

CONTRIBUTING ORGANIZATIONAL FACTORS TO DRIVER FATIGUE BASED ON THE
COMPLIANCE, SAFETY, ACCOUNTABILITY (CSA 2010) MEASUREMENT SYSTEM
by

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Fatigue is considered as one of the main causes of motor carrier crashes. To control this hazard, Federal Motor Carrier Safety Administration (FMCSA) enforces prescriptive Hours-of-Service (HOS) regulation. Over the last decade, an emerging consensus has questioned the efficiency of this perspective regulation. Consequently, a comprehensive approach called Fatigue Risk Management System (FRMS) is becoming popular in the fatigue science. FRMS has transferred the focus of responsibility for safety away from the regulatory bodies towards companies and individuals.

On the other hand, motor carriers should be able to identify which of their organizational factors have contributed to their fatigue performance; thus, they will be able to enhance their fatigue performance by improving the contributed organizational factors to their fatigue performance.

This research project aimed to investigate the organizational factors and associated safety practices that have been contributed to fatigue performance. 134 motor carriers with acceptable and unacceptable fatigue performance were studied. The Compliance, Safety, Accountability (CSA 2010) measurement system was used to determine the motor carriers' fatigue performance.

The organizational factors which were studied include: management commitment, schedule design, HOS management, and training system. Constructing elements for each of these organizational factors were identified by the literature review.

Based on the results of the study, it is suggested that safety budget (as a management commitment element), percentage of drivers with regular schedule (as a schedule design element), and utilization of electronic logbook (as an HOS management element) are contributing factors to fatigue performance among the motor carriers. Consequently, motor carriers that are looking for improving their fatigue performance may consider implementing best safety practices to improve their fatigue performance.

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A Thesis

Presented To the Faculty of the Department of Technology Systems

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by

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LIST OF ABBREVIATIONS

Abbreviation	Meaning
AFP	Acceptable Fatigue Performance
BASIC	Behavior Analysis and Safety Improvement Category
CMV	Commercial Motor Vehicle
CSA	Compliance, Safety, Accountability
CLT	Central Limit Theorem
DOE	Design of Experiment
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FMCSR	Federal Motor Carrier Safety Regulation
FMSC	Fatigue Management Steering Committee
FRI	Fatigue-Related Incident
FRMS	Fatigue Risk Management System
HMR	Hazardous Material Regulation
HOS	Hours Of Services
IRB	Institutional Review Board
OH&S	Occupational Health and Safety
OO	Owner Operator
OOS	Out Of Service
PASW	Predictive Analytics SoftWare
PSWM	Prior Sleep Wake Model
SMS	Safety Management System
UFP	Unacceptable Fatigue Performance

CHAPTER 1: INTRODUCTION

In recent years, the movement of freights on highways in the United States remained at the same level; however, the total number of highway fatalities declined from 42,708 in 2006 to 33,808 in 2009 – a 20% reduction (Bureau of Transportation, 2011). Although, this is a reasonable reduction, still the number of accidents on highways is high. Among 33,808 fatalities on highways in 2009, 31% of the fatalities (10,850 cases) were truck occupants (Bureau of Transportation, 2011). This indicates that truck accidents are important issue within the US transportation sector.

Driving while fatigued is a major concern among truck occupants. Estimates of the role of fatigue in motor vehicle crashes is various in the previous research studies. Typical range cited goes from 13% (Balkin, Horrey, Graeber, Czeisler, & Dinges, 2011; Perttula & Ojala, 2011) to 20% of road crashes occurring on the major roads and motorways (P. Gander et al., 2011).

In order to control fatigue hazard in the United States, Federal Motor Carrier Safety Administration (FMCSA) introduced perspective Hours-of-Service (HOS) regulations. This regulation defines and enforces limits on duration of resting and driving time that Commercial Motor Vehicle (CMV) drivers are allowed to take (Federal Motor Carrier Safety Administration, 2011).

The main purpose of the HOS regulation is to ensure drivers are provided with enough opportunity to sleep; though, a driver may be provided with the opportunity to sleep, yet be fatigued as a result of non-driving tasks or show behavioral symptoms of being fatigued. After reviewing various studies, it was found that an emerging consensus has questioned the efficiency of these perspective regulations (Dawson & McCulloch, 2005). Consequently, a comprehensive

approach called Fatigue Risk Management System (FRMS) is becoming popular in the fatigue science (Dawson & McCulloch, 2005). FRMS approaches fatigue in a holistic way and has transferred the focus of responsibility for safety away from the regulatory bodies towards companies and individuals.

Compliance, Safety, Accountability (CSA)

FMCSA introduced Compliance, Safety, Accountability (CSA 2010) measurement system to improve large truck and bus safety and ultimately reduce crashes, injuries, and fatalities which are related to CMVs (Federal Motor Carrier Safety Administration, 2012). CSA measurement system evaluates motor carriers based on the violations they have received during inspections. CSA 2010 assesses motor carriers based on seven categories: Unsafe Driving, Fatigued Driving, Driver Fitness, Control Substance/Alcohol, Vehicle Maintenance, Cargo-Related, and Crash Indicator.

FMCSA has specified intervention threshold levels for each category. If a carrier receives a ranking higher than the threshold level on a category, they will undergo more inspection by FMCSA officers. The first step in the intervention process is to inform carriers with unacceptable performance by a warning letter. If carriers continue to perform above the specified thresholds, they will undergo a more rigorous inspection by FMCSA, which costs both the regulatory bodies and motor carriers.

Contributing Organizational Factors to Fatigue Performance

Fatigue control measures are categorized into three levels: regulatory, organizational, and individual. This study focuses on the organizational factors that contribute to fatigue performance. Organizational factors are elements that define an organization's character,

property, function and impact (Department of Energy, 2009). The contributing organizational factors to fatigue performance that have been studied in this paper were: management commitment, schedule design, HOS management, and fatigue training system.

Management commitment for safety-related activities has been a component for successful safety programs (Zohar, 1980). In a study by Arboleda (2003), they found top management commitment was a key factor to safety culture among drivers, dispatchers, and safety directors. Also, at the supervisory level, workers' safety compliance is higher when supervisors are involved with workers in the accident prevention programs and management decision making processes regarding safety (Simard & Marchand, 1997).

Schedule design covers the driving schedule regularity and driver autonomy issues. One of the aspects that makes driving on the roads an especial task is the level of supervision on drivers. In the studied research papers, there was a debate on the level of driver autonomy in the trucking industry. Karasek (1981) described stress reduction as a positive aspect of driver autonomy. In another study by Feyer and Williams (1995), they stated by improving driver autonomy, drivers will take more rest when they become fatigued. On the other hand, some studies indicated the negative aspects of driver autonomy as working early in the morning and late at night, when higher levels of fatigue-related accidents occurs (Soccomanno, 1996).

Motor carriers may develop an HOS management framework to ensure their drivers have received sufficient sleep and are in compliance with legal limits. For instance, a carrier may utilize their vehicles by electronic logbook and on-board monitoring devices to monitor the level of fatigue. Another management practice is to ensure that drivers are qualified for driving tasks. Some people suffer from certain sleep disorders that deprive them of driving for a long time. For

example, people who suffer from sleep apnea feel obstruction during sleep which causes lack of sufficient sleep (National Institutes of Health, 2010) and expose them to a fatigue-related risky situation.

Effective fatigue training system is another organizational factor which contributes to driver fatigue. Drivers who have received safety-related training understand safety regulations and their own organizational viewpoint on driver fatigue. Thus, they will be more aware about the hazards that are associated with their job (Griffin & Neal, 2000). Arboleda (2003) identified that driver fatigue training is a significant predictor of safety culture in the trucking industry. Therefore, they suggested driver fatigue training should be a primary focus in developing safety programs.

Although work-related driving crashes is one of the most common causes of death, injury, and absence from work (Bureau of Transportation, 2011), very limited research has progressed in establishing effective strategies to control work-related road crashes. Even among these research studies, the majority of them have focused on the driver-based data and overlooked the importance of the contributing organizational factors to driver fatigue.

This study begins by providing the research background that identified driver fatigue in trucking industry. Given this framework, hypotheses are offered specifying the association between the identified organizational factors and fatigue performance of the motor carriers. Next, design of the research and methodology is discussed. This is followed by providing the results related to hypotheses. The remainder of the paper is dedicated to discussion of the findings and developing conclusions and recommendations.

CHAPTER 2: RESEARCH BACKGROUND

Driving while fatigued is one of the main causes of CMV crash injuries (Balkin et al., 2011; P. Gander et al., 2011). Estimates of the role of fatigue in motor vehicle crashes is various in the studied research papers. Typical range cited goes from 13% (Balkin et al., 2011; Perttula & Ojala, 2011) to 20% of road crashes occurring on major roads and motorways (P. Gander et al., 2011).

Research studies have shown an association between increasing fatigue which may result in increasing error rates and ultimately reduces safety (Dawson & McCulloch, 2005; Perttula & Ojala, 2011). Accordingly, safety professionals have argued that fatigue is a preventable workplace hazard that organizations may control before it results to an actual accident or injury.

Definition

Managing the health and safety risks associated with fatigue in a workplace requires a clear definition of fatigue. Gander (2011) stated the following operational definition to characterize fatigue:

“Fatigue is the inability to function at the desired level due to incomplete recovery from the demands of prior work and other activities. There are two forms of fatigue: acute and chronic fatigue. Acute fatigue can occur when there is inadequate time to rest and recover from a work period. Cumulative (chronic) fatigue occurs when there is insufficient recovery from acute fatigue over time. Recovery from fatigue requires sufficient good quality sleep.”

Lack of sleep is a significant predictor of accidents, driver fatigue, and fatigue-related crashes (Dawson & McCulloch, 2005; P. Gander et al., 2011; Perttula & Ojala, 2011).

Considering the previous statement, preventing driver fatigue generally is recognized as one of the most important safety issues within the trucking industry.

Hours-of-Service Regulation

To control occupational road crashes resulted from fatigue, governmental bodies have developed compliance-based prescriptive regulations on agreed set of rules for managing hours of work. FMCSA has introduced and enforced HOS regulation in the US. This regulation put restrictions on the following time intervals:

- Maximum time awake for work
- Duration of continuous time on duty
- Minimum opportunities for sleep.

Table 2-1 tabulated the final version of the HOS regulation (Federal Motor Carrier Safety Administration, 2011). It demonstrates the designated limits for both property-carrying and passenger-carrying CMV drivers. Based on this regulation, a CMV driver should document the following time intervals, routinely:

- **On-duty time:** all time from when a driver begins to work or is required to be in readiness to work until the driver is relieved from work and all responsibility for performing work.
- **Driving time:** the time that driver spent at the driving of a CMV.
- **Sleeper berth time:** any amount of time spent inside the sleeper berth (e.g., resting or sleeping).
- **Off-duty time:** any time not spent on-duty, driving, or in the sleeper berth.

Table 2-1: Hours-of-Service (HOS) rules by FMCSA

Property-Carrying CMV Drivers	Passenger-Carrying CMV Drivers
<p>11-Hour Driving Limit May drive a maximum of 11 hours after 10 consecutive hours off duty.</p>	<p>10-Hour Driving Limit May drive a maximum of 10 hours after 8 consecutive hours off duty.</p>
<p>14-Hour Limit May not drive beyond the 14th consecutive hour after coming on duty, following 10 consecutive hours off duty. Off-duty time does not extend the 14-hour period.</p>	<p>15-Hour On-Duty Limit May not drive after having been on duty for 15 hours, following 8 consecutive hours off duty. Off-duty time is not included in the 15-hour period.</p>
<p>60/70-Hour On-Duty Limit May not drive after 60/70 hours on duty in 7/8 consecutive days. A driver may restart a 7/8 consecutive day period after taking 34 or more consecutive hours off duty.</p>	<p>60/70-Hour On-Duty Limit May not drive after 60/70 hours on duty in 7/8 consecutive days.</p>
<p>Sleeper Berth Provision Drivers using the sleeper berth provision must take at least 8 consecutive hours in the sleeper berth, plus a separate 2 consecutive hours either in the sleeper berth, off duty, or any combination of the two.</p>	<p>Sleeper Berth Provision Drivers using a sleeper berth must take at least 8 hours in the sleeper berth, and may split the sleeper-berth time into two periods provided neither is less than 2 hours.</p>

Source: (Federal Motor Carrier Safety Administration, 2011)

To enforce HOS regulation, CMV drivers are obliged to record and keep a daily logbook in the cab and keep their status updated whenever they drive or take rest. A sample logbook is shown in Figure 2-1.

The logbook form is titled "Driver's Daily Vehicle Inspection Report" and includes the following sections:

- Header:** USA Truck, Inc. 3200 Industrial Park Rd. Van Buren, AR 72956. Driver: JOHN DOE.
- Date and Time:** 01/02/2008. Grid from 12:00 to 11:00.
- Activity Tracking:**
 - 1: OFF DUTY: 3 hours
 - 2: SLEEPER: 10 hours
 - 3: DRIVING: 10.5 hours
 - 4: ON DUTY (NOT DRIVING): 0.5 hours
 - 5: REMARKS: LITTLE ROCK, AR PTI; DALLAS, TX LUNCH; CORSICANA, TX LOADING; HOUSTON, TX DINNER; ORANGE, TX OFF DUTY.
- Summary:**
 - Total Hours: 24
 - Hours Worked Last 7 Days: 30.75
 - Hours Available Today: 39.25
 - Hours Worked Today: 11
- Inspection Report:**
 - DATE: 1-2-08
 - Tractor Number: 6788
 - Trailer Number 1: 54321
 - Trailer Number 2: 651
 - Driver's Signature: JOHN DOE
 - Remarks: I detect no defect or deficiency in this motor vehicle as would be likely to affect the safety of its operation or result in its mechanical breakdown.
- Signatures:** MECHANICS SIGNATURE and DRIVER'S SIGNATURE.

Figure 2-1: Sample logbook

Fatigue Risk Management System (FRMS)

Most traditional approaches to fatigue management have focused on HOS regulation. In practice, this regulation if properly enforced only ensures that drivers will be provided with the opportunity to sleep and does not specify whether they are fatigued or not. In another words, perspective HOS regulation is not a sufficient tool in order to ensure that drivers have taken enough rest and are adequate to drive.

There is an emerging consensus that HOS regulation is an ineffective fatigue control measure based on poor scientific defensibility and lack of operational flexibility. Furthermore, implementation of HOS regulation is constantly negotiated between employers, workers' unions, and FMCSA for reasons other than safety issues. For instance, an increase in the flexibility of HOS regulation has often been interpreted (by employees and their representative) as a dishonest attempt to deregulate or disrupt the current or proposed HOS regulation. On the other hand, tightening of HOS regulation has sometimes been interpreted (by employer groups and their advocates) as an insincere attempt to leverage pay and conditions. Consequently, the HOS regulation approach is considered as a labor relations issue, rather than safety management tool (McCulloch, Fletcher, & Dawson, 2003).

To date, most alternative approaches to prescriptive HOS regulation includes fatigue management systems within the general context of Safety Management Systems (SMS) (Dawson & McCulloch, 2005). Based on the SMS, fatigue is considered as a “preventable occupational health and safety (OH&S) hazard” and may be controlled by a risk-based approach.

In 2005, Dawson introduced a conceptual model called Fatigue Risk Management System (FRMS) which is presented in Figure 2-2 (Dawson & McCulloch, 2005). Based on this model, fatigue is considered as a hazard. In order to control this hazard, control measures may be

developed based on the hierarchy of controls. In the fatigue and safety sciences, the concept of FRMS has transferred the focus of responsibility for safety away from the regulator bodies towards companies and individuals.

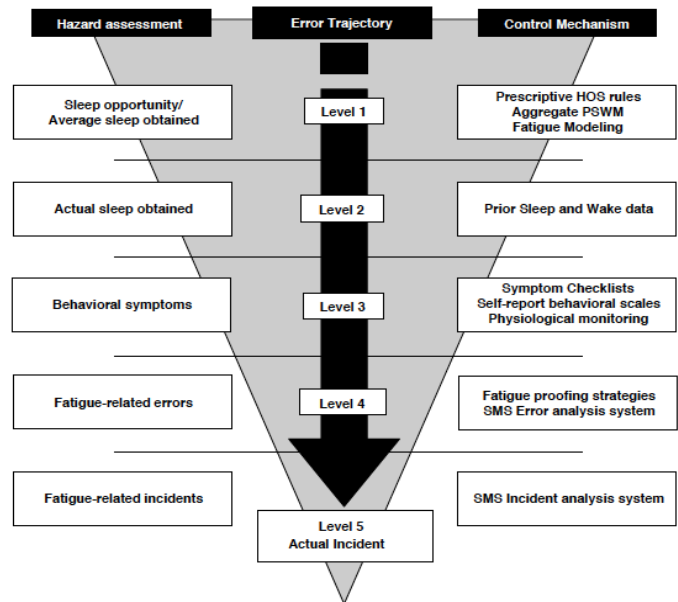


Figure 2-2: Fatigue Risk Management System (FRMS) Model

Based on the FRMS, there are five levels of “error trajectory” to occur a fatigue-related incident (FRI). Potentially, this model can be utilized to identify the root causes of FRIs in a logical and consistent manner. FRMS model indicates that the majority of incidences occur when there is not enough opportunity to sleep, which is presented on the first level of the model. On the second level of the error trajectory to FRIs, there are situations that employees who are given an opportunity to sleep may have not obtained it. These situations may happen as a result of individual difference, non-work demand, and sleep disorders.

On the third level, employees who obtained what is considered, on average, sufficient sleep may experience fatigue-related behavioral symptoms. A common behavioral symptom could be falling asleep at the wheel, which may result into lane or track change. These behavioral

symptoms are considered as near misses of actual crash. On the fourth level, some of these near misses may result into fatigue-related errors. These errors are actually near misses that could result into FRI. On the fifth level, there are some events that actually turn to be a FRI.

Likewise, there are specific control measures for each level of error trajectory. The first level of control measure is to ensure that drivers have been provided with an adequate opportunity for sleep. Typically, HOS regulation covers the first level of control. Providing drivers with enough opportunity for sleep is not a sufficient control measure. In the second level, there should be some control measures to ensure that drivers who are given an adequate opportunity for sleep have actually obtained it.

At the third level, it should be ensured that drivers who had obtained what is considered sufficient sleep are not experiencing actual fatigue-related behaviors. The use of symptom checklist or subjective fatigue scales are examples of control procedures at this level.

Similarly, control measures at the fourth level identify the occurrence of fatigue-related errors that could be resulted into FRIs. Control measures on this level are more technology-related such as: lane trackers, head and blink monitors, etc. Finally, an effective FRMS would require an incident analysis and investigation procedure to investigate FRIs in situations that all control mechanisms failed to prevent the incident.

Compliance, Safety, Accountability (CSA)

Compliance, Safety, Accountability (CSA) is an FMCSA standard to improve large truck and bus safety and ultimately reduce crashes, injuries, and fatalities which are related to CMVs (Federal Motor Carrier Safety Administration, 2012). CSA operational model consists of three components that are shown in Figure 2-3. According to this standard, all commercial motor

vehicles are inspected based on the Federal Motor Carrier Safety Regulations (FMCSRs) and Hazardous Material Regulations (HMRs). Based on CSA, each carrier is assessed in seven categories: Unsafe Driving, Fatigued Driving, Driver Fitness, Control Substance/Alcohol, Vehicle Maintenance, Cargo-Related, and Crash Indicator.

There are specific threshold levels for each category that if a company exceeds them, motor carriers will be further investigated in the intervention phase. These carriers, at first will receive a warning letter. If they continue to perform above the specified thresholds, they will be inspected more rigorously by FMCSA, which costs both the regulatory bodies and motor carriers.

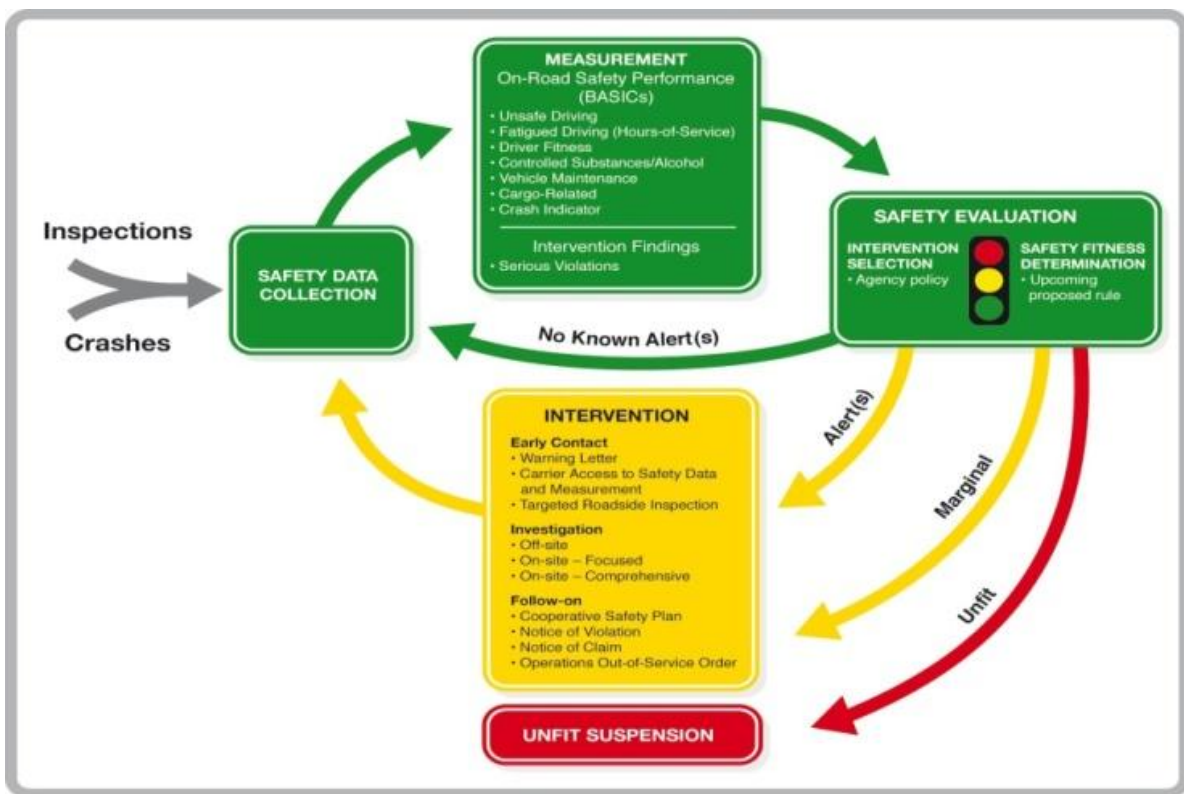


Figure 2-3: CSA operational model

Categories that motor carriers are evaluated are called Behavior Analysis and Safety Improvement Categories (BASICS) and are defined as follows (Federal Motor Carrier Safety Administration, 2012):

- **Unsafe Driving:** operation of CMV in a dangerous or careless manner. Example violations: speeding, reckless driving, improper lane change, and inattention.
- **Fatigued Driving (HOS):** operation of CMVs by drivers who are ill, fatigued, or in non-compliance with the HOS regulations. Example violations: exceeding HOS, maintaining an incomplete or inaccurate logbook.
- **Driver Fitness:** operation of CMVs by drivers who are unfit to operate a CMV due to lack of training, experience, or medical qualifications. Example violations: failure to have a valid and appropriate commercial driver's license.
- **Controlled Substance/Alcohol:** operation of CMVs by drivers who are impaired due to alcohol, illegal drugs, and misuse of prescription or over-the-counter medications. Example violations: use or possession of controlled substances/alcohol.
- **Vehicle Maintenance:** failure to properly maintain a CMV. Example violations: brakes, lights, and other mechanical defects, and failure to make required repairs.
- **Cargo-Related:** failure to properly prevent shifting loads, spilled or dropped cargo, overloading, and unsafe handling of hazardous materials on a CMV. Example violations: improper load securement, cargo retention.
- **Crash Indicator:** histories or patterns of high crash involvement, including frequency and severity.

Based on the CSA methodology, carriers are ranked and those that receive unacceptable safety performance among the similar groups have been identified and preceded for further interventions.

Fatigued Driving Category in CSA 2010

CSA 2010 covers the fatigue-related issues in the Fatigued Driving category. This category involves the violations that resulted from operating a CMV by drivers who are ill, fatigued, or in non-compliance with the HOS regulation (Federal Motor Carrier Safety Administration, 2012). Appendix A is a complete list of roadside inspection violations used in the calculation of Fatigued Driving percentile.

CSA 2010 utilize relevant violations recorded during roadside inspections to calculate Fatigue Driving percentile. The assigned percentile reflects each carrier's safety posture relative to carriers with similar numbers of relevant inspections.

Calculation of Fatigued Driving Measure

The equation used for calculating Fatigued Driving category measure is as follows (Federal Motor Carrier Safety Administration, 2012):

$$BASIC\ Measure = \frac{Total\ of\ time\ and\ severity\ weighted\ applicable\ violations}{Total\ time\ weight\ of\ relevant\ inspections}$$

Equation 2-1

Terms used in this equation are defined as follows:

- **Applicable violation:** any violation in a roadside inspection that matches the FMCSRs listed for Fatigued Driving (Appendix A) during the past 24 months.

- **Relevant inspection:** any driver inspection including those that do not result in a violation in the BASIC, or any other inspection resulting in an applicable BASIC violation.
- **Severity weight:** an score which is assigned to each applicable violation with a value dependent on two parts:
 - i. The level of crash risk relative to the other violations comprising the BASIC measurement. This level is assigned to each applicable violation ranging from 1 (less severe) to 10 (most severe). Violations' corresponding severity weights are presented in Appendix A.
 - ii. Whether or not the violation resulted in an out-of-service (OOS) condition. If an OOS has occurred, an OOS weight of 2 is then added to the severity weights.
- **Time weight:** a time weight of 1, 2, or 3 is assigned to each applicable violation and each relevant inspection based on its age. Violations/inspections recorded in the past 6 months receive a time weight of 3. Violations/inspections recorded between 6 and 12 months ago receive a time weight of 2. All violations/inspections recorded earlier (older than 12 months but within the past 24 months) receive a time weight of 1. This time weight places more emphasis on results of recent inspections relative to older inspections.
- **Time and severity weighted violation:** a violation's severity weight multiplied by its time weight.

Calculation of Fatigued Driving Percentile Rank

CSA methodology applies data sufficiency standards and safety event grouping to assign a percentile rank to carriers. This percentile rank is utilized as a safety performance measure for motor carriers. Calculation of percentile rank is as follows:

1. Firstly, the number of relevant inspection and number of inspections with at least one BASIC violation is determined. Then, carriers will be assigned a safety event grouping based on their number of relevant inspections. Table 2-2 indicates the safety event grouping for the Fatigued Driving category.
2. Within each group, all the carriers' BASIC measures are ranked in ascending order. The ranked values are transformed into percentile from 0 (representing the lowest BASIC measure) to 100 (representing the highest BASIC measure). Thus, the higher the percentile, the worse safety performance the carrier has performed when comparing to other motor carriers.

Table 2-2: Safety event groups for the Fatigued Driving category

Safety event group	Number of relevant inspections
1	3-10
2	11-20
3	21-100
4	101-500
5	501+

Contributing Organizational Factors to Fatigue Performance

There are three different operational levels when it comes to fatigue risk management: regulatory, organizational, and individual levels. However, these three levels are significantly interacted with each other, this study focuses on organizational factors and the control measures

that an organization may take in order to control fatigue hazard. Organizational factors are elements that define an organization's character, property, function, and impact (Department of Energy, 2009).

A wide range of organizational factors have been identified which may impact fatigue management in transportation sector. Some of the articles studied the organizational factors in the safety culture concept. Reasen (1998) mentioned that improvement in organizational safety culture is more effective than increased supervision or more rigorous procedures in enhancing safety performance.

Arnold (2001) studied the factors that negatively and positively may impact fatigue in transportation including:

- The cultural, regulatory, and enforcement environments;
- The size of the company;
- The nature of the business (type of transported material);
- The level of commitment to health and safety in the company;
- The presence of SMS, including systems for non-punitive reporting of safety concerns;
- The nature of supervision (in transport operations employees are typically mobile and can be out of contact with supervisors for a long period of time);
- Incentives;
- The level of knowledge about fatigue among staff; and;
- For individual employees, their perceived quality of working and domestic life.

Arboleda (2003) studied 116 trucking firms to identify how different positions within an organization have different perception of safety culture. The organizational levels they analyzed

were: drivers, dispatchers (who are the supervisors in the trucking industry), and safety directors. They found safety training, opportunity for safety participation, and management commitment to safety are antecedents of safety culture in all organizational levels.

Moses (1994) studied 75,500 registered truck firms in the Federal Highway Administration (FHWA) database. They analyzed the entire FHWA motor carrier safety records and identified the following factors as contributing factors to fatigue in motor carriers:

- Demographic differences (size, type of operation, and employment)
- Fatigue training system
- Driver recruitment
- Compliance management.

The purpose of this study is to examine the current knowledge and practices in regard to organizational factors in the field of fatigue risk management. Considering this point and the above studies, the organizational factors that are studied in more detail are as follows:

- Management commitment
- Schedule design
- HOS management
- Training system.

Management commitment

Management support and appreciation for safety-related activities has been a condition for successful safety programs (Zohar, 1980). Management commitment is recognized as an important predictor of employees' compliance with safety measures. Also, in the supervisory level, workers' safety compliance is higher when supervisors are involved with workers in the

accident prevention programs and management decision making processes regarding safety (Simard & Marchand, 1997).

In Arboleda (2003) study, they found top management commitment was a very influential factor to safety culture among drivers, dispatchers, and safety directors. Based on the above studies, safety program evaluation, fatigue risk management policy, and safety incentives were identified as elements of management commitment factor.

Safety program evaluation

An important challenge for the FRMS is the evaluation of the implemented safety programs. This challenge also applies more broadly to safety management systems, as safety program evaluation is a key factor in the overall safety management continuous improvement process. Self-evaluation is an intrinsic feature of safety management systems, including FRMS, which helps organizations to learn and develop their own safety management strategies in a changing environment (P. Gander et al., 2011).

Ideally, an organization may evaluate its FRMS by comparing its fatigue performance before and after implementation of the safety programs. This process may be conducted both internally and/or externally. The choice of improvement indicators is essential. Typically, fatigue reduction and productivity improvement are leading indicators of FRMS.

Fatigue risk management policy

Fatigue risk management policy should be part of a company's safety policy and it must be open and transparent. An effective fatigue risk management policy should at least cover the following elements (P. Gander et al., 2011):

- Commitment to the fatigue risk management from the highest level of the organization;
- Specification of accountability for fatigue risk management in the organization;
- Description of the responsibilities of company management and employees;
- Terms of references for the Fatigue Management Steering Committee (FMSC), including frequency of meetings;
- Documentation of fatigue reporting mechanisms;
- Policies for identifying and managing employees who are fatigued;
- Commitment to provide training;
- Commitment to act on recommendations regarding fatigue risk management arising from internal audits.

Safety incentives

Historically, work that is more hazardous attracts higher remuneration and fosters less safe practices (P. Gander et al., 2011). The common practice of paying truck drivers by the distance travelled or by the load delivered may encourage speeding and excessive hours of work and has been identified as contributor to major truck crashes (National Transportation Safety Board, 1995).

Schedule Design

One of the greatest aspects of over-the-road truck driving work is the autonomy to set one's own work schedule (i.e. determine when to drive and when to rest). Flexible work schedule increasingly are being adopted by organizations to satisfy employees' desire for this form of autonomy.

There are different research studies that mentioned the positive and negative aspects of driver autonomy. Karasek (1981) stated that employee's autonomy seems to diminish the amount of perceived overload and provides a control measure to cope with stress. In a study by Feyer and Williams (1992), they surveyed 960 truck drivers and suggested shorter trips and greater flexibility in arranging the timing and scheduling of trips were related to lower levels of reported fatigue. They concluded when drivers are provided with more flexible schedule they were more likely to arrange their time to overcome fatigue and avoid starting their trips in the early hours of the morning.

Furthermore, scheduling autonomy may create positive effects by allowing drivers to use their own unique circadian rhythms. Also, autonomy for drivers allows them to adjust themselves to unpredictable driving situations such as: heavy traffic, weather problems, and accommodate individual differences in the need for sleeping and rest.

On the other hand, permitting scheduling autonomy may have unintended negative effects when it interferes with suppliers and customer schedules. In fact, drivers have to stick to the customer needs; otherwise, there would be some negative effects for the organization they work for. In practice, this form of job autonomy in the trucking industry may become a hazard if drivers work at night or in the early morning, when there is a higher possibility of fatigue-related accident (Soccomanno, 1996).

Scheduling autonomy also allows drivers to deviate from the natural 24-hour rhythm of work that favors daytime work schedules over nighttime work schedules that cause circadian fatigue (Soccomanno, 1996). Even in situations that drivers have less autonomy over work, fatigue may occur. Braver et al. (1999) found that dispatchers rarely think they are assigning tight schedules to drivers, while drivers report feeling pressured by dispatchers to continue driving even when they are fatigued (Chatterjee et al., 1996).

Overall, in the trucking industry drivers' autonomy may not have all the positive implications that the literature describes for other industries (Karasek et al., 1981). For instance, in the Soccomanno (1996) study, they stated reducing driver autonomy by requiring drivers to drive the same hours each day following prescribed routes could enhance safety, as these practices diminish fatigue. Moreover, if hours of work are not well monitored and non-driving work is not compensated, there would be an incentive for drivers to exercise their job autonomy and drive longer to increase their compensation based on mileage reimbursement (Williams, 2001).

Hours-of-Service (HOS) Management

Fatigue differs from most of OH&S hazards such as exposure to noise, toxic substances, and fall/slip hazards. The difference is that fatigue is affected by all of the waking activities, not only those that are work-related. An organization may develop an HOS compliance program in order to control fatigue. The purpose of HOS management program is to provide adequate opportunity to sleep for drivers. In the following sections, an overview of the HOS management program is presented.

Restrictions on the amount of sleep and wakefulness

Based on the FRMS, employers should ensure that employees who have been provided with the opportunity to sleep (by HOS regulation) have actually obtained it. In recent years, there has been an emerging consensus that many of perspective shift work rules do not provide a reliable control mechanism that prevents fatigued individuals from unsafe working practices (Dawson & McCulloch, 2005). This is primarily due to a failure to distinguish between non-work and sleep time in determining the recovery value of time-off.

Dawson (2005) suggested that knowledge of the frequency distribution of prior sleep and wake hours could give a rational basis for determining the level of fatigue an individual is likely to experience within a given shift. He introduced Prior Sleep Wake Model (PSWM) which is presented in Figure 2-4. Based on this model, effective fatigue-risk management can be determined by an algorithm that is comprised of three simple calculations:

- X: prior sleep in the last 24 hours
- Y: prior sleep in the last 48 hours
- Z: the length of wakefulness from awaking to the end of work.

To facilitate PSWM, organizations should develop appropriate threshold levels for each of the stated criteria. It is important to note that the thresholds may potentially vary as a function of fatigue-related risk within a workplace. For example, the threshold values may be adjusted to a more conservative level for a task that exposes employees to a higher level of fatigue.

Then, prior to commencing work, an employee should determine whether they have obtained the required threshold for being sleep and awake or not. Where obtained

sleep does not meet the threshold, there would be a significant increase in the likelihood of a fatigue-related error. In this situation, the organization should implement appropriate hazard control procedures for the individual.

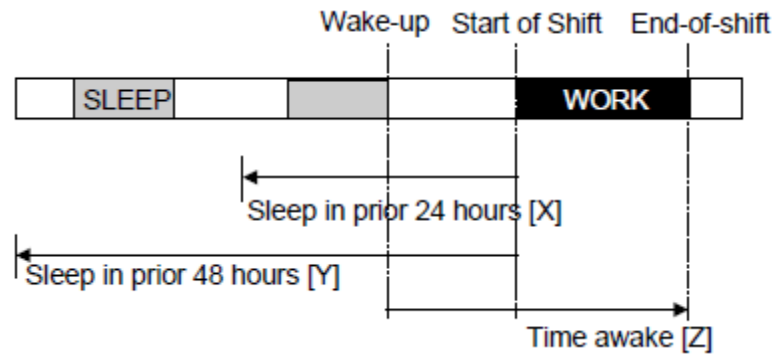


Figure 2-4: Dawson's Prior Sleep Wake Model (PSWM)

Also, a carrier may prevent drivers of driving after being declared as OOS. This situation occurs when a driver have been driving more than the regulated limits. In Australia and New Zealand, there is a regulation named “chain of responsibility” offences (P. Gander et al., 2011). Based on this regulation, a person who employs or controls drivers subject to the HOS regulation limits can be fined up to \$25,000 if they knew, or should have known, that a driver under their authority breached those limits.

Logbook system

Based on the HOS regulation, drivers have to keep their work logbook properly updated (Federal Motor Carrier Safety Administration, 2011). Commonly, there are paper logbooks that drivers fill out daily. These logbooks are investigated during roadside inspections. Filling out a paper logbook typically comes with human errors. Moreover, keeping track of the working and driving hours may be overlooked by some drivers.

Thus, some companies have changed their logbook system to electronic logbook system, which drivers have a better control on their hours of driving.

Medical examination

An important part of an FRMS is to ensure that drivers are qualified for driving tasks (P. Gander et al., 2011). Some people have certain sleep disorders that deprive them of driving for a long time. For instance, people who suffer from sleep apnea feel obstruction during sleep, causing lack of sufficient sleep (National Institutes of Health, 2010) and exposing them to a fatigue-related risky situation. To manage these risks, strategies that include diagnosis and treatment of sleep disorders should be available in a timely manner and there should be a clear policy around conditions of return to work.

Fatigue reporting system

In order to reduce the likelihood of similar incidents or accidents, the safety management system in the trucking industry largely depends on reporting. Fatigue reporting can be a part of a wider hazard reporting system. If a fatigue reporting system properly implemented and more near misses are reported, there would be higher probability that the situations that provoke FRIs be identified and controlled.

Steps to encourage a reporting culture include: making the process of reporting easy, report fatigues as soon as possible, make informative feedback to the reporter on action taken, obvious policy against disciplinary action unless the event involves

deliberate action, and the opportunity for confidentiality and anonymity (P. Gander et al., 2011).

Modern approaches in safety management emphasize the use of “leading indicators” (those which appear early in the existing of risk), rather than the more traditional focus on “lagging indicators” (including actual incidents), which appear later and often require a more urgent response (Reason, 1997). Fatigue reporting system is a good example of a leading indicator and responding to the reported cases can be viewed as a proactive or even preventive measure rather than responding reactively to FRIs (P. Gander et al., 2011).

Voluntary fatigue reporting system provides one type of ongoing monitoring of fatigue hazard in an organization. In addition, information can be gathered through methods such as staff surveys and other routinely collected information such as absenteeism, staff turnover, and internal/external audits, etc.

On-board control devices

A number of technologies have been developed that aims to detect operator fatigue in real time (Balkin et al., 2011). These technologies are onboard devices that monitor drivers’ state or level of performance as well as devices that predict fatigue in advance of work cycle or trip. Examples of these technologies are: lane trackers, video capture systems, head and eye blink monitors. These devices can be used either to trigger alarms or to activate other safety systems. For instance, head and eye blink systems monitor eye closure and in cases extreme drowsiness is evident, an alert signal will be

triggered. In an effective FRMS, it is important to consider balance of investment in technologies to detect fatigue versus strategies to mitigate it.

Fatigue Training System

Based on a report by Federal Highway Administration (1997), driver training is considered as one of the most fundamental elements in an FRMS. Drivers who have received safety-related training understand organizational safety incentive systems, have greater knowledge regarding the regulations and why they have to adhere to them, and are more aware about the hazards in their workplace (Griffin & Neal, 2000).

Arboleda et al. (2003) identified that driver fatigue training is a significant predictor of safety culture in the trucking industry. Therefore, they suggested driver fatigue training should be a primary focus in developing a safety program. An effective FRMS provides a common knowledge and should include (P. Gander et al., 2011):

- Explanation of the current state of knowledge about physiological, psychological, and operational factors that cause fatigue;
- Discussion of the specific operational hazards that are exacerbated by fatigue;
- Education on the use of appropriate fatigue mitigation strategies, including strategies to assist drivers to arrive at work in the least fatigued condition and tactics to help maintain a safe level of functioning at work and commuting home;
- Role and responsibilities for fatigue reporting system, consequences of coming to work too tired, what to do about chronic sleep problems, etc.

Training and education should be specified for different groups in the organization. Thus, the content and depth of knowledge may vary for managers, drivers, dispatchers, and safety staff. Enabling employees to be aware about the nature of fatigue and how they can control it will diminish the view that fatigue is somehow an indication of personal inadequacy. This awareness shows that fatigue is a normal consequence of an imbalance between the exertion of work and other waking activities and is recovered by sleeping (P. Gander et al., 2011).

Evaluation of the effectiveness of driver fatigue training is an overlooked area. An evaluation of a fatigue training program for light and heavy vehicle drivers who were working for a major oil company found significant improvement in knowledge immediately after a 2-hour live training session, which was still effective for the following 26 months after the training (P. H. Gander, Le Quesne, L., Armstrong, H., Feyer., 2005). At follow-up, the great majority of the study group rated their training as at least moderately useful. About half of the group, reported changing their fatigue management strategies at home as a result of training, and half of them reported changing their strategies at work. They concluded that fatigue training is useful for developing a fatigue management culture within an organization.

A comprehensive FRMS includes both strategies to reduce the likelihood of employees being fatigued at work (e.g., better work schedule) and strategies to mitigate the risk represented by a fatigue-impaired driver in the workplace (e.g., prior sleep wake model).

CHAPTER 3: ASSESSMENT OF OPPORTUNITIES

This chapter explores the identified problems in fatigue management in the trucking industry. It continues with the objectives of this study and the proposed hypotheses.

Statement of the Problem

The threshold level for Fatigued Driving category in CSA measurement system is 65. Carriers which receive a percentile ranking above this threshold will be in the intervention zone by FMCSA. According to the CSA database released on December 2011, there were more than 27,000 motor carriers which have received rankings above the specified threshold level on Fatigued Driving category. These carriers should implement fatigue control measures in their organizations to control fatigue and reduce their rankings; otherwise, they will be held in the intervention zone and will undergo comprehensive inspections and follow-up actions.

CSA 2010 has proved that there were 27,000 motor carriers with an obvious unacceptable performance in Fatigued Driving category. In practice, driver fatigue is not limited to these carriers which have received a score above threshold level in CSA. In fact, CSA 2010 is not a validated measurement system and it may incorrectly overlook some carriers with unacceptable safety performance. Consequently, there may be more carriers that suffer from not properly managing fatigue hazard in their organization. As an example, in December 2011, there were 9,000 motor carriers that received a percentile above 50 and below 65, yet they were not covered in the intervention process by FMCSA.

These carriers should monitor and manage their fatigued driving performance and improve their scores before they are transferred to the intervention zone. In this way, they will be able to handle the problem in a timely manner and focus more on the long-term and effective

control measures instead of some short-term and expensive ones. Also, there is a possibility that FMCSA changes the threshold level which will be resulted into a sudden obligation of improvement in the Fatigued Driving category for some carriers.

Even carriers that have received rankings below 50 and are considered acceptable in their performance on Fatigued Driving category may consider their Fatigued Driving ranking as an external evaluation measure to monitor their fatigue performance. In fact, they may utilize this external tool to evaluate how their corrective actions affected their fatigue performance. Overall, improvement on Fatigued Driving category would benefit all the registered carriers in the CSA database.

Based on the CSA intervention process, carriers that have received a ranking percentile above the threshold level in Fatigue Driving category have received warning letters. However, the only information available to these carriers is the number and type of violations that they have received.

In order to improve Fatigued Driving ranking, a carrier may implement different safety programs. But the point is that there are limited scientific studies to suggest that a specific control measure (i.e., training, management commitment, medical examination, remuneration and incentives, etc.) will result into an improvement in fatigue management and specifically Fatigued Driving category in CSA.

Secondly, carriers with unacceptable fatigue performance should be able to identify which of their organizational factors and associated safety practices contributed to their unacceptable fatigue performance. Accordingly, they will be able to develop plans to improve those organizational factors and implement the safety programs tailored to their organizational needs.

Thirdly, even carriers with acceptable fatigue performance may not recognize which of their organizational factors and implemented safety practices have contributed to their fatigue performance. In this regard, they may implement a control measure which is not recommended to contribute to fatigue performance improvement or overlook some safety practices that had contributed to their fatigue performance.

Finally, because of the nature of CSA measurement system which is based on the HOS regulation, carriers with unacceptable fatigue performance may emphasis on complying with HOS regulation. Although, this control measure only fulfill the first level of FRMS, carriers should be informed that there are other control measures on the higher levels of FRMS that contribute to their fatigue performance as well.

Objectives

In order to improve the implementation of FRMS, a better understanding of the complex relationship between organizational factors and fatigue performance is essential. The organizational factors that have been studied in this research project were introduced in Chapter (2). In all of the stated studies, the main focus of the researchers was to determine if there was any positive or negative association between organizational factors and safety performance. Indeed, there is limited research on measuring effectiveness of implemented safety programs to control fatigue based on an integrated and external safety measurement system like CSA 2010.

The purpose of this research project was to identify the contributing organizational factors that resulted into acceptable or unacceptable performance for motor carriers in the Fatigued Driving category. The results of this research would assist carriers to plan to improve or keep their fatigue performance below the threshold levels effectively and efficiently.

Followings are the hypotheses of this research project:

1. Management is more committed to safety in carriers with better fatigue performance.
2. Carriers that consider more fatigue and safety issues in route and schedule design phase have better fatigue performance.
3. Carriers that have implemented more safety programs to manage their drivers' hours-of-services have better fatigue performance.
4. Carriers that provide more training to their employees (dispatchers and drivers) have better fatigue performance.

CHAPTER 4: METHODOLOGY

As it was explained in Chapter (3), the main hypothesis of this study was to determine the organizational factors that contribute to fatigue performance. To address this issue, motor carriers with the best and the worst fatigue performance had been selected from the CSA 2010 database. A survey instrument which addresses fatigue and safety control measures in the motor vehicle industry was developed. Then, the surveys were distributed between the selected motor carriers and the received responses were analyzed to support or reject the hypotheses of this study.

Carrier Selection

All of the motor carriers, which are authorized to operate in the United States, have a unique DOT number. In December 2010, FMCSA implemented CSA 2010 on all of the registered motor carriers, nationwide. CSA 2010 provides an external and integrated safety performance assessment tool to evaluate motor carriers. Therefore, in order to obtain the necessary information for the objectives of this study the CSA database was utilized.

CSA database have been acquired through the FMCSA Website. There are two categories of information for each carrier in the database. The first category is the general information which covers: DOT number, contact information, and number of power units and drivers. The second category of information is the rankings of the motor carriers on each CSA category. A list of the available information for each carrier in the CSA database is presented in Appendix B.

Based on the scope of this research, motor carriers that did not match the criteria of the study were removed from the target population. Following criteria were considered when selecting motor carriers from the target population:

- **Carrier headquarters inside the United States:** in the CSA database, there are a number of carriers which their headquarters are not located in the United States. Headquarters of the majority of them are located in Canada and Mexico. In fact, the environment and regulatory organizations that have jurisdiction over them are outside of the US. These motor carriers were removed from the target population.
- **Minimum number of 10 drivers:** truck drivers who are operating their own trucks are considered as Owner-Operators (OO). These truck drivers are not considered as an organization, yet they have specific records in the CSA database. Thus, studying these operators would not assist to identify the contributing organizational factors to fatigue performance. Consequently, in order to properly address the motor carriers that inherit an organizational framework, it was assumed that they should employ a minimum number of 10 drivers. In this case, these companies may develop safety programs to control their fatigue performance. Another purpose was to remove small firms that operate only seasonally. Considering these points, motor carriers with less than 10 drivers were removed from the database.
- **Not registered as passenger transportation:** safety regulations, CSA intervention thresholds, and nature of the passenger transportation carriers are different from other motor carriers. Consequently, motor carriers which transport passengers were removed from the database.
- **Available data on Fatigued Driving and Unsafe Driving categories:** as it was mentioned in Chapter 2, CSA measurement system evaluates motor carriers based on seven different categories: Unsafe Driving, Fatigued Driving, Driver Fitness, Controlled Substance/Alcohol, Vehicle Maintenance, Cargo-Related, and Crash Indicator. The

category which covers fatigue-related issues and HOS regulation is Fatigued Driving category. In addition to Fatigued Driving category, Unsafe Driving category was considered in this study as a safety performance indicator for motor carriers. The rationale behind choosing a second criterion as a safety performance indicator was that currently CSA 2010 is not a validated evaluation system. For example, a carrier may have been ranked as unacceptable in Fatigued Driving category, in condition that the carrier was incorrectly evaluated as unacceptable in that category. However, if a carrier has been ranked in two different categories as unacceptable, it is more likely for the carrier to perform unacceptable. Thus, carriers which had data on both Fatigued Driving and Unsafe Driving categories were selected for further consideration.

After removing the carriers that did not meet the above criteria, the remnant carriers shaped the target population.

Based on the Fatigued Driving scale, motor carriers are ranked from 0 to 100, which higher ranking on the scale indicates worse safety performance for that carrier. Consequently, this scale has been utilized to select the motor carriers with the best and the worst fatigue performance. Based on the hypothesis, it was assumed that these two study populations, carriers with the best and the worst fatigue performance, possessed different organizational factors that resulted into different fatigue performance among carriers.

The rankings that carriers have received on Fatigue Driving and Unsafe Driving categories indicated whether they had “acceptable” or “unacceptable” fatigue performance. Those carriers that had received rankings below 25 in Fatigued Driving and Unsafe Driving categories were considered as carriers with “acceptable fatigue performance” (AFP) and carriers

that had received rankings above 75 on these categories were considered as carriers with “unacceptable fatigue performance” (UFP). The rationale to choose these intervals was to select the companies with the best and the worst fatigue performance as further from each other as possible. Figure 4-1 illustrates the position of the acceptable and unacceptable fatigue performance study populations on the Fatigued Driving ranking scale.

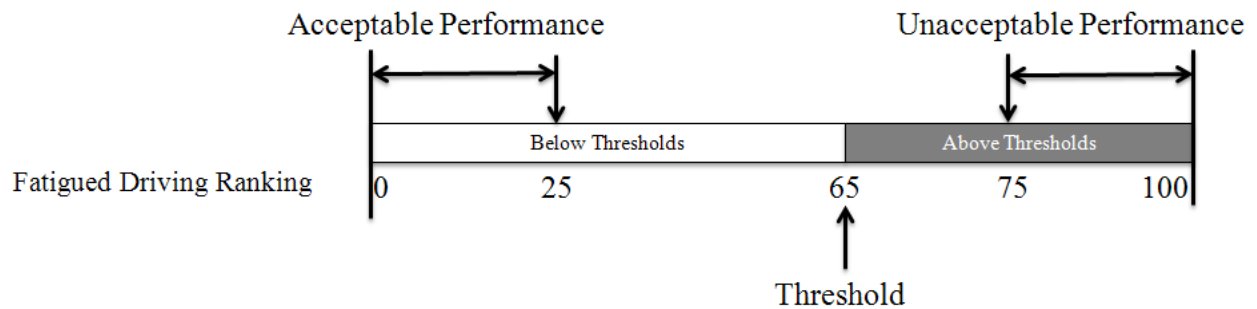


Figure 4-1: Carriers with unacceptable and acceptable fatigue performance on Fatigued Driving scale

As it is presented in Table 4-1, by December 2011, there were 1,278,153 registered motor carriers in the CSA database. 12,489 of the registered carriers met the criteria for this study. Among these carriers, 1,116 motor carriers ranked below 25 on Unsafe Driving and Fatigued Driving categories and 724 motor carriers ranked above 75 on these categories. These last two populations shaped the study populations for this research.

Table 4-1: Number of motor carriers in target and study populations

		Number of motor carriers
Total number of registered motor carriers		1,278,153
Carriers that meet the criteria for this research		12,489
Fatigue Performance Categories	Acceptable	1,116
	Unacceptable	724

Survey Development

In order to gather information from the motor carriers a survey instrument was developed. The basis of the survey for this study was a survey by Arbodela (2003). Their survey was customized based on the literature review and hypotheses of this study. Table 4-2 indicates the identified dependent and independent variables which were related to the hypotheses of the study. For each of the dependent and independent variables, a question was considered in the survey.

Questions were developed in four categories: management commitment, schedule design, HOS management, and training system. Overall, there were 28 questions concerning the safety practices that the company has implemented in order to control fatigue. Indeed, there were not any questions regarding individuals or their perception on driver fatigue; instead questions mainly focused on the safety practices that an organization may implement to control driver fatigue.

Table 4-2: Dependent and independent variables

No.	Organizational factor	Dependent variable	Independent variable
1	Management commitment	CSA Fatigued Driving	Safety program evaluation
			Follow-up programs
			Formal fatigue control policy
			Safety budget
			Incentives – on-time delivery
			Incentives – safe driving
2	Schedule design	CSA Fatigued Driving	Considering individual differences
			Fatigue issues considerations in route design
			Fatigue issues considerations in schedule design
			Solo drivers
			Team drivers
			Fixed schedule
			Irregular schedule
3	Hours-of-Service management	CSA Fatigued Driving	24-Hours restrictions
			7-days restrictions
			Determination the least limit of sleep hours before work
			Restriction of wakefulness
			Prevent drivers of driving after being declared as out-of-service
			Logbook system
			Medical examination
			On-board devices
			Reporting system
			Prevent drivers of loading/unloading
			Contact with shippers
			Give more time for flexible schedule
4	Training system	CSA Fatigued Driving	New drivers training
			Dispatchers training
			Training evaluation
			Training frequency
			CSA training

Then, the draft survey was distributed between 22 experts to obtain their comments on the survey. Experts were in various fields from linguistics and survey development to safety and transportation professionals. Appendix C is the email which was sent to the experts. The main areas of the concern that had been asked from the experts were:

- Appropriateness in length
- Clearness of the questions
- Reaction of the respondents to think about their organizations
- Survey navigation
- Survey interface.

Besides the above areas of concern, comments from experts were received about the possible questions that might be added to or be removed from the survey. Experts provided their ideas on how survey questions might be changed to address driver fatigue issues more properly and receive more responses from the motor carriers. Afterwards, the survey was revised and the final version of the survey was submitted for the institutional review board (IRB) approval to the East Carolina University IRB Committee. The survey and IRB Approval is provided in Appendix D, and Appendix E, consecutively.

Data Gathering

Participants of the survey were email addresses that motor carriers declared to FMCSA for corresponding purposes. These email addresses were available on the CSA database. It was assumed that the persons who check these emails had authority in their company and were familiar with their organization's safety management.

The survey was published on an on-line survey provider called “Qualtrics”. By using this Web-based software, paper survey was transformed to a Web-based version. Then, surveys were distributed between the selected carriers. The email that the carriers had received is provided in Appendix F. In the emails that motor carriers had received, it was indicated that they should respond in two weeks. Furthermore, three reminder emails had been sent to them in the following two weeks of launching the survey.

Data Analysis

Once the survey participation deadline was passed, the completed responses were exported from the “Qualtrics” to PASW (Predictive Analytics SoftWare) Version 18. Afterwards, data analysis was conducted to reject or retain the hypotheses of this study. The statistical tests that were utilized were based on the nature of the dependent and independent variables (James D. Leeper, 2000). Table 4-3 presents these statistical testes. Based on the nature of the dependent variable, Chi-square and Mann-Whitney tests were performed to assess the difference in distribution between motor carriers with acceptable and unacceptable fatigue performance. Then, based on the procedure for each statistical test, null hypothesis were rejected or retained.

Table 4-3: Selection of statistical tests

Nature of independent variable	Nature of dependent variable(s)	Test(s)
1 IV with 2 levels (independent groups)	Interval and normal	2 independent sample t-test
	Ordinal or interval	Mann-Whitney test
	Categorical	Chi-square test
		Fisher's exact test
1 IV with 2 or more levels (independent groups)	Interval and normal	One-way ANOVA
	Ordinal or interval	Mann-Whitney test Kruskal-Wallis Test
	Categorical	Chi-square test
		Fisher's exact test

CHAPTER 5: RESULT

The link for the surveys was emailed to 1,369 motor carriers which met the participation criteria. According to the criteria introduced in Chapter (4), 846 (61.8%) carriers were in the AFP category and 505 (36.9%) carriers were in the UFP category. Among them, 94 AFP carriers (11.1% of the total AFP carriers) and 40 UFP carriers (7.9% of the total UFP carriers) responded to the survey. Table 5-1 shows the frequency of the participated carriers in the study.

	N	n	Percent
AFP	846	94	70.1
UFP	505	40	29.9
Total	1351	134	100.0

For each organizational factor category (management commitment, schedule design, HOS management, training system) a list of contributing elements were identified. These elements were presented in Table 4-2. Then, hypotheses of the research, based on Table 4-3 were tested by the proper statistical tools.

Management Commitment

Table 5-2 shows the null hypotheses and results of statistical tools for management commitment factor. There were two null hypotheses that were rejected. The distributions of the safety program evaluation variable were not the same in the two study population ($\chi^2 (1, n=134) = 4.1, p= .043$). As it is shown in Figure 5-1, in a situation that all of the UFP carriers ($n=40$) stated they evaluated their safety programs, 90% ($n=85$) of the AFP carriers declared they implemented a safety evaluation program.

Another variable which showed different distribution among two groups was the amount of allocated budget for safety ($U (1) = 1270, Z= -2.9, p= .003$). 51% ($n= 47$) of the AFP carriers

allocated budgets above \$ 20,001 per year for their safety programs; on contrary, 23% (n=9) of UFP carriers assigned the same amount of budget per year. Figure 5-2 shows that carriers that have assigned more safety budget have performed better regarding driver fatigue.

Table 5-2: Null hypotheses and results of statistical tests for management commitment factor

No	Null Hypothesis	Dependent variable	Independent variable	Test	n	Test Value	DF	Z Value	P Value	Decision
1	The distribution of “safety program evaluation” is the same across categories of fatigue performance.	CSA Fatigued Driving	Safety program evaluation	Chi-Square	134	4.1	1	-	.043	Reject
2	The distribution of “follow-up programs” is the same across categories of fatigue performance.	CSA Fatigued Driving	Follow-up programs	Chi-Square	134	1.4	1	-	.230	Retain
3	The distribution of “formal policy” is the same across categories of fatigue performance.	CSA Fatigued Driving	Formal policy	Chi-Square	134	0.0	1	-	.868	Retain
4	The distribution of “safety budget” is the same across categories of fatigue performance.	CSA Fatigued Driving	Safety budget	Mann-Whitney Test	134	1270.0	1	-2.9	.003	Reject
5	The distribution of “Incentives – on-time delivery” is the same across categories of fatigue performance.	CSA Fatigued Driving	Incentives – on-time delivery	Chi-Square	134	3.6	1	-	.059	Retain
6	The distribution of “Incentives – safe driving” is the same across categories of fatigue performance.	CSA Fatigued Driving	Incentives – safe driving	Chi-Square	134	0.7	1	-	.395	Retain

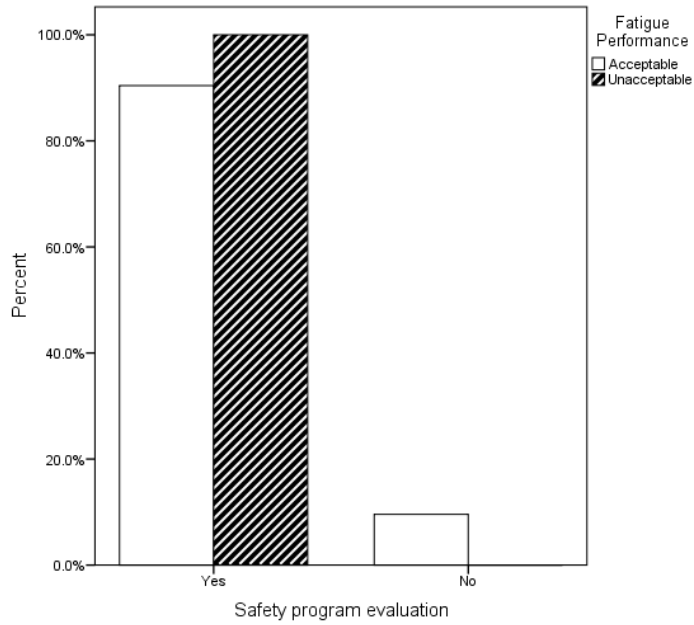


Figure 5-1: Distribution of carriers that evaluates their safety program within different categories of fatigue performance

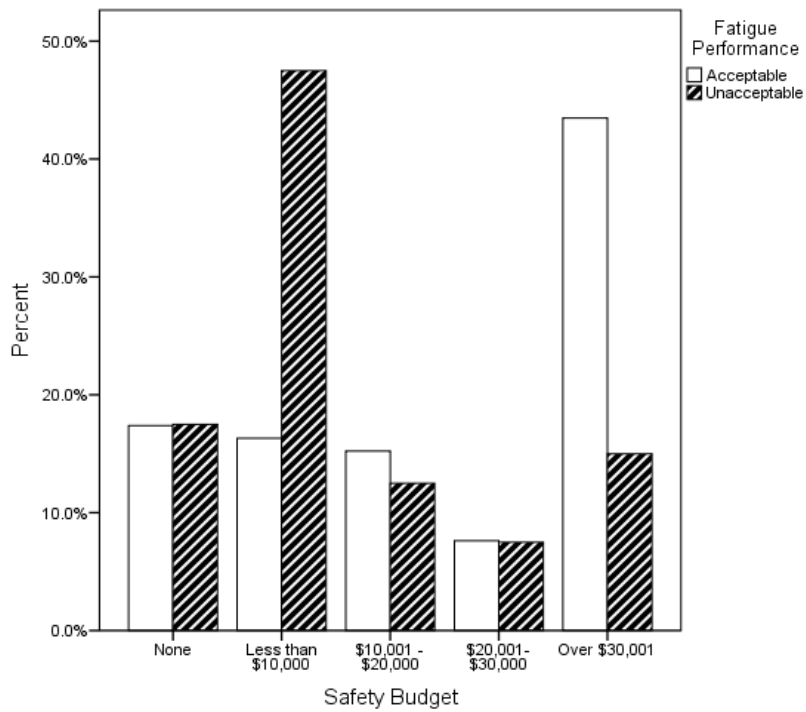


Figure 5-2: Safety budget distribution within different categories of fatigue performance

Schedule Design

Table 5-3 shows the null hypotheses and results of the statistical tools for the schedule design factor. All of the null hypotheses related to the schedule design factor were rejected. There were more UFP carriers that considered individual differences when assigning driving tasks to their drivers ($\chi^2 (1, n=125) = 16.3, p<.001$). Figure 5-3 shows that 52% (n= 45) of AFP carriers and 90% (n= 34) of UFP carriers considered this point in their company.

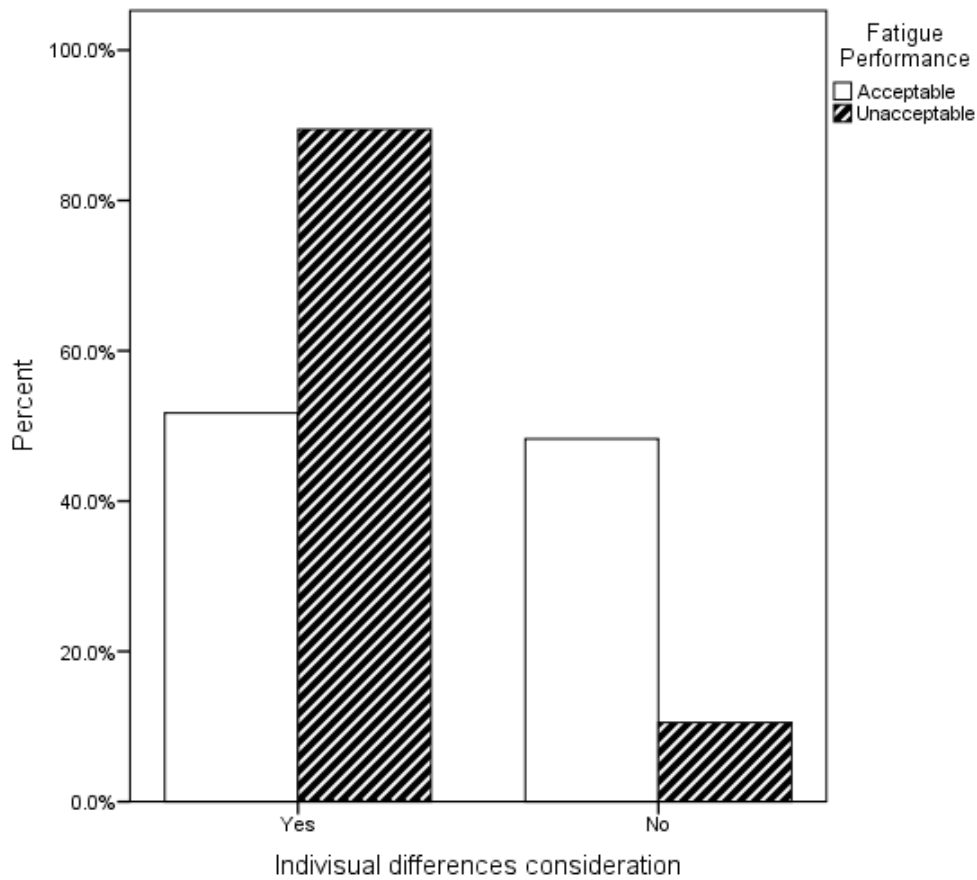


Figure 5-3: Percentage of individual differences consideration within categories of fatigue performance

Table 5-3: Null hypotheses and results of statistical tests for schedule design factor

No.	Null Hypothesis	Dependent variable	Independent variable	Test	n	Test Value	DF	Z Value	P Value	Decision
7	The distribution of “considering individual differences” is the same across categories of fatigue performance.	CSA Fatigued Driving	Considering individual differences	Chi-Square	125	16.3	1	-	<.001	Reject
8	The distribution of “Fatigue issues considerations in route design” is the same across categories of fatigue performance.	CSA Fatigued Driving	Fatigue issues considerations in route design	Chi-Square	126	14.3	1	-	<.001	Reject
9	The distribution of “Fatigue issues considerations in schedule design” is the same across categories of fatigue performance.	CSA Fatigued Driving	Fatigue issues considerations in schedule design	Chi-Square	129	9.3	1	-	.002	Reject
10	The distribution of “Team drivers” is the same across categories of fatigue performance.	CSA Fatigued Driving	Team drivers	Mann-Whitney Test	134	1500.5	1	-2.3	.025	Reject
11	The distribution of “Irregular schedule” is the same across categories of fatigue performance.	CSA Fatigued Driving	Irregular schedule	Mann-Whitney Test	134	681.5	1	-5.0	<.001	Reject

Regarding considering fatigue issues in the design phase, more UFP carriers considered fatigue issues in route and schedule design. As it is shown in Figure 5-4, 55% (n=48) of AFP carriers and 90% (n=34) of UFP carriers considered fatigue issues while planning routes (χ^2 (1, n=126) = 14.2, p<.001). Likewise, 63% (n= 57) of AFP carriers and 90% (n= 34) of UFP carriers considered fatigue issues while designing schedule (χ^2 (1, n=129) = 9.3, p=.002).

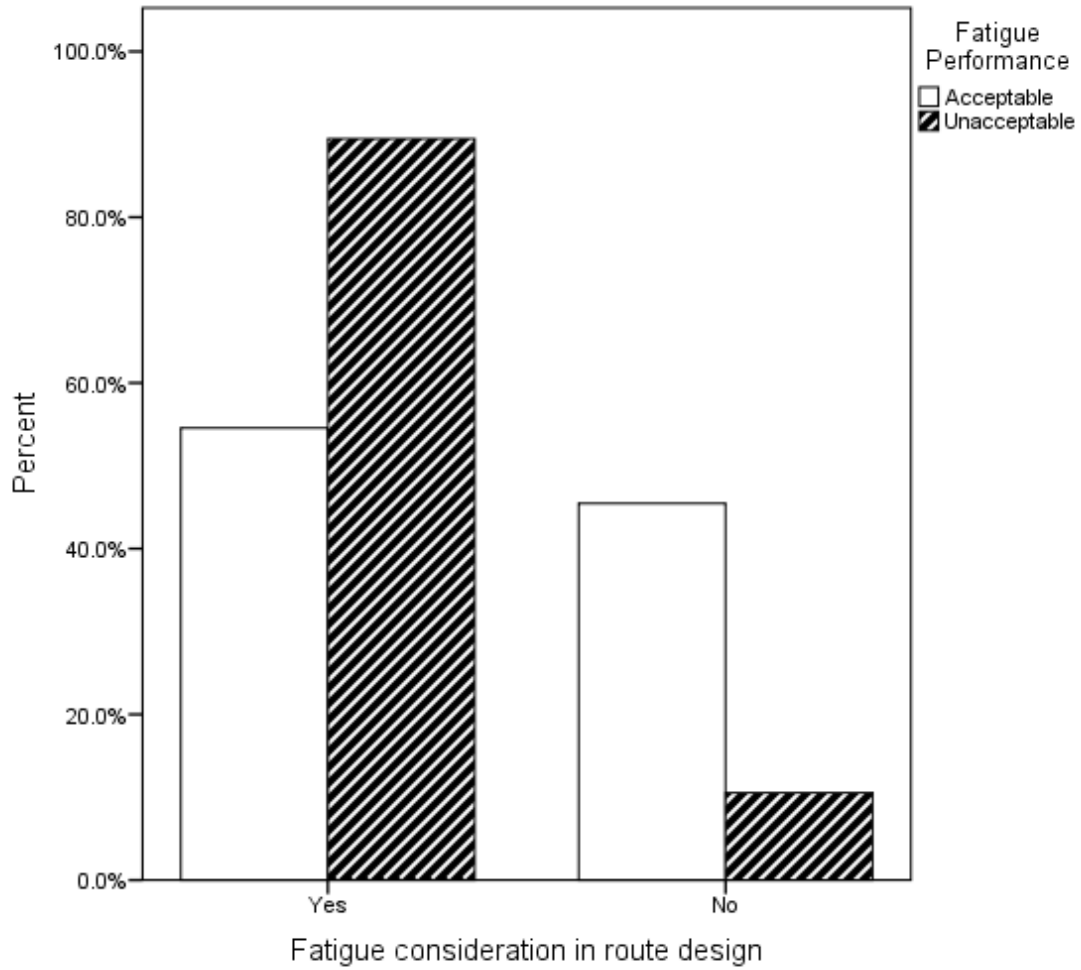


Figure 5-4: Fatigue considerations in route design within different categories of fatigue performance

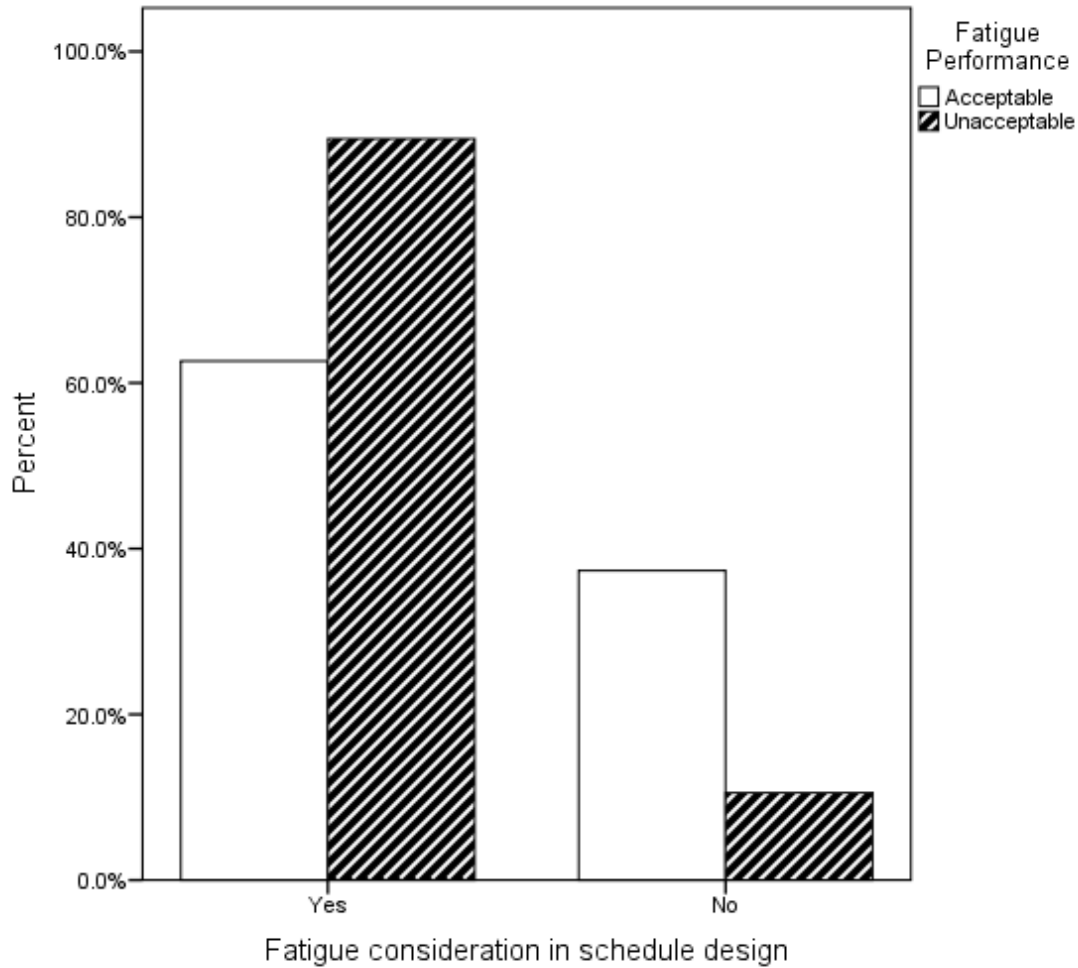


Figure 5-5: Fatigue considerations in schedule design within different categories of fatigue performance

Percentage of team drivers was higher in AFP carriers. Also, the reported percentages of team drivers among AFP carriers was more deviate ($U(1) = 1500.5, Z = -2.2, p = .025$), ($M_{AFP} = 3.9, SD_{AFP} = 14.2; M_{UFP} = 3.1, SD_{UFP} = 8.2$). On contrary, percentage of drivers with irregular and unpredicted driving schedule was higher among UFP carriers; though, the reported percentage of drivers with irregular schedules deviates more among AFP carriers ($U(1) = 681.5, Z = -6.0, p < .001$), ($M_{AFP} = 39.2, SD_{AFP} = 39.6; M_{UFP} = 89.5, SD_{UFP} = 23.5$).

Figure 5-6 shows that drivers in UFP carriers were working under more unpredicted and irregular schedule.

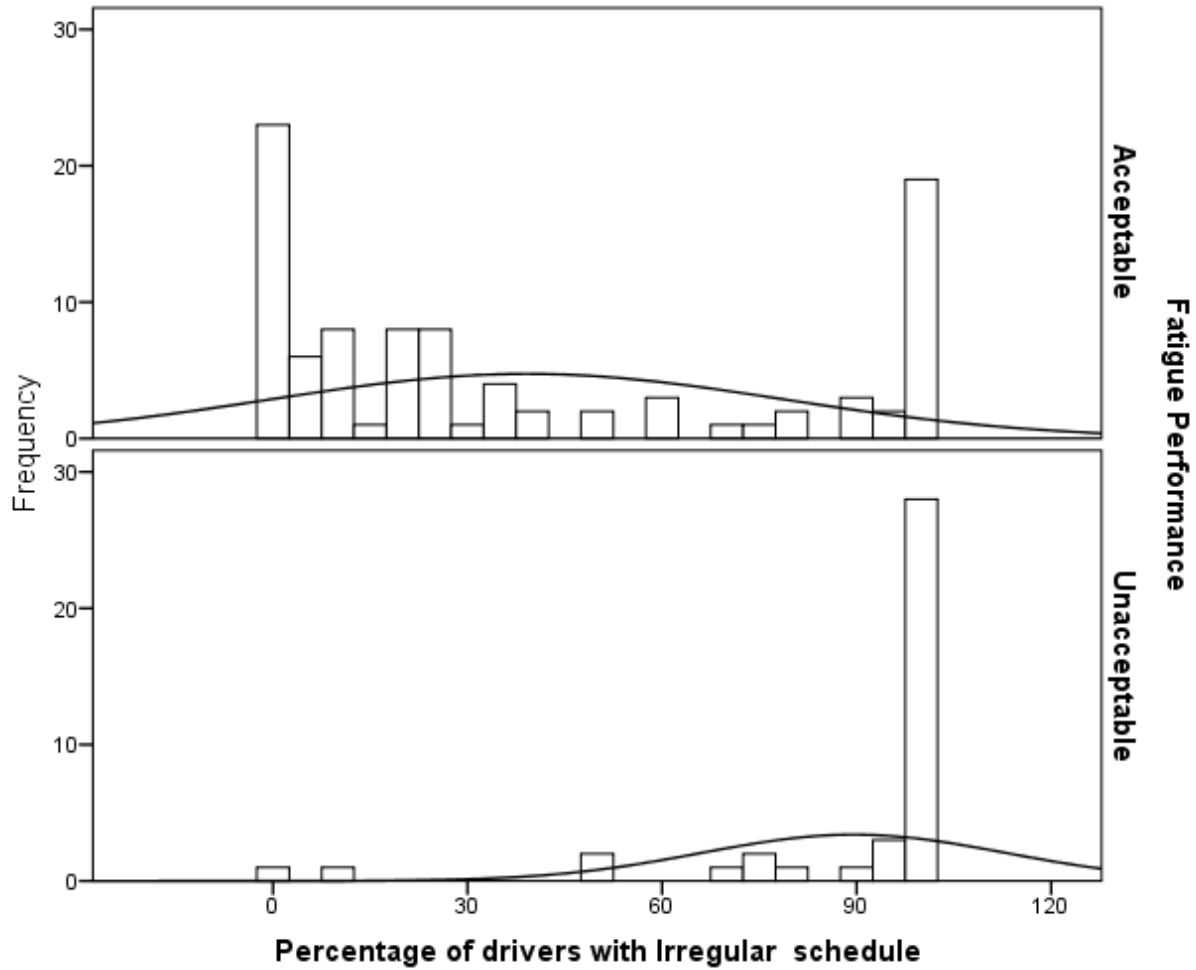


Figure 5-6: Percentage of drivers with irregular schedule within different fatigue performance categories

HOS Management

Table 5-4 shows the null hypotheses and results of statistical tools for HOS management factor. There were more AFP carriers that have utilized their motor vehicles by electronic logbook to monitor their driver's hours of services ($\chi^2 (1, n=134) = 12.6, p=.001$). As it is indicated in Table 5-7, 44% (n= 41) of AFP carriers installed electronic logbook on their motor vehicles; on contrary, only 13% (n= 5) of UFP carriers have utilized their motor vehicles by the same device.

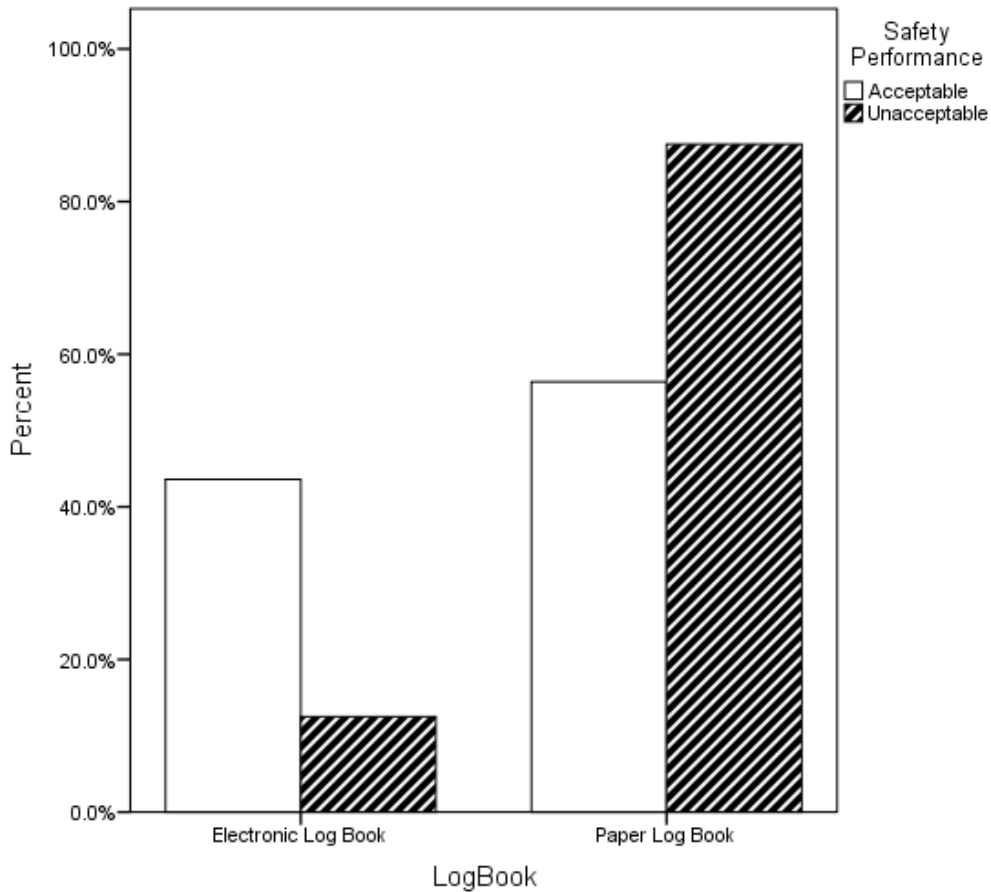


Figure 5-7: Electronic and paper logbook utilization within different categories of fatigue performance

Table 5-4: Null hypotheses and results of statistical tests for HOS management factor

No.	Null Hypothesis	Dependent variable	Independent variable	Test	n	Test Value	DF	Z Value	P Value	Decision
12	The distribution of “24-Hours restrictions” is the same across categories of fatigue performance.	CSA Fatigued Driving	24-Hours restrictions	Chi-Square	134	3.7	2	-	.138	Retain
13	The distribution of “7-days restrictions” is the same across categories of fatigue performance.	CSA Fatigued Driving	7-days restrictions	Chi-Square	134	1.7	2	-	.429	Retain
14	The distribution of “Determination the least limit of sleep hours before work” is the same across categories of fatigue performance.	CSA Fatigued Driving	Determination the least limit of sleep hours before work	Chi-Square	131	2.3	2	-	.312	Retain
15	The distribution of “Restriction of wakefulness” is the same across categories of fatigue performance.	CSA Fatigued Driving	Restriction of wakefulness	Chi-Square	130	4.7	2	-	.094	Retain
16	The distribution of “Prevent drivers of driving after being declared as out-of-service” is the same across categories of fatigue performance.	CSA Fatigued Driving	Prevent drivers of driving after being declared as out-of-service	Chi-Square	134	4.0	2	-	.135	Retain
17	The distribution of “Logbook system” is the same across categories of fatigue performance.	CSA Fatigued Driving	Logbook system	Chi-Square	134	12.6	1	-	.001	Reject
18	The distribution of “Medical examination” is the same across categories of fatigue performance.	CSA Fatigued Driving	Medical examination	Chi-Square	127	1.9	1	-	.106	Retain
19	The distribution of “On-board devices” is the same across categories of fatigue performance.	CSA Fatigued Driving	On-board devices	Chi-Square	134	3.6	1	-	.059	Retain
20	The distribution of “Reporting system” is the same across categories of fatigue performance.	CSA Fatigued Driving	Reporting system	Chi-Square	131	4.6	1	-	.033	Reject
21	The distribution of “Prevent drivers of loading/unloading” is the same across categories of fatigue performance.	CSA Fatigued Driving	Prevent drivers of loading/unloading	Chi-Square	120	16.8	1	-	<.001	Reject
22	The distribution of “Contact with shippers” is the same across categories of fatigue performance.	CSA Fatigued Driving	Contact with shippers	Chi-Square	112	1.9	1	-	.165	Retain
23	The distribution of “Give more time for flexible schedule” is the same across categories of fatigue performance.	CSA Fatigued Driving	Give more time for flexible schedule	Chi-Square	122	2.2	1	-	.137	Retain

There were more UFP carriers that have implemented a reporting system for their drivers to report fatigue to the company ($\chi^2 (1, n=131) = 4.7, p=.033$). As it is shown in Figure 5-8, 69% (n=64) of AFP carriers implemented a reporting system; on the other hand, 87% (n= 33) of UFP carriers have implemented such a reporting system.

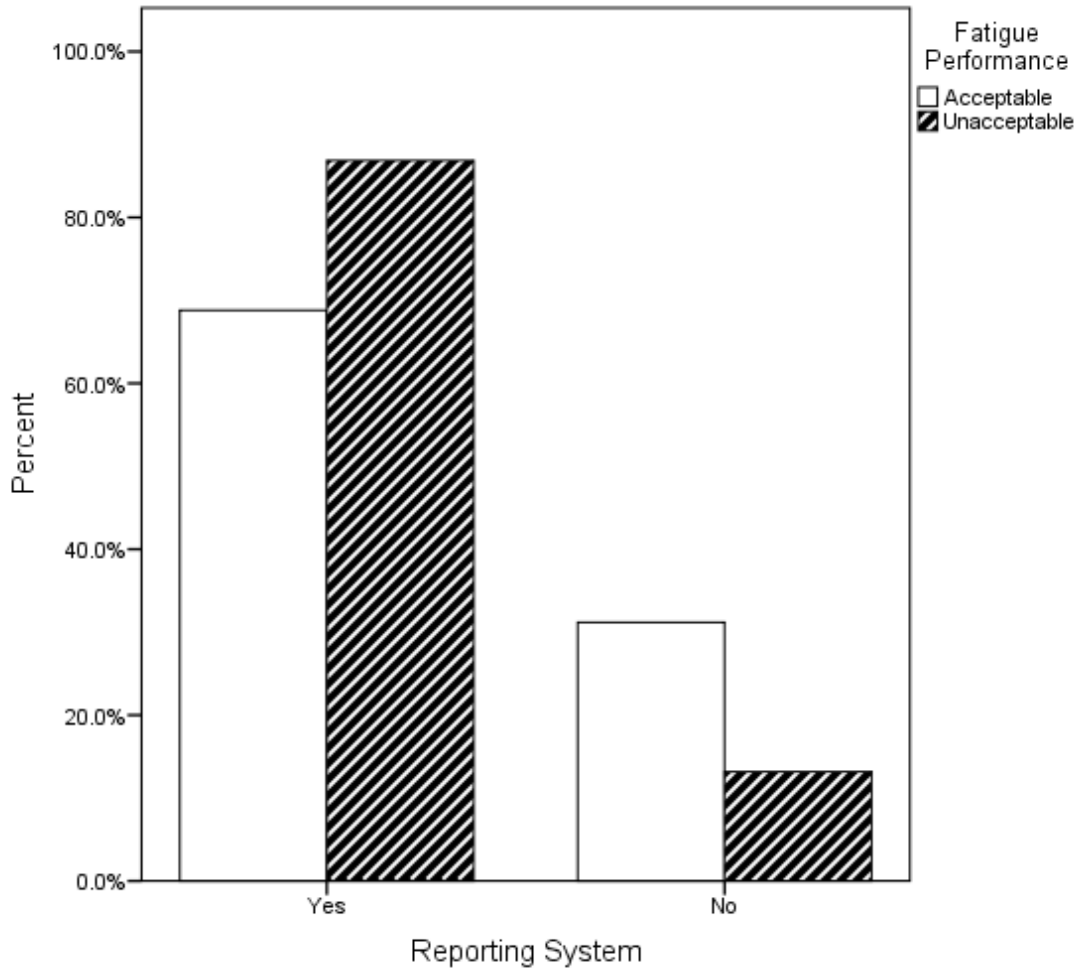


Figure 5-8: Implementing fatigue reporting system within different categories of fatigue performance

Comparing to AFP carriers, there were more UFP carriers that prevented their drivers of loading/unloading tasks ($\chi^2(1, n=120) = 16.8, p < .001$). Figure 5-9 shows that 63% (n=24) of UFP carriers prevented their drivers of loading/unloading tasks; in a situation that only 25% (n=20) of AFP carriers prevented their drivers of these tasks.

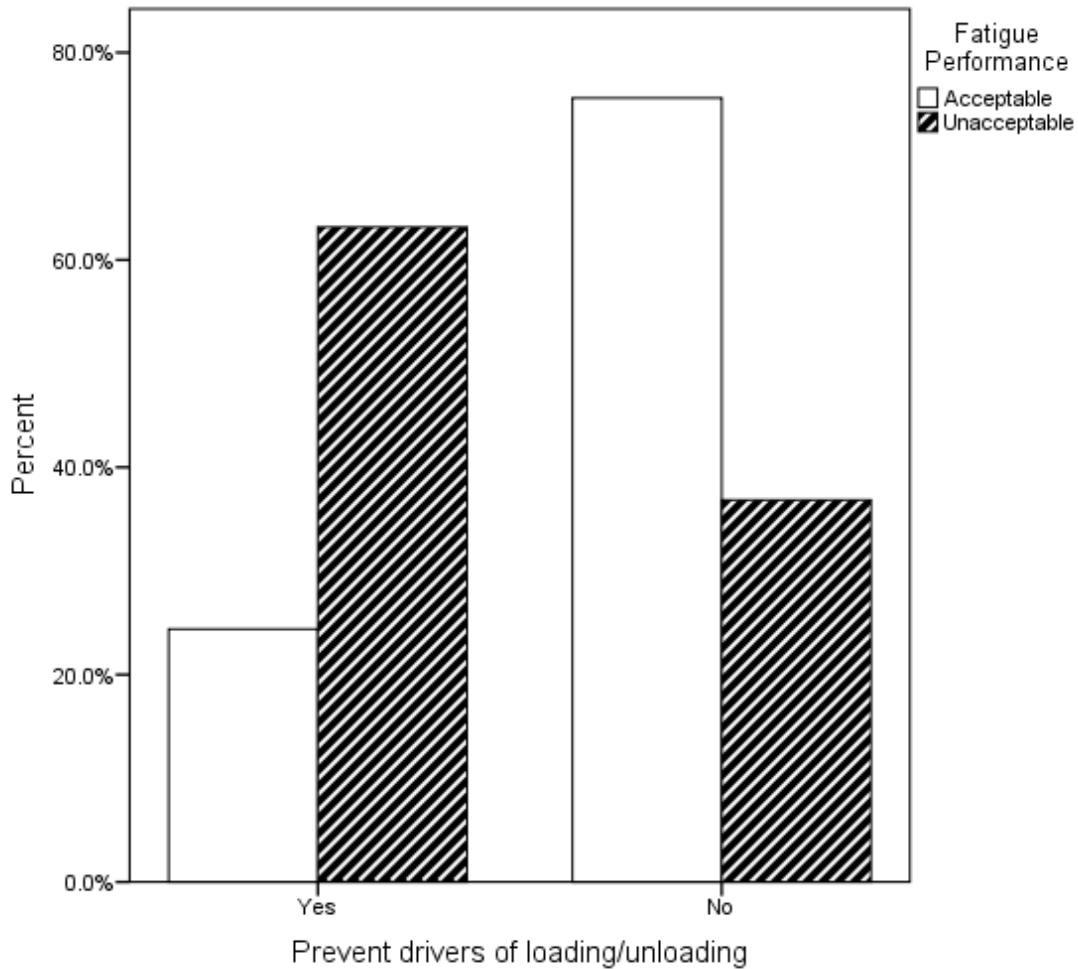


Figure 5-9 Preventing drivers of loading/unloading task within different categories of fatigue performance

Fatigue Training System

Table 5-5 shows the null hypotheses and results of statistical tools for fatigue training system factor. There were more UFP carriers that trained their dispatchers on driver fatigue issues ($\chi^2 (1, n=131) = 8.2, p=.004$). As it is shown in Figure 5-10, 82% (n=31) of UFP carriers and 55% (n=51) of AFP carriers trained their dispatchers on driver fatigue. Also, more UFP carriers evaluated their fatigue training system ($\chi^2 (1, n=130) = 6.8, p=.009$). Figure 5-11 shows that 51% (n=20) of UFP carriers and 28% (n=25) of AFP carriers had implemented a fatigue training evaluation system.

Table 5-5: Null hypotheses and results of statistical tests for fatigue training system factor

No.	Null Hypothesis	Dependent variable	Independent variable	Test	n	Test Value	DF	Z Value	P Value	Decision
24	The distribution of “New drivers training” is the same across categories of fatigue performance.	CSA Fatigued Driving	New drivers training	Chi-Square	134	1.1	1	-	.301	Retain
25	The distribution of “Dispatchers training” is the same across categories of fatigue performance.	CSA Fatigued Driving	Dispatchers training	Chi-Square	131	8.2	1	-	.004	Reject
26	The distribution of “Training evaluation” is the same across categories of fatigue performance.	CSA Fatigued Driving	Training evaluation	Chi-Square	130	6.8	1	-	.009	Reject
27	The distribution of “Training frequency” is the same across categories of fatigue performance.	CSA Fatigued Driving	Training frequency	Mann-Whitney Test	134	1504.0	1	-1.93	.53	Retain

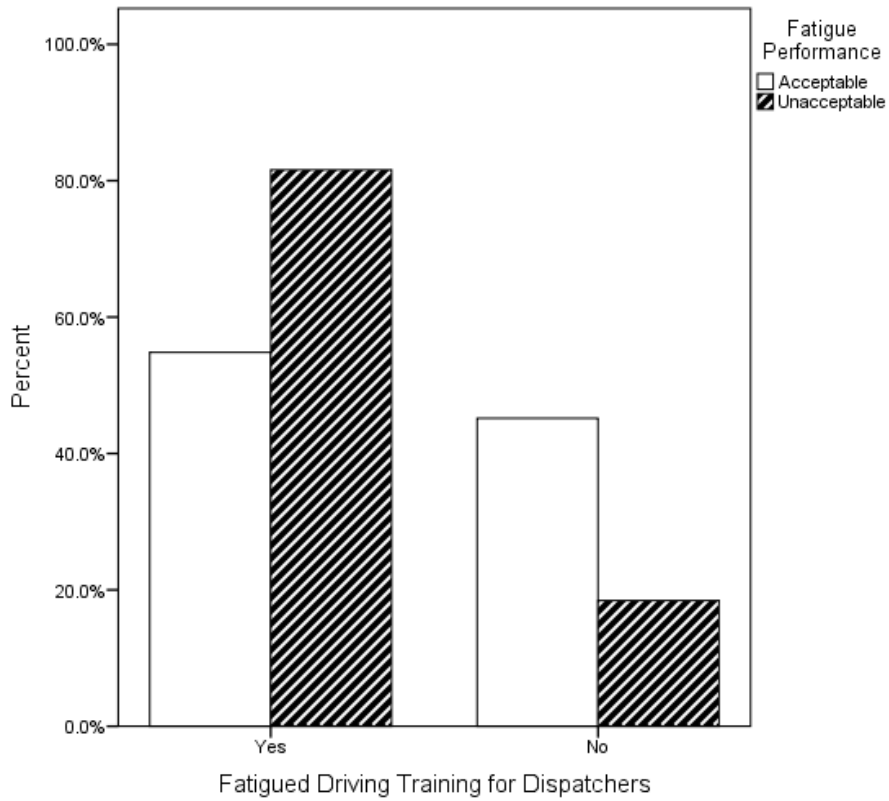


Figure 5-10: Dispatcher training on driver fatigue within different categories of fatigue performance

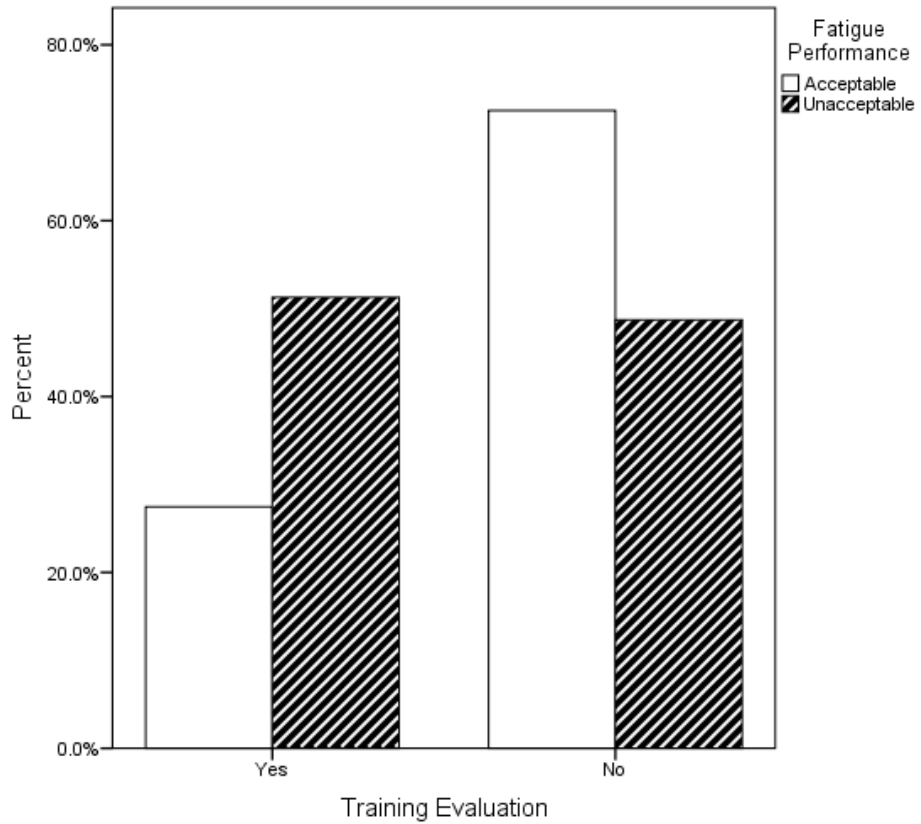


Figure 5-11: Training evaluation within different categories of fatigue performance

Other null hypotheses in Table 5-2 to Table 5-5 could not be rejected based on the findings of this study; thus, these hypotheses were retained.

CHAPTER 6: DISCUSSION

Results of the study show that comparing to AFP carriers, more UFP carriers have evaluated their safety programs. Also, more UFP carriers have evaluated their training system. These findings show that UFP carriers have recognized there was a problem in their safety programs and have evaluated their safety programs to identify problems. This finding confirms the notion by Gander (2011) that safety program evaluation is an important feature of safety management system in a changing environment.

Safety program evaluation may be conducted as a “why-it-went-wrong” or “how-we-can-improve-it” meetings to thoroughly audit and evaluate safety programs. Carriers were not asked about any specific programs regarding safety evaluation; thus, they may have implemented an ineffective safety evaluation program, yet they consider that as an evaluation measure.

The point that more UFP carriers have evaluated their safety programs shows implementation of CSA 2010 by FMCSA made these carriers more aware about their unacceptable fatigue performance. Consequently, they have initiated evaluation programs to identify problems.

Management assigned more budgets to enhance safety in AFP carriers. One of the reasons for this difference is that participated AFP carriers were larger organizations. Means of the total number of employed drivers were 550 (SD=1,031) for AFP carriers and 91 (SD=196) for UFP carriers. However, larger organizations usually allocates more budget on safety, the difference in the amount of allocated safety budget may indicate management commitment to safety in AFP carriers. This conforms Aroboleda (2003) study that stated top management commitment was an influential factor to safety culture and consequently safety performance.

Motor carriers have performed drastically different regarding considering fatigue issues in route and schedule design. More UFP carriers considered fatigue in route and schedule design phase. Also, UFP carriers have considered individual differences more than AFP carriers when assigning driving tasks. One of the reasons for these endeavors by UFP carriers could be the fact that these carriers have performed unacceptable regarding fatigue and have implemented some safety program to improve their fatigue performance.

Drivers in AFP carriers followed more restricted and fixed schedules. This difference shows that the more fixed the schedule, the better fatigue performance. This finding confirms Soccomanno (1996) study that indicated reducing driver autonomy by requiring drivers to drive the same hours each day could enhance safety, as this practice diminishes fatigue. Also, the percentage of team driving was higher among AFP carriers which show this practice may enhance fatigue performance as well.

More AFP carriers utilized electronic logbook for documenting and monitoring their drivers' hours-of-services. Motor carriers receive violations in case their drivers have filled out logbooks inaccurately (Federal Motor Carrier Safety Administration, 2012). This can be one of the reasons that UFP carriers have received more violations regarding HOS regulation. An electronic monitoring system reduces the human intervention and makes logbooks more accurate.

Gander (2011) mentioned fatigue reporting system is a proactive fatigue control measure. In order to reduce the likelihood of similar incidents or accidents, safety management system in the trucking industry largely depends on reporting. Based on the results of this study, more UFP

carriers have implemented fatigue reporting systems, which indicates these carriers have implemented some safety programs to improve their fatigue performance.

More UFP carriers considered fatigue training for dispatchers and have evaluated their training systems. These shows UFP carriers identified training system as an important safety program to improve fatigue performance. However, because of the lack of reevaluation of these carriers in this study, it cannot be concluded whether these training systems were implemented effectively or not.

Overall, there are three different interpretations regarding safety practices that are implemented by UFP carriers. Firstly, because of the CSA warning letters that UFP carriers have received, they have initiated different safety programs to control their fatigue performance. The results of these endeavors can be traced based on the future evaluations. Another interpretation could be the possibility that safety programs that are implemented by UFP carriers are not contributed to fatigue performance improvement. Thus, in spite of implementing a safety program, there is minor improvement in fatigue performance.

Thirdly, it may be suggested that these programs are effective to fatigue performance, but are not properly implemented by UFP carriers. In order to properly distinguish between these three interpretations, it is suggested that the future studies evaluate fatigue performance of participated AFP and UFP carriers to identify how these safety programs contributes to fatigue performance.

CHAPTER 7: CONCLUSIONS

This study compared the organizational factors of 94 AFP motor carriers with 40 UFP motor carriers. It was hypothesized that these companies possessed specific organizational factors that resulted into their current fatigue performance. Results of the study show that safety budget (as a management commitment element), percentage of drivers with regular schedule (as a schedule design element), and utilization of electronic logbook (as an HOS management element) are contributing factors to improve fatigue performance in motor carriers. Figure 7-1 shows the schematic diagram of the contributing factors to fatigue performance.

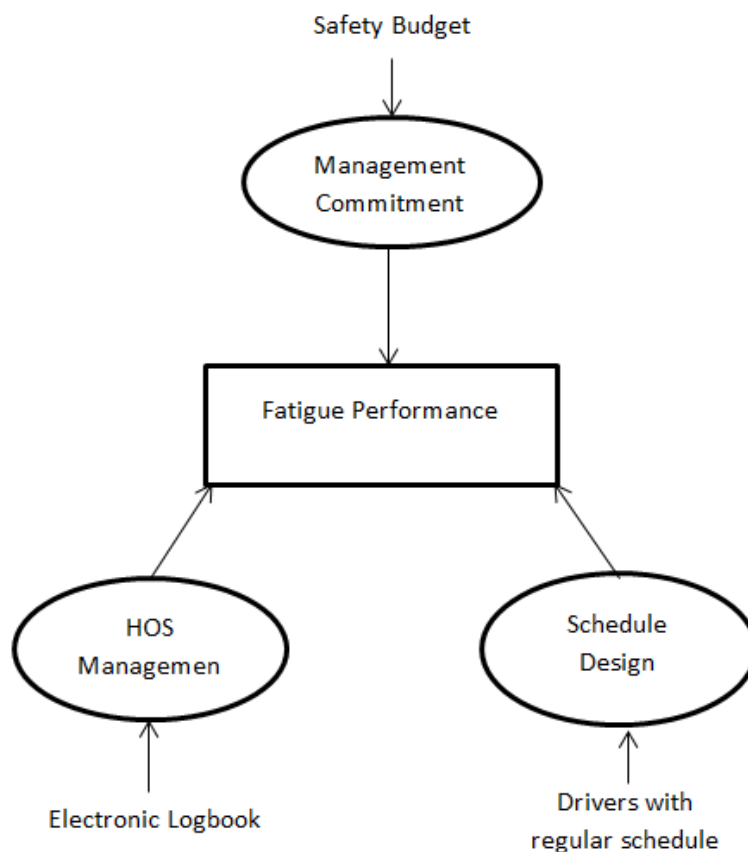


Figure 7-1: Contributing factors to fatigue performance

Certainly, for each organizational factor there may be more elements that are contributed to fatigue performance, but the results of this study could only suggest safety budget, electronic logbook, and regular schedule as elements of contributing factors to fatigue performance. Motor carriers that plan to improve their fatigue performance may implement these safety practices in their organizations.

In summary, implementing an external evaluation system like CSA 2010 has enabled interested parties in the transportation industry to identify how motor carriers are performing. According to CSA 2010 methodology, motor carriers are compared to their peers based on the type and number of their CMVs. Hence, this approach to safety evaluation is a new performance evaluation philosophy in safety science which is practiced in the industry. CSA 2010 has initiated awareness among motor carriers with unacceptable fatigue performance and made them evaluate and implement different safety practices in order to improve their fatigue performance.

Recommendations

Based on the results of this study, followings are recommendations to motor carriers in order to improve fatigue performance:

- CMV drivers follow a schedule for their driving and working tasks. Following a specific schedule is a practice that indicates to help preventing driver fatigue.
- Motor carriers utilize their motor vehicles by electronic logbook to document and trace their drivers' hours-of-services. Electronic logbook system would reduce human error and enhance drivers' ability to trace their hours of services.

- Management allocates more budgets to safety. Carriers that have assigned more budgets to safety performed better regarding fatigue. Allocating safety budget is an important antecedent of management commitment to safety.

Implementing these safety practices is not only suggested to motor carriers with unacceptable fatigue performance, but also carriers with acceptable fatigue performance is recommended to follow these practices to perform sustainably regarding their fatigue performance.

Limitations and Recommendations for Future Studies

Before conducting this research study, there were not similar evaluation studies based on the CSA 2010 in the transportation industry. Besides, this research study was conducted without any funding and in a limited time period as a Master's Thesis. These issues brought some limitations to the methodology and data analysis of the study. Limitations and recommendations of this study are as follows:

- This research was conducted through a survey, which is a self-reported instrument. The observed relationships may have been inflated artificially as a result of conservative responses. However, some studies show the magnitude of inflation may be overestimated (Crampton & Wagner, 1994), utilizing survey was identified as the only practical means of operationalizing the variables examined in this study in a large sample of motor carriers. In order to verify the results of the study, it is recommended for future studies to conduct a random on-site interview with some carriers to evaluate the implemented programs.

- This research was a cross-sectional study. There were some safety programs that UFP carriers have implemented. The design of the research prevented us from suggesting whether implemented safety practices by UFP carriers positively contribute to fatigue performance or not. It is recommended for future studies to reevaluate the participated carriers after a year to identify whether implemented safety programs affect CSA Fatigued Driving percentile in the long term or not. Secondly, if these programs contribute to fatigue performance, it should be studied whether these programs are effectively implemented by AFP and UFP carriers or not.
- This research only studied carriers with unacceptable and acceptable fatigue performance. It is recommended for future research to study the average population regarding fatigue performance as well.
- It is recommended to implement a measurement system like CSA 2010 in other industries. By doing so, there would be an external measurement system to evaluate how companies are performing regarding safety.
- The data was analyzed based on the statistical tests. Because of the variation of the data, it is recommended to utilize decision making and design of experiment (DOE) techniques to validate the study as well.
- Based on the Central Limit Theorem (CLT), it was assumed that participated carriers represented the acceptable and unacceptable fatigue performance carriers. For the future studies, it is recommended that participated carriers in these two populations be randomly sampled.
- It is recommended for future studies to focus on the safety practices that based on the results of this study have been suggested to contribute to fatigue performance.

The instrumented survey in this study was developed based on a survey by Arboleda (2003) and reviewing previous studies. For the future studies, it is recommended to consider the following points regarding the survey:

- The elements of organizational factors were identified through reviewing previous studies. It is recommended that these elements be weighted by a panel of experts to indicate how these elements are constructing organizational factors. This practice will improve the construct of survey.
- Questions should be developed in a way that improves Cronbach's Alpha. This practice will improve reliability of the survey.
- In the survey, it was mentioned that participants of the study are "trucking companies". Consequently, some motor carriers such as: oil, gas, and retail companies responded that they are not considered as trucking company. It is recommended that trucking companies be reworded to "motor carriers" for future studies.

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APPENDIX A: FATIGUED DRIVING VIOLATIONS

Table 2. CSMS Fatigued Driving (HOS) BASIC Violations¹				
Section	Violation Description Shown on Driver/Vehicle Examination Report Given to CMV Driver after Roadside Inspection	Violation Group Description	Violation Severity Weight	Violation in the DSMS (Y/N)
392.2H	State/Local Hours-of-Service (HOS)	Hours	7	Y
392.3	Operating a CMV while ill/fatigued	Jumping OOS/Driving Fatigued	10	Y
395.1(h)(1)	15, 20, 70/80 HOS violations (Alaska-Property)	Hours	7	Y
395.1(h)(2)	15, 20, 70/80 HOS violations (Alaska-Passenger)	Hours	7	Y
395.1(h)(3)	Adverse driving conditions violations (Alaska)	Hours	7	Y
395.1(o)	16 hour rule violation (Property)	Hours	7	Y
395.3(a)(1)	Requiring or permitting driver to drive more than 11 hours	Hours	7	Y
395.3(a)(2)	Requiring or permitting driver to drive after 14 hours on duty	Hours	7	Y
395.3(b)	60/70 - hour rule violation	Hours	7	Y
395.3(c)	34 -hour restart violation (Property)	Hours	7	Y
395.3A1R	11 hour rule violation (Property)	Hours	7	Y
395.3A2R	14 hour rule violation (Property)	Hours	7	Y
395.3BR	60/70 - hour rule violation (Property)	Hours	7	Y
395.5(a)(1)	10 - hour rule violation (Passenger)	Hours	7	Y
395.5(a)(2)	15 - hour rule violation (Passenger)	Hours	7	Y
395.5(b)	60/70 - hour rule violation (Passenger)	Hours	7	Y
395.8	Log violation (general/form and manner)	Other Log/Form & Manner	2	Y
395.8(a)	No driver's record of duty status	Incomplete/Wrong Log	5	Y
395.8(e)	False report of driver's record of duty status	False Log	7	Y
395.8(f)(1)	Driver's record of duty status not current	Incomplete/Wrong Log	5	Y
395.13(d)	Driving after being declared out-of-service	Jumping OOS/Driving Fatigued	10	Y

¹ Violation severity weights reflect the relative importance of each violation within each BASIC.

Table 2. CSMS Fatigued Driving (HOS) BASIC Violations²				
Section	Violation Description Shown on Driver/Vehicle Examination Report Given to CMV Driver after Roadside Inspection	Violation Group Description	Violation Severity Weight	Violation in the DSMS (Y/N)
395.15(b)	Onboard recording device information requirements not met	EOBR Related	1	Y
395.15(c)	Onboard recording device improper form and manner	EOBR Related	1	Y
395.15(f)	Onboard recording device failure and driver failure to reconstruct duty status	EOBR Related	1	Y
395.15(g)	On-board recording device information not available	EOBR Related	1	Y
395.15(i)(5)	Onboard recording device does not display required information	EOBR Related	1	N
398.6	Violation of hours of service regulations—migrant workers	Hours	7	Y

² Violation severity weights reflect the relative importance of each violation within each BASIC.

APPENDIX B: AVAILABLE INFORMATION ON CSA DATABASE

#	Code in the Database	Description	#	Code in the Database	Description
1	DOT_NUMBER	Unique USDOT Number of the Motor Carrier	27	INSP_TOTAL	Total Number of Inspections for the measurement period (24 months)
2	LEGAL_NAME	Legal name of a carrier	28	DRIVER_INSP_TOTAL	Total Number of Driver Inspections for the measurement period
3	DBA_NAME	Carrier's Doing-Business-As name	29	DRIVER_OOS_INSP_TOTAL	Total Number of Driver Inspections containing at least one Driver Out-of-Service Violation
4	CARRIER_OPERATION	Codes identifying carriers' type of Operation; A = Interstate, B = Intrastate Hazmat, C = Intrastate Non-Hazmat	30	VEHICLE_INSP_TOTAL	Total Number of Vehicle Inspections for the measurement period
5	HM_FLAG	Carrier is subject to placardable HM threshold (Y = Yes, N = No)	31	VEHICLE_OOS_INSP_TOTAL	Total Number of Vehicle Inspections containing at least one Vehicle Out-of-Service violation
6	PC_FLAG	Carrier is registered to transport passenger(s) (Y = Yes, N = No)	32	UNSAFE_DRIV_PCT	Unsafe Driving BASIC Roadside Performance Percentile
7	PHY_STREET	Physical street address of a carrier	33	UNSAFE_DRIV_RD_ALERT	Unsafe Driving BASIC Roadside Performance Over Threshold Indicator (Y = Over Intervention Threshold)

#	Code in the Database	Description	#	Code in the Database	Description
8	PHY_CITY	Physical city of a carrier	34	UNSAFE_DRIV_SV	Unsafe Driving BASIC Serious Violation Indicator (Y = Serious Violation from investigation within previous 12 months)
9	PHY_STATE	Physical state of a carrier	35	UNSAFE_DRIV_BASIC_ALERT	Unsafe Driving Overall BASIC Indicator (Y - Roadside Performance Percentile over threshold and/or Serious Violation within previous 12 months)
10	PHY_ZIP	Physical zip code of a carrier	36	FATIGUE_DRIV_PCT	Fatigued Driving (Hours-of-Service) BASIC Roadside Performance Percentile
11	PHY_COUNTRY	Physical country of a carrier	37	FATIGUE_DRIV_RD_ALERT	Fatigued Driving (Hours-of-Service) BASIC Roadside Performance Over Threshold Indicator (Y = Over Intervention Threshold)
12	MAILING_STREET	Mail street address of a carrier	38	FATIGUE_DRIV_SV	Fatigued Driving (Hours-of-Service) BASIC Serious Violation Indicator (Y = Serious Violation within previous 12 months)
13	MAILING_CITY	Mail city of a carrier	39	FATIGUE_DRIV_BASIC_ALERT	Fatigued Driving (Hours-of-Service) BASIC Indicator

#	Code in the Database	Description	#	Code in the Database	Description
14	MAILING_STATE	Mail state of a carrier	40	DRIV_FIT_PCT	Driver Fitness BASIC Roadside Performance Percentile
15	MAILING_ZIP	Mail zip code of a carrier	41	DRIV_FIT_RD_ALERT	Driver Fitness BASIC Roadside Performance Over Threshold Indicator (Y = Over Intervention Threshold)
16	MAILING_COUNTRY	Mail country of a carrier	42	DRIV_FIT_SV	Driver Fitness BASIC Serious Violation Indicator (Y = Serious Violation from investigation within previous 12 months)
17	TELEPHONE	Contact telephone number	43	DRIV_FIT_BASIC_ALERT	Driver Fitness BASIC Indicator (Y - Roadside Performance Percentile over threshold and/or Serious Violation within previous 12 months)
18	FAX	Fax Number	44	CONTR_SUBST_PCT	Controlled Substances and Alcohol BASIC Roadside Performance Percentile
19	EMAIL_ADDRESS	Contact email address	45	CONTR_SUBST_RD_ALERT	Controlled Substances and Alcohol BASIC Roadside Performance Over Threshold Indicator (Y = Over Intervention Threshold)
20	MCS150_DATE	Latest date MCS-150 was filed	46	CONTR_SUBST_SV	Controlled Substances and Alcohol BASIC Serious Violation Indicator

#	Code in the Database	Description	#	Code in the Database	Description
21	MCS150_MILEAGE	Vehicle Mileage Traveled (VMT) reported on the carrier's MCS-150 form	47	CONTR_SUBST_BASIC_ALERT	Controlled Substances and Alcohol BASIC Indicator (Y - Roadside Performance Percentile over threshold and/or Serious Violation within previous 12 months)
22	MCS150_MILEAGE_YEAR	Year for which VMT was reported	48	VEH_MAINT_PCT	Vehicle Maintenance BASIC Roadside Performance Percentile
23	ADD_DATE	Date when carrier information was added to MCMIS Database System	49	VEH_MAINT_RD_ALERT	Vehicle Maintenance BASIC Roadside Performance Over Threshold Indicator (Y = Over Intervention Threshold)
24	OIC_STATE	FMCSA State office with oversight for this carrier	50	VEH_MAINT_SV	Vehicle Maintenance BASIC Serious Violation Indicator (Y = Serious Violation from investigation within previous 12 months)
25	NBR_POWER_UNIT	Number of power units reported	51	VEH_MAINT_BASIC_ALERT	Vehicle Maintenance BASIC Indicator (Y - Roadside Performance Percentile over threshold and/or Serious Violation within previous 12 months)
26	DRIVER_TOTAL	Number of drivers reported	52		

APPENDIX C: EMAIL TO THE EXPERT PANEL

Dear Expert,

I am requesting your help in providing feedback on a survey, since you are an expert in transportation safety.

This survey is a part of my Master of Science Thesis in the Occupational Safety program at East Carolina University. The purpose of this study is to identify the organizational factors that contribute to trucking companies' safety performance, based on the Compliance Safety Accountability (CSA) system. I am seeking your response by **Monday, January 30, 2012**.

Would you please take a few minutes to complete the survey and provide your feedback?

I am specifically interested to know if the survey meets the following characteristics:

- Appropriate in length
- Questions are clearly stated
- Helps the respondents to think about his/her organization
- Easy to access
- Easy to navigate.

After your review and feedback, this survey will be modified and distributed among a randomly selected group of trucking companies. Your feedback will help us to enhance the effectiveness of this survey in the design phase and before it is launched.

In the survey, specific space is designated for **“your comments”** regarding each question. If you have no comments to a question, simply go to the next question. A link to the survey is:

https://ecu.qualtrics.com/SE/?SID=SV_efEjseA709YRJUU

Thank you in advance for sharing your expertise to help the safety profession excel and grow based on scientific findings. I am looking forward to receiving your comments by

Monday, January 30, 2012.

Best Regards,

Hootan Tabar

APPENDIX D: SURVEY

Introduction

As a person who is involved with safety challenges in a trucking company, you are invited to participate in a research study by completing an on-line survey. The purpose of this study is to determine how trucking companies can improve their safety performance and subsequently improves their Compliance, Safety, Accountability (CSA 2010) percentile ranks. Your participation in this survey will be anonymous and voluntary. It should take approximately 10 -12 minutes to complete the survey.

Risks/Discomforts:

There are no known risks to you and your Company if you complete this survey.

Benefits:

As a benefit for participating in this survey, you will receive the results and findings of this study with specific recommendations. This is a great opportunity to share your knowledge and expertise in order to collectively improve the efforts of safety professionals and more specifically, safety in the trucking industry. The results and findings of this study will be in aggregated format and names or identities will not be released.

Confidentiality:

All data obtained from participants will be kept confidential. The results and findings of this study will be in aggregated format, and names or identities will not be released.

Participation:

Participation in this research study is voluntary. You have the right to withdraw at any time or refuse to participate entirely without any penalty.

Questions about the Research:

If you have any questions regarding this survey, you may contact Occupational Safety program at East Carolina University, at 252-328-9716, fonoonih@ecu.edu.

I have read and understood the above, and I accept to participate in this study.

- Yes
- No

If No Is Selected, Then Skip to End of Survey

Q1 Which best describes your job duties?

- Only responsible for carrier safety
- Responsible for carrier safety but with additional duties (e.g., dispatching, human resources, etc.)
- Other (please specify duties briefly) _____

Q2 What is the primary type of your Company's business? (Check all that apply.)

- Truckload
- Less-than-Truckload
- Bulk/Tankers
- Hazmat
- Specialized
- Other (please specify) _____

Q3 Approximately, how many drivers are employed in each category in your Company? (Put 0 if it is not applicable.)

- _____ Company drivers
- _____ Owner-operators
- _____ Temporary
- _____ Leased drivers
- _____ Other

Q4 How does your Company pay your drivers? (Check all that apply.)

- By salary
- By the mile
- By hour
- By trip
- By percentage of the load
- Other (please specify) _____

Q5 For which of the followings do your drivers receive incentives or bonus (e.g., cash, gift cards, etc.)?

	Yes	No	I do not know
On-time delivery	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Safe driving	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

In the following questions, please respond with “Yes” if the sentences are applicable in your Company and “No” if they are not applicable.

Q6 Our Company evaluates driving safety programs regularly.

- Yes
- No
- I do not know

Q7 After evaluating the driving safety programs, our Company has a process in place to follow-up with corrective actions to address all deficiencies (i.e., engineering controls, disciplinary actions, training, etc.).

- Yes
- No
- I do not know

Q8 Our Company has a formal policy regarding managing drivers' fatigue.

- Yes
- No
- I do not know

Q9 Our Company has a reporting system in place that drivers can inform the Company in case they experience fatigue or fatigue-related incidents.

- Yes
- No
- I do not know

Q10 Our Company's annual driving safety budget is:

- None
- Less than \$10,000
- \$10,001 - \$20,000
- \$20,001- \$30,000
- Over \$30,001

Q11 Regarding the Hours-of-Service (HOS) regulation by FMCSA, our Company has policy/procedures that:

	Yes, and it is a written policy	Yes, but it is not a written policy	No	I do not know
Restrict the amount of driving time per 24 hours	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Restrict the amount of driving time per 7-day period	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Restrict the amount of sleep before starting the work	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Restrict the amount of wakefulness before starting the work	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prevent drivers from driving after being declared out-of-service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q12 What kind of log book system does your Company utilize?

- Paper Log Book
- Electronic Log Book
- I do not know
- Other (please specify) _____

Q13 Which of the following strategies is implemented in your Company for controlling drivers' fatigue?

	Yes	No	I do not know
Prevent drivers of loading/unloading	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Contract with shippers/receivers that require idling pay at the dock	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Give drivers more time for a flexible schedule	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q14 Our Company evaluates sleep disorders such as sleep apnea during medical examination.

- Yes
- No
- I do not know

Q15 Our Company has installed on-board devices such as "lane tracker system," "head and eye blink monitors," in our trucks that monitor drivers' fatigue level.

- Yes
- No
- I do not know

Q16 Our Company encourages dispatchers to take individual drivers' differences into account when making driving assignments? (i.e., some drivers maybe more or less susceptible to fatigue, some drivers may experience more drowsiness when driving at night.)

- Yes
- No
- I do not know

Q17 Our Company considers fatigued driving issues when assigning ROUTES to drivers.

- Yes
- No
- I do not know

Q18 Our Company considers fatigued driving issues when assigning/designing driver SCHEDULES.

- Yes
- No
- I do not know

Q19 Approximately, what percentage of your drivers falls into each classification? (Total should be 100; put 0 if it is not applicable in your Company.)

_____ Percentage of solo drivers
_____ Percentage of team drivers (a pair of drivers for each truck)

Q20 Approximately, what percentage of your drivers falls into each category? (Total should be 100; put 0 if it is not applicable in your Company.)

_____ Percentage of fixed schedule drivers
_____ Percentage of drivers with Irregular and unpredictable schedule

The following questions are related to Fatigued Driving training. (Training on Fatigued Driving covers Hours-of-Service (HOS), Night Driving, Fatigue, Fatigue Control, etc.)

Q21 Fatigued Driving is included in our Company's safety training programs for new drivers.

- Yes
- No
- I do not know

Q22 Dispatchers in our Company receive training on Fatigued Driving.

- Yes
- No
- I do not know

Q23 Our Company has a process in place to evaluate the effectiveness of our Fatigued Driving training programs.

- Yes
- No
- I do not know

Q24 How frequently does your Company provide refresher training on Fatigued Driving to your drivers?

- Never
- At least once a month
- At least once every six months
- At least once a year
- As needed

Q25 Which method(s) does your Company use to train your drivers? (Check all that apply.)

- Face-to-face training sessions
- Computer-based training sessions
- Verbal instruction by dispatchers
- Other (please specify) _____

Q26 Has your Company provided training directly related to CSA 2010 to your drivers?

- Yes, we had one training session or related activity
- Yes, we have had two or more training sessions or related activities
- No

Q27 In this section, please provide your Company's CSA percentile ranks on Unsafe Driving and Fatigued Driving categories. Input the numbers without percentage sign (%).

Unsafe Driving:
Fatigued Driving (Hours-of-Service):

Q28 How many reportable crashes with injuries/fatalities have your Company reported to the FMCSA during the last two years?

Number of reportable crashes with Injuries/fatalities:

If you do not have the required information in the above questions, it can be obtained through the FMCSA website: www.ai.fmcsa.dot.gov/sms



APPENDIX E: IRB APPROVAL



EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board Office
1L-09 Brody Medical Sciences Building- Mail Stop 682
600 Moye Boulevard · Greenville, NC 27834
Office 252-744-2914 · Fax 252-744-2284 · www.ecu.edu/irb

Notification of Exempt Certification

From: Social/Behavioral IRB
To: [Hossein Hosseini Tabar](mailto:Hossein.Hosseini.Tabar)
CC: [Hamid Fonooni](mailto:Hamid.Fonooni)
Date: 2/8/2012
Re: [UMCIRB 12-000064](#)
Contributing Organizational Factors Resulted into Fatigued Driving in Motor Carriers Based on the Compliance, Safety, Accountability (CSA 2010) Measurement System

I am pleased to inform you that your research submission has been certified as exempt on 2/7/2012. This study is eligible for Exempt Certification under category #2.

It is your responsibility to ensure that this research is conducted in the manner reported in your application and/or protocol, as well as being consistent with the ethical principles of the Belmont Report and your profession.

This research study does not require any additional interaction with the UMCIRB unless there are proposed changes to this study. Any change, prior to implementing that change, must be submitted to the UMCIRB for review and approval. The UMCIRB will determine if the change impacts the eligibility of the research for exempt status. If more substantive review is required, you will be notified within five business days.

The UMCIRB office will hold your exemption application for a period of five years from the date of this letter. If you wish to continue this protocol beyond this period, you will need to submit an Exemption Certification request at least 30 days before the end of the five year period.

The Chairperson (or designee) does not have a potential for conflict of interest on this study.

IRB00000705 East Carolina U IRB #1 (Biomedical) IORG0000418
IRB00003781 East Carolina U IRB #2 (Behavioral/SS) IORG0000418 IRB00004973
East Carolina U IRB #4 (Behavioral/SS Summer) IORG0000418

APPENDIX F: EMAIL TO COMPANIES

If you are not in charge of safety in your Company, please forward this email to the person who is in charge of safety:

Master of Science in Occupational Safety program at East Carolina University is conducting a study to determine how trucking companies can improve their safety performance and subsequently improve their Compliance, Safety, Accountability (CSA 2010) percentile ranks.

Your participation in this survey will be **anonymous** and **voluntary**. It should take approximately **8-10 minutes** to complete the survey.

As a benefit for participating in this survey, you will receive the results and findings of this study with specific recommendations. This is a great opportunity to share your knowledge and expertise in order to collectively improve the efforts of safety professionals and more specifically, safety in the trucking industry. **The results and findings of this study will be in aggregated format and names or identities will not be released.**

To start the survey, please click on: [“Take the Survey”](#)

Or, Copy and paste the URL below into your internet browser:

[https://ecu.qualtrics.com/WRQualtricsSurveyEngine/?Q_SS=blvPToU4ZvA295a_efEjseA709YRJUJ&_ =1](https://ecu.qualtrics.com/WRQualtricsSurveyEngine/?Q_SS=blvPToU4ZvA295a_efEjseA709YRJUJ&_=)

Thank you in advance for your willingness to share your expertise to help the safety profession excel and grow based on scientific findings. We are looking forward to receiving your response by **March 6, 2012**.

Cordially,
Hootan Tabar
Research Assistant
MS, Occupational Safety
East Carolina University
241 Science and Technology Building
Greenville, NC 27858