5), 7.4 for Diagnosis and Treatment of Sleep Apnea (n = 5), and 7.25 for

Evaluation of Corporate and Field Data (n = 4). When rating how the FMP affected individual dispatchers, ratings fell within the same range but with slightly lower averages. These were 6.4 for Educational Activities (n = 5), 6.8 for Scheduling/Dispatch Guidance (n = 5), 7.4 for Diagnosis and Treatment of Sleep Apnea (n = 5), and 6 for Evaluation of Corporate and Field Data (n = 4).

One dispatcher provided the following comment at the end of the AMSE: information on fatigue in managing workloads is useful, but that they can communicate better with the customers by using HOS because it is “quantifiable”.

7 RESULTS

Results for the following classes of variables are reported below:

1. Overall study period
2. Duty days
3. Work demands
4. Factors contributing to fatigue
5. Sleep
6. Naps
7. Subjective mood ratings
8. Critical events
9. Psychomotor vigilance task
10. Driver education program quizzes
11. Driver reason for participation
12. Corporate Measures

Individual site results are shown in Appendix M. Only descriptive statistics are provided since the sample sizes are too small to do between-site comparisons. This limitation was known from the outset of the study and is inherent in the study design.

Continuous data were analyzed using repeated-measures analysis of variance (ANOVA), to analyze the effect of study phase (pre vs. post-FMP), and depending on the variable, type of day (work vs. rest days), or time of day (start vs. end of day). For each variable, drivers were divided into subgroups based on their RDI score, their level of CPAP Adherence, or their ESS Score. RDI score is an objective indicator of sleep apnea severity. Categories were: No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15). There is likely a difference in performance and sleep between those with moderate and those with severe sleep apnea. However, our sample of drivers with severe sleep apnea (n=7) was too small to consider separately, and thus the data for drivers with severe and moderate sleep apnea were combined. CPAP Adherence is an objective measure of driver use of CPAP equipment.. Subgroups were: No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time) ESS is a measure of subjective sleepiness which is not well-correlated with RDI. ESS score subgroups were: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24). Thus, three ANOVAs were carried out for each variable.

Discrete data (e.g., frequency counts of drivers having a close call or not) were analyzed using McNemar's test of proportions. Linear regression was also used to determine the effect of RDI raw scores and ESS raw scores on frequency counts.

Each driver contributed one value (i.e., averaged over multiple days) to the results sections for Duty Days (7.2), Work Demands (7.3), Factors Contributing to Fatigue (7.4), Sleep (7.5), Naps (7.6), Subjective Mood Ratings (7.7), Critical Events (7.8), and Psychomotor Vigilance Tasks (7.9). As an example, drivers only contributed one value

to the between-groups analysis whether they completed 11 on-duty days or three on-duty days. This was done to ensure that the results of each driver were weighted equally.

For some analyses it was more appropriate to include multiple values for each driver. For example, it was more suitable to examine all start times across multiple duty days for each driver rather than average over multiple days. For the following results sections each driver contributed multiple values (i.e., repeated over multiple days):

- Start time (7.2.2)
- End time (7.2.3)
- Length of duty period vs. shift start time (7.2.6)
- Critical events and driving exposure (7.9)

Tables 7-1, 7-2 and 7-3 below show a summary of the significant (and near-significant) results pre-FMP compared to post-FMP, based on RDI Score, CPAP Adherence and ESS Score. The primary goal of this study is to document the main effect of the FMP implementation on fatigue-related variables (i.e., comparison of pre- vs. post-FMP). The primary dependent variables are subjective levels of fatigue, number of close calls (e.g., incidents of near falling asleep at the wheel or near collisions), sleep parameters (sleep duration, quality, efficiency) and psychomotor performance (reaction time, lapses).

In the scientific development of this project, the use multifactorial ANOVA to describe the efficacy of the FMP intervention on these dependent variables was considered. During that process the importance of considering individual driver characteristics as a contributor to the efficiency of the FMP intervention became apparent. Grouping variables such as RDI score (categorized by severity of respiratory disturbances during sleep), CPAP treatment (categorized by absence of treatment, CPAP treatment adherent, or non-adherent) and ESS score (characterized by severity of baseline sleepiness) were judged to be scientifically and clinically important grouping variables. For these reasons, several three factors ANOVAs were used with different grouping strategies. These grouping strategies were considered one of the ANOVA factors and were based on RDI scores, CPAP treatment and ESS score as detailed below. Other factors considered in the ANOVA were: FMP period (Pre-FMP, Post-FMP), type of day (rest day, duty day), and time of day (start of day, end of day).

Table 7-1 Effect of Study Phase (pre-FMP vs. post-FMP) – By RDI Score

	Main Effect	Interactions with Study Phase				Description
	Pre vs. Post	RDI x study phase	Duty vs. Rest	Start vs. End of Day	Day 1 vs. Day 5	
DUTY DAYS						
Start Time						
End Time						
Drive Time	t*	t				Shorter drive time post-FMP
Duty Time						
Length of duty vs. start of shift time						
Night Drivers	p <.05					More night drivers post-FMP
WORK DEMANDS						
Mental Demands						
Physical Demands						
Stress						
Intensity						
FACTORS CONTRIBUTING TO FATIGUE						
Loading + Unloading						
Driving Conditions						
Time Waiting						
SUBJECTIVE MOOD RATINGS						
Aches + Pains						
Happy + Sad						
Calm + Excited						
Fatigue	t					Less reported fatigue post-FMP
SLEEP						
Reported Duration of Main Sleep						
Reported Total Sleep in Last 24 hours		p <.01				No Abnormality group, more sleep post-FMP
Subjective sleep quality	p <.05					Better sleep quality post-FMP
Sleep latency (actigraphy)						
Time spent in bed for main sleep episode (PDA, Actigraphy)						
Duration of Main Sleep Period (Actigraphy)						

	Main Effect	Interactions with Study Phase				Description
	Pre vs. Post	RDI x study phase	Duty vs. Rest	Start vs. End of Day	Day 1 vs. Day 5	
Sleep Achieved During Main Sleep Period (Actigraph)			p <.01			For duty days, more total sleep time post-FMP
Sleep Efficiency (Time In Bed)			p <.05			Pre-FMP, better sleep efficiency during rest days. Post-FMP, no more difference between rest and duty days
NAPS						
Mean Nap Duration						
CRITICAL EVENTS						
Critical Events	p < .05 (1)	t (2)				(1) Fewer critical events post-FMP (2) Fewer critical events for No Abnormality group post-FMP
PSYCHOMOTOR VIGILANCE TASK						
PVT reaction time						
PVT reaction speed						
PVT minor lapses	p < .05					For duty days, more minor lapses post-FMP

* t = trend
** greyed out column indicates analyses not performed

Table 7-2 Effect of Study Phase (pre-FMP vs. post-FMP) – By CPAP Adherence

	Main Effect	Interactions with Study Phase				Description
	Pre vs. Post	CPAP Adher-ence x Study Phase	Duty vs. Rest	Start vs. End of Day	Day 1 vs. Day 5	
DUTY DAYS						
Start Time						
End Time						
Drive Time						
Duty Time	t*					Longer duty time post-FMP
Length of duty vs. start of shift time						
Night Drivers						
WORK DEMANDS						
Mental Demands						
Physical Demands						

	Main Effect	Interactions with Study Phase				Description
	Pre vs. Post	CPAP Adher-ence x Study Phase	Duty vs. Rest	Start vs. End of Day	Day 1 vs. Day 5	
Stress						
Intensity						
FACTORS CONTRIBUTING TO FATIGUE						
Loading + Unloading						
Driving Conditions						
Time Waiting	t					Higher contribution to fatigue post-FMP
SUBJECTIVE MOOD RATINGS						
Aches + Pains	$p < .01$					More aches and pains post-FMP
Happy + Sad						
Calm + Excited						
Fatigue						
SLEEP						
Reported Duration of Main Sleep						
Reported Total Sleep in Last 24 hours		$p < .01$				No CPAP group had more sleep post-FMP
Subjective sleep quality						
Sleep latency (actigraphy)						
Time spent in bed for main sleep episode (PDA, Actigraphy)						
Duration of Main Sleep Period (Actigraphy)						
Sleep Achieved During Main Sleep Period (Actigraph)			$p < .01$			For duty days, more total sleep post-FMP
Sleep Efficiency (Time In Bed)			$p <.05$			Pre-FMP, better sleep efficiency during rest days. Post-FMP, no more difference between rest and duty days
NAPS						
Mean Nap Duration						
CRITICAL EVENTS						
Critical Events						

	Main Effect	Interactions with Study Phase				Description
	Pre vs. Post	CPAP Adher-ence x Study Phase	Duty vs. Rest	Start vs. End of Day	Day 1 vs. Day 5	
PSYCHOMOTOR VIGILANCE TASK						
PVT reaction time		t				For rest days, faster reaction time post-FMP in the CPAP adherent group.
PVT reaction speed		p < .05				For rest days, faster reaction speed post-FMP in the CPAP adherent group.
PVT minor lapses	t (1)	t (2)		p < .05 (3)		(1) For duty days, more minor lapses post-FMP (2) For rest days, more minor lapses in the CPAP Non-Adherent group post-FMP (3) For duty days, more minor lapses post-FMP at the end of day

* t + trend

** greyed out column indicates analyses not performed

Table 7-3 Effect of Study Phase (pre-FMP vs. post-FMP) – By ESS Score

	Main Effect	Interactions with Study Phase				Description
	Pre vs. Post	ESS Score x Study Phase	Duty vs. Rest	Start vs. End of Day	Day 1 vs. Day 5	
DUTY DAYS						
Start Time						
End Time		t*				For No Abnormality group, fewer shifts ended between 00:00 – 05:59 post-FMP
Drive Time						
Duty Time						
Length of duty vs. start of shift time						
Night Drivers						

	Main Effect	Interactions with Study Phase				Description
	Pre vs. Post	ESS Score x Study Phase	Duty vs. Rest	Start vs. End of Day	Day 1 vs. Day 5	
WORK DEMANDS						
Mental Demands		p < .01				Higher mental demands for Severe Abnormality and lower mental demands for other two subgroups post-FMP
Physical Demands						
Stress	p < .05 (1)	p < .01 (2)				(1) Lower stress post-FMP (2) Lower stress for Severe Abnormality group and increased for other two groups, post-FMP
Intensity	p < .01 (1)	p < .01 (2)				(1) Less intensity post-FMP (2) Intensity decreased for Severe Abnormality group and increased slightly for other two groups
FACTORS CONTRIBUTING TO FATIGUE						
Loading + Unloading						
Driving Conditions	p < .02 (1)	p < .01 (2)				(1) Less contribution of driving conditions to fatigue. (2) Ratings decreased for Moderate and Sever Abnormality groups and increased for No Abnormality group
Time Waiting						
SUBJECTIVE MOOD RATINGS						
Aches + Pains						
Happy + Sad	t					More happy post-FMP
Calm + Excited						
Fatigue						
SLEEP						
Reported Duration of Main Sleep						
Reported Total Sleep in Last 24 hours						
Subjective sleep quality	t					Higher subjective sleep quality post-FMP.

	Main Effect	Interactions with Study Phase				Description
	Pre vs. Post	ESS Score x Study Phase	Duty vs. Rest	Start vs. End of Day	Day 1 vs. Day 5	
Sleep latency (actigraphy)						
Time spent in bed for main sleep episode (PDA, Actigraphy)						
Duration of Main Sleep Period (Actigraphy)						
Sleep Achieved During Main Sleep Period (Actigraph)			t			Longer total sleep time post-FMP for duty days
Sleep Efficiency (Time in Bed)						
NAPS						
Mean Nap Duration		p < .05 (1) (2)				(1) For rest days, Moderate Abnormality group had longer naps post-FMP (2) For rest days, Severe Abnormality group had shorter naps post-FMP
CRITICAL EVENTS						
Critical Events		p < .05				Fewer critical events for No Abnormality group
PSYCHOMOTOR VIGILANCE TASK						
PVT reaction time		p < .05 (1) (2)		p < .05 (1) (2)		(1) For the start of rest days, No Abnormality group had slower reaction times post-FMP (2) For the start of rest days, Severe Abnormality group had faster reaction times post-FMP

	Main Effect	Interactions with Study Phase				Description
	Pre vs. Post	ESS Score x Study Phase	Duty vs. Rest	Start vs. End of Day	Day 1 vs. Day 5	
PVT reaction speed		p < .05 (1) t (2)		p < .05 (1) t (2)		(1) For the start of rest days, No Abnormality group had slower reaction speed post-FMP (2) For the start of rest days, Severe Abnormality group had faster reaction speed post-FMP
PVT minor lapses		t				For rest days, less minor lapses post-FMP in the moderate group.

*t = trend
** greyed out column indicates analyses not performed

7.1 Overall Study period

7.1.1 Length of Study period

The average study period length decreased by 0.71 days from 9.26 days pre-FMP to 8.55 days post-FMP. A t-test comparison of means revealed that this decrease was significant (t(76) = 3.02, p = .003)) (see Table 7-4).

Table 7-4 Length of Study Period by Region

Region	N	Pre-FMP Mean (SD) (days)	Post-FMP Mean (SD) (days)
Québec	29	9.41 (1.92)	8.45 (1.40)
Alberta	24	9.04 (1.81)	8.54 (2.11)
California	24	9.29 (1.27)	8.67 (1.86)
TOTAL	**77**	**9.26 (1.69)**	**8.55 (1.77)**

7.1.2 Total Number of Duty Days in Study period

There was no significant change in the mean number of duty days in the study period from pre-FMP to post-FMP (t(76) = 1.44, p = .154)) (see Table 7-5).

Table 7-5 Mean Number of Duty Days in Study Period by Region

Region	N	Pre-FMP Mean (SD) (days)	Post-FMP Mean (SD) (days)
Québec	29	5.41 (1.43)	5.14 (1.53)
Alberta	24	5.54 (1.35)	5.21 (1.32)
California	24	6.00 (1.64)	5.67 (1.90)
TOTAL	**77**	**5.64 (1.48)**	**5.32 (1.59)**

7.1.3 Total Number of Rest Days in Study period

The average number of rest days decreased by 0.40 days from 3.62 days pre-FMP to 3.22 days post-FMP. A t-test comparison of means revealed that this decrease was significant ($t(76) = 2.08$, $p = .041$)) (see Table 7-6).

Table 7-6 Mean Number of Rest Days in Study Period

Region	N	Pre-FMP Mean (SD) (days)	Post-FMP Mean (SD) (days)
Québec	29	4.00 (1.41)	3.31 (1.14)
Alberta	24	3.50 (1.56)	3.33 (1.69)
California	24	3.29 (1.40)	3.00 (0.98)
TOTAL	**77**	**3.62 (1.47)**	**3.22 (1.28)**

7.1.4 Total Number of Consecutive Rest Days Prior to Duty Period

There was no significant change in the number of consecutive rest days prior to the main duty period, from pre-FMP to post-FMP ($t(76) = 0.38$, $p = .708$)) (see Table 7-7).

Table 7-7 Mean Number of Rest Days Prior to Main Duty Period by Region

Region	N	Pre-FMP Mean (SD) (days)	Post-FMP Mean (SD) (days)
Québec	29	1.62 (0.86)	1.62 (0.90)
Alberta	24	1.71 (0.86)	1.58 (1.06)
California	24	1.54 (0.88)	1.50 (0.59)
TOTAL	**77**	**1.62 (0.86)**	**1.57 (0.86)**

7.1.5 Length of Main Duty Period (Consecutive Days)

There was no significant change in the mean number of consecutive days comprising the main duty period, from pre-FMP to post-FMP ($t(76) = 0.87$, $p = .385$)) (see Table 7-8).

Table 7-8 Length of Main Duty Period (Consecutive Days)

Region	N	Pre-FMP Mean (SD) (days)	Post-FMP Mean (SD) (days)
Québec	29	5.00 (1.22)	4.93 (0.96)
Alberta	24	5.08 (1.50)	4.58 (1.41)
California	24	5.00 (1.35)	5.08 (1.41)
TOTAL	**77**	**5.03 (1.34)**	**4.87 (1.26)**

7.1.6 Total Number of Consecutive Rest Days after Main Duty Period

There was no significant change in the number of consecutive rest days following the main duty period, from pre-FMP to post-FMP ($t(76) = 1.49$, $p = .140$)) (see Table 7-9).

Table 7-9 Mean Number of Consecutive Rest Days after Duty Period

Region	N	Pre-FMP Mean (SD) (days)	Post-FMP Mean (SD) (days)
Québec	29	2.24 (0.64)	1.66 (0.72)
Alberta	24	1.71 (0.95)	1.75 (1.26)
California	24	1.46 (0.59)	1.50 (0.78)
TOTAL	**77**	**1.83 (0.80)**	**1.64 (0.93)**

7.2 Duty Days

7.2.1 Verification of Data Entry Schedule

Drivers were asked to fill out questionnaires, on the PDA, four times per day (on awakening, start of day, end of day, and before bed) and perform PVT reaction time tests twice per work/rest day (start of day, end of day) for all rest and duty days during the study period. In order to validate the time at which the subjective data were collected, a comparison was made between the self-reported 'end of shift' time with the timestamp recorded when the end of day survey was completed (i.e., when subjective measures such as mood, level of fatigue, etc were collected) (Note: It was not possible to conduct a similar analysis for the start of duty periods since participants were not asked to key in their "shift start time"). Subjects were instructed to complete this questionnaire immediately after their work shift was complete. This analysis was conducted for all duty days for all drivers. Compliance was defined as an elapsed time of less than 2 hours from the self reported "Shift End Time" to the timestamp recorded for the "End of work" questionnaire.

Overall, out of 410 duty days, one-third (33 percent) were non-compliant. Table 7-10 shows the proportion of subjects, by region, that had 0, 1, 2 or >2 non-compliant duty days during the study period. On average, about one-quarter (26 percent) of all subjects were fully compliant (i.e., they completed the "End of Day" questionnaire within 2 hours of the end of their shift for all duty days during the study period) and approximately two-thirds (26 percent + 39 percent= 65 percent) of all subjects had at most one non-compliant duty day. One-quarter of all subjects (25 percent) had three or more non-compliant duty days during the study period.

Table 7-10 Proportion of Drivers who completed the "End of Work" Questionnaire less than Two Hours after their Shift (post-FMP)

	N	Proportion of Drivers with 0, 1, 2 or >2 Non-Compliant Duty Days			
		0	1	2	>2
All Drivers (Post FMP)	77	26%	39%	10%	25%

An analysis was done to compare self-reported End of Duty time to the time at which drivers completed the End of Day questionnaire (see Figure 7-1). The graph below plots, for each hour of the day, the difference between the proportion of drivers who reported ending their duty period during that hour to the proportion of drivers time who actually filled out the End of Day questionnaire during that hour. If drivers filled out the End of Day questionnaire as soon as they finished their duty period, the graph below would be a flat line (0 percent). Positive values indicate that more drivers reported ending their shift during that hour compared to those that actually filled out the End of Day questionnaire during that hour, negative values represent the reverse. For both phases, drivers who reported finishing their duty period between 22:00 and 01:00 were the least likely to complete the End of Day questionnaire at that time.

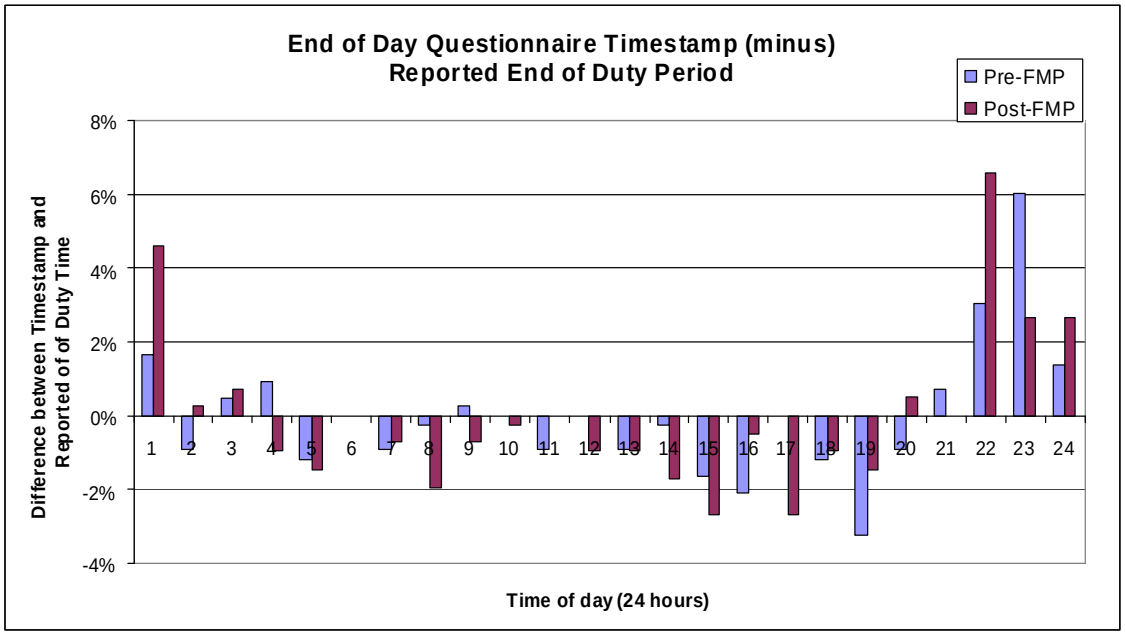


Figure 7-1 Comparison of self-reported end of duty time to the time at which drivers completed the end of day questionnaire

7.2.2 Start Time

7.2.2.1 Overall Results

Shift start time was based on the timestamp recorded when the '*Start of Day*' PDA questionnaire was filled out. Figure 7-2 compares shift start times for pre- and post-FMP.

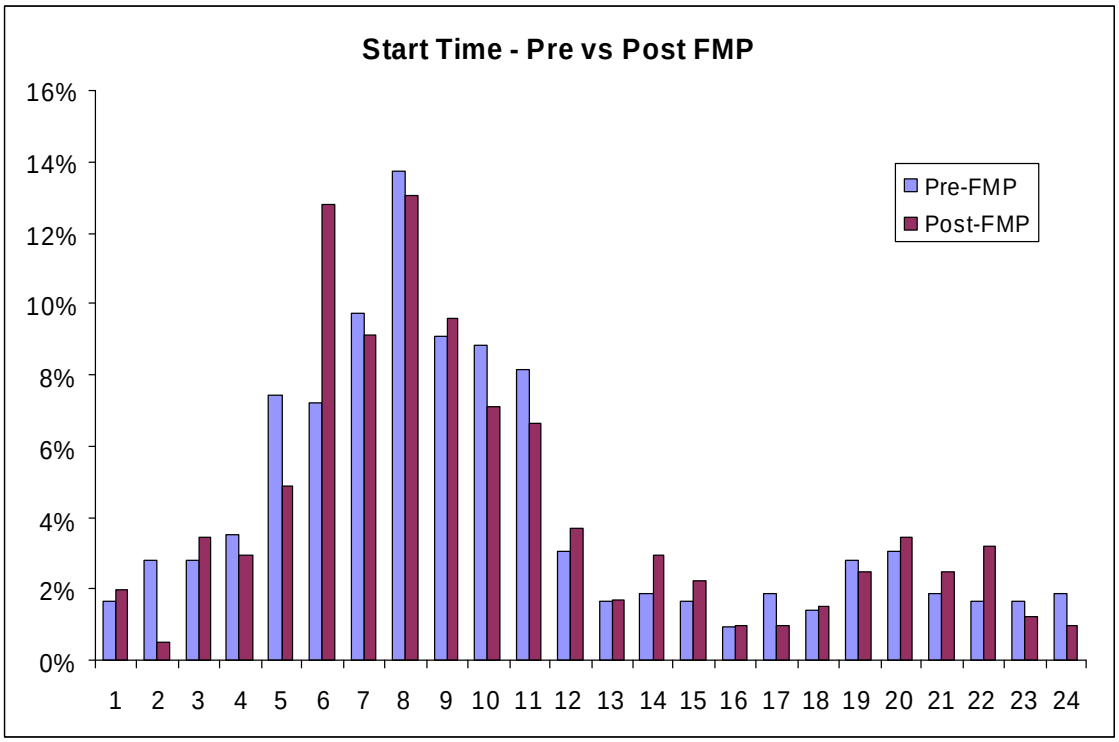


Figure 7-2 Start of day: Pre- vs. post-FMP

Shifts that start between 18:00 and 20:59 should be avoided since they result in more driving hours at night when drivers' circadian rhythms are at their lowest. Comparisons were made, based on RDI score, CPAP Adherence, and ESS Score, of the proportion of shifts that were started between 18:00 and 20:59, pre-FMP vs. post-FMP. McNemar's test for correlated proportions was used to compare start times by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between pre-FMP and post-FMP. There were no main effects of study phase.

7.2.2.2 RDI Score

Drivers were subdivided into three subgroups based on their RDI score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15) (see Table 7-11). McNemar's test for correlated proportions was used to compare the proportions of start times that occurred between 18:00 and 20:59, pre-FMP vs. post-FMP. There were no significant differences within subgroups.

Table 7-11 Start of Day by RDI Score

RDI Score	Pre-FMP		Post-FMP	
	N	Start of Day 18:00 – 20:59 (%)	N	Start of Day 18:00 – 20:59 (%)
No Abnormality (RDI <5)	141	9.2%	120	4.2%
Mild Abnormality (RDI: 5 – 14.9)	173	3.5%	165	6.1%
Moderate to Severe (RDI ≥15)	116	10.3%	93	12.4%

7.2.2.3 CPAP ADHERENCE

Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time) (see Table 7-12). McNemar's test for correlated proportions was used to compare the proportions of start times that occurred between 18:00 and 20:59, pre-FMP vs. post-FMP. There were no significant differences within subgroups.

Table 7-12 Start of Day by CPAP Adherence

CPAP Adherence	Pre-FMP		Post-FMP	
	N	Start of Day 18:00 – 20:59 (%)	N	Start of Day 18:00 – 20:59 (%)
No CPAP Required	201	8.0%	189	3.3%
CPAP Adherent (>4 hrs (70%))	84	1.2%	83	9.6%
CPAP Non-Adherent (<4 hrs (70%))	122	6.6%	114	7.0%

7.2.2.4 ESS SCORE

Drivers were subdivided into three subgroups according to their ESS score; No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24) (see Table 7-13). McNemar's test for correlated proportions was used to compare the proportions of start times that occurred between 18:00 and 20:59, pre-FMP vs. post-FMP. There were no significant differences within subgroups.

Table 7-13 Start of Day by ESS Score

ESS Score	Pre-FMP		Post-FMP	
	N	Start of Day 18:00 – 20:59 (%)	N	Start of Day 18:00 – 20:59 (%)
No Abnormality (0-10)	303	7.6%	285	3.9%
Moderate (11-16)	81	1.2%	74	6.8%
Severe (17-24)	17	0.0%	17	17.6%

7.2.3 End Time

7.2.3.1 Overall Results

Shift end time was based on driver response to a question in the "End of Day" PDA questionnaire. A histogram showing the distributions of pre-FMP and post-FMP end times is shown in Figure 7-3. McNemar's test for correlated proportions was used to compare end times by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between pre-FMP and post-FMP. There were no main effects of study phase.

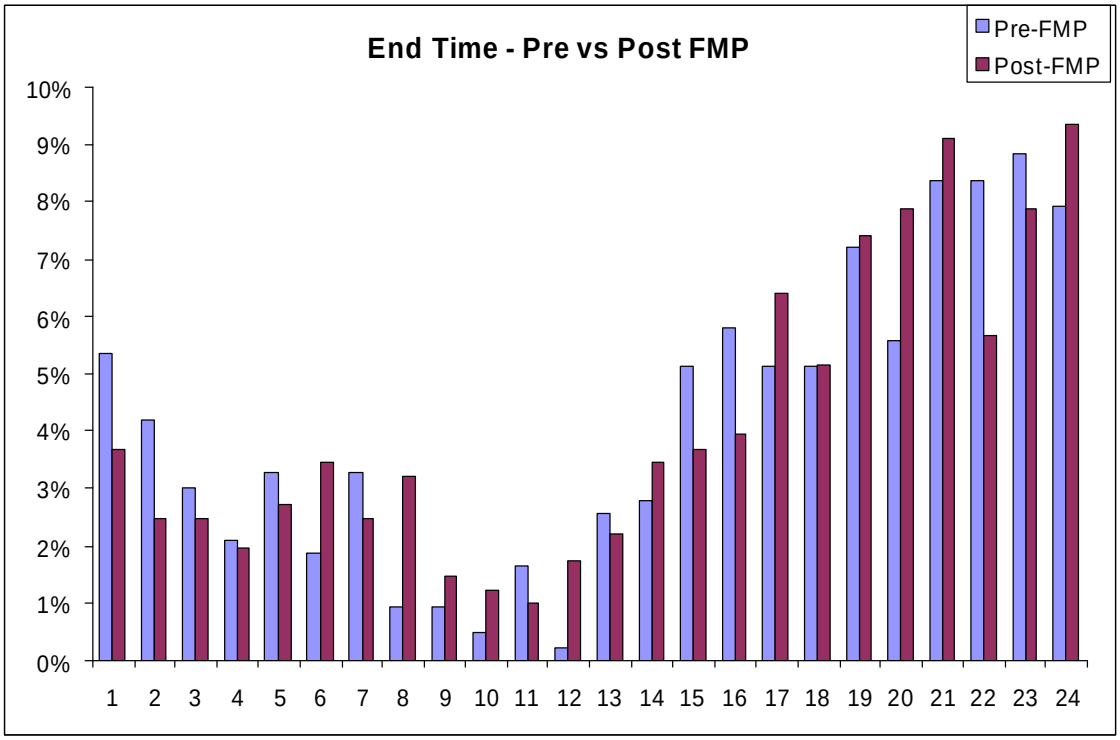


Figure 7-3 End of shift – pre vs. post FMP

Shifts that end between 00:00 and 05:59 should be avoided as they result in driving during night hours drivers' circadian rhythms are at their lowest. Comparisons were made, based on RDI score, CPAP Adherence, and ESS Score, of the proportion of shifts that ended between 00:00 and 05:59, pre-FMP vs. post-FMP.

7.2.3.2 RDI Score

Drivers were subdivided into three subgroups based on their RDI score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15) (see Table 7-14). McNemar's test for correlated proportions was used to compare the proportions of end times that occurred between 00:00 and 05:59, pre-FMP vs. post-FMP. There were no significant differences within subgroups.

Table 7-14 End of Day by RDI Score

RDI Score	Pre-FMP		Post-FMP	
	N	End of Day 00:00 – 05:59 (%)	N	End of Day 00:00 – 05:59 (%)
No Abnormality (RDI <5)	141	24.8%	125	18.3%
Mild Abnormality (RDI: 5 to 14.9)	173	15.6%	165	13.3%
Moderate to Severe (RDI ≥15)	116	19.8%	121	19.8%

7.2.3.3 CPAP ADHERENCE

Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time) (see Table 7-15). McNemar's test for correlated proportions was used to compare the proportions of end times that occurred between 00:00 and 05:59, pre-FMP vs. post-FMP. There were no significant differences within subgroups.

Table 7-15 End of Day by CPAP Compliance

CPAP Adherence	Pre-FMP		Post-FMP	
	N	End of Day 00:00 – 05:59 (%)	N	End of Day 00:00 – 05:59 (%)
No CPAP Required	201	22.9%	189	18.5%
CPAP Adherent (> 4 hrs (70%))	84	13.1%	83	16.9%
CPAP Non-Adherent (< 4 hrs (70%))	122	14.8%	114	9.6%

7.2.3.4 ESS SCORE

Drivers were subdivided into three subgroups according to their ESS score; No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24) (see Table 7-16). McNemar's test for correlated proportions was used to compare the proportions of end times that occurred between 00:00 and 05:59, pre-FMP vs. post-FMP. For the No Abnormality group, there was a trend toward fewer shifts ending between 00:00 and 05:59, post-FMP (p = .099). There were no significant differences within the other subgroups.

Table 7-16 End of Day by ESS Score

ESS Score	Pre-FMP		Post-FMP	
	N	End of Day 00:00 – 05:59 (%)	N	End of Day 00:00 – 05:59 (%)
No Abnormality (0-10)	303	18.8%	280	14.3%
Moderate (11-16)	81	14.8%	74	18.9%
Severe (17-24)	17	23.5%	17	17.6%

7.2.4 Drive Time

7.2.4.1 Overall Results

Drive time was collected using the PDA at the end of each shift. A repeated-measures ANOVA was used to compare drive time by subgroup (RDI Score, CPAP Adherence or ESS Score – see next section for detailed results) between pre-FMP and post-FMP. There was a trend towards shorter mean drive time post-FMP, based on RDI Score analysis. There were no main effects of RDI Score, CPAP Adherence, or ESS Score.

7.2.4.2 RDI Score:

Drivers were subdivided into three subgroups based on their RDI score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15) (see Table 7-17). A repeated-measures ANOVA was used to compare mean drive time by RDI score subgroup between study phases. Within subjects, there was a trend towards an effect of pre vs. post FMP on mean drive time ($F(1,74) = 3.048$, $p = .085$). Drive time increased for drivers with mild abnormality, but decreased for the other two groups ($F(2,74) = 3.859$, $p = .063$). There was no main effect of RDI score ($F(2,74) = 1.16$, $p = .320$).

Table 7-17 Mean Drive Time by RDI Score

RDI Score	N	Pre-FMP Mean (SD) (hours)	Post-FMP Mean (SD) (hours)
No Abnormality (RDI <5)	26	8.10 (1.70)	7.42 (2.10)
Mild Abnormality (RDI: 5-14.9)	30	7.63 (2.03)	7.90 (2.10)
Moderate to Severe (RDI ≥15)	21	7.35 (2.15)	6.76 (1.77)

7.2.4.3 CPAP Adherence

Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time) (see Table 7-18). A repeated-measures ANOVA was used to compare mean drive time by CPAP compliance subgroup between study phases. There was no effect of study phase on mean drive time ($F(1,69) = 1.08$, $p = .302$). There was no main effect of CPAP Adherence ($F(2, 69) = 2.058$, $p = .136$).

Table 7-18 Mean Drive Time by CPAP Adherence

CPAP Adherence	N	Pre-FMP Mean (SD) (hours)	Post-FMP Mean (SD) (hours)
No CPAP required	37	7.99 (1.91)	7.49 (2.21)
CPAP Adherent (>4 hrs (70%))	15	8.23 (1.90)	7.94 (1.27)
CPAP Non-Adherent (<4 hrs (70%))	20	6.89 (1.86)	7.02 (1.97)

7.2.4.4 ESS SCORE

Drivers were subdivided into three subgroups according to their Epworth Sleepiness Scale (ESS) score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24). Means are shown in Table 7-19. A repeated-measures ANOVA was used to compare mean drive time by ESS score subgroup between study phases. There was no effect of study phase on mean drive time ($F(1,72) = 0.71$, $p = .40$). There was no main effect of ESS Score ($F=0.315$, $p = .814$).

Table 7-19 Mean Drive Time by ESS Score

ESS Score	N	Pre-FMP	Post-FMP
		Mean (SD) (hours)	Mean (SD) (hours)
No Abnormality (0-10)	59	7.76 (2.08)	7.53 (2.22)
Moderate (11-16)	13	7.60 (1.60)	7.36 (0.92)
Severe (17-24)	4	7.65 (1.66)	6.32 (2.05)

7.2.5 Duty Time

7.2.5.1 OVERALL RESULTS

Duty time was collected using the PDA at the end of each shift. A repeated-measures ANOVA was used to compare duty time by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between pre-FMP and post-FMP. There was a trend toward longer mean duty time post-FMP, based on CPAP adherence analysis. Also, there was a main effect of CPAP Adherence. Drivers that were CPAP Non-Adherent had significantly shorter mean duty time than both of the other groups. There were no main effects of RDI Score or ESS Score.

7.2.5.2 RDI SCORE

Drivers were subdivided into three subgroups based on their RDI score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15) (see Table 7-20). A repeated-measures ANOVA was used to compare mean duty time by RDI score subgroup between study phases. Within-subjects, there was no effect of pre vs. post FMP on mean duty time ($F(1,74) = 1.58$, $p = .213$). There was no effect of RDI score ($F(2,74) = 2.361$, $p = .101$).

Table 7-20 Mean Duty Time by RDI Score

RDI Score	N	Pre-FMP	Post-FMP
		Mean (SD) (hours)	Mean (SD) (hours)
No Abnormality (RDI <5)	26	11.87 (2.05)	11.90 (1.51)
Mild Abnormality (RDI: 5-14.9)	30	11.17 (1.93)	11.59 (1.75)
Moderate to Severe (RDI ≥5)	21	10.71 (1.84)	11.05 (1.80)

7.2.5.3 CPAP ADHERENCE

Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time) (see Table 7-21). A repeated-measures ANOVA was used to compare mean duty time by CPAP compliance subgroup between study phases. Within subjects, there was a trend toward longer mean duty time pre vs. post-FMP ($F(1,69) = 3.47$, $p = .067$) but no interaction between adherence subgroup and study phase ($F(=2,69) = 2.03$, $p = .139$). There was a main effect of CPAP Adherence ($F(2,69) = 4.71$, $p = .012$). Pairwise comparisons showed that the CPAP Non-Adherent group had a significantly shorter mean duty time as compared to the CPAP Adherent ($p = .023$) and No CPAP ($p = .025$) groups (see Figure 7-4).

Table 7-21 Mean Duty Time by CPAP Adherence

CPAP Adherence	N	Pre-FMP Mean (SD) (hours)	Post-FMP Mean (SD) (hours)
No CPAP Required	37	11.76 (2.18)	11.69 (1.79)
CPAP Adherent (>4 hrs (70%))	15	11.79 (1.95)	12.19 (1.35)
CPAP Non-Adherent (<4 hrs (70%))	20	10.16 (0.94)	11.10 (1.29)

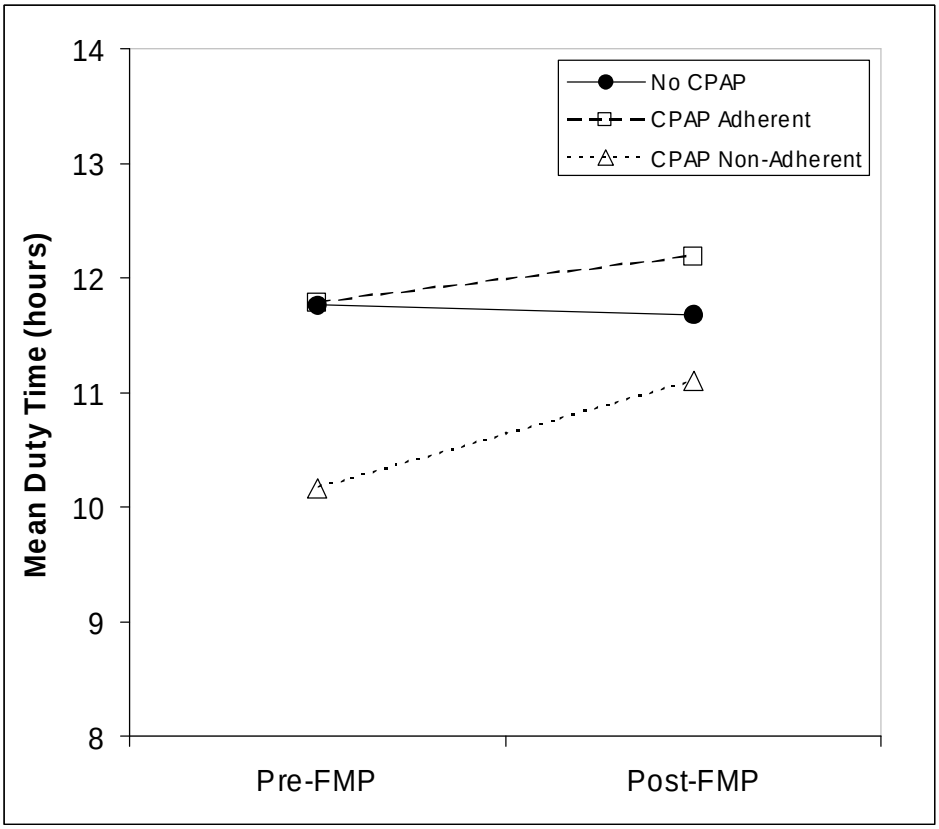


Figure 7-4 Mean duty time by CPAP adherence

7.2.5.4 ESS SCORE

Drivers were subdivided into three subgroups according to their Epworth Sleepiness Scale (ESS) score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24). Means are shown in Table 7-22. A repeated-measures ANOVA was used to compare mean duty time by ESS score subgroup between study phases. There was no effect of study phase on mean duty time ($F(1,73) = .11$, $p = .915$). There was no main effect of ESS Score ($F(3,73) = .315$, $p = .814$).

Table 7-22 Mean Duty Time by ESS Score

ESS Score	N	Pre-FMP	Post-FMP
		Mean (SD) (hours)	Mean (SD) (hours)
No Abnormality (0-10)	59	11.21 (2.09)	11.43 (1.74)
Moderate (11-16)	13	11.54 (1.70)	12.44 (1.32)
Severe (17-24)	4	11.79 (1.34)	10.90 (1.51)

7.2.6 Length of Duty vs. Time at Start of Shift

A comparison was made between length of duty periods for shifts that began in mid-morning (06:00 – 08:59) as compared to early evening (18:00 – 20:59) (see Table 7-23). An analysis of variance showed that shifts initiated mid-morning are significantly longer than shifts that start in the early evening ($F(1,331) = 13.38$, $p < .001$). There was no significant difference in mean duty period length from pre-FMP to post-FMP ($F(1,331) = 2.55$, $p = .111$) (see Figure 7-5).

Table 7-23 Length of Duty Period vs. Shift Start Time

Shift Start Time	Pre-FMP		Post-FMP		Total	
	N	Mean Duty Time (hours)	N	Mean Duty Time (hours)	N	Mean Duty Time (hours)
Morning (06:00 – 08:59)	132	10.98 (3.77)	142	12.03 (2.90)	274	11.51 (3.51)
Evening (18:00 – 20:59)	31	9.42 (4.72)	30	9.95 (3.72)	61	9.69 (3.51)
TOTAL	**163**	**10.68 (3.97)**	**172**	**11.67 (3.15)**		

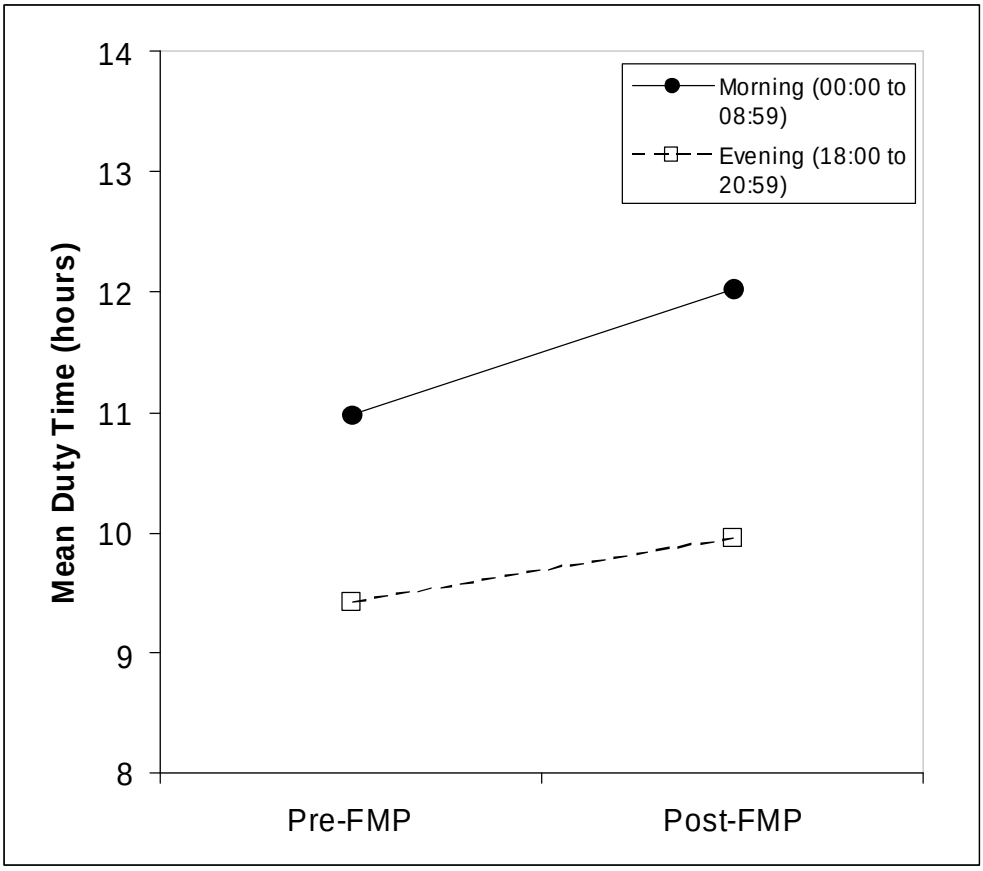


Figure 7-5 Length of duty period vs. shift start time

7.2.7 Night Drivers

Participants were categorized as "night drivers" if 25 percent of their total duty time during the study period occurred between 00:00 and 06:00. (Note: In the pre-FMP report the definition specified 25 percent of *total driving time* during the study period between 00:00 and 06:00. The preferred definition of night drivers is based on driving time; however, driving time could not be separated from duty time during this time period). Using McNemar's test of proportions, there was a significant increase in the proportion of "night drivers" post-FMP as compared to pre-FMP (18.2 percent vs. 7.8 percent, p = .021). See Table 7-24 for details.

Table 7-24 Proportion of Night Drivers

	N	Proportion of Participants Who Were "Night Drivers"	
		Pre-FMP	Post-FMP
All Drivers	77	7.8%	18.2%

A comparison was made between the proportion of all "night driving" hours (i.e., duty hours between 00:00 to 06:00) pre-FMP compared to post-FMP. Using McNemar's test of proportions, there was no significant difference from pre- to post-FMP; in both cases the proportion of night driving hours was 10.4 percent of the total. Further examination

of the data reveals that the post-FMP night drivers did more night driving hours whereas the post-FMP drivers not so classified because they did not meet the 25 percent threshold, did fewer night hours post-FMP (see Table 7-25). The proportion of drivers who did not drive at all between 00:00 and 06:00 nearly doubled from 18 percent pre-FMP to 32 percent post-FMP. For the remaining drivers, the percentage of driving time that occurred between 00:00 and 06:00 increased from 12.8 percent to 15.5 percent.

Table 7-25 Night Driving Hours (00:00 to 05:59)

	Pre-FMP			N	Post-FMP	
	N	Number of night driving hours (mean)	% of all hours spent driving at night (mean)	N	Number of night driving hours (mean)	% of all hours spent driving at night (mean)
Night driver	6	18.8	35%	14	22.2	41%
Not night driver	71	5.4	8%	63	2.4	4%

"Night drivers" increased proportion of time spent driving at night
"Not night drivers" reduced night driving hours by over 50%

7.3 Work Demands

7.3.1 Mental Demands of Duty Period

7.3.1.1 Overall Results

At the end of each duty period, drivers were asked to rate how mentally demanding their duty period was on a scale of 1 (not at all demanding) to 100 (extremely mentally demanding). A repeated-measures ANOVA was used to compare mental demands duration by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between pre-FMP and post-FMP. There was no main effect of study period but there was a significant interaction between study phase and ESS Score. There was a significant decrease in reported mental demands for the Severe Abnormality group post-FMP as compared to a small increase for the other two subgroups. There were no main effects of RDI Score, CPAP Adherence, or ESS Score.

7.3.1.2 RDI Score

Drivers were subdivided into three subgroups based on their RDI score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15). Mean ratings are shown in Table 7-26. A repeated-measures ANOVA was used to compare RDI score between study phases. There was no effect of study phase ($F(1,74) = .53$, $p = .470$) or RDI subgroup ($F(2,74) = .14$, $p = .869$) on reported mental demands of the duty period.

Table 7-26 Mental Demands of Duty period by RDI Score

RDI Score	N	Pre-FMP	Post-FMP
		Mean (SD)	Mean (SD)
No Abnormality (RDI <5)	26	30.8 (18.4)	30.0 (15.9)
Mild Abnormality (RDI: 5-14.9)	30	32.3 (14.4)	32.6 (16.5)
Moderate to Severe (RDI ≥15)	21	32.7 (14.1)	29.4 (20.2)

Note: 1 = Not at all demanding, 100 = Extremely mentally demanding

7.3.1.3 CPAP ADHERENCE

Drivers were subdivided into three subgroups according to whether they complied with CPAP: No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time). Mean ratings are shown in Table 7-27. A repeated-measures ANOVA was used to compare CPAP adherence between study phases. There was no effect of study phase ($F(1,69) = .48$, $p = .492$) or CPAP adherence subgroup $F(2,69) = 1.50$, $p = .231$) on reported mental demands of the duty period.

Table 7-27 Mental Demands of Duty Period by CPAP Adherence

CPAP Adherence	N	Pre-FMP	Post-FMP
		Mean (SD)	Mean (SD)
No CPAP Required	37	30.0 (17.9)	27.5 (16.6)
CPAP Adherent (>4 hrs (70%))	15	30.5 (12.5)	34.9 (17.6)
CPAP Non-Adherent (<4 hrs (70%))	20	35.9 (13.6)	37.6 (16.0)

Note: 1 = Not at all demanding, 100 = Extremely mentally demanding

7.3.1.4 ESS SCORE

Drivers were subdivided into three subgroups according to their Epworth Sleepiness Scale (ESS) score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24). Mean ratings are shown in Table 7-28. A repeated-measures ANOVA was used to compare ESS score between study phases. There was no main effect of study phase but there was an interaction between study phase and ESS score. There was a significant decrease in reported mental demands for the Severe Abnormality group post-FMP ($F(1,73) = 9.83$, $p = .002$) as compared to a small increase for the other two subgroups ($F(2,73) = 8.85$, $p = .001$) (see Figure 7-6).

Table 7-28 Mental Demands of Duty Period by ESS Score

ESS Score	N	Pre-FMP	Post-FMP
		Mean (SD)	Mean (SD)
No Abnormality (0-10)	59	29.7 (15.6)	29.8 (17.8)
Moderate (11-16)	13	34.2 (9.9)	37.5 (14.4)
Severe (17-24)	4	53.8 (16.1)	25.6 (17.5)

Note: 1 = Not at all demanding, 100 = Extremely mentally demanding

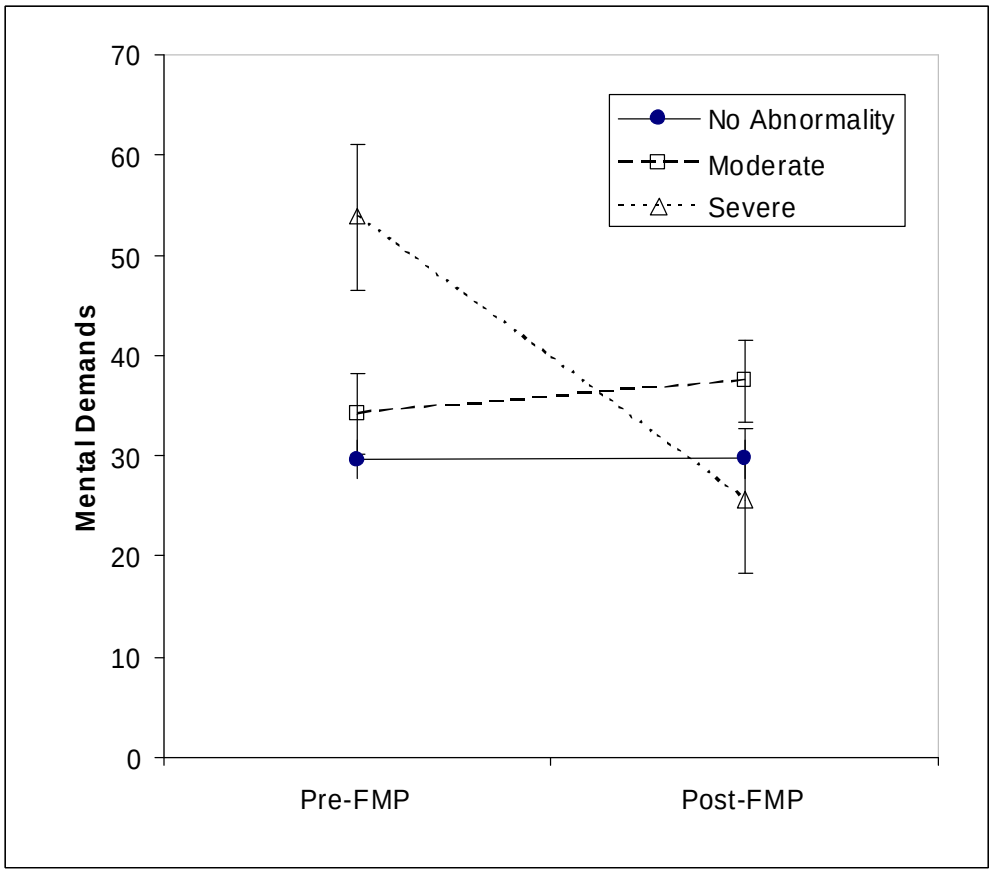


Figure 7-6 Mental demands of duty period by ESS score

7.3.2 Physical Demands of Duty Period

7.3.2.1 Overall Results

At the end of each duty period, drivers were asked to rate how physically demanding their duty period was on a scale of 1 (not at all demanding) to 100 (extremely physically demanding). A repeated-measures ANOVA was used to compare physical demands by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between pre-FMP and post-FMP. There was no main effect of study period. There was a main effect of CPAP Adherence; the CPAP Non-Adherent group reported significantly more physical demands as compared to the CPAP Adherent group. There were no main effects of RDI Score or ESS Score.

7.3.2.2 RDI Score

Drivers were subdivided into three subgroups based on their RDI score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15) . Mean ratings are shown in Table 7-29. A repeated-measures ANOVA was used to compare RDI score between study phases. There was no effect of study phase ($F(1,74) = .089$, $p = .766$) or RDI subgroup ($F(2,74) = .930$, $p = .399$) on reported physical demands of the duty period.

Table 7-29 Physical Demands of Duty Period by RDI Score

RDI Score	N	Pre-FMP	Post-FMP
		Mean (SD)	Mean (SD)
No Abnormality (RDI < 5)	26	27.9 (16.2)	29.2 (16.9)
Mild Abnormality (RDI: 5 – 14.9)	30	28.2 (15.2)	29.4 (17.5)
Moderate to Severe (RDI ≥ 15)	21	30.0 (19.6)	25.8 (20.6)

Note: 1 = Not at all demanding, 100 = Extremely physically demanding

7.3.2.3 CPAP ADHERENCE

Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time). Mean ratings are shown in Table 7-30. A repeated-measures ANOVA was used to compare CPAP adherence between study phases. There was no effect of study phase ($F(1,69) = .246$, $p = .621$) on reported mental demands, however there was a significant main effect of CPAP adherence ($F(2,69) = 3.19$, $p = .047$). On average, the CPAP Non-Adherent group reported significantly more physical demands as compared to the CPAP Adherent group ($p = .014$) (see Figure 7-7).

Table 7-30 Physical Demands of Duty Period by CPAP Adherence

CPAP Adherence	N	Pre-FMP	Post-FMP
		Mean (SD)	Mean (SD)
No CPAP Required	37	26.1 (15.8)	25.8 (16.6)
CPAP Adherent (> 4 hrs (70%))	15	27.7 (14.7)	30.0 (18.0)
CPAP Non-Adherent (< 4 hrs (70%))	20	35.8 (17.7)	36.8 (18.2)

Note: 1 = Not at all demanding, 100 = Extremely physically demanding

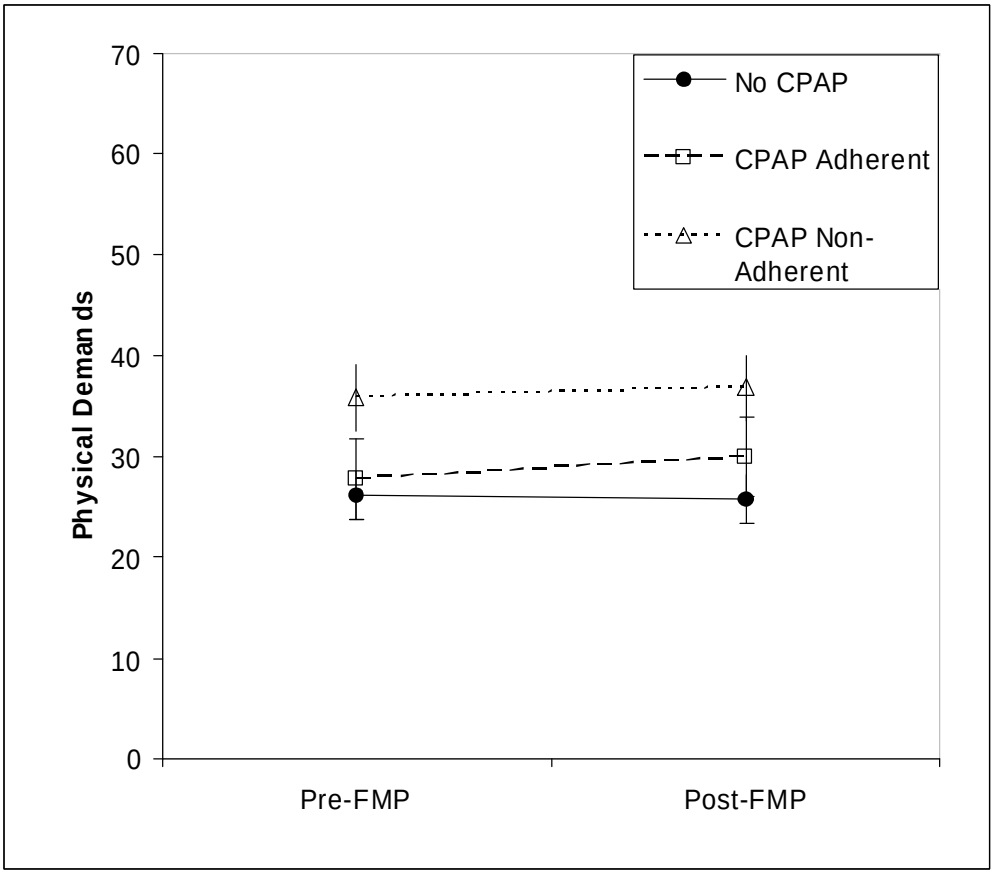


Figure 7-7 Physical demands of duty period by CPAP adherence

7.3.2.4 ESS SCORE

Drivers were subdivided into three subgroups according to their Epworth Sleepiness Scale (ESS) score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24). Mean ratings are shown in Table 7-31. A repeated-measures ANOVA was used to compare ESS score between study phases. There was no effect of study phase ($F(1,73) = .866$, $p = .355$) or ESS subgroups ($F(2,73) = .573$, $p = .566$) on reported physical demands of the duty period.

Table 7-31 Physical Demands of Duty Period by ESS Score

ESS Score	N	Pre-FMP	Post-FMP
		Mean (SD)	Mean (SD)
No Abnormality (0-10)	59	27.4 (16.6)	28.1 (18.5)
Moderate (11-16)	13	33.7 (14.9)	31.4 (16.8)
Severe (17-24)	4	34.8 (21.1)	27.9 (18.2)

Note: 1 = Not at all demanding, 100 = Extremely physically demanding

7.3.3 Stress of Duty Period

At the end of each duty period, drivers were asked to rate how stressful their duty period was on a scale of 1 (not at all stressful) to 100 (extremely stressful). A repeated-measures ANOVA was used to compare stress by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between pre-FMP and post-FMP. There was a main effect of study period based on ESS Score analysis; there was a significant decrease in mean stress ratings from pre-FMP to post-FMP. There was also a significant interaction between study phase and ESS Score; mean stress ratings for the Severe Abnormality group decreased from pre-FMP to post-FMP and increased for the other two groups. There was a trend towards a main effect of CPAP Adherence; the CPAP Non-Adherent group reported more physical demands as compared to the CPAP Adherent group. There was no main effect of RDI Score.

7.3.3.1 RDI Score

Drivers were subdivided into three subgroups based on their RDI score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15). Mean ratings are shown in Table 7-32. A repeated-measures ANOVA was used to compare RDI score between study phases. There was no effect of study phase ($F(1,74) = .249$, $p = .620$) or RDI subgroup ($F(2,74) = .600$, $p = .551$) on reported stress of the duty period.

Table 7-32 Stress of Duty Period by RDI Score

RDI Score	N	Pre-FMP	Post-FMP
		Mean (SD)	Mean (SD)
No Abnormality (RDI <5)	26	27.7 (21.6)	28.9 (15.6)
Mild Abnormality (RDI: 5-14.9)	30	32.1 (19.2)	34.6 (21.7)
Moderate to Severe (RDI ≥15)	21	33.1 (17.3)	32.0 (20.3)

Note: 1 = Not at all stressful, 100 = Extremely Stressful

7.3.3.2 CPAP Adherence

Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time). Mean ratings are shown in Table 7-33. A repeated-measures ANOVA was used to compare CPAP Adherence between study phases. There was no effect of study phase ($F(1,69) = 2.40$, $p = .126$) on reported stress of duty period. There was a trend towards a main effect of CPAP Adherence (Adherence $F(2,69) = 2.57$, $p = .084$). The CPAP Non-Adherent group reported significantly higher stress levels than the No CPAP Required group ($p = .034$) (see Figure 7-8).

Table 7-33 Stress of Duty Period by CPAP Adherence

CPAP Adherence	N	Pre-FMP Mean (SD)	Post-FMP Mean (SD)
No CPAP Required	37	27.0 (21.1)	27.4 (17.3)
CPAP Adherent (> 4 hrs (70%))	15	31.9 (17.3)	36.9 (20.6)
CPAP Non-Adherent (< 4 hrs (70%))	20	36.8 (17.5)	39.1 (19.6)

Note: 1 = Not at all stressful, 100 = Extremely Stressful

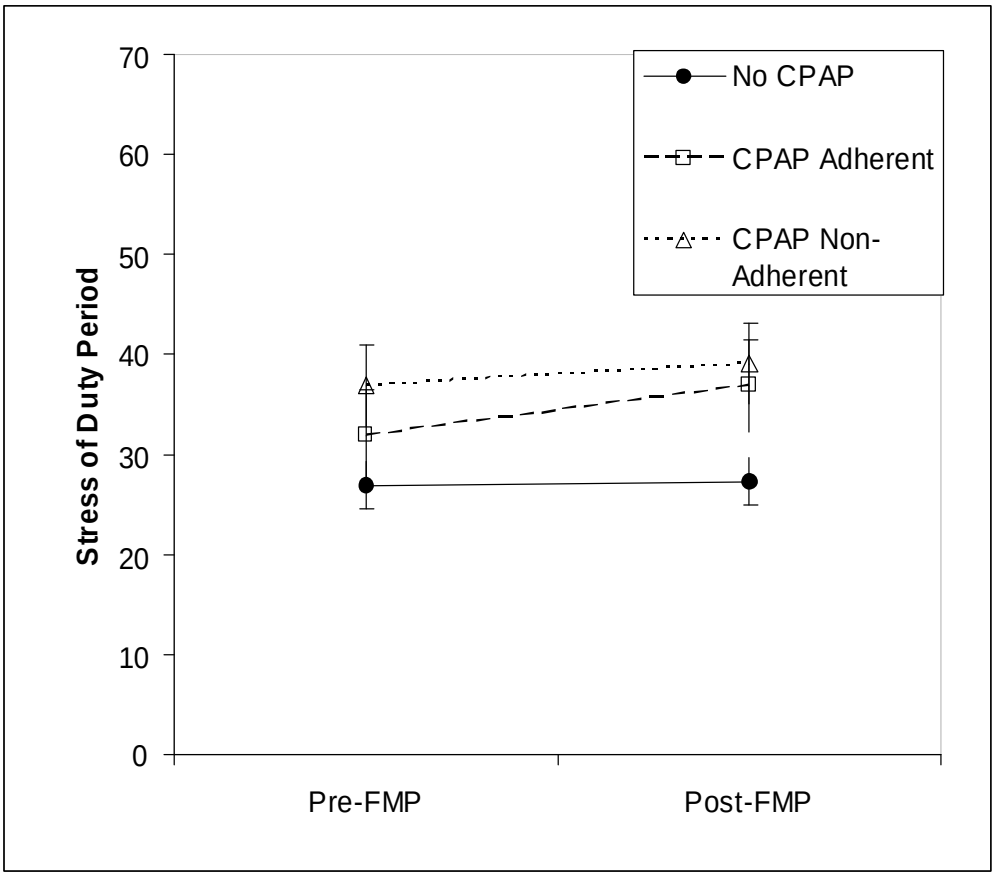


Figure 7-8 Stress of duty period by CPAP adherence

7.3.3.3 ESS SCORE

Drivers were subdivided into three subgroups according to their Epworth Sleepiness Scale (ESS) score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24). Mean ratings are shown in Table 7-34. A repeated-measures ANOVA was used to compare ESS score between study phases. There was a significant decrease in mean stress ratings from pre-FMP to post FMP ($F(1,73) = 4.07$, $p = .047$) and there was a significant interaction between study phase and ESS score ($F(2,73) = 5.57$, $p = .006$). Stress ratings for the Severe Abnormality group decreased from pre-FMP to post-FMP and increased for the other two groups (see Figure 7-9).

Table 7-34 Stress of Duty Period by ESS Score

ESS Score	N	Pre-FMP	Post-FMP
		Mean (SD)	Mean (SD)
No Abnormality (0-10)	59	29.1 (20.0)	31.5 (19.4)
Moderate (11-16)	13	34.3 (12.5)	36.9 (18.1)
Severe (17-24)	4	50.2 (24.2)	28.6 (24.1)

Note: 1 = Not at all stressful, 100 = Extremely Stressful

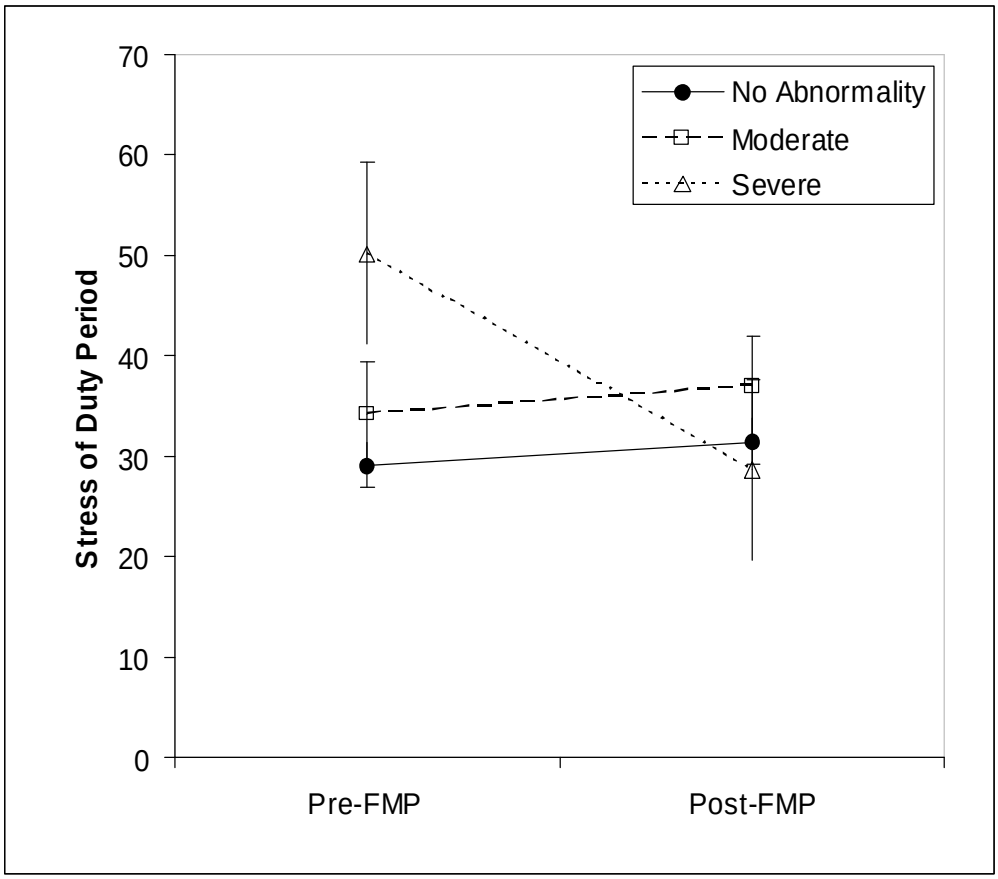


Figure 7-9 Stress of duty period by ESS score

7.3.4 Intensity of Duty Period

At the end of each duty period, drivers were asked to rate how intense their duty period was on a scale of 1 (not at all intense) to 100 (extremely intense). A repeated-measures ANOVA was used to compare intensity of duty period by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between pre-FMP and post-FMP. There was no main effect of study period based on ESS Score analysis; there was a significant decrease in the reported intensity of duty period from pre-FMP to post-FMP. There was also a significant interaction between study phase and ESS Score; the duty period intensity decreased significantly for the Severe Abnormality group and increased slightly for the other two groups. There was a main

effect of RDI Score; the No Abnormality group reported significantly higher intensity of duty compared to the other two groups. There was no main effect of CPAP Adherence.

7.3.4.1 RDI SCORE

Drivers were subdivided into three subgroups based on their RDI score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15) . Mean ratings are shown in Table 7-35. A repeated-measures ANOVA was used to compare RDI score between study phases. There was no effect of study phase ($F(1,74) = 1.02$, $p = .316$) but there was a significant effect of RDI group ($F(2,74) = 3.25$, $p = .045$). The No Abnormality group reported significantly higher intensity of duty period compared to the Moderate to Severe Abnormality group ($p = .013$) (see Figure 7-10).

Table 7-35 Intensity of Duty Period by RDI Score

RDI Score	N	Pre-FMP	Post-FMP
		Mean (SD)	Mean (SD)
No Abnormality (RDI <5)	26	53.5 (13.0)	53.7 (12.9)
Mild Abnormality (RDI: 5-14.9)	30	47.3 (18.5)	49.1 (18.5)
Moderate to Severe (RDI ≥15)	21	46.6 (13.2)	39.6 (15.8)

Note: 1 = Not at all intense, 100 = Extremely intense

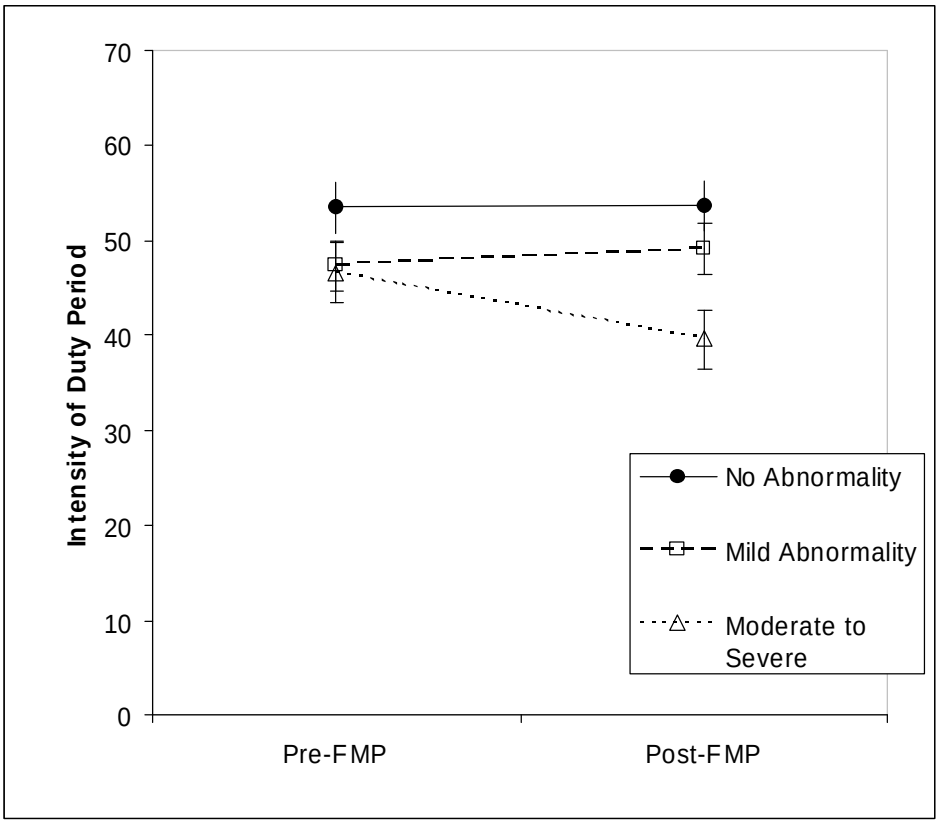


Figure 7-10 Intensity of duty period by RDI score

7.3.4.2 CPAP ADHERENCE

Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time). Mean ratings are shown in Table 7-36. A repeated-measures ANOVA was used to compare CPAP Adherence between study phases. There was no effect of study phase ($F(1,69) = .83$, $p = .366$) or adherence subgroup ($F(2,69) = 1.60$, $p = .208$) on reported duty period intensity.

Table 7-36 Intensity of Duty Period by CPAP Adherence

CPAP Adherence	N	Pre-FMP	Post-FMP
		Mean (SD)	Mean (SD)
No CPAP Required	37	51.6 (15.3)	52.1 (16.3)
CPAP Adherent (>4 hrs (70%))	15	49.4 (15.6)	43.4 (15.0)
CPAP Non-Adherent (<4 hrs (70%))	20	44.9 (17.4)	45.5 (19.0)

Note: 1 = Not at all intense, 100 = Extremely intense

7.3.4.3 ESS SCORE

Drivers were subdivided into three subgroups according to their Epworth Sleepiness Scale (ESS) score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24). Mean ratings are shown in Table 7-37. A repeated-measures ANOVA was used to compare ESS score between study phases. Overall, there was a significant decrease in the reported intensity of duty period, pre-FMP vs. post-FMP ($F(1,73) = 8.42$, $p = .005$) and a significant interaction between study phase and ESS Score ($F(2,73) = 5.80$, $p = .005$). Duty period intensity decreased significantly for the Severe Abnormality group and increased slightly for the other two groups ($p = .001$) (see Figure 7-11).

Table 7-37 Intensity of Duty Period by ESS Score

ESS Score	N	Pre-FMP	Post-FMP
		Mean (SD)	Mean (SD)
No Abnormality (0-10)	59	49.7 (15.4)	50.0 (16.5)
Moderate (11-16)	13	46.6 (17.7)	46.7 (16.7)
Severe (17-24)	4	54.5 (11.0)	30.9 (7.1)

Note: 1 = Not at all intense, 100 = Extremely intense

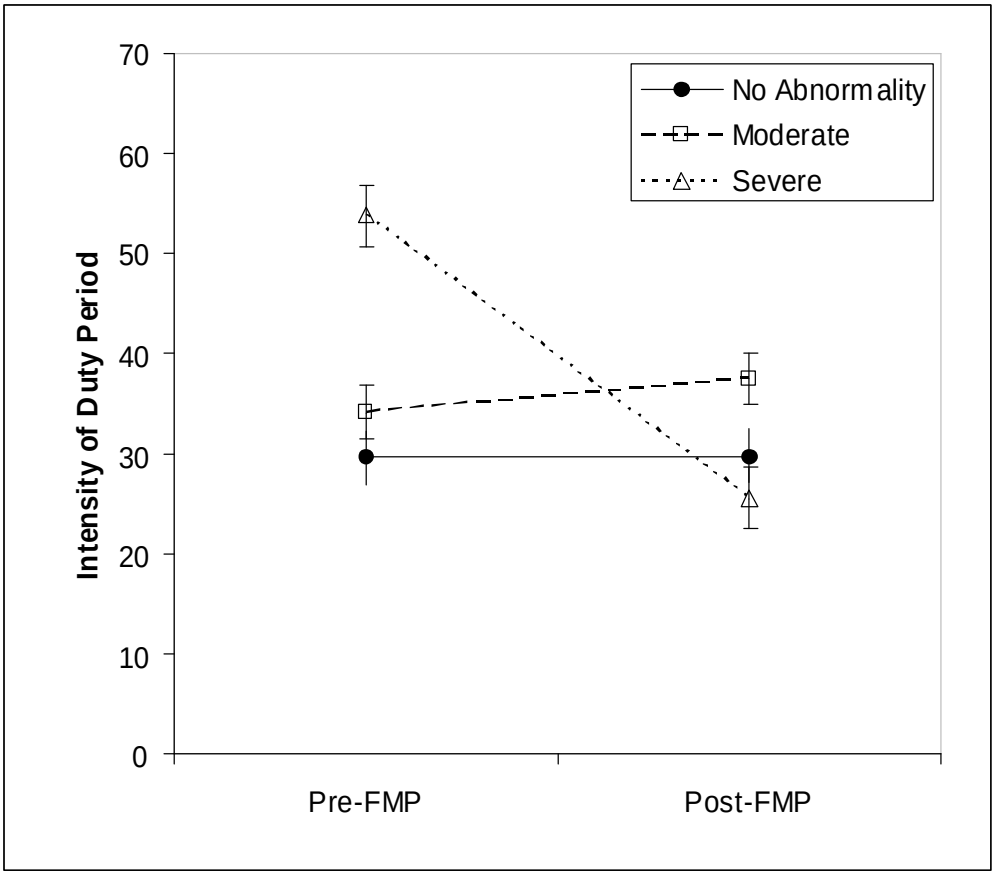


Figure 7-11 Intensity of duty period by ESS score

7.4 Factors Contributing to Fatigue

At the end of each duty period, drivers were asked to rate how much the following three factors contributed to their fatigue:

1. Loading and/or unloading
2. Driving conditions
3. Time spent waiting

Each of these factors is analyzed in the following sections.

7.4.1 Loading and/or Unloading

At the end of each duty period, drivers were asked to rate how much loading and/or unloading contributed to their fatigue on a scale of 1 (not at all) to 100 (extremely). A repeated-measures ANOVA was used to compare the contribution of loading/unloading to fatigue by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between pre-FMP and post-FMP. There was no main effect of study period. There were no main effects of RDI Score, CPAP Adherence, or ESS Score.

7.4.1.1 RDI Score

Drivers were subdivided into three subgroups based on their RDI score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15). Mean ratings are shown in Table 7-38. A repeated-measures ANOVA was used to compare RDI score between study phases. There was no main effect pre-FMP vs. post-FMP ($F(1,74) = .47$, $p = .496$) or between RDI score groups ($F(2,74) = .07$, $p = .935$).

Table 7-38 Contribution of Loading/Unloading to Fatigue by RDI Score

RDI Score	N	Pre-FMP	Post-FMP
		Mean (SD)	Mean (SD)
No Abnormality (RDI < 5)	26	23.9 (18.7)	22.2 (16.9)
Mild Abnormality (RDI: 5 – 14.9)	30	24.2 (20.3)	24.3 (20.5)
Moderate to Severe (RDI ≥ 15)	21	26.0 (19.5)	23.8 (20.2)

Note: 1 = Not at all demanding, 100 = Extremely

7.4.1.2 CPAP Adherence

Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time). Mean ratings are shown in Table 7-39. A repeated-measures ANOVA was used to compare CPAP adherence between study phases. There was no main effect pre-FMP vs. post-FMP ($F(1,69) = .34$, $p = .562$) or between CPAP adherence groups ($F(2,69) = .54$, $p = .585$).

Table 7-39 Contribution of Loading/Unloading to Fatigue by CPAP Adherence

CPAP Adherence	N	Pre-FMP	Post-FMP
		Mean (SD)	Mean (SD)
No CPAP Required	37	23.7 (18.8)	22.2 (20.3)
CPAP Adherent (> 4 hrs (70%))	15	30.4 (24.7)	26.5 (22.2)
CPAP Non-Adherent (< 4 hrs (70%))	20	24.4 (15.7)	26.0 (15.2)

Note: 1 = Not at all demanding, 100 = Extremely

7.4.1.3 ESS Score

Drivers were subdivided into three subgroups according to their Epworth Sleepiness Scale (ESS) score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24). Mean ratings are shown in Table 7-40. A repeated-measures ANOVA was used to compare ESS score between study phases. There was no main effect pre-FMP vs. post-FMP ($F(1,73) = .61$, $p = .436$) or between ESS score groups ($F(2,73) = .09$, $p = .910$).

Table 7-40 Contribution of Loading/Unloading to Fatigue by ESS Score

ESS Score	N	Pre-FMP	Post-FMP
		Mean (SD)	Mean (SD)
No Abnormality (0-10)	59	24.1 (20.5)	23.5 (19.3)
Moderate (11-16)	13	26.8 (15.7)	25.4 (18.3)
Severe (17-24)	4	26.9 (15.9)	21.4 (21.8)

Note: 1 = Not at all demanding, 100 = Extremely

7.4.2 Driving Conditions

At the end of each duty period, drivers were asked to rate how much driving conditions contributed to their fatigue on a scale of 1 (not at all) to 100 (extremely). A repeated-measures ANOVA was used to compare the contribution of driving conditions to fatigue by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between pre-FMP and post-FMP. There was a main effect of study period based on ESS Score analysis. The interaction between study phases and ESS Score was also significant; the mean ratings of the No Abnormality group increased from pre-FMP to post-FMP and decreased for the other two groups. There was a main effect of CPAP Adherence; the CPAP Non-Adherent group reported that driving conditions had a much greater contribution to fatigue compared to the other two groups. There was no main effect of RDI Score.

7.4.2.1 RDI Score

Drivers were subdivided into three subgroups based on their RDI score: No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15). Mean ratings are shown in Table 7-41. A repeated-measures ANOVA was used to compare RDI score between study phases. There was no main effect pre-FMP vs. post-FMP ($F(1,74) = .40$, $p = .530$) or between RDI score groups ($F(2,74) = .77$, $p = .467$).

Table 7-41 Contribution of Driving Conditions to Fatigue by RDI Score

RDI Score	N	Pre-FMP	Post-FMP
		Mean (SD)	Mean (SD)
No Abnormality (RDI <5)	26	26.3 (18.3)	29.8 (15.6)
Mild Abnormality (RDI: 5-14.9)	30	30.7 (17.6)	34.6 (19.1)
Moderate to Severe (RDI ≥15)	21	31.0 (18.2)	28.6 (19.0)

Note: 1 = Not at all, 100 = Extremely

7.4.2.2 CPAP Adherence

Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time). Mean ratings are shown in Table 7-42. A repeated-measures ANOVA was used to compare CPAP adherence between study phases. There was no main effect pre-FMP vs. post-FMP ($F(1,69) = .80$, $p = .375$) however there was a significant effect of CPAP adherence

(F(2,69) = 3.90, p = .025). CPAP Non-Adherent group reported that driving conditions had a much greater contribution to fatigue compared to the CPAP Adherent (p = .041) and No CPAP groups (.009) (see Figure 7-12).

Table 7-42 Contribution of Driving Conditions to Fatigue by CPAP Adherence

CPAP Adherence	N	Pre-FMP	Post-FMP
		Mean (SD)	Mean (SD)
No CPAP Required	37	25.8 (18.2)	29.8 (17.1)
CPAP Adherent (> 4 hrs (70%))	15	26.7 (18.5)	29.8 (18.3)
CPAP Non-Adherent (< 4 hrs (70%))	20	37.5 (15.2)	38.2 (18.7)

Note: 1 = Not at all, 100 = Extremely

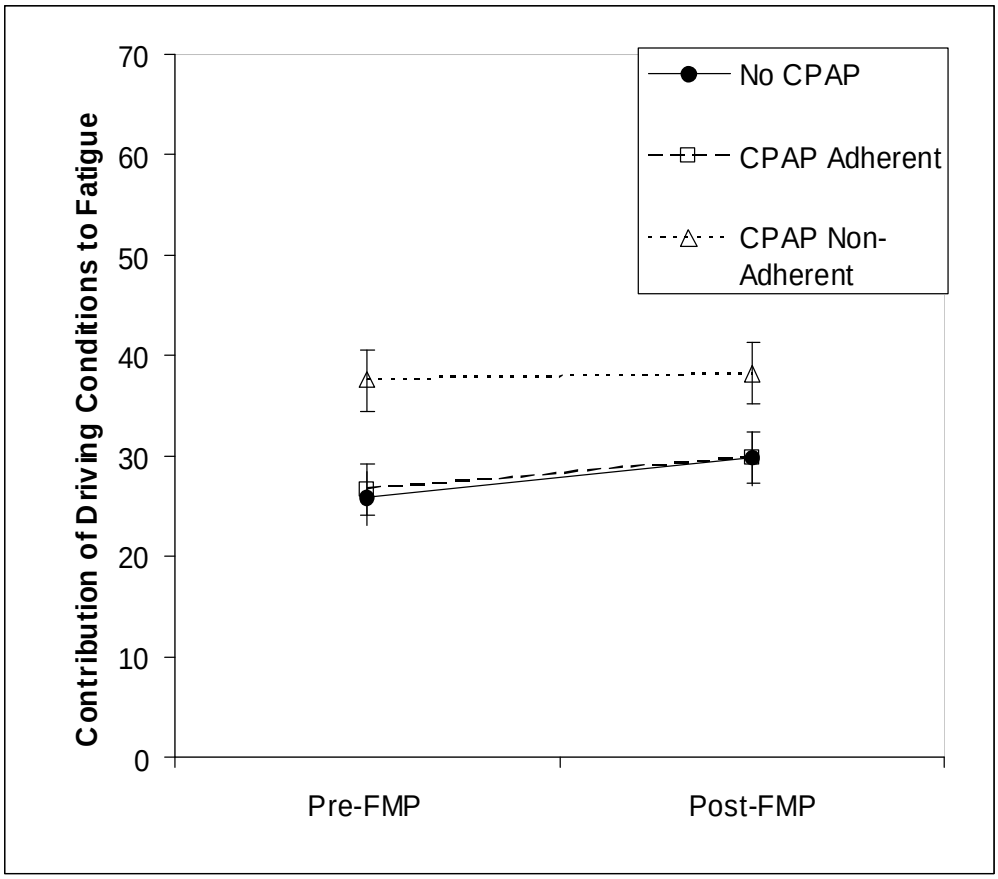


Figure 7-12 Contribution of driving conditions to fatigue by CPAP adherence

7.4.2.3 ESS SCORE

Drivers were subdivided into three subgroups according to their Epworth Sleepiness Scale (ESS) score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24). Mean ratings are shown in Table 7-43. A repeated-measures ANOVA was used to compare ESS score between study phases. There was a significant change in the reported contribution of driving conditions to

fatigue, pre-FMP vs. post-FMP ($F(1,73) = 6.22$, $p = .015$) and the interaction between study phase and ESS score groups was also significant ($F(2,73) = 7.29$, $p = .001$). The mean ratings of the No Abnormality group increased from pre-FMP to post-FMP whereas they decreased for the Moderate Abnormality and Severe Abnormality groups (see Figure 7-13).

Table 7-43 Contribution of Driving Conditions to Fatigue by ESS Score

ESS Score	N	Pre-FMP	Post-FMP
		Mean (SD)	Mean (SD)
No Abnormality (0-10)	59	26.0 (17.5)	32.5 (18.8)
Moderate (11-16)	13	37.2 (15.4)	29.7 (14.6)
Severe (17-24)	4	50.9 (11.7)	21.1 (15.9)

Note: 1 = Not at all, 100 = Extremely

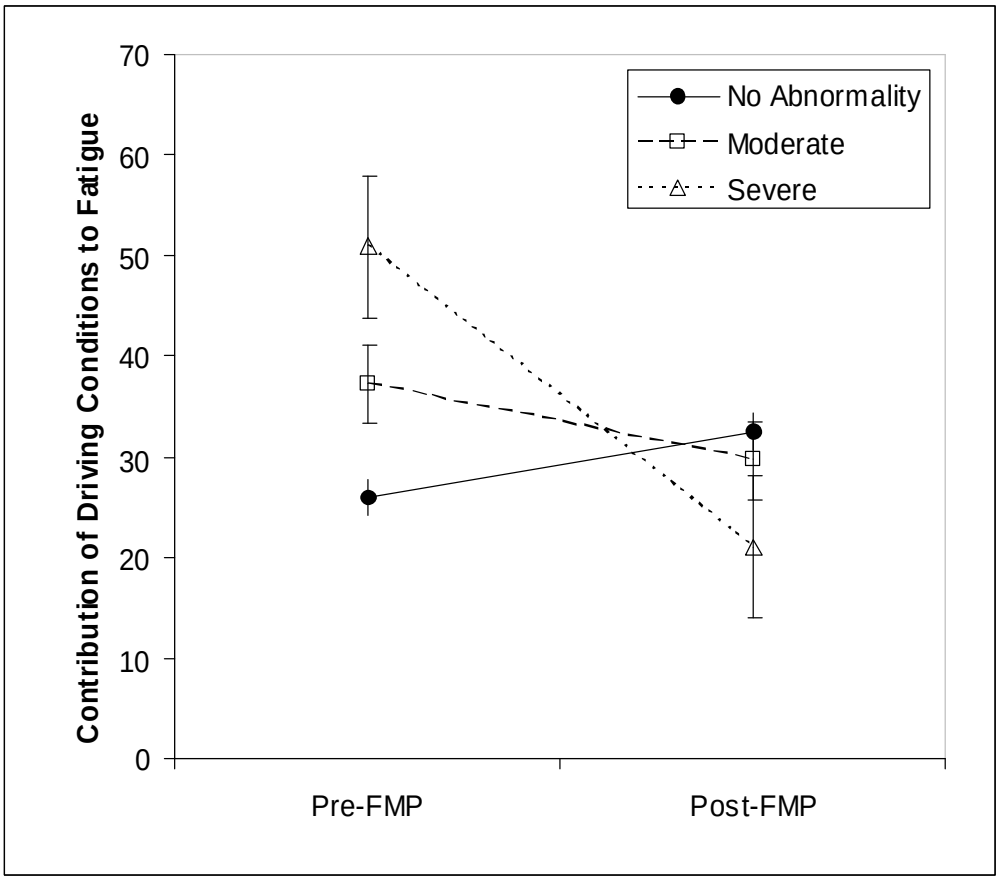


Figure 7-13 Contribution of driving conditions to fatigue by ESS score

7.4.3 Time Spent Waiting

At the end of each duty period, drivers were asked to rate how much time spent waiting contributed to their fatigue on a scale of 1 (not at all) to 100 (extremely). A repeated-measures ANOVA was used to compare the contribution of time spent waiting to fatigue by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between study phases. There was a trend toward higher contribution

to time spent waiting to fatigue post-FMP compared to pre-FMP, based on CPAP Adherence analysis. There were no main effects of RDI Score, CPAP Adherence, or ESS Score.

7.4.3.1 RDI SCORE

Drivers were subdivided into three subgroups based on their RDI score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15). Mean ratings are shown in Table 7-44. A repeated-measures ANOVA was used to compare RDI score between study phases. There was no main effect pre-FMP vs. post-FMP ($F(1,74) = 1.84$, $p = .180$) or between RDI score groups ($F(2,74) = .106$, $p = .900$).

Table 7-44 Contribution of Time Spent Waiting to Fatigue by RDI Score

RDI Score	N	Pre-FMP	Post-FMP
		Mean (SD)	Mean (SD)
No Abnormality (RDI <5)	26	24.8 (18.1)	31.5 (16.5)
Mild Abnormality (RDI: 5-14.9)	30	26.1 (18.2)	26.8 (22.0)
Moderate to Severe (RDI ≥15)	21	25.0 (22.5)	27.0 (23.9)

Note: 1 = Not at all, 100 = Extremely

7.4.3.2 CPAP ADHERENCE

Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time). Mean ratings are shown in Table 7-45. A repeated-measures ANOVA was used to compare CPAP adherence between study phases. There was a trend toward higher contribution of time spent waiting to fatigue post-FMP compared to pre-FMP ($F(1,69) = 2.94$, $p = .091$). There was no main effect of CPAP adherence ($F(2,69) = .514$, $p = .600$).

Table 7-45 Contribution of Time Spent Waiting to Fatigue by CPAP Adherence

CPAP Adherence	N	Pre-FMP	Post-FMP
		Mean (SD)	Mean (SD)
No CPAP Required	37	23.4 (17.3)	27.9 (17.6)
CPAP Adherent (> 4 hrs (70%))	15	28.4 (25.0)	33.6 (25.1)
CPAP Non-Adherent (< 4 hrs (70%))	20	26.6 (17.7)	29.6 (23.6)

Note: 1 = Not at all, 100 = Extremely

7.4.3.3 ESS SCORE

Drivers were subdivided into three subgroups according to their Epworth Sleepiness Scale (ESS) score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24). Mean ratings are shown in Table 7-46. A repeated-measures ANOVA was used to compare ESS score between study phases. There was no main effect pre-FMP vs. post-FMP ($F(1,73) = .41$, $p = .526$) or between ESS score groups ($F(2,73) = 1.30$, $p = .278$).

Table 7-46 Contribution of Time Spent Waiting to Fatigue by ESS Score

ESS Score	N	Pre-FMP	Post-FMP
		Mean (SD)	Mean (SD)
No Abnormality (0-10)	59	24.8 (20.1)	29.7 (21.3)
Moderate (11-16)	13	22.6 (13.3)	23.5 (16.5)
Severe (17-24)	4	45.4 (13.0)	32.1 (24.3)

Note: 1 = Not at all, 100 = Extremely

7.5 Sleep

An Actiwatch (AW-64, MiniMitter, Oregon USA) and PDA (Zire 22, Palm Corp, California USA) was used by drivers to document their sleep-wake behaviour. Drivers were asked to press the Actiwatch event marker each time they went to and got out of bed, whether for a nap or their main sleep episode. Bedtimes, waketimes and subjective sleep quality were reported on the PDA device. Actiwatch recording is based on activity levels. Data are analysed by 15-second bins called epochs. When activity levels fall below a threshold limit, the corresponding epoch is scored as sleep, otherwise it is scored as waking. Several sleep variables can be calculated based on these scored epochs such as the duration of the sleep episode, total sleep time, and sleep efficiency.. The Actiwatch software (Actiware, MiniMitter, Oregon USA) was used to define several sleep parameters including sleep onset and the final awakening at the end of the main sleep period. Sleep latency (actigraphy) is defined as the interval between bedtime and the beginning of the sleep period (sleep onset). The sleep period is defined as the interval between the beginning of the sleep period and the final awakening at the end of the main sleep episode. Total sleep time during the sleep period is the sum of all epochs documented as sleep during this period. It is also equivalent to the duration of the main sleep period from which duration of epochs scored as awake is subtracted. Sleep efficiency based on time in bed is the percentage of epochs considered as sleep in the interval between bedtime and wake time.

7.5.1 Reported Duration of Main Sleep Period

7.5.1.1 Overall Results

The reported duration of the main sleep period was collected using the PDA every day on rest and duty days. Upon awakening from their main sleep period, drivers were asked to estimate the duration of their main sleep period by inputting the hours and minutes using the touch screen interface. A repeated-measures ANOVA was used to compare reported duration of the main sleep period by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between study phases and type of day. There was no main effect of study phase. There was a main effect of type of day observed throughout all subgroup analyses with drivers reporting longer main sleep period duration during rest days compared to duty days. There were no main effects of RDI Score, CPAP Adherence, or ESS Score.

7.5.1.2 RDI Score

Drivers were subdivided into three subgroups based on their RDI Score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15) (see Table 7-47). A repeated-measures ANOVA was used to compare main sleep period duration (factors: RDI Score x Study Phase x Type of Day). There was no

main effect of study phase ($F(1,62) = 1.64$, $p = .205$) or of RDI Score ($F(2,62) = .343$, $p = .711$). However, there was a significant main effect of type of day with longer main sleep duration reported during rest days vs. duty days ($F(1,62) = 59.09$, $p < 0.01$). There were no significant two-way or three-way interactions when considering RDI Score ($F(2,62) \leq 2.28$, $p \geq .111$; $F(2,62) = 2.25$, $p = .114$; respectively).

Table 7-47 Reported Duration of Main Sleep Period by RDI Score

RDI Score	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (hour)	Mean (SD) (hours)	Mean (SD) (hours)	Mean (SD) (hours)
No Abnormality (RDI <5)	23	7.52 (1.11)	6.07 (1.41)	7.35 (1.20)	6.78 (1.00)
Mild Abnormality (RDI: 5-14.9)	24	7.28 (1.33)	6.43 (0.75)	7.64 (0.97)	6.60 (0.94)
Moderate to Severe (RDI ≥15)	18	7.66 (1.36)	6.79 (0.96)	7.47 (0.95)	6.63 (1.09)

7.5.1.3 CPAP ADHERENCE

Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time) (see Table 7-48). A repeated-measures ANOVA was used to compare the reported duration of the main sleep period (factors: CPAP Adherence x Study Phase x Type of Day). There was no main effect of study phase ($F(1,57) = .76$, $p = .388$) or of CPAP Adherence ($F(2,57) = .110$, $p = .896$). However, there was a significant main effect of type of day with longer main sleep period duration reported during rest days vs. duty days ($F(1,57) = 55.57$, $p < 0.01$). There were no significant two-way or three-way interactions when considering CPAP Adherence ($F(2,57) \leq 1.29$, $p \geq .298$; $F(2,57) = .467$, $p = .639$; respectively).

Table 7-48 Reported Duration of Main Sleep Period by CPAP Adherence

CPAP Adherence	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (hour)	Mean (SD) (hour)	Mean (SD) (hour)	Mean (SD) (hour)
No CPAP Required	31	7.50 (1.22)	6.12 (1.21)	7.50 (1.11)	6.63 (1.01)
CPAP Adherent (> 4 hrs (70%))	14	7.70 (1.20)	6.46 (0.93)	7.53 (0.78)	6.52 (0.75)
CPAP Non-Adherent (< 4 hrs (70%))	15	7.22 (1.54)	6.58 (0.88)	7.33 (1.27)	6.62 (0.99)

7.5.1.4 ESS SCORE

Drivers were subdivided into three subgroups according to their ESS Score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24) (see Table 7-49). A repeated-measures ANOVA was used to compare the reported duration of the main sleep period (factors: ESS Score x

Study Phase x Type of Day). There was no main effect of study phase ($F(1,61) = .875$, $p = .353$) or of ESS Score ($F(2,61) = .087$, $p = .917$). However, there was a significant effect of type of day with a longer reported duration of the main sleep period during rest days vs. duty days ($F(1,61) = 19.91$, $p < 0.01$). There were no significant two-way or three-way interactions when considering ESS Score ($F(2,61) \leq 1.43$, $p \geq .246$; $F(2,61) = 6.97$, $p = .502$; respectively).

Table 7-49 Reported Duration of Main Sleep Period by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (hour)	Mean (SD) (hour)	Mean (SD) (hour)	Mean (SD) (hour)
No Abnormality (0-10)	49	7.44 (1.22)	6.46 (1.14)	7.56 (1.06)	6.72 (1.03)
Moderate (11-16)	12	7.82 (1.40)	6.16 (0.93)	7.39 (0.93)	6.38 (0.54)
Severe (17-24)	3	7.33 (1.01)	6.28 (1.41)	7.17 (1.26)	7.22 (1.87)

7.5.2 Reported Total Sleep in Last 24 Hours

7.5.2.1 Overall Results

Total sleep reported in last 24 hours was based on the PDA questionnaire filled out every morning on rest and duty days. A repeated-measures ANOVA was used to compare reported total sleep in last 24 hours by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between study phases and type of days. There was no main effect of study phase, but there was a main effect of type of day observed throughout all subgroup analyses with drivers reporting more total sleep time in the 24 hours preceding rest days than in the 24 hours preceding duty days. . There was a significant interaction between study phase and RDI Score; reported total sleep in last 24 hours increased post-FMP for drivers in the No Abnormality group where as there were non-significant changes for the other two groups. There was a significant interaction between study phase and CPAP Adherence; reported total sleep in last 24 hours increased post-FMP for the No CPAP group but there were non-significant reductions for the other two groups. There was no main effect of ESS Score.

7.5.2.2 RDI Score

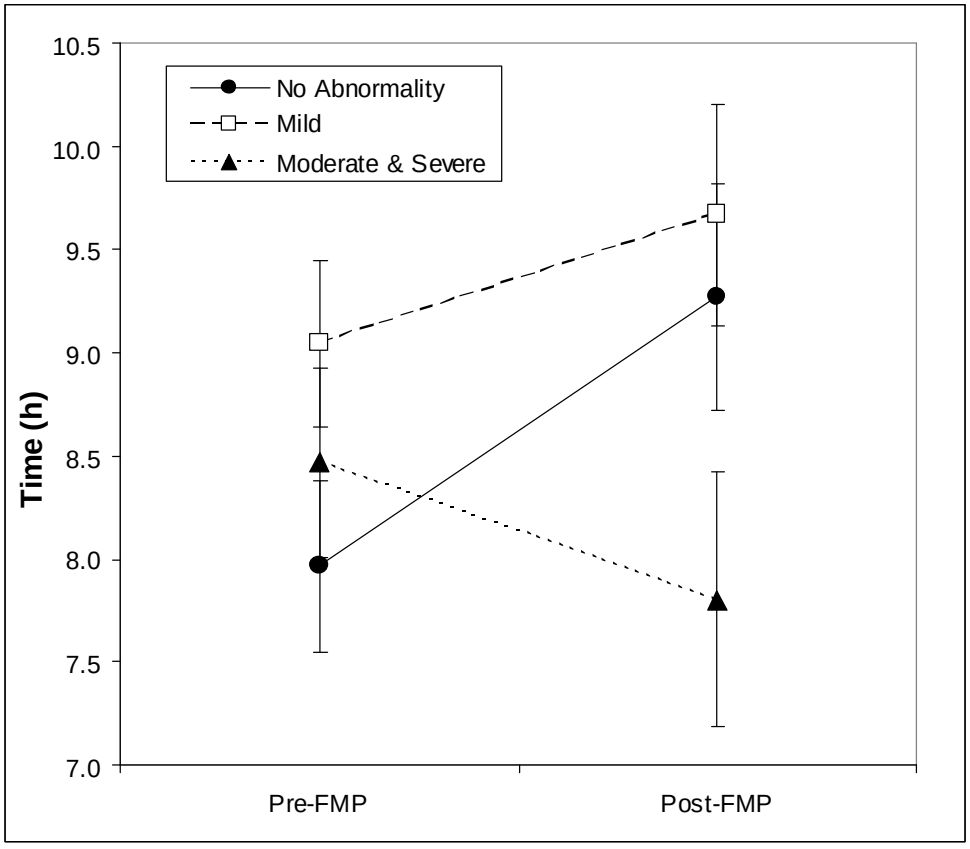
Drivers were subdivided into three subgroups based on their RDI Score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15) (see Table 7-50). A repeated-measures ANOVA was used to compare total sleep reported in the last 24 hours (factors: RDI Score x Study Phase x Type of Day). There was no main effect of study phase ($F(1,62) = 2.21$, $p = .142$) or of RDI Score ($F(2,62) = 1.94$, $p = .152$). However, there was a significant main effect of type of day with more total sleep reported before rest than duty days ($F(1,62) = 22.59$, $p < 0.01$).

There was a significant interaction of study phase and RDI Score for reported total sleep in last 24 hours ($F(2,62) = 3.88$, $p = .026$) (see Figure 7-14). Reported total sleep in last 24 hours increased post FMP for drivers in the No Abnormality RDI group ($p =$

.007) whereas there were non significant changes in the other two RDI groups ($p \geq .182$; see Figure 7-14). Pre-FMP, there was a trend for more reported total sleep in last 24 hours for the No Abnormality compared to the Mild Abnormality group ($p = .064$). Post-FMP, total sleep in last 24 hours in the Moderate to Severe Abnormality group was significantly shorter than the Mild Abnormality group ($p = .027$) and almost significantly shorter than the No Abnormality RDI group ($p = .082$). There was no significant three-way interaction ($F(2,62) = 1.07$, $p = .351$).

Table 7-50 Reported Total Sleep in Last 24 Hours by RDI Score

RDI Score	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (hour)	Mean (SD) (hour)	Mean (SD) (hour)	Mean (SD) (hour)
No Abnormality (RDI < 5)	23	8.36 (1.62)	7.57 (2.03)	9.52 (3.27)	9.02 (3.03)
Mild Abnormality (RDI: 5 – 14.9)	24	9.41 (2.42)	8.68 (2.39)	10.26 (3.19)	9.08 (2.90)
Moderate to Severe (RDI ≥ 15)	18	8.89 (2.31)	8.05 (1.86)	7.97 (1.16)	7.64 (1.91)



*: Significant difference, $p < 0.05$
**: Significant difference, $p < 0.01$

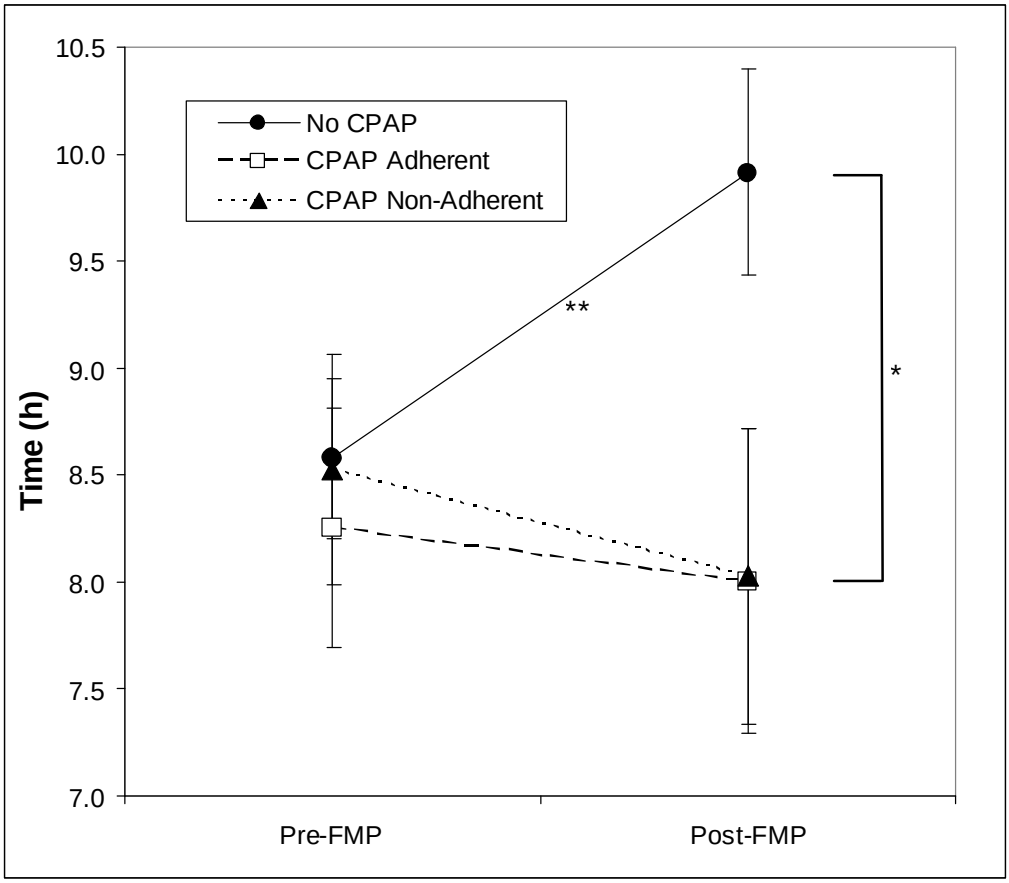
Figure 7-14 Reported total sleep in the last 24 hours, study phase x RDI score interaction

7.5.2.3 CPAP ADHERENCE

Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time) (see Table 7-51). A repeated-measures ANOVA was used to compare reported total sleep in last 24 hours (factors: CPAP Adherence x Study Phase x Type of Day). There was no main effect of study phase ($F(1,57) = .374$, $p = .543$) or of RDI Score ($F(2,57) = 1.87$, $p = .164$). However, there was a significant main effect of type of day with more total sleep in the last 24 hours reported before rest than duty days ($F(1,57) = 37.48$, $p < 0.01$). There was a significant interaction of study phase and CPAP Adherence group for reported total sleep in last 24 hours ($F(2,57) = 4.14$, $p = .021$) (see Figure 7-15). Reported total sleep in last 24 hours increased post-FMP for drivers with no CPAP ($p = 0.002$) but there were non-significant reductions for the other groups ($p \geq .406$). Pre-FMP, there was no difference between groups ($p \geq .630$). Post-FMP, the no CPAP group had significantly more reported total sleep in last 24 hours compared to the CPAP adherent ($p = .030$) and CPAP non-adherent groups ($p = .028$). There was no significant three-way interaction ($F(2,57) = .375$, $p = .689$).

Table 7-51 Reported Total Sleep in Last 24 Hours by CPAP Adherence

CPAP Adherence	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (hour)	Mean (SD) (hour)	Mean (SD) (hour)	Mean (SD) (hour)
No CPAP Required	31	8.93 (2.20)	8.22 (2.48)	10.36 (3.49)	9.47 (3.08)
CPAP Adherent (> 4 hrs (70%))	14	8.88 (1.66)	7.62 (1.29)	8.44 (2.02)	7.56 (1.82)
CPAP Non-Adherent (< 4 hrs (70%))	15	8.78 (2.81)	8.27 (2.42)	8.42 (2.14)	7.63 (2.46)



*: Significant difference, $p < 0.05$
**: Significant difference, $p < 0.01$

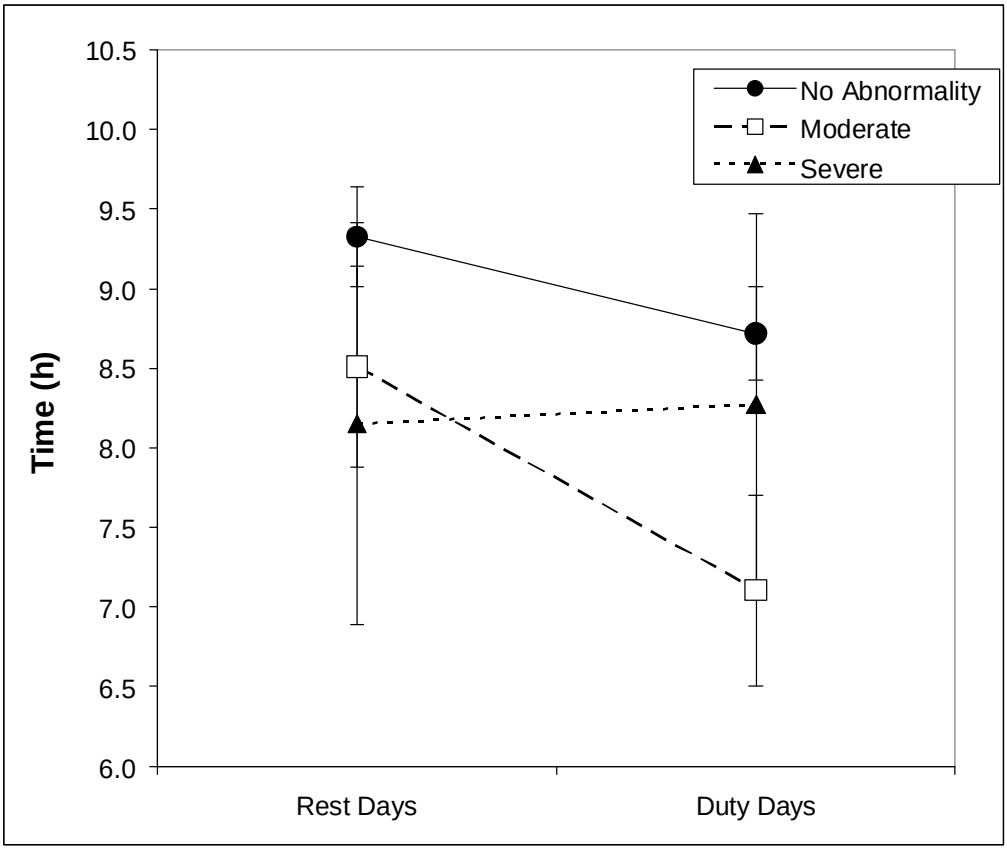
Figure 7-15 Reported total sleep in the last 24 Hours, study phase x CPAP adherence interaction

7.5.2.4 ESS SCORE:

Drivers were subdivided into three subgroups according to their ESS Score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24) (see Table 7-52). A repeated-measures ANOVA was used to compare reported total sleep in last 24 hours (factors: ESS Score x Study Phase x Type of Day). There was no main effect of study phase ($F(1,61) = .127$, $p = .722$) or of ESS Score ($F(2,61) = 1.81$, $p = .173$). However, there was a significant main effect of type of day with more total sleep in the last 24 hours reported before rest than duty days ($F(1,61) = 5.871$, $p = .018$). There was a trend for an interaction of type of day and ESS Score for reported total sleep in last 24 hours ($F(2,51) = 4.16$, $p = .058$) (see Figure 7-16). Reported total sleep in last 24 hours was greater during rest days for drivers in the No Abnormality or Moderate Abnormality groups ($p = .001$, $p < .001$, respectively) whereas there was difference for drivers with Severe Abnormality ($p = .861$). During rest days, there was no difference between groups ($p \geq .370$). Post-FMP, drivers in the No Abnormality group reported significantly more reported total sleep in last 24 hours compared to drivers in the Moderate Abnormality group ($p = .019$).There was no significant three-way interaction ($F(2,61) = .599$, $p = .552$).

Table 7-52 Reported Total Sleep in Last 24 Hours by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (hours)	Mean (SD) (hours)	Mean (SD) (hours)	Mean (SD) (hours)
No Abnormality (0-10)	49	8.99 (2.34)	8.34 (2.36)	9.66 (3.15)	9.10 (3.01)
Moderate (11-16)	12	8.54 (1.56)	7.28 (0.82)	8.48 (2.15)	6.94 (0.53)
Severe (17-24)	3	8.47 (1.12)	7.91 (2.13)	7.83 (0.76)	8.63 (0.46)



*: Significant difference, $p < 0.05$
**: Significant difference, $p < 0.01$

Figure 7-16 Reported total sleep in the last 24 hours, type of day x ESS score interaction

7.5.3 Subjective Sleep Quality

7.5.3.1 Overall Results

Subjective sleep quality was based on a PDA questionnaire filled out every morning on rest and duty days. A repeated-measures ANOVA was used to compare subjective sleep quality by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between study phases and type of days. There was a main effect of study phase for RDI Score subgroup analyses with drivers reporting better subjective sleep quality post-FMP vs. pre-FMP. There were no main effects of RDI Score, CPAP Adherence, or ESS Score.

7.5.3.2 RDI Score

Drivers were subdivided into three subgroups based on their RDI Score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15) (see Table 7-53). A repeated-measures ANOVA was used to compare subjective sleep quality (factors: RDI Score x Study Phase x Type of Day). There was a significant main effect of study phase with better subjective sleep quality post vs. pre-FMP ($F(1,62) = 7.02$ $p = .010$) (see Figure 7-17) and there was no effect of type of day ($F(1,62) = 1.98$, $p = 264$). There was also no main effect of RDI Score ($F(2,62) = .475$, $p = .624$).There were no significant two-way or three-way interactions when considering RDI Score ($F(2, 62) \leq 1.37$, $p \geq .262$; $F(2, 62) = .459$, $p = .634$; respectively).

Table 7-53 Subjective Sleep Quality by RDI Score

RDI Score	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) [a]	Mean (SD) [a]	Mean (SD) [a]	Mean (SD) [a]
No Abnormality (RDI < 5)	23	68.50 (22.15)	62.31 (18.29)	71.29 (20.63)	69.91 (15.55)
Mild Abnormality (RDI: 5 – 14.9)	24	62.42 (17.81)	64 (15.29)	65.63 (19.26)	66.51 (13.85)
Moderate to Severe (RDI ≥ 15)	18	67.45 (16.24)	62.83 (17.20)	73.05 (18.74)	70.53 (16.67)

a. Means are expressed as score: 1 = Extremely bad; 100 = Extremely Good.

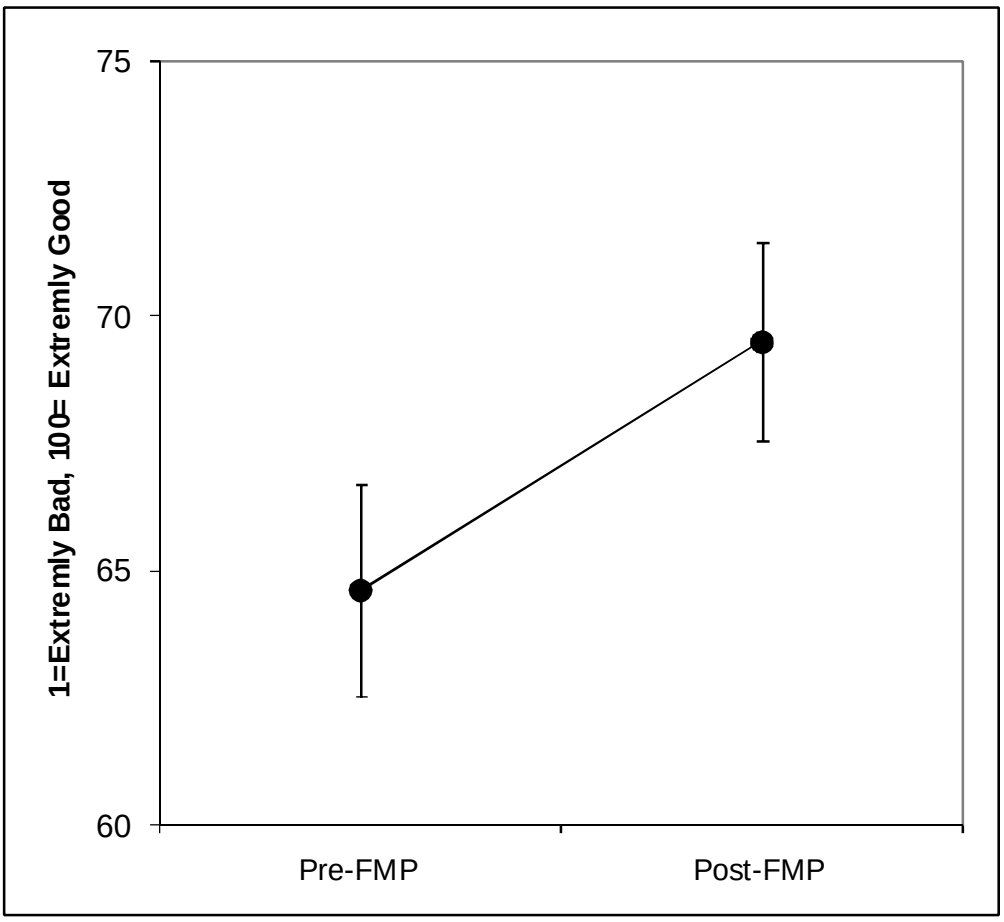


Figure 7-17 Subjective sleep quality

7.5.3.3 CPAP ADHERENCE

Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time) (see Table7.54). A repeated-measures ANOVA was used to compare subjective sleep quality (factors: CPAP Adherence x Study Phase x Type of Day). There was no significant main effect of study phase ($F(1,57) = 2.20$ $p = .144$), of type of day ($F(1,57) = .931$, $p = .339$), or of CPAP Adherence ($F(2,57) = 1.62$, $p> = .206$). There were no significant two-way or three-way interactions with CPAP Adherence ($F(2, 57) \leq .794$, $p \geq .457$; $F(2,57) = .959$, $p = .383$; respectively).

Table 7-54 Subjective Sleep Quality by CPAP Adherence

CPAP Adherence	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) [a]	Mean (SD) [a]	Mean (SD) [a]	Mean (SD) [a]
No CPAP Required	31	68.97 (20.70)	63.98 (17.36)	71.63 (19.27)	70.23 (14.54)
CPAP Adherent (> 4 hrs (70%))	14	63.99 (20.58)	65.92 (19.33)	69.35 (15.45)	69.39 (14.70)
CPAP Non-Adherent (< 4 hrs (70%))	15	64.27 (14.91)	57.74 (12.49)	59.75 (21.65)	61.01 (13.91)

a. Means are expressed as score: 1 = Extremely bad; 100 = Extremely Good.

7.5.3.4 ESS SCORE

Drivers were subdivided into three subgroups according to their ESS Score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24) (see Table 7-55). A repeated-measures ANOVA was used to compare subjective sleep quality (factors: ESS Score x Study Phase x Type of Day). There was a trend for a main effect of study phase with better subjective sleep quality post-FMP compared to pre-FMP ($F(1,61) = 3.28$ $p = .075$,). There was no main effect of type of day ($F(1,61) = .263$, $p = .610$) or of ESS Score ($F(2,61) = .688$, $p = .507$). There were no significant two-way or three-way interactions with ESS Score ($F(2,61) \leq .342$, $p \geq .712$; $F(2,61) = 1.44$, $p = .246$; respectively).

Table 7-55 Subjective Sleep Quality by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) [a]	Mean (SD) [a]	Mean (SD) [a]	Mean (SD) [a]
No Abnormality (0-10)	49	66.64 (19.49)	63.83 (16.58)	70.82 (20.17)	68.78 (15.09)
Moderate (11-16)	12	66.85 (18.73)	61.61 (15.80)	66.82 (14.74)	66.92 (14.33)
Severe (17-24)	3	56.84 (14.19)	48.48 (16.64)	57.83 (29.97)	68.46 (19.08)

a. Means are expressed as score: 1 = Extremely bad; 100 = Extremely Good.

7.5.4 Sleep Latency (Actigraphy)

7.5.4.1 OVERALL RESULTS

Sleep latency (actigraphy) is based on actigraphy and is expressed in minutes. A repeated-measures ANOVA was used to compare sleep latency (actigraphy) by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between study phases and type of days. There was no main effect for study phase. There were no main effects of RDI Score, CPAP Adherence, or ESS Score.

7.5.4.2 RDI SCORE

Drivers were subdivided into three subgroups based on their RDI Score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15) (see Table 7-56). A repeated-measures ANOVA was used to compare sleep latency (actigraphy) (factors: RDI Score x Study Phase x Type of Day). There were no main effects of study phase ($F(1,62) = .716$, $p = .401$), type of day ($F(1,62) = 1.38$, $p = .245$), or RDI Score ($F(2,62) = .920$, $p = .404$). There were no significant two-way or three-way interactions with RDI Score ($F(2,62) \leq 1.01$, $p \geq .341$; $F(2, 62) = .084$, $p = .920$; respectively).

Table 7-56 Sleep Latency (Actigraphy) by RDI Score

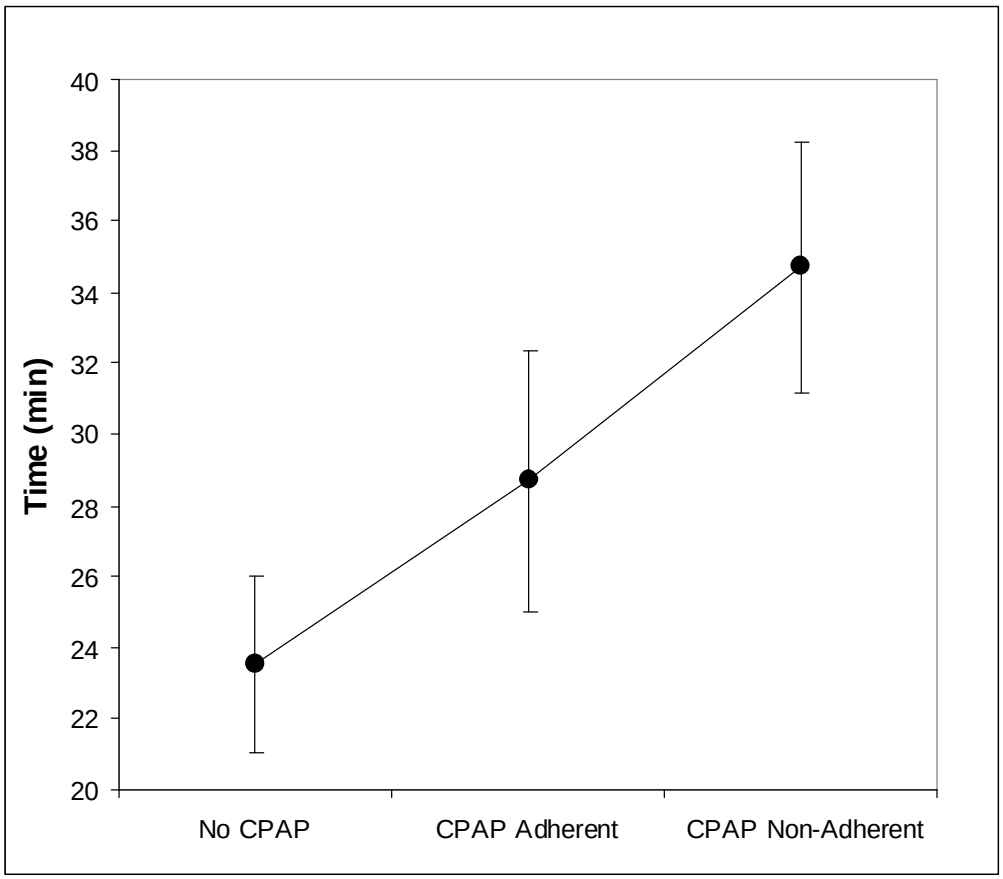
RDI Score	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (minutes)	Mean (SD) (minutes)	Mean (SD) (minutes)	Mean (SD) (minutes)
No Abnormality (RDI < 5)	23	18.74 (12.69)	27.38 (18.13)	23.78 (18.38)	24.88 (16.77)
Mild Abnormality (RDI: 5 – 14.9)	24	23.67 (15.24)	32.57 (27.25)	26.96 (25.19)	28.99 (18.28)
Moderate to Severe (RDI ≥ 15)	18	33.50 (34.85)	32.72 (28.46)	27.11 (27.60)	23.30 (11.77)

7.5.4.3 CPAP ADHERENCE

Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time) (see Table 7-57). A repeated-measures ANOVA was used to compare sleep latency (actigraphy) (factors: CPAP Adherence x Study Phase x Type of Day). There was no main effect of study phase ($F(1,57) = .554$, $p = .460$) or type of day ($F(1,57) = 1.47$, $p = .230$) but there was a significant main effect of CPAP Adherence ($F(2,57) = 3.44$, $p = .039$) (see Figure 7-18). Drivers with no CPAP had a shorter sleep latency (actigraphy) compared to drivers in the CPAP non-adherent group. There was no significant two-way or three-way interaction with CPAP Adherence ($F(2,57) \leq 1.62$, $p \geq .207$; $F(2,57) = .915$, $p = .406$; respectively).

Table 7-57 Sleep Latency (Actigraphy) by CPAP Adherence

CPAP Adherence	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (minutes)	Mean (SD) (minutes)	Mean (SD) (minutes)	Mean (SD) (minutes)
No CPAP Required	31	20.87 (17.18)	26.85 (16.96)	21.16 (18.04)	25.23 (17.57)
CPAP Adherent (> 4 hrs (70%))	14	20.57 (12.50)	37.52 (31.95)	28.79 (30.49)	27.84 (17.59)
CPAP Non-Adherent (< 4 hrs (70%))	15	38.60 (34.63)	36.30 (31.62)	34.47 (28.11)	29.42 (12.57)



*: Significant difference, $p < 0.05$

Figure 7-18 Sleep latency (actigraphy), main effect of CPAP adherence

7.5.4.4 ESS SCORE

Drivers were subdivided into three subgroups according to their ESS Score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24) (see Table 7-58). A repeated-measures ANOVA was used to compare sleep latency (actigraphy) (factors: ESS Score x Study Phase x Type of Day). There was no main effect of study phase ($F(1,61) = .453$, $p = .503$), type of day ($F(1,61) = 1.027$, $p = .308$), or ESS Score ($F(2,61) = .749$, $p = .477$). There was no significant two-way or three-way interaction with ESS Score ($F(2,61) \leq 1.03$, $p \geq .3.64$; $F(2,61) = .855$, $p = .430$; respectively).

Table 7-58 Sleep Latency (Actigraphy) by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (minutes)	Mean (SD) (minutes)	Mean (SD) (minutes)	Mean (SD) (minutes)
No Abnormality (0-10)	49	25.71 (24.21)	31.36 (25.43)	27.29 (23.18)	24.88 (13.23)
Moderate (11-16)	12	23.08 (15.14)	30.12 (24.74)	16.67 (12.52)	29.67 (23.56)
Severe (17-24)	3	20.33 (16.44)	18.83 (5.17)	14.67 (15.57)	17.92 (17.47)

7.5.5 Time Spent in Bed for Main Sleep Episode (PDA, Actigraphy)

7.5.5.1 Overall Results

Time spent in bed was calculated based on the interval between the self-reported time into and out of bed and was verified with actigraphy. A repeated-measures ANOVA was used to compare time spent in bed by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between study phases and type of days. There was no main effect of study phase. A main effect of type of day was observed throughout all subgroup analyses with drivers reporting longer time spent in bed during rest days compared to duty days. There were no main effects of RDI Score, CPAP Adherence, or ESS Score.

7.5.5.2 RDI Score

Drivers were subdivided into three subgroups based on their RDI Score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15) (see Table 7-59). A repeated-measures ANOVA was used to compare time spent in bed (factors: RDI Score x Study Phase x Type of Day). There was no main effect of study phase ($F(1,62) = 1.65$, $p = .203$) or RDI Score ($F(2,62) = .041$, $p = .960$) but there was a significant main effect of type of day with longer time spent in bed during rest days compared to duty days ($F(1,62) = 56.86$, $p < 0.001$). There were no significant two-way or three-way interactions with RDI Score ($F(2,62) \leq 1.52$, $p \geq .226$; $F(2,62) = 2.00$, $p = .144$; respectively).

Table 7-59 Time spent in bed for main sleep episode (PDA, Actigraphy) by RDI Score

RDI Score	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (hours)	Mean (SD) (hours)	Mean (SD) (hours)	Mean (SD) (hours)
No Abnormality (RDI <5)	23	8.17 (1.19)	6.59 (1.45)	8.10 (1.34)	7.55 (1.68)
Mild Abnormality (RDI: 5-14.9)	24	8.14 (1.66)	6.90 (0.89)	8.13 (0.99)	7.11 (1.13)
Moderate to Severe (RDI ≥15)	18	8.15 (1.18)	7.22 (0.84)	8.17 (1.28)	7.05 (0.90)

7.5.5.3 CPAP ADHERENCE

Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time) (see Table 7-60). A repeated-measures ANOVA was used to compare time spent in bed (factors: CPAP Adherence x Study Phase x Type of Day). There was no main effect of study phase ($F(1,57) = .910$, $p = .344$) or CPAP Adherence ($F(2,57) = .015$, $p = .986$) but there was a significant effect of type of day with longer time spent in bed during rest days compared to duty days ($F(1,57) = 52.55$, $p < 0.001$). There were no significant two-way or three-way interactions with CPAP Adherence ($F(2,57) \leq 1.38$, $p \geq .260$; $F(2,57) = .778$, $p = .464$; respectively).

Table 7-60 Time Spent in Bed for Main Sleep Episode (PDA, Actigraphy) by CPAP Adherence

CPAP Adherence	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (hours)	Mean (SD) (hours)	Mean (SD) (hours)	Mean (SD) (hours)
No CPAP Required	31	8.21 (1.37)	6.68 (1.31)	8.20 (1.20)	7.32 (1.59)
CPAP Adherent (>4 hrs (70%))	14	8.45 (1.32)	6.96 (0.97)	8.05 (1.13)	6.95 (0.87)
CPAP Non-Adherent (<4 hrs (70%))	15	7.83 (1.53)	7 (0.86)	8.20 (1.39)	7.20 (0.93)

7.5.5.4 ESS SCORE

Drivers were subdivided into three subgroups according to their ESS Score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24) (see Table 7-61). A repeated-measures ANOVA was used to compare time spent in bed (factors: ESS Score x Study Phase x Type of Day). There was no main effect of study phase ($F(1,61) = 1.27$, $p = .263$) or ESS Score ($F(2,61) = .399$, $p = .673$) but there was a significant effect of type of day with longer time spent in bed during rest days compared to duty days ($F(1,61) = 16.58$, $p < 0.001$). There were no significant two-way or three-way interactions with ESS Score ($F(2,61) \leq 1.82$, $p \geq .170$; $F(2,61) = .818$, $p = .446$; respectively).

Table 7-61 Time Spent in Bed for Main Sleep Episode (PDA, Actigraphy) by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (hours)	Mean (SD) (hours)	Mean (SD) (hours)	Mean (SD) (hours)
No Abnormality (0-10)	49	8.13 (1.33)	6.95 (1.18)	8.24 (1.19)	7.32 (1.41)
Moderate (11-16)	12	8.66 (1.32)	6.61 (0.86)	7.93 (1.27)	6.88 (0.62)
Severe (17-24)	3	7.34 (1.25)	6.45 (1.19)	7.50 (0.75)	7.74 (1.74)

7.5.6 Duration of Main Sleep Period (Actigraphy)

7.5.6.1 Overall Results

The sleep period is defined as the interval between sleep onset and the final awakening from the main sleep period. It is based on actigraphy and is expressed in hours. This parameter does not take into account the composition of the sleep period, e.g., the proportion of epochs scored as sleep or waking within the sleep period itself. A repeated-measures ANOVA was used to compare the duration of the main sleep period based on actigraphy by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between study phases and type of days. There was no main effect of study phase. A main effect of type of day was observed throughout the analysis with drivers reporting longer sleep period based on actigraphy during rest days compared to duty days. There were no main effects of RDI Score, CPAP Adherence, or ESS Score.

7.5.6.2 RDI Score

Drivers were subdivided into three subgroups based on their RDI Score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15) (see Table 7-62). A repeated-measures ANOVA was used to compare the duration of the main sleep period based on actigraphy (factors: RDI Score x Study Phase x Type of Day). There was no main effect of study phase ($F(1,62) = 2.57$, $p = .114$) or RDI Score ($F(2,62) = .030$, $p = .971$) but there was a significant effect of type of day with longer main sleep period during rest days compared to duty days ($F(1,62) = 64.66$, $p < .001$). There were no significant two-way or three-way interactions with RDI Score ($F(2,62) \leq .219$, $p \geq .804$; $F(2,62) = 1.98$, $p = .146$; respectively).

Table 7-62 Duration of Main Sleep Period (Actigraphy) by RDI Score

RDI Score	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (hours)	Mean (SD) (hours)	Mean (SD) (hours)	Mean (SD) (hours)
No Abnormality (RDI <5)	23	7.53 (1.24)	5.88 (1.32)	7.31 (1.12)	6.67 (1.07)
Mild Abnormality (RDI: 5-14.9)	24	7.29 (1.51)	6.15 (0.78)	7.46 (1.16)	6.36 (1.06)
Moderate to Severe (RDI ≥15)	18	7.30 (1.28)	6.34 (0.84)	7.39 (1.17)	6.44 (0.87)

7.5.6.3 CPAP ADHERENCE

Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time) (see Table 7-63). A repeated-measures ANOVA was used to compare the duration of the main sleep period based on actigraphy (factors: CPAP Adherence x Study Phase x Type of Day). There was no main effect of study phase ($F(1,57) = 2.15$, $p = .148$) or CPAP Adherence ($F(2,57) = .288$, $p = .751$) but there was a significant effect of type of day with a longer main sleep period during rest days compared to duty days ($F(1,57) = 59.78$, $p < .001$). There were no significant two-way or three-way interactions with CPAP Adherence ($F(2,57) \leq .798$, $p \geq .455$; $F(2,57) = .366$, $p = .695$; respectively).

Table 7-63 Duration of Main Sleep Period (Actigraphy) by CPAP Adherence

CPAP Adherence	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (hours)	Mean (SD) (hours)	Mean (SD) (hours)	Mean (SD) (hours)
No CPAP Required	31	7.52 (1.32)	5.99 (1.21)	7.50 (1.10)	6.46 (1.10)
CPAP Adherent (>4 hrs (70%))	14	7.55 (1.15)	6.09 (0.72)	7.27 (0.92)	6.31 (0.76)
CPAP Non-Adherent (<4 hrs (70%))	15	6.93 (1.66)	6.06 (0.80)	7.31 (1.50)	6.44 (0.87)

7.5.6.4 ESS SCORE

Drivers were subdivided into three subgroups according to their ESS Score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24) (see Table 7-64). A repeated-measures ANOVA was used to compare the duration of the main sleep period based on actigraphy (factors: ESS Score x Study Phase x Type of Day). There was no main effect of study phase ($F(1,61) = 2.33$, $p = .132$) or ESS Score ($F(2,61) = .095$, $p = .909$) but there was a significant effect of type of day with a longer main sleep period during rest vs. duty days ($F(1,61) \leq 18.97$, $p \geq .001$). There was no significant two-way or three-way interaction with ESS Score ($F(2,61) \geq 2.23$, $p = .126$; $F(2,61) = .259$, $p = .759$; respectively).

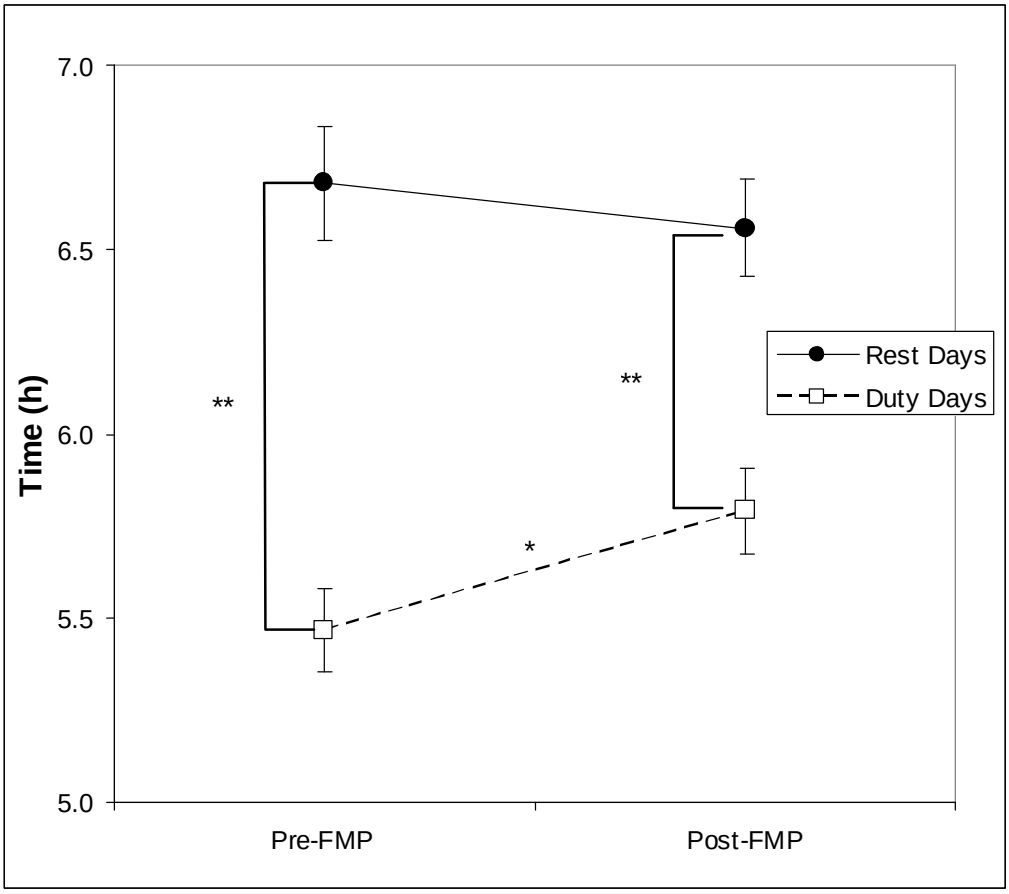
Table 7-64 Duration of Main Sleep Period (Actigraphy) by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (hours)	Mean (SD) (hours)	Mean (SD) (hours)	Mean (SD) (hours)
No Abnormality (0-10)	49	7.38 (1.31)	6.17 (1.09)	7.45 (1.12)	6.55 (1.02)
Moderate (11-16)	12	7.79 (1.21)	5.92 (0.63)	7.42 (1.16)	6.17 (0.57)
Severe (17-24)	3	6.75 (1.55)	5.93 (1.43)	7.02 (0.56)	7.20 (2.00)

7.5.7 Sleep Achieved during Main Sleep Period (Actigraphy)

7.5.7.1 Overall Results

The main sleep period is divided into 15-sec epochs which are scored as either sleep or waking by the Actiwatch software. The sums of all epochs scored as sleep within the main sleep period can be computed and is referred to as the "sleep achieved during the main sleep period" and is expressed in hours. This measurement is also equivalent to the duration of the main sleep episode from which the time spent awake during the sleep period is subtracted. A repeated-measures ANOVA was used to compare sleep achieved during the main sleep period based on actigraphy by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between study phases and type of days. There was no main effect of study phase. There was a main effect of type of day observed throughout the analysis with longer sleep achieved during the main sleep period on rest days compared to duty days. There was also a significant interaction of type of day and study phase (see Figure 7-19). For rest days, sleep achieved during the main sleep period was not significantly longer pre-FMP vs. post-FMP. For duty days, sleep achieved during the main sleep period was significantly longer during post-FMP compared to pre-FMP. There no main effects of RDI Score, CPAP Adherence, or ESS Score.



*: Significant difference, p < 0.05
**: Significant difference, p < 0.01

Figure 7-19 Sleep achieved during main sleep period (actigraphy), study phase x type of day interaction

7.5.7.2 RDI SCORE

Drivers were subdivided into three subgroups based on their RDI Score: No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15) (see Table 7-65). A repeated-measures ANOVA was used to compare sleep achieved during main sleep period (factors: RDI Score x Study Phase x Type of Day). There was no main effect of study phase ($F(1,62) = .916$, $p = .342$) or of RDI Score ($F(2,62) = .005$, $p = .995$).

However, there was a significant interaction of type of day and study phase ($F(1,62) = 4.52$, $p = .037$) (see Figure 7-19). For duty days, drivers had a longer sleep achieved during the main sleep period post-FMP vs. pre-FMP ($p = .008$). Overall, drivers had a longer sleep achieved during the main sleep period on rest days compared to duty days ($p < .001$). There was also a significant main effect of type of day with longer sleep achieved during the main sleep period on rest days compared to duty days ($F(1,62) = 65.04$, $p < .001$). There were no significant two-way or three-way interactions with RDI Score ($F(2,62) \leq .308$, $p \geq .736$; $F(2,62) = 1.63$, $p = .205$; respectively).

Table 7-65 Sleep Achieved During Main Sleep Period (Actigraphy) by RDI Score

RDI Score	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (hours)	Mean (SD) (hours)	Mean (SD) (hours)	Mean (SD) (hours)
No Abnormality (RDI <5)	23	6.79 (1.10)	5.25 (1.20)	6.52 (0.99)	5.95 (1.02)
Mild Abnormality (RDI: 5-14.9)	24	6.69 (1.40)	5.49 (0.73)	6.59 (1.11)	5.67 (0.98)
Moderate to Severe (RDI ≥15)	18	6.56 (1.17)	5.66 (0.69)	6.56 (1.05)	5.75 (0.72)

7.5.7.3 CPAP ADHERENCE

Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time) (see Table 7-66). A repeated-measures ANOVA was used to compare sleep achieved during the main sleep period based on actigraphy (factors: CPAP Adherence x Study Phase x Type of Day). There was no main effect of study phase ($F(1,57) = .659$, $p = .426$) or of CPAP Adherence ($F(2,57) = .498$, $p = .611$) but there was a trend for an interaction of type of day and study phase ($F(1,57) = 3.40$, $p = .070$). For duty days, there was more sleep achieved during the main sleep period post-FMP as compared to pre-FMP ($p = .023$). Overall, there was more sleep achieved during the main sleep period on rest days compared to duty days ($p < .001$). There was also a significant main effect of type of day with longer sleep achieved during the main sleep period on rest days compared to duty days ($F(1,57) = 63.33$, $p < .001$). There were no significant two-way or three-way interactions with CPAP Adherence ($F(2,57) \leq .980$, $p \geq .382$; $F(2,57) = .550$, $p = .580$; respectively).

Table 7-66 Sleep Achieved During the Main Sleep Period based on Actigraphy by CPAP Adherence

CPAP Adherence	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (hours)	Mean (SD) (hours)	Mean (SD) (hours)	Mean (SD) (hours)
No CPAP Required	31	6.78 (1.14)	5.33 (1.09)	6.69 (0.97)	5.76 (1.05)
CPAP Adherent (>4 hrs (70%))	14	6.98 (1.25)	5.45 (0.63)	6.52 (0.86)	5.73 (0.62)
CPAP Non-Adherent (<4 hrs (70%))	15	6.25 (1.47)	5.43 (0.76)	6.42 (1.37)	5.67 (0.83)

7.5.7.4 ESS SCORE

Drivers were subdivided into three subgroups according to their ESS Score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24) (see Table 7-67). A repeated-measures ANOVA was used to compare sleep achieved during the main sleep period based on actigraphy

(factors: ESS Score x Study Phase x Type of Day). There was no main effect of study phase ($F(1,61) = 2.09$, $p = .153$) or ESS Score ($F(2,61) = .053$, $p = .949$) but there was a trend for an interaction of type of day and study phase ($F(1,61) = 3.28$, $p = .075$). Pre-FMP and post-FMP, there was more sleep achieved during the main sleep period on rest days compared to duty days ($p \leq .029$). There was also more sleep achieved post-FMP compared to pre-FMP for duty days ($p = .006$). There was a significant effect of type of day with longer sleep achieved during the main sleep period on rest days compared to duty days ($F(1,61) = 19.38$, $p < 0.001$). There was no significant two-way or three-way interaction with ESS Score ($F(2,61) \leq 2.36$, $p \geq .103$; $F(2,61) = 3.66$, $p = .695$; respectively).

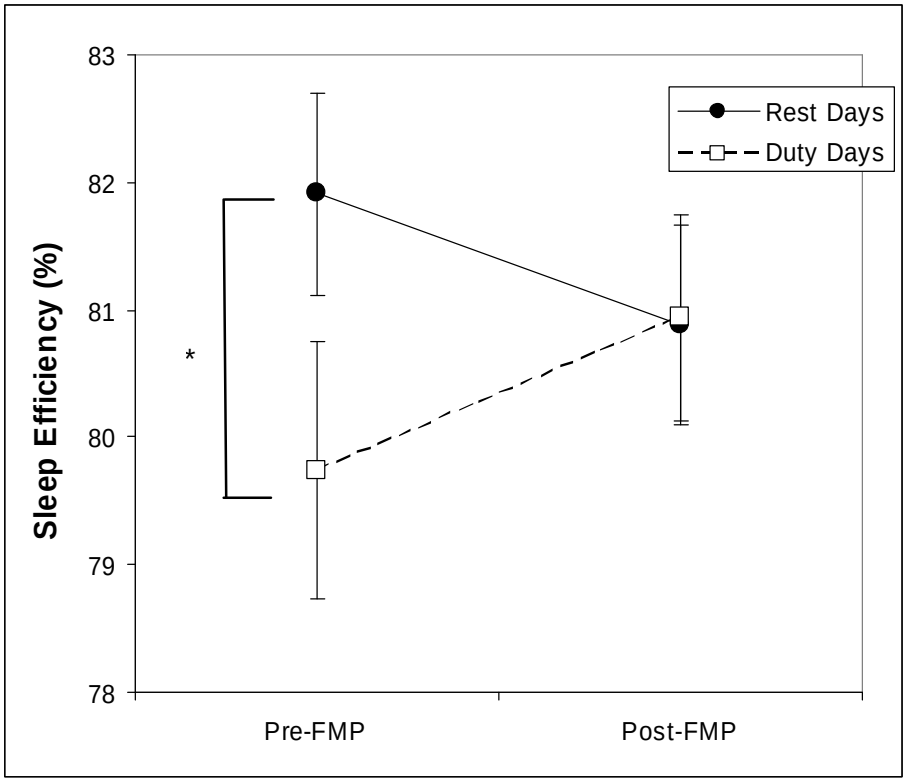
Table 7-67 Sleep Achieved During the Main Sleep Period based on Actigraphy by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (hours)	Mean (SD) (hours)	Mean (SD) (hours)	Mean (SD) (hours)
No Abnormality (0-10)	49	6.67 (1.17)	5.52 (0.97)	6.59 (1.01)	5.82 (0.93)
Moderate (11-16)	12	7.17 (1.15)	5.29 (0.60)	6.68 (1.03)	5.61 (0.52)
Severe (17-24)	3	6.04 (1.31)	5.29 (1.03)	6.37 (0.39)	6.51 (1.76)

7.5.8 Sleep Efficiency during Time in Bed (Actigraphy)

7.5.8.1 Overall Results

Sleep efficiency while in bed is based on actigraphy and is the percent of time spent asleep in the interval between bedtime and wake time (e.g., from the time the driver gets into and out of bed for his main sleep period). A repeated-measures ANOVA was used to compare sleep efficiency during the time in bed by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between study phases and type of days. There was no main effect of study phase but there was a significant interaction of type of day and study phase (see Figure 7-20) for RDI Score and CPAP Adherence analyses. Pre-FMP, sleep efficiency during the time in bed increased during rest days compare to duty days, but not during post-FMP. There were no main effects of RDI Score, CPAP Adherence, or ESS Score.



*: Significant difference, p < 0.05
**: Significant difference, p < 0.01

Figure 7-20 Sleep efficiency during the time in bed, study phase x type of day interaction

7.5.8.2 RDI SCORE

Drivers were subdivided into three subgroups based on their RDI Score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15) (see Table 7-68). A repeated-measures ANOVA was used to compare sleep efficiency during the time in bed (factors: RDI Score x Study Phase x Type of Day). There was no main effect of study phase ($F(1,62) = .014$, $p = .908$), type of day ($F(1,62) = 2.72$, $p = .104$), or RDI Score ($F(2,62) = .144$, $p = .866$). There was a significant interaction of type of day and study phase ($F(1,62) = 4.13$, $p = .046$). Pre-FMP, there was better sleep efficiency during rest days compared to duty days ($p = .013$). There were no significant two-way or three-way interactions with RDI Score ($F(2,62) \leq 1.60$, $p = .211$; $F(2,62) = .118$, $p = .889$; respectively).

Table 7-68 Sleep Efficiency during the Time in Bed by RDI Score

RDI Score	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (%)	Mean (SD) (%)	Mean (SD) (%)	Mean (SD) (%)
No Abnormality (RDI <5)	23	82.93 (5.41)	79.70 (6.29)	81.65 (7.60)	81.34 (6.46)
Mild Abnormality (RDI: 5-14.9)	24	82.66 (5.85)	79.63 (8.68)	80.69 (7.92)	79.77 (7.36)
Moderate to Severe (RDI ≥15)	18	80.14 (8.75)	79.92 (9.37)	80.31 (7.40)	81.72 (4.87)

7.5.8.3 CPAP ADHERENCE

Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time) (see Table 7-69). A repeated-measures ANOVA was used to compare sleep efficiency during the time in bed (factors: CPAP Adherence x Study Phase x Type of Day). There was no main effect of study phase ($F(1,57) = .077$, $p = .782$), type of day ($F(1,57) = 2.665$, $p = 0.108$), or CPAP Adherence ($F(2,57) = 1.268$, $p = .289$). There was a significant interaction of type of day and study phase ($F(1,57) = 4.34$, $p = .042$). Pre-FMP, there was better sleep efficiency during rest days compared to work days ($p = .018$). There were no significant two-way or three-way interactions with CPAP Adherence ($F(2,57) \leq 1.581$, $p \geq .215$; $F(2,57) = .479$, $p = .622$; respectively).

Table 7-69 Sleep Efficiency during the Time in Bed by CPAP Adherence

CPAP Adherence	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (%)	Mean (SD) (%)	Mean (SD) (%)	Mean (SD) (%)
No CPAP Required	31	82.84 (5.15)	79.70 (6.82)	82.50 (6.69)	80.52 (6.60)
CPAP Adherent (>4 hrs (70%))	14	82.45 (8.14)	79.76 (7.94)	81.55 (7.98)	82.75 (5.86)
CPAP Non-Adherent (<4 hrs (70%))	15	79.65 (8.31)	78.35 (10.9)	77.74 (9.05)	79.03 (6.91)

7.5.8.4 ESS SCORE

Drivers were subdivided into three subgroups according to their ESS Score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24) (see Table 7-70). A repeated-measures ANOVA was used to compare sleep efficiency during the time in bed (factors: ESS Score x Study Phase x Type of Day). There was no main effect of study phase ($F(1,61) = 1.257$, $p = .267$), type of day ($F(1,61) = 1.83$, $p = .181$), or ESS Score ($F(2,61) = .672$, $p = .515$).There were no significant two-way or three-way interactions with ESS Score ($F(2,61) \leq 1.06$, $p \geq .353$; $F(2,61) = 547$, $p = .586$; respectively).

Table 7-70 Sleep Efficiency during the Time in Bed by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (%)	Mean (SD) (%)	Mean (SD) (%)	Mean (SD) (%)
No Abnormality (0-10)	49	82.10 (6.85)	79.97 (8.00)	80.34 (6.97)	80.76 (6.15)
Moderate (11-16)	12	83.16 (5.15)	80.18 (6.63)	84.58 (5.01)	81.81 (5.99)
Severe (17-24)	3	81.60 (6.01)	81.17 (6.52)	85.23 (4.62)	84.00 (7.98)

7.6 Naps

7.6.1 Mean Nap Duration

7.6.1.1 Overall Results

Mean Nap duration was based on a PDA questionnaire filled out at the end of each day on rest and duty days. A repeated-measures ANOVA was used to compare mean nap duration by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between study phases and type of days. There was no main effect of study phase. There were no main effects of RDI Score, CPAP Adherence, or ESS Score.

7.6.1.2 RDI Score

Drivers were subdivided into three subgroups based on their RDI Score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15) (see Table 7-71). A repeated-measures ANOVA was used to compare mean nap duration (factors: RDI Score x Study Phase x Type of Day). There were no main effects of study phase ($F(1,62) = .030$, $p = .863$), type of day ($F(1,62) = .706$, $p = .404$), or RDI Score ($F(2,62) = .116$, $p = .891$). There were no significant two-way or three-way interactions with RDI Score ($F(2,62) \leq 1.85$, $p \geq .167$; $F(2,62) = .620$, $p = .541$; respectively).

Table 7-71 Mean Nap Duration by RDI Score

RDI Score	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (minutes)	Mean (SD) (minutes)	Mean (SD) (minutes)	Mean (SD) (minutes)
No Abnormality (RDI < 5)	23	17.22 (36.96)	22.26 (35.94)	11.82 (30.42)	10.92 (20.58)
Mild Abnormality (RDI: 5 – 14.9)	24	15.48 (33.18)	22.02 (25.68)	19.02 (45.18)	15.66 (27.36)
Moderate to Severe (RDI ≥ 15)	18	10.32 (16.02)	14.46 (27.18)	13.56 (25.98)	27.24 (57.60)

7.6.1.3 CPAP ADHERENCE

Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time) (see Table 7-72). A repeated-measures ANOVA was used to compare mean nap duration (factors: CPAP Adherence x Study Phase x Type of Day). There were no main effects of study phase ($F(1,62) = .005$, $p = .943$), type of day ($F(1,62) = .000$, $p = .995$), or CPAP Adherence ($F(2,62) = .030$, $p = .970$). There were no significant two-way or three-way interactions with CPAP Adherence ($F(2,62) \leq 2.11$, $p \geq .130$; $F(2,62) = 1.73$, $p = .187$; respectively).

Table 7-72 Mean nap duration by CPAP Adherence

CPAP Adherence	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (minutes)	Mean (SD) (minutes)	Mean (SD) (minutes)	Mean (SD) (minutes)
No CPAP Required	31	19.68 (40.56)	21.66 (34.62)	9.18 (26.52)	14.76 (26.70)
CPAP Adherent (> 4 hrs (70%))	14	13.98 (20.88)	16.50 (20.94)	19.68 (29.46)	10.44 (14.28)
CPAP Non-Adherent (< 4 hrs (70%))	15	5.46 (11.52)	19.08 (23.46)	27.54 (54.90)	13.26 (19.08)

7.6.1.4 ESS SCORE

Drivers were subdivided into three subgroups according to their ESS Score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24) (see Table 7-73). A repeated-measures ANOVA was used to compare mean nap duration (factors: ESS Score x Study Phase x Type of Day). There were no main effects of study phase ($F(1,62) = 1.46$, $p = .231$), type of day ($F(1,62) = .001$, $p = .970$), or ESS Score ($F(2,62) = .345$, $p = .710$). There were no significant two-way with ESS Score ($F(2,62) \leq 2.23$, $p \geq .116$) but there was a significant three-way interaction ($F(2,62) = 3.26$, $p = .045$). During rest days at pre-FMP, the Severe Abnormality group had significantly longer mean nap duration compared to the other groups ($p \leq .046$). During rest days at post-FMP, there was a trend for an increased mean nap duration in the Moderate Abnormality group compared to the No Abnormality group ($p = 0.08$). Drivers in the Moderate Abnormality group had longer mean nap duration ($p = .035$) post-FMP vs. pre-FMP during rest days, while the Severe Abnormality group had shorter mean nap duration ($p = .038$) post vs. pre-FMP (see Figure 7-21).

Table 7-73 Mean Nap Duration by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Rest Days	Duty Days	Rest Days	Duty Days
		Mean (SD) (minutes)	Mean (SD) (minutes)	Mean (SD) (minutes)	Mean (SD) (minutes)
No Abnormality (0-10)	49	14.82 (28.02)	19.44 (31.92)	12.00 (33.12)	18.24 (41.04)
Moderate (11-16)	12	6.06 (12.42)	20.76 (18.36)	32.04 (44.58)	11.52 (11.58)
Severe (17-24)	3	51.18 (88.68)	26.58 (46.08)	00.00 (00.00)	21.60 (37.44)

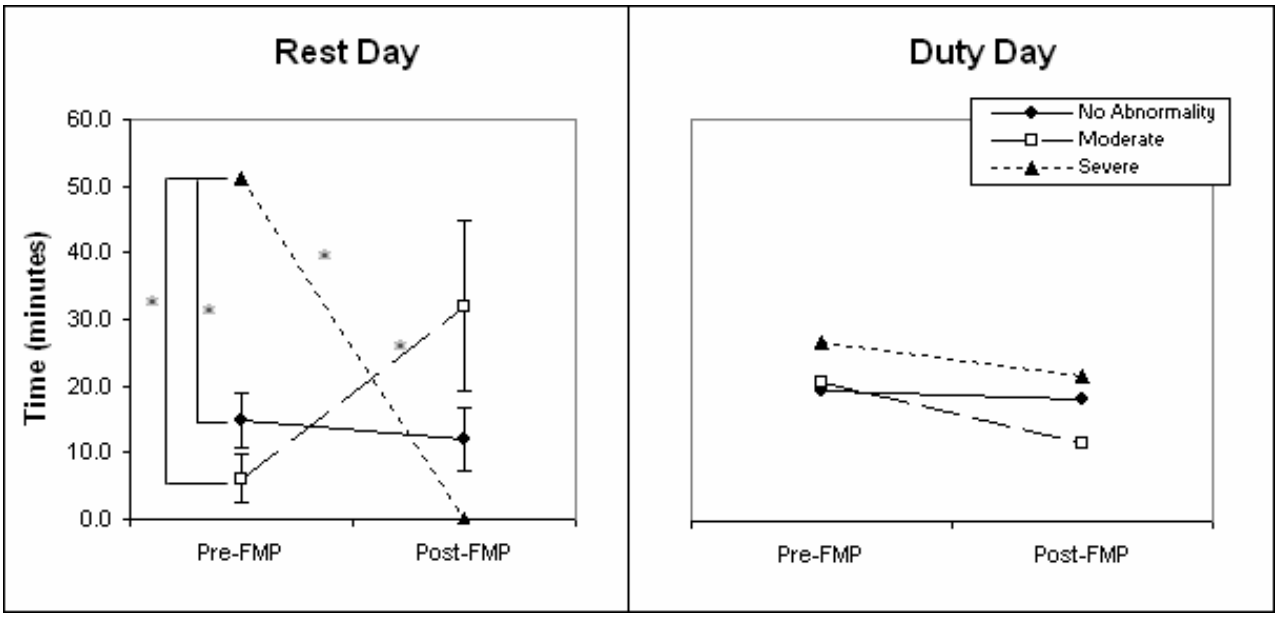


Figure 7-21 Mean nap duration by ESS score, three-way interaction

7.6.2 Napping Behaviour

There were no differences between pre and post-FMP in the percentage of drivers who napped. Table 7-74 shows the average percentage of drivers who napped, the average daily nap duration for all drivers or for those who napped.

Table 7-74 Napping Behaviour

	Pre-FMP		Post-FMP	
	Rest Days	Duty Days	Rest Days	Duty Days
Average drivers who napped (%)	35.38%	56.92%	32.31%	49.23%
Average daily nap duration for all drivers (min SD)	14.68 (30.67)	19.98 (29.80)	14.95 (35.23)	17.21 (36.62)
Average nap duration for drivers who napped (min SD)	41.47 (39.67)	35.10 (32.15)	46.29 (49.48)	34.95 (46.14)

7.7 Subjective Mood Ratings

At the start and end of each duty period, drivers were asked to rate the following subjective mood factors:

1. Aches and pains
2. Feeling happy or sad
3. Feeling calm or excited
4. Level of fatigue

Each of these factors is analyzed in the following sections.

7.7.1 Aches and Pains

At the start and end of each duty period, drivers were asked to rate the level of aches and pains they were feeling on a scale of 1 (none at all) to 100 (many aches and pains). A repeated-measures ANOVA was used to compare aches and pains by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between study phase and time of day. For duty days, there was no main effect of study period but drivers reported significantly more aches and pains at the end of their shift compared to the start of their shift. For rest days there no main effects of RDI Score, CPAP Adherence, or ESS Score. For duty days there were no main effects of RDI Score, CPAP Adherence, or ESS Score.

7.7.1.1 RDI Score

Rest Days: Drivers were subdivided into three subgroups based on their RDI score: No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15). Mean ratings are shown in Table 7-75. A repeated-measures ANOVA was used to compare RDI score between study phases and time of day. Drivers reported more aches and pains post-FMP compared to pre-FMP ($F(1,73) = 4.59$, $p = .035$) (see Figure 7-22) . There was no main effect of time of day ($F(1,73) = .32$, $p = .573$) or RDI Score ($F(2,73) = .007$, $p = .993$).

Table 7-75 Aches and Pains during Rest Days by RDI Score

RDI Score	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No Abnormality (RDI <5)	26	18.7 (17.3)	18.9 (16.5)	21.4 (17.7)	23.4 (19.3)
Mild Abnormality (RDI: 5-14.9)	30	22.2 (17.6)	17.6 (16.8)	21.3 (18.0)	23.0 (19.7)
Moderate to Severe (RDI ≥15)	21	17.8 (17.3)	18.6 (16.5)	21.6 (17.7)	24.6 (19.3)

Note: 1 = None at all, 100 = Many aches and pains

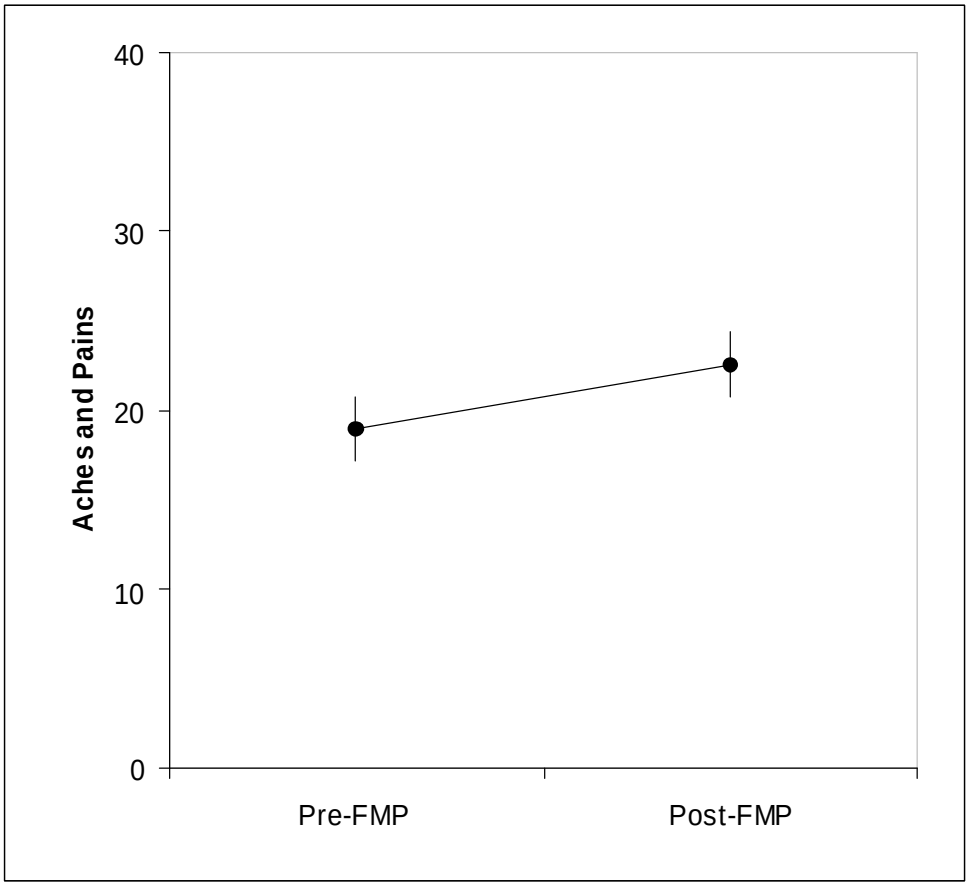


Figure 7-22 Aches and pains during rest days by RDI Score

Duty Days: Drivers were subdivided into three subgroups based on their RDI score: No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15). Mean ratings are shown in Table 7-76. A repeated-measures ANOVA was used to compare RDI score between study phases and time of day. There was no main effect pre-FMP vs. post-FMP ($F(1,74) = 2.26$, $p = .137$) or RDI score ($F(2,74) = .40$, $p = .670$). Drivers reported feeling significantly more aches and pains at the end of their shift as compared to at the start ($F(1,74) = 19.53$, $p < .001$) (see Figure 7-23).

Table 7-76 Aches and Pains during Duty Days by RDI Score

RDI Score	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No Abnormality (RDI <5)	26	18.0 (13.6)	21.6 (16.3)	19.7 (15.5)	21.9 (19.2)
Mild Abnormality (RDI: 5-14.9)	30	18.0 (15.3)	23.6 (20.6)	23.7 (18.9)	29.8 (23.3)
Moderate to Severe (RDI ≥15)	21	20.9 (16.4)	25.6 (19.5)	22.7 (20.6)	26.3 (23.3)

Note: 1 = None at all, 100 = Many aches and pains

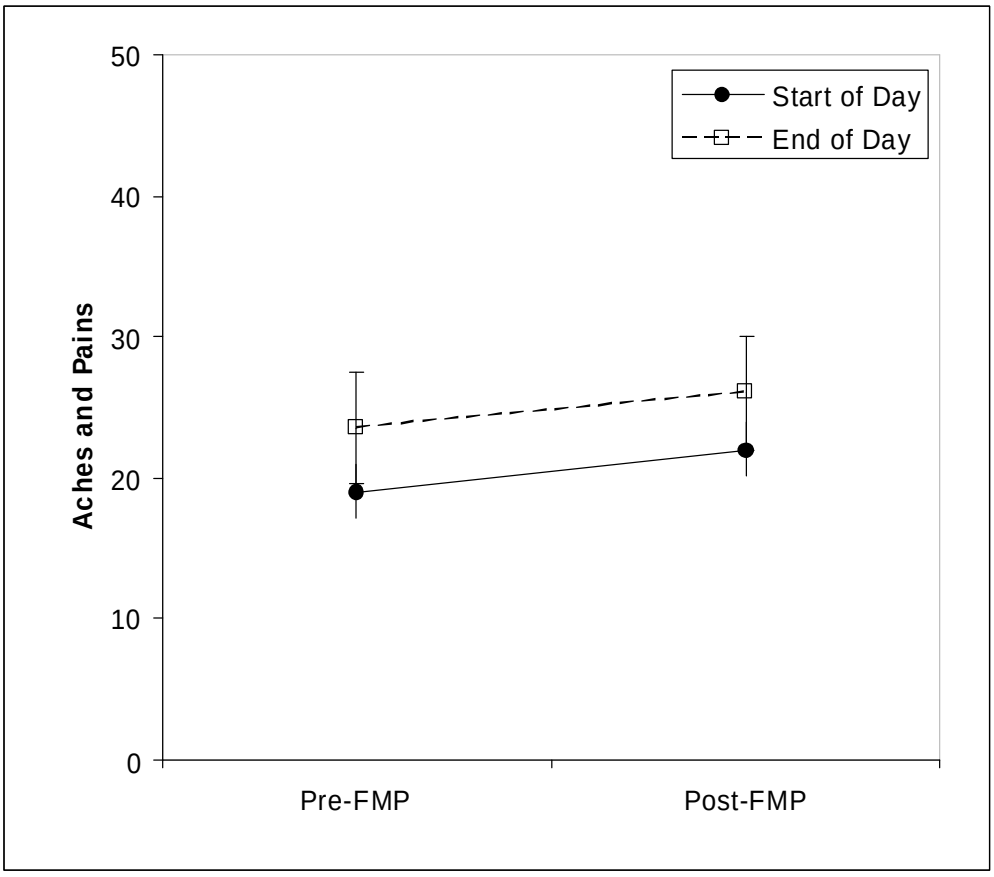


Figure 7-23 Aches and pains during duty days by RDI Score

7.7.1.2 CPAP ADHERENCE

Rest Days: Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time). Mean ratings are shown in Table 7-77. A repeated-measures ANOVA was used to compare RDI score between study phases and time of day. There was no main effect of study

phase (F(1,73) = .419, p = .519), time of day (F(1,73) = .185, p = .668) or CPAP Adherence (F(2,72) = 1.76, p = .162).

Table 7-77 Aches and Pains during Rest Days by CPAP Adherence

CPAP Adherence	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No CPAP Required	37	19.1 (17.5)	15.9 (16.3)	18.6 (16.7)	21.1 (18.5)
CPAP Adherent (>4 hrs (70%))	15	19.5 (18.1)	18.1 (16.9)	26.1 (17.3)	28.4 (19.1)
CPAP Non-Adherent (<4 hrs (70%))	20	21.9 (17.5)	23.4 (16.3)	27.5 (16.7)	29.3 (18.5)

Note: 1 = None at all, 100 = Many aches and pains

Duty Days: Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time). Mean ratings are shown in Table 7-78. A repeated-measures ANOVA was used to compare CPAP adherence between study phases and time of day. On average, drivers reported significantly more aches and pains post-FMP as compared to pre-FMP (F(1,69) = 7.56, p = .008) and more aches and pains at the end of the day compared to the start of the day (F(1,69) = 23.3, p < .001) (see Figure 7-24). There was no effect of CPAP Adherence (F(2,69) = 1.86, p = .163).

Table 7-78 Aches and Pains during Duty Days by CPAP Adherence

CPAP Adherence	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No CPAP Required	37	17.7 (14.0)	21.5 (18.5)	19.2 (16.1)	22.1 (19.2)
CPAP Adherent (>4 hrs (70%))	15	18.4 (14.5)	24.6 (19.7)	28.0 (19.6)	34.7 (23.2)
CPAP Non-Adherent (<4 hrs (70%))	20	22.1 (17.1)	28.4 (19.5)	27.9 (19.1)	33.2 (23.4)

Note: 1 = None at all, 100 = Many aches and pains

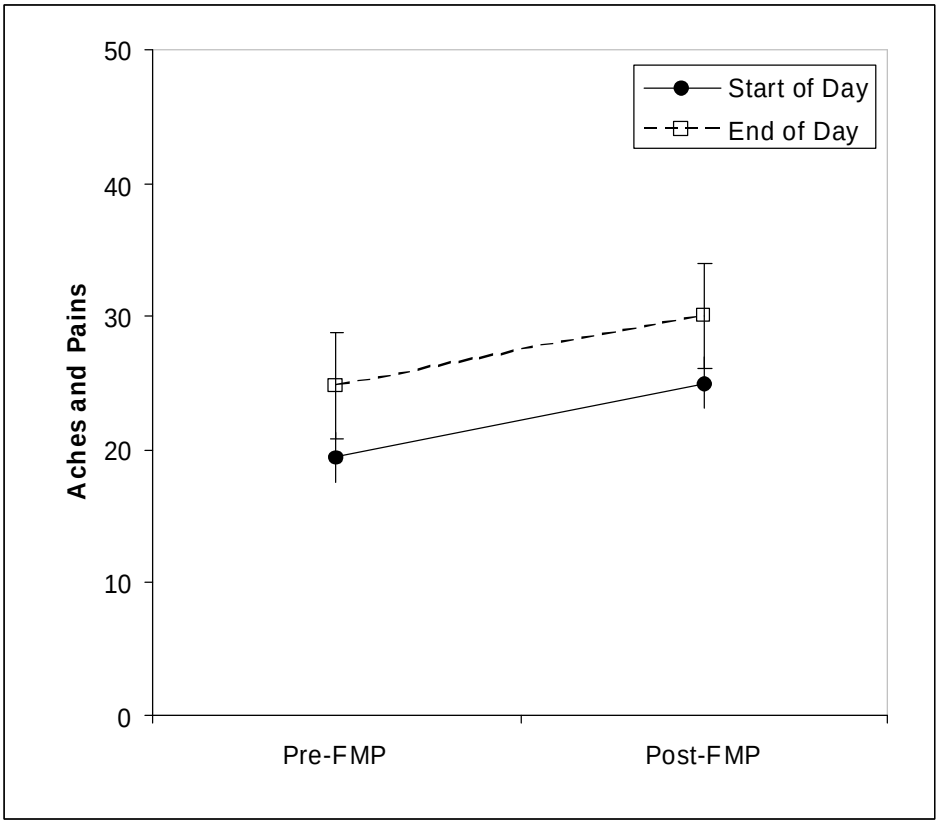


Figure 7-24 Aches and pains during duty days by CPAP Adherence

7.7.1.3 ESS SCORE

Rest days: Drivers were subdivided into three subgroups according to their Epworth Sleepiness Scale (ESS) score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24). Mean ratings are shown in Table 7-79. There was no effect of study phase ($F(1,73) = .056$, $p = .813$), time of day ($F(1,73) = .394$, $p = .532$) or ESS Score ($F(3,72) = .758$, $p = .521$).

Table 7-79 Aches and Pains during Rest Days by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No Abnormality (0-10)	59	18.1 (17.3)	16.9 (16.4)	20.3 (17.7)	23.3 (19.5)
Moderate (11-16)	13	25.8 (17.2)	22.0 (16.2)	28.3 (17.5)	27.1 (19.3)
Severe (17-24)	4	26.0 (17.2)	29.5 (16.2)	15.7 (17.5)	19.5 (19.3)

Note: 1 = None at all, 100 = Many aches and pains

Duty days: Drivers were subdivided into three subgroups according to their Epworth Sleepiness Scale (ESS) score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24). Mean ratings are shown in Table 7-80. A repeated-measures ANOVA was used to compare ESS score between

study phases and time of day. There was no main effect pre-FMP vs. post-FMP ($F(1,73) = .005$, $p = .946$) and no effect of ESS score ($F(2,73) = .25$, $p = .783$).There was a trend toward more aches and pains at the end of day compared to start of day ($F(1,73) = 3.56$, $p = .063$)

Table 7-80 Aches and Pains during Duty Days by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No Abnormality (0-10)	59	17.9 (15.0)	23.2 (19.2)	21.5 (18.1)	26.3 (22.0)
Moderate (11-16)	13	21.6 (16.3)	24.2 (18.1)	26.7 (19.5)	30.2 (23.3)
Severe (17-24)	4	24.2 (10.8)	28.5 (18.0)	19.0 (17.9)	17.1 (18.9)

Note: 1 = None at all, 100 = Many aches and pains

7.7.2 Feeling Happy or Sad

At the start and end of each duty period, drivers were asked to rate how happy or sad they were feeling on a scale of 1 (happy) to 100 (sad). A repeated-measures ANOVA was used to compare mood ratings by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between study phase and time of day. There was no main effect of study period but drivers reported feeling significantly happier at the start of their shift compared to the end of their shift. For rest days, there were no main effects of RDI Score, CPAP Adherence, or ESS Score. For duty days, there were no main effects or RDI Score or ESS Score, but there was a trend towards a main effect of CPAP Adherence.

7.7.2.1 RDI Score

Rest days: Drivers were subdivided into three subgroups based on their RDI score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15). Mean ratings are shown in Table 7-81. A repeated-measures ANOVA was used to compare RDI score between study phases and time of day. There was no main effect of study phase ($F(1,73) = .017$, $p = .896$) or RDI score ($F(2,73) = 2.228$, $p = .115$). There was a trend toward drivers reporting feeling more alert at the end of the day compared to the start ($F(1,73) = 3.661$, $p = .060$).

Table 7-81 Happy or Sad during Rest Days by RDI Score

RDI Score	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No Abnormality (RDI <5)	26	21.0 (14.8)	22.3 (15.0)	18.7 (15.7)	21.5 (17.2)
Mild Abnormality (RDI: 5-14.9)	30	18. 0(15.1)	18.9 (15.3)	23.1 (16.0)	21.2 (17.5)
Moderate to Severe (RDI ≥15)	21	25.2 (14.8)	31.3 (15.0)	25.5 (15.7)	28.8 (17.2)

Note: 1 = Happy, 100 = Sad

Duty Days: Drivers were subdivided into three subgroups based on their RDI score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15). Mean ratings are shown in Table 7-82. A repeated-measures ANOVA was used to compare RDI score between study phases and time of day. There was no main effect of pre-FMP vs. post-FMP ($F(1,74) = 1.79$, $p = .185$) or RDI score ($F(2,74) = 1.14$, $p = .327$). Drivers reported feeling significantly more happy at the start of their duty day as compared to the end of their duty day ($F(1,74) = 5.70$, $p = .019$) (see Figure 7-25).

Table 7-82 Feeling Happy or Sad during Duty Days by RDI Score

RDI Score	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No Abnormality (RDI <5)	26	26.3 (18.1)	26.3 (17.5)	22.0 (15.6)	25.3 (16.0)
Mild Abnormality (RDI: 5-14.9)	30	26.2 (16.9)	29.2 (14.7)	28.9 (18.0)	28.4 (20.9)
Moderate to Severe (RDI ≥15)	21	32.7 (14.7)	33.9 (15.1)	26.6 (15.3)	33.1 (16.7)

Note: 1 = Happy, 100 = Sad

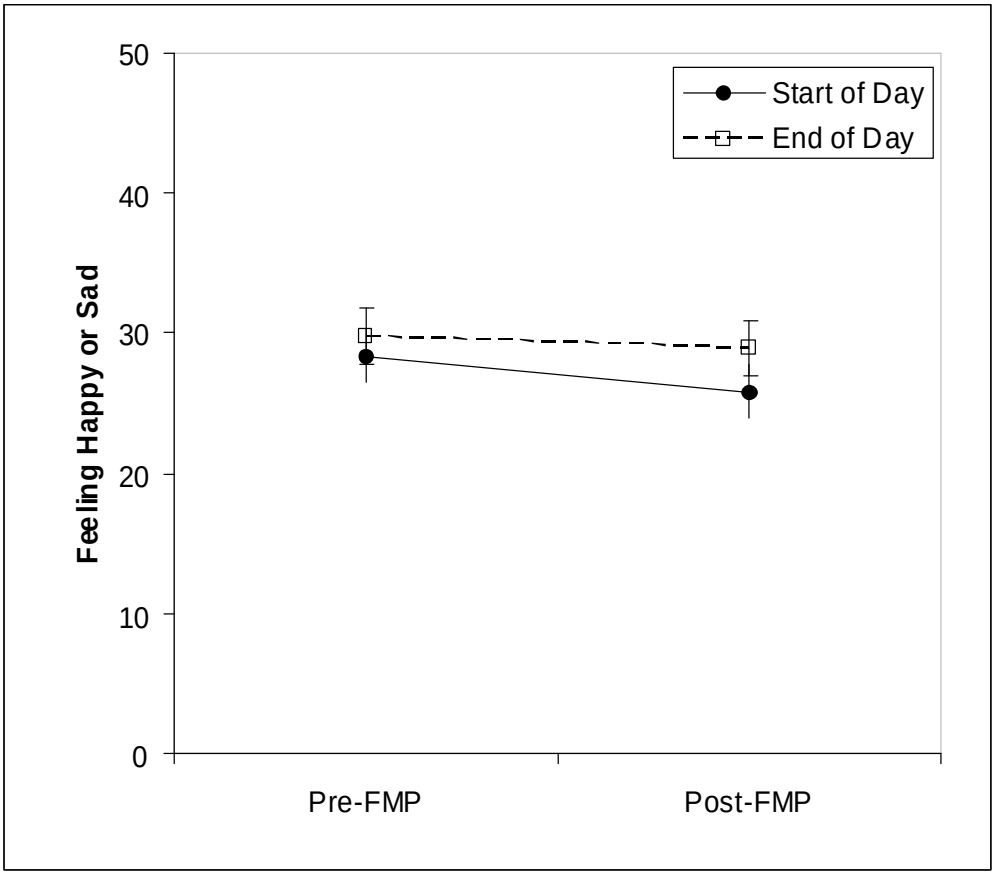


Figure 7-25 Feeling happy or sad during duty days by RDI Score

7.7.2.2 CPAP ADHERENCE

Rest days: Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time). Mean ratings are shown in Table 7-83. A repeated-measures ANOVA was used to compare CPAP adherence between study phases and time of day. There was no main effect of study phase ($F(1,73) = 1.272$, $p = .263$), time of day ($F(1,73) = 2.155$, $p = .146$), or CPAP Adherence ($F(3,72) = 1.564$, $p = .206$).

Table 7-83 Feeling Happy or Sad during Rest Days by CPAP Adherence

CPAP Adherence	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No CPAP Required	37	19.8 (15.1)	19.5 (15.4)	19.3 (15.4)	20.4 (17.0)
CPAP Adherent (>4 hrs (70%))	15	22.5 (15.6)	25.2 (16.0)	26.6 (15.9)	27.6 (17.6)
CPAP Non-Adherent (<4 hrs (70%))	20	22.1 (15.1)	28.7 (15.4)	27.4 (15.4)	28.7 (17.0)

Note: 1 = Happy, 100 = Sad

Duty Days: Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time). Mean ratings are shown in Table 7-84. A repeated-measures ANOVA was used to compare CPAP adherence between study phases and time of day. There was no main effect pre-FMP vs. post-FMP ($F(1,69) = .71$, $p = .404$) and there was a trend towards a main effect of CPAP Adherence ($F(2,69) = 2.71$, $p = .074$). Drivers were significantly happier at the start of their day compared to at the end of their day ($F(1,69) = 6.22$, $p = .015$) (see Figure 7-26).

Table 7-84 Feeling Happy or Sad during Duty Days by CPAP Adherence

CPAP Adherence	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No CPAP Required	37	25.4 (18.7)	25.3 (17.2)	21.3 (15.1)	24.0 (16.7)
CPAP Adherent (>4 hrs (70%))	15	28.1 (14.8)	30.6 (14.9)	32.4 (18.6)	38.9 (22.6)
CPAP Non-Adherent (<4 hrs (70%))	20	30.4 (15.1)	34.6 (13.3)	31.9 (14.5)	31.4 (14.8)

Note: 1 = Happy, 100 = Sad

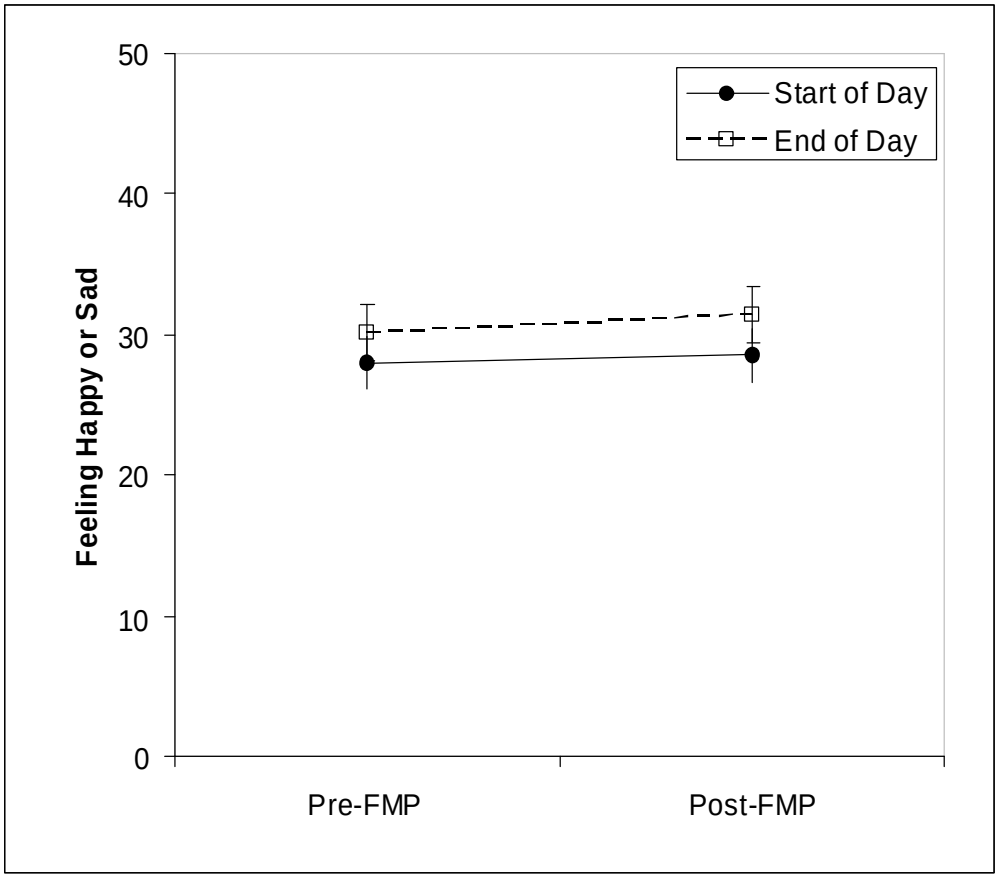


Figure 7-26 Feeling happy or sad during duty days by CPAP adherence

7.7.2.3 ESS SCORE

Rest days: Drivers were subdivided into three subgroups according to their Epworth Sleepiness Scale (ESS) score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24). Mean ratings are shown in Table 7-85. A repeated-measures ANOVA was used to compare ESS score between study phases and time of day. There was no main effect of study phase ($F(1,73) = 1.13$, $p = .291$), time of day ($F(1,73) = 2.057$, $p = .156$), or ESS score ($F(1,73) = .915$, $p = .438$).

Table 7-85 Feeling Happy or Sad during Rest Days by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No Abnormality (0-10)	59	20.3 (14.9)	22.5 (15.5)	22.5 (16.0)	24.2 (17.6)
Moderate (11-16)	13	25.8 (14.8)	23.7 (15.4)	22.7 (15.9)	20.9 (17.4)
Severe (17-24)	4	26.3 (14.8)	40.3 (15.4)	22.3 (15.9)	25.0 (17.4)

Note: 1 = Happy, 100 = Sad

Duty days: Drivers were subdivided into three subgroups according to their Epworth Sleepiness Scale (ESS) score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24). Mean ratings are shown in Table 7-86. A repeated-measures ANOVA was used to compare ESS score between study phases and time of day. There was no main effect of time of day ($F(1,73) = .284$, $p = .595$) or ESS score ($F(2,73) = .85$, $p = .430$). There was a trend towards drivers reporting being more happy post-FMP compared to pre-FMP ($F(1,73) = 3.38$, $p = .070$).

Table 7-86 Feeling Happy or Sad during Duty Days by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No Abnormality (0-10)	59	27.4 (17.8)	28.9 (16.6)	25.3 (16.6)	28.3 (18.6)
Moderate (11-16)	13	26.5 (9.1)	30.0 (9.2)	28.4 (13.4)	32.0 (16.0)
Severe (17-24)	4	44.8 (15.2)	42.2 (17.4)	33.1 (24.6)	29.3 (20.5)

Note: 1 = Happy, 100 = Sad

7.7.3 Feeling Calm or Excited

At the start and end of each duty period, drivers were asked to rate how calm or excited they were feeling on a scale of 1 (calm) to 100 (excited). A repeated-measures ANOVA was used to compare calmness ratings by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between study phase and time of day. There was no main effect of study period or time of day but there was a main effect of RDI Score. The No Abnormality group reported feeling significantly more calm than the other two groups. For rest days there were no main effects of RDI Score, CPAP Adherence, or ESS Score. For duty days there were no main effects of CPAP Adherence or ESS Score, but there was a trend toward an effect of RDI Score; the No Abnormality group reported feeling significantly more calm than the Mild Abnormality group.

7.7.3.1 RDI Score

Rest days: Drivers were subdivided into three subgroups based on their RDI score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15). Mean ratings are shown in Table 7-87. A repeated-measures ANOVA was used to compare RDI score between study phases and time of day. There was no main effect of study phase ($F(1,73) = .687$, $p = .410$), time of day ($F(1,73) = 1.824$, $p = .181$), or RDI score ($F(1,73) = 1.801$, $p = .172$).

Table 7-87 Feeling Calm or Excited during Rest Days by RDI Score

RDI Score	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No Abnormality (RDI <5)	26	21.3 (18.9)	25.1 (19.8)	23.5 (20.1)	21.8 (19.1)
Mild Abnormality (RDI: 5-14.9)	30	34.1 (19.2)	30.4 (20.2)	30.2 (20.4)	31.2 (19.5)
Moderate to Severe (RDI ≥15)	21	31.9 (18.9)	23.3 (19.8)	26.0 (20.1)	25.7 (19.1)

Note: 1 = Calm, 100 = Excited

Duty days: Drivers were subdivided into three subgroups based on their RDI score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15). Mean ratings are shown in Table 7-88. A repeated-measures ANOVA was used to compare RDI score between study phases and time of day. There was no main effect of study phase ($F(1,74) = .02$, $p = .891$) or start vs. end of day ($F(1,74) = 1.56$, $p = .215$). There was a trend toward an effect of RDI score ($F(2,74) = 2.56$, $p = .082$). The No Abnormality group was significantly more calm than the Mild Abnormality group ($p = .033$) (see Figure 7-27).

Table 7-88 Feeling Calm or Excited during Duty Days by RDI Score

RDI Score	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No Abnormality (RDI <5)	26	24.1 (16.5)	24.9 (15.7)	22.8 (14.3)	25.7 (15.9)
Mild Abnormality (RDI: 5-14.9)	30	32.5 (20.9)	34.4 (19.4)	34.0 (22.2)	34.4 (23.2)
Moderate to Severe (RDI ≥15)	21	25.5 (13.4)	28.9 (13.7)	26.8 (18.5)	25.6 (14.9)

Note: 1 = Calm, 100 = Excited

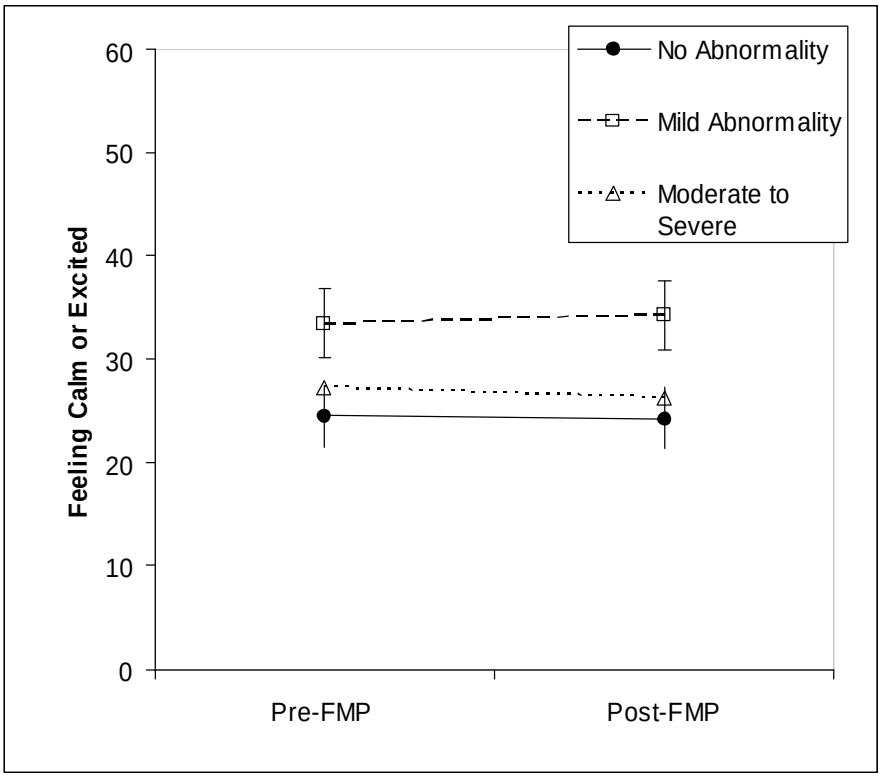


Figure 7-27 Feeling calm or exited during duty days by RDI score

7.7.3.2 CPAP ADHERENCE

Rest days: Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time). Mean ratings are shown in Table 7-89. A repeated-measures ANOVA was used to compare CPAP adherence between study phases and time of day. There was a trend toward drivers reporting feeling more calm post-FMP ($F(1,72) = 2.911$, $p = .092$) and toward drivers feeling more calm at the end of the day ($F(1,72) = 3.05$, $p = .085$). There was no main effect of CPAP adherence ($F(2,72) = .518$, $p = .672$).

Table 7-89 Feeling Calm or Excited during Rest Days by CPAP Adherence

CPAP Adherence	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No CPAP Required	37	27.9 (19.8)	29.6 (19.9)	26.2 (19.9)	26.3 (26.3)
CPAP Adherent (>4 hrs (70%))	15	28.3 (20.5)	20.6 (20.6)	28.1 (20.6)	28.9 (19.9)
CPAP Non-Adherent (<4 hrs (70%))	20	31.4 (19.8)	26.7 (19.9)	30.6 (19.9)	29.0 (19.2)

Note: 1 = Calm, 100 = Excited

Duty days: Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time). Mean ratings are shown in Table 7-90. A repeated-measures ANOVA was used to compare CPAP adherence between study phases and time of day. There were no main effects of study phase ($F(1,69) = .52$, $p = .473$), time of day ($F(1,69) = .472$, $p = .494$), or CPAP adherence ($F(2,69) = .51$, $p = .604$).

Table 7-90 Feeling Calm or Excited during Duty Days by CPAP Adherence

CPAP Adherence	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No CPAP Required	37	28.1 (20.8)	28.1 (19.3)	26.5 (19.8)	29.0 (19.9)
CPAP Adherent (>4 hrs (70%))	15	24.0 (13.7)	28.3 (15.7)	28.7 (19.0)	31.6 (21.8)
CPAP Non-Adherent (<4 hrs (70%))	20	32.7 (14.0)	32.9 (14.7)	34.8 (18.1)	29.3 (16.3)

Note: 1 = Calm, 100 = Excited

7.7.3.3 ESS SCORE

Rest days: Drivers were subdivided into three subgroups according to their Epworth Sleepiness Scale (ESS) score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24). Mean ratings are shown in Table 7-91. A repeated-measures ANOVA was used to compare ESS score between study phases and time of day. There was no main effect of study phase ($F(1,73) = 1.292$, $p = .260$), time of day ($F(1,73) = 1.334$, $p = .252$), or ESS score ($F(3,72) = .692$, $p = .560$).

Table 7-91 Feeling Calm or Excited during Rest Days by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No Abnormality (0-10)	59	29.5 (19.9)	27.4 (20.1)	26.4 (20.2)	27.6 (19.6)
Moderate (11-16)	13	26.7 (19.7)	21.8 (19.9)	26.5 (20.1)	25.1 (19.4)
Severe (17-24)	4	35.3 (19.7)	35.5 (19.9)	37.8 (20.1)	21.0 (19.4)

Note: 1 = Calm, 100 = Excited

Duty days: Drivers were subdivided into three subgroups according to their Epworth Sleepiness Scale (ESS) score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24). Mean ratings are shown in Table 7-92. A repeated-measures ANOVA was used to compare ESS score between study phases and time of day. There were no main effects of study phase ($F(1,73) = .49$, $p = .485$) or ESS score ($F(2,73) = .61$, $p = .546$). There was a trend towards drivers feeling more calm at the start of their day ($F(1,73) = 3.06$, $p = .084$)

Table 7-92 Feeling Calm or Excited during Duty Days by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No Abnormality (0-10)	59	28.6 (18.9)	30.2 (18.1)	28.8 (20.1)	30.3 (19.5)
Moderate (11-16)	13	24.2 (14.3)	24.9 (10.4)	27.4 (14.4)	24.1 (15.0)
Severe (17-24)	4	30.7 (13.1)	44.5 (5.1)	29.3 (20.8)	34.1 (23.9)

Note: 1 = Calm, 100 = Excited

7.7.4 Level of Fatigue

At the start and end of each duty period, drivers were asked to rate the level of fatigue they were feeling on a scale of 1 (sleepy) to 100 (alert). A repeated-measures ANOVA was used to compare level of fatigue rating by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between study phase and time of day. There was a trend towards drivers reported feeling more alert post-FMP compared to pre-FMP on rest days. There was a main effect of time of day; for all subgroups, drivers reported feeling significantly more alert at the start of their duty period compared to at the end of their duty period. For rest days there were no main effects of RDI Score or CPAP Adherence, but there was a main effect of ESS Score; the Moderate Abnormality and Severe Abnormality groups reported feeling more alert than the No Abnormality group. For duty days there were no main effects of RDI Score or CPAP Adherence but there was a main effect of ESS Score; the No Abnormality group reported feeling significantly less fatigued than the Moderate Abnormality group.

7.7.4.1 RDI Score

Rest days: Drivers were subdivided into three subgroups based on their RDI score: No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15). Mean ratings are shown in Table 7-93. A repeated-measures ANOVA was used to compare RDI score between study phases and start vs. end of day. Drivers reported feeling significantly more sleepy at the end of rest days compared to at the start ($F(1,73) = 136.21$, $p < .001$) (see Figure 7-28). There was no main effect of study phase ($F(1,73) = .196$, $p = .659$) or RDI score ($F(2,73) = .059$, $p = .943$).

Table 7-93 Level of Fatigue during Rest Days by RDI Score

RDI Score	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No Abnormality (RDI <5)	26	69.5 (19.0)	53.9 (21.1)	72.3 (17.8)	49.7 (20.7)
Mild Abnormality (RDI: 5-14.9)	30	72.4 (19.3)	48.6 (21.5)	74.1 (18.1)	53.7 (21.1)
Moderate to Severe (RDI ≥15)	21	74.5 (19.0)	47.0 (21.1)	73.2 (17.8)	48.2 (20.7)

Note: 1 = Sleepy, 100 = Alert

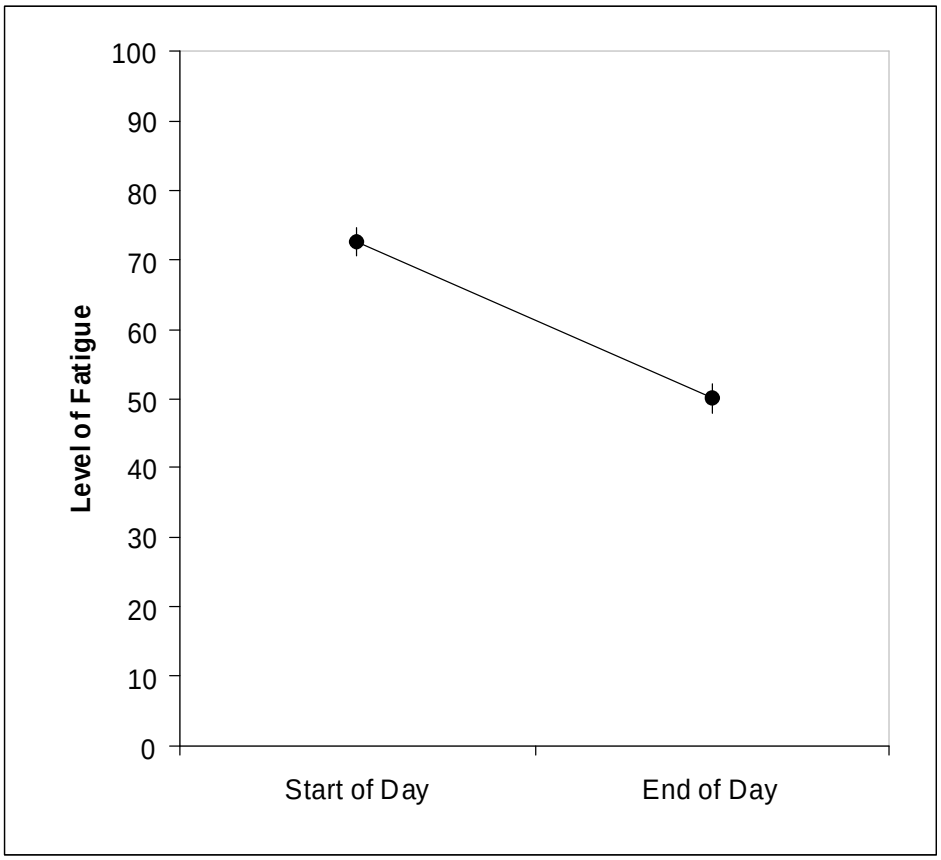


Figure 7-28 Level of fatigue during rest days by RDI Score

Duty days: Drivers were subdivided into three subgroups based on their RDI score: No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15). Mean ratings are shown in Table 7-94. A repeated-measures ANOVA was used to compare RDI score between study phases and start vs. end of day. Drivers reported being significantly more alert at the start of their duty day, as compared to the end of their duty day ($F(1,74) = 130.4$, $p < .001$), and there was a trend towards drivers reporting less fatigue post-FMP as compared to pre-FMP ($F(1,74) = 3.03$, $p = .086$) (see Figure 7-29). There was no main effect of RDI ($F(2,74) = .82$, $p = .445$).

Table 7-94 Level of Fatigue during Duty Days by RDI Score

RDI Score	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No Abnormality (RDI <5)	26	70.3 (19.2)	48.5 (21.8)	72.2 (20.0)	54.9 (22.7)
Mild Abnormality (RDI: 5-14.9)	30	69.5 (15.7)	44.8 (19.5)	70.9 (16.4)	43.6 (18.0)
Moderate to Severe (RDI ≥15)	21	73.1 (13.3)	47.2 (19.6)	73.9 (17.8)	53.4 (23.1)

Note: 1 = Sleepy, 100 = Alert

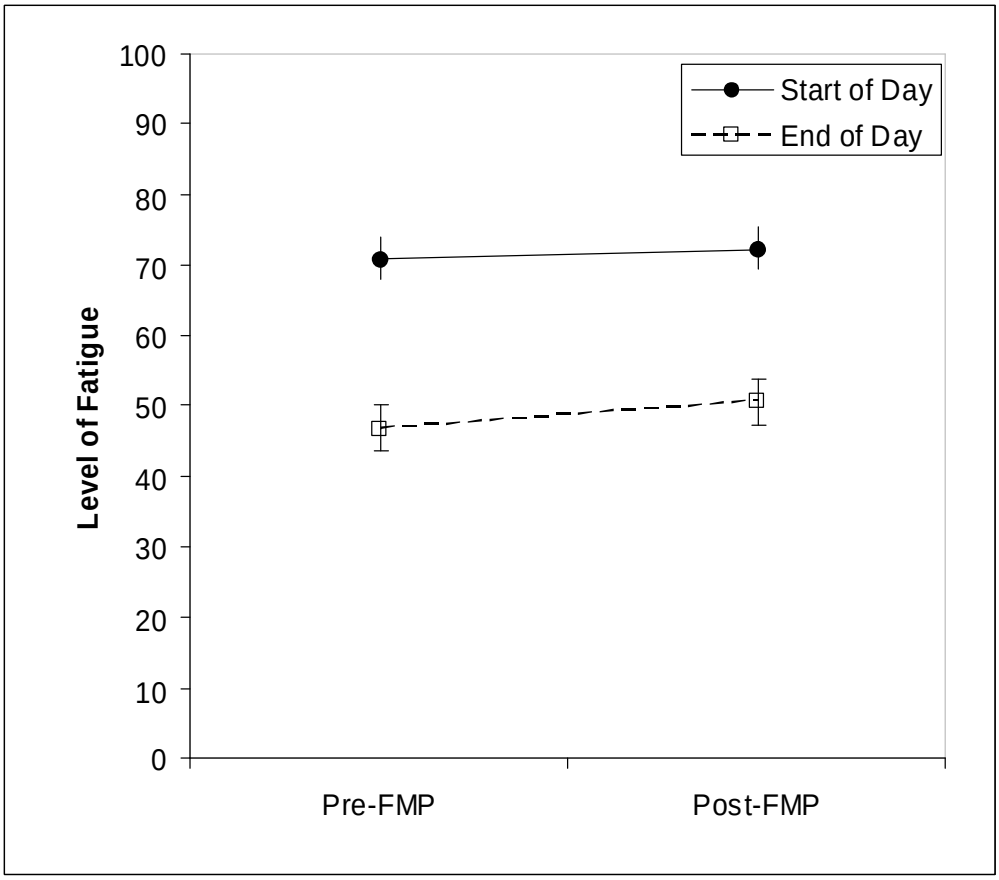


Figure 7-29 Level of fatigue during duty days by RDI Score

7.7.4.2 CPAP ADHERENCE

Rest days: Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time). Mean ratings are shown in Table 7-95. A repeated-measures ANOVA was used to compare CPAP adherence between study phases and time of day. Drivers reported feeling significantly more sleepy at the end of rest days compared to at the start ($F(1,73) = 105.06$, $p < .001$). There was a trend towards drivers reported feeling more alert post-FMP compared to pre-FMP ($F(1,73) = 3.407$, $p = .069$) (Figure 7-30). There was no main effect of CPAP Adherence ($F(1,73) = .294$, $p = .829$).

Table 7-95 Level of Fatigue during Rest Days by CPAP Adherence

CPAP Adherence	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No CPAP Required	37	71.6 (18.9)	55.0 (20.7)	72.0 (17.5)	52.8 (20.8)
CPAP Adherent (>4 hrs (70%))	15	67.0 (19.5)	50.4 (21.4)	71.4 (18.1)	49.6 (21.5)
CPAP Non-Adherent (<4 hrs (70%))	20	77.3 (18.9)	42.3 (20.7)	73.0 (17.5)	46.8 (20.8)

Note: 1 = Sleepy, 100 = Alert

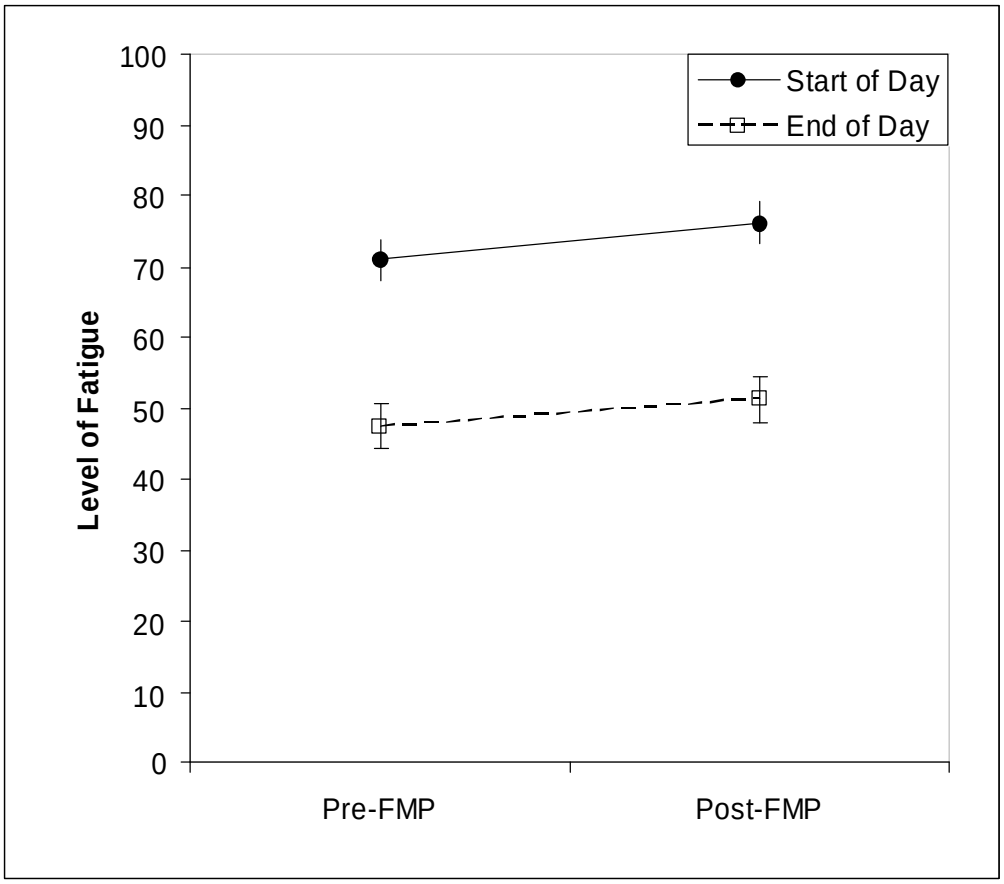


Figure 7-30 Level of fatigue during rest days by CPAP Adherence

Duty days: Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time). Mean ratings are shown in Table 7-96 A repeated-measures ANOVA was used to compare CPAP adherence between study phases and time of day. Drivers reported being significantly less fatigued at the start of their duty day, as compared to the end of their duty day ($F(1,69) = 121.2$, $p < .001$). There was no main effect of study phase ($F(1,69) = .72$, $p = .399$) or CPAP Adherence ($F(2,69) = .36$, $p = .699$) (see Figure 7-31).

Table 7-96 Level of Fatigue during Duty Days by CPAP Adherence

CPAP Adherence	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No CPAP Required	37	70.1 (19.0)	50.8 (22.1)	71.2 (19.5)	52.3 (22.2)
CPAP Adherent (>4 hrs (70%))	15	70.9 (14.8)	45.0 (24.5)	72.9 (15.5)	46.8 (25.4)
CPAP Non-Adherent (<4 hrs (70%))	20	72.5 (10.1)	42.1 (13.5)	69.1 (15.9)	46.6 (17.0)

Note: 1 = Sleepy, 100 = Alert

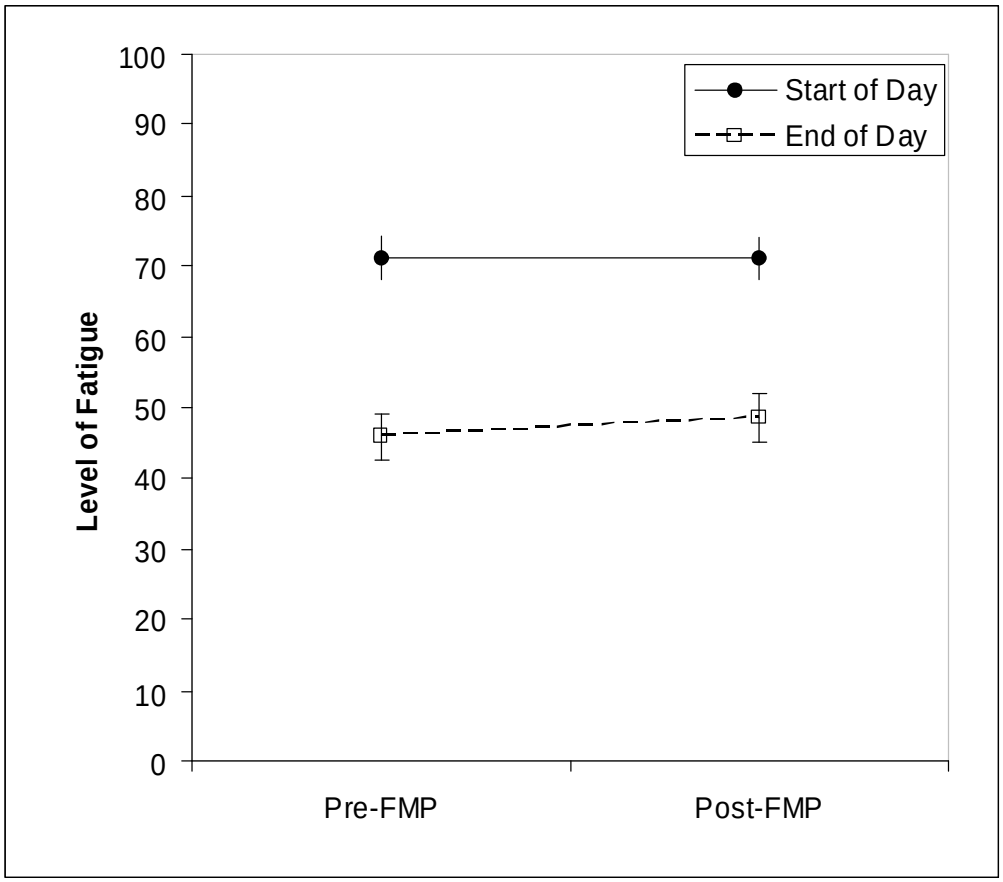


Figure 7-31 Level of fatigue during duty days by CPAP Adherence

7.7.4.3 ESS SCORE

Rest days: Drivers were subdivided into three subgroups according to their Epworth Sleepiness Scale (ESS) score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24). Mean ratings are shown in Table 7-97. A repeated-measures ANOVA was used to compare ESS score between study phases and time of day. Drivers reported feeling significantly more sleepy at the end of rest days compared to at the start ($F(1,72) = 16.104$, $p < .001$) (see

Figure 7-32). There was a main effect of CPAP Adherence ($F(3,72) = 4.171$, $p = .009$). The Moderate Abnormality ($p = .032$) and Severe Abnormality ($p = .035$) groups reported feeling more alert than the No Abnormality group. There was a trend towards drivers reported feeling more alert post-FMP compared to pre-FMP ($F(1,72) = 3.218$, $p = .077$).

Table 7-97 Level of Fatigue during Rest Days by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No Abnormality (0-10)	59	74.8 (18.3)	51.9 (20.9)	74.6 (17.6)	52.8 (19.7)
Moderate (11-16)	13	63.7 (18.1)	46.2 (20.7)	67.5 (17.4)	40.2 (19.5)
Severe (17-24)	4	53.5 (18.1)	30.3 (20.7)	65.8 (17.4)	43.8 (19.5)

Note: 1 = Sleepy, 100 = Alert

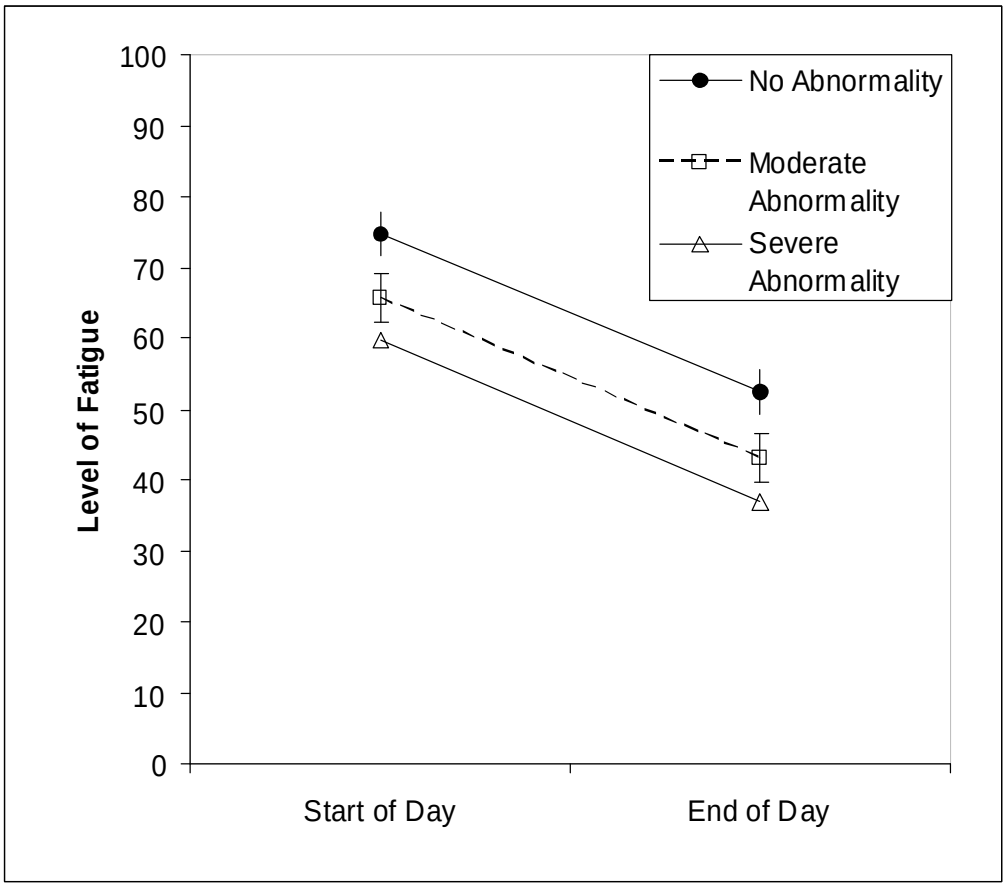


Figure 7-32 Level of fatigue during rest days by ESS score

Duty days: Drivers were subdivided into three subgroups according to their Epworth Sleepiness Scale (ESS) score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24). Mean ratings are shown in

Table 7-98. A repeated-measures ANOVA was used to compare ESS score between study phases and time of day. Drivers reported being significantly less fatigued at the start of their duty day, as compared to the end of their duty day ($F(1,73) = 34.8$, $p < .001$) and there was a significant effect of ESS Score ($F(2,73) = 4.88$, $p = .010$). The No Abnormality group reported feeling significantly less fatigued than the Moderate Abnormality group ($p = .008$) and less fatigued (trend only) than the Severe Abnormality group ($p = .07$) (see Figure 7-33).

Table 7-98 Level of Fatigue by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Start	End	Start	End
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
No Abnormality (0-10)	59	72.6 (15.6)	49.1 (20.1)	74.4 (16.8)	52.9 (20.8)
Moderate (11-16)	13	67.1 (12.5)	36.2 (18.9)	65.0 (13.5)	34.2 (18.3)
Severe (17-24)	4	48.3 (18.3)	38.6 (8.8)	54.8 (30.9)	54.1 (23.0)

Note: 1 = Sleepy, 100 = Alert

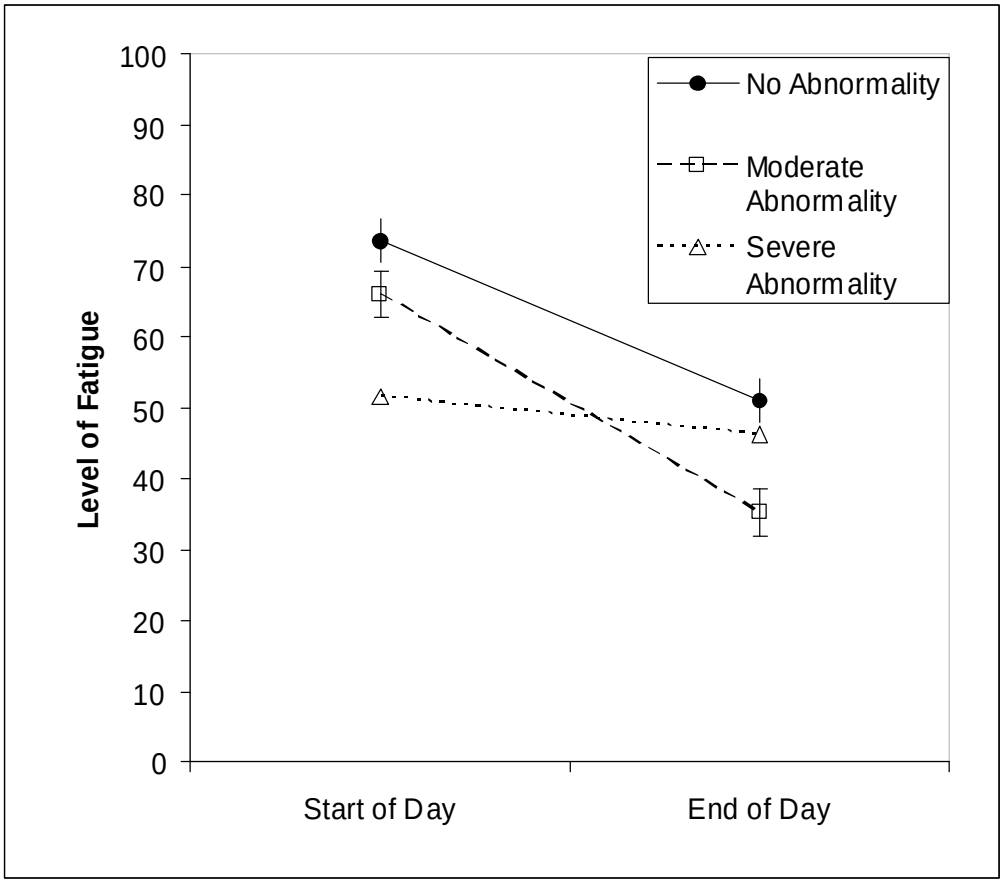


Figure 7-33 Level of fatigue by ESS score

7.8 Critical Events

7.8.1 Overall Results

At the end of every duty day drivers were asked if they nodded off or had a close call during their shift. These have been grouped together and referred to as “critical events”. Linear regression was used to determine the effect of raw scores on the number of critical events, pre- vs. post-FMP. Overall, there was a significant reduction in critical events from pre-FMP to post-FMP ($p = .004$). Linear regression was also used to compare correlation by subgroup (RDI Score, ESS Score, see next section for detailed results), The linear regression analysis could not be performed with CPAP subgroups because the measure for compliance was not a continuous variable.

McNemar’s test of proportions was used to compare number of drivers reporting critical events by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between study phases.

7.8.2 RDI Score

Linear regression was used to determine the effect of RDI raw scores on the number of critical events, pre- vs. post-FMP. High RDI score was associated with more pre-FMP critical events ($F(1,75) = 5.22$, $p = .025$) (see Figure 7-34). The reduction in critical events, pre-FMP minus post-FMP, was also significantly correlated with RDI score with greater reductions for those with higher RDI scores ($F(1,75) = 4.03$, $p = 0.048$) (see Figure 7-35).

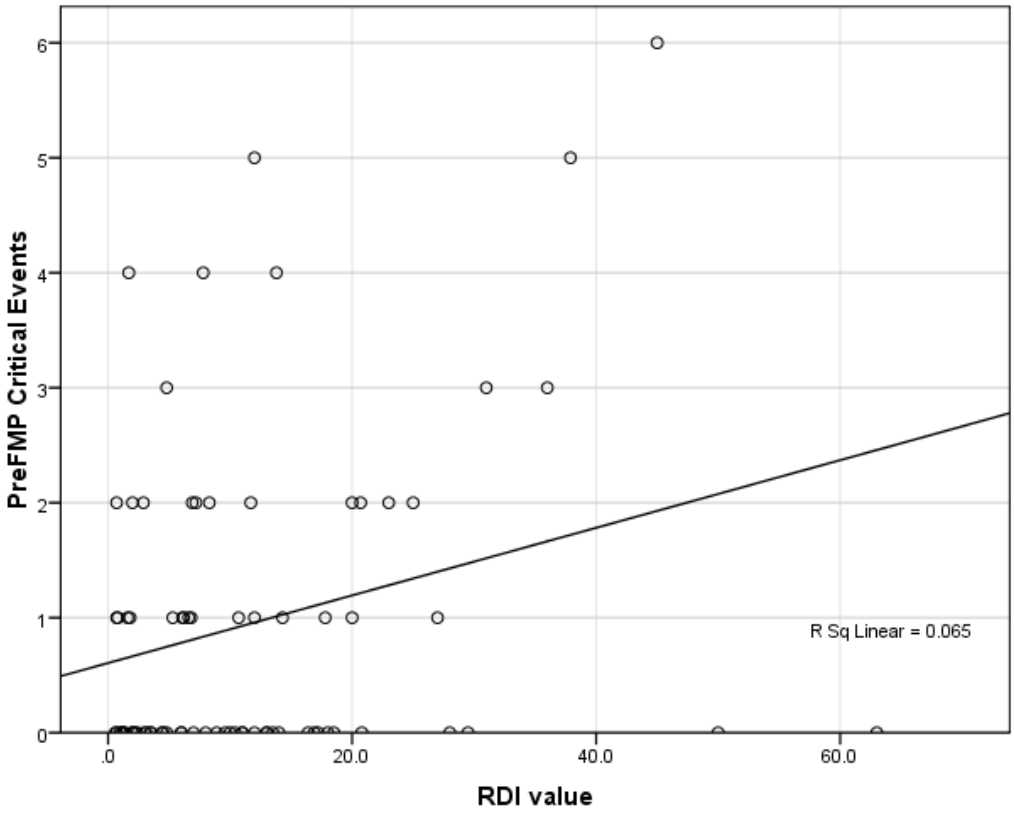


Figure 7-34 Number of pre-FMP critical events vs. RDI score

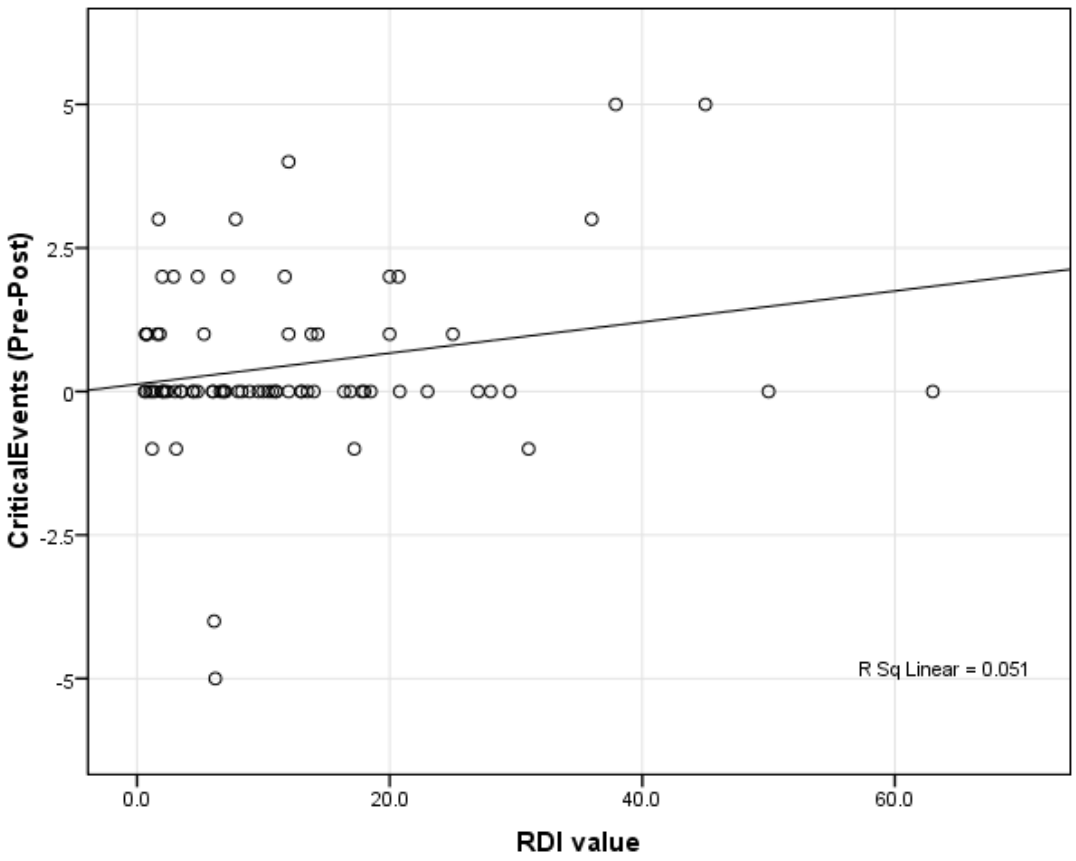


Figure 7-35 Reduction in critical events (pre-FMP minus post-FMP) versus RDI score

Drivers were subdivided into three subgroups based on their RDI score: No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15) (see Table 7-99 and Figure 7-36). McNemar's test for correlated proportions was used to compare the proportion of drivers with critical events, pre-FMP vs. post-FMP. The results are shown in Table 7-99. There was a trend for fewer drivers reporting critical events in the Mild Abnormality group(Pre vs. Post = 50. percent to 33.3 percent, p = 0.62).

Table 7-99 Proportion of Drivers Reporting at least One Critical Event by RDI Score

RDI Group	Pre-FMP			Post-FMP		
	N	Driver had one or more Critical event	%	N	Driver had one or more Critical event	%
No Abnormality (RDI <5)	26	9	34.6%	26	5	19.2%
Mild Abnormality (RDI: 5-14.9)	30	15 *	50.0%	30	10 *	33.3%
Moderate to Severe (RDI ≥15)	21	11	52.4%	21	7	33.3%
TOTAL	**77**	**35****	**45.5%**	**77**	**22**	**28.6%**

- *McNemar's Test (Mild Abnormality, Pre/post) p = .062*

*** McNemar's Test (Total, Pre/post), p = .004*

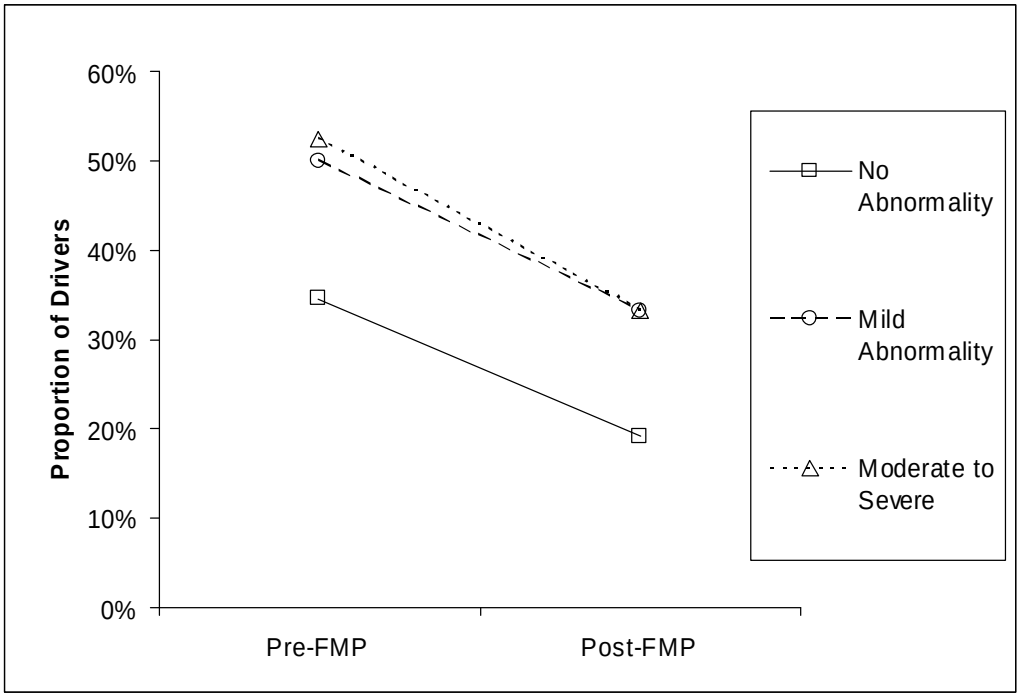


Figure 7-36 Proportion of drivers reporting at least one critical event by RDI score

7.8.3 CPAP Adherence

Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time). McNemar's test for correlated proportions was used to compare the proportion of drivers with critical events, pre-FMP vs. post-FMP. The results are shown in Table 7-100. The reductions within these subgroups were not significant.

Table 7-100 Proportion of Drivers Reporting at least One Critical Event by CPAP Adherence

CPAP Adherence Group	Pre-FMP			Post-FMP		
	N	Driver had one or more Critical event	%	N	Driver had one or more Critical event	%
No CPAP Required	37	14	37.8%	37	8	21.6%
CPAP Adherent (>4 hrs (70%))	15	10	66.7%	15	8	53.3%
CPAP Non-Adherent (<4 hrs (70%))	20	8	40.0%	20	4	20.0%
TOTAL	**72**	**32**	**44.4%**	**72**	**20**	**27.8%**

7.8.4 ESS Score

Linear regression was used to determine the effect of Epworth Sleepiness Scale raw scores on the number of critical events, pre- vs. post-FMP. High ESS score was associated with more pre-FMP critical events ($F(1,75) = 5.81$, $p = .018$) (see Figure 7-37).

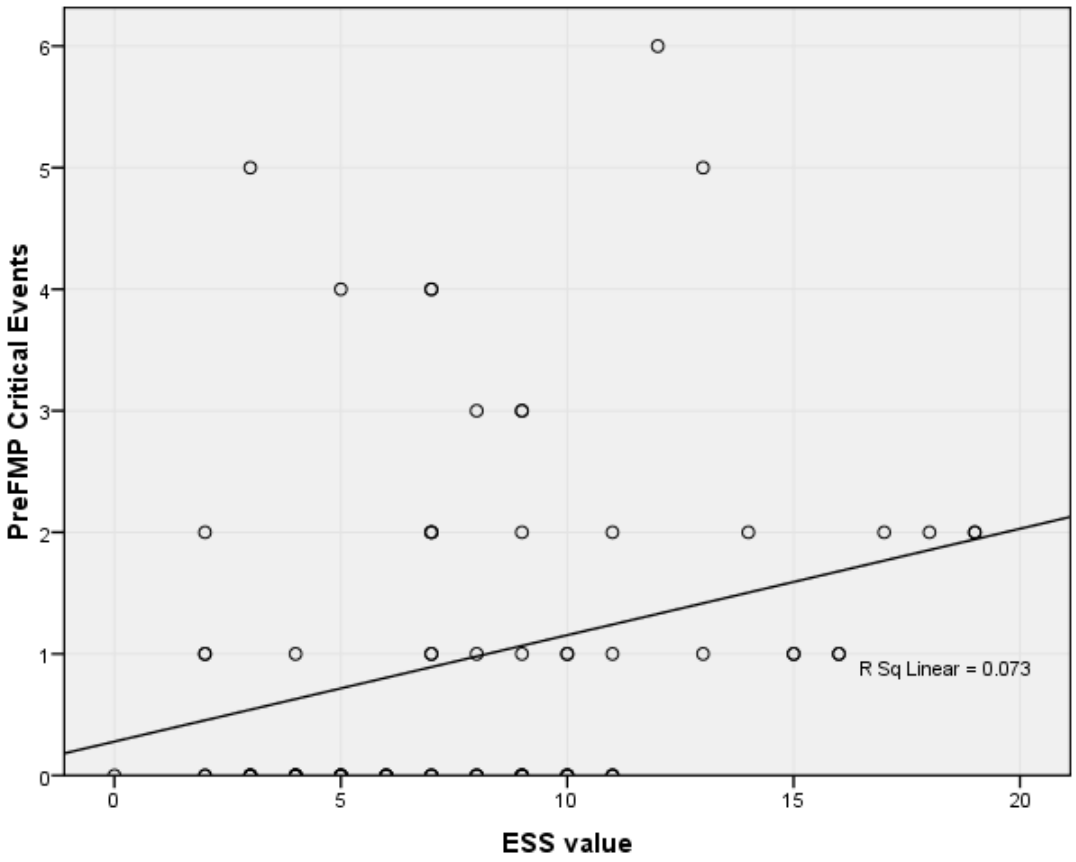


Figure 7-37 Number of pre-FMP critical events versus ESS score

Drivers were subdivided into three subgroups according to their ESS score; No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24). All three ESS score subgroups had fewer drivers with critical events post-FMP as compared to pre-FMP(see Table 7-101). McNemar's test for correlated proportions was used to compare the number of drivers with critical events, pre-FMP vs. post-FMP. The results are shown in Table 7-101. Using McNemar's test, the reduction in critical events for drivers with No Abnormality was found to be significant (35.6 percent to 20.3 percent, $p = .035$) (see Figure 7-38).

Table 7-101 Number of Drivers Reporting at least One Critical Event by ESS Score

ESS Group	Pre-FMP			Post-FMP		
	N	Driver had one or more Critical event	%	N	Driver had one or more Critical event	%
No Abnormality (0-10)	59	21 *	35.6%	59	12 *	20.3%
Moderate (11-16)	13	10	76.9%	13	8	61.5%
Severe (17-24)	4	4	100.0%	4	2	50.0%
TOTAL	**76**	**35**	**46.1%**	**76**	**22**	**28.9%**

** McNemar's Test (No Abnormality, Pre/post) p = .035*

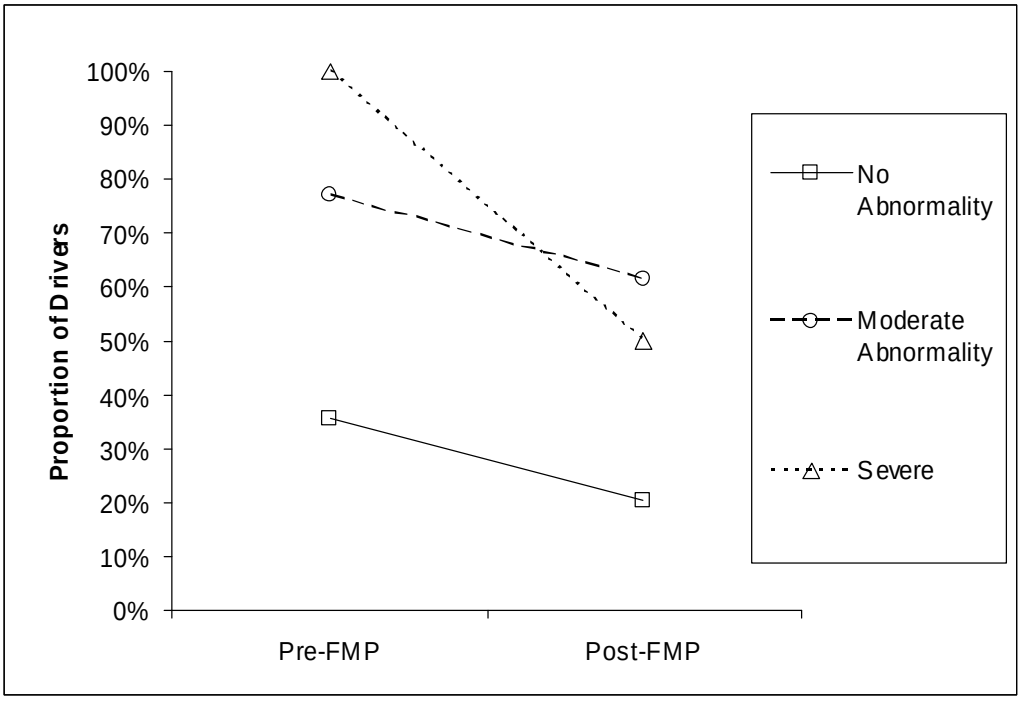


Figure 7-38 Proportion of drivers reporting at least one critical event by ESS Score

7.8.5 Critical Events and Driving Exposure

Québec and Alberta reported the number of kilometres driven by participating drivers during each phase of the study. A comparison was made of the distance travelled per reported critical event. On average, there was a 40 percent reduction from pre to post FMP in the rate of critical events by distance travelled; Pre-FMP drivers had 1 critical event per 24,064 km driven (45 critical events over 1,082,880 km driven), and post-FMP drivers had one critical event per 33,722 km driven (29 critical events over 977,955 km driven).

7.9 Sleep and Critical Events

7.9.1 Length of Main Sleep Period Prior to Critical Events

Table 7-102 shows a comparison between the average length of the main sleep period preceding a shift where drivers had a close call or nodded off. Post-FMP, on average, drivers had a shorter sleep period before having a critical event while driving (mean = 6.08 hours, SD = 1.83) as compared to shifts where they did not have a critical event (mean = 6.69 hours, SD = 1.41). A t-test comparison of means revealed this difference in mean sleep periods was significant (t(404) = 2.43, p = .016) (see Figure 7-39).

Table 7-102 Length of Main Sleep Period before Critical Events

	Pre-FMP		Post-FMP	
	N	Mean	N	Mean
Critical Event	69	6.43 (1.54)	36	6.08 (1.83)
No Critical Event	397	6.39 (1.69)	370	6.69 (1.41)

** t-test, post-FMP: t(404) = 2.43, p = .016*

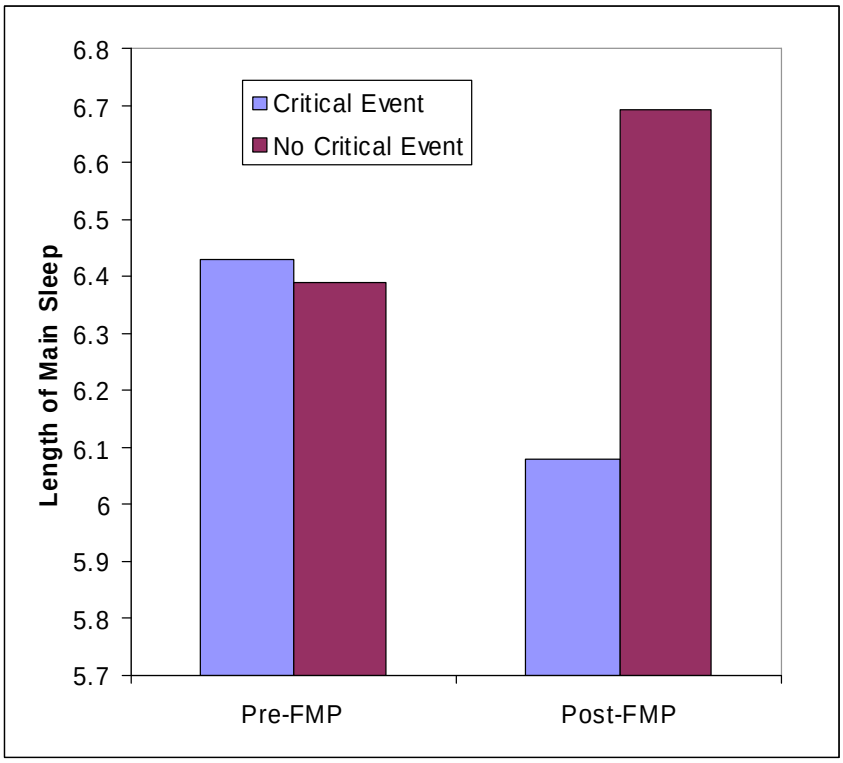


Figure 7-39 Length of main sleep period before critical events

7.9.2 Short Sleep Periods and Critical Events

Table 7-103 shows a comparison was made, pre-FMP vs. post-FMP, between the proportion of main sleep periods less than six hours in length (self-reported). Pre-FMP 31.2 percent of all shifts were preceded by main sleep periods that were less than six hours in length as compared to 24.4 percent post-FMP. McNemar's test for correlated proportions revealed that this decrease was significant (p = .039) (see Figure 7-40).

Table 7-103 Short Sleep Periods Preceding Critical Events

	Pre-FMP		Post-FMP	
	N	%	N	%
< 6 hours	134	31.2%	99	24.4%
≥ 6 hours	296	68.8%	307	75.6%

** McNemar's test (Main Sleep Periods < 6 hours, Pre/post) p = 0.039*

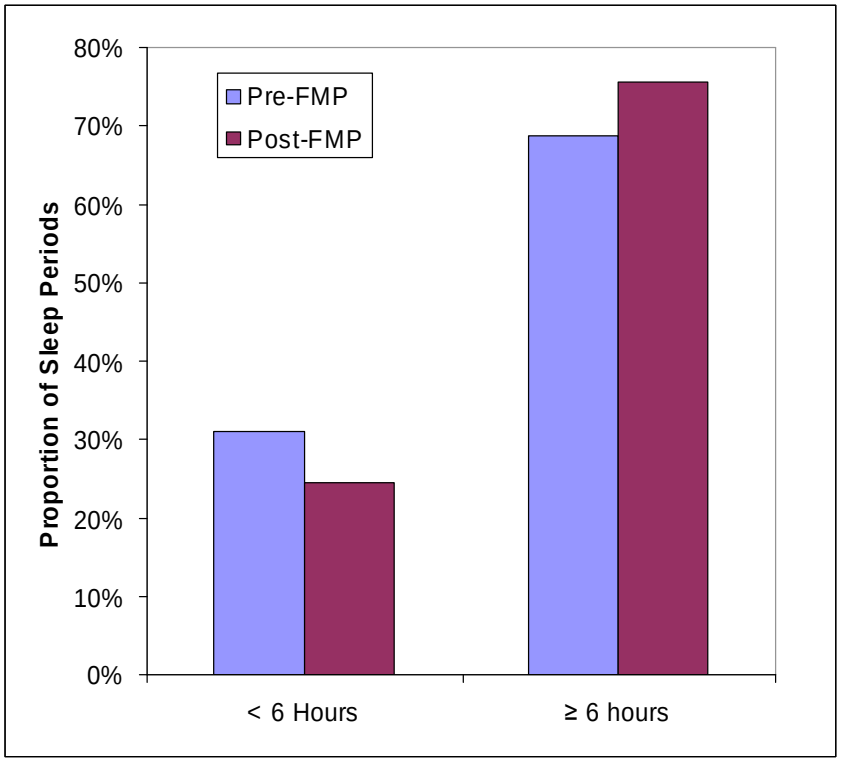


Figure 7-40 Short sleep periods preceding critical events

7.10 Psychomotor Vigilance Tasks

Vigilance was objectively assessed using a PDA version of the psychomotor vigilance task (PVT) and administered on a PDA-Z22 device (Palm Inc., Sunnyvale, California). During duty days, PVT sessions were performed at start and end of work. During rest days, PVT sessions were performed two hours after waking and two hours before going to bed. Each PVT session lasted ten minutes and consisted of multiple reaction tests in which the participants were instructed to press a button as fast as possible when they saw a visual stimulus. Average reaction time (in milliseconds), reaction speed (in sec^{-1} as 1 / reaction time), and counts of minor lapses (defined as reaction times greater than 500 milliseconds) were computed for every PVT session. These parameters were averaged per driver for the type of days (duty vs. rest), the time of day (start vs. end) and the condition (pre vs. post FMP). Data were then averaged across the study group or sub-groups.

A detailed review of our data set was done in order to ensure its reliability. Only subjects presenting a complete data set were analyzed. PVT sessions with missing values due to technical problems were first excluded. As every PVT session had to be preceded by a PDA questionnaire, a data validity check was applied by computing the time interval between each PVT session and its corresponding PDA questionnaire. Data were judged unreliable if this interval exceeded 2 hours and were thus excluded. This was judged as a good compromise between data quality and conserving most of the data possible pre and post FMP (91.8 percent and 90.7 percent, respectively, based on that exclusion criteria alone).

The interval between the start-of-day and the end-of-day PVT sessions was also computed and a distribution graph of this interval was created. Data points that fell outside the 95 percent confidence interval of this distribution were considered unreliable and were thus excluded. Overall, approximately 79 percent of start and end of day PVT sessions were completed in a time interval ranging from 10 to 16 hours. PVT sessions separated by time intervals smaller or greater than two standard deviations from the mean (mean = 14.31 hours, sd = 4.48) were excluded from further analysis.

As two PVT sessions were scheduled each day, every PVT session that was orphaned because of another exclusion criteria was also excluded. In order to minimize the effect of extreme values in performance across individuals, reaction times, reaction speed, and minor lapses are analyzed as median ± sd. A logarithm transformation was applied to the minor lapses count prior to the analysis in order to normalize the data distribution.

All PVT parameters were subdivided into different subgroups based on their RDI Score, their CPAP Adherence or their ESS Score. Normality of data distribution was verified and a transformation was used when the data were not normally distributed. A repeated-measures ANOVA was used to compare each PVT parameter for study phase (i.e., pre vs. post FMP), at different times of day (i.e., start vs. end of day), and for different types of day (i.e., rest vs. duty days).When results were common to most analyses for a same PVT parameter, they were reported as overall results.

7.10.1 Reaction Time

7.10.1.1 Overall Results

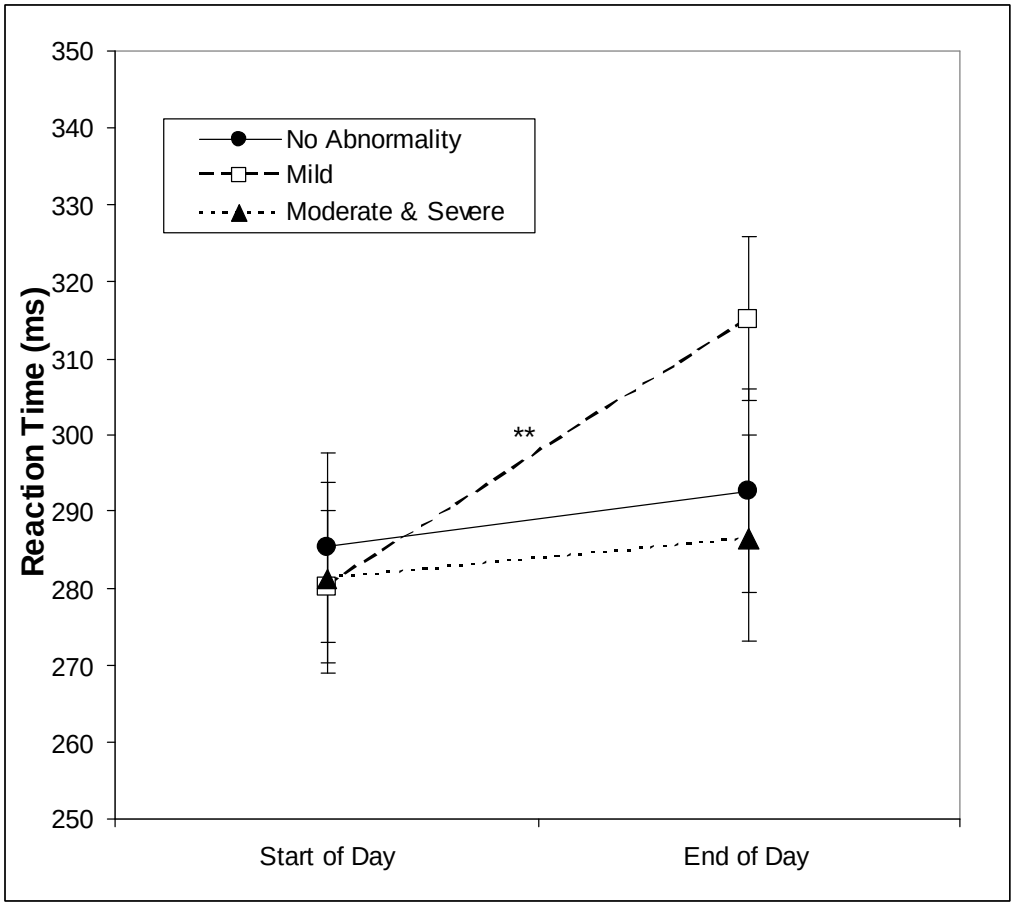
Reaction time was averaged per driver and expressed in milliseconds. A repeated-measures ANOVA was used to compare reaction time between study phases (e.g., pre vs. post-FMP), between time of day (e.g., start vs. end of day), and between type of day (e.g., rest vs. duty days) by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results). There was no main effect of study phase. A main effect of time of day was observed throughout all subgroup analyses and revealed that reaction times were longer at end of day compared to the start of day. For rest days there were no main effects of RDI Score or CPAP Adherence, but there was a main effect of ESS Score; mean reaction times were longer in the Severe Abnormality group as compared to the other two groups. For duty days there were no main effects of RDI Score, CPAP Adherence or ESS Score.

7.10.1.2 RDI SCORE

Rest days: Drivers were subdivided into three subgroups based on their RDI Score: No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15) (see Table 7-104). A repeated-measures ANOVA was used to compare reaction time during rest days (factors: RDI Score x Study Phase x Time of Day). There was no main effect of study phase ($F(1,40) = .192$, $p = .664$) or RDI Score ($F(2,40) = .422$, $p = .659$) but there was a significant main effect of time of day with longer reaction times at the end of day compared to the start of day ($F(1,40) = 10.136$, $p = .003$). There was also a significant interaction of time of day and RDI Score for reaction time during rest days ($F(2,40) = 4.30$, $p = .02$, see Figure 7-41). For the Mild Abnormality group, reaction times were longer at the end of day compared to the start of day ($p < .001$). No changes were observed in the other RDI groups ($p \geq .425$). There was no significant three-way interaction ($F(2,40) = 1.595$, $p = .216$).

Table 7-104 Reaction Time during Rest Days by RDI Score

RDI Score	N	Pre-FMP		Post-FMP	
		Start of Day	End of Day	Start of Day	End of Day
		Mean (SD) (milliseconds)	Mean (SD) (milliseconds)	Mean (SD) (milliseconds)	Mean (SD) (milliseconds)
No Abnormality (RDI < 5)	12	282.74 (54.54)	295.13 (44.40)	287.87 (51.45)	290.31 (54.01)
Mild Abnormality (RDI: 5 – 14.9)	19	275.04 (38.85)	316.87 (58.87)	285.22 (52.88)	313.24 (48.02)
Moderate to Severe (RDI ≥ 15)	12	281.53 (37.02)	282.78 (36.77)	281.11 (41.87)	290.20 (52.68)



**: Significant difference, p < 0.01

Figure 7-41 Reaction time during rest days, time of day x RDI score interaction

Duty days: Drivers were subdivided into three subgroups based on their RDI Score: No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15) (see Table 7-105). A repeated-measures ANOVA was used to compare reaction time during duty days (factors: RDI Score x Study Phase x Time of Day). There was no main effect of study phase ($F(1,49) = 1.83$, $p = .183$) or RDI Score ($F(2,49) = .334$, $p = .718$) but there was a trend for a significant main effect of time of day with longer reaction times at the end of day compared to the start of day ($F(1,49) = 3.30$, $p = .075$). There were no significant two-way or three-way interactions with RDI Score ($F(2,49) \leq .465$, $p \geq .631$; $F(2,49) = 1.484$, $p = .237$; respectively).

Table 7-105 Reaction Time during Duty Days by RDI Score

RDI Score	N	Pre-FMP		Post-FMP	
		Start of Day	End of Day	Start of Day	End of Day
		Mean (SD) (milliseconds)	Mean (SD) (milliseconds)	Mean (SD) (milliseconds)	Mean (SD) (milliseconds)
No Abnormality (RDI <5)	15	288.07 (66.60)	286.20 (39.04)	281.03 (53.17)	298.79 (57.85)
Mild Abnormality (RDI: 5-14.9)	21	294.53 (64.92)	300.37 (79.46)	301.31 (57.51)	315.59 (62.75)
Moderate to Severe (RDI ≥15)	16	288.03 (48.00)	294.27 (50.30)	297.96 (58.65)	295.48 (45.36)

7.10.1.3 CPAP ADHERENCE

Rest days: Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time) (see Table 7-106). A repeated-measures ANOVA was used to compare reaction time during rest days (factors: CPAP Adherence x Study Phase x Time of Day). There was no main effect of study phase ($F(1,36) = .293$, $p = .592$) or CPAP Adherence ($F(2,36) = .041$, $p = .960$) but there was a significant main effect of time of day with longer reaction times at the end of day compared to the start of day ($F(1,36) = 13.53$, $p = .001$). There was a trend for a significant interaction of study phase and CPAP Adherence for reaction time during rest days ($F(2,36) = 2.80$, $p = .074$, see Figure 7-42). For the CPAP Adherent group, reaction times were shorter post-FMP compared to pre-FMP ($p = .065$). This difference was not seen for the other CPAP Adherence groups ($p \geq .170$). There was no significant three-way interaction ($F(2,36) = 1.04$, $p = .365$).

Table 7-106 Reaction Time during Rest Days by CPAP Adherence

CPAP Adherence	N	Pre-FMP		Post-FMP	
		Start of Day	End of Day	Start of Day	End of Day
		Mean (SD) (milliseconds)	Mean (SD) (milliseconds)	Mean (SD) (milliseconds)	Mean (SD) (milliseconds)
No CPAP Required	18	283.91 (48.14)	295.41 (42.78)	287.58 (45.64)	292.33 (45.82)
CPAP Adherent (>4 hrs (70%))	8	286.61 (32.35)	306.35 (57.55)	267.81 (28.46)	289 (40.47)
CPAP Non-Adherent (< 4 hrs (70%))	13	258.01 (33.16)	302.63 (63.63)	278.11 (50.21)	303.37 (60.64)

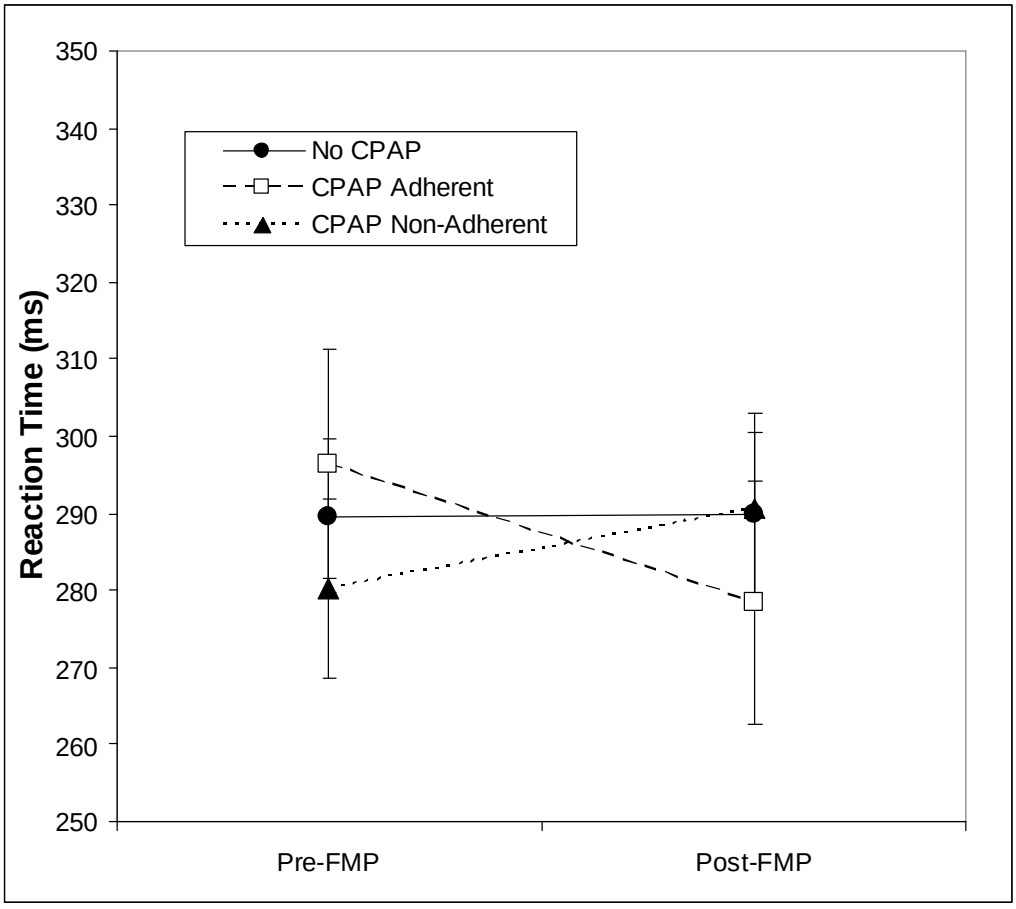


Figure 7-42 Reaction time during rest days, study phase x CPAP adherence interaction

Duty days: Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time) (see Table 7-107). A repeated-measures ANOVA was used to compare reaction time during duty days (factors: CPAP Adherence x Study Phase x Time of Day). There was no main effect of study phase ($F(1,44) = 1.21$, $p = .277$), time of day ($F(1,44) = 2.14$, $p = .135$), or CPAP Adherence ($F(2,44) = .466$, $p = .631$).There were no significant two-way or three-way interactions with RDI Score ($F(2,44) \leq 1.39$, $p \geq .260$; $F(2,44) = 1.15$, $p = .327$; respectively).

Table 7-107 Reaction Time during Duty Days by CPAP Adherence

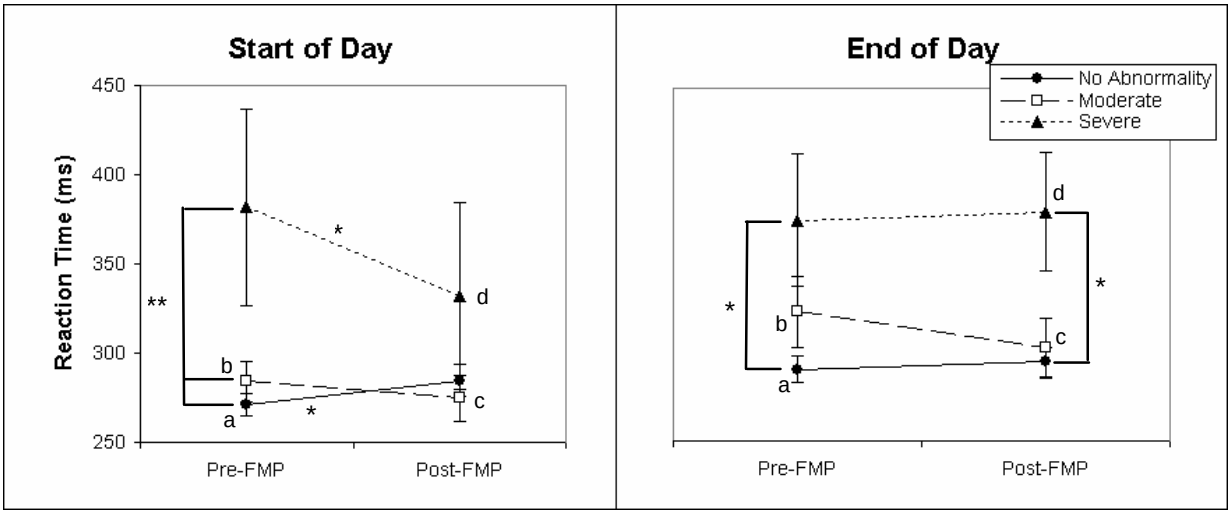
CPAP Adherence	N	Pre-FMP		Post-FMP	
		Start of Day	End of Day	Start of Day	End of Day
		Mean (SD) (milliseconds)	Mean (SD) (milliseconds)	Mean (SD) (milliseconds)	Mean (SD) (milliseconds)
No CPAP Required	22	295.48 (77.83)	295.35 (80.01)	289.11 (58)	308.05 (68.64)
CPAP Adherent (>4 hrs (70%))	11	300.45 (51.06)	297.29 (46.75)	304.33 (41.85)	299.95 (50.40)
CPAP Non-Adherent (<4 hrs (70%))	14	270.10 (34.62)	283.01 (42.05)	281.52 (62.10)	291.34 (40)

7.10.1.4 ESS SCORE

Rest days: Drivers were subdivided into three subgroups according to their ESS Score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24) (see Table 7-108 and Figure 7-43). A repeated-measures ANOVA was used to compare reaction time during rest days (factors: ESS Score x Study Phase x Time of Day). There was no main effect of study phase ($F(1,40) = 1.24$, $p = .273$) but there was a main significant effect of time of day with longer reaction times at the end vs. start of day ($F(1,40) = 6.34$, $p = .016$). There was also a main effect of ESS Score ($F(2,40) = 4.414$, $p = .019$). Reaction times were longer in the Severe vs. Moderate or No Abnormality ESS groups ($p = .015$, $p = .057$, respectively). There was a trend for an interaction of study phase and ESS Score for reaction time during rest days ($F(2,40) = 2.61$, $p = .086$, see Figure 7-43). Pre-FMP, reaction times were longer for the Severe Abnormality group compared to the other groups ($p \leq .012$). Post-FMP, there was a trend for longer reaction times in the Severe Abnormality group compared to the other groups ($p \leq .069$). There was a significant three-way interaction ($F(2,40) = 3.851$, $p = .030$. At start of day, there was an increase in reaction time post-FMP compared to pre FMP in the No Abnormality group ($p = .024$) and a decrease in reaction time for the Severe Abnormality group ($p = .037$). At the start of day during pre-FMP, the Severe Abnormality group had a longer reaction time compared to the other group ($p \leq .001$). At the end of day, reaction times were longer for the Severe Abnormality group compared to the No Abnormality group during pre-FMP ($p = .019$) and post-FMP ($p = .022$). There was an increase in reaction time at the end of day compared to start of day in all group and every study states ($p \leq .040$) except for the No Abnormality group post-FMP and Severe Abnormality group pre-FMP.

Table 7-108 Reaction Time during Rest Days by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Start of Day	End of Day	Start of Day	End of Day
		Mean (SD) (milliseconds)	Mean (SD) (milliseconds)	Mean (SD) (milliseconds)	Mean (SD) (milliseconds)
No Abnormality (0-10)	32	271.17 (34.75)	290.51 (42.69)	284.72 (49.55)	294.77 (48.42)
Moderate (11-16)	9	284.03 (33.05)	323.24 (61.11)	274.66 (38.92)	302.78 (51.36)
Severe (17-24)	2	381.67 (77.78)	375.00 (53.03)	332.00 (73.54)	380 (47.14)



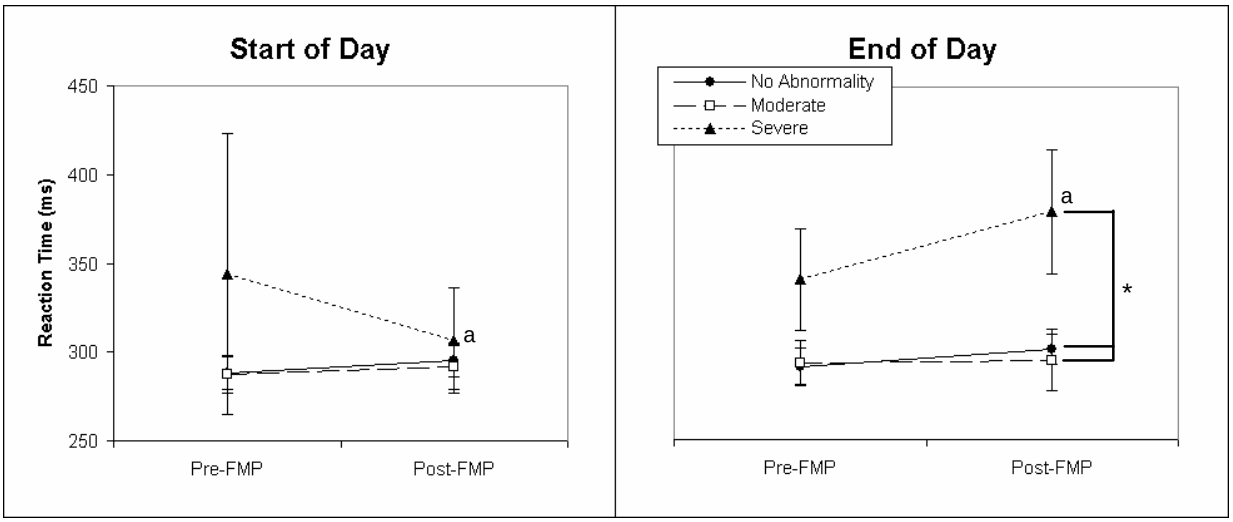
*: Significant difference, p < 0.05
**: Significant difference, p < 0.01
a : Significant difference Start vs. End of Day in pre FMP, No abnormality ESS group, p < 0.05
b : Significant difference Start vs. End of Day in pre FMP, Moderate ESS group, p < 0.01
c : Significant difference Start vs. End of Day in post FMP, Moderate ESS group, p < 0.05
d : Significant difference Start vs. End of Day in post FMP, Severe ESS group, p < 0.05

Figure 7-43 Reaction time during rest days by ESS score, three-way interaction

Duty days: Drivers were subdivided into three subgroups according to their ESS Score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24) (see Table 7-109). A repeated-measures ANOVA was used to compare reaction time during duty days (factors: ESS Score x Study Phase x Time of Day). There was no main effect of study phase ($F(1,48) = .248$, $p = .621$) or ESS Score ($F(2,48) = 1.24$, $p = .307$) but there was a significant main effect of time of day with longer reaction times at the end of day compared to start of day ($F(1,48) = 6.37$, $p = .015$). There was no significant two-way interaction ($F(2, 48) \leq 2.01$, $p \geq .145$). There was a significant three-way interaction ($F(2,48) = 3.940$, $p = .026$, see Figure 7-44). At the end of day, reaction times were longer for the Severe Abnormality group compared to the other groups post-FMP ($p \leq .027$). There was an increase in reaction time at the end of day compared to the start of day for the Severe Abnormality group post-FMP ($p = .001$).

Table 7-109 Reaction Time during Duty Days by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Start of Day	End of Day	Start of Day	End of Day
		Mean (SD) (milliseconds)	Mean (SD) (milliseconds)	Mean (SD) (milliseconds)	Mean (SD) (milliseconds)
No Abnormality (0-10)	40	288.10 (57.17)	291.37 (65.27)	295.37 (60.76)	301.38 (54.99)
Moderate (11-16)	8	287.29 (30.44)	293.51 (36.12)	291.57 (35.36)	295.11 (49.32)
Severe (17-24)	3	344.17 (137.21)	341.00 (50.07)	306.50 (51.59)	379.33 (61.33)



*: Significant difference, $p < 0.05$
a : Significant difference Start vs. End of Day in post FMP, Severe ESS group, $p < 0.05$.

Figure 7-44 Reaction time during duty days by ESS score, three-way interaction

7.10.2 Reaction Speed

7.10.2.1 Overall Results

Reaction speed is the reaction time expressed in sec^{-1}. Reaction speed is often the method used to report psychomotor performance. A repeated-measures ANOVA was used to compare reaction speed during rest days and duty days by subgroup (e.g., RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between study phases and type of days. There was no main effect of study phase but there was a main effect of time of day for all subgroup analyses and faster reaction speed at the start of day compared to the end of day. On rest days there were no main effects of RDI Score or CPAP Adherence, but there was a trend towards an effect of ESS Score; reaction speed was slower for drivers in the Severe Abnormality group compared to the other two groups. On duty days there were no main effects of RDI Score, CPAP Adherence, or ESS Score.

7.10.2.2 RDI SCORE

Rest days: Drivers were subdivided into three subgroups based on their RDI Score: No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15) (see Table 7-110). A repeated-measures ANOVA was used to compare reaction speed during rest days (factors: RDI Score x Study Phase x Time of Day). There was no main effect of study phase ($F(1,40) = .070$, $p = .793$) or RDI Score ($F(2,40) = .246$, $p = .783$) but there was a significant main effect of time of day with greater reaction speed at the start vs. end of day ($F(1,40) = 12.33$, $p = .001$). There was a significant interaction of time of day x RDI Score for reaction speed during rest days ($F(2,40) = .551$, $p = .013$, see Figure 7-45). More specifically, there was a trend for a faster reaction speed at the start of day compared to the end of day in all groups ($p \leq .097$). There was no significant three-way interaction ($F(2,40) = 1.47$, $p = .242$).

Table 7-110 Reaction Speed during Rest Days by RDI Score

RDI Score	N	Pre-FMP		Post-FMP	
		Start of Day	End of Day	Start of Day	End of Day
		Mean (SD) (1/seconds)	Mean (SD) (1/seconds)	Mean (SD) (1/seconds)	Mean (SD) (1/seconds)
No Abnormality (RDI < 5)	12	3.64 (0.54)	3.46 (0.43)	3.57 (0.55)	3.55 (0.58)
Mild Abnormality (RDI: 5 – 14.9)	19	3.73 (0.55)	3.28 (0.57)	3.63 (0.64)	3.29 (0.50)
Moderate to Severe (RDI ≥ 15)	12	3.62 (0.45)	3.60 (0.45)	3.64 (0.47)	3.55 (0.59)

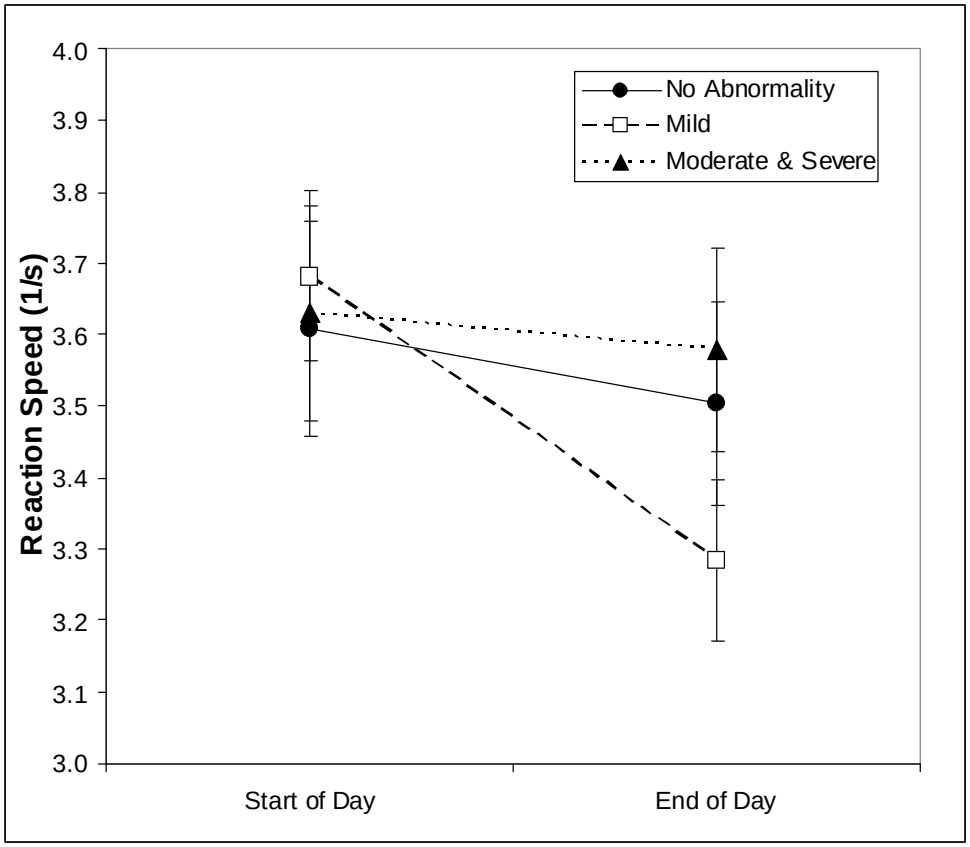


Figure 7-45 Reaction speed during rest days, time of day x RDI score interaction

Duty days: Drivers were subdivided into three subgroups based on their RDI Score: No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15) (see Table 7-111). A repeated-measures ANOVA was used to compare reaction speed during duty days (factors: RDI Score x Study Phase x Time of Day). There was no main effect of study phase ($F(1,49) = 2.72$, $p = .105$) or RDI Score ($F(2,49) = .271$, $p = .764$) but there was a significant effect of time of day with faster reaction speed at the start of day compared to the end of day ($F(1,49) = 5.66$, $p = .021$). There were no significant two-way or three-way interactions with RDI Score ($F(2, 49) \leq .548$, $p \geq .582$; $F(2, 49) = 1.12$, $p = .335$; respectively).

Table 7-111 Reaction Speed during Duty Days by RDI Score

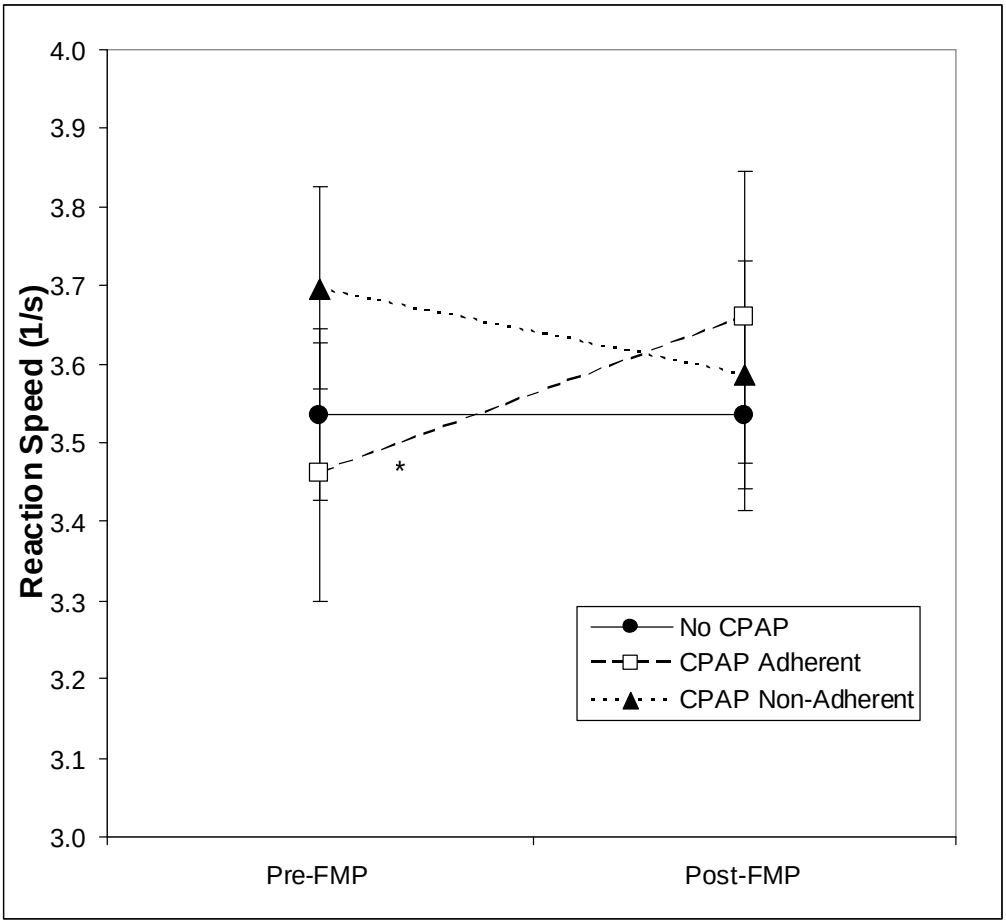
RDI Score	N	Pre-FMP		Post-FMP	
		Start of Day	End of Day	Start of Day	End of Day
		Mean (SD) (1/seconds)	Mean (SD) (1/seconds)	Mean (SD) (1/seconds)	Mean (SD) (1/seconds)
No Abnormality (RDI <5)	15	3.61 (0.59)	3.56 (0.44)	3.63 (0.61)	3.46 (0.55)
Mild Abnormality (RDI: 5-14.9)	21	3.53 (0.59)	3.48 (0.58)	3.45 (0.61)	3.29 (0.54)
Moderate to Severe (RDI ≥15)	16	3.57 (0.50)	3.49 (0.55)	3.50 (0.55)	3.48 (0.49)

7.10.2.3 CPAP ADHERENCE

Rest days: Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time) (see Table 7-112). A repeated-measures ANOVA was used to compare reaction speed during rest days (factors: CPAP Adherence x Study Phase x Time of Day). There was no main effect of study phase ($F(1,36) = .409$, $p = .527$) or CPAP Adherence ($F(2,36) = .192$, $p = .826$) but there was a significant main effect of time of day with faster speed at the start of day compared to end of day ($F(1,36) = 15.16$, $p < .001$). There was a significant interaction of study phase and CPAP Adherence for reaction speed during rest days ($F(2,36) = 3.30$, $p = .048$, see Figure 7-46). Reaction speed was faster post-FMP compared to pre FMP for the CPAP Adherent group ($p = .044$) but not for the other groups ($p \geq .142$). There was a trend for a significant interaction of time of day and CPAP Adherence for reaction speed during rest days ($F(2,36) = 2.58$, $p = .090$, see Figure 7-47). Reaction speed was lower at the end vs. start of day for the CPAP Non-Adherent group ($p < .001$) but not for the other groups ($p \geq .119$). There was no significant three-way interaction ($F(2,36) = 1.81$, $p = .319$).

Table 7-112 Reaction Speed during Rest Days by CPAP Adherence

CPAP Adherence	N	Pre-FMP		Post-FMP	
		Start of Day	End of Day	Start of Day	End of Day
		Mean (SD) (1/seconds)	Mean (SD) (1/seconds)	Mean (SD) (1/seconds)	Mean (SD) (1/seconds)
No CPAP Required	18	3.61 (0.50)	3.46 (0.45)	3.57 (0.52)	3.51 (0.50)
CPAP Adherent (>4 hrs (70%))	8	3.55 (0.37)	3.37 (0.53)	3.78 (0.37)	3.55 (0.48)
CPAP Non-Adherent (<4 hrs (70%))	13	3.95 (0.54)	3.44 (0.65)	3.74 (0.66)	3.43 (0.66)



*: Significant difference, $p < 0.05$

Figure 7-46 Reaction speed during rest days, study phase x CPAP adherence

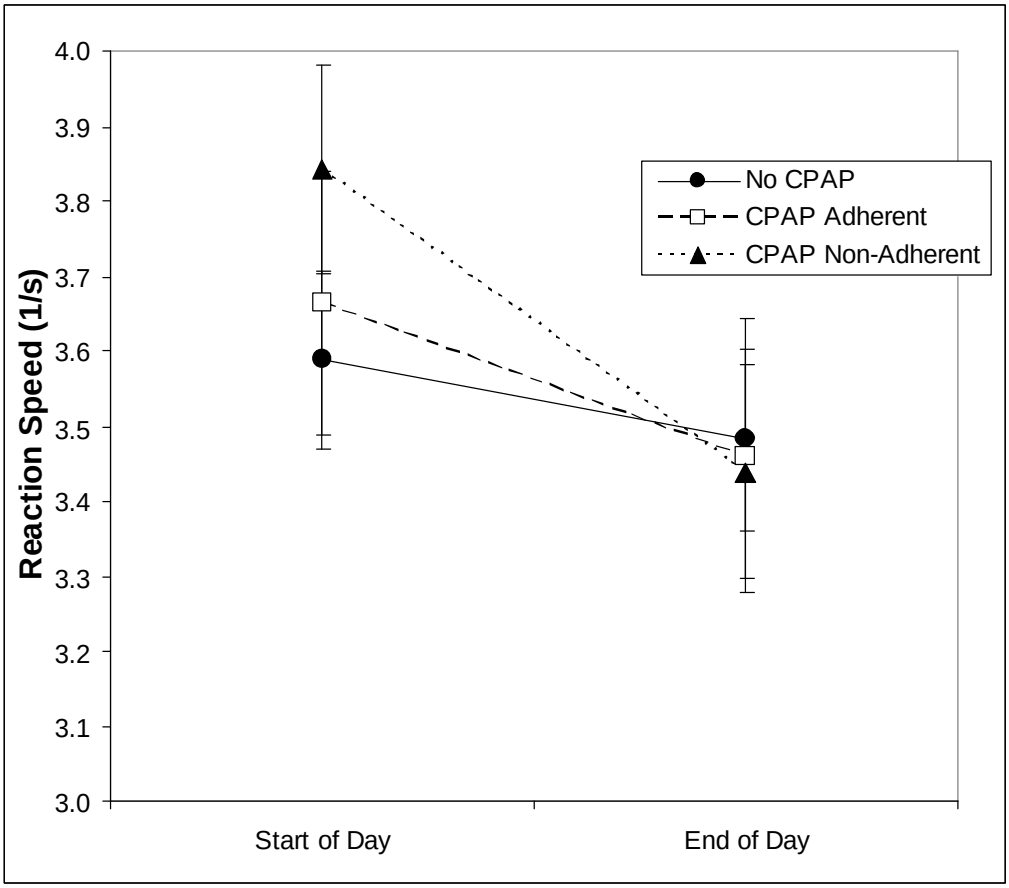


Figure 7-47 Reaction speed during rest days, time of day x CPAP adherence interaction

Duty days: Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (< 4 hours/night, 70 percent of the time) (see Table 7-113). A repeated-measures ANOVA was used to compare reaction speed during duty days (factors: CPAP Adherence x Study Phase x Time of Day). There was no main effect of study phase ($F(1,44) = 1.61$, $p = .211$) or of CPAP Adherence ($F(2,44) = .637$, $p = .534$). However, there was a significant main effect of time of day with greater speed at the start vs. end of day ($F(1,44) = 4.59$, $p = .038$). There were no significant two-way or three-way interactions with RDI Score ($F(2, 44) \leq 2.10$, $p \geq .134$; $F(2, 44) = 1.02$, $p = .351$; respectively).

Table 7-113 Reaction Speed during Duty Days by CPAP Adherence

CPAP Adherence	N	Pre-FMP		Post-FMP	
		Start of Day	End of Day	Start of Day	End of Day
		Mean (SD) (1/seconds)	Mean (SD) (1/seconds)	Mean (SD) (1/seconds)	Mean (SD) (1/seconds)
No CPAP Required	22	3.56 (0.65)	3.55 (0.60)	3.56 (0.60)	3.38 (0.58)
CPAP Adherent (> 4 hrs (70%))	11	3.42 (0.50)	3.44 (0.52)	3.40 (0.42)	3.43 (0.53)
CPAP Non-Adherent (< 4 hrs (70%))	14	3.78 (0.45)	3.61 (0.46)	3.69 (0.66)	3.52 (0.44)

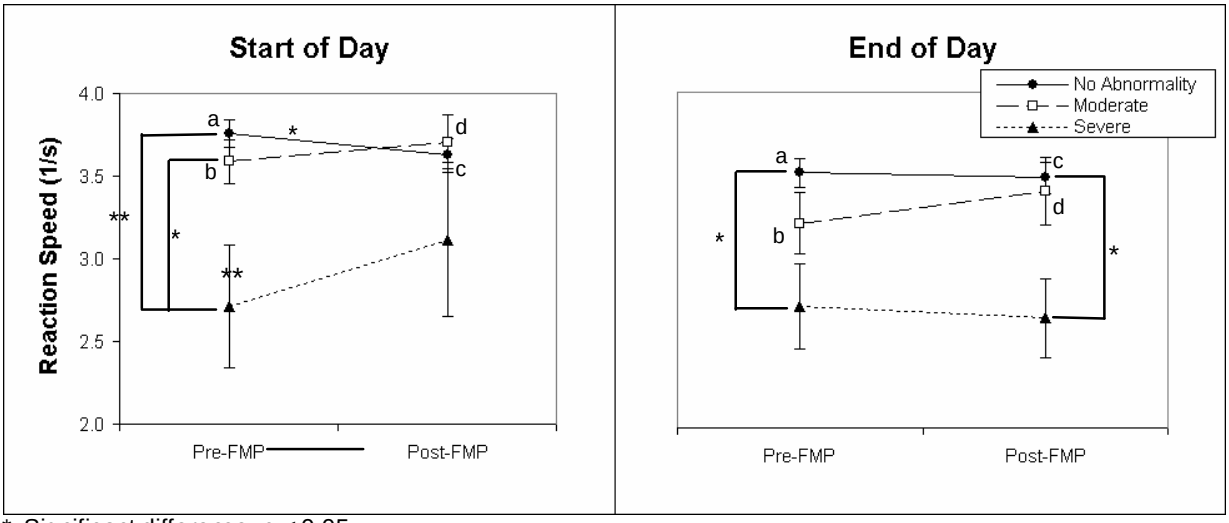
7.10.2.4 ESS SCORE

Rest days: Drivers were subdivided into three subgroups according to their ESS Score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24) (see Table 7-114, Figure 7-48). A repeated-measures ANOVA was used to compare reaction speed during rest days (factors: ESS Score x Study Phase x Time of Day). There was no significant main effect of study phase ($F(1,40) = .993$, $p = .325$) but there was a significant effect of time of day, with greater reaction speed at the start of day compared to the end of day ($F(1,40) = 6.26$, $p = .017$). There was a trend towards an effect of ESS Score ($F(2,40) = 3.09$, $p = .056$). Reaction speed was slower for drivers in the Severe Abnormality group compared to the Moderate Abnormality ($p = .015$) and No Abnormality groups ($p = .057$). There was trend for an interaction of study phase and ESS Score for reaction speed during rest days ($F(2,40) = 2.45$, $p = .099$, see Figure 7-48). Pre-FMP, reaction speed was lower for the Severe Abnormality compared to the other groups ($p \leq .042$). Post-FMP, there was a trend for lower reaction speed in the Severe Abnormality group compared to the No Abnormality group ($p = .083$) but not the Moderate Abnormality group ($p = .105$). There was a trend for a three-way interaction ($F(2,40) = 2.541$, $p = .091$. At the start of day, there was a reduction in reaction speed post-FMP compared to pre-FMP in the No Abnormality group ($p = .027$). At the start of day, there was a trend for an increase in reaction speed post-FMP compared to pre-FMP. At the start of day during pre-FMP, the Severe Abnormality group had a slower reaction speed compared to the other groups ($p \leq .021$). At end of day, reaction speeds were slower for the Severe Abnormality group compared to the No Abnormality group, for both pre-FMP ($p = .030$) and post-FMP ($p = .038$) FMP. There was a reduction in reaction speed at the end of day compared to start of day in the No Abnormality ($p \leq .041$) and Mild Abnormality ($p \leq .019$) groups but not in the Severe Abnormality group, for both pre-FMP and post-FMP.

Table 7-114 Reaction Speed during Rest Days by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Start of Day	End of Day	Start of Day	End of Day
		Mean (SD) (1/seconds)	Mean (SD) (1/seconds)	Mean (SD) (1/seconds)	Mean (SD) (1/seconds)
No Abnormality (0-10)	32	3.76 (0.48)	3.52 (0.47)	3.63 (0.58)	3.49 (0.52)
Moderate (11-16)	9	3.59 (0.40)	3.22 (0.55)	3.71 (0.49)	3.41 (0.60)
Severe (17-24)	2	2.71 (0.52)	2.73 (0.36)	3.12 (0.66)	2.66 (0.33)

*: Significant difference, $p < 0.05$
**: Significant difference, $p < 0.01$



*: Significant difference, $p < 0.05$
**: Significant difference, $p < 0.01$
a : Significant difference Start vs. End of Day in pre FMP, No Abnormality ESS group, $p < 0.01$
b : Significant difference Start vs. End of Day in pre FMP, Moderate ESS group, $p < 0.05$
c : Significant difference Start vs. End of Day in post FMP, No Abnormality ESS group, $p < 0.05$
d : Significant difference Start vs. End of Day in post FMP, Moderate ESS group, $p < 0.05$

Figure 7-48 Reaction speed during rest days by ESS score, three-way interaction

Duty days: Drivers were subdivided into three subgroups according to their ESS Score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24) (see Table 7-115). A repeated-measures ANOVA was used to compare reaction speed during duty days (factors: ESS Score x Study Phase x Time of Day). There was no significant main effect of study phase ($F(1,48) = 1.63$, $p = .208$) or ESS Score ($F(2,48) = 1.50$, $p = .234$) but there was a significant main effect of time of day with shorter reaction speed at the start of day compared to the end of day ($F(1,48) = 6,27$, $p = .016$). There were no significant two-way or three-way interactions with RDI Score ($F(2, 48) \leq 1.62$, $p \geq .209$; $F(2, 48) = .500$, $p = .610$; respectively).

Table 7-115 Reaction Speed during Duty Days by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Start of Day	End of Day	Start of Day	End of Day
		Mean (SD) (1/seconds)	Mean (SD) (1/seconds)	Mean (SD) (1/seconds)	Mean (SD) (1/seconds)
No Abnormality (0-10)	40	3.59 (0.56)	3.55 (0.54)	3.53 (0.62)	3.42 (0.51)
Moderate (11-16)	8	3.53 (0.34)	3.47 (0.44)	3.50 (0.43)	3.49 (0.53)
Severe (17-24)	3	3.22 (0.99)	2.99 (0.45)	3.13 (0.32)	2.70 (0.39)

7.10.3 Minor Lapses

7.10.3.1 Overall Results

Minor lapses are defined as reaction times greater than 500 milliseconds during PVT sessions. The number of minor lapses occurring per PVT session was averaged by driver, for rest and duty days, for start and end-of-day PVTs. The analyses were performed on log-transformed minor lapses count in order to normalize the data distribution.

Rest days: A repeated-measures ANOVA was used to compare minor lapses count by subgroup (RDI Score, CPAP Adherence or ESS Score – see next section for detailed results) between study phases and type of days. A main effect of time of day was observed on RDI score and CPAP adherence analyses and showed that there were more minor lapses at the end of day compared to the start of day. There were no main effects of RDI Score or CPAP Adherence but there was a main effect of ESS Score; drivers in the Severe Abnormality group had significantly more lapses than the other two groups.

Duty days: A repeated-measures ANOVA was used to compare minor lapses count by subgroup (RDI Score, CPAP Adherence or ESS Score, see next section for detailed results) between study phases and type of days. A main effect of study phase was observed for RDI Score and CPAP Adherence group analyses and showed that there were more minor lapses post-FMP compared to pre-FMP in these analyses.

7.10.3.2 RDI Score

Rest days: Drivers were subdivided into three subgroups based on their RDI Score: No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15) (see Table 7-116). A repeated-measures ANOVA was used to compare minor lapses count during rest days (factors: RDI Score x Study Phase x Time of Day). There was no main effect of study phase ($F(1,40) = .084$, $p = .773$) or RDI Score ($F(2,40) = .1.064$, $p = .355$) but there was a significant main effect of time of day with more minor lapses at the end of day compared to the start of day ($F(1,40) = 6.47$, $p = .115$). There was a significant interaction of time of day and RDI Score for minor lapses during rest days ($F(2,40) = 3.41$, $p = .043$, see Figure 7-49). For the Mild Abnormality group, minor lapses increased at the end of day compared to the start of rest days ($p < .001$), whereas there were no differences in the other groups ($p \geq 0.015$).

Table 7-116 Minor Lapses during Rest Days by RDI Score

RDI Score	N	Pre-FMP		Post-FMP	
		Start of Day	End of Day	Start of Day	End of Day
		Mean (SD) (count)	Mean (SD) (count)	Mean (SD) (count)	Mean (SD) (count)
No Abnormality (RDI <5)	12	0.52 (0.29)	0.59 (0.26)	0.53 (0.28)	0.57 (0.27)
Mild Abnormality (RDI: 5-14.9)	19	0.51 (0.30)	0.76 (0.24)	0.59 (0.33)	0.71 (0.30)
Moderate to Severe (RDI ≥15)	12	0.53 (0.32)	0.48 (0.31)	0.50 (0.34)	0.55 (0.37)

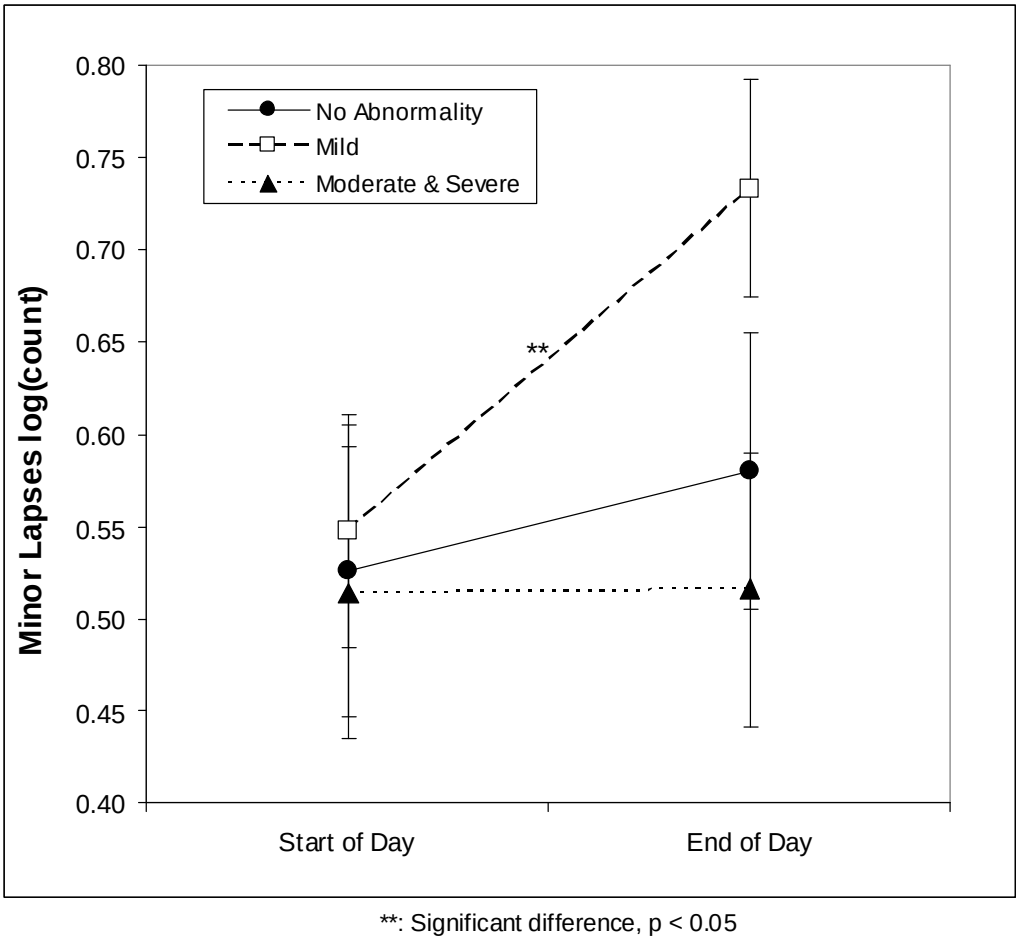


Figure 7-49 Minor lapses during rest days, time of day x RDI score interaction

Duty days: Drivers were subdivided into three subgroups based on their RDI Score; No Abnormality (RDI <5), Mild Abnormality (RDI: 5 to 14.9), Moderate and Severe (RDI ≥15) (see Table 7-117). A repeated-measures ANOVA was used to compare minor lapses during duty days (factors: RDI Score x Study Phase x Time of Day). There was no main effect of time of day ($F(1,49) = .322$, $p = .573$) or RDI Score

(F(2,49) = .339, p = .714) but there was a significant main effect of study phase, with more minor lapses post-FMP compared to pre-FMP (F(1,49) = 4.41, p = .041). There were no significant two-way or three-way interactions with RDI Score (F(2,49) ≤ .2.54, p ≥ .117; F(2,49) = 1.633, p = .206; respectively).

Table 7-117 Minor Lapses during Duty Days by RDI Score

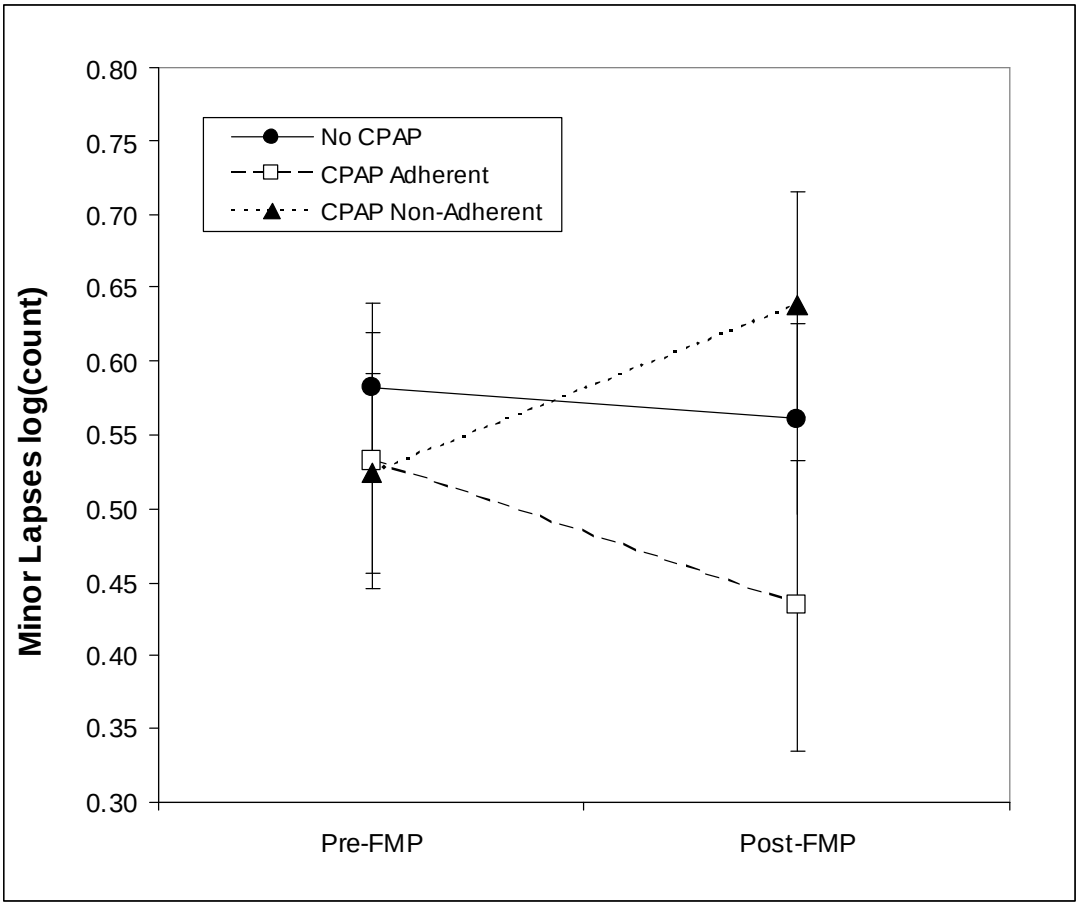
RDI Score	N	Pre-FMP		Post-FMP	
		Start of Day	End of Day	Start of Day	End of Day
		Mean (SD) (log of count)	Mean (SD) (log of count)	Mean (SD) (log of count)	Mean (SD) (log of count)
No Abnormality (RDI <5)	15	0.54 (0.26)	0.57 (0.21)	0.57 (0.26)	0.57 (0.32)
Mild Abnormality (RDI: 5-14.9)	21	0.58 (0.32)	0.55 (0.31)	0.66 (0.27)	0.74 (0.23)
Moderate to Severe (RDI ≥15)	16	0.59 (0.36)	0.55 (0.34)	0.59 (0.36)	0.63 (0.29)

7.10.3.3 CPAP ADHERENCE

Rest days: Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time) (see Table 7-118). A repeated-measures ANOVA was used to compare minor lapses count during rest days (factors: CPAP Adherence x Study Phase x Time of Day). There was no main effect of study phase (F(1,36) = .002, p = .963) or CPAP Adherence (F(2,36) = .468, p = .630) but there was a significant main effect of time of day with more minor lapses at the end of day compared to the start of day (F(1,36) = 8.49, p = .006). There was a trend for an interaction of study phase and CPAP Adherence for minor lapses during rest days (F(2,36) = 3.07, p = .059, see Figure 7-50) There were significantly more minor lapses post-FMP compared to pre-FMP in the CPAP Non-Adherent group (p = .049). There was no significant three-way interaction (F(2,36) = 1.889, p = .166).

Table 7-118 Minor Lapses during Rest Days by CPAP Adherence

CPAP Adherence	N	Pre-FMP		Post-FMP	
		Start of Day	End of Day	Start of Day	End of Day
		Mean (SD) (log of count)	Mean (SD) (log of count)	Mean (SD) (log of count)	Mean (SD) (log of count)
No CPAP Required	18	0.55 (0.26)	0.61 (0.24)	0.53 (0.32)	0.59 (0.27)
CPAP Adherent (>4 hrs (70%))	8	0.48 (0.30)	0.58 (0.35)	0.33 (0.32)	0.54 (0.31)
CPAP Non-Adherent (<4 hrs (70%))	13	0.41 (0.32)	0.64 (0.34)	0.63 (0.25)	0.65 (0.39)



*: Significant difference, $p < 0.05$

Figure 7-50 Minor lapses during rest days, study phase x CPAP adherence interaction

Duty days Drivers were subdivided into three subgroups according to whether they complied with CPAP; No CPAP required, CPAP Adherent (>4 hours/night, 70 percent of the time), and CPAP Non-Adherent (<4 hours/night, 70 percent of the time) (see Table 7-119). A repeated-measures ANOVA was used to compare minor lapses count during duty days (factors: CPAP Adherence x Study Phase x Time of Day). There was a main effect of study phase with more minor lapses post-FMP compared to pre-FMP ($F(1,44) = 6.24$, $p = .016$). There was no main effect of time of day ($F(1,44) = .403$, $p = .529$) or CPAP Adherence ($F(2,44) = .080$, $p = .923$). There was a significant interaction between study phase and time of day ($F(1,44) = 6.94$, $p = 0.012$, see Figure 7-49) with more minor lapses at the end of day post vs. pre FMP. There were no three-way interactions with CPAP group ($F(2, 44) = .767$, $p = .471$).

Table 7-119 Minor Lapses during Duty Days by CPAP Adherence

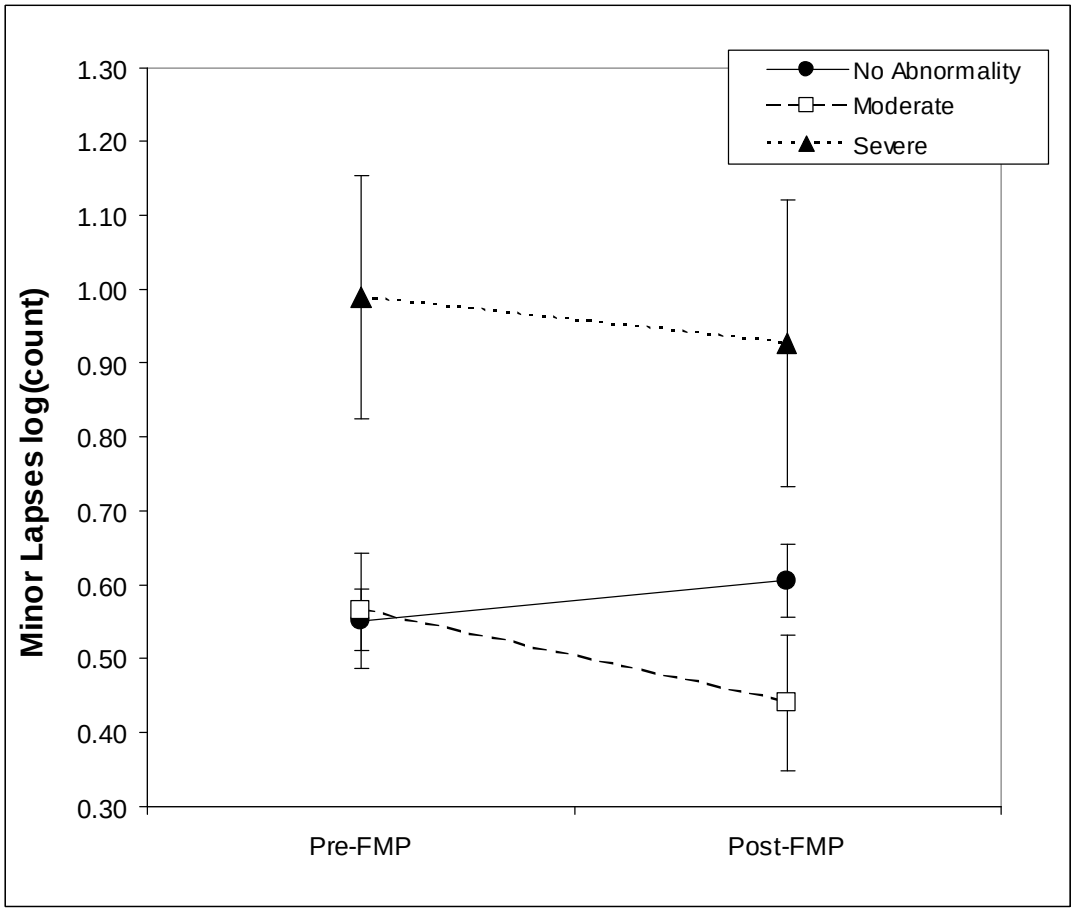
CPAP Adherence	N	Pre-FMP		Post-FMP	
		Start of Day	End of Day	Start of Day	End of Day
		Mean (SD) (log of count)	Mean (SD) (log of count)	Mean (SD) (log of count)	Mean (SD) (log of count)
No CPAP Required	22	0.56 (0.30)	0.54 (0.28)	0.59 (0.27)	0.62 (0.33)
CPAP Adherent (> 4 hrs (70%))	11	0.51 (0.4)	0.44 (0.36)	0.59 (0.37)	0.66 (0.25)
CPAP Non-Adherent (< 4 hrs (70%))	14	0.55 (0.28)	0.57 (0.25)	0.58 (0.28)	0.66 (0.25)

7.10.3.4 ESS SCORE

Rest days: Drivers were subdivided into three subgroups according to their ESS Score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24) (see Table 7-120). A repeated-measures ANOVA was used to compare minor lapses during rest days (factors: ESS Score x Study Phase x Time of Day). There was no main effect of study phase ($F(1,40) = .703$, $p = .407$) and no main effect of time of day ($F(1,40) = 2.58$, $p = .116$). There was a trend for a main effect of ESS Score ($F(2,40) = 3.09$, $p = .057$) with drivers in the Severe Abnormality group having more minor lapses than those in the Moderate Abnormality ($p = .045$) and No Abnormality groups ($p = .081$). There was a trend for an interaction of study phase and ESS Score for minor lapses during rest days ($F(2,40) = 2.97$, $p = .063$, see Figure 7-51). For rest days, there was a decrease in minor lapses pre-FMP compared to post-FMP in the Moderate Abnormality group ($p = .068$) but no change in the Severe Abnormality group ($p = .657$) or Abnormality group ($p = .134$). In general, the Severe Abnormality group showed more minor lapses than the other groups (no abnormality $p = .014$, moderate $p = .025$).There was no significant three-way interaction ($F(2,40) = .418$, $p = .661$).

Table 7-120 Minor Lapses during Rest Days by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Start of Day	End of Day	Start of Day	End of Day
		Mean (SD) (log of count)	Mean (SD) (log of count)	Mean (SD) (log of count)	Mean (SD) (log of count)
No Abnormality (0-10)	32	0.50 (0.27)	0.61 (0.24)	0.58 (0.30)	0.63 (0.29)
Moderate (11-16)	9	0.48 (0.31)	0.65 (0.42)	0.36 (0.31)	0.52 (0.39)
Severe (17-24)	2	1.02 (0.19)	0.96 (0.27)	0.87 (0.23)	0.99 (0.19)



*: Significant difference, $p < 0.05$

Figure 7-51 Minor lapses during rest days, FMP x ESS score interaction

Duty days: Drivers were subdivided into three subgroups according to their ESS Score: No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24) (see Table 7-121). A repeated-measures ANOVA was used to compare minor lapses during rest days (factors: ESS Score x Study Phase x Time of Day). There was no significant main effect of study phase ($F(1,48) = 1.182$, $p = .282$) or time of day ($F(1,48) = 2.65$, $p = .110$), or of ESS Score ($F(2,48) = .976$, $p = .384$) and there were no significant two-way or three-way interactions with RDI Score ($F(2,48) \leq 2.65$, $p \geq .110$; $F(2,48) = .470$, $p = .628$, respectively).

Table 7-121 Minor Lapses during Duty Days by ESS Score

ESS Score	N	Pre-FMP		Post-FMP	
		Start of Day	End of Day	Start of Day	End of Day
		Mean (SD) (log of count)	Mean (SD) (log of count)	Mean (SD) (log of count)	Mean (SD) (log of count)
No Abnormality (0-10)	40	0.59 (0.31)	0.55 (0.28)	0.63 (0.29)	0.65 (0.29)
Moderate (11-16)	8	0.48 (0.27)	0.50 (0.33)	0.53 (0.34)	0.62 (0.27)
Severe (17-24)	3	0.67 (0.50)	0.85 (0.20)	0.72 (0.26)	0.83 (0.35)

7.11 Driver Reason for Participation

Drivers were asked to rate the importance of a list of items with regards to their decision to participate in the fatigue management project (see Table 7-122). Overall, the incentives that were rated as the most important were:

1. Possibility of being treated by a sleep disorder specialist (2.25)
2. To take part in the fatigue management training given by scientific team (2.12)
3. Free access to CPAP (1.79)

Table 7-122 Incentive Quiz Results

	Incentive	Québec (n=29)	Alberta (n=24)	California (n=24)	Total (n=77)
1	The financial compensation	1.71 (.98)	1.04 (1.19)	1.48 (.95)	1.43 (1.06)
2	The possibility of being treated by a sleep disorder specialist	2.83 (.38)	2.08 (.97)	1.71 (.95)	2.25 (.92)
3	Free access to CPAP	2.54 (0.74)	1.50 (1.06)	1.17 (1.03)	1.79 (1.11)
4	It's an international project	2.10 (.90)	1.25 (.99)	1.29 (1.00)	1.58 (1.03)
5	To take part in the fatigue management training given by the scientific team	2.76 (.51)	1.71 (.86)	1.75 (.90)	2.12 (.90)
6	To help with family situations	2.10 (1.18)	1.50 (1.14)	1.29 (1.04)	1.66 (1.17)
7	Because family asked me to participate	0.93 (1.07)	.18 (.66)	.38 (.77)	.53 (.92)
8	To please employer	0.75 (0.97)	.30 (.76)	.46 (.66)	.52 (.83)

0 = low importance, 1 = average importance, 2= high importance, 3 = very high importance

Subjective scores on the importance of each item as an incentive to participate to the FMP program is expressed for each site as a mean (SD). Overall across the three sites, items that were judged as having an average high importance (≥2) were "accessibility of CPAP treatment" and "education on fatigue management". Drivers felt that their participation was not motivated by requests from their family members or employers. This observation supports that their participation in the study was voluntary.

7.12 Corporate Results

Changes in corporate culture were addressed by means of a questionnaire on perceptions of fatigue management policies and practices as well as by individual performance measures specific to each company.

7.12.1 AMSE Results

The AMSE inquires about five elements of an FMP: education, alertness strategies, scheduling, healthy sleep, and organizational elements, with 20 questions about specific FMP activities. AMSE responses can reflect an individual's firsthand knowledge and experience about an activity, perceived efforts, and an organization's corporate culture in relation to FMP activities. The AMSE results showed statistically significant increases/improvements in four of the five FMP elements (education, alertness strategies, healthy sleep, organizational elements) (see Table 7-123). Although dispatchers were included in activities, there were no specific FMP efforts directed at changing scheduling policies and practices. Therefore, no significant change in this element was expected. However, the FMP did include activities that specifically involved education, alertness strategies, healthy sleep, and organizational elements. Therefore, the significant changes in AMSE responses post-FMP appear to reflect improvements in firsthand knowledge and experience, perceived efforts, and/or the organization's corporate culture.

Of the 20 specific questions asked, 19 showed an increase/improvement in the post-FMP AMSE. Only one question, related to workplace rest facilities, showed a decrease – from 8 percent to 6 percent in the post-FMP AMSE. The smallest increase involved an organizational element related to an identified individual to coordinate FMP activities (pre-FMP = 25 percent, post-FMP = 28 percent). The largest increase was found in the educational element related to drivers receiving fatigue education (pre-FMP = 33 percent, post-FMP = 79 percent). Eight of the 19 specific questions that showed increases/improvements in post-FMP AMSE ratings reached a statistically significant level ($p < .01$).

Table 7-123 AMSE Questionnaire Results

			Pre-FMP	Post-FMP	Note (*)
Education	1	Are drivers provided training about fatigue, including the physiological causes and effects, and safety-related risks?	33%	79%	$p < .01$
	2	Are others who affect overall safety (e.g., schedulers, mgmt, dispatchers) provided training on these issues?	34%	68%	$p < .01$
	3	Is there a method to assess the effectiveness of training activities (e.g., pre-post-training quizzes)?	33%	51%	$p < .01$
	4	Is there a mechanism to determine whether the training information used is scientifically valid and current?	22%	36%	t*
Alertness Strategies	5	Are drivers and other personnel provided training on alertness strategies?	33%	65%	$p < .01$
	6	Are there clear written policies regarding the use of alertness strategies?	36%	43%	
	7	Are there explicit written policies regarding on-duty rest opportunities?	49%	65%	

			Pre-FMP	Post-FMP	Note (*)
	8	Not including your sleeper berth, are there facilities to support workplace rest opportunities (e.g., break room that can be made quiet and dark to take a nap)?	8%	6%	
	9	Is there a process for evaluating the scientific validity, effectiveness, and safety of alertness strategies *before implementing them?*	14%	24%	
	10	*Once in use*, is there a process for evaluating the scientific validity, effectiveness, and safety of alertness strategies?	14%	26%	
Scheduling	11	Do scheduling practices *for all personnel* explicitly address fatigue issues based on information from scientifically valid resources?	18%	27%	
	12	Are there written organizational policies, besides the federal regulations, regarding basic work/rest parameters for all personnel (e.g., minimum duration of off-periods, maximum work time, etc)?	41%	48%	
	13	Is there an explicit written procedure that is used for exceptions to these policies?	20%	29%	
Healthy Sleep	14	Is information offered to drivers and other personnel about sleep disorders, how to recognize sleep disorders, and how to get help if they suspect they have a sleep disorder?	27%	46%	$p < .01$
	15	Is there a written policy that addresses diagnosis, treatment, and continued duty status of personnel with possible sleep disorders?	15%	30%	$p < .01$
Organizational	16	Does your organization have an integrated alertness management program that includes education, alertness strategies, scheduling, and healthy sleep?	25%	41%	$p < .01$
	17	Is there an individual identified to coordinate alertness management activities?	25%	28%	
	18	Are alertness management activities ongoing (as opposed to, for example, a one-time training)?	18%	27%	
	19	Is management involved in alertness management activities and policy development?	39%	47%	
	20	Are alertness management activities integrated into the regular practices of the organization, such as safety programs, recurrent training, and standard procedures?	44%	54%	

* t = trend

7.12.2 Site Specific Corporate Measures

7.12.2.1 QUÉBEC

In Québec, corporate measures were analyzed for drivers who completed the entire study and comprise the following: number of days when the driver was absent, number of infractions against road regulations, number of accidents, total hours of driving, total of hours waiting during duty, total hours of rest at work and at home, distance travelled, number of panic brakes. The first four measures were supplied by the human resources department and the remaining five were downloaded from the truck's black box or driver logbook. Data from the black box were downloaded monthly. To account for inter-individual and study phase difference in driving distance, results are expressed as counts per 100 km. Results are summarized in Table 7-124.

In Québec, corporate measures were collected pre-FMP over an eight-month period (September 2006 to April 2007) and post-FMP over a four-month period (February

2008 to May 2008). These periods cover the pre- and post-FMP data collection during which PDA and Actiwatch recordings were carried out. During the study, 29 drivers completed both pre- and post-FMP data collection which each lasted 10 days. In the pre-FMP condition nine accidents were reported by eight drivers of this group whereas no accidents were reported by any of these 29 drivers during the post-FMP condition.

Paired t-tests were used to compare corporate measures pre versus post-FMP. There was a significant reduction of number of infractions per 100 km ($p<0.01$) and number of accidents per 100 km ($p<0.01$) during the post-FMP compared to pre-FMP condition. In addition, there was a trend for a reduction of absent days per 100 km post compared to pre-FMP. There was a significant increase in total driving hours per 100 km ($p<0.01$) and total hours waiting per 100 km ($p<0.05$) post vs. pre-FMP, but there was no difference in the total hours rested per 100 km, total driving distance, or number of panic brakes per 100 km.

Table 7-124 Québec Corporate Measures Pre and Post-FMP Data

PRE-FMP DATA					
	N	**Mean**	**Sd**	**Min**	**Max**
Absent days per 100 km	29	3.98×10^{-3}	11.7×10^{-3}	0.00	51.0×10^{-3}
Number of road infractions per 100 km	29	0.63×10^{-3}	0.76×10^{-3}	0.00	2.27×10^{-3}
Number of accidents per 100 km	29	0.46×10^{-3}	0.70×10^{-3}	0.00	2.27×10^{-3}
Total driving hours per 100 km	29	1.33	0.19	0.74	1.58
Totals hours waiting on duty per 100 km	29	0.302	0.163	0.133	0.809
Total hours rested per 100 km	29	4.89	0.26	3.93	5.63
Distance travelled (km)	29	12257	2206	6795	16004
Number of panic brakes per 100 km	19	3.98×10^{-3}	3.98×10^{-3}	3.98×10^{-3}	3.98×10^{-3}

POST-FMP DATA						
	N	**Mean**	**Sd**	**Min**	**Max**	**Pre vs. Post**
Absent days per 100 km	29	0.00	0.00	0.00	0.00	t
Number of road infractions per 100 km	29	0.00	0.00	0.00	0.00	p<0.01
Number of accidents per 100 km	29	0.00	0.00	0.00	0.00	p<0.01
Total driving hours per 100 km	29	1.67	0.55	0.51	3.80	p<0.01
Totals hours waiting on duty per	27	0.376	0.253	0.000	0.988	p<0.05
Total hours rested per 100 km	28	5.15	1.18	0.00	6.83	n.s.
Distance travelled (km)	29	11459	4235	2814	Z19986	n.s.
Number of panic brakes per 100	10	1.32×10^{-3}	5.24×10^{-3}	0.00	25.7×10^{-3}	n.s.

7.12.2.2 ALBERTA

In Alberta, during the three-month pre-FMP data gathering period, six accidents were reported with a total cost of $6,448.32. Five violations were reported. During the three month post-FMP data gathering period, seven accidents were reported with a total cost of $113,377.71. Three violations were reported.

Rapid speed change is defined as acceleration or deceleration of 11 kilometres/hour/second. There was a total of 415 during the pre-FMP data gathering period and 301 during the post-FMP data gathering period. A paired t-test reported a two-tailed P value of 0.3. Total kilometres driven for the Alberta drivers during the pre-FMP data gathering period was 727,427 and post-FMP was 645,644. A paired t-test reported a two-tailed P value of 0.06. Rapid speed changes per 1000 Km were normalized for the distance driven and a paired t test reported a two-tailed P value of 0.8.

The corporate measures for the pre-FMP three month period (August – October 2007) and the post-FMP three month period (June – August 2008) are summarized in Table 7-125.

Table 7-125 Pre and Post-FMP Corporate Data Collection (3 months each)

	N	Mean		SD		p value	Minimum		Maximum	
		Pre	Post	Pre	Post		Pre	Post	Pre	Post
Number of accidents	23	0.26	0.30	0.32	0.63	0.8	0	0	2	2
Number of violations	23	0.22	0.13	0.52	0.46	0.5	0	0	2	2
Number of rapid speed changes (RSC)	23	18.04	13.09	21.43	19.16	0.3	0	0	75	57
Km driven	22	31627	29347	17437	16998	0.06	2582	2052	63179	55738
RSC/1000 km	22	1.12	1.18	1.64	2.20	0.8	0	0	5.81	8.77

7.12.2.3 CALIFORNIA

In California, corporate measures were collected over a three-month period during the pre-FMP data collection period (January 1 – March 31, 2007). Data for all 42 driver participants who collected pre-FMP data were received and reported. The total costs associated with these collected corporate measures were $23,937.04.

Two drivers (7.1 percent) were involved in accidents. Neither of the accidents entailed fatalities or injuries and both occurred during daytime hours and under clear weather conditions. One of the accidents involved backing up; the other one, the truck was hit by another vehicle.

Two drivers (7.1 percent) had worker's compensation claims. A sprain/strain was reported for one claim and a concussion for the other. Lifting was involved in one claim and handling an object in the other.

A total of 26 medical claims were reported by seven of the 42 drivers (14.3 percent) for the pre-FMP period. For all 42 drivers, this resulted in an average of 0.6 claims per driver ranging from zero to 13 claims. For the seven drivers presenting claims, this resulted in an average of 3.7 claims per driver ranging from one to 13 claims.

Post-FMP corporate measures were collected over another three-month period (April 1 to June 30, 2008) for all 25 drivers who collected post-FMP data. No costs are associated with the accident data (i.e., no damage or submitted costs were reported), and no worker's compensation claims were reported during the three-month period.

Three drivers (12 percent) were involved in one accident each for a total of three accidents during the three-month post-FMP period. None of the accidents entailed fatalities or injuries, and all occurred during daytime hours and under clear weather conditions. One accident involved turning; another involved a dropped trailer; in the third, the truck hit a parked vehicle.

A total of 38 medical claims were reported by 7 of the 25 drivers (28.0 percent) for the post-FMP period. For all 25 drivers this resulted in an average of 1.52 claims per driver ranging from 0-18 claims. For the 7 drivers presenting claims, this resulted in an average of 5.43 claims per driver ranging from 1 to 18 claims. The total associated costs for the medical claims post-FMP were $15,785.40, ranging from $8.00 to $5,413.00 per service. A paired t-test reported a two-tailed P value of 0.25.

The corporate measures for the pre-FMP and the post-FMP periods are summarized in Table 7-126.

Table 7-126 Pre and Post-FMP Corporate Data Collection (3 months each)

	N		Mean		SD		Min		Max	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Accidents	42	25	$34	$0	$195	$0	$0	$0	$1260	$0
Worker's compensation	42	25	$395	$0	$2468	$0	$0	$0	$16000	$0
Medical claims	42	25	$141	$631	$643	$2462	$0	$ 0	$4120	$12373

7.12.2.4 CORPORATE MEASURES SUMMARY

A list of potential corporate measures were identified that included representative measures from vehicle operation, accidents/violations, human resources (e.g., medical claims), and other sources. This list was then provided to each participant carrier to determine what corporate measures were available from that particular carrier. It was acknowledged that carriers would differ in the measures available (e.g., in-vehicle data obtained) and specifics of the form that data would be provided. Therefore, corporate measures were collected that were relevant and available for each participant carrier and were not intended to be consistent across the study sites. Corporate measures that were collected included accident data, worker's compensation claims, medical claims, violations, rapid speed changes, and associated costs. Also, given the rarity of major accidents, other corporate measures were hypothesized to provide more face valid and meaningful representation of FMP effects. Finally, given the different N's between the pre- and post-FMP periods, the different measures between participant carriers, and the small number of occurrences for some measures, it was not possible to show statistically significant changes between the study conditions (although statistical tests were performed).

Overall corporate measures indicated an improvement in company performance with significantly fewer road infractions and accidents and a trend for reduction of absent days per kilometre travelled in Québec. Statistical analysis indicated changes in corporate measures in Alberta and California were not significant.

7.13 Summary of Pre vs. Post-FMP Results

The effects of the FMP on driver schedules, work demands, factors contributing to fatigue, sleep variables, mood, psychomotor vigilance task performance and close calls are summarized and discussed below.

7.13.1 Effects on Schedule

7.13.1.1 Overall Study period

The study protocol called for en-route data to be collected during a four to six day duty period. In addition, data was to be collected during a two-day period during the rest days preceding and following the en-route data collection. On average, the study period length was 9.26 days pre-FMP and 8.55 days post-FMP. A t-test showed that the decrease of 0.71 days from pre to post test was significant, but was mainly due to a decrease in rest days by 0.40 days from 3.62 days pre-FMP to 3.22 days post-FMP.

7.13.1.2 Duty Days

As discussed in Section 7.7, drivers were supposed to fill out questionnaires on mood, mental and physical demands, on awakening, at the start of day, at the end of day, and before bed; PVT was to be completed at the start and the end of the day. A check was made to determine when drivers actually filled out questionnaires and completed the PVT performance test as compared to when they were supposed to do this. This was checked on work days at the end of shift only by comparing the self-reported 'end of shift' time with the timestamp recorded when the end of day survey was completed. Compliance was defined as an elapsed time of less than two hours from the self reported "Shift End Time" to the timestamp recorded for the "End of work" questionnaire.

Overall, out of 410 duty days, one-third (33 percent) were non-compliant. Approximately two-thirds (65 percent) of all subjects had zero or one non-compliant duty day. One-quarter of all subjects (25 percent) had three or more non-compliant duty days during the study period. Data from drivers were included in the analyses if there was sufficient data to create a complete data file (i.e., mean values available per duty/rest day, start/end of shift, and pre/post FMP).

7.13.1.3 Shift Schedule

Shift start times were based on start of day questionnaire timestamp; shift end times were based on when drivers reported that they ended their shift. Start times and end times were compared pre and post FMP. In particular the proportion of shifts that ended between 00:00 and 05:59 was examined to see if drivers were more likely to avoid night time driving post FMP vs. pre FMP. No significant change was found.

Similarly there was no significant change in drive time (pre vs. post FMP, 7.71 vs. 7.43 hours) FMP, and no significant change in duty time (pre vs. post FMP, 11.28 vs. 11.55 hours). However, there was an interaction between drive time and RDI level in that it increased for drivers in the Mild Abnormality category, but decreased for the other two groups. When drive time was analyzed with respect to CPAP adherence, there was a trend toward longer mean duty time pre as compared to post-FMP but no interaction between adherence subgroup and study phase. There was a main effect of CPAP Adherence; the CPAP Non-Adherent group had a significantly shorter mean duty time as compared to the CPAP Adherent and No CPAP.

A comparison was made between lengths of duty periods for shifts that began in mid-morning (06:00 to 08:59) as compared to early evening (18:00 to 20:59). Only 22 percent of shifts were evening/night shifts. These were significantly shorter than shifts that started in the morning (9.69 hours vs. 11.51 hours). However, there were no significant differences in mean duty period length from pre-FMP to post-FMP and no interaction between morning/evening start times and study period.

It was expected that there would be less night driving post compared to pre FMP. Participants were categorized as "night drivers" if 25 percent of their total duty time during the study period occurred between 00:00 and 06:00. Contrary to expectation, there were significantly more "night drivers" post-FMP as compared to pre-FMP (18.2 percent vs. 7.8 percent).

7.13.2 Work Demands

With respect to work demands, at the end of each shift, drivers scored mental demands, physical demands, stress of duty period and intensity of duty period on a scale of 1 to 100, with 1 being not at all demanding and 100 being extremely demanding. Mean effects for the entire duty period were compared for pre vs. post FMP. In addition the effects for the first day of the shift were compared to those for the last day of the shift. When measures were analyzed by RDI, ESS, and CPAP Adherent sub-group, there were a number of main and interaction effects related to study phase.

When mental demands data were analyzed by ESS, there was a significant decrease for the Severe Abnormality group post-FMP as compared to pre-FMP, and a significant but much smaller increase for the other two subgroups. Stress of duty period ratings showed a significant decrease in mean stress post-FMP, and, similarly to the mental demands data, there was a significant interaction between study phase and ESS score. Stress ratings for the Severe Abnormality group decreased from pre-FMP to post-FMP and increased for the other two groups. Similar to the findings for mental demands and stress of duty period, intensity of duty period also showed a significant decrease from pre to post-FMP as well as a significant interaction between study phase and ESS score. Intensity of duty period decreased significantly for the Severe Abnormality group and increased significantly but to a much smaller degree for the other two groups.

With respect to physical demands, stress of duty period and intensity of duty period, there were no effects of study phase and only one analysis in each case finding subgroup effects. The CPAP Non-Adherent group reported significantly more physical demands as compared to the CPAP Adherent group. Similarly, stress of duty period was found to be higher for the CPAP Non-Adherent group than for the No CPAP Required group. With respect to intensity of the duty period, there was no effect of study phase but there was a significant effect of RDI group, in that the No Abnormality group reported significantly higher intensity of duty period as compared to the Moderate to Severe Abnormality group.

7.13.3 Factors Contributing to Fatigue

At the end of each duty period, three factors potentially contributing to fatigue were assessed: loading and/or unloading, driving conditions and time spent waiting, on a scale of 1 (not at all) to 100 (extremely). Loading and/or unloading showed no effect of

study phase, nor were there effects associated with the RDI, CPAP Adherence or ESS sub-groups.

There was an effect of study phase on the rating of driving conditions, when data were analyzed by ESS sub-group. There was also an interaction between study phase and sub-group. The mean ratings of the No Abnormality group increased from pre-FMP to post-FMP whereas they decreased for the Moderate Abnormality and Severe Abnormality groups. When driving conditions were analyzed by CPAP adherence, the CPAP Non-Adherent group reported that driving conditions had a much greater contribution to fatigue compared to the CPAP Adherent and No CPAP groups.

Time spent waiting did not contribute differently to fatigue by study phase, nor by RDI, CPAP Adherent or ESS sub-group.

7.13.4 Sleep Variables

Subjective sleep variables were calculated based on PDA responses (reported duration of main sleep period, reported total sleep in the last 24 hours, subjective sleep quality) and objective sleep variables were calculated based on actigraphy data (sleep latency, time spent in bed for main sleep period, duration of main sleep period, sleep achieved during the main sleep period, and sleep efficiency during the time in bed).

There was a main effect of study phase on subjective sleep quality (PDA). Drivers reported a 5.5 percent significant improvement in subjective sleep quality post vs. pre FMP; this improvement was especially pronounced for duty days (10.1 percent).

During the pre FMP condition, sleep efficiency during time in bed (actigraphy) was reduced by 2.2 percent on duty days as compared to rest days. No such difference was observed during the post FMP condition. This lack of difference between duty and rest days during post FMP was mainly due to an improvement of sleep efficiency during duty days (+1.1 percent).

Drivers had 20 minutes (5.9 percent) longer main sleep period (actigraphy) during duty days in the post FMP condition, a significant improvement compared to the pre FMP condition.

Subgroup differences were found for sleep reported in the last 24 hours. Namely, drivers in the No Abnormality RDI group reported 1 hour 18 minutes (16.4 percent) more sleep in the last 24 hours in the post as compared to the pre FMP phase, whereas those in the Moderate to Severe RDI group showed no significant difference. Similarly, drivers in the No CPAP group reported sleeping 1 hour 20 minutes (15.6 percent) more in the last 24 hours during the post vs. pre FMP. This increase was significant, whereas no changes were observed for drivers with CPAP, either adherent or not.

Apart from study phase effects, drivers slept about an hour less during duty as compared to rest days. In particular reported duration of main sleep was reduced by 56 minutes (12.5 percent) (PDA), reported total sleep in the last 24 hours was reduced by 44 minutes (8.1 percent)(PDA), sleep achieved during the main sleep period (actigraphy) was reduced by 59 minutes (15.0 percent), and the duration of main sleep period (actigraphy) was reduced by 64 minutes (14.5 percent).

The lowest sleep latency (actigraphy) was observed in drivers with no CPAP followed by drivers adherent to CPAP, and then by drivers non-adherent to CPAP. A significant difference was observed between the first and the last group with 11 minutes (47.5 percent) greater sleep latency (actigraphy) in the CPAP non-adherent group compared to the no CPAP group.

7.13.5 Mood Ratings

At the start and end of each duty period, drivers were asked to rate the following subjective mood factors on a scale of 1 to 100: aches and pains (1 = none at all; 100 = many aches and pains), feeling happy or sad (1 = happy; 100 = sad). feeling calm or excited (1 = calm, 100 = excited), level of fatigue (1 = sleepy, 100 = alert).

With respect to aches and pains, there was no main effect for study phase when analyzed by RDI or ESS score, nor were there main effects for RDI, CPAP or ESS score. However, when these data were analyzed by CPAP Adherence group, drivers reported significantly more aches and pains post-FMP as compared to pre-FMP. There was no effect of CPAP Adherence ($F(2,69) = 1.86$, $p = .163$). There was also a significant effect for the start vs. end of shift; with drivers feeling significantly more aches and pains at the end of their shift as compared to at the start.

With respect to feeling happy or sad, there was no main effect of pre-FMP vs. post-FMP or RDI sub-group. However drivers reported feeling significantly more happy at the start of their duty day as compared to the end of their duty day. When feeling happy or sad was analyzed by CPAP Adherence there was no main effect of study phase, but there was a trend towards a main effect of CPAP Adherence, with those in the No CPAP Required group happier than the other two groups. Also drivers were significantly happier at the start of their day compared to at the end of their day.

With respect to feeling calm and excited, there was no main effect of study phase, or start vs. end of day. There was a trend toward an effect of RDI score ($F(2,74) = 2.56$, $p = .082$). The No Abnormality group was significantly more calm than the Mild Abnormality group.

With respect to level of fatigue, there was a trend towards drivers reporting less fatigue post-FMP as compared to pre-FMP. Drivers reported being significantly less fatigued at the start of their duty day, as compared to the end of their duty day. There was no main effect of RDI. When the same data were analyzed with respect to CPAP Adherence group, and with respect to ESS, drivers reported significantly less fatigue at the start of their duty day, as compared to the end of their duty day. However, there was no main effect of study phase, CPAP Adherence or ESS Score.

7.13.6 Psychomotor Vigilance Test

Vigilance was objectively assessed twice every day during rest and duty days. The most consistent finding was a significant reduction in psychomotor performance at the end as compared to the start of the day. This tendency was observed during both duty and rest days.

7.13.6.1 REST DAYS

Reaction time was increased by 5.6 percent, reaction speed was reduced by 5.1 percent and minor lapses were increased by 19.9 percent at the end as compared to the start of day on rest days. Reaction time was increased by 2.3 percent, and reaction speed was reduced by 2.5 percent at the end of day as compared to the start of day on duty days. When looking at the results for the different subgroups, drivers had longer reaction times (+28.7 percent), lower reaction speed (-22.1 percent) and more minor lapses (+111.2 percent) in the severe ESS score group compared to no abnormality ESS group. There was also a significant interaction (study phase x time of day x ESS group) for reaction time and reaction speed. More specifically, at the start of day during the pre FMP condition, drivers in the severe ESS group performed significantly more poorly than drivers in the no abnormality ESS group (reaction time increased by 40.7 percent; reaction speed reduced by 27.9 percent) and in the Moderate ESS group (reaction time increased by 34.4 percent; reaction speed reduced by 24.5 percent). However, no significant group difference was observed in the post-FMP condition because of a significant improvement (e.g., 13 percent reduction of reaction time) in the post as compared to the pre-FMP condition for the Severe ESS group at the start of day. Drivers in the No Abnormality ESS group had longer reaction times (5 percent) and lower reaction speed (3.6 percent) during post as compared to pre-FMP.

When looking at CPAP adherence, drivers from the CPAP adherent group had a significant 5.7 percent improvement in reaction speed and a trend for a reduction in reaction time (by 6.1 percent) for post as compared to pre-FMP. Furthermore, there were 23.4 percent more minor lapses in the CPAP non-adherent group post as compared to the pre FMP whereas there were no significant decreases in the CPAP adherent group. No significant effect of conditions was observed in drivers of the No CPAP group.

7.13.6.2 DUTY DAYS

For drivers in the severe ESS group, reaction time at the end of their duty days post-FMP was comparable to that observed at the end of duty days pre-FMP. This resulted in a significant deterioration (23.8 percent) of vigilance in the post-FMP condition at the end as compared to the start of duty days. For the two other ESS groups, reaction time was stable throughout duty days during both pre and post-FMP phases.

Drivers had significantly (CPAP and RDI analysis) more minor lapses (+13.3 percent) during the post as compared to the pre-FMP study phase.

7.13.7 Critical Events

Overall, the proportion of drivers with at least one critical event (i.e., nod off or close call) at least once decreased from pre to post FMP (45.5 percent to 28.6 percent). Linear regression was used to determine the effect of RDI raw scores on the number of critical events, pre- vs. post-FMP. High RDI score was associated with significantly more pre-FMP critical events. The drop in critical events, pre-FMP minus post-FMP, was also significantly correlated with RDI score in that the Mild Abnormality group had a significant reduction in drivers with critical events (pre vs. post = 50.0 percent to 33.3 percent, $p = .004$). The reduction for the Moderate and Severe group was similar in size, but there were fewer drivers, which likely contributed to the lack of significance

of the effect for this group. There was a significant effect of CPAP Adherence with a trend towards fewer critical events for the No CPAP Required (37.8 percent to 21.6 percent, p = .109) groups.

A linear regression analysis showed that high ESS scores were associated with more pre-FMP critical events. The same was not true for post-FMP critical events (of which there were fewer: 22 vs. 35).

Drivers were subdivided into three subgroups according to their ESS score; No Abnormality (score 0 to 10), Moderate Abnormality (score 11 to 16), Severe Abnormality (score 17 to 24). All three ESS score subgroups had fewer drivers with critical events post-FMP as compared to pre-FMP. The reduction in critical events (35.6 percent to 20.3 percent) for drivers with No Abnormality was found to be significant.

8 DISCUSSION

8.1 Clinical Findings

8.1.1 Pre-Test Questionnaires

ANC and, to some extent, MAP proved to be reasonable predictors of sleep apnea. ANC for the entire population of drivers indicated a moderate probability for sleep apnea. Drivers with sleep apnea, as indicated by RDI greater than five, had a highly elevated mean ANC score indicative of high probability of sleep apnea. Overall, this corresponds with previous data from the literature and indicates that ANC might serve as a reasonable predictor of severe sleep apnea (Flemons and Reimer 2002). Based on these findings, the ANC may have utility as a screening instrument for sleep apnea in commercial drivers. Using a predictive cut off of 43, the ANC has a sensitivity of 82.8 percent and a specificity of 64 percent. In addition, it correctly identified all drivers in our sample with severe sleep apnea. It should be noted that the sensitivity of the ANC may be artificially elevated by the high prevalence of sleep apnea in our volunteer population compared to the entire population of drivers because the prevalence of sleep apnea may be higher in our group than in the general commercial vehicle driver population (see Section 8.1.5).

By contrast, neither ESS nor SAQLI correlated with RDI, and drivers with severe sleep apnea displayed near normal values. This lack of correlation between symptoms (ESS and SAQLI) and severity of sleep apnea, as defined by RDI, agrees with published reports (Pack et al. 2002). The mean values for SAQLI were normal in Québec and California drivers but modestly depressed in the Alberta drivers. Overall, though, approximately 25 percent of drivers had moderate or severe sleepiness and a comparable amount had moderate or severe impairment of quality of life, even though these indices were not correlated with severity of sleep apnea.

8.1.2 Feasibility of Screening for Sleep Apnea using Portable Monitor Testing

A number of portable monitors for in-home assessment of sleep apnea are available. Many of these provide adequate diagnostic accuracy for clinical purposes. The present study examined the feasibility of two different methods of applying the recorder clinically (one face-to-face instructions and one mailed to drivers) and using two different types of oximeters (one reflective and one transmittance). Both methods and both diagnostic devices appear to be feasible and have an acceptable high success rate (86 percent).

The two recorders differed in the method of pre-test instruction of the driver. For the Remmers Sleep Recorder (used in Québec and Alberta) a face-to-face instructional session with a technician was employed. For the ARES (used in California) the device was mailed to the driver with hard copy instructions enclosed. The studies proved to have high success rates (92 percent in Alberta; 79 percent in Québec, and 90 percent in California). Nonetheless, two drivers objected to the testing and dropped out of the study apparently in relation to this issue. Overall however, screening for sleep apnea using an accurate home monitor has been shown to be feasible from a convenience and cost perspective and well accepted by almost all participating drivers.

8.1.3 Confidentiality and Sleep Apnea Diagnosis

One major concern regarding screening for sleep apnea in the context of commercial drivers is maintenance of confidentiality. Also, issues such as a required non-driving period after initiation of CPAP or non-compliance with CPAP therapy may force the treating physician to take actions regarding vehicular safety. For example, in a single instance in Alberta, a well-intentioned physician inappropriately breached confidentiality over concern regarding a no-driving period after initiation of CPAP. In the process of resolving this situation, it became clear that specific policies regarding these issues are critical for clarity among all participants (i.e., drivers, companies, treating physicians). Subsequent to the initiation of this project in 2005, a consensus statement from a joint task force recommended a two-week no-drive period (Hartenbaum et al. 2006).

8.1.4 Sleep Apnea Treatment: Cost and Implications

Difficulties also were encountered in California and Québec in getting the financial support of the insurance companies necessary to support a comprehensive therapeutic approach with continuing access to advice regarding CPAP use and adjustment. It may be important to involve this industry along with the commercial vehicle industry, and governmental representatives in order to secure funds for the adequate screening, diagnosis, and treatment of commercial drivers.

8.1.5 Prevalence of Sleep Apnea

Perhaps the most significant sleep disorders finding is that 71.3 percent of drivers were found to have sleep apnea, with 31.9 percent being moderate to severe sleep apnea. These values are higher than previously reported, using the same criteria, in a large study of randomly selected commercial drivers (Pack, Dinges, & Maislin, 2002) where the prevalence of sleep apnea determined by PSG was found to be approximately 30 percent. Differences in subject selection (random versus volunteer) may have contributed to the higher prevalence of sleep apnea in the current study. Portable monitoring in the home tends to yield a lower value of RDI than PSG probably because of greater time spent supine in the PSG. Thus, the method of evaluating RDI in the current study seems unlikely to explain the difference. Using a portable monitor, Stoohs et al. (1995) reported a prevalence of sleep apnea in volunteer long haul drivers which is comparable to that observed in the current study (Stoohs et al. 1995). Importantly this study, like the present one, used volunteer subjects whereas Pack et al. studied randomly selected drivers. Drivers were asked for their reasons for volunteering for the study. The possibility of being treated by a sleep disorder specialist and free treatment for sleep apnea, were two of the top three reasons given for participation. This may account for a selection bias and the observed high number of drivers with sleep apnea in the present study (Access to fatigue education was the third reason for participation.)

California drivers had significantly higher prevalence of sleep apnea than those in Québec or Alberta. The reason for this is not apparent as the predictors of sleep apnea (ANC and MAP) were comparable in all three sites. The index of oxygen status during sleep (fraction of night below 90 percent O_2 Sat) in California drivers was comparable to Québec and lower than that reported in Alberta. The California site used a different portable monitor for assessment of respiratory status during sleep than Québec and Alberta and accordingly, technical differences in detecting respiratory disturbances

may have been one factor that contributed to the apparent higher prevalence of sleep apnea in the California group.

The fraction of night with O_2 Sat below 90 percent was strikingly higher in Alberta and a review of data showed this is related to four drivers with very severe O_2 desaturation throughout the night. The sleep study results for each of these drivers were reviewed and three were found to be valid and one artifactual. The sites where the drivers were studied in Alberta are at moderate altitude (approximately 3,700 feet as opposed to about 100 feet in Québec and California). This means that the inspired pressure of oxygen is somewhat lower (10 torr) in Alberta than at sea level. This would accentuate the oxyhemoglobin desaturation during an apnea. However, the effect is rather small for this altitude, so that the greater fraction of the night below 90 percent in Alberta cannot be explained by the mild-high altitude.

8.1.6 Adherence to Therapy

There were large differences between California and the other two sites in adherence. For Québec and Alberta, the 42 percent of drivers with sleep apnea were treated with CPAP, whereas, this figure is higher in California (68 percent) (see Table 8-1). Adherence data was collected for the vast majority (85 percent) of the drivers who were prescribed CPAP. The severity and driver symptoms did not differ for those drivers started on CPAP between the three sites as there were no differences in mean RDI or mean ESS amongst the three sites (see Table 8-1). The fairly low ESS value and fraction of the night below 90 percent oxygen saturation would be negative predictors for adherence to therapy. However, the drivers in Alberta were significantly more hypoxic on average than those drivers at the other two sites which may lead to higher adherence in this group.

Table 8-1: Data on Drivers for whom CPAP was Prescribed

	Québec	Alberta	California
CPAP prescribed (N and %)	15 (45%)	13 (39%)	19 (68%)
CPAP prescribed and adherence data (N)	12	11	17
RDI for CPAP prescribed and adherence data (mean)	19 $hr.^{-1}$	16.2 $hr.^{-1}$	19.9 $hr.^{-1}$
ESS for CPAP prescribed and adherence data (mean)	8.2	10	8
Time <90% for CPAP prescribed and adherence data (mean)	4.2%	11.3%	3.8%
Adherence rate N (%)	7 (60%)	8 (69%)	1 (5%)
Nightly CPAP usage (mean)	4.4 hr	4.4 hr	1.2 hr
Number of drivers having at least one face-to face post-CPAP initiation visit N (%)	10 (83%)	11 (100%)	6 (35%)
TOTAL	33	33	28

Adherence to therapy of CPAP treated drivers in Québec was 60 percent and in Alberta was 69 percent and this is comparable to, or exceeds, most of the reports in the literature (Weaver & Grunstein, 2008). By contrast, the CPAP adherence rate for California drivers was 5 percent, much lower than expected and much lower than observed in Québec and Alberta. However, another report of CPAP adherence in commercial motor vehicle drivers diagnosed with sleep apnea indicates that the adherence rates are much lower (5 percent) than those described for undifferentiated populations of apneics and comparable to that observed in California (Parks et al. 2009). Perhaps county-specific economic or cultural factors may influence CPAP adherence. Identifying these and ameliorating their influence would be important in improving the compliance outcome of drivers with sleep apnea. Whatever factors influence adherence in commercial drivers, the methods used in Alberta and Québec yield adherence that is comparable to that observed in the general community and may be acceptable from a safety perspective.

All drivers with obstructive sleep apnea were seen by a sleep physician. All sites used similar CPAP units, with a mixture of auto and fixed pressure limits. The observed site differences in adherence rate may be related to differences between face-to-face interactions between the driver and the clinical staff. Québec and Alberta used a diagnostic method which employed a pre-treatment face-to-face visit, whereas, California employed a method that involved no face-to-face pre-treatment interaction. Probably more significantly, the drivers in Québec and Alberta were more likely to have a face-to-face visit with a member of the clinical staff after CPAP initiation, see Table 8-127. In Alberta, 100 percent of drivers were seen in a face-to-face clinical visit post treatment initiation. This compares to 83 percent in Québec and 35 percent in California. The difference in the number of face-to-face visits between Alberta/Québec and California was significant ($p = .02$). The relationship between the percent of drivers who received at least one post-treatment face-to-face clinical visit and adherence is shown in Figure 8-54.

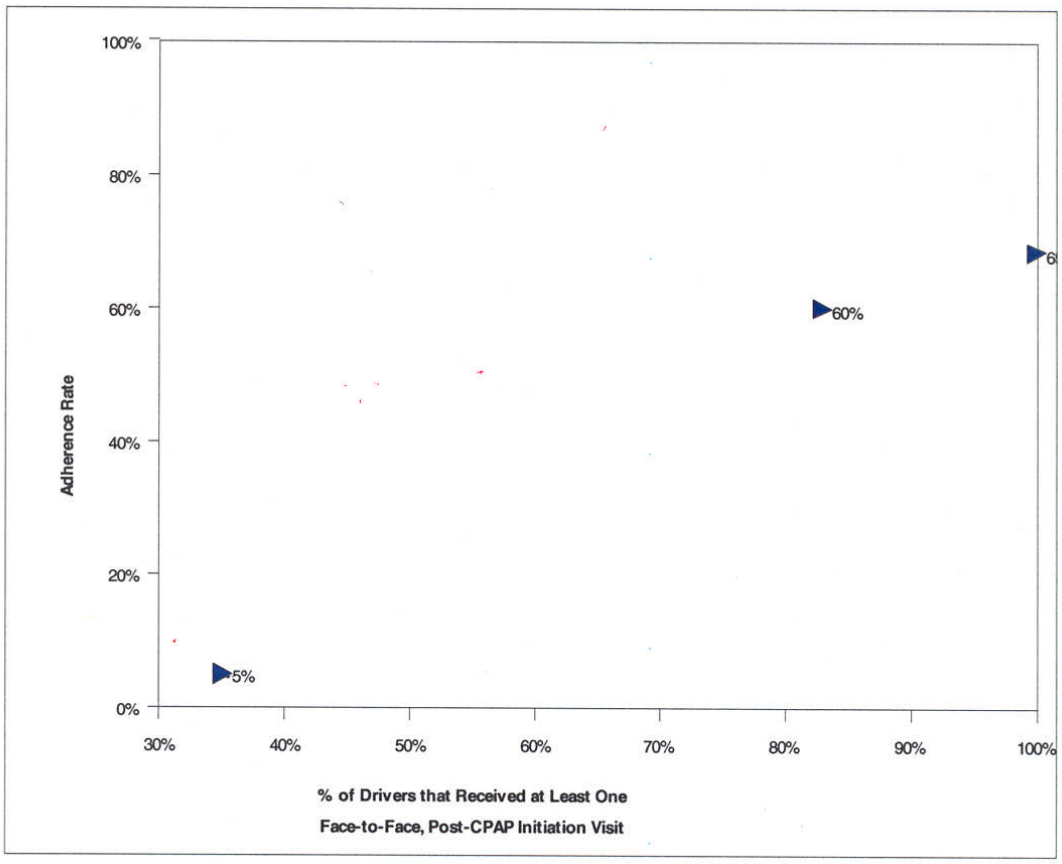


Figure 8-1 Relationship between percentage of drivers who received at least one post-treatment face-to-face clinical visit and adherence

The literature suggests that certain methods are more effective than others for promoting therapeutic adherence (Weaver and Grunstein 2008). For example, phone follow-up after treatment initiation is reported to be ineffective (Fletcher and Luckett 1991). Face-to-face follow-up clinical visits, such as used in Alberta and Québec, are known to promote a higher compliance rate (Hoy et al. 1999). Our results agree with these reports in that the adherence rates at the three sites correlates with post-treatment follow-up rates, i.e., percentage of drivers having at least one post-treatment face-to-face visit. The role of drivers' schedules, distance to treatment sites, and time/travel costs need further examination to understand their effects on adherence after treatment has been initiated. While there is no report in the literature evaluating the influence of a face-to-face visit in testing (i.e., pre-treatment face-to-face visit), the use of a testing method requiring a face-to-face visit in Québec and Alberta may have contributed to a higher adherence rate in these two centres.

Although the 60 to 70 percent compliance rate achieved in Québec and Alberta is in agreement with the adherence rate reported for general clinical experience, this may not be sufficient from a safety point of view and is not a question addressed by this study. However, the compliance level in commercial drivers might be improved using additional techniques. For example, treatment educational programs directed at CPAP adherence and self-management techniques were not used in this study but could be used to improve adherence. These involve substantial interaction and peer leadership

and may have a considerable role in improving compliance amongst commercial drivers (Stepnowsky et al. 2007).

The safety implications of CPAP adherence rate is not well established in the literature; hence, the importance of our findings regarding compliance is uncertain. The findings do, however, raise many important questions for discussion and potentially further research that would delineate the role and meaning of compliance rates in safety and future FMP efforts.

This project breaks new ground through implementation of a program that involves sleep disorders diagnosis, treatment, and compliance evaluation. Our results demonstrate that reasonable compliance rates (60 to 70 percent) can be achieved in a population of commercial drivers with sleep apnea. Whether or not these rates can be improved is uncertain but promising methods for achieving this end are now available. Two Level 1 evidence clinical trials demonstrated CPAP treatment improved quality of life and decreased sleepiness (Jenkinson et al. 1999; Gay et al. 2006). Minimal results in this one project, especially given the many differences and confounding factors, are not appropriately used to question the efficacy of CPAP treatment. Rather, the findings raise questions regarding the parameters relevant to effective treatment and outcomes in this population in these circumstances.

8.1.7 Review of Data Derived from Clinical Evaluations

Data from three sites were pooled and revealed that ANC (Adjusted Neck Circumference), MAP (Multivariable Apnea Prediction) and Epworth were normally distributed. SAQLI (Sleep Apnea Quality of Life Index), RDI (Respiratory Disturbance Index) and oxygen displayed skewed distributions as would be expected. Seventy-one percent of drivers (67 of 94 participants) were diagnosed as having sleep apnea (RDI greater than 5 $hr.^{-1}$). Of the total sample (n=94), 39.4 percent had mild (RDI 5 to 14.9), 23.4 percent moderate (RDI 15 to 19.9) and 8.5 percent severe (RDI ≥30) sleep apnea. Oxygen distributions were less striking showing that only seven percent were moderate but eight percent were severe.

Epworth scores indicated that nearly two-thirds (63.4 percent) of the drivers were sleepy (mild ESS 7 to 10, 38.7 percent, moderate ESS 11 to 16, 19.3 percent, and severe ESS 17 to 24, 5.4 percent). SAQLI scores indicated that 16 percent of drivers had severely compromised quality of life (SAQLI <4) that could be related to sleep apnea (moderate SAQLI 4 to 5, 12.7 percent, mild SAQLI 5 to 6, 29.8 percent). The ANC stratification indicated that nearly one third (30.3 percent) had low probability of sleep apnea (ANC <43), nearly half (47.2 percent) had intermediate probability (ANC 43 to 48), and the remaining twenty percent (22.5 percent) had a high probability (ANC >48). The ANC was reasonably correlated with the RDI but the MAP, by contrast was not. No correlation was observed between ESS and RDI and only a weak correlation was observed between SAQLI and RDI.

8.2 Education Program Implementation

The initial challenge in implementing the education program was to condense educational materials to accommodate drivers' diverse schedules and geographic distribution. Based on interactions with each of the trucking companies, It was clear that the original plan to deliver four educational modules, each 1.5 hours, over multiple sessions was not practical under the existing protocol and carrier operations. As a

result each site modified the original plan using a variety of approaches, for example half day training sessions incorporating three modules at once.

A train-the-trainer approach was planned but too difficult to implement at two of the sites (Québec and California); instead training was done by members of the research team. In California, due to the wide geographic dispersion of drivers, web training was also used. Debriefing the trainers revealed that most felt some concerns regarding their level of knowledge – which they judged insufficient- to provide good training sessions. A similar situation occurred during Phase 2 of the FMP where eight drivers had to be trained directly by the project leader in Québec instead of using a train-the-trainer approach (Moscovitch et al., 2006). One Alberta trainer reported that while the handouts were used during the course, the trainer suspected that they were thrown away before even leaving the premises which is usual in his experience.

Family members were invited to training sessions but time constraints related to the drivers' schedules made it difficult for many family members to attend. Drivers were, however, encouraged to share the course material they received with their families. Several drivers in Québec mentioned that their spouses were very interested in knowing more about sleep and fatigue.

Although there are no formal data to demonstrate the effectiveness of family involvement to facilitate change related to an FMP, there are data in a variety of other arenas that show behavioural change can be encouraged by support (Renjilian et al. 2001) Therefore, educating family members about fatigue issues and their potential role in obtaining effective FMP outcomes is recommended as a component of a comprehensive FMP.

There are several lessons learned that emerge from the educational activities that can be useful in future FMP efforts. First, it appears that multiple mechanisms will be needed to address the differences among operational settings and drivers. Second, there is perhaps core information that can be identified for incorporation into an FMP and "additional" content that can be made available although not required. These issues are especially relevant given time and schedule constraints. Third, FMP activities should use adult learning principles and some level of interaction with scientific experts to develop this FMP element.

8.3 Pre vs. Post Effects of FMP

At the outset of this study a number of hypotheses were identified concerning the impacts of a comprehensive FMP involving 1) educational sessions at all levels of the drivers' company, the drivers and their families, 2) sleep disorder diagnosis and treatment and 3) interaction with dispatchers and management with the aim of improving dispatch practice with regard to fatigue. These hypotheses were as follows:

1. A comprehensive FMP will:
    a. Improve drivers' awareness of good sleep practices
    b. Result in increased sleep time during work days as measured by sleep-wake logs and actigraphy as well as improved sleep quality as measured by post sleep questionnaires
    c. Improve psychomotor performance during work days and reduce the number of close calls (near accidents) experienced while driving

2. Sleep disorder screening and treatment is feasible as part of an integrated, comprehensive FMP and will result in substantial reduction of fatigue levels at work and improvement of sleep duration and quality in affected drivers
3. Ongoing consultations with company representatives as part of an integrated FMP will improve fatigue management practices in the company as measured by an assessment of fatigue management policies before and after implementation of the FMP and as measured by improvements in corporate indicators.

Each of these hypotheses is considered below, with respect to whether it was supported or not by the pre versus post-FMP findings.

8.3.1 Hypothesis 1: FMP will improve sleep and performance

Hypothesis 1a: A comprehensive FMP will improve drivers' awareness of good sleep practices.

This hypothesis was supported by the following findings:

- At the one site with a pre/post comparison of knowledge, there was an average improved score by 4.5 percent (based on 16 questions) gained in the education on sleep practices.

Hypothesis 1b: A comprehensive FMP will result in increased sleep time during work days as measured by sleep-wake logs and actigraphy as well as improved sleep quality as measured by post sleep questionnaires

This hypothesis was supported by the following findings:

- Drivers reported significantly better subjective sleep quality post-FMP vs. pre-FMP (when analyzed by RDI; trend when analyzed by ESS). The improvement was 7.6 percent post vs. pre-FMP; this improvement was especially pronounced for duty days (9.1 percent).
- Drivers had longer main sleep periods based on actigraphy during rest days as compared to duty days (significant when analyzed by RDI, CPAP; trend when analyzed by ESS), for both pre and post-FMP. Pre-FMP sleep was longer on rest days compared to duty days, whereas post-FMP, there was no longer a significant difference. The result was a better balance in that post-FMP, main sleep periods for rest and duty days were more similar than they had been pre-FMP.
- During the pre-FMP condition, sleep efficiency, based on actigraphy, during time in bed was 2.2 percent less on duty days as compared to rest days. No such difference was observed during the post-FMP condition. This lack of difference between duty and rest days during post-FMP was mainly due to a significant improvement of sleep efficiency during duty days. This again indicates a better balance between sleep on duty days and sleep on rest days.

- Drivers achieved 20 minutes (5.9 percent) greater sleep duration during the main sleep period based on actigraphy during duty days in the post-FMP condition, a significant improvement compared to the pre-FMP condition.
- There was a significant increase in the percentage of drivers who reported obtaining more than six hours of sleep before their shift. Pre-FMP, 31.2 percent of all shifts were preceded by main sleep periods that were less than six hours in length as compared to 24.4 percent post-FMP.

Hypothesis 1c: A comprehensive FMP will improve psychomotor performance during work days and reduce the number of close calls (near accidents) experienced while driving.

This hypothesis was supported by the following findings:

- There was a trend towards drivers reporting less fatigue post-FMP as compared to pre-FMP, when analyzed by RDI subgroup, although not when analyzed by CPAP or ESS subgroup.
- There was a significant reduction in reported critical events from pre- to post-FMP. Overall, the number of drivers with at least one critical event (i.e., nod off or close call) decreased from pre- to post-FMP (45.5 percent to 28.6 percent).
- When the number of critical events was controlled for exposure by dividing by kilometres driven (Québec and Alberta only, California exposure not available), there was a 40 percent decrease in the rate of critical events reported (1 critical event per 24,064 km driven pre-FMP to 1 critical event per 33,722 km driven post-FMP)

The reduction in critical events reported from pre to post-FMP was substantial. This is a subjective measure, dependent on driver reporting, rather than an objective measure. However, evidence for its validity comes from several sources. First, post-FMP data provided evidence linking the duration of the sleep period to the occurrence of critical events. On average, post-FMP drivers had a significantly shorter sleep period before having a critical event while driving (mean = 6.08 hours) as compared to shifts where they did not have a critical event (mean = 6.69 hours). Second, when linear regression was used to determine the effect of RDI and Epworth Sleepiness Scale scores on the number of critical events, pre- vs. post-FMP, High RDI and High ESS scores were associated with more pre-FMP critical events.

The hypothesis was partially supported by the following finding:

- During rest days, but not during duty days, drivers in the CPAP adherent group had a trend for shorter reaction time and significantly greater reaction speed post-FMP vs. pre-FMP.
- During rest days, but not during duty days, drivers in the CPAP adherent group displayed a non-significant reduction in the number of minor lapses. This observation contrasted with the significant increase in minor lapses in the post vs. pre-FMP condition for drivers in the CPAP non-adherent group.

The hypothesis was not supported by the following finding:

- For duty days, drivers had significantly more minor lapses during the post-FMP as compared to the pre-FMP study phase when analyzed by RDI Subgroup and a trend when analyzed by CPAP Adherence Subgroup.

Despite the limited number of positive PVT findings, drivers did report more sleep per 24 hours in the post- vs. pre-FMP condition for all duty and rest days and about 20 minutes more sleep achieved during the main sleep period on duty days. These observations are relevant since extra sleep, through either sleep extension or short, discrete naps is an extremely effective strategy for improving alertness and performance. For example, chronically sleep deprived individuals in a work setting showed a Multiple Sleep Latency Test (MSLT) score in the pathological sleepy range and were then allowed to obtain extra sleep through sleep extension. The extra sleep increased their MSLT score to within a "normal" range (Howard et al. 2003). Also, a 26-minute nap has been shown to increase performance by 34 percent and alertness by 54 percent. This has been demonstrated in high-performance, safety-sensitive operational environments such as commercial airline pilots while in-flight, with similar finding in physicians and nurses working in an emergency medicine department (Rosekind et al. 1994; Smith-Coggins et al. 2006). This hypothesis would appear to have been too restrictive as it does not reference possible changes on rest days. FMP effect on PVT parameters were observed on rest days and these may have significance for daytime performance on duty days.

8.3.2 Hypothesis 2: Sleep disorder treatment will benefit affected drivers

Hypothesis 2: Sleep disorder screening and treatment is feasible as part of a comprehensive FMP and will result in substantial reduction of fatigue levels at work and improvement of sleep duration and quality in affected drivers.

This hypothesis was supported by the following findings:

- Two portable, home monitors (Remmers Sleep Recorder and ARES Unicorder) were used to screen for sleep apnea in participating drivers. These sleep studies proved to be convenient, inexpensive, well accepted, and have a high success rate (86 percent). (The success rate measures the fraction of total studies that are technically satisfactory.) For the Remmers Sleep Recorder (used in Québec and Alberta), a face-to-face instructional session with a technician was employed. For the ARES (used in California) the device was mailed to the drivers with hard copy instructions enclosed.
- The RDI values indicated that 71.3 percent of the drivers have sleep apnea and 31.9 percent of them are moderate-to-severe cases. This prevalence is higher than reported in a randomized sample of commercial drivers and may reflect a sampling bias due to the free access to sleep diagnosis and treatment offered to participating drivers in this study.
- Adherence to therapy of CPAP treated drivers in Québec and Alberta was 60 percent and 69 percent respectively and this is comparable to, or exceeds, most of the reports in the literature which concern undifferentiated populations of apneics. The adherence rate for the California drivers treated with CPAP was lower (5 percent) than expected from those reported for

undifferentiated population studies (Weaver and Grunstein 2008), but comparable to that reported in a recent study of CPAP adherence in CMV sleep apneics (Parks et al. 2009). The observed site difference may be related to the difference in the percent of drivers with face-to-face interactions with the clinical staff. As noted above, Québec and Alberta used a diagnostic method which employed a face-to-face instructional visit in contrast to California which employed a method that did not. Probably more significant, the drivers in Québec and Alberta were more likely to have a face-to-face visit with a member of the clinical staff after CPAP initiation (Alberta, 100 percent; Québec, 83 percent; California, 35 percent). The observed differences may also be related to other unidentified country-related factors.

- Overall, drivers – regardless of the presence of sleep disorders diagnosis (primarily sleep apnea) – showed a significant increase in total sleep achieved in the main sleep period (actigraphically documented)
- There was a trend for a reduction from pre- to post-FMP in reported critical events for drivers with RDI Mild Abnormality. There was a significant reduction from pre- to post-FMP in reported critical events for drivers with No ESS Abnormality and for ESS Mild Abnormality.
- Based on linear regression analysis, there were more reported critical events for those with higher RDI and higher ESS raw scores. The reduction in critical events from pre- to post-FMP, also was significantly correlated with RDI scores with greater reductions for those with higher RDI scores.
- There were significantly more minor lapses post-FMP compared to pre-FMP in the CPAP Non-Adherent group during rest days
- Drivers in the CPAP adherent group demonstrated a trend for a shorter reaction time in the post-FMP vs. pre-FMP for rest days although not for duty days

The hypothesis was partially supported by the following findings:

- Drivers reported longer total sleep in the last 24 hours post-FMP as compared to pre-FMP but only for the RDI No Abnormality group (by 1 hour and 18 minutes) and the No CPAP group (by 1 hour and 20 minutes)
- The 20 minutes greater sleep duration during the main sleep period (actigraphy) is even more pronounced if only drivers in the No CPAP and the No RDI Abnormality subgroups are considered. The drivers in the No CPAP group reported sleeping 28 minutes more, and in the No RDI Abnormality group, 47 minutes more during the post- vs. pre-FMP.

8.3.3 Hypothesis 3: FMP will improve company practices and policies

Hypothesis 3: Ongoing consultations with company representatives as part of a comprehensive FMP will improve fatigue management practices in the company as measured by an assessment of fatigue management policies before and after implementation of the FMP and as measured by improvements in corporate indicators.

This hypothesis was supported by the following findings:

- The AMSE results from drivers showed statistically significant increases/improvements in four (education, alertness strategies, healthy sleep, organization) of the five FMP elements.

- Overall corporate measures indicated an improvement in company performance with significantly fewer road infractions and accidents and a trend for reduction of absent days per kilometre travelled in Québec. Statistical analysis indicated changes in corporate measures in Alberta and California were not significant.

The hypothesis is not supported by the following:

- More night drivers were observed post-FMP. In addition, those drivers so classified drove more hours at night post as compared to pre-FMP.

It should be noted that the period of observation in the present project is rather limited for the purpose of adequately quantifying corporate cultural changes regarding fatigue management. It was not the purpose of the present study to systematically quantify corporate and cultural changes towards fatigue-related issues. Nevertheless, an effort to standardize assessment of corporate changes at each site was made by administering the AMSE questionnaire to various participants (drivers, managers, dispatchers) during the pre- and post-FMP data collection. Across the three sites, a substantial improvement from pre- to post-FMP was observed in the percentage of responders who reported that there was corporate support of education during the post- vs. pre-FMP condition. A moderate increase in the percentage of respondents who considered positive company involvement with regards to alertness strategies, scheduling and healthy sleep was observed. Answers to these questions reflect the respondents' perception of company support of these key aspects of fatigue management.

In addition to the AMSE questionnaire, corporate data were collected at each site depending on their availability. There is thus some site variability in the capacity to evaluate the impact of an FMP program on corporate measures. Moreover, it is recognized that some corporate measures such as number of incidents and accidents require a longer period of observation before meaningful conclusions can be drawn. Furthermore, data were collected over different time periods, and there could be important seasonal differences in corporate measures such as crash risk and absenteeism rate that may have confounded the data, making it more difficult to find significant effects. These limitations should be considered when designing the future Phase 4 of the FMP project and developing monitoring tools for corporate change. In that context, corporate measures that are more specific to the participating drivers, such as number of infractions and possibly absenteeism and sick days, could be more sensitive to the period of observation.

While more night drivers were observed post-FMP, and they drove more hours at night, it is impossible to know if this difference occurred in response to operational demands. Nevertheless, night hours overall including all drivers did not increase. In addition, drivers reported more sleep per 24 hours in the post vs. pre-FMP condition for all duty and rest days This observation is relevant since extra sleep, through either sleep extension or short, discrete naps is an extremely effective strategy to improve alertness and performance. For example, chronically sleep deprived individuals in a work setting

showed a Multiple Sleep Latency Test (MSLT) score in the pathological sleepy range and were then allowed to obtain extra sleep through sleep extension. The extra sleep increased their MSLT score to within a "normal" range (Howard et al. 2003). Also, a 26-minute nap has been shown to increase performance by 34 percent and alertness by 54 percent. This has been demonstrated in high-performance, safety-sensitive operational environments such as commercial airline pilots while in-flight, with similar finding in physicians and nurses working in an emergency medicine department (Rosekind et al. 1994; Smith-Coggins et al. 2006).

8.4 Duty vs. Rest Days

Nearly all sleep parameters were improved during rest days compared to duty days. More specifically, drivers spent significantly more time in bed, reported longer sleep periods, achieved greater sleep during their main sleep period and had more efficient sleep during rest days compared to duty days. Reported sleep per 24 hours was also greater during rest vs. duty days. Sleep was subjectively evaluated as deeper but of similar quality during rest days compared to duty days. Altogether these results indicate that drivers used their rest days to recover from their duty days. However, the average total sleep time achieved during their main sleep periods is only 6 hours 37 minutes on rest days compared to 5 hours 38 minutes on duty days. When considering total sleep achieved per 24 hours, drivers reported sleeping 9 hours 4 minutes during rest days vs. 8 hours 20 minutes during duty days. Thus, during rest days, drivers slept an additional 59 minutes per main sleep period and 44 minutes per 24 hours, respectively. There was no main effect of type of day on napping behaviour.

8.5 Start vs. End of Days

PVT parameters indicate worse performance at the end compared to the start of the day. More specifically, reaction time was significantly increased by four percent at the end of the day vs. the start of the day; the increase was two percent on rest days and six percent on duty days. Minor lapses were significantly increased by 20 percent at the end of the day vs. the start of day on rest days but no significant changes were observed on duty days. These results indicate that driver performance was sensitive to the duration of waking. They are consistent with prior studies reporting that the risk of sleepiness at work in irregular shift systems would increase by about 15 to 35 percent for each additional hour worked or for each hour of sleep missed (Härmä, Sallinen, Ranta, Mutanen, & Müller, 2002; Sallinen, Härmä, Mutanen, Ranta, Virkkala, & Müller, 2003).

8.6 Interaction with Dispatchers and Corporate Measures

Focus groups or individual interviews were used to obtain insights into dispatcher scheduling practices and challenges. At all sites dispatchers indicated there were numerous factors to be considered in scheduling in addition to preventing fatigue. These included: availability of drivers and equipment, HOS rules, driver family needs, driver requirements for time off due to fatigue, the collective bargaining agreement with respect to seniority, customs switchovers and customer needs. Software tools to assist in scheduling were used in Québec but not in Alberta or California.

During the FMP part of the project, dispatchers from Québec who were responsible for the participating drivers attended an educational session on the core module. They also met a second time with the investigator just prior to the post-FMP data collection

in order to discuss their dispatching strategies and how these could be improved to reduce driver fatigue.

In Alberta, most dispatchers interviewed responded that there were no formal procedures for scheduling. However, one dispatcher was able to point to more formal procedures which are documented in the Dispatch Procedures Manual (effective date June 2005 revision 1.0). This manual included Sections 7.6 Dispatching with subsections entitled: dispatching priorities, dispatching ECL resources, dispatching load assignment, dispatching Bill of Lading and driver instructions, and dispatching split deliveries. Also, Section 7.7: Delivery Exceptions – delays, diversions, was found in the manual (see Appendix L).

In California, one dispatcher noted that drivers who operate during the day are assigned different hours compared to ones who operate at night, in an apparent effort to reduce night time driving when possible. It was not specified whether these "different" hours were longer or shorter and a brief examination of drivers' schedules did not show day as compared to night differences. This was apparently intended to acknowledge circadian influences but it was not an explicit policy or practice based on scientific resources.

Due to the fact that dispatch/scheduling policies and practices were significantly different between sites, it was clear from the outset that attempting to impose standardized interventions in this area was impractical. Nonetheless, it was initially expected that the FMP implementation, with education, AMSE assessment and discussion with the dispatchers would lead to positive scheduling changes. This did not occur. Improvements in scheduling to reduce fatigue were not seen in that there was no change in start times or in the number of hours driven at night. Furthermore, more drivers were classified as night drivers post-FMP and these drivers drove more hours at night post-FMP. Further research should address potential scheduling improvements, providing dispatchers and managers a range of explicit scheduling approaches that might be used to reduce fatigue.

It should be noted that the period of observation in the present project is rather limited for the purpose of adequately quantifying corporate cultural changes regarding fatigue management. It was not the purpose of the present study to systematically quantify corporate changes. Nevertheless, an effort to standardize assessment of corporate changes at each site was made by administering the AMSE questionnaire to various participants (drivers, managers, dispatchers) during the pre and post-FMP data collection. This questionnaire evaluated various aspects of the corporate involvement towards an integrated alertness management program. It included questions on fatigue education, alertness strategies, scheduling, and company support for healthy sleep. Across the three sites, a substantial improvement from pre to post-FMP was observed in the percentage of responders who reported that there was corporate support of education during the post vs. pre-FMP condition (average of +28 percent on education support-related questions). A moderate increase in the percentage of respondents who considered positive company involvement with regards to alertness strategies (+12 percent), scheduling (+8.3 percent) and healthy sleep (+17 percent) was observed. Answers to these questions reflect the respondents' perception of company support of these key aspects of fatigue management.

In addition to the AMSE questionnaire, corporate data were collected at each site depending on their availability. There is thus some site variability in our capacity to evaluate the impact of an FMP program on corporate measures. Moreover, it is recognized that some corporate measures such as number of incidents and accidents require a longer period of observation before meaningful conclusions can be drawn. This limitation should be considered when designing the future Phase 4 of the FMP project and developing monitoring tools for corporate changes. In that context, corporate measures that are more specific to the participating drivers, such as number of infractions and possibly absenteeism and sick days, could be more sensitive to the period of observation.

Changes in corporate culture were addressed by means of a questionnaire (i.e., AMSE) on perceptions of fatigue management policies and practices as well as by individual performance measures specific to each company.

On the AMSE, there was a significant increase in the number of reported fatigue management activities in four of the five FMP elements (education, alertness strategies, healthy sleep, organizational elements). These significant changes in AMSE responses post-FMP appeared to reflect improvements in firsthand knowledge and experience, perceived efforts, and/or the organization's corporate culture. Although dispatchers were included in FMP activities, there were no specific FMP efforts directed at changing scheduling policies and practices. Therefore, no significant change in this element was expected. Of the 20 specific questions asked on the AMSE, 19 showed an increase/improvement in the post-FMP AMSE. The smallest increase involved an organizational element: an identified individual to co-ordinate FMP activities. The largest increase was found in the educational element related to drivers receiving fatigue education. Eight of the 19 specific questions that showed increases/improvements in post-FMP AMSE ratings reached a statistically significant level ($p<.01$).

Corporate measures over a three-month period indicated an improvement in company performance with significantly fewer road infractions and accidents and a trend for reduction of absent days per kilometre travelled in Québec. Changes at the Alberta and California sites were not significant.

8.7 Cultural Change Indications

Although an AMSE evaluation was carried out, the duration of the study is too short to reliably and completely quantify the changes of company and drivers' culture as it pertains to fatigue-related issues. Nevertheless, throughout the course of the FMP project, several incidents occurred that suggest a certain degree of cultural change was taking place.

For instance, during the interactive sessions with dispatchers in Québec, there were exchanges of opinion among various dispatchers regarding their involvement in driver fatigue. Some dispatchers were quite sensitive to accommodating the drivers' need for rest when establishing their work schedules. These proactive dispatchers expressed publicly their opinion on the importance of the dispatcher role in improving drivers' alertness and safety on the road. This led to discussion with other dispatchers who considered that it was the drivers' own responsibility to manage their life around their driving schedule which they self-selected.

Throughout the meeting with the drivers in Québec, the research team witnessed the exchange of information among drivers regarding the importance and personal benefits of being screened and treated for sleep apnea. Similar positive interactions were observed in Alberta. Even though participants were reminded that the project was to be done under the greatest standards of confidentiality, several drivers who were already treated for sleep apnea spontaneously shared their own personal stories with their colleagues. Finally, a high level manager of the participating company in Québec made it a priority to be proactive in the screening and treatment of all their drivers for sleep apnea.

In California, the AMSE findings that indicated increases/improvements in fatigue management activities were anecdotally reinforced during education sessions, phone interactions, and when working with other company personnel (non-drivers). These included spontaneous comments about the value of education, the use of an alertness strategy or some scheduling issue that would benefit from being addressed through a fatigue management perspective.

8.8 Implementation and Data Collection Challenges

The present project led to the collection of various types of data in a significant number of drivers located in three different sites (Québec, Alberta, and California). This comprehensive FMP project involved standardizing data collection and intervention as much as feasible across the three sites and collecting driver-based and company-based data in the field while drivers were operating on their normal revenue generating routes. The investigators had to take into consideration the atypical schedules of the drivers at every step of the project such as during screening, pre-FMP and post-FMP data collection, the planning of educational sessions, and sleep apnea testing and treatment. Despite these difficulties, a total of 121 drivers completed the pre-FMP data collection, 94 underwent sleep apnea testing, and 77 completed all phases of the study, resulting in a completion rate of 64 percent. The rate of study drop-out (36 percent) was slightly higher than originally expected (30 percent), but nonetheless allowed us to gather relevant information to test the proposed hypotheses. Once data were collected, substantial time and effort was spent on evaluating the quality of data collected in the field and analysing only reliable data (e.g., see Section 7.10 for the processing of PVT data). For example, driver bedtimes as reported by the PDA device were compared to the actigraph recordings. Data were excluded if there was a substantial deviation of collection time between measures. Despite the differences across individuals and sites, and the heterogeneity of work conditions and scheduling practices during field data collection, a series of positive findings could be drawn from this project as reported in the executive summary.

Overall, these results support the feasibility and usefulness of a comprehensive company-wide FMP.

9 BEST PRACTICE GUIDELINES

The present study has demonstrated the feasibility of a company-wide FMP that comprises an educational component, offered to drivers, family members, managers, and dispatchers, a data collection component covering corporate measures and driver-based data, and a clinical intervention component designed to test and treat sleep disorders such as sleep apnea.

With regards to education, the present project revealed that the educational sessions should be planned with enough flexibility such that they are sensitive to companies' operational constraints including the drivers' atypical schedules and multiple locations. The educational sessions should be kept to a reasonable duration (e.g., 60 minutes or less) in order to maximise attendance per session, facilitate their integration with the actual operations, and minimize their costs. Some resistance to use a train-the-trainer approach was observed at two sites. Specific efforts could be developed to recruit and train trainers who are comfortable with the science underlying fatigue-management and the operational realities of the CMV industry. Various modes of presentations could be developed such as web conferences, e-teaching, interactive educative CDs, although face-to-face interactions with trainers and experts is suggested at regular intervals in order to improve long-term retention and foster interactive discussions. To support the education sessions, three newsletters were circulated over the course of the FMP intervention to keep drivers and managers informed of relevant news on fatigue-related issues for the CMV industry.

Future efforts should explore strategies to extend educational activities to other sectors of the industry (e.g., receivers, customers), to train more managers and dispatchers within each company, and to better reach out to family members. This last action would be beneficial in improving family-work balance and drivers' self-involvement in adopting fatigue-wise behaviours. In this context, mixed group interactions, led by scientific experts, are recommended in order to identify obstacles to cultural changes, engage in problem-solving discussions and develop solutions. While an attempt was made in the present project to encourage participants' self-involvement in their fatigue-management education by setting up a website for frequently asked questions (FAQ), participants did not use the site.

With respect to whether an FMP should include sleep apnea screening, the following statistically significant findings relating to apneic drivers on rest days should be considered:

- CPAP adherent apneics displayed a significant improvement post-FMP in reaction speed and non-significant improvement in number of minor lapses by PVT
- CPAP non-adherent apneics displayed a significant worsening post-FMP in the number of minor lapses

In terms of the clinical intervention component, the present study has underlined the feasibility, but yet the difficulties involved in sleep apnea testing and treatment of CMV drivers. Namely, the atypical drivers' work schedules, their geographical dispersion, and regional inequalities in terms of accessibility to clinical teams are obstacles for extending this intervention component to the whole industry. Issues such as financial

coverage, involvement of insurers, and development of clinical standards for large scale screening, treatment initiation and follow-up should be addressed. Nonetheless, the results of the present study reinforce the idea that diagnosis and successful treatment of drivers with sleep apnea constitutes an important component of a comprehensive FMP.

Sleep apnea treatment should also be based on a comprehensive clinical assessment and not limited to the simplistic approach of treating an RDI number instead of a patient and only providing a CPAP machine. Initiatives to improve the long-term adherence rate to CPAP should be encouraged. The circumstances surrounding driver support are critical early in CPAP initiation. Face-to-face interaction is far superior to phone contacts. A best practice recommendation would be, at minimum, at least one face-to-face follow-up interaction with a member of a clinical team with each driver started on CPAP. Driver education, problem-solving resources, and support group meetings may be important in relation to CPAP therapy adherence. Finally, peer led self-management sessions for drivers on CPAP might be of considerable positive influence in promoting CPAP adherence within the CMV industry.

The medical/scientific literature very clearly shows that sleep apnea represents a significant health and safety risk and that CPAP is an effective treatment for sleep apnea. Data from a variety of sources indicate that the prevalence of sleep apnea in commercial truck drivers warrants the diagnosis and treatment of sleep apnea in this population. Effective treatment of this group represents a significant opportunity to enhance health and safety factors for these individuals and the trucking industry. The improvement in vigilance performance may be one of the most relevant measures with regards to critical events which were, as discussed early, observed to be less post-FMP.

Finally, it is critical to acknowledge that effectively managing fatigue in commercial trucking is a shared responsibility that cannot be successfully addressed by a single industry group. Trucking companies, individual drivers, regulatory authorities, safety advocates, company personnel, shippers, and others all play a role in addressing the complex factors that create fatigue-related safety risks in commercial trucking. Successfully managing fatigue will require a shared responsibility that involves each group acknowledging and identifying their role in reducing known fatigue-related risks. A collaborative, shared responsibility approach that involves multiple components (i.e., education and training, sleep disorder diagnosis and treatment, corporate and individual driver efforts, etc.) offers the greatest opportunity to effectively manage fatigue-related safety risks in commercial trucking.

Also, the present project indicated that the involvement of company top management is essential in supporting the implementation of a comprehensive FMP. Future efforts should include measures of change in corporate culture as it pertains to fatigue management, documentation of how and to which level interventions are integrated within each company, identification of obstacles and solutions for an effective approach, and collection of relevant corporate measures and road safety indicators over a longer period of time. This will help to monitor and more accurately assess the benefits of implementing a comprehensive FMP within the industry.

10 FUTURE RESEARCH

The “comprehensive” FMP that was implemented and evaluated in this project comprised three elements: 1) education, 2) sleep apnea screening (diagnosis and treatment) and 3) interaction with dispatchers and managers with the aim of helping them consider drivers’ fatigue in their dispatching practice. This FMP did not include formal modifications of scheduling practices, in-vehicle technology, shift scheduling computer models or specific dispatching changes resulting from a fatigue-oriented analysis of current dispatching practice at each company. It is clear that the more multi-faceted the program, the more likely behaviour is to be impacted. Any changes or scientific recommendations should take into account the complexity and sensitivities of real-world operations. More research is needed to determine which versions of each of these elements as well as which combination of elements is most effective in improving behaviour. Of equal importance to commercial interests, evaluation of which combination of elements provides the best return on investment is also needed.

As noted above, adherence to treatment is very much affected by the circumstances surrounding driver support early in CPAP initiation. Face-to-face interaction is far superior to telephone contact and is recommended. Education about CPAP use and what the driver’s diagnosis entails appears critical and needs to be evaluated. Support group meetings may be important in relation to CPAP therapy adherence, and peer led self-management sessions may be the best format. Further study to determine the effectiveness and utility of such approaches is recommended to improve diagnosis management. The present project has identified the need for the field of sleep medicine to develop standards for the safe treatment and follow-up of apneic drivers.

The data from this project support the idea that identifying and successfully treating drivers with sleep apnea promotes an improvement in psychomotor vigilance. However, more research will be required, examining longer treatment periods and compliance issues, to determine how to best extend the known beneficial effects of CPAP treatment to the challenging environment of commercial trucking.

Diagnosis of drivers with a high probability of sleep apnea and subsequent treatment is an important goal for a FMP. However, strategies, cost effectiveness and operational feasibility need to be determined with further research. Thus, tools to adequately and reliably pre-test or screen for drivers at the greatest risk for sleep apnea and for ensuring rapid, proper clinical care, follow-up and adherence should be developed. Moreover, more corporate measures should be gathered to better document the economic and road safety implication of such major initiatives. While screening CMV drivers at risk for severe sleep apnea may be one useful strategy, the diagnostic utility of screening procedures such as ANC as an industry approach is unknown, although promising. Given the accuracy and convenience of portable monitoring, the comprehensive use of such monitoring is recommended. While the ANC may be useful as a pre-test assessment, it is no substitute for direct cardio-respiratory investigation during sleep.

Overall, our results show that on rest days psychomotor performance is improved in apneic drivers who adhere to CPAP treatment compared to those who do not adhere to treatment. The only cautionary note here is that these findings are based on a small number of drivers, in highly variable field conditions, and, therefore, need to be confirmed in a larger study. That these analyses indicate improved psychomotor

performance limited to rest days may seem counter-intuitive or even disappointing. Nevertheless, it is important to underline that duty days are linked to a significant sleep-wake disruption due to irregular working schedules that can limit our ability to detect more subtle between-group differences associated with CPAP adherence. Thus, the specific clinical benefits of detecting and treating sleep apnea should be based also on a critical review of other relevant clinical studies. Furthermore, confounding factors such as change in the temporal organization of duty days were observed in the post vs. pre-FMP condition and might have further complicated the analyses of performance data in the study group. Indeed, more drivers defined themselves as “night drivers” during the post-FMP vs. pre-FMP condition. Despite these operational limitations, the overall effects of CPAP adherence on performance were in the expected direction.

11 CONCLUSIONS

At the outset of this study our hypotheses concerning a comprehensive FMP, involving 1) educational sessions at all levels of the drivers' company, the drivers and their families, 2) sleep disorder diagnosis and treatment and 3) interaction with dispatchers and management with the aim of improving dispatch practice with regard to fatigue, were as follows:

1. A comprehensive FMP will:
    a. Improve drivers' awareness of good sleep practices
    b. Result in increased sleep time during work days as measured by sleep-wake logs and actigraphy as well as improved sleep quality as measured by post sleep questionnaires
    c. Improve psychomotor performance during work days and reduce the number of close calls (near accidents) experienced while driving
2. Sleep disorder screening and treatment is feasible as part of an integrated, comprehensive FMP and will result in substantial reduction of fatigue levels at work and improvement of sleep duration and quality in affected drivers
3. Ongoing consultations with company representatives as part of an integrated FMP will improve fatigue management practices in the company as measured by an assessment of fatigue management policies before and after implementation of the FMP and as measured by improvements in corporate indicators.

With respect to the first hypothesis, there were sleep-related improvements post vs. pre-FMP in subjective sleep quality with the greatest effect on duty days and in sleep achieved during the main sleep period post vs. pre-FMP for duty days. The changes that occurred in sleep efficiency indicated a better balance between rest and duty days.

In association with these improvements in sleep length and quality, there was a trend towards drivers reporting less fatigue post-FMP as compared to pre-FMP. There was a significant reduction in the number of drivers reporting one or more critical events (i.e., nod off or close call) from pre- to post- FMP and a significant reduction in critical events per kilometre driven for the two sites with available distance data.

With respect to the second hypothesis, post- versus pre-FMP changes in PVT data related to drivers affected by sleep apnea were only found for rest days. Changes during the rest days were in the expected direction: improvement in the CPAP adherent group and deterioration in the CPAP non-adherent group.

Results observed in these groups during duty days with respect to reported sleep in the prior 24 hours and minor lapses are more difficult to reconcile with this second hypotheses. At the start of duty and rest days, drivers unaffected by sleep apnea (RDI No Abnormality and No CPAP) reported having slept significantly more in the prior 24 hours in the post- vs. pre-FMP condition. The number of minor lapses increased during duty days in the post- vs. pre-FMP condition. This difference was significant at the end but not at the start of duty days. Confounding factors such as change in the temporal organization of duty days might have complicated the analyses of performance data in the study group. It is worth mentioning that more drivers defined

themselves as “night drivers” during the post-FMP vs. pre-FMP condition. This database thus calls for further and more refined analyses in order to better account for factors such as the variability observed across and within subjects in work scheduling, the organization of their sleep-wake cycle, and changes in their clinical status.

With respect to the third hypothesis, a survey of fatigue management practices post as compared to pre-FMP showed significant increases/improvements in reported and perceived fatigue management activities. Specifically, there were significant increases reported for education, alertness strategies, healthy sleep, and organizational elements. The one element that did not show a significant improvement was scheduling. Night driving remained the same post-FMP in that number of hours driven at night did not change. However more night drivers were observed post-FMP. In addition, those drivers so classified drove more hours at night post as compared to pre-FMP. Given that there were no FMP activities focused specifically on changing scheduling policies and practices, this appears to accurately reflect actual implementation.

Corporate measures over a three-month period indicated an improvement in company performance with significantly fewer road infractions and accidents and a trend for reduction of absent days per kilometre travelled in Québec. Changes at the Alberta and California sites were not significant.

Given the complexity of defining and measuring corporate measures and corporate culture relevant to fatigue management, these significant findings demonstrate that the FMP had important and beneficial effects beyond the individual drivers that were reflected more broadly within the organization.

Overall, the present study demonstrates the feasibility of implementing a comprehensive FMP program, using a company-based approach within the CMV industry. This approach has beneficial impacts on individual drivers’ well-being and safe behaviour. Drivers benefit from sleep disorder screening and treatment and receive education on sleep and fatigue highly relevant to their work. The present study shows the positive impact that an FMP program had on drivers’ sleep-wake behaviour and performance. In addition, it demonstrated a beneficial effect on corporate health and safety measures of absenteeism and crash rate.

The results of this study lead to a number of suggested areas of future research that might be explored in Phase 4. The FMP examined in this study comprised education and screening of drivers and broader corporate interaction elements. Other elements such as scheduling software, in-vehicle technology and dispatching practice changes might also have been considered. Research is needed to determine the optimal combination. This study has also identified the need for better sleep apnea screening tools and an improved understanding of how adherence to CPAP therapy can be improved, contributing to the safe treatment of apneic drivers in the challenging environment of commercial trucking.

A comprehensive FMP approach at the company and industry level is a promising approach for an efficient and long-term reduction in the experience of fatigue. Only such systematic interventions can have a real influence and lead to desirable cultural changes that will allow all players, especially individual drivers, to have the potential to put in place effective fatigue countermeasures when needed. Moreover, such an

approach is important to identify the obstacles and solutions to a fundamental change of behaviour towards safe scheduling and sleep-wake behaviours within the industry.

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APPENDIX A

LETTER OF AGREEMENT – ENGLISH

Name:

Company:

Address:

City, Province/State, Postal Code/ZIP:

Re: Letter of Agreement

Dear **Name:**

This letter serves to outline **company name's** participation in the project entitled "Field Test of a Comprehensive Fatigue Management Program: A Comparison with Current Company Practices." The project is being sponsored by:

- Alberta Infrastructure and Transportation (INFTRA)
- Alberta Workers' Compensation Board (WCB)
- Commission de la santé et de la sécurité du travail du Québec (CSST)
- Société de l'assurance automobile du Québec (SAAQ)
- Transport Canada (TC), including both the Road Safety Directorate and the Transportation Development Centre (TDC)
- U.S. Department of Transportation (DOT), acting through the Federal Motor Carrier Safety Administration (FMCSA)

In-kind, operational, and other support to the project is also provided by the motor carrier industry through the participation of:

- Association du camionnage du Québec (ACQ)
- Alberta Motor Transport Association (AMTA)
- American Transportation Research Institute (ATRI), of the American Trucking Associations
- Canadian Trucking Alliance (CTA)

This project, which focuses specifically on the implementation and evaluation of a comprehensive Fatigue Management Program (FMP), is the third phase in a series of projects to address fatigue in the North American trucking industry. Participating companies will be selected from Alberta, Québec & California.

The objective of the project is to address practical, operational aspects of FMP implementation, identify obstacles/solutions at a company level, compare a comprehensive FMP to current company fatigue management practices and evaluate the effect of an FMP

on driver sleep and on company safety and corporate measures. The FMP will include the following:

1. Educational activities
2. Scheduling/dispatch guidance
3. Diagnosis and treatment of sleep apnea
4. Evaluation of corporate and field data

All aspects of the project will receive approval by an Institutional Review Board for protection of individuals involved in human research projects and all data/results will be reported in a group format to maintain confidentiality and anonymity. Sleep apnea diagnosis and treatment information collected by the medical specialist will be covered by doctor/patient confidentiality and therefore, will not be communicated to the company. The medical specialist will provide the investigators with anonymous summary group data at the end of the project for analyses.

This letter is not intended as a contract but serves to outline the mutual expectations between **company name** and the Investigators throughout the 24-month commitment associated with this initiative.

Through your participation in this project, **company name** will receive, at no direct cost, and benefit from the following:

- Comprehensive FMP that includes education, scheduling guidance, and diagnosis and treatment of sleep apnea
- Quantified outcomes to establish FMP effects on fatigue and safety
- Summary group findings for the field component
- Leading scientists who help apply latest findings based on neutral, objective evaluation
- Recognition as providing leadership in establishing an industry FMP model
- Recognition as being supportive of rested, healthy and safe drivers

In return for receipt of these FMP components and benefits, **company name** agrees to:

- Commit to implementation of full FMP (all component activities)
- Meet protocol requirements regarding protection of individual driver confidentiality
- Permit drivers to decide whether or not to volunteer without prejudice or repercussion
- Meet all project administrative and regulatory requirements outlined (e.g., scheduled U.S. & Canadian HOS compliant revenue generating routes)
- Collaborate on a regular basis with Investigators to implement and monitor policy, process, and FMP activity implementation

The following are examples of required company-specific activities: additional site-specific requirements may be requested to accomplish the goals of the program.

- Provide opportunity for company personnel to attend 4 educational sessions (about 1.5 hours each)
- Provide an appropriate number of individuals to be trained as FMP trainers, including attendance at 1/2 day training session

- Provide appropriate dispatchers to assist in identifying routes suitable for data collection
- Provide appropriate HR personnel or other relevant individuals to assist in identifying and collecting pre- and post-FMP company measures
- Provide appropriate personnel HR (e.g., managers, HR, dispatchers, drivers) to participate in internal FMP operational group

There is already agreement among the sponsors and the investigators that while the project is in progress, all inquiries (e.g., media, other companies, etc.) will be directed to Transport Canada. As a company involved in the FMP project, it is expected that **company name** will be held to this same commitment. It is expressly understood by all parties that this Letter of Agreement shall not constitute a formal and binding agreement between the parties. This letter reflects an understanding of the discussions that have taken place regarding mutual expectations for participation in this initiative. This letter does not create any legal rights or obligations between the participating company and the principal investigators.

By volunteering to be part of this groundbreaking project, **company name** is making a significant contribution toward ongoing efforts to mitigate the effects of driver fatigue and enhance highway safety by helping to establish scientific data on the effects and benefits of the implementation of an FMP in the trucking industry.

Sincerely,

Investigator Name
Investigator Title
Investigator Affiliation

Read and approved:

Company Name

By: _____

Title: _____

Date: _____

APPENDIX B

DRIVER PRE-SCREENING QUESTIONNAIRE

Subject #: _____

Effects of a Fatigue Management Program on Fatigue in the Commercial Motor Vehicle Industry

This Questionnaire is part of a multi-phase study designed to investigate the effectiveness of a fatigue management program in commercial motor vehicle operations. Your answers provide important information concerning experiences within the industry.

This survey is intended to assist us to identify drivers who are both interested and qualify to participate in the study. If you are considering participation in this study, please fill out the entire survey, including your contact information and leave it with a representative. If, however, you are not interested in **full** study participation, you can still contribute by taking a few seconds to complete the "Background Information" portion of this questionnaire.

All answers are completely confidential and will be seen only by members of the research team.

Your time and cooperation in filling out this questionnaire is greatly appreciated.

DRIVER INFORMATION

1. How long have you been a commercial driver? _____ years _____months
2. Do you currently hold a valid CMV licence? Yes ❒ No ❒
3. Have you worked for a least 3 years as a Class I commercial driver? Yes ❒ No ❒
4. Do you have a personal driving record indicative of a safe driver? Yes ❒ No ❒
5. In your opinion, is your current driving schedule fatiguing? Yes ❒ No ❒
6. Are you a team driver? Yes ❒ No ❒
7. Have you had any "at fault" involvement in a fatal accident (involving either a work-related or personal vehicle) in the past three years? Yes ❒ No ❒
8. Have you had any prior conviction for logbook falsification, or any history of unsafe driving? Yes ❒ No ❒
9. Approximately what percentage of your driving occurs between 10 p.m. and 6 a.m.? _____%

BACKGROUND INFORMATION

Age: _____years _____ months Height: _____ ~in ~cm Weight _____~lbs ~kg

Gender: Male ❒ Female ❒ Neck size: _____ ~in ~cm

Do you have hypertension/high blood pressure? Yes ❒ No ❒

STUDY PARTICIPATION

I am interested in learning more about potential participation in this study. Yes ❒ No ❒

I am willing to be screened and treated for sleep apnea. Yes ❒ No ❒

If yes, please provide your contact information below:

_____ _____

(Print Name) (Signature)

_____ _____

(Home Phone) (Home Address)

APPENDIX C

DRIVER CONSENT FORM

(Letterhead)

TEMPLATE CONSENT FORM FOR COMPREHENSIVE FATIGUE MANAGEMENT PROGRAM

INVESTIGATOR:

Name:

Title:

Address:

Phone:

TITLE: **Effects of a Fatigue Management Program on Fatigue in the Commercial Motor Vehicle Industry**

SPONSORS

- Alberta Infrastructure and Transportation (INFTRA)
- Alberta Workers' Compensation Board (WCB)
- Commission de la santé et de la sécurité du travail du Québec (CSST)
- Société de l'assurance automobile du Québec (SAAQ)
- Transport Canada (TC), including both the Road Safety Directorate and the Transportation Development Centre (TDC)
- U.S. Department of Transportation (DOT), acting through the Federal Motor Carrier Safety Administration (FMCSA)

In-kind, operational, and other financial support to the project is also provided by the motor carrier industry through the participation of:

- Association du camionnage du Québec (ACQ)
- Alberta Motor Transport Association (AMTA)
- American Transportation Research Institute (ATRI), of the American Trucking Associations
- Canadian Trucking Alliance (CTA)

You are being asked to take part in a research study. Before agreeing to participate in this study, it is important that you read and understand the following explanation of the purpose, procedures, benefits, discomforts, risks and precautions associated with this study, as well as your right to refuse to participate or withdraw from the study at any time. In order to decide whether you wish to participate in this research study, you should understand enough about the study's risks and benefits to be able to make an informed decision. Please ask the study staff to explain any words you don't understand before signing this consent form. Make sure all of your questions have been answered to your satisfaction before signing this document.

PURPOSE

Research clearly demonstrates that fatigue is a serious problem for the trucking industry. To address the many factors that can create fatigue, there is a need to develop a comprehensive Fatigue Management Program (FMP) that will benefit the industry, regulatory agencies, insurance companies and the public at large.

You have been asked to participate in a study that is designed to assess whether a comprehensive FMP will provide a greater reduction in driver fatigue and have a more positive impact on operations than do companies' current fatigue management practices. This information will help our understanding of fatigue and recovery and may influence policy makers in the future with regard to driving regulations.

During the study researchers will work intensively with your company over a one-year period to integrate the FMP into the entire operation and to provide ongoing support. The ongoing consultation will help your company develop policies and implement practices consistent with an FMP as well as develop solutions with experts in areas where implementation proves to be challenging.

To demonstrate the effects of an FMP, driver and company data will be compared before and after FMP intervention. The results of the study will demonstrate whether a comprehensive FMP reduces fatigue.

PROCEDURES

The study will begin with an assessment of whether or not you are eligible to participate. You are eligible for the study as long as you have met medical requirements for licensing as determined by your company and are willing to participate in this study voluntarily. To get other basic information about you and your driving, we would like your permission to review and collect information about your previous driving experience and health problems from the company's employment information. If you are eligible, you will be shown how to use a wrist Actigraph and a handheld device (PDA) to answer questions related to fatigue.

The study consists of 4 steps:

1. Data collection during your regular route during a 2-week period
2. Sleep disorder assessment and treatment
3. Educational workshops on fatigue for you, your families, dispatchers and management
4. Data collection during your regular route during a 2-week period

The study will be spread over an 18-month period and a total of 120 drivers and their partners will be recruited in three locations (i.e., 40 drivers in each location): Quebec, Alberta and the United States.

Step 1: Before Fatigue Management Education Program

During Step 1 and Step 4 you will be asked to drive a normal revenue-generating route within the applicable hours-of-service regulations in the jurisdictions in which you will be driving. You will be asked to drive a minimum 4 – 5 day driving period. Night driving (between the hours of 10 p.m. and 6 a.m. local standard time) will be targeted within the company to comprise at least

50% of the driving. At all times in this study, you should always exercise your own judgement with regard to your ability to drive and only drive if you feel that you can drive safely.

The study will involve measures of sleep length and measures of fatigue and sleepiness during periods of driving during a 4 – 5 day driving period. Data will also be collected during the 2 rest days before and after the driving period. Your sleep will be assessed using an Actigraph, which is a wristwatch device that records arm movements, over an 8 – 10 day period. It allows the study investigators to determine when you are awake or asleep during the study days. You will be asked to wear this device for the entire 8 – 10 days (apart from showering). During this entire 8 – 10 day period you will be asked to answer questions using a hand-held device, such as a PDA, upon awakening, before going to sleep, and at the beginning and end of each period of duty or rest day. The measures should take approximately, 2 – 5 minutes to complete each time. In addition, you will be requested to perform a 10-minute reaction time test twice a day. On work days, this reaction time test will be scheduled before and after your shift. On rest day, it will be scheduled in the 2 hours following and preceding your sleep period. Prior to the study start, you will be asked to complete 3 practice sessions on this test.

Step 2: Sleep Apnea Assessment and Treatment

During this step you will undergo an in-home diagnostic evaluation for sleep apnea. Sleep apnea is a focus of the diagnostic testing because the scientific literature shows that it is common among commercial drivers and that sleep apnea increases the risk of crashes. **All participants** must see a medical specialist for interpretation of the test results and additional investigation for sleep apnea and other sleep disorders such as narcolepsy. This physician will recommend appropriate treatment for any disorder that you are found to have. If sleep apnea is diagnosed, you will quickly be provided with appropriate therapy, such as nasal continuous positive airway pressure (by means of a mask worn during sleep) or a dental appliance worn during sleep. The results of your sleep study will be revealed to no one other than the medical sleep specialist who is bound by the usual patient-doctor confidentiality agreement. The physician will disclose the information to no one **unless there is a safety concern resulting from your failure to adhere to therapy or the physician has a legal duty to report your condition to the transportation or licensing authorities. In such a case the provincial/state authorities may be notified and you may be dropped from the study. Under no circumstances will the identifiable results of your sleep study or your response to sleep therapy be provided to your employer.**

The researchers will receive information about how many drivers were diagnosed with sleep disorders, those who start CPAP treatment, those who start oral appliance treatment, those who complete treatment, and mean hours of CPAP usage, but this information will be anonymous. Information about specific drivers will not be revealed to the researchers or to the company. They will be known only by a confidential participant identification number given to you at the start of the study. Furthermore, the researchers will receive no information regarding your response to or adherence to therapy unless there is a safety concern resulting from your failure to adhere to therapy. At the end of the study, the medical sleep specialist will send the researcher a list of results based on the anonymous participant numbers of all participants. The researchers will be given anonymous data about the group of participating drivers, but neither they, nor your employer will be informed of the results of your individual medical screening and/or your compliance to treatment.

Step 3: Educational Session on Fatigue Management

During this step participants will be asked to participate in four 1.5-hour sessions. The first session will focus on general fatigue management strategies. Additional modules will focus on

trip planning, wellness and lifestyle, and sleep and sleep disorders. At the end of each session, participants will be asked to complete an evaluation form. To assess how much participants have learned, participants will be asked to compete a questionnaire about fatigue before participating in the educational sessions, and then again after completing all the sessions. Participants will use their confidential participant number when completing their evaluations and fatigue questionnaire so that their data can remain anonymous. Under no circumstances will your evaluations or questionnaires be provided to your employer.

Step 4: After Fatigue Management Education Program

This step is identical to Step 1. As in Step 1, your sleep will be assessed using an Actigraph over approximately 8 – 10 days. As in Step 1, you will be asked to drive your normal revenue-generating route for a minimum of 4 – 5 days during that 8 – 10 day period. You will use the PDA to answer questions about fatigue and sleepiness. You will also be requested to perform the 10-minute reaction time test twice a day on rest and work days. As this step takes place after the educational sessions on fatigue management sessions, it will allow researchers to compare the data collected before and after the FMP, to determine if it was beneficial.

RISKS

There are no serious anticipated risks with this study because the driving that you will be doing will be normal operational driving for you. You will not be asked to operate outside of your normal driving schedules or outside of the driving regulations in the jurisdiction that you are driving. None of the testing procedures carry any inherent risk or interfere with your ability to operate the vehicle. The PDA device is not to be operated while you are driving your vehicle, only when it is parked.

We made every effort to identify any possible risk. However, **t**here may be unknown risks of participating in this study. Any new information that the researchers become aware of and that might influence your risk as a research subject or your decision to remain in the study will be conveyed to you.

In the unlikely event that an incident or accident occurs during this study, information gathered about your fatigue and performance levels will be kept confidential unless otherwise required under law. There is a risk that these research records could be subpoenaed under law.

BENEFITS

You and your company may benefit by participating in this study as you will be educated about fatigue as well as receiving screening for sleep apnea and other sleep disorders. If you are diagnosed with sleep apnea you will be provided with treatment. The standard treatment for sleep apnea is continuous positive airway pressure (CPAP). This is a mask applied to the nose which is connected to a bedside air pressure generator. This treatment has no ill affects and is completely effective when used. If nasal CPAP is recommended by the medical sleep specialist, you will be provided this free of charge. An alternative treatment (if you have mild or moderate sleep apnea) is a dental appliance. You wear a device when you sleep. This appliance covers all your teeth and pulls the jaw forward. It is not completely effective in all patients. The benefits resulting from treatment of sleep apnea include improved well-being, reduced fatigue and better performance. If you have sleep apnea, treatment reduces the risk of an accident in addition to improving energy and well being. The treatment may also reduce the possibility of a stroke or a heart attack.

Your company will benefit by participating in this study as management will be assisted in implementing FMP programs, which should assist in reducing fatigue experienced by drivers. In addition, the results may advance our understanding of fatigue and may influence future policy decisions.

CONFIDENTIALITY

All information obtained during the study, including the information listed in the Physician Letter, will be held in strict confidence unless required by law. No information will be released to the company, sponsor or any regulatory authority, including the Research Ethics Board, unless all identifying information is removed. No names or identifying information will be used in any publication or presentations. By signing this consent form, you are giving your permission for your information to be inspected.

PARTICIPANT RIGHTS AND RESPONSIBILITIES

The following section summarizes your rights and responsibilities.

I understand that I am to:

- Give correct information about my driving history over the past 3 years and my age
- Give a photocopy of my valid driver's licence for use for proof of age and licensing to drive
- Drive in a safe manner at all times
- Never use the PDA to answer questions or perform a reaction time test when I am driving my vehicle, only when parked
- Answer questions about fatigue and alertness to the best of my ability
- Perform the reaction time test to the best of my ability
- Comply with treatment if diagnosed with sleep apnea or other sleep disorder

I understand the following are my rights:

- My participation is entirely voluntary and I am free to discontinue the study at any time and for any reason.
- I can ask questions about my participation at any time in the study before or after I sign this agreement
- I can be asked to leave the study if the researcher believes it is in my best interest, or if I fail to cooperate with requirements and procedures
- If I leave the study before completion I will receive a stipend prorated according to time spent
- I will be told beforehand about changes to the conditions of the study, and will be given the opportunity to either withdraw or sign a revised informed consent form
- My name will appear only in restricted confidential files, stored in a locked file at Site Name and a participant number will be used for all other purposes, including all reports and publications
- My identity will not be revealed unless mandated by law or demanded by ethical considerations **(e.g., you are diagnosed with severe sleep apnea and refuse to comply with treatment, in which case the treating physician may have the legal duty to report you to the licensing authorities as a safety risk and to the investigator who will drop you from the study)**

- I will receive a signed copy of this consent form

PARTICIPATION

Your participation in this study is voluntary. You can choose not to participate or you may withdraw at any time without affecting your status as a driver. If you choose to withdraw from the study, you do not have to provide a reason for that decision. Furthermore, the researchers reserve the right to drop any participant at any time but their reason(s) will not be made known to your employer.

COMPENSATION

You will receive a stipend of C$350 to acknowledge your involvement and efforts during each data collection step (i.e., Step 1 and Step 4) for a total of C$700. You will also be provided with a stipend of C$300 for participating in sleep apnea/disorders diagnostic testing.

QUESTIONS

If you have any questions about the study, please call **Dr. Investigator** at **phone number**. If you have any questions about your rights as a research subject, please call **Dr. Ethics Head** who is the Chair of the Ethics Board who reviewed this study at **phone number**. This person is not involved in the study.

CONSENT

I have had the opportunity to review and discuss this study and my questions have been answered to my satisfaction. I consent to take part in the study with the understanding I may withdraw at any time without affecting my status with the company or as a driver. I have received a signed copy of this consent form. I voluntarily consent to participate in this study.

Subject's Name (Please Print)	Signature	Date

I confirm that I have explained the nature and purpose of the study to the subject named above. I have answered all questions to be best of my ability.

Name of Person Obtaining Consent	Signature	Date

APPENDIX D

GENERAL HISTORY QUESTIONNAIRE

Subject #: _____

Effects of a Fatigue Management Program on Fatigue in the Commercial Motor Vehicle Industry

This Questionnaire is part of a multi-phase study designed to investigate the effectiveness of a fatigue management program in commercial motor vehicle operations. Your answers provide important information concerning experiences within the industry.

Please read and answer each question carefully.

All answers are completely confidential and will be seen only by members of the research team.

Your time and cooperation in filling out this questionnaire is greatly appreciated.

GENERAL INFORMATION

1. Age: _____

2. Gender: Male ❒ Female ❒

3. Height: _____ (❒cm / ❒inches) Weight: _____(❒kg / ❒lbs.)

4. a. How many **years** have you been a commercial driver? _____

   b. How many **years** have you been driving for this company? _____

5. Type of route schedule: Variable ❒ Fixed ❒

6. Are you working the same hours day-to-day or do they change?

   Same hours ❒ Hours change ❒

7. How many years have you been doing this type of schedule? _____ years)

8. Do you drive/work mainly during:

   Day ❒ Night ❒ A Combination ❒

9. Primary type of operation you currently perform (Check all that apply):

   Bus ❒ Tanker ❒ Reefer ❒ Dry Van ❒ Flatbed ❒

   Hazardous Materials ❒ Load/Unload ❒ Other ❒ _____ (specify)

10. How far did you continue with formal education?

    Some high school ❒ Grade 12 diploma ❒ Some college ❒

    University degree ❒ Technical school ❒ Other ❒ _____ (specify)

MEDICAL INFORMATION

1. a. Do you take any prescription or non-prescription medication on a regular basis?

Yes ❒ No ❒

b. If yes, please fill in the table:

Type of Medication	Medical Condition

2. a. Do you have any other medical problems on an ongoing basis?

(i.e. high blood pressure, epilepsy, diabetes)?

Yes ❒ No ❒

b. If yes, please describe: _____

_____

_____

3. a. Do you routinely take on the road with you any prescription or non-prescription medications (i.e. caffeine pills, sleeping pills, aspirin, natural alternatives/herbal remedies)?

Yes ❒ No ❒

b. If yes, please list what type(s): _____

_____

_____

4. a. Do you currently smoke cigarettes? Yes ❒ No ❒

b. If yes, how many cigarettes do you smoke on average per day?_____

c. If no, have you ever smoked? Yes ❒ No ❒

d. If yes, how long ago did you quit _____(years)

5. Do you drink caffeinated drinks? Yes ❒ No ❒

6. How often do you drink alcohol?

Daily ❒ Several times a week ❒ Weekly ❒ Rarely ❒ Never ❒

SCHEDULING AND SLEEP

1. What hours are you ***commonly*** working? (Please use the 24-hour clock)

   (i) From: _____ To: _____ (ii) From:_____ To:_____ (iii) From:_____ To:_____

2. Given your most common schedule, what time do you consider the ***beginning*** of the day?

   _____
   (Use the 24-hour clock)

3. In a typical 24 hour period how many sleep periods (sleeps greater than 1.5 hours) do you take while on a route?

   No sleep periods ❒ 1 sleep period ❒
   2 sleep periods ❒ 3 or more sleep periods ❒

4. a. When do you like taking your major sleep period?

   Before a duty period ❒
   Right before the second duty period ❒
   As soon as I get home ❒

   b. Why do you prefer sleeping at this time?: _____

5. Where do you spend your main sleep period?

   At home ❒ Motel ❒ Sleeper berth ❒ Other ❒ _____(specify)

6. a. In a typical 24-hour period how many naps do you take? _____

   b. On average, how long do you nap? _____(in minutes)

	Worse			**Same**			**Much better**
7. Please rate your sleep in a berth compared to that at home.	❒	❒	❒	❒	❒	❒	❒

	Too little			**Just right**			**Too much**
8. How much sleep do you feel you get?	❒	❒	❒	❒	❒	❒	❒

	Much less			**Same**			**Much more**
9. Do you find daytime sleeping as restful as nighttime sleeping?	❒	❒	❒	❒	❒	❒	❒

	Much less			Same			Much more
10. Have you found it more difficult to cope with driving schedules as you have grown older?	❒	❒	❒	❒	❒	❒	❒

	More morning			Neutral			More Evg.
11. One hears about "morning" and "evening" types of people. Which one of these types do you consider yourself to be?	❒	❒	❒	❒	❒	❒	❒

	Never						Always
12. When you are slowed down by driving conditions, how often do you get less sleep in order to keep up with your delivery schedules?	❒	❒	❒	❒	❒	❒	❒

	Less Alert			No change			Alert longer
13. When you are required to do physical tasks related to your driving, such as loading, unloading or putting on tire chains, how does this affect your alertness on the road? Are you:	❒	❒	❒	❒	❒	❒	❒

	Less Alert			No change			Alert longer
14. How do long waits (due to road closures or loads not ready) affect your alertness on the road? Are you:	❒	❒	❒	❒	❒	❒	❒

15. a. In normal situations, how many hours do you like to drive before stopping for a break? _____ (in hours)

    b. In normal situations, how long is your usual stop? _____ (in hours)

SLEEP AND WELL-BEING INFORMATION SECTION

How often do you?

	Never		Sometimes		Always
1. Feel fit and healthy	❒	❒	❒	❒	❒
2. Fall asleep easily	❒	❒	❒	❒	❒
3. Wake up easily	❒	❒	❒	❒	❒
4. Sleep well through the night	❒	❒	❒	❒	❒
5. Feel moody or grumpy	❒	❒	❒	❒	❒
6. Feel tired and drained of energy	❒	❒	❒	❒	❒
7. Suffer from constipation or diarrhoea	❒	❒	❒	❒	❒
8. Feel your heart racing or skipping	❒	❒	❒	❒	❒
9. Have headaches	❒	❒	❒	❒	❒
10. Momentarily freeze on the job when you are extremely tired	❒	❒	❒	❒	❒
11. Find your appetite disturbed	❒	❒	❒	❒	❒
12. Suffer from heartburn, indigestion, stomach ache	❒	❒	❒	❒	❒
13. Feel nauseous	❒	❒	❒	❒	❒
14. Feel dizzy	❒	❒	❒	❒	❒
15. Feel dissatisfied with your sex life	❒	❒	❒	❒	❒
16. Engage in regular physical activity	❒	❒	❒	❒	❒
17. Experience lapses in your attention	❒	❒	❒	❒	❒
18. Eat 3 nutritious meals a day	❒	❒	❒	❒	❒

I am satisfied with…

	Strongly agree				Strongly disagree
19. The kind of work I do (commercial driving)	❒	❒	❒	❒	❒
20. The job as a whole	❒	❒	❒	❒	❒
21. The shift cycle I drive (i.e., days-on, days-off)	❒	❒	❒	❒	❒
22. The schedule I drive (i.e., daily time of work)	❒	❒	❒	❒	❒

COPING WITH SHIFTWORK

People use different methods to cope with fatigue and trucking. Which of the following methods do you use?

To help cope with fatigue I…

	Never		Sometimes		Always
1. Try to get an adequate amount of sleep daily	❒	❒	❒	❒	❒
2. Nap to catch up on sleep at home	❒	❒	❒	❒	❒
3. Nap on breaks	❒	❒	❒	❒	❒
4. Take a short walk to get some fresh air	❒	❒	❒	❒	❒
5. Drink water at work when I am tired	❒	❒	❒	❒	❒
6. Drink coffee, tea or cola to perk me up	❒	❒	❒	❒	❒
7. Have a smoke when I feel tired	❒	❒	❒	❒	❒
8. Exercise regularly	❒	❒	❒	❒	❒
9. Avoid alcohol	❒	❒	❒	❒	❒
10. Eat nutritiously	❒	❒	❒	❒	❒
11. Take vitamins, health supplements etc	❒	❒	❒	❒	❒
12. Read in bed to fall asleep	❒	❒	❒	❒	❒
13. Keep my bedroom very dark while I sleep	❒	❒	❒	❒	❒
14. Take a hot shower or bath	❒	❒	❒	❒	❒
15. Tell my spouse or partner (and/or family) to keep quiet while I sleep	❒	❒	❒	❒	❒
16. Drink alcoholic beverages to fall asleep	❒	❒	❒	❒	❒
17. Perform relaxation exercises or yoga	❒	❒	❒	❒	❒
18. Engage in sexual activity	❒	❒	❒	❒	❒
19. Try to avoid working overtime	❒	❒	❒	❒	❒
20. Have a smoke to relax	❒	❒	❒	❒	❒
21. Watch TV to relax	❒	❒	❒	❒	❒
22. Take some time to just be alone	❒	❒	❒	❒	❒
23. Plan my time carefully	❒	❒	❒	❒	❒
24. Spend time with my spouse and/or family	❒	❒	❒	❒	❒

FATIGUE AND ALERTNESS

	Very Low	Low	Average	High	Very high
1. How *physically* demanding is your work?	❒	❒	❒	❒	❒
2. How *mentally* demanding is your work?	❒	❒	❒	❒	❒
3. How *stressful* is your work?	❒	❒	❒	❒	❒
4. How *boring* is your work?	❒	❒	❒	❒	❒
5. How *fatiguing* is your work?	❒	❒	❒	❒	❒

	5 or less hours	5 hours	6 hours	7 hours	8 or more hours
6. How many hours of sleep per day do you feel you *need* to feel alert and well rested?	❒	❒	❒	❒	❒
7. How many hours of sleep per day on average are you *actually getting* on days that you work?	❒	❒	❒	❒	❒
8. How many hours of sleep on average are you actually getting on your *days off*?	❒	❒	❒	❒	❒

	Never	Seldom	Sometimes	Frequently	Very Frequently
9. How frequently do you use *stimulants* (caffeine, nicotine, etc.) to help yourself stay awake and mentally alert?	❒	❒	❒	❒	❒
10. How frequently do you use *sleeping pills* to help yourself fall asleep?	❒	❒	❒	❒	❒
11. How frequently do you use *alcoholic beverages* to help yourself fall asleep?	❒	❒	❒	❒	❒
12. How often are you fatigued to the point that you drift into sleep while working?	❒	❒	❒	❒	❒
13. How often has fatigue caused you to be absent from work in the past year?	❒	❒	❒	❒	❒
14. Do you generally have trouble falling asleep?	❒	❒	❒	❒	❒
15. Are you a sound sleeper? (Once you fall asleep, you generally stay in deep sleep until it's time to get up)	❒	❒	❒	❒	❒

	Never	Seldom	Sometimes	Frequently	Very Frequently
16. Do you find it easy to get good sleep during the daytime hours?	❒	❒	❒	❒	❒
17. Do you feel your current schedule is making you overly tired or fatigued?	❒	❒	❒	❒	❒
18. If yes, does this fatigue make you frequently feel drowsy while working?	❒	❒	❒	❒	❒
19. Do you feel any need for increased alertness on the job (i.e., feeling more mentally sharp and energetic vs. drowsy or sluggish)?	❒	❒	❒	❒	❒

	Never	Several times a year	Several times per month	Several times per week	Once or more per shift
20. How often do you feel that your alertness is impaired to the point where you are not mentally effective while working?	❒	❒	❒	❒	❒
21. How often do you feel *physically* fatigued to the point where you are not physically or mentally effective while working?	❒	❒	❒	❒	❒
22. How often do you become irritable while working?	❒	❒	❒	❒	❒
23. How often do you make mistakes or mental errors while working?	❒	❒	❒	❒	❒

	Never	Seldom	Don't know	Often	Almost always
24. Do you feel tired when you wake up?	❒	❒	❒	❒	❒

	None	One or two	Three or four	Five or six	Seven or more
25. How many times in the past year have you briefly nodded off or fallen asleep while driving to or from work?	❒	❒	❒	❒	❒
26 How many motor vehicle accidents or near-accidents did you have in the past year?	❒	❒	❒	❒	❒

	1-17	18-20	21-23	24-26	27 or more
27. During the last two weeks that you worked, what was the longest number of hours you went without sleep?	❒	❒	❒	❒	❒

	Does not apply	No problem	Slight problem	Moderate problem	Major problem
28. How much of a problem is being "too tired" to do anything with your family?	❒	❒	❒	❒	❒

	Almost never	Quite seldom	Don't know	Quite often	Almost always
29. How often is your appetite disturbed?	❒	❒	❒	❒	❒

FAMILY, PARTNERS, FRIENDS

	Living alone	Shared accommodation	Living with partner	Living with family
1. Living status	❒	❒	❒	❒

	Yes	No	N/A
2. Do you have any children in the household?	❒	❒	❒
3. If yes, are any children 6 years old or younger?	❒	❒	❒
4. Do you feel that fatigue due to your work schedule or your schedule in general, has affected your family life?	❒	❒	❒
5. Do you feel the need to sacrifice some sleep time in order to spend more time with your family or friends?	❒	❒	❒

QUALITY OF LIFE

Please answer every question. Some questions look like others, but each one is different. Please take the time to read and answer each question carefully by marking the box that best represents your response

	Excellent	Very good	Good	Fair	Poor
1. In general, would you say your health is:	❒	❒	❒	❒	❒

2. The following items are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

	Yes, Limited a Lot	Yes, Limited a Little	No, Not Limited at All
a. **Moderate activities**, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf	❒	❒	❒
b. Climbing **several** flights of stairs	❒	❒	❒

3. During the **past 4 weeks**, have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

	Yes	No
a. **Accomplished less** than you would like	❒	❒
b. Were limited in the **kind** of work or other activities	❒	❒

4. During the **past 4 weeks**, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

	Yes	No
a. **Accomplished less** than you would like	❒	❒
b. Didn't do work or other activities as **carefully** as usual	❒	❒

	Not at all	A little bit	Moderately	Quite a bit	Extremely
5. During the **past 4 weeks**, how much did pain interfere with your normal work (including both work outside the home and housework)?	❒	❒	❒	❒	❒

6. These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the **past 4 weeks…**

	All of the Time	Most of the Time	A Good Bit of the Time	Some of the Time	A Little of the Time	None of the Time
a. Have felt calm and peaceful?	❒	❒	❒	❒	❒	❒
b. Did you have a lot of energy?	❒	❒	❒	❒	❒	❒
c. Have you felt downhearted and blue?	❒	❒	❒	❒	❒	❒

	All of the Time	Most of the Time	Some of the Time	A Little of the Time	None of the Time
7. During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting your friends, relatives, etc.)?	❒	❒	❒	❒	❒

SATISFACTION

	None		Some		A Lot
1. What do you feel is your current level of knowledge on fatigue and fatigue management?	❒	❒	❒	❒	❒

2.	Not at all		Some-what		A lot
a. Generally, how much do you think **drivers** could benefit from a fatigue management program?	❒	❒	❒	❒	❒
b. Specifically, how much could **you** benefit from participation in a fatigue management program?	❒	❒	❒	❒	❒
c. How much do you think **your family** could benefit from information on fatigue and living with a shift worker countermeasures?	❒	❒	❒	❒	❒

3.	None		Some		A Lot
a. Rate your typical level of fatigue:	❒	❒	❒	❒	❒

	Very Poorly				Very Effectively
b. How effectively do you deal with fatigue?	❒	❒	❒	❒	❒

APPENDIX E

PARTNER SATISFACTION SURVEY FOR FAMILY MEMBERS

Subject #: _____

Effects of a Fatigue Management Program on Fatigue in the Commercial Motor Vehicle Industry

This Questionnaire is part of a multi-phase study designed to investigate the effectiveness of a fatigue management program in commercial motor vehicle operations. Your answers provide important information concerning experiences within the industry.

Please read and answer each question carefully.

All answers are completely confidential and will be seen only by members of the research team

Your time and cooperation in filling out this questionnaire is greatly appreciated.

A "partner" can be anyone who would have enough information and interaction with you to answer the following questions. Some examples are: wife, husband, common-law partner, girlfriend, boyfriend, son, daughter, roommate, mother, father etc.

Due to the variety of relationships mentioned above, not all questions will apply. If a question does not apply or if you do not wish to supply an answer then skip the question.

	Low			Medium			High
1. Please rate your knowledge about the underlying effects of fatigue on the commercial motor driver	❒	❒	❒	❒	❒	❒	❒
2. Rate the level of fatigue you see typically in your partner	❒	❒	❒	❒	❒	❒	❒

3. a. Have you ever found family life to be difficult as a result of your partner's job as a truck driver?

Yes ❒ No ❒

a. If yes, please describe these difficult times and why you felt that they were difficult) i.e. beginning of relationship, childcare problems, etc.): _____

_____

_____

_____

4. How has the schedule of being a truck driver affected your partner in the following areas:

	Most affected		Neutral		Least affected	Not applicable
a. Love life/sexual relationship	❒	❒	❒	❒	❒	❒
b. Interaction with children	❒	❒	❒	❒	❒	❒
c. Day to day chores	❒	❒	❒	❒	❒	❒
d. Social activities	❒	❒	❒	❒	❒	❒
e. Interaction as a family or with other family member	❒	❒	❒	❒	❒	❒

5. How has fatigue affected your partner's life in the following areas:

	Most affected		Neutral		Least affected	Not applicable
a. Love life/sexual relationship	❒	❒	❒	❒	❒	❒
b. Interaction with children	❒	❒	❒	❒	❒	❒
c. Day to day chores	❒	❒	❒	❒	❒	❒
d. Social activities	❒	❒	❒	❒	❒	❒
e. Interaction as a family or with other family member	❒	❒	❒	❒	❒	❒

	Very effectively			Neutral			Not effectively
6. How effectively does your partner deal with fatigue?	❒	❒	❒	❒	❒	❒	❒

	Very affected			Neutral			Not affected
7. How much does your partner's fatigue currently affect your relationship and family life?	❒	❒	❒	❒	❒	❒	❒

8. Do you feel that a fatigue management program would benefit?: (check all that apply)

Your partner in his/her job ❒ Yourself ❒

Your partner in his/her home-life ❒ Any children or family members ❒

9. Do you feel a fatigue management program would be very beneficial to:

	Very beneficial	Somewhat	Not beneficial
Your partner?	❒	❒	❒
To you and your family?	❒	❒	❒

No opinion/don't know ❒

10. Would you be interested in learning more about fatigue management and family life?

Yes ❒ No ❒

11. Which would be the best media for providing information to you/and or your family?

Pamphlets ❒ Books ❒ Videos ❒ Discussion groups ❒

Presentation geared to partners and/or families ❒ Other ❒ _____(specify)

Thank you for your assistance in completing this survey.

ALERTNESS SOLUTIONS

APPENDIX F

FATIGUE MANAGEMENT ASSESSMENT

ALERTNESS MANAGEMENT SAFETY EVALUATION: PRE-FMP

ALERTNESS SOLUTIONS

Subject #: _____

Effects of a Fatigue Management Program on Fatigue in the Commercial Motor Vehicle Industry

This Questionnaire is part of a multi-phase study designed to investigate the effectiveness of a fatigue management program in commercial motor vehicle operations. Your answers provide important information concerning experiences within the industry.

Please read and answer each question carefully.

All answers are completely confidential and will be seen only by members of the research team

Your time and cooperation in filling out this questionnaire is greatly appreciated.

ALERTNESS MANAGEMENT SAFETY EVALUATION: PRE-FMP

Ongoing evaluations of a trucking company's practices, policies, and procedures can help to maintain the highest standards of safety. Like other common safety considerations, alertness management activities contribute to the safety of operations, and therefore should be included in periodic safety evaluations. This Alertness Management Safety Evaluation was created to provide information about specific alertness management strategies relevant to activities in your trucking company. This evaluation addresses five main areas of alertness management.

A.	EDUCATION	YES	NO
1.	Are drivers provided training about fatigue, including the physiological causes and effects, and safety-related risks?	❒	❒
2.	Are others who affect overall safety (e.g., schedulers, management, dispatchers) provided training on these issues?	❒	❒
3.	Is there a method to assess the effectiveness of training activities (e.g., pre-post-training quizzes)?	❒	❒
4.	Is there a mechanism to determine whether the training information used is scientifically valid and current?	❒	❒
Education Totals		____	____

B.	ALERTNESS STRATEGIES	YES	NO
5.	Are drivers and other personnel provided training on alertness strategies?	❒	❒
6.	Are there clear written policies regarding the use of alertness strategies?	❒	❒
7.	Are there explicit written policies regarding on-duty rest opportunities?	❒	❒
8.	Not including your sleeper berth, are there facilities to support workplace rest opportunities (e.g., break room that can be made quiet and dark to take a nap after a duty period, prior to your drive home)?	❒	❒

B.	ALERTNESS STRATEGIES (cont'd.)	YES	NO
9.	Is there a process for evaluating the scientific validity, effectiveness, and safety of alertness strategies *before implementing them?*	❒	❒
10.	*Once in use*, is there a process for evaluating the scientific validity, effectiveness, and safety of alertness strategies?	❒	❒
Alertness Strategies Totals		____	____

C.	SCHEDULING	YES	NO
11.	Do scheduling practices *for all personnel* explicitly address fatigue issues based on information from scientifically valid resources?	❒	❒
12.	Are there written organizational policies, besides the federal regulations, regarding basic work/rest parameters for all personnel (i.e., minimum duration of off-periods, maximum work time, maximum number of consecutive work periods, and recovery time between work cycles)?	❒	❒
13.	Is there an explicit written procedure that is used for exceptions to these policies?	❒	❒
Scheduling Totals		____	____

D.	HEALTHY SLEEP	YES	NO
14.	Is information offered to drivers and other personnel about sleep disorders, how to recognize sleep disorders, and how to get help if they suspect they have a sleep disorder?	❒	❒
15.	Is there a written policy that addresses diagnosis, treatment, and continued duty status of personnel with possible sleep disorders?	❒	❒
Healthy Sleep Totals		____	____

E.	ORGANIZATIONAL	YES	NO
16.	Does your organization have an integrated alertness management program that includes education, alertness strategies, scheduling, and healthy sleep?	❒	❒
17.	Is there an individual identified to coordinate alertness management activities?	❒	❒
18.	Are alertness management activities ongoing (as opposed to, for example, a one-time training)?	❒	❒
19.	Is management involved in alertness management activities and policy development?	❒	❒
20.	Are alertness management activities integrated into the regular practices of the organization, such as safety programs, recurrent training, and standard procedures?	❒	❒
Organizational Totals		____	____

Thank you for your assistance in completing this survey.

APPENDIX F

FATIGUE MANAGEMENT ASSESSMENT

ALERTNESS MANAGEMENT SAFETY EVALUATION: POST-FMP

ALERTNESS SOLUTIONS

Subject #: _____

Effects of a Fatigue Management Program on Fatigue in the Commercial Motor Vehicle Industry

This Questionnaire is part of a multi-phase study designed to investigate the effectiveness of a fatigue management program in commercial motor vehicle operations. Your answers provide important information concerning experiences within the industry.

Please read and answer each question carefully.

All answers are completely confidential and will be seen only by members of the research team

Your time and cooperation in filling out this questionnaire is greatly appreciated.

ALERTNESS MANAGEMENT SAFETY EVALUATION: POST-FMP

Ongoing evaluations of a trucking company's practices, policies, and procedures can help to maintain the highest standards of safety. Like other common safety considerations, alertness management activities contribute to the safety of operations, and therefore should be included in periodic safety evaluations. This Alertness Management Safety Evaluation was created to provide information about specific alertness management strategies relevant to activities in your trucking company. This evaluation addresses five main areas of alertness management.

A.	EDUCATION	YES	NO
1.	Are drivers provided training about fatigue, including the physiological causes and effects, and safety-related risks?	❒	❒
2.	Are others who affect overall safety (e.g., schedulers, management, dispatchers) provided training on these issues?	❒	❒
3.	Is there a method to assess the effectiveness of training activities (e.g., pre-post-training quizzes)?	❒	❒
4.	Is there a mechanism to determine whether the training information used is scientifically valid and current?	❒	❒
Education Totals		____	____

B.	ALERTNESS STRATEGIES	YES	NO
5.	Are drivers and other personnel provided training on alertness strategies?	❒	❒
6.	Are there clear written policies regarding the use of alertness strategies?	❒	❒
7.	Are there explicit written policies regarding on-duty rest opportunities?	❒	❒
8.	Not including your sleeper berth, are there facilities to support workplace rest opportunities (e.g., break room that can be made quiet and dark to take a nap after a duty period, prior to your drive home)?	❒	❒

B.	ALERTNESS STRATEGIES (cont'd.)	YES	NO
9.	Is there a process for evaluating the scientific validity, effectiveness, and safety of alertness strategies *before implementing them?*	❒	❒
10.	*Once in use*, is there a process for evaluating the scientific validity, effectiveness, and safety of alertness strategies?	❒	❒
Alertness Strategies Totals		____	____

C.	SCHEDULING	YES	NO
11.	Do scheduling practices *for all personnel* explicitly address fatigue issues based on information from scientifically valid resources?	❒	❒
12.	Are there written organizational policies, besides the federal regulations, regarding basic work/rest parameters for all personnel (i.e., minimum duration of off-periods, maximum work time, maximum number of consecutive work periods, and recovery time between work cycles)?	❒	❒
13.	Is there an explicit written procedure that is used for exceptions to these policies?	❒	❒
Scheduling Totals		____	____

D.	HEALTHY SLEEP	YES	NO
14.	Is information offered to drivers and other personnel about sleep disorders, how to recognize sleep disorders, and how to get help if they suspect they have a sleep disorder?	❒	❒
15.	Is there a written policy that addresses diagnosis, treatment, and continued duty status of personnel with possible sleep disorders?	❒	❒
Healthy Sleep Totals		____	____

E.	ORGANIZATIONAL	YES	NO
16.	Does your organization have an integrated alertness management program that includes education, alertness strategies, scheduling, and healthy sleep?	❒	❒
17.	Is there an individual identified to coordinate alertness management activities?	❒	❒
18.	Are alertness management activities ongoing (as opposed to, for example, a one-time training)?	❒	❒
19.	Is management involved in alertness management activities and policy development?	❒	❒
20.	Are alertness management activities integrated into the regular practices of the organization, such as safety programs, recurrent training, and standard procedures?	❒	❒
Organizational Totals		____	____

21. Does your organization use any fatigue management technologies (e.g., lane tracker, on-line drowsiness device, etc.) as part of an overall FMP? ____ yes ____ no

a. If yes, what is the name of the device and how long has it been in use?

_____

_____

b. Tell us about your experience with the device (e.g., how it is used, its effectiveness, difficulties encountered, plans for expansion).

_____

_____

_____

_____

22. What do you think were the **most effective** aspects of the FMP and why?

_____

_____

_____

_____

_____

_____

23. What do you think were the **least effective** aspects of the FMP and why?

_____

_____

_____

_____

_____

_____

24. What suggestions to have to change the FMP?

_____

_____

ALERTNESS SOLUTIONS

_____

_____

_____

_____

25. Please rate how much you believe each of the following FMP elements affected **your organization**.

a) Educational activities

Extremely negative				No effect			Extremely positive		N/A
1	2	3	4	5	6	7	8	9	

b) Scheduling/dispatch guidance

Extremely negative				No effect			Extremely positive		N/A
1	2	3	4	5	6	7	8	9	

c) Diagnosis and treatment of sleep apnea

Extremely negative				No effect			Extremely positive		N/A
1	2	3	4	5	6	7	8	9	

d) Evaluation of corporate and field data

Extremely negative				No effect			Extremely positive		N/A
1	2	3	4	5	6	7	8	9	

26. Please rate how much you believe each of the following FMP elements affected **you as an individual**.

a) Educational activities

Extremely negative				No effect			Extremely positive		N/A
1	2	3	4	5	6	7	8	9	

b) Scheduling/dispatch guidance

Extremely negative				No effect			Extremely positive		N/A
1	2	3	4	5	6	7	8	9	

c) Diagnosis and treatment of sleep apnea

Extremely negative				No effect			Extremely positive		N/A
1	2	3	4	5	6	7	8	9	

d) Evaluation of corporate and field data

Extremely negative				No effect			Extremely positive		N/A
1	2	3	4	5	6	7	8	9	

27. Please provide any other comments you believe would be helpful to the project.

_____

_____

_____

_____

_____

_____

Thank you for your assistance in completing this survey.

APPENDIX G

EDUCATIONAL QUIZZES

Subject #:_____ **Date:** _____

CORE MODULE

Please check one correct answer for each question: a), b), c), or d).

1. The goals of this fatigue management program are
    a) To influence drivers to obtain adequate rest
    b) To educate dispatchers about sleep science relevant to scheduling practices
    c) To influence shippers and receivers to avoid unreasonable schedule demands
    d) All of the above

2. The estimated percent of heavy truck accidents involving fatigue is:
    a) 5 – 10%
    b) 15 – 20%
    c) 30 – 40%
    d) Over 50%

3. Which of the following statements is true?
    a) Time of day has a bigger effect on fatigue than time on duty
    b) Sleep length has a bigger effect on fatigue than does sleep quality
    c) Regular schedules are just as likely to produce fatigue as regular ones
    d) None of the above

4. The longest sleep is obtained if you go to bed at:
    a) Midnight
    b) 6:00 a.m.
    c) Noon
    d) 6:00 p.m.

5. Driving at night and sleeping during the day can result in:
    a) Increased sleepiness and fatigue
    b) Lower mental alertness
    c) Interrupted sleep
    d) All of the above

6. Being awake for 20 to 25 hours has been shown to be equal to a blood alcohol level of:
    a) 0.05%
    b) 0.10%
    c) 0.15%
    d) >0.15%

7. Hours of service regulations:
    a) Are all that is needed to manage fatigue
    b) Fail to consider time-of-day effects
    c) Consider quality and quantity of rest
    d) All of the above

8. Single-vehicle accidents are most likely to occur:
    a) 2:00 – 4:00 a.m.
    b) 7:00 – 9:00 a.m.
    c) 2:00 – 4:00 p.m.
    d) 10:00 p.m. – midnight

CORRECT ANSWERS

Question #	Answer
1	d)
2	c)
3	a)
4	a)
5	d)
6	b)
7	b)
8	a)

Subject #:_____ **Date: _____**

TRIP PLANNING KNOWLEDGE ASSESSMENT

Please check one correct answer for each question: a), b), c), or d).

1. The best times to plan a nap are:
   a) Between midnight and 6:00 a.m. and between 1:00 p.m. and 4:00 p.m.
   b) Between 10:00 a.m. and noon and between 7:00 p.m. and 10:00 p.m.
   c) Between 6:00 a.m. and 10:00 a.m. and between 6:00 p.m. and 10:00 p.m.
   d) None of the above

2. Concerning the recovery period:
   a) The recovery period should be longer after night shifts than after day shifts
   b) The recovery period should be longer when working irregular schedules
   c) The recovery period should be longer after working more shifts in a row
   d) All of the above

3. Concerning your level of alertness:
   a) How alert you feel at the beginning of a shift is a good indicator of your fitness for duty.
   b) How much you slept in the prior day affects your level of alertness
   c) We are usually good judges of our level of alertness
   d) All of the above

4. Concerning your ability to sleep:
   a) If the last time you slept was 12 hours ago, you will fall asleep more rapidly at 6:00 a.m. than at 10:00 p.m.
   b) You will sleep less if you go to bed at 6:00 a.m. than at 10:00 p.m.
   c) You will accumulate a sleep debt if you go to bed at 6:00 a.m. several days in a row
   d) All of the above

5. Concerning sleep inertia:
   a) Sleep inertia refers to the time it takes to fall asleep
   b) Sleep inertia is not affected by time of day
   c) Sleep inertia impairs your driving performance after a nap
   d) Sleep inertia last only a few seconds and is not a real concern when planning a trip

6. Concerning the time-of-day effect:
   a) People generally feel sluggish in the mid-afternoon and after midnight
   b) The longer you have been awake, the more adapted you are to the time-of-day effect
   c) You feel more alert at the end of an evening and it is always fine to accept a shift then
   d) Growing older make you more resistant to the time-of-day effect

7. Concerning amount of sleep:

    a) Most adults require between 7 and 8 hours of sleep on average for peak performance

    b) Night shift workers sleep an average of 1-3 hours less per day and their sleep is poorer in slow wave sleep than day shift workers

    c) Driving across 2 time zones eastward in the same day, can affect one's ability to fall asleep

    d) all of the above

8. Concerning amount of driving:

    a) Driving for more than 10 hours can result in drowsiness, short attention span, irritability, decreased concentration and memory

    b) When the above signs appear, you can fix it by stopping your truck, drinking a cup of coffee, and returning to the road to make your delivery on time

    c) If you feel alert, you can accept a shift, even though you have only slept 4 hours in the prior day

    d) You should never discuss a change in delivery time with dispatchers, even if you are tired

CORRECT ANSWERS

Question #	Answer
1	a)
2	d)
3	b)
4	d)
5	c)
6	a)
7	d)
8	a)

Subject #:_____ **Date: _____**

SLEEP AND SLEEP DISORDERS MODULE

Please check one correct answer for each question: a), b), c), or d).

1. Which of following statements is true regarding the stages of sleep?
    a) REM sleep refers to “Relaxed Eye Movements”
    b) Stages NREM 3 and 4 comprise deep sleep
    c) It is difficult for a person to be awakened from stages NREM 1 and 2 sleep
    d) All of the above

2. The amount of sleep required during each 24-hour day:
    a) Depends primarily on external light and dark cycles
    b) Ranges between a minimum 6 and a maximum of 10 hours for adults
    c) Is determined by your diet
    e) None of the above

3. Sleep debt:
    a) Can be reversed with caffeine
    b) Occurs only if daily sleep loss exceeds 60 minutes
    c) Refers to missed sleep that you needed but did not get
    d) a & c only

4. Sleep disorders:
    a) Are mainly due to worry or psychological problems
    b) Are dealt with easily
    c) Have various physiological or psychological causes
    d) Are usually only temporary

5. Which of the following statements is NOT true?
    a) Sleep disorders can reduce alertness and performance
    b) Sleep disorders affect millions of people
    c) Sleep disorders can affect mood, alertness and productivity
    d) Sleep disorders only affect unhealthy middle-aged men

6. Which of the following statements is NOT true?
    a) Insomnia is the inability to fall asleep or stay asleep
    b) Stress is the most common cause of short-term insomnia
    c) People with chronic forms of insomnia function normally during daytime
    d) Chronic insomnia occurs for at least one month

7. Sleep apnea describes:
    a) Movement of the eyes during sleep
    b) Pauses in breathing during sleep
    c) Excess movement of the legs during sleep
    d) The inability to maintain sleep throughout the night

8. Which of the following is NOT a treatment for sleep apnea?
    a) Medication
    b) Oral appliance
    c) Continuous positive airway pressure (CPAP)
    d) Surgery

CORRECT ANSWERS

Question #	Answer
1	b)
2	b)
3	c)
4	c)
5	d)
6	c)
7	b)
8	a)

Subject #:_____ **Date: _____**

WELLNESS AND LIFESTYLE

Please check one correct answer for each question: a), b), c), or d).

1. Obesity can contribute to sleep problems, which can lead to excessive fatigue during the day. To lose weight you need to:

   a) Eliminate ***all*** carbohydrates from your diet
   b) Eliminate ***all*** cholesterol from your diet
   c) Have your energy intake (the food you eat) be ***less*** than your energy output (physical activities)
   d) Have your energy intake (the food you eat) be ***more*** than your energy output (physical activities)

2. Physical fitness involves the performance of the heart and lungs, and the muscles of the body. Regular exercise will improve your:

   a) Quality of sleep
   b) Mood
   c) Job performance
   d) All of the above

3. Stress affects different people differently and may result in physical, mental, or emotional symptoms. Which of the following is an effective strategy for coping with stress?

   a) Using relaxation techniques
   b) Setting limits
   c) Stop smoking and limit caffeine
   d) All of the above

4. We always seem to find a reason why we can't exercise. Which of the following is a real road block to exercise?

   a) Lack of skills or facilities
   b) Lack of free time
   c) a & b
   d) None of the above

5. We might work more efficiently under a moderate amount of stress, whereas excessive stress can reduce performance. Which of the following is ***not*** true of too much stress? FIX

   a) It allows you to get all the sleep you need
   b) It raises your blood pressure
   c) It can affect your mood
   d) It can cause headaches

6. Exercise offers so many health benefits but for exercise to be successful and increase well being it:
    a) Must be done for 30 minutes or more at one time
    b) Must be done for 45 minutes or more at one time
    c) Can be done at short intervals over the course of the day
    d) None of the above

7. Even a small amount of weight loss (even 10% of your body weight) will help reduce the risk of obesity-related diseases. Which of the following also helps reduce these risks?
    a) Quitting smoking
    b) Limiting alcohol intake
    c) Asking for low-fat menu options on the road
    d) All of the above

8. Good eating habits, regular exercise, and stress management all improve sleep quality and daytime alertness. Which of the following is true:
    a) All good habits happen overnight
    b) A healthy lifestyle is a family affair
    c) If you miss one exercise opportunity, you might as well give up
    d) If you eat too much at one meal, you might as well give up

CORRECT ANSWERS

Question #	Answer
1	c)
2	d)
3	d)
4	a)
5	a)
6	c)
7	d)
8	b)

APPENDIX H

SLEEP APNEA SYNDROME (SAS) SCREENING TOOLS

EPWORTH SLEEPINESS SCALE

Subject #: _____

Effects of a Fatigue Management Program on Fatigue in the Commercial Motor Vehicle Industry

This Questionnaire is part of a multi-phase study designed to investigate the effectiveness of a fatigue management program in commercial motor vehicle operations. Your answers provide important information concerning experiences within the industry.

Please read and answer each question carefully.

All answers are completely confidential and will be seen only by members of the research team

Your time and cooperation in filling out this questionnaire is greatly appreciated.

EPWORTH SLEEPINESS SCALE

How likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired? This refers to your usual way of life in recent times. Even if you have not done some of these things recently try to work out how they would have affected you. Use the following scale to choose the most appropriate reaction for each situation.

SITUATION	CHANCE OF DOZING			
	Never	Slight	Moderate	High
Sitting and reading	0	1	2	3
Watching TV	0	1	2	3
Sitting, inactive in a public place (e.g., a theater or a meeting)	0	1	2	3
As a passenger in a car for an hour without a break	0	1	2	3
Lying down to rest in the afternoon when circumstances permit	0	1	2	3
Sitting and talking to someone	0	1	2	3
Sitting quietly after a lunch without alcohol	0	1	2	3
In a car, while stopped for a few minutes in traffic	0	1	2	3
TOTAL				

Thank you for your assistance in completing this survey.

APPENDIX I

SLEEP APNEA SYNDROME (SAS) SCREENING TOOLS

SLEEP APNEA QUALITY OF LIFE INDEX (SAQLI)

Subject #: _____

Effects of a Fatigue Management Program on Fatigue in the Commercial Motor Vehicle Industry

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Please read and answer each question carefully.

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SLEEP APNEA QUALITY OF LIFE INDEX (SAQLI)

We would like to understand the impact that sleep apnea and/or snoring have had on your daily activities, emotions, social interactions, and about symptoms that may have resulted.

1. How much have you had to push yourself to remain alert during a typical day (e.g. work, school, childcare, housework?)	❒ not at all ❒ a small amount ❒ a small to moderate amount ❒ a moderate amount ❒ a moderate to large amount ❒ a large amount ❒ a very large amount

2. How often have you had to use all your energy to accomplish your most important activity (e.g. work, school, childcare, housework?)	❒ never ❒ a small amount of the time ❒ a small to moderate amount of the time ❒ a moderate amount of the time ❒ a moderate to large amount of the time ❒ a large amount of the time ❒ a very large amount of the time

I

3. How much difficulty have you had finding the energy to do other activities (e.g. exercise, relaxing activities?)	❒ no difficulty ❒ a small amount ❒ a small to moderate amount ❒ a moderate amount ❒ a moderate to large amount ❒ a large amount ❒ a very large amount

4. How much difficulty have you had fighting to stay awake?	❒ no difficulty ❒ a small amount ❒ a small to moderate amount ❒ a moderate amount ❒ a moderate to large amount ❒ a large amount ❒ a very large amount

5. How much of a problem has it been to be told that your snoring is irritating?	❒ no problem ❒ a small problem ❒ a small to moderate problem ❒ a moderate problem ❒ a moderate to large problem ❒ a large problem ❒ a very large problem

6. How much of a problem have frequent conflicts or arguments been?	❒ no difficulty ❒ a small amount ❒ a small to moderate amount ❒ a moderate amount ❒ a moderate to large amount ❒ a large amount ❒ a very large amount

I

7. How often have you looked for excuses for being tired?	❒ never ❒ a small amount of the time ❒ a small to moderate amount of the time ❒ a moderate amount of the time ❒ a moderate to large amount of the time ❒ a large amount of the time ❒ a very large amount of the time

8. How often have you not wanted to do things with your family and/or friends?	❒ never ❒ a small amount of the time ❒ a small to moderate amount of the time ❒ a moderate amount of the time ❒ a moderate to large amount of the time ❒ a large amount of the time ❒ a very large amount of the time

9. How often have you felt depressed, down, or hopeless?	❒ never ❒ a small amount of the time ❒ a small to moderate amount of the time ❒ a moderate amount of the time ❒ a moderate to large amount of the time ❒ a large amount of the time ❒ a very large amount of the time

10. How often have you been impatient?	❒ never ❒ a small amount of the time ❒ a small to moderate amount of the time ❒ a moderate amount of the time ❒ a moderate to large amount of the time ❒ a large amount of the time ❒ a very large amount of the time

I

11. How much of a problem has it been to cope with everyday issues?	❒ no problem ❒ a small problem ❒ a small to moderate problem ❒ a moderate problem ❒ a moderate to large problem ❒ a large problem ❒ a very large problem

12. How much of a problem have you had with decreased energy?	❒ no problem ❒ a small problem ❒ a small to moderate problem ❒ a moderate problem ❒ a moderate to large problem ❒ a large problem ❒ a very large problem

13. How much of a problem have you had with fatigue?	❒ no problem ❒ a small problem ❒ a small to moderate problem ❒ a moderate problem ❒ a moderate to large problem ❒ a large problem ❒ a very large problem

14. How much of a problem have you had waking up feeling unrefreshed?	❒ no problem ❒ a small problem ❒ a small to moderate problem ❒ a moderate problem ❒ a moderate to large problem ❒ a large problem ❒ a very large problem

Thank you for your assistance in completing this survey.

I

APPENDIX J

MAP SLEEP SYMPTOM-FREQUENCY QUESTIONAIRE

Center for Sleep and Respiratory Neurobiology:
MAP Sleep Symptom Frequency

Subject #: _____

Effects of a Fatigue Management Program on Fatigue in the Commercial Motor Vehicle Industry

This Questionnaire is part of a multi-phase study designed to investigate the effectiveness of a fatigue management program in commercial motor vehicle operations. Your answers provide important information concerning experiences within the industry.

Please read and answer each question carefully.

All answers are completely confidential and will be seen only by members of the research team

Your time and cooperation in filling out this questionnaire is greatly appreciated.

MAP SLEEP SYMPTOM-FREQUENCY QUESTIONAIRE

During the last month, on how many nights or days per week have you had or been told you had the following (please check only one box per question):

	(0) Never	(1) Rarely (less than once a week)	(2) Sometimes (1-2 times per week)	(3) Frequently (3-4 times per week)	(4) Always (5-7 times per week)	(5) Do not know
1. Loud snoring	❒	❒	❒	❒	❒	❒
2. Your legs feel jumpy or jerk	❒	❒	❒	❒	❒	❒
3. Difficulty falling asleep	❒	❒	❒	❒	❒	❒
4. Frequent awakenings	❒	❒	❒	❒	❒	❒
5. Snorting or gasping	❒	❒	❒	❒	❒	❒
6. Falling asleep when at work	❒	❒	❒	❒	❒	❒
7. Frequent tossing, turning, or thrashing	❒	❒	❒	❒	❒	❒

	(0) Never	(1) Rarely (less than once a week)	(2) Sometimes (1-2 times per week)	(3) Frequently (3-4 times per week)	(4) Always (5-7 times per week)	(5) Do not know
8. Your breathing stops or you choke or struggle for breath	❒	❒	❒	❒	❒	❒
9. Excessive sleepiness	❒	❒	❒	❒	❒	❒
10. Morning headaches	❒	❒	❒	❒	❒	❒
11. Falling asleep while driving	❒	❒	❒	❒	❒	❒
12. Feeling paralyzed, unable to move for short periods when falling asleep or awakening	❒	❒	❒	❒	❒	❒
13. Find yourself in a vivid dreamlike state when falling asleep or awakening even though you know you are awake	❒	❒	❒	❒	❒	❒
14. Any snoring	❒	❒	❒	❒	❒	❒

Thank you for your assistance in completing this survey.

APPENDIX K

FMP DRIVER INSTRUCTION BOOKLET

TABLE OF CONTENTS

1 INTRODUCTION

The Fatigue Management Program (FMP) is a preventative effort to address fatigue in the commercial transportation industry. The success of this project rests on the participation of the commercial drivers that take part – people like you! Please take the time to wear the Actigraph as requested and to enter all answers to questions using the PALM Pilot (Personal Digital Assistant – PDA).

Your cooperation is greatly appreciated and we thank you for your time and effort. Should you have any questions or concerns, please contact your field coordinator.

Field Coordinator: _____ Phone number: _____

2 PALM PILOT INSTRUCTIONS

2.1 General information

This section contains instructions for how to use the PALM Pilot as well as guidelines describing how to respond to the various types of questions. Even if you have never used a PALM Pilot before, you will find the device very easy to use. The screen is touch-sensitive so you can use the tip of your finger to answer the questions. If you find that the buttons are too small you can use the special pen, which comes with the device, to press the onscreen buttons. You will be using one of the PALM Pilot's shown below in Figure 1.

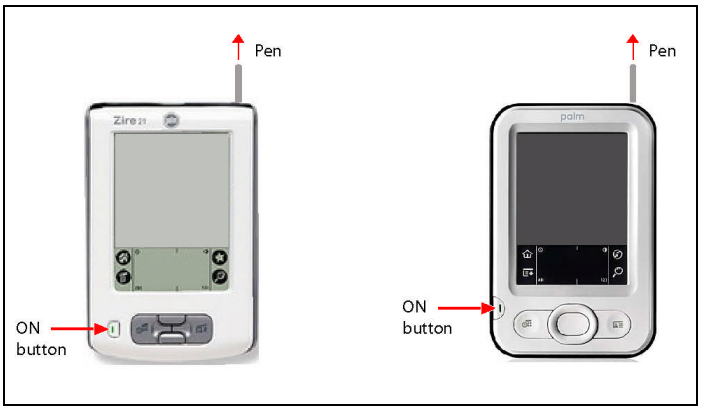

Figure 1 PALM Pilot devices (Z-21 on left, Z-22 on right)

The PALM Pilot can be turned on or off using the button on the lower left corner. If you leave the unit on without touching it for over one minute the screen will turn off automatically. The PALM Pilot will remember what screen you were on and will return to that screen the next time you turn it on.

When you first turn on the device the main menu screen appears as shown in Figure 2. At the top right corner of the screen is a meter showing the battery life. If the PALM Pilot is fully charged the meter will be fully gray. It is a good idea to charge the device each day. There are four buttons in the middle of the screen that access the questionnaires which need to be filled out each day. The timing of when each of these questionnaires are to be completed will be discussed in Section 4 – Daily Schedule. You will notice that the only one of the four buttons in the middle of the screen has bold black text whereas the others have grey text. The buttons with grey text are not available to be used until the previous questionnaires are complete. There is a button at the bottom of the page to access the Actigraph log. More instructions about the use of the Actigraph can be found in Section 3.

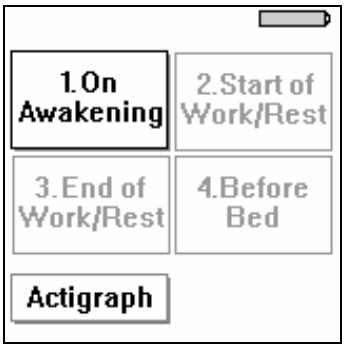

Figure 2 Main menu screen

2.2 Question types

The following are samples of the different types of questions that you will be asked.

1. Button choice

Using the tip of your finger press the button that matches your answer and press NEXT to go to the next question. Please note that the NEXT button does not appear until after you have made a selection.

Before

After

2. Time or Date entry

Press the "+" and "-" buttons to select the time when you went to sleep. You need to press the "Hours" or "Minutes" buttons to switch between entering the hour and the minute. For example, to enter "10:30 PM" you will need to do the following:

1. With the "Hours" button highlighted, press and hold the "+" button until the time reads "10:00 PM"
2. Press the "Minutes" button so that it is highlighted
3. Press and hold the "+" button until the time reads "10:30 PM"

Once the correct time is shown press NEXT to go to the next question.

Before

After

3. Slider ratings

Using the very tip of your finger (or fingernail) indicate the quality of your last sleep in the range between “very poor” and “excellent”. You can slide your finger along the scale to adjust your rating. If you experience difficulty in moving the slider on the scale you can tap another place on the scale. The special pen that comes with the PALM Pilot can also be used to move the slider (see Figure 1). Press NEXT to accept your answer and go to the next question.

Before

After

4. End of section

At the end of each questionnaire you will see a screen like this. You can press the “BACK” button to review your answers or press “DONE” to return to the main menu. **Once you return to the main menu you cannot go back and review your answers.**

*** Please note:** **It is very important that you do not attempt to use the PALM Pilot while your truck is in motion!**

3 ACTIGRAPH INSTRUCTIONS

Figure 3 Sample images of actigraphs

The Actigraph is worn like a wristwatch and should be worn on your non-dominant wrist. For example, if you are right-handed you should wear the Actigraph on your left wrist. **This device is not waterproof** so you will need to take it off when you take a shower, bath, go swimming, or any other water related activity. The Actigraph must be worn at ALL other times, **including sleeping**.

Before and after every time you go to sleep, **either for a nap or a main sleep period**, you must press the event button on the Actigraph. Each time you take off the Actigraph please fill in the Actigraph log on the PALM pilot indicating when and why the Actigraph was removed.

Please be aware that the Actigraph is a very delicate and expensive piece of equipment. **Please handle with care**.

4 DAILY SCHEDULE

For both rest days and duty days there are four short questionnaires that need to be filled out on the PDA. The timing and sequence of these activities is very important.

4.1 Rest Days

On rest days the four questionnaires should be completed as shown below in Figure 4. These questionnaires need to be filled out:

1. ON AWAKENING – in the first 10 minutes after waking from main sleep period
2. START OF WORK/REST – in the first 2 hours after waking up
3. END OF WORK/REST – in the last 2 hours before going to bed
4. BEFORE BED – in the 10 minutes before going to bed

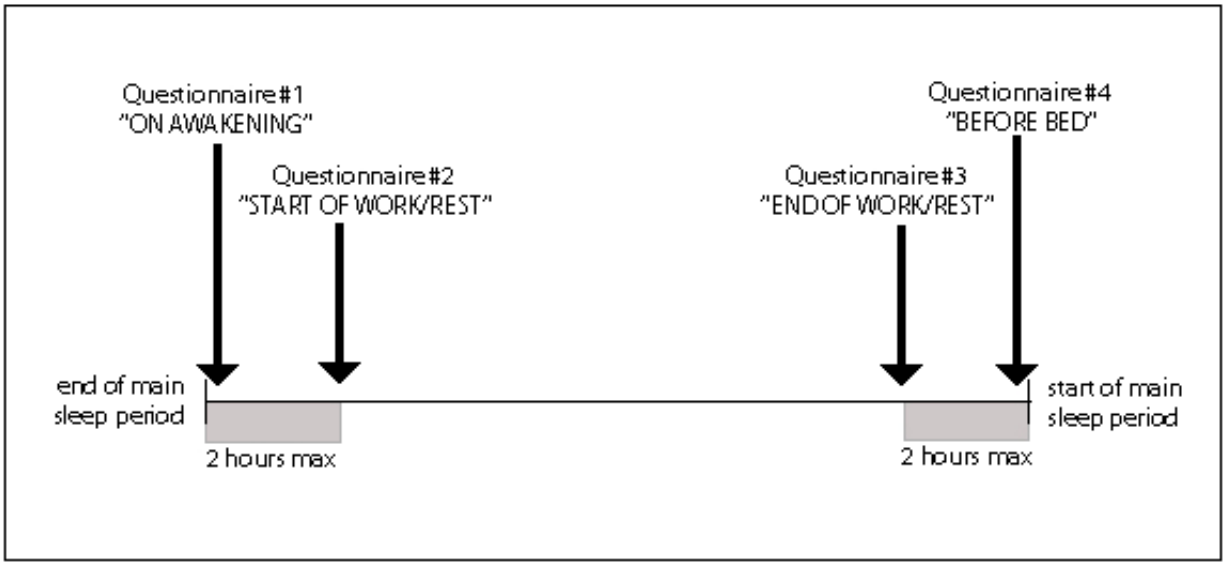

Figure 4 Schedule for rest days

4.2 Duty Days

Figure 5 below illustrates the times when the questionnaires are to be filled out on duty days. On duty days the questionnaires need to be filled out:

1. ON AWAKENING – in the first 10 minutes after waking up
2. START OF WORK/REST – just before you start your duty period *
3. END OF WORK/REST – just after you complete your duty period *
4. BEFORE BED – in the 10 minutes before going to bed

*** Please note: It is very important that you do not attempt to use the PALM Pilot while your truck is in motion!**

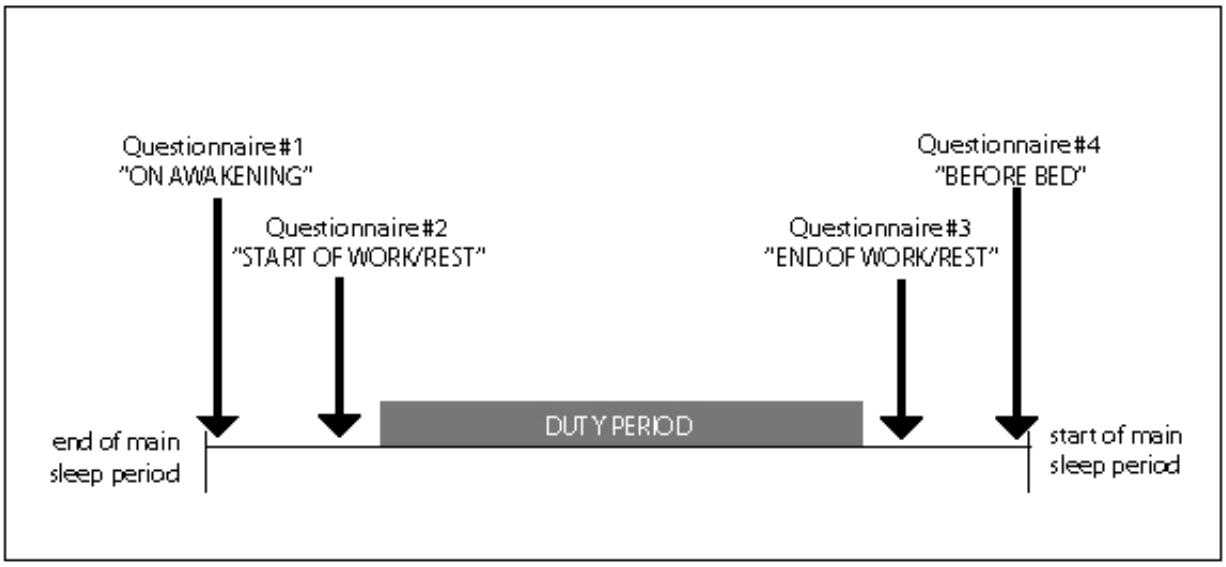

Figure 5 Schedule for duty days

If you are on a split shift, Figure 6 below illustrates when you should complete each questionnaire:

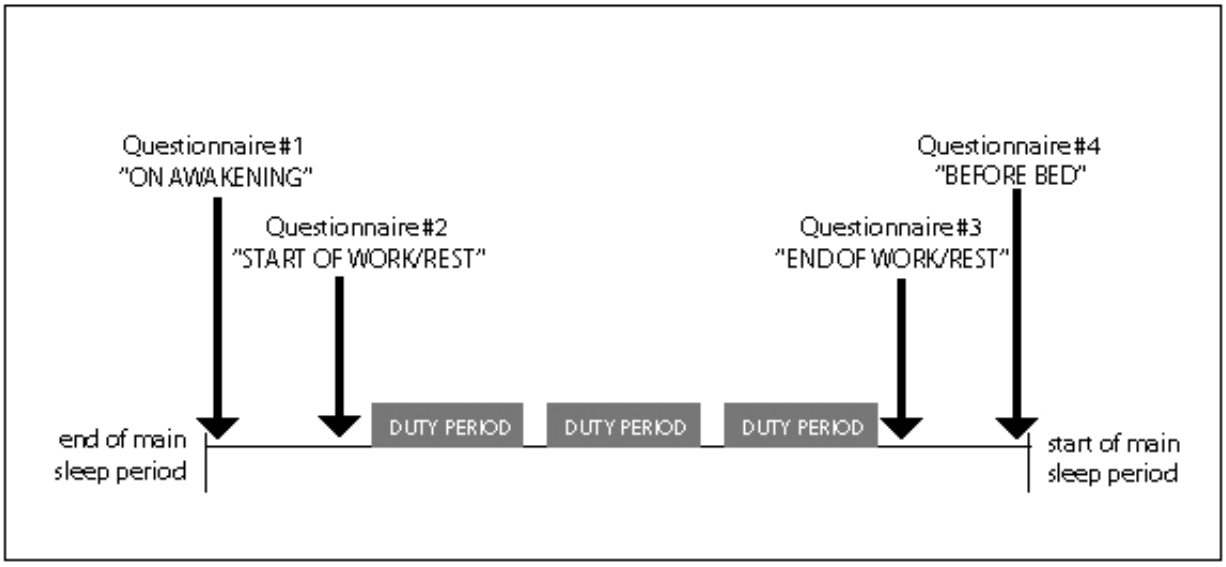

Figure 6 Schedule for split shift

ADDENDUM – COMPLETE QUESTIONNAIRE LIST

"On Awakening" Questionnaire:

	Question:	Comments:
1.	Bed time?	
2.	Wakeup time?	
3.	Length of last sleep?	
4.	Rate your last sleep:	
5.	Total sleep over last 24 hours?	

"Start of Work/Rest" Questionnaire:

	Question:	Comments:
1.	Any aches and pains?	
2.	How is your mood?	
3.	Rate the way you feel?	
4.	Fatigue level?	

"End of Work/Rest" Questionnaire:

	Question:	Comments:
1.	Was today a duty or rest day?	
2.	Any aches and pains?	
3.	How is your mood?	
4.	Rate the way you feel?	
5.	Fatigue level?	
6.	What time did your shift end?	
7.	Total duty time?	
8.	Total drive time?	
9.	How mentally demanding was your duty period?	
10.	How physically demanding was your duty period?	
11.	How stressful was your duty period?	
12.	How much did loading/unloading contribute to fatigue?	
13.	How much did driving conditions contribute to fatigue?	
14.	How much did time spent waiting contribute to fatigue?	
15.	How was your duty period?	
16.	Did you experience any close calls while driving?	
17.	Did you nod off at any time while driving?	
18.	Current time zone?	
19.	Did you have a split shift today?	
20.	What time did you stop working?	
21.	What time did you start up again?	

"Before Bed" Questionnaire:

	Question:	Comments:
1.	Fatigue level?	
2.	Did you take any naps today?	
3.	Time first nap started?	
4.	Nap 1 length?	
5.	Did you take another nap? (repeat twice)	
6.	Time next nap started?	
7.	Nap 2 length?	

APPENDIX L

DISPATCH PROCEDURES MANUAL

7.3 Order Size

a) Orders are usually for 8 axle units.
b) Some customer sites have smaller storage and can only receive smaller orders.

7.4 Order Confirmation

a) Orders are confirmed verbally when the customer phones in.
b) E-mail and fax orders are acknowledged with a B/L #.

7.5 Order Changes

a) Customers often change their orders due to sudden changes in their business caused by weather, delivery truck repairs, end user demand changes, etc.
b) Changes should be made to the order immediately noting by whom, date, and time.

7.6 Dispatching

7.6.1 Dispatching Priorities

a) Orders are received, processed, and given a B/L #.
b) Dispatch sorts the orders by shipping date to allow enough time to plan, travel to the origin, load, and reach the destination on time.
c) The customer specifies locations and accounts for loading.
d) Some customers are rigid in their origin points while others can be more flexible.
e) Customers must approve where to load because it is not up to ECL to make purchase decisions.
f) Loading on the wrong account or at the wrong location can make a huge difference in the customer's landed cost.

7.6.2 Dispatching ECL Resources

a) Dispatch uses a highway dispatch sheet **H:\Dispatch\Dispatch Sheets\LPG June** for worksheets or **2005LPG** for archive; access from 17th only) to organize trailer, tractor, and driver availability.
b) Dispatch must work with Calgary and Edmonton Fuel dispatchers and SCD dispatchers, to maximize resources and maintain customer service to all ECL customers.

7.6.3 Dispatching Load Assignment

a) Loads are assigned by priority to specific drivers and equipment based on distance to loading point, delivery time capabilities, loading qualifications at various origins, hours of service availability, US qualified, safety considerations such as off-road and mountain skills, seniority, equipment reliability, driver on time record, etc.
b) Dispatch must also look ahead to plan future loads, with consideration to equipment positioning for reloading (to minimize empty miles) and hours of service availability.

7.6.4 Dispatching Bill of Lading and Driver Instructions

a) Once dispatch has matched an order to a driver and equipment, the B/L is assigned to a trip #. The trip # is specific to a driver, a truck, and trailer.
b) One trip # can have several B/L #'s assigned; however, a new trip # should be generated when a driver starts a new assignment from a company branch, when equipment is changed, and when a new pay period begins.
c) The B/L, which includes driver instructions, is printed at dispatch and given to the driver; or, the information can be carefully conveyed to the driver by phone or satellite messaging.
d) The driver determines maximum payload based on equipment capacity and product density. The driver then proceeds with the assignment.

7.6.5 Dispatching Split Deliveries

a) A split delivery is a shipment with more than one origin and/or destination.
b) Each partial pickup or partial delivery needs a separate B/L #.
c) Split deliveries are usually two shipments on a unit consisting of two trailers.
d) The front and back trailers have different destinations, B/L #'s, and shipper's loading tickets.

7.7 Delivery Exceptions – Delays, Diversions

7.7.1 Delivery Exceptions - Delays

a) ECL, customers, and other parties can cause delays.
b) Drivers must report delays to dispatch.
c) Dispatch must decide if the load will be late and react by making dispatch changes or simply advising the customer and re-negotiating the delivery time.
d) The delay should be explained and noted in **Vogue\Dispatch\Order\Notes\Billing** so administration can charge the customer, if applicable, and pay the driver, if applicable. Administration must know who caused the delay, customer or ECL, so they can decide who is chargeable.

7.7.2 Delivery Exceptions - Diversions

a) Diversions can be caused when a load arrives and won't fit.
b) This can be caused by a dispatch error or a customer error.
c) The customer is contacted for instructions or an ASR destination is found.
d) Usually, the original destination tank is filled to 85% capacity and the balance is then diverted to another location.
e) The driver calculates the volume for each delivery by using tank gauges.
f) A B/L is generated to cover the new partial shipment with the origin being the original source

APPENDIX M

REGIONAL RESULTS

OVERALL STUDY PERIOD

Table 1 **Table 1 Length of Study Period – By Region**

Region	Pre-FMP		Post-FMP	
	N	Mean	N	Mean
Québec	29	9.41 (1.92)	29	8.45 (1.40)
Alberta	24	9.04 (1.81)	24	8.54 (2.11)
California	24	9.29 (1.27)	24	8.67 (1.86)
TOTAL	77	9.26 (1.69)	77	8.55 (1.77)

Table 2 **Mean Number of Duty Days in Study Period – By Region**

Region	Pre-FMP		Post-FMP	
	N	Mean	N	Mean
Québec	29	5.41 (1.43)	29	5.14 (1.53)
Alberta	24	5.54 (1.35)	24	5.21 (1.32)
California	24	6.00 (1.64)	24	5.67 (1.90)
TOTAL	77	5.64 (1.48)	77	5.32 (1.59)

Table 3 **Mean Number of Rest Days in Study Period – By Region**

Region	Pre-FMP		Post-FMP	
	N	Mean	N	Mean
Québec	29	4.00 (1.41)	29	3.31 (1.14)
Alberta	24	3.50 (1.56)	24	3.33 (1.69)
California	24	3.29 (1.40)	24	3.00 (0.98)
TOTAL	77	3.62 (1.47)	77	3.22 (1.28)

Table 4 **Mean Number of Rest Days Prior to Main Duty Period – By Region**

Region	Pre-FMP		Post-FMP	
	N	Mean	N	Mean
Québec	29	1.62 (0.86)	29	1.62 (0.90)
Alberta	24	1.71 (0.86)	24	1.58 (1.06)
California	24	1.54 (0.88)	24	1.50 (0.59)
TOTAL	77	1.62 (0.86)	77	1.57 (0.86)

Table 5 Length of Main Duty Period (Consecutive Days) – By Region

Region	Pre-FMP		Post-FMP	
	N	Mean	N	Mean
Québec	29	5.00 (1.22)	29	4.93 (0.96)
Alberta	24	5.08 (1.50)	24	4.58 (1.41)
California	24	5.00 (1.35)	24	5.08 (1.41)
TOTAL	77	5.03 (1.34)	77	4.87 (1.26)

Table 6 Mean Number of Consecutive Rest Days after Duty Period – By Region

Region	Pre-FMP		Post-FMP	
	N	Mean	N	Mean
Québec	29	2.24 (0.64)	29	1.66 (0.72)
Alberta	24	1.71 (0.95)	24	1.75 (1.26)
California	24	1.46 (0.59)	24	1.50 (0.78)
TOTAL	77	1.83 (0.80)	77	1.64 (0.93)

DUTY DAYS

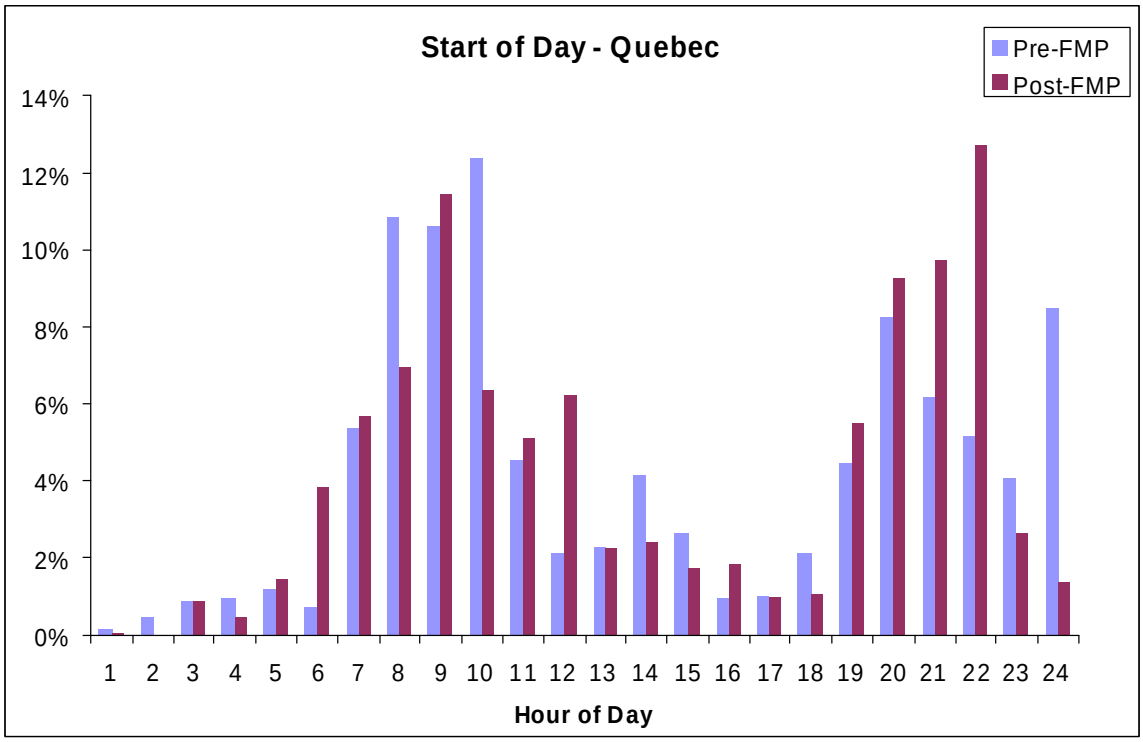

Figure 1 **Start of Day – Quebec (Pre vs. Post-FMP)**

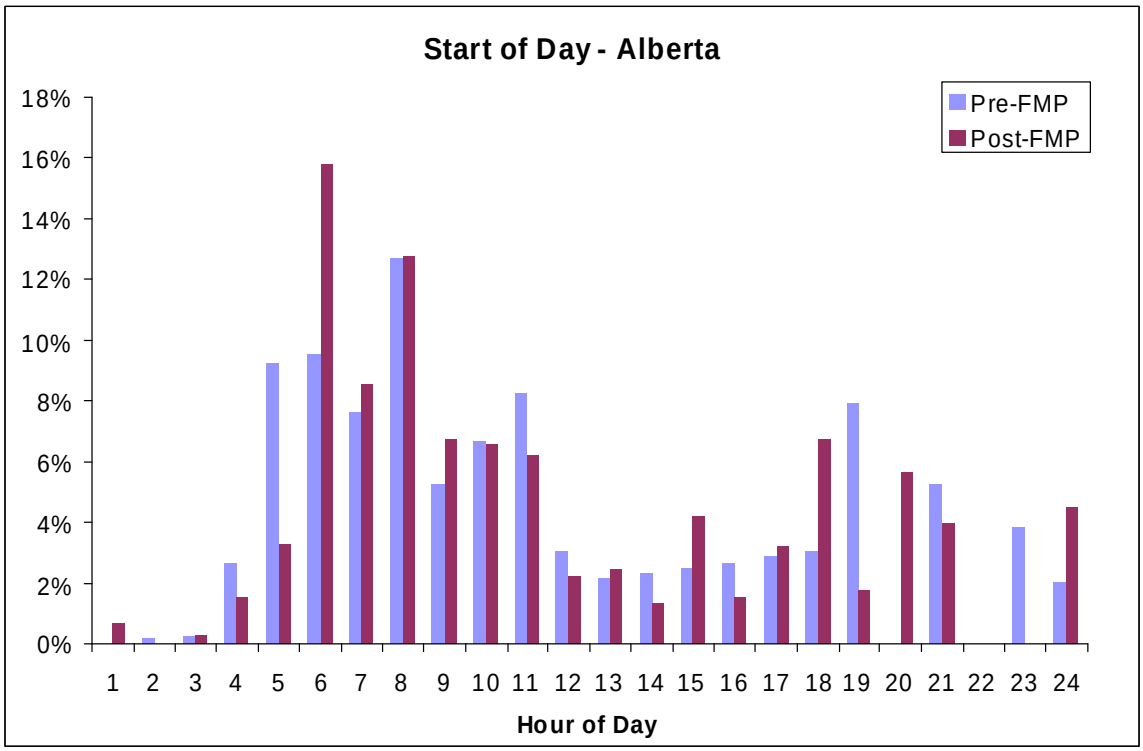

Figure 2 **Start of Day – Alberta (Pre vs. Post-FMP)**

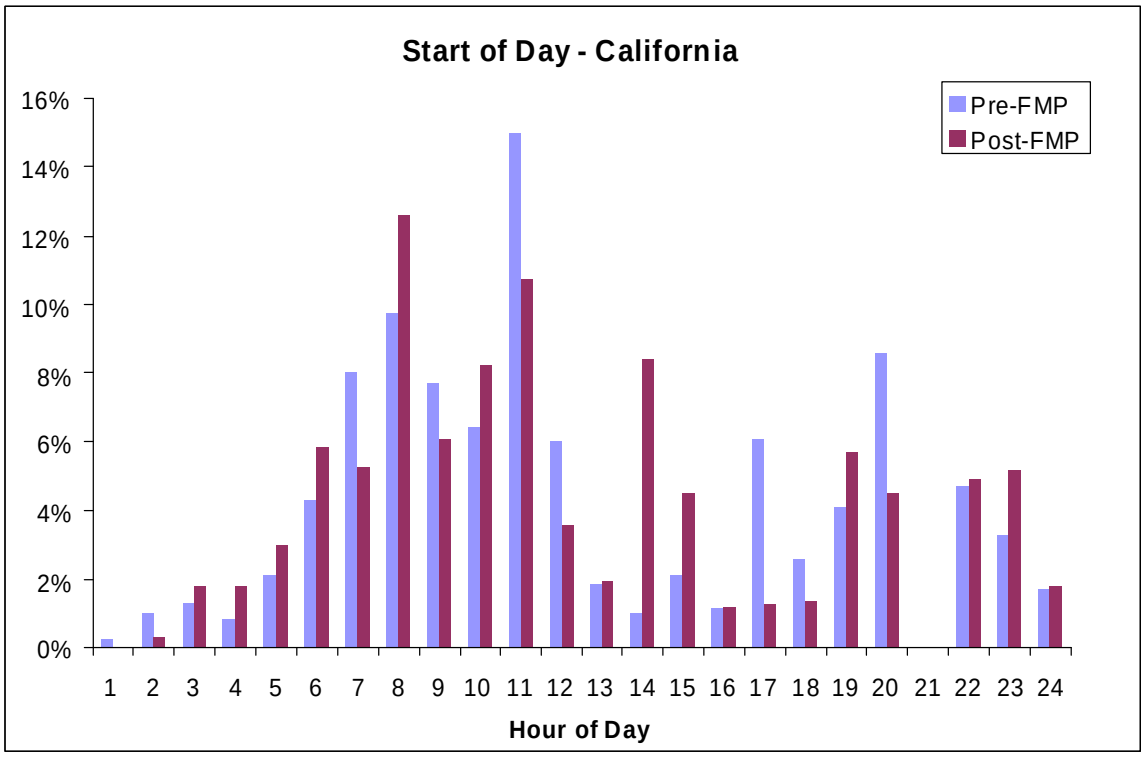

Figure 3 **Start of Day – California (Pre vs. Post-FMP)**

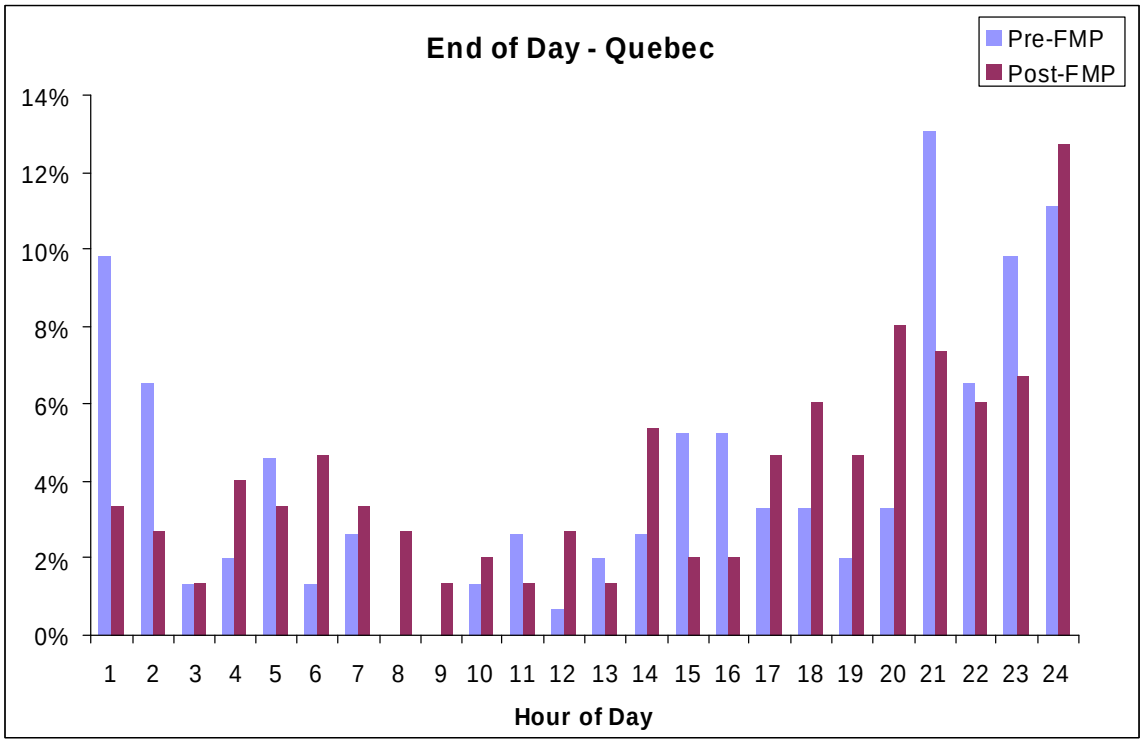

Figure 4 End of Day – Quebec (Pre vs. Post-FMP)

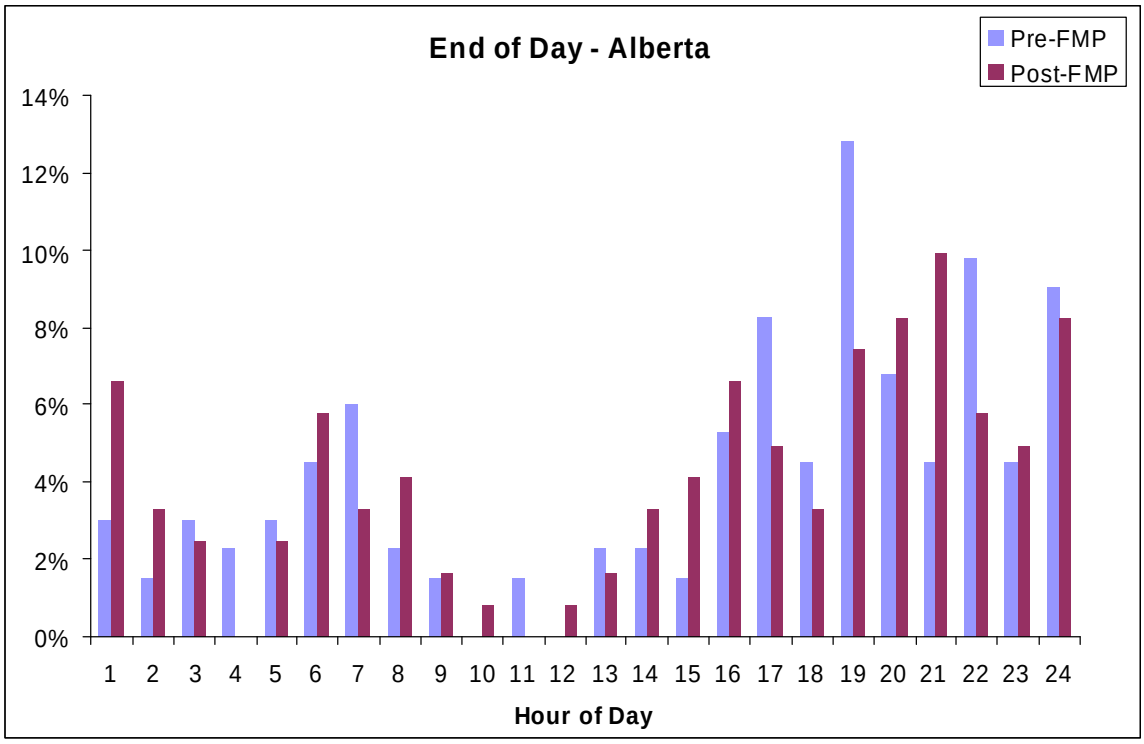

Figure 5 End of Day – Alberta (Pre vs. Post-FMP)

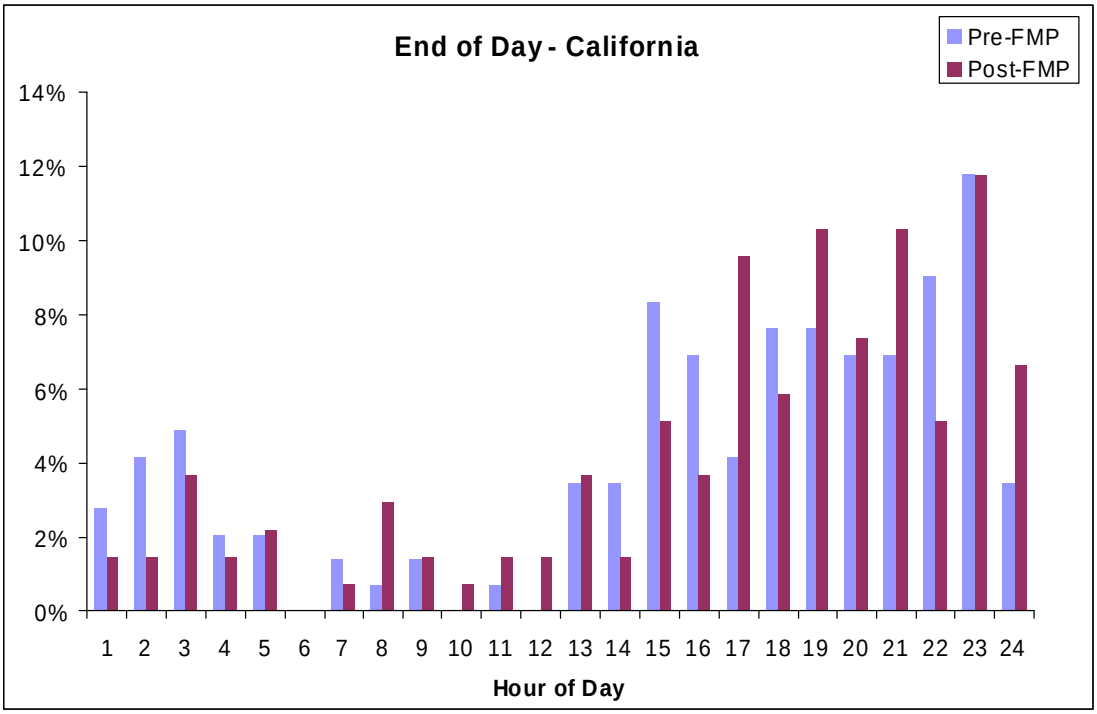

Figure 6 End of Day – California (Pre vs. Post-FMP)

Table 7 Mean Drive Time – By Region

Region	Pre-FMP		Post-FMP	
	N	Mean	N	Mean
Québec	29	8.08 (1.27)	29	8.21 (1.62)
Alberta	24	8.12 (2.57)	24	7.21 (2.27)
California	24	6.85 (1.74)	24	6.70 (1.99)
TOTAL	77	7.71 (1.96)	77	7.43 (2.04)

Table 8 Mean Duty Time – By Region

Region	Pre-FMP		Post-FMP	
	N	Mean	N	Mean
Québec	29	11.23 (1.77)	29	12.01 (1.29)
Alberta	24	12.58 (2.07)	24	11.99 (2.12)
California	24	10.04 (1.23)	24	10.55 (1.21)
TOTAL	77	11.28 (1.98)	77	11.55 (1.70)

Table 9 Proportion of Night Drivers

	Proportion of Night Drivers	
	Pre-FMP	Post-FMP
Québec	6.9%	24.1%
Alberta	8.3%	16.7%
California	8.3%	12.5%
TOTAL	**7.8%**	**18.2%**

WORK DEMANDS

Table 10 Mental Demands of Duty Period – By Region

	Pre-FMP				Post-FMP		
	N	Mean	SD		N	Mean	SD
Québec	29	28.2	15.8		29	28.9	17.9
Alberta	24	34.1	16.8		24	29.4	15.6
California	24	34.2	13.8		24	34.6	18.0
TOTAL	**77**	**31.9**	**15.6**		**77**	**30.9**	**17.2**

Note: 1 = Not at all demanding, 100 = Extremely mentally demanding

Table 11 Physical Demands of Duty Period - Mean

	Pre-FMP				Post-FMP		
	N	Mean	SD		N	Mean	SD
Québec	29	22.5	13.2		29	23.6	18.4
Alberta	24	30.4	16.4		24	28.2	12.5
California	24	34.1	18.6		24	34.3	21.0
TOTAL	**77**	**28.6**	**16.6**		**77**	**28.4**	**18.0**

Note: 1 = Not at all demanding, 100 = Extremely physically demanding

Table 12 Stress of Duty Period – By Region

	Pre-FMP				Post-FMP		
	N	Mean	SD		N	Mean	SD
Québec	29	27.1	20.3		29	30.1	20.6
Alberta	24	32.6	21.1		24	31.3	16.4
California	24	33.8	16.5		24	34.9	20.8
TOTAL	77	30.9	19.5		77	32.0	19.3

Note: 1 = Not at all stressful, 100 = Extremely Stressful

Table 13 Intensity of Duty Period – By Region

	Pre-FMP				Post-FMP		
	N	Mean	SD		N	Mean	SD
Québec	29	57.3	12.5		29	56.1	14.9
Alberta	24	45.6	17.6		24	45.1	17.5
California	24	43.1	12.6		24	41.3	14.8
TOTAL	**77**	**49.2**	**15.5**		**77**	**48.1**	**16.8**

Note: 1 = Not at all intense, 100 = Extremely intense

FACTORS CONTRIBUTING TO FATIGUE

Table 14 Contribution of Loading/Unloading to Fatigue – By Region

	Pre-FMP				Post-FMP		
	N	**Mean**	**SD**		**N**	**Mean**	**SD**
Québec	29	19.5	21.0		29	15.7	17.6
Alberta	24	30.7	19.2		24	30.0	20.8
California	24	24.7	16.0		24	26.2	16.0
TOTAL	**77**	**24.6**	**19.3**		**77**	**23.4**	**19.0**

Note: 1 = Not at all, 100 = Extremely

Table 15 Contribution of Driving Conditions to Fatigue – By Region

	Pre-FMP				Post-FMP		
	N	**Mean**	**SD**		**N**	**Mean**	**SD**
Québec	29	24.9	17.6		29	32.3	19.2
Alberta	24	25.8	17.7		24	26.9	14.5
California	24	38	15.8		24	34.6	19.3
TOTAL	**77**	**29.3**	**17.9**		**77**	**31.3**	**17.9**

Note: 1 = Not at all, 100 = Extremely

Table 16 Contribution of Time Spent Waiting to Fatigue – By Region

	Pre-FMP				Post-FMP		
	N	**Mean**	**SD**		**N**	**Mean**	**SD**
Québec	29	25.2	21.1		29	27.4	22.1
Alberta	24	25.9	18.7		24	28.8	16.8
California	24	25	17.9		24	29.5	23.2
TOTAL	**77**	**25.4**	**19.2**		**77**	**28.5**	**20.7**

Note: 1 = Not at all, 100 = Extremely

SLEEP

Table 17 Reported Duration of Main Sleep Period – By Region

	Pre-FMP						Post-FMP					
	Rest Days			Duty Days			Rest Days			Duty Days		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Québec	27	7.3	1.2	27	6.4	1.5	27	7.5	1.0	27	6.7	0.9
Alberta	18	7.9	1.3	18	6.5	0.7	18	7.4	0.9	18	6.6	0.8
California	20	7.3	1.4	20	6.4	0.8	20	7.6	1.2	20	6.6	1.3
TOTAL	**65**	**7.5**	**1.1**	**65**	**6.4**	**1.1**	**65**	**7.5**	**1.0**	**65**	**6.7**	**1.0**

Table 18 Reported Total Sleep in Last 24 Hours – By Region

	Pre-FMP						Post-FMP					
	Rest Days			Duty Days			Rest Days			Duty Days		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Québec	27	8.8	1.4	27	8.2	2.0	27	9.8	2.8	27	9.0	2.7
Alberta	18	8.5	1.8	18	7.5	1.6	18	8.2	2.4	18	8.0	1.7
California	20	9.5	3.0	20	8.6	2.7	20	9.8	3.4	20	8.7	3.5
TOTAL	**65**	**8.9**	**2.2**	**65**	**8.1**	**2.2**	**65**	**9.4**	**2.9**	**65**	**8.7**	**2.7**

Table 19 Subjective Sleep Quality – By Region

	Pre-FMP						Post-FMP					
	Rest Days			Duty Days			Rest Days			Duty Days		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Québec	27	73.3	20.2	27	69.5	16.1	27	78.5	19.2	27	73.8	16.2
Alberta	18	53.8	16.6	18	55.1	18.0	18	61.9	14.0	18	63.9	13.8
California	20	67.0	13.8	20	61.5	13.0	20	64.7	20.4	20	66.6	13.5
TOTAL	**65**	**66.0**	**16.7**	**65**	**63.1**	**16.7**	**65**	**69.7**	**19.6**	**65**	**68.8**	**15.1**

Note: 0 = Worst Sleep Quality, 100 = Best Sleep Quality

Table 20 Sleep Latency (Actigraphy) – By Region

	Pre-FMP						Post-FMP					
	Rest Days			Duty Days			Rest Days			Duty Days		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Québec	27	20.0	11.8	27	33.2	21.4	27	29.0	24.8	27	23.4	14.0
Alberta	18	25.4	19.0	18	30.6	25.0	18	20.6	17.1	18	29.7	19.8
California	20	30.3	33.0	20	27.7	28.8	20	25.9	26.6	20	26.0	15.2
TOTAL	**65**	**24.6**	**24.5**	**65**	**30.8**	**24.5**	**65**	**25.7**	**23.4**	**65**	**26.0**	**16.1**

Table 21 Time Spent in Bed for Main Sleep Episode (PDA, Actigraphy) – By Region

	Pre-FMP						Post-FMP					
	Rest Days			Duty Days			Rest Days			Duty Days		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Québec	27	8.1	1.4	27	6.9	1.4	27	8.4	1.2	27	7.5	1.5
Alberta	18	8.5	1.4	18	6.7	0.9	18	7.6	1.0	18	7.0	0.8
California	20	8.0	1.3	20	6.9	0.8	20	8.3	1.2	20	7.2	1.3
TOTAL	**65**	**8.2**	**1.1**	**65**	**6.9**	**1.1**	**65**	**8.1**	**1.2**	**65**	**7.3**	**1.3**

Table 22 Duration of Main Sleep Period (Actigraphy) – By Region

	Pre-FMP						Post-FMP					
	Rest Days			Duty Days			Rest Days			Duty Days		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Québec	27	7.3	1.3	27	6.1	1.3	27	7.5	1.0	27	6.7	0.9
Alberta	18	7.8	1.3	18	6.0	0.8	18	7.1	1.0	18	6.2	0.9
California	20	7.2	1.5	20	6.2	0.9	20	7.5	1.4	20	6.5	1.3
TOTAL	**65**	**7.4**	**1.0**	**65**	**6.1**	**1.0**	**65**	**7.4**	**1.1**	**65**	**6.5**	**1.0**

Table 23 Sleep Duration Achieved During Main Sleep Episode (Actigraphy) – By Region

	Pre-FMP						Post-FMP					
	Rest Days			Duty Days			Rest Days			Duty Days		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Québec	27	6.5	1.2	27	5.4	1.1	27	6.6	1.0	27	5.9	0.9
Alberta	18	7.1	1.1	18	5.4	0.8	18	6.4	0.9	18	5.7	0.8
California	20	6.5	1.4	20	5.6	0.8	20	6.7	1.2	20	5.7	1.1
TOTAL	**65**	**6.7**	**0.9**	**65**	**5.5**	**0.9**	**65**	**6.6**	**1.0**	**65**	**5.8**	**0.9**

Table 24 Sleep Efficiency During Time in Bed (Actigraphy) – By Region

	Pre-FMP						Post-FMP					
	Rest Days			Duty Days			Rest Days			Duty Days		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Québec	27	81.3%	6.6%	27	78.0%	5.1%	27	79.6%	8.1%	27	81.5%	6.1%
Alberta	18	83.8%	5.1%	18	81.1%	8.5%	18	83.8%	5.0%	18	82.0%	7.1%
California	20	81.4%	7.8%	20	80.9%	10.4%	20	80.1%	8.4%	20	79.0%	6.0%
TOTAL	**65**	**82.1%**	**8.0%**	**65**	**79.7%**	**8.0%**	**65**	**80.9%**	**7.6%**	**65**	**80.9%**	**6.4%**

NAPS

Table 25 Driver Who Napped -- By Region

	Pre-FMP				Post-FMP			
	Rest Days		Duty Days		Rest Days		Duty Days	
	N	Mean	N	Mean	N	Mean	N	Mean
Québec	27	44.4%	27	63.0%	27	29.6%	27	48.1%
Alberta	18	33.3%	18	61.1%	18	33.3%	18	44.4%
California	20	25.0%	20	45.0%	20	35.0%	20	55.0%
TOTAL	**65**	**35.4%**	**65**	**56.9%**	**65**	**32.3%**	**65**	**49.2%**

Table 26 Average Daily Nap Duration for All Drivers – By Region

	Pre-FMP						Post-FMP					
	Rest Days			Duty Days			Rest Days			Duty Days		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Québec	27	14.8	20.0	27	31.9	37.8	27	9.8	23.1	27	26.7	50.2
Alberta	18	16.4	40.0	18	10.5	17.9	18	10.9	28.3	18	7.4	16.7
California	20	12.9	34.4	20	12.5	20.0	20	25.5	50.6	20	13.2	24.1
TOTAL	**65**	**14.7**	**30.7**	**65**	**20.0**	**29.8**	**65**	**15.0**	**35.2**	**65**	**17.2**	**36.6**

Table 27 Average Nap Duration for Drivers Who Napped – By Region

	Pre-FMP						Post-FMP					
	Rest Days			Duty Days			Rest Days			Duty Days		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Québec	12	33.4	16.5	17	50.6	36.3	8	33.2	33.1	13	55.4	61.2
Alberta	6	49.3	59.1	11	17.1	20.5	6	32.8	43.1	8	16.7	22.4
California	5	51.6	55.9	9	27.8	21.7	7	72.8	64.1	11	24.0	28.6
TOTAL	**23**	**41.5**	**39.7**	**37**	**35.1**	**32.1**	**21**	**46.3**	**49.5**	**32**	**35.0**	**46.1**

SUBJECTIVE MOOD RATINGS

Table 28 Aches and Pains, Rest Days – By Region

	Pre-FMP						Post-FMP					
	Start of Day			End of Day			Start of Day			End of Day		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Québec	29	13.9	15.7	29	14.3	15.4	29	15.6	15.1	29	18.0	17.1
Alberta	24	30.3	19.2	24	23.5	17.9	24	24.3	17.6	24	29.8	20.7
California	24	15.5	11.4	24	18.0	14.5	24	25.2	18.8	24	24.0	18.3
TOTAL	77	19.5	17.2	77	18.3	16.2	77	21.4	17.5	77	23.6	19.1

Table 29 Aches and Pains, Duty Days – By Region

	Pre-FMP						Post-FMP					
	Start of Day			End of Day			Start of Day			End of Day		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Québec	29	13.3	12.8	29	18.1	16.9	29	17.4	17.8	29	21.4	22.4
Alberta	24	26.1	15.8	24	30.9	21.0	24	25.5	17.2	24	31.2	20.4
California	24	18.2	13.8	24	22.4	16.7	24	24.2	19.2	24	27.0	22.6
TOTAL	77	18.8	14.9	77	23.4	18.8	77	22.1	18.2	77	26.2	22.0

Table 30 Mood, Rest Days – By Region

	Pre-FMP						Post-FMP					
	Start of Day			End of Day			Start of Day			End of Day		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Québec	29	14.7	11.8	29	17.6	15.1	29	16.0	14.0	29	18.9	17.3
Alberta	24	30.3	17.6	24	26.8	16.5	24	25.1	16.9	24	24.6	17.4
California	24	19.4	10.7	24	27.8	13.4	24	26.8	14.7	24	27.4	16.7
TOTAL	77	21.0	15.0	77	23.6	15.6	77	22.3	15.8	77	23.4	17.3

Table 31 Mood, Duty Days – By Region

	Pre-FMP						Post-FMP					
	Start of Day			End of Day			Start of Day			End of Day		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Québec	29	21.7	15.8	29	25.1	16.5	29	19.7	16.6	29	26.7	21.3
Alberta	24	33.9	17.9	24	32.8	16.4	24	28.9	16.0	24	31.1	17.5
California	24	29.8	14.6	24	31.4	14.0	24	30.6	15.2	24	28.6	15.3
TOTAL	77	28.0	16.8	77	29.5	15.9	77	25.9	16.5	77	28.6	18.3

Table 32 Calm vs. Excited, Rest Days – By Region

	Pre-FMP							Post-FMP					
	Start of Day			End of Day				Start of Day			End of Day		
	N	Mean	SD	N	Mean	SD		N	Mean	SD	N	Mean	SD
Québec	29	17.8	12.6	29	16.7	13.4		29	15.2	11.6	29	18.7	14.3
Alberta	24	35.5	22.4	24	36.7	24.8		24	34.4	22.4	24	31.0	21.3
California	24	35.2	18.1	24	27.5	15.5		24	32.5	19.7	24	31.2	20.1
TOTAL	77	28.7	19.6	77	26.3	19.9		77	26.7	20.0	77	26.5	19.3

Table 33 Calm vs. Excited, Duty Days – By Region

	Pre-FMP							Post-FMP					
	Start of Day			End of Day				Start of Day			End of Day		
	N	Mean	SD	N	Mean	SD		N	Mean	SD	N	Mean	SD
Québec	29	19.5	16.0	29	24.6	16.8		29	20.4	16.5	29	26.9	19.9
Alberta	24	30.9	19.2	24	31.0	19.5		24	29.6	17.8	24	30.8	18.7
California	24	34.6	14.9	24	34.5	13.3		24	36.5	20.6	24	29.8	19.1
TOTAL	77	27.7	17.8	77	29.7	17.0		77	28.3	19.2	77	29.0	19.1

Table 34 Level of Fatigue, Rest Days – By Region

	Pre-FMP							Post-FMP					
	Start of Day			End of Day				Start of Day			End of Day		
	N	Mean	SD	N	Mean	SD		N	Mean	SD	N	Mean	SD
Québec	29	74.8	19.0	29	56.8	23.3		29	81.2	18.1	29	57.7	20.0
Alberta	24	61.5	20.4	24	46.7	21.0		24	65.0	18.0	24	43.5	17.2
California	24	79.6	11.1	24	46.0	16.8		24	72.2	12.5	24	50.1	22.3
TOTAL	77	72.1	18.8	77	50.3	21.1		77	73.2	17.6	77	50.8	20.6

Table 35 Level of Fatigue, Duty Days – By Region

	Pre-FMP							Post-FMP					
	Start of Day			End of Day				Start of Day			End of Day		
	N	Mean	SD	N	Mean	SD		N	Mean	SD	N	Mean	SD
Québec	29	77.7	15.6	29	50.5	18.6		29	80.7	15.8	29	54.4	24.2
Alberta	24	58.6	15.8	24	40.6	23.9		24	64.5	19.3	24	43.3	20.9
California	24	74.4	9.8	24	48.3	17.0		24	69.5	14.9	24	51.8	17.3
TOTAL	77	70.7	16.2	77	46.7	20.1		77	72.2	17.9	77	50.1	21.5

CRITICAL EVENTS

Table 36 Number of drivers reporting at least one critical event – By Region

By Region	Pre-FMP			Post-FMP		
	N	Driver had one or more Critical event	%	N	Driver had one or more Critical event	%
Québec	29	14	48%	29	11	38%
Alberta	24	13	54%	24	6	25%
California	24	8	33%	24	5	21%
TOTAL	**77**	**35**	**45%**	**77**	**22**	**29%**

PSYCHOMOTOR VIGILANCE TASKS (PVT)

Table 37 Reaction Time Rest Days – By Region

	Pre-FMP						Post-FMP					
	Start of Day			End of Day			Start of Day			End of Day		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Québec	12	282.2	30.2	12	304.2	47.3	12	292.2	47.1	12	312.7	41.8
Alberta	14	293.3	50.5	14	305.9	46.6	14	296.5	90.2	14	303.9	52.7
California	17	265.0	40.3	17	295.4	58.2	17	269.9	44.9	17	288.8	55.9
TOTAL	**43**	**279.0**	**50.7**	**43**	**301.3**	**50.7**	**43**	**284.8**	**48.6**	**43**	**300.4**	**51.1**

Table 38 Reaction Time Duty Days – By Region

	Pre-FMP						Post-FMP					
	Start of Day			End of Day			Start of Day			End of Day		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Québec	12	286.0	31.9	15	287.8	37.4	15	300.1	43.9	15	298.0	34.4
Alberta	19	318.7	81.8	19	315.1	82.0	19	312.4	92.6	19	329.6	74.6
California	18	265.0	34.1	18	278.1	44.2	18	270.8	56.2	18	283.7	37.4
TOTAL	**52**	**290.7**	**60.6**	**52**	**294.4**	**60.6**	**52**	**294.4**	**56.2**	**52**	**304.6**	**56.2**

Table 39 Minor Lapses Rest Days – By Region

	Pre-FMP						Post-FMP					
	Start of Day			End of Day			Start of Day			End of Day		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Québec	12	5.4	5.2	12	8.5	10.2	12	7.5	14.3	12	11.0	12.1
Alberta	14	7.3	13.3	14	10.2	13.1	14	7.9	4.1	14	9.8	13.1
California	17	4.6	7.0	17	9.0	14.0	17	5.4	7.4	17	9.3	13.6
TOTAL	**43**	**5.7**	**12.5**	**43**	**9.2**	**12.5**	**43**	**6.8**	**10.2**	**43**	**9.9**	**12.7**

Table 40 Minor Lapses Duty Days – By Region

	Pre-FMP						Post-FMP					
	Start of Day			End of Day			Start of Day			End of Day		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Québec	12	6.1	7.5	15	5.1	6.1	15	8.3	10.8	15	7.6	8.6
Alberta	19	14.9	24.9	19	11.2	22.1	19	11.9	12.8	19	17.1	22.2
California	18	4.9	7.5	18	5.5	9.9	18	6.7	15.5	18	6.7	10.5
TOTAL	**52**	**8.9**	**14.9**	**52**	**7.5**	**14.9**	**52**	**9.0**	**13.4**	**52**	**10.7**	**16.0**

DRIVER EVALUATION OF NEW KNOWLEDGE

Table 41 Driver Quizzes – Core Module – By Region

	CORE MODULE	Pre-FMP	Post-FMP			
		Alberta (n=24)	Québec (n=29)	Alberta (n=24)	California (n=24)	Total (n=77)
1	The goals of this fatigue management program	96%	74%	92%	71%	78%
2	The estimated percent of heavy truck accidents involving fatigue is 30 – 40%	32%	24%	44%	50%	37%
3	Time of day has a bigger effect on fatigue than does sleep quality	48%	18%	48%	25%	29%
4	The longest sleep is obtained if you go to bed at midnight	80%	82%	86%	62%	75%
5	Driving at night and sleeping during the day can result in … all of the above	84%	74%	88%	100%	85%
6	Being awake for 20 to 25 hours has been shown to be equal to a blood alcohol level of 0.10%	36%	63%	68%	75%	68%
7	Hours of service regulations fail to consider time-of-day effects	32%	42%	28%	54%	41%
8	Single vehicle accidents are most likely to occur between 2:00 – 4:00 a.m.	40%	82%	48%	62%	67%
	AVERAGE SCORE	**56%**	**57%**	**63%**	**62%**	**60%**

Table 42 Driver Quizzes – Trip Planning Module – By Region

	TRIP PLANNING	Pre-FMP	Post-FMP			
		Alberta (n=24	Québec (n=29)	Alberta (n=24	California (n=24	Total (n=77)
1	The best times to plan a nap are between 00:00 – 06:00 and between 13:00 – 16:00	72%	63%	52%	58%	58%
2	Concerning the recovery period … all of the above	92%	73%	88%	92%	83%
3	How much you slept in the prior day affects your level of alertness	28%	50%	32%	58%	47%
4	Consider your ability to sleep … all of the above	52%	47%	56%	54%	52%
5	Sleep inertia impairs your driving performance after a nap	48%	53%	60%	46%	53%
6	People generally feel sluggish in the mid-afternoon and after midnight	88%	77%	80%	79%	79%
7	Considering amount of sleep … all of the above	56%	57%	80%	71%	68%
8	Driving for more than 10 hours can result in drowsiness, short attention span, irritability, decreased concentration and memory	92%	83%	92%	75%	84%
	AVERAGE SCORE	**66%**	**63%**	**68%**	**67%**	**66%**

Table 43 Driver Quizzes – Sleep Disorders Module – By Region

	SLEEP DISORDERS	Post-FMP			
		Québec (n=29)	Alberta (n=0)	California (n=24)	Total (n=53)
1	Stages NREM 3 and 4 comprise deep sleep	29%	n/a	50%	38%
2	The amount of sleep required during each 24-hour day ranges between 6 and 10 hours for adults	90%	n/a	75%	84%
3	Sleep debt refers to missed sleep that you needed but did not get	84%	n/a	87%	85%
4	Sleep disorders have various physiological or psychological causes	71%	n/a	75%	73%
5	Sleep disorders DO NOT only affect unhealthy middle-aged men	87%	n/a	92%	89%
6	People with chronic forms of insomnia DO NOT function normally during daytime	61%	n/a	46%	54%
7	Sleep apnea describes pauses in breathing during sleep	100%	n/a	62%	84%
8	Medication IS NOT a treatment for sleep apnea	90%	n/a	62%	78%
	AVERAGE SCORE	**77%**		**69%**	**73%**

Table 44 Driver Quizzes – Wellness and Lifestyle Module – By Region

	WELLNESS AND LIFESTYLE	Post-FMP			
		Québec (n=29)	Alberta (n=0)	California (n=24)	Total (n=53)
1	To lose weight you need to have energy intake be less than your energy output	80%	n/a	83%	81%
2	Regular exercise will improve … all of the above	97%	n/a	92%	94%
3	Effective strategy for coping with stress … all of the above	90%	n/a	83%	87%
4	Lack of skills or facilities is a real road block to exercise	0%	n/a	12%	6%
5	Too much stress DOES NOT allow you to get all the sleep you need	87%	n/a	83%	85%
6	For exercise to be successful and increase well being it can be done at short intervals over the course of the day	40%	n/a	42%	41%
7	In order to help reduce the risk of obesity-related diseases … al of the above	87%	n/a	83%	85%
8	A healthy lifestyle is a family affair	80%	n/a	83%	81%
	AVERAGE SCORE	**70%**		**70%**	**70%**

PURPOSE OF DRIVER PARTICIPATION

Table 45 Purpose of Driver Participation – By Region

	Québec (n=29)	Alberta (n=18)	California (n=24)	Total (n=71)
The possibility of being treated by a sleep disorder specialist	2.82 (0.39)	1.88 (1.05)	1.68 (1.00)	2.21 (0.96)
To take part in the fatigue management training given by the scientific team	2.75 (0.52)	1.59 (1.00)	1.86 (0.83)	2.16 (0.91)
Free access to CPAP	2.54 (0.74)	1.24 (1.09)	1.18 (1.05)	1.76 (1.14)
To help with family situations	2.18 (1.12)	1.24 (1.09)	1.23 (1.02)	1.63 (1.17)
It's an international project	2.18 (0.82)	1.06 (0.97)	1.32 (1.04)	1.61 (1.04)
The financial compensation	1.71 (0.98)	1.00 (0.41)	1.45 (1.03)	1.45 (1.06)
Because my family asked me to participate	0.96 (1.07)	0.18 (0.73)	0.27 (0.55)	0.54 (0.91)
To please my employer	0.75 (0.97)	0.24 (0.75)	0.36 (0.58)	0.49 (0.82)

0 = low, 1 = average, 2= high, 3 = very high