A MODEL FOR PREDICTING TRACTOR-TRAILER TRUCK DRIVERS' JOB PERFORMANCE RELATED TO HIGHWAY SAFETY

PREPARED BY:

Fredrick Muyia Nafukho, PhD[1] and Barbara E. Hinton Ed.D. Department of Rehabilitation, Human Resources and Communication Disorders, University of Arkansas

FUNDED BY:
Mack-Blackwell Rural Transportation Center, University of Arkansas

June 2004

---

[1] *Fredrick M. Nafukho is an Assistant Professor and Barbara E. Hinton is a Professor and Head, Department of Rehabilitation Human Resources and Communication Disorders, University of Arkansas*

Acknowledgements

The authors wish to express appreciation for the financial support used to conduct this study, which was provided by the U.S. Department of Transportation grant to the Mack-Blackwell Transportation Center. Our sincere thanks also go to our graduate assistants Gene Huang Yang and Carroll M. Graham. We would also like to thank the employees of the transportation company who worked tirelessly to provide us with the data.

Abstract

A number of factors may contribute to road traffic accidents, namely: reckless driving, having un-road worthy vehicles on the road, and poor conditions of the roads. However, this study examined the performance of tractor-trailer truck drivers in a leading transportation company in the United States of America. Limited research has addressed the issue of working conditions of the drivers, especially incentive, compensation, and workplace variables and how these variables affect job performance in terms of reduced accidents. Therefore, the primary purpose of this study was to determine how tractor-trailer truck drivers' job performance could be improved while at the same time ensuring increased revenue for the transportation companies employing them. The target population for the study comprised of tractor-trailer truck drivers employed by a major transportation company in the U.S. The researchers obtained data on the drivers from the database maintained by the company. Data were obtained for 14,340 drivers. The data used in the study included demographic, incentive, compensation and workplace variables. The results of the of study showed that a statistically significant model did exist that explained the variance in the dependent variable, the number of accidents which was used as a measure of driver performance. The variables cost of accidents, miles driven per month, safety bonus, pay time off, drivers' age and salary earned combined explained 3.2% of the changes in the dependent variable (number of accidents) in the study. The demographic variables miles driven and age of the driver had linear and positive relationship with the dependent variable, number of accidents. Based on the results of the study, several policy implications and recommendations for further studies are made.

Table of Contents

List of Tables

List of Figures

Introduction

Transportation is an important sector of the U. S. Economy. It moves people and goods, employs millions of workers, and generates revenue. To show the importance of transportation to the U. S. economy, transportation related goods and services contributed $980 billion to a $ 9.26 trillion U. S. Gross Domestic Product in 1999 (U. S. Department of Transportation, 2000). The U.S. transportation system is an extensive, inter-related network of public and private roads, airports, railroads, transit routes, waterways, terminals, ports, and pipeline. In the case of a roadway, which is the focus of this study, there are 46,564 miles of interstate highway, 113,995 miles of other national highway system roads and 3,771,456 miles of other roads (U. S. Department of Transportation, 2000).

To ensure economic development of the rural areas and the agricultural sector, for instance, there is need for an efficient, reliable and safe road transport system (Khayesi, 1993). Despite the fact that road transportation plays an important role in the development process, a negative phenomenon of road traffic accidents consumes part of the revenue generated from this important sector. This may be in the form of loss of life and goods through accidents or loss of revenue through insurance claims and lawsuits filed. A concern of the U.S. Department of Transportation is to promote safety. Despite the progress made in reducing fatalities, transportation remains the leading cause of accidental deaths and injuries in the United States. For instance, in 1999 about 95 percent of transportation fatalities and an even higher percentage of injuries occurred on the nation's roadways (U. S. Department of Labor, 2002).

Road traffic accidents are a threat to human capital development. They also affect the economy negatively since insurance companies incur huge expenses when compensating the accident victims (Ray, 1998). Weinberger (1998) identifies six performance factors that enhance individual, group or organizational performance. These include consequences, incentives and rewards; data and information, the feedback and standards of performance; individual capacity, the capabilities of an individual's performance, and motives and expectations, skills and knowledge that employees hold (Weinberger, 1998, Gilbert, 1978, Gilbert, 1988, & Rosenberg, 1996). Robinson and Robinson (1996) observe that employees who have been trained in a set of skills, in this case safe driving skills, but work in an environment that does not support those skills will eventually stop applying the skills. Thus, the work environment governs whether or not the employees utilize the skills learned. According to Robinson and Robinson (1996), all significant causes of performance deficiencies must be resolved if performance improvement is to be achieved. To do this, research on possible deficiencies is important. The way transportation companies manage their drivers has significant impact on the bottom line (Ray, 1998; Hinton & McVittie, 1994). For example, by raising the wages of truck drivers, J.B. Hunt, was able to reduce the rate of accidents per driver (Belzer, Rodriquez and Sedo, 2002). However, there was no return on investment.

Statement of the Problem

A number of factors may contribute to road traffic accidents, namely: reckless driving, having un-road worthy vehicles on the road, and poor conditions of the roads. However, this study examines the contribution of the over-the-road tractor-trailer truck drivers toward the occurrence of road traffic accidents. The study addresses the issue of demographic variables and working conditions of the drivers and how these issues affect job performance in terms of reduced number of crashes per driver and in increased revenue to companies employing them.

Project Objective

The primary purpose of this study was to develop a model for predicting tractor-trailer truck drivers' job performance related to highway safety. The research focused on how over-the-road tractor-trailer truck drivers' job performance can be improved while ensuring increased revenue for the transportation companies employing them.

The Research Questions

The following research questions guided the study:

1. What are the demographic variables associated with safe driving?
2. What driver characteristics are associated with road traffic accidents?
3. In what ways do the working conditions of drivers affect driver safety?
4. What compensation variables are provided to the drivers in the study, and how do they affect the drivers' job performance?
5. How do workplace variables affect the drivers' job performance?

Literature Review

Workplace Death and Highway Safety

Workplace and working condition variables potentially affect the performance of the driver's ability to carry out the mission of delivering products in a safe and timely manner. These variables, if not addressed appropriately, may contribute to fatalities, injuries, delays, litigation, and various problems effecting driver performance. Internal and external stressors and a range of other variables within the parameter of the workplace influence the performance of the driver.

The Bureau of Labor Statistics observed that in the years 1995-2001, truck drivers experienced the greatest number of injuries and lost work time. Though injuries declined for all other occupations by approximately 20 percent, the injury rate for truckers increased by nearly five percent. Back problems, muscle strains, vision impairment, digestive disruptions, and kidney malfunctions are common physical problems affecting the performance of tractor-trailer drivers (http://www.bls.gov/iif/oshcfoi1.htm).

Though the workplace death rate continued to fall in 2002, the highways were the most dangerous place for the American worker. A recent survey of occupations with a minimum of 30 fatalities and 45,000 workers employed in 2002 reveals 25 truck driver deaths occurred for every 100,000 on-the-job fatalities recorded. Categorized in this quantitative manner, truck driving is one of the top ten on-the-job killers of U.S. workers. Furthermore, recent data indicates that when considering average fatality rate for *all occupations*, truck drivers ranked higher than any cited in the Current Population Survey of Numbers and Rates of Fatal Occupational Injuries for Selected Occupations, 2002. The average fatality rate for *all occupations* was 4.0 in 2002. Considering the numbers and rates of fatal occupational injuries for selected occupations for 2002, truck driver deaths were the highest with 808 lives lost as compared to others such as farm 519, sales 347, construction 302, police and detectives 140, and electricians 116. Additionally, fatal transportation incidents varied between men and women in 2002. Transportation incidents, as a whole, resulting in fatalities were responsible for 43% of the deaths of males and 46% of fatalities to females (http://www.ai.volpe.dot.gov/CarrierResearchResults/. The residual fallout, psychologically speaking, takes its toll on the performance of the operator of these large trucks (Palmer, 2000).

Performance of the tractor-trailer driver is indisputably interrupted when accidents occur during the course of delivering goods and services to the customer. The U.S. Department of Transportation reported that in 2001, 5,082 people were killed and 131,000 injured in collisions involving a large truck. In that same year truck tractors pulling semi-trailers accounted for 62%

of the trucks involved in fatal crashes and more than 50% of the trucks involved in nonfatal crashes. On a more positive note, large truck crashes per million vehicle miles traveled have declined each year since 1997, resulting in a six per cent decrease. However, fatal crashes involving large trucks increased from 1991 to 2001 (http://www.ai.volpe.dot.gov/. The increase was up approximately ten percent. The results of a study examining occupant deaths in large crashes in the United States over the period of twenty-five years noted, “In 1975, large trucks were involved in 9% of all passenger vehicle occupant fatalities. By 1999, this percentage had risen to 12%. Large trucks were involved in 17% of passenger vehicle occupant deaths in multiple-vehicle crashes in 1975 and 23% in 1999” (Lyman & Braver, 2003, p. 731). Thus, the issue of workplace safety as it relates to truck drivers requires a steady and continuous research.

Scheduling Practices and Driver Performance

Crum and Morrow (2002), examined the carrier-scheduling practices on truck driver fatigue. It was established from this study that tractor-trailer driver performance was affected by the state of tiredness at the beginning of the workweek, obscurity of rest stops, schedules of receivers, and the additional requirements to assist in the loading and unloading of merchandise. These factors were significant in predicting fatigue and performance deficiencies. Similarly, in a study involving 700 commercial goods drivers and their managers operating across 17 countries, Adams-Guppy and Guppy (2003), noted, “there were significant associations found between fatigue experiences and driver and management systems of break taking and route scheduling” (p. 763). Adams-Guppy and Guppy (2003) further suggested that increased involvement of drivers in the management of risk factors within their own operating environment was viewed as an important issue when it comes to improving driver performance. The issue of tractor truck driver performance world over should be examined from a systems approach perspective. The approach requires identification of problems; strategy formulation; setting of targets and performance monitoring (Breen & Seay, 2004)

Driver Stress and Its Effect on Performance

Kamp (1994) indicates employee stress within the workplace, such as fast-approaching deadlines, personality problems or stressors related to issues outside work like marital problems and health issues may impair overall performance of workers. Bernard, Bouck, and Young (2000) noted that psychological stress was a relevant factor in the injury and illnesses of truck drivers due to long hours, reckless actions by other drivers, and a lack of exercise. According to Orris, et al., (1997), based on the Global Stress Index portion of the Symptom Checklist SCL-90, package truck drivers are in the 91^{st} percentile, strongly suggesting they are more likely to experience psychological disorders due to stressors not experienced by those employed in other occupations. In the case of tractor-trailer drivers, they may experience fatigue, emotional problems, and become distracted while traveling towards their intended destination. Thus, the operator may make a driving error and performance is affected due to the resulting consequences. These stressors ultimately impact driver retention, absenteeism, worker's compensation claims, customer service rates, the organization's economics, company reputation, and the competitive advantage of the motor fleet operation. Palmer (2000) reported that females represented approximately five percent of current truck drivers in the United States of America. Additional stress factors may affect the female drivers because they are more likely to experience sexual harassment, a feeling of isolation due to an absence of social support, limited job opportunities, and issues of time management relating to responsibilities at home. Lacking adequate resources and representing a minority position within the trucking industry, a decline in female driver performance may follow (Bernard, Bouck, & Young, 2000).

Highway Safety and Human factors

Van-Steenburg (as cited in Schultz, 1998; Williams, 1999) argued that human error is named as the likely cause of fatalities in truck crashes more so than defects of truck-trailer equipment. This was due to significant improvements in the mechanical condition of trucks, especially as compared to 1986, when as many as 39 percent of trucks inspected were placed out of service. Today's figures reflect that approximately 20 percent of the trucks are unfit for transporting cargo along America's highways. However, "The driver is a crucial factor in determining a carrier's accident rate. Traits such as experience, proficiency behind the wheel, and intelligence often make the difference between incurring or avoiding a traffic mishap" (Bruning, 1989, p. 42).

Substance Abuse and Highway Safety

According to the US Department of Labor's, Census of Fatal Occupational Injuries, only 1 percent of large truck drivers in fatal crashes was intoxicated at or above the blood alcohol content (BAC) level of 0.08 grams per deciliter, compared to 23 percent of car and light truck drivers and 29 percent of motorcycle drivers. The percentage of large truck drivers intoxicated at or above this level dropped from 1.5 percent in 2000 to 1.1 percent in 2001 (Federal law prohibits driving a large truck with a 0.02 BAC level or higher). About 5 percent of fatal crashes and 4 percent of nonfatal crashes involving large trucks occurred in a construction/maintenance work zone. However, 22 percent of all fatal crashes that occurred in a work zone involved a large truck. The majority of large truck crashes occurred in good weather (86 percent), on dry roads (83 percent), during the daytime (69 percent), and on weekdays (85 percent). Eighty-two percent of all fatal truck crashes involved at least one other vehicle, usually a passenger vehicle. Some of the most common factors cited for drivers of large trucks and drivers of passenger vehicles were the same as passenger vehicles: driving too fast, running off the road or out of the traffic lane, and failure to yield the right of way (http://www.fmcsa.dot.gov/factsfigs/dashome.htm).

Cullen (1999) reported that the outcome of “Operation Trucker Check” in California, 9% of the truckers in the study tested positive for drugs in their system. Although it may be difficult to generalize the results of this operation to other states within the country, the information gained does underscore the importance of monitoring substance abuse among drivers and how it may directly influence driver performance.

Shanoff (2003) provided useful information regarding random testing programs for drug and alcohol usage among truckers with commercial drivers licenses (CDL) that test positive. As noted, “Estimated positive usage rate for drugs, based on random testing in 2001, was 1.5%. For 2000, this same rate was estimated to be 2.0%. Based on the levels of precision achieved for these two survey years, the change from 2000 to 2001 was not statistically significant” (Shanoff, 2003, p. 28). Based on the new rule issued by the Federal Motor Carrier Safety Administration (FMSCA) of the U.S. Department of Transportation, truck drivers may have their driving privileges suspended, canceled, or revoked if found guilty of operating under the influence of drugs or alcohol (Shanoff, 2003).

Highway Safety and Driver Fatigue

In a study conducted by Crum, Morrow, Olsgard, and Roke (2001), it was concluded, “driving environment plays a key role in driver fatigue . . . a large percentage of drivers are at high risk for experiencing fatigue on the job” (p. 133). Fatigue has the ability to impair a tractor-trailer driver’s cognitive functions and ultimately affect processes that are vital to the safe operation of an 80,000-pound tractor-trailer rig. Fatigue may occur without any recognized physical exertion, and the driver may not be aware of existing impairments.

The other risk to safe driving is the drowsiness that often accompanies fatigue. Easily underestimated during driver performance, fatigue and lack of sleep can create a recipe for a substantial driver error. Long work hours, sleep deprivation, nighttime driving, and irregular schedules may cause fatigue-induced drowsiness that ultimately impairs sustained attention and safe driving functions (Wylie, 2000). According to a study by Milter, Miller, Lipsitz, Walsh, & Wylie (1997), "drivers averaged 5.18 hours in bed per day over the five-day study (range, 3.83 hours of sleep for those on the steady 13 hour night schedule to 5.38 hours of sleep for those on the steady 10-hour day schedule) (p. 755)." Furthermore, "long-haul truck drivers in this study obtained less sleep than is required for alertness on the job" (ibid, p. 755).

In Australia a study involving long distance heavy vehicle drivers, truck operators "reported that fatigue affected their driving by slowing their reactions, impairing their gear changing and steering and by making them drive too slowly" (Williamson, Feyer, Friswell, & Sadural, 2001, p. 7). According to the Federal Motor Carrier Safety Administration (FMCSA) driver fatigue is a key safety issue in commercial motor vehicle (CMV) transportation (http://www.fmcsa.dot.gov/safetyprogs/research/cmvfatiguestudy.htm). CMV drivers are allowed to drive up to 10 hours continuously, they often are required to drive at night, and work schedules that may be unpredictable and unorthodox. There is a far greater possibly of being involved in a fatigue-related crash than non-commercial drivers, especially at night. Compared to fatigue, other factors such as alcohol, speeding, or inclement conditions are far less important (http://www.fmcsa.gov/safetyprogs/research/driverfatigue.htm). Additionally, Lyznicki, Doege, Davis and Williams (1998, p. 1910) noted, "the large mass, high mileage exposure, and long operational life of large trucks increase the likelihood that these vehicles will be involved in a sleep-related crash during the lifetime of the vehicle. Injuries and property damage are likely to be severe in these crashes". Regarding the human factor, Atkinson (2002, p. 36) observed "many drivers are lacking supervision and logbooks are sometimes doctored, making it difficult to monitor actual driving times. Drivers are also attracted to financial gains when additional shipments can be acquired and the need for sleep is often not addressed." Efforts to modify hours-of-service by truck drivers (effective January 4, 2004) by the U.S. Department of Transportation was aimed at allowing more driving, but trim total on-duty time. Creating the benefit of two full nights of rest and the elimination of built up fatigue, Bearth (2003, p. 36) noted, "A restart provision allows truckers to start a new weekly cycle if they take 34 consecutive hours off. The new rules allow drivers 14 hours of work, of which 11 can be driving, and then require 10 hours off. The weekly limits of 60 hours in seven days or 70 hours in eight days remain the same."

Petty (2003) states, "Driver fatigue is emerging as a new frontier in risk management. We must recognize that drivers' on-duty hours-of-service reports paint an incomplete account of their overall fitness to drive. The full story often remains untold until it's too late" (p. 34). Furthermore, other variables must be considered, such as existing feelings of tiredness, previous sleep during the past week, consecutive work days, and accumulated sleep which all affect driver performance. As noted, "Many fatigue-related accidents occur despite compliance with government hours-of-service regulations" (Petty, 2003, p. 34). Too often driver performance is affected and the outcome is a disastrous and costly accidents.

Sponsored by the U.S. Department of Transportation, the 1995 National Truck and Bus Safety Summit assembly agreed that fatigue was the number one safety issue of the motor carrier community. According to the 1997 Federal Highway Administration (FHWA) Driver Fatigue and Alertness Study, fatigue was also reported as the leading factor in heavy truck accidents (http://www.fmcsa.dot.gov/safetyprogs/research/cmvfatiguestudy.htm). Described as a 4.45 million dollar, 7-year landmark study, it provides information related to driver alertness, physiological and psychological states of the driver, and driving performance in actual revenue-generating trips. Massive amounts of data accessed information related to time-of-day driving, duration of driving, and cumulative fatigue across days, quantity and quality of sleep, and other areas pertinent to fatigue and commercial driving experiences. Inadequate amounts of sleep obtained by the driver and the strong tendency for drowsiness were found to be the two major variables most associated with nighttime crashes. In addition, the drivers in the study were found to be generally poor judges of their own levels of fatigue/alertness (http://www.fmcsa.dot.gov/safetyprogs/research/cmvfatiguestudy.htm). Adequate sleep is the countermeasure to fatigue and the necessary action for reliable and safe performance of the tractor-trailer driver.

There are some exceptions to traditional empirical findings in the literature on the influence of fatigue and driver performance. Drissel and Spiegel (2003) found that in the retail industry, unlike the long haul industry, drivers operating between the hours of midnight through 5:00 a. m., who typically took rest periods at home, were not found to be more dangerous than average.

Driver Experience and Performance

With the goal of attaining the best driver performance possible, most trucking organizations make reference to and recognize the value of recruiting, selecting, and hiring experienced tractor-trailer drivers in their recruitment programs. Incentives for bringing these drivers on board are noted in the trucking industry literature. In addition, most organizations acknowledge that experience (a legal driving history) is preferred in the selectivity process (Mejza, Barnard, Corsi, & Keane, 2003; Monaco & Williams, 2000). Mejza, et al., (2003) asked respondents (carriers) "to rate how important or unimportant certain non-personality characteristics relating to driving experience, legal history, and personality were to their company's decision to hire a company-employed driver. Concerning driver selectivity and performance…" From the findings of this study, it is noted, "the lack of prior alcohol or drug-related violations, chargeable crashes, speeding tickets, and traffic violations along with driving experience with other carriers—are most important to the their firm's company driver and owner-operator hiring decisions."(Ibid, p. 21). However, the shortage of empirical evidence on the subject of experience as a factor and its effect on performance is ominous to say the least. Corsi, Fanara, and Roberts (1984) indicated that drivers for carriers with a history of high accident rates, with less than 2 years experience, less than 30 years of age, and not using a seat belt, had a disproportionate number of accidents. As a result of improved education, training, and technology, accident rates involving large trucks and drivers with less than one year of experience have declined from figures exceeding 50 percent (Bruning, 1989, p. 42). In a more recent study involving factors that influence driver safety in the trucking industry, Williams (1999), noted:

> Experience seems to have a positive effect on the safety measures, but is undoubtedly skewed somewhat because of high correlation with age. Drivers with 1 year of experience reported the highest percent of accidents at almost 28%. As the drivers gain experience, the accident rate declines, with some fluctuation, and bottoms out around 11% for drivers with 6-8 years experience. The rate then begins a slow incline to 16.84% for drivers with 16 or more years of experience. (p. 140)

Miles Driven, Number of Registered Vehicles, and the Effect on Performance

The United States' Department of Transportation Analysis Division of Federal Motor Carrier Safety Administration offers insightful statistical information on large truck crash facts for the years 1975-2001. These statistics allow one to gain a more accurate perspective on variables that may affect driver and organizational performance. According to this report, over the past 20 years (from 1981 to 2001) there has been a 37-percent increase in registered large trucks and a 91-percent increase in miles traveled by large trucks. The number of large trucks involved in fatal crashes each year has declined by 8 percent, and the vehicle involvement rate for large trucks in fatal crashes has declined by 52 percent. Over the past 10 years (from 1991 to 2001) there has been a 27-percent increase in registered large trucks and a 39-percent increase in miles traveled by large trucks. The number of large trucks involved in injury crashes each year has increased by 15 percent over the past 10 years, and the vehicle involvement rate for large trucks in injury crashes has declined by 17 percent. (http://www.fmsca.dot.gov/safetyprogs/research/

Regarding the miles driven and percentage of crashes reported, Williams (1999) made the following important findings:

> As annual miles driven increases, so does the percent of reported accidents, moving violations and logbook violations. Of those drivers reporting 50,000 miles or less driven in the past year, 10% reported being involved in an accident, 20% received a moving violation, and 35% reported violating their logbooks. These figures increase as annual mileage increases and are 20%, 30%, and 67%, respectively, for those drivers reporting over 160,000 miles in the last year. This positive relationship is expected, as it is likely that those driving more miles are violating hours of service regulations and hence are more likely to be involved in an accident or receive a moving violation. The more miles

> driven, the more likely a driver is to be cited for a moving violation and the more hours they have to falsify their logbooks to make up for the obtainable, but probably illegal, miles driven. (p. 142)

Driver Education, Training, and Its Effect on Performance

The need for driver education, training, and its effect on performance is highlighted by Craig Lynch, driver-finishing manager with U.S. Express. Lynch says, “we see a very positive correlation between putting good drivers out there on the highway and the bottom line” (Leavitt, 2000, p. 5). Furthermore, Lynch adds, “with approximately 7 million trucks crisscrossing the country each day it is essential that drivers receive the most up-to-date training that is available” (Leavitt, 2000, p. 6). Deyo (2003) observed that there were not enough qualified drivers to sustain the present workload, much less the forecasted needs of the future. As noted, “approximately $30 trillion worth of cargo will be transported in the United States by 2020, compared with $9 trillion today. By 2020, tonnage will increase by nearly 70 percent above the current levels of 15 billion tons” (p. 58).

Relating to the status of education held by tractor-trailer drivers, Williams (1999) noted that drivers with college degrees are more likely to violate the hours of service regulations, yet this same group is “least likely to have received a moving violation (17% versus 30% for the remainder of the sample)” (p. 143). Underscoring the humanitarian need of improving driver performance as revealed in a summary of commercial driver training and performance management, it was stated:

> Approximately 2/3rds of all “harm” from combination-unit truck crashes, and approximately 85 percent of fatalities, occur “outside” the truck; i.e., to other vehicles and vehicle occupants involved in crashes with trucks. The vast majority of these crashes

> are due to human error—either of a non-commercial driver involved in the crash or the truck driver himself or herself. (http://www.fmcsa.dot.gov/safetyprogs/research/cmv)

Highlighting the significance of driver training and a safer performance, commercial driver training/education and driver testing/licensing were named as two of the top ten CMV safety issues at the 1995 FHWA-sponsored National Truck and Bus Safety Summit. As noted, "a report by the U.S. Congress, Office of Technology Assessment cited lack of training as one of the most common factors in commercial vehicle accidents" (http://www.fmcsa.dot.gov/safetyprogs/.). During the International Truck and Bus Safety Research and Policy Symposium held in April 2002, at Knoxville, Tennessee, USA, commercial driver training was named as the number one of thirty-four recommendations necessary to improve driver safety. The participants suggested, "the federal government should mandate and develop standardized Commercial Motor Vehicle driver training which shall include entry-level, sustained (in-service), and remedial training to teach the proper skills, performance, and behaviors necessary to be a CMV driver" (National Safety Council, 2002, p. 1). According to Large Truck Crash Facts 2001, published by the U.S. Department of Transportation, Analysis Division, FMCSA, over the past ten years "vehicle involvement rate for large trucks in injury crashes has declined by 17 percent" (http://www.ai.volpe.dot.gov/CarrierResearchResults/HTML/2001Crashfacts/2001LargeTuckCrashFacts.htm). Fickes (2000) credits these safety improvements to comprehensive driver training programs among the carriers in the trucking and waste management industry.

In a study involving management practices as antecedents of safety culture within the trucking industry, Arboleda, Morrow, Crum, & Shelly (2003, p. 189) noted, "driver fatigue training, driver opportunity for safety input, and top management commitment to safety were perceived to be integral determinants of safety culture."

Driver Incentives and Performance

Some scholars have argued that incentives and rewards manipulate and stifle intrinsic motivation and do more harm than good. However, incentives have also been found to have a profound effect on the performance of employees. Incentives, especially as they relate to safe driver performance, should be used when employees consciously know what to do, yet fail to follow through. Motivational intervention is needed to achieve the goal of satisfactory performance and abundant bottom-line results confirm their overall effectiveness (Geller, 1999).

Mejza, et al., (2003) suggested that driver performance may be affected by reinforcing driving behavior. For example, using a database from 13,053 reports, Moses and Savage (1992) (as cited in Mejza, et al., 2003) found “significant association between the presence of safety incentive programs and total carrier accidents and injuries” (p. 18). Also, according to Geller (1999), (as cited in Mejza, et al., 2003), “reinforcement activity is characterized by antecedent events (incentives and disincentives) and/or consequent events (rewards and penalties) that can be used in combination to support specific behavior intervention strategies” (p.18). Moser (2001) believes reinforcements needed not be expensive and may include gift certificates, vehicle accessories or upgrades, and citations that instill positive attitudes. In a Canadian study involving data from 40 trucking companies, the findings revealed that 70 percent of the companies interviewed had safety incentive programs and the industry spent $30 to $50 million annually on funding these programs (Barton, Tardif, Wilde, & Bergeron, 1998, p. 22).

Finally, reporting on the International Truck & Bus Safety Research Symposium, in Knoxville, Tennessee, Barton and Tardif (2002) indicated that senior management must demonstrate a high priority for incentive programs, budget accordingly, empower a coordinator, and include input from those who will be likely recipients of incentives. Involving employees in all aspects of the planning and implementation designates ownership and is more likely to provide positive performance outcomes. Also, the recipients must view the incentive as valuable or it may fail to motivate the performance to an acceptable level (Barton &Tardif, 2002).

Driver Salary and Its Influence on Performance

In a study sponsored by the FHA/FMCSA, researchers used data sets at three different levels to examine the link between driver pay and driver safety. As noted, “It establishes a relationship that is important for policy purposes because it suggests that low driver pay, which we expect is linked to low but unmeasured human capital, may be an important predictor of truck driver safety” (Belzer, Rodriguez, & Sedo, 2002, p. 1). Further, Belzer, et al., (2002) observed:

> Driver pay has a strong effect on safety outcomes. These results are consistent with economic theory because we expect that carriers pay drivers according to their market value, and that value is determined by their personal employment history, driving record, training and education, experience, driving skills, temperament, and other unmeasured factors. (p. 8).

From the review of the related literature, it has been established that a combination of variables such as salary, training, education, background characteristics, experience, miles driven, stress, substance abuse, fatigue and incentives determine driver performance and highway safety. What is not very clear is to what extent each of these variables determine the performance of specific truck drivers’ performance hence the need for additional empirical research. The primary purpose of this study was to develop a model for predicting tractor-trailer truck drivers’ job performance related to highway safety.

RESEARCH METHODS

Data Sources

The data utilized in this study were obtained from a major transportation company in the United States of America. The transportation company that provided data for this study maintains a database for tractor-trailer truck drivers. We obtained data for 14,340 drivers for the year 2002.

Data Analysis

Previous academic studies focusing on transportation have used regression techniques on accident rates (Belzer, Rodriquez, & Sedo, 2002; Hinton & McVittie, 1994; Nafukho & Hinton, 2003). We found this technique relevant to the current study. We also determined correlations between number of crashes per driver and several variables studied in this research. A correlational analysis, together with a stepwise regression analysis, was used to determine the relationship between a number of predictor variables and the dependent variable number of accidents per driver. In addition, descriptive statistics were employed in the data analyses with means and standard deviations reported and discussed. The Statistical Package for Social Sciences computer program was used for data analyses.

Variables Employed in the Analyses

In order to determine job performance of the drivers in the study, it was important to establish a functional relationship between dependent and independent variables in the study. The dependent variable, number of crashes per driver was correlated with accidents per driver and the financial loss incurred per driver by the employer. The independent variables included salary, gender, marital status, age, race, miles driven per month, times of dispatching, miles driven per month, pay time off, and safety bonus provided by the employer.

Limitations

While the literature reviewed in this study show that drivers' experience, use of alcohol and training are important variables that determine performance, these variables were not addressed in this study. The transportation company involved in the study reported that all truck drivers received training before being allowed to drive trucks. Since all the 14,340 in the drivers were considered trained (according to the company), the variable training became a constant and could not be studied. All efforts to get data on drivers' level of education and alcohol related cases by the researchers did not yield any results.

Results

This section of the report contains the results of the study that sought to determine the variables that could predict the performance of tractor-trailer drivers in one of the largest transportation companies in the United States of America. The study was designed to answer the following research questions: What are the demographic variables associated with safe driving? What driver characteristics are associated with road traffic accidents? In what ways do the working conditions of drivers affect highway safety? What compensation and incentive variables are provided to the drivers in the study, and how do they affect the drivers' job performance? How do workplace variables such as scheduling and miles driven per month affect the drivers' job performance?

Background Characteristics of the Tractor-Trailer Drivers in the Study

The majority of the drivers in the study were male. Data in Table 1 show that of the 14,340 drivers, 13,945 (97.2%) were male while, 395 (2.8) were female. Figure 1 further illustrates the gender of the subjects in the study.

Table 1
Gender of the drivers in the study

Variable	Frequency	Percent
Male	13945	97.2
Female	395	2.8
Total	14340	100.0

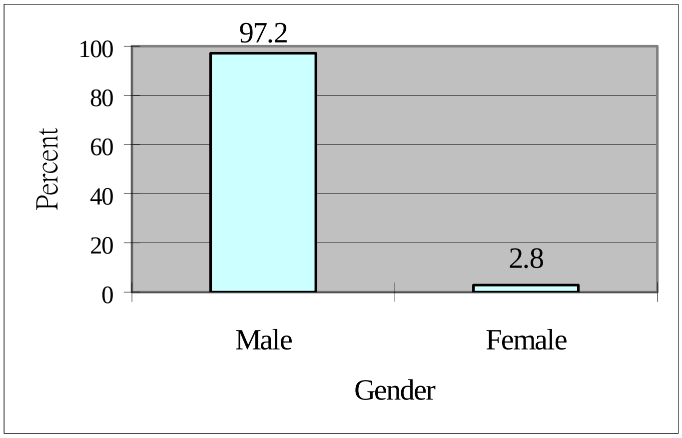

Figure 1. Gender of the drivers

Drivers' marital status may have a role in determining the performance of drivers. As shown in Table 2, 8,172 (57%) of the drivers were married, 5,019 (35%) were single while 974 (6.8%) were divorced. A summary of these statistics is presented in Table 2 and Figure 2.

Table 2
Marital status of the drivers in the study

Variable	Frequency	Percent
Common-Law	2	.0
Divorced	974	6.8
Separated	111	.8
Head of Household	11	.1
Married	8172	57.0
Single	5019	35.0
Unknown	9	.1
Widowed	38	.3
No Response	4	.0
Total	14340	100.0

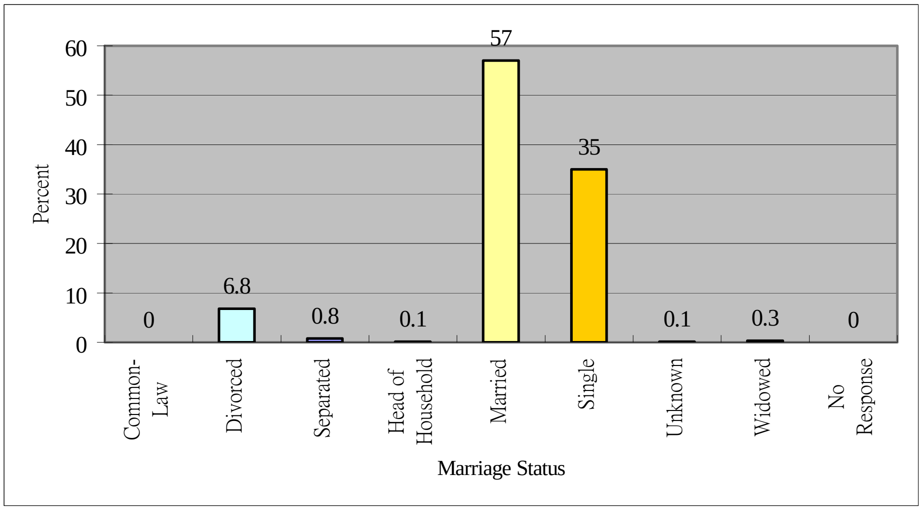

Figure 2. Marital status of the drivers

Data in Table 3 show that a majority of the drivers, 9,622 (67.1%) were White, 2,918 (20.3%) were Black, while 684 (4.8%) were Hispanic. A summary of the statistics on ethnicity of the drivers in the study is shown in Table 3 and Figure 3.

Table 3
Ethnic background of the drivers in the Study

Variable	Frequency	Percent
White	9622	67.1
Black	2918	20.3
Hispanic	684	4.8
Asian/Pacific Islander	106	.7
American Indian/Alaskan Native	338	2.4
Not Applicable	668	4.7
No Response	4	.0
Total	14340	100.0

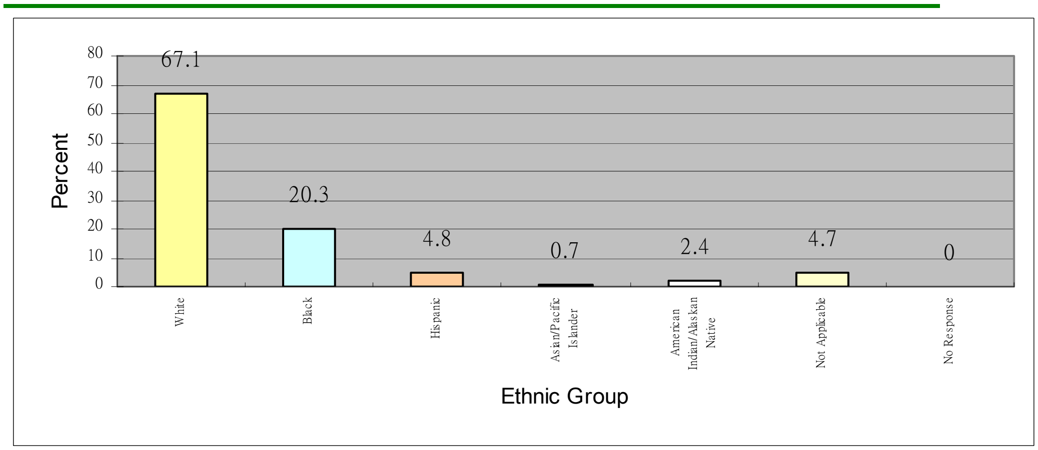

Figure 3. Ethnic background of the drivers

Performance of the Drivers in the Study

The primary purpose of this study was to determine a model that could predict driver performance. Driver performance was measured in terms of whether or not the drivers had accidents and the cost implications of these accidents to the organization. Data in Table 4 show that of the population of 14,340 drivers in the study, 11,576 (80.73%) had no accidents while 2,764 (19.27 %) of the drivers had experienced accidents. This is further illustrated in Figure 4.

Table 4
Population of drivers with accidents compared to no-accident drivers

Variable	Frequency	Percent
Population of Accident	2764	19.27
Population of No-Accident	11576	80.73
Total Population	14340	100.00

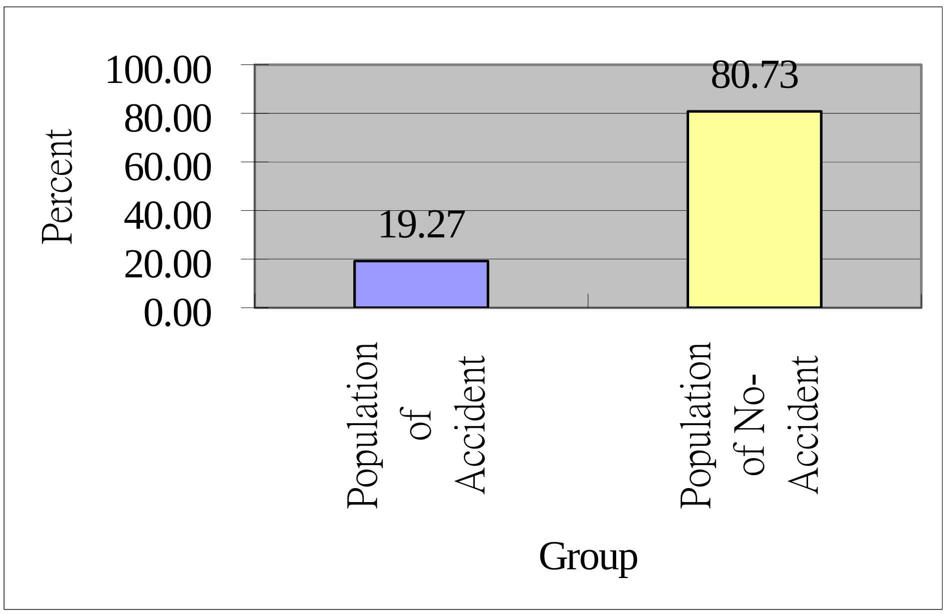

Figure 4. Population of drivers with accidents compared to those with no accidents

Besides determining the number of drivers with or without accidents, it was found important to establish the number of times the drivers in the study had accidents. As shown in Table 5, of the 2,764 drivers with accidents, a majority, 2,351 (85.1%) had one accident. This was followed by another 370 (13.4%) of the drivers who had experienced accidents twice. A small number of the drivers, 43 (1.6%) had experienced accidents three times. The cost implication of the accidents to the company is further illustrated in Figure 5. The average cost of the accident to the company for a driver with only one accident was $5,379. This average cost increased with the number of accidents per driver.

Table 5
Number of accidents

Number of Accidents	Frequency	Percent
One time	2351	85.1
Two times	370	13.4
Three times	43	1.6
Total	2764	100.0

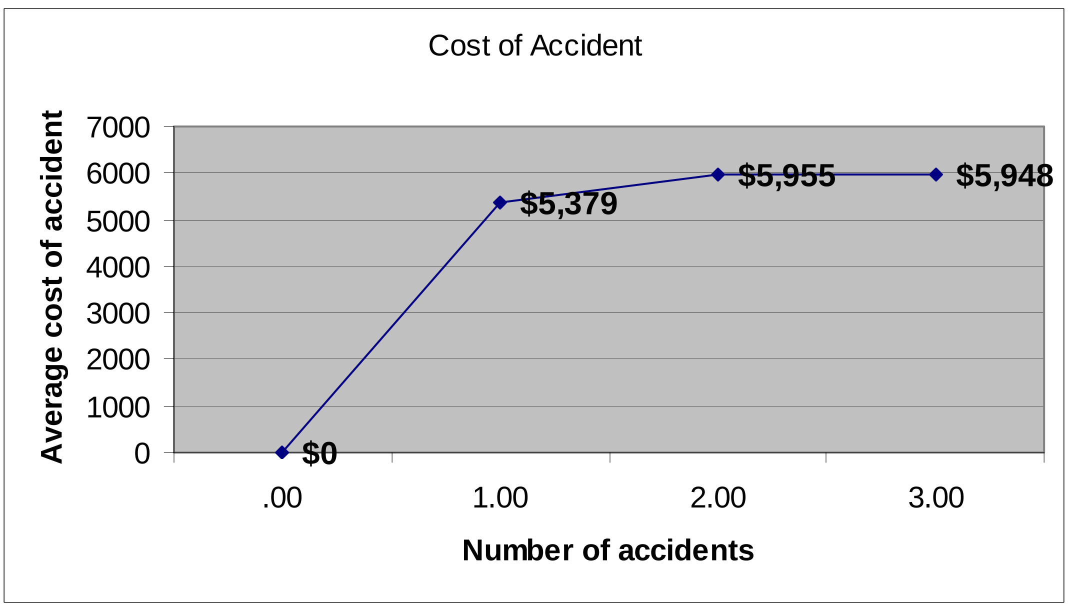

Figure 5. The number of accidents per driver

Data in Table 6 show the means and standard deviations of key variables in the study for the tractor-trailer drivers' population of 14,340 and for the accident sample of drivers of 2,764. As shown in Table 6, drivers who had accidents had a mean age of 46.30 years as compared to the entire population of drivers with a mean age of 45.56. Table 6 shows further that the pay time off for the entire population had a mean of $452.94, the mean pay time off for the drivers with accidents was $433.07. The other interesting finding shown in Table 6 is the miles driven per month for the two categories of the drivers. While the entire population had a mean of 4,365.34 miles driven per month, the accident category had a higher mean of 4,998.09 miles driven per month. Regarding safety bonus, Table 6 illustrates further that the accident category of drivers had a lower mean of $158.97 compared to the entire population mean of $167.26. The maximum amount of dollars incurred as cost of accident for the transportation company was $1,054,844. The maximum amount of salary earned was $74,138.83. The youngest driver in the study was 24 years, while the oldest driver in the study was 80 years. Summaries of the descriptive statistics are presented in Table 6.

Table 6
Descriptive statistics for the total and the accident populations

Variable	M*	SD*	M**	SD**	Minimum *	Maximum*
Pay time off	452.94	903.87	433.07	866.19	0	7019
Safety Bonus	167.26	399.69	158.97	360.50	0	2902.68
Salary	22094.42	16277.17	25145.14	15143.75	0	74,138.83
Number of accidents	0.22	0.49	1.16	0.41	1	3
Cost of Accidents	1053.70	18675.73	5464.76	42252.71	0	1054844
Age	45.56	10.03	46.30	10.40	24	80
Miles Per Month	4365.34	3418.44	3418.44	4998.09	0	19237
Times of Dispatching	10.86	13.49	12.17	13.04	0	162
Miles Per Time	537.68	306.53	555.36	276.07	0	2786
Driver performance	1.19	0.39	-	-	1	2

Notes
* Means, standard deviations, minimum and maximum values for the entire population N=14,340, ** Means and standard deviation values for the accidents population.

The graph presented in Figure 6, shows the random nature of the relationship between the workplace variable, scheduling in number of dispatches and the average cost of the accident. From the graph, one can appreciate the random nature of accidents. While one would expect that with more dispatches allocated to a given driver, the more the likelihood of accidents occurring. But, as seen in Figure 6, this is not true.

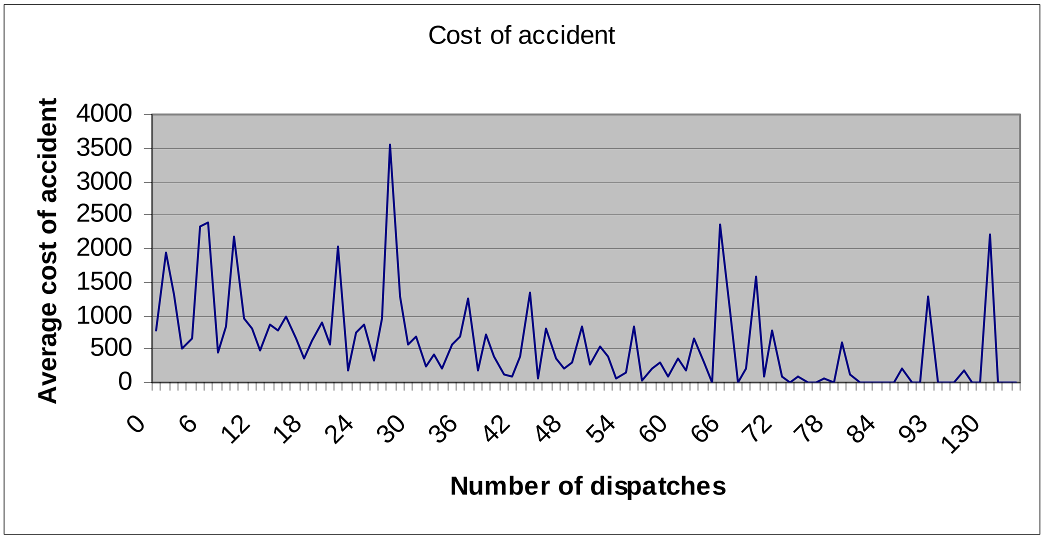

Figure 6. Relationship between average cost of accident and number of dispatches

The graph presented in Figure 7 shows how the numbers of accidents occurring affect the company's bottom line. For instance, with zero accidents, the company incurs no cost associated with accidents. This is the ideal situation that all transportation companies should seek to attain.

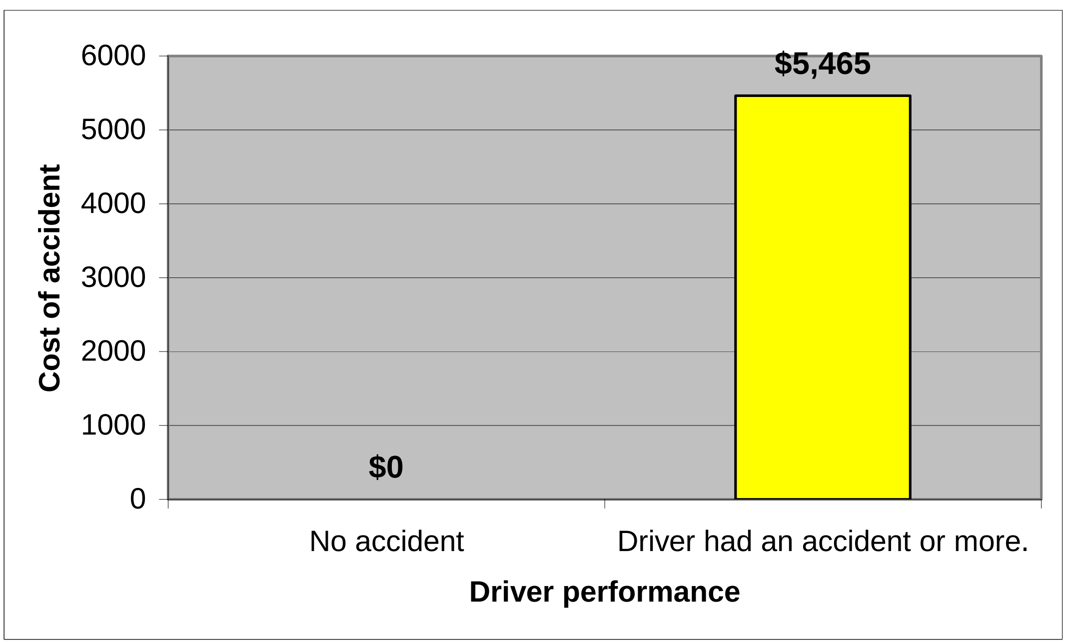

Figure 7. Relationship between cost of accident and driver performance

Determining the Relationship between the Performance of the Drivers and the Predictor Variables in the Study

The main research questions in the study sought to provide answers regarding the kind of relationships that existed between predictor variables such as drivers' demographic characteristics, compensation variables, workplace variables and driver performance. Table 7 shows the correlations between the predictor variables and the dependent variable, number of accidents/crashes. For interpretation of correlation coefficients, Davis' proposed set of descriptors was used (Davis, 1971). The coefficients and their descriptions are as follows:

Coefficient	Description
.70 or higher	Very strong association
.50 to .69	Substantial association
.30 to .49	Moderate association
.10 to .29	Low association
.01 to .09	Negligible association

Appropriate statistical procedures were selected to measure the relationships based on the level of measurement variables being studied. A Pearson Product Moment Correlation Coefficient was used to measure this relationship.

As the results in Table 7 show, variables salary and miles driven per month had significant degree of association with the number of accidents ($r = .091$, $p < .01$; r =. 092, $p < .01$ respectively), while the variables age, times of dispatching and miles per time for the entire population had a positive and significant negligible association with the number of traffic accidents. In the case of the accident population, the variables miles per month and age had a significant degree of association with the number of accidents. The association was a positive negligible relationship ($r = .053$, $p < .01$, $r = .07$, $p < .01$ respectively). While the variable safety bonus had a significant negative degree of association with the number of accidents ($r = -.024$, $p < .05$).

Table 7
Correlations between predictor variables and number of accidents per driver

Variable	N	r	*p*
Total Population			
Pay Time off	14,340	-0.014	.102
Safety Bonus	14,340	-0.015	.070
Salary	14,340	0.091	.000**
Miles Per Month	14,340	0.092	.000**
Age	14,340	0.045	.000**
Times of Dispatching	14,340	0.041	.000**
Miles Per Time	14,340	0.033	.000**
Accidents Population			
Pay Time off	2,764	-0.024	.209
Safety Bonus	2,764	-0.039	.038*
Salary	2,764	0.036	.060
Miles Per Month	2,764	0.053	.005**
Age	2,764	0.070	.000**

** Correlation is significant at the 0.01 Level (Two tailed)
*Correlation is significant at the 0.05 Level (Two tailed)

Regression Analysis Results

In addition to the descriptive and correlation results in the previous sections of this report, a further statistical analysis was undertaken by estimating the various stepwise regression equations. This was found particularly important for the purpose of determining the effect of predictor variables pay time off, cost of accidents, times of dispatching, miles driven per month, salary and age on the dependent variable number of accidents.

Prior to stepwise regression analysis, a simple correlation matrix was determined to establish whether the variables had any tendencies of multicollinearity. As the coefficients in Table 8 show the variables were not collinear. As expected the variables cost of accidents, miles driven per month, and salary are positively correlated with the response variable, number of accidents.

Table 8.
Coefficients of correlations matrix

Variable	PTO	SB	S	NOA	COA	TOD	MPM	GND	MS	ENTY	A	MPT	DP
PTO	1.000												
SB	0.511**	1.000											
S	0.502**	0.493**	1.000										
NOA	-0.014	-0.015	0.091**	1.000									
COA	-0.004	-0.011	-0.014*	0.109**	1.000								
TOD	0.117**	0.111**	0.654**	0.041**	-0.011	1.000							
MPM	0.533**	0.558**	0.875**	0.092**	-0.012	0.346**	1.000						
GND	-0.031**	-0.020*	-0.035**	0.010	-0.004	-0.019*	-0.037**	1.000					
MS	-0.070**	-0.053	-0.086**	0.016	0.007	-0.060**	-0.068**	-0.007	1.000				
ENTY	-0.114**	-0.094**	-0.167**	0.006	0.007	-0.073**	-0.182**	-0.003	0.086**	1.000			
A	0.211**	0.191**	0.240**	0.045**	0.007	0.113**	0.235**	0.005	-0.120**	-0.131**	1.000		
MPT	0.173**	0.153**	0.047**	0.033**	0.006	-0.364**	0.275**	0.006	0.015	-0.098**	0.059**	1.000	
DP	-0.011	-0.010	0.092**	0.931**	0.115**	0.047**	0.090**	0.011	0.015	0.003	0.036**	0.026**	1.000

Notes

PTO	Pay time off
SB	Safety bonus
S	Salary
NOA	Number of accident
COA	Cost of accidents
TOD	Times of dispatching
MPM	Miles of per month
GND	Gender
MS	Marriage status
ENTY	Ethnicity
A	Age
MPT	Miles per time
DP	Driver performance

To determine whether a model existed that could predict driver performance in terms of the number of accidents, stepwise regression analyses were carried out in order to examine which of the predictor variables correlated significantly with the dependent variable number of accidents. Table 9 summarizes this analysis. In this regression equation, variables were added that increased the explained variance by one percent or more as long as the regression equation remained significant. As shown in Table 9, the variable, which entered the regression model, first was cost of accident.

Considered alone, this variable explained 1.2% of the variance in the number of accidents that occurred among the 14,340 drivers in the study. Five additional variables explained an additional 2.0% of the variance in the number of accidents among the drivers in the study. These variables were the following: miles driven per month, safety bonus, pay time off, age and salary earned. These six variables explained a total of 3.2% of the variance in the number of accidents among truck drivers in the study (see Table 9).

Table 9
Stepwise regression using cost of accident, miles per month, safety bonus, pay time off, and age to predict the number of accidents

Source of Variation	**SS**	df	**MS**	**F-ratio**	***p***
Regression	110.386	6	18.398	77.897	<.001
Residual	3385.125	14333	.236		
Total	3495.510	14339			

Variables	R^2 Cumulative	R^2 Change	F Change	P Change	Beta
Cost of accident	.012	.012	172.866	.000	.110
Miles Per Month	.021	.009	128.048	.000	.122
Safety bonus	.027	.006	93.339	.000	-.077
Pay time off	.030	.003	41.412	.000	-.072
Age	.031	.001	17.153	.000	.034
Salary	.032	.001	9.208	.002	.052

The Relationship between Miles Driven, Age, and Number of Accidents

It was found necessary to examine further the issue of driver performance in the study. To do this, we examined the means and standard deviations of two important variables, the drivers' age, miles driven per month and compared these parameters to the variable number of accidents per driver. As shown in Table 10, the mean of the miles driven increased with the number of accidents. For instance drivers who had three accidents during the year of investigation, had the highest mean of miles driven (M=5,501.88, SD =2425.99), while the drivers who had only one accident, had the lowest mean of the miles driven (M = 4,924.78, SD =3266.15). The issue of the rising number of accidents with the additional miles driven is further illustrated in Figure 8.

Table 10
The mean and standard deviations of miles driven per month and the number of accidents

Number of Accidents	N	M Miles driven per month	SD
1.00	2351	4924.7823	3266.15328
2.00	370	5405.5568	3020.65161
3.00	43	5501.8837	2425.99899
Total	2764	4998.0922	3226.77336

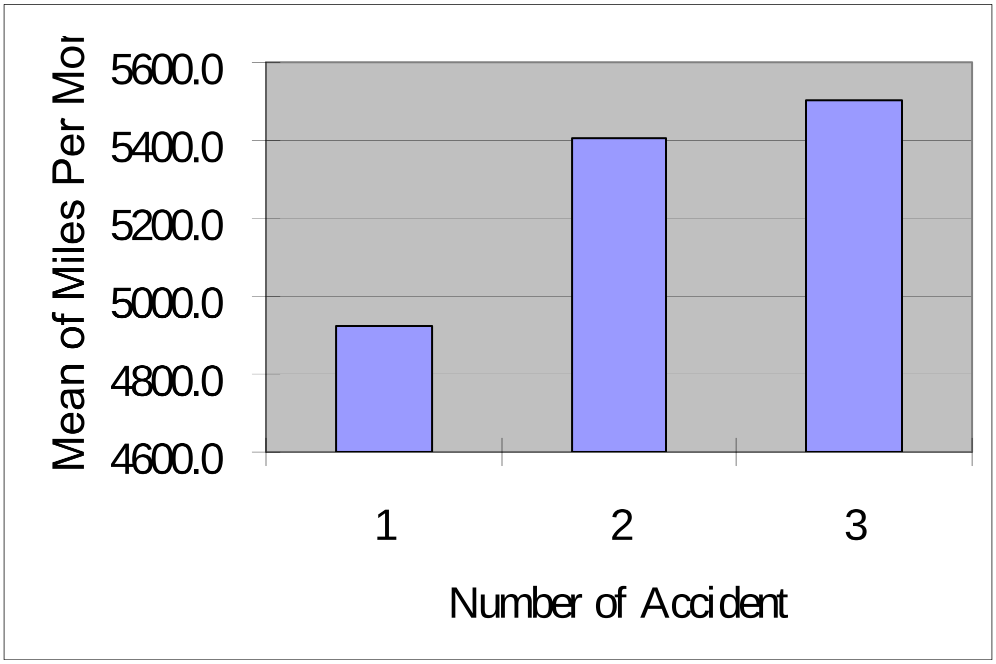

Figure 8. The bar graph showing the relationship between average miles driven per month and number of accidents

Based on the data obtained for this study, Figure 8 shows there existed a positive relationship between the average miles driven per month and the number of accidents. Thus, the more miles driven the more likelihood of causing accidents.

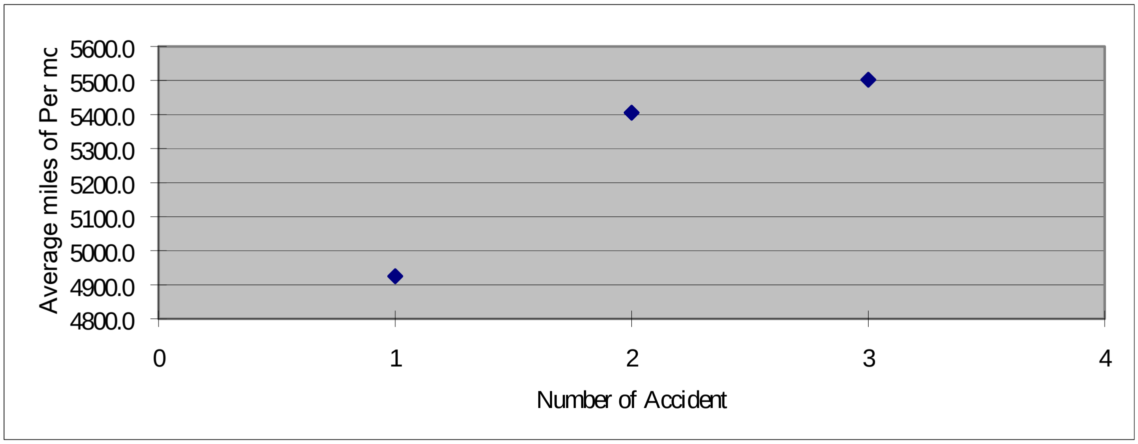

Figure 9. The graph showing the positive relationship between average miles per month and number of accidents

The other interesting variable that we explored further was the age of the drivers. It is interesting to note that drivers with advanced age caused more accidents than younger drivers in the study. Data in Table 11 show that older drivers had more accidents than younger drivers. For instance drivers who had caused with accidents had a mean age of 49.3 years, while the drivers who had caused only one accident had a mean age of 46 years. The figures are illustrated further in Figure 9 which shows a positive relationship between the average age of the drivers and the number of accidents.

Table 11
The mean and standard deviations of drivers' age and the number of accidents

Number of Accidents	N	M Age	SD Age
1.00	2351	46.0017	10.25788
2.00	370	47.8784	11.03106
3.00	43	49.2093	11.31067
Total	2764	46.3027	10.40343

Figure 10. Graph showing the positive relationship between average age of the drivers and the number of accidents in the study

Conclusions

The primary purpose of this study was to develop a model for predicting tractor-trailer truck drivers' job performance related to highway safety. The research focused on how over-the-road tractor-trailer truck drivers' job performance could be improved while ensuring increased revenue for the transportation companies employing them. Based on the findings of this study, the following conclusions, implications and recommendations were derived:

A statistically significant model did exist that explained the variance in the dependent variable, the number of accidents in the study that was used as a measure of driver performance. Six variables predicted the variance in the dependent variable. The variables cost of accidents, miles driven per month, safety bonus, pay time off, drivers' age and salary earned combined explained 3.2% of the changes in the dependent variable (number of accidents) in the study. While the coefficient of determination (R^2 = .032) is small, when translated into monetary terms 3.2% of the accidents could significantly affect the company's bottom line. The fact that the incentive variables safety bonus and pay time off entered the regression model supports the notion that incentives have a strong and positive effect on driver performance, which determines highway safety (Belzer, Rodriquez & Sedo, 2002; Geller, 1999; Mejza et al. 2003). However, it has also been established that pay incentives for the drivers did not automatically lead to an increase in the companies' bottom line (Ray, 1998).

The variables associated with the driver performance and safety in the study included salary, miles driven per month, age of the driver, times of dispatching and miles driven per time. This conclusion is supported by the fact that there existed a low and a positively significant association between salary earned, miles driven per month and number of accidents ($r = .091$, $p < .01$; $r = .092$, $p < .092$, respectively). In addition the variables age of the driver, times of dispatching and miles covered in a specific time period had negligible significant association with number of accidents per driver. While the coefficients are negligible, they are positive and statistically significant. This finding is in agreement with studies that have examined driver performance and these predictor variables (Crum & Morrow, 2002; Adams-Guppy & Guppy, 2003; Wylie, 2000).

A majority of the drivers in the study were good performers. For instance, 80.73% of the drivers in the study had no accidents during the year of investigation while 19.27% of the drivers had accidents. This finding shows the quality of drivers employed by the transportation company involved in the study. It also supports the earlier findings by Bruning (1989) who argued that the driver was a crucial factor in determining a transportation company's accident rate. The very low percentage of accidents by driver during the year of investigation could be as a result of high turnover among drivers. Thus, the drivers whose records were examined in this study may have comprised of drivers employed within the year of investigation.

The results of the study showed a linear and positive relationship between the average miles driven per month and the number of accidents per driver. This is an interesting finding which supports the current efforts by the U.S. Department of Transportation that aims at allowing more driving, but trims total on-duty time. Since the drivers are paid based on the miles driven, the finding raises a major challenge to the transportation companies on the need to revisit the payment mode of the drivers. For instance, should the drivers be paid based on the monetary value accruing from the goods transported or on the mileage covered?

The other interesting finding in this study relates to the drivers age and the number of accidents. There existed a linear and positive relationship between the average age of the drivers and the number of accidents caused. The average age for the total population of 14,340 was 45.56 while that of the accident only population of 2,764 was 46.30 years. The youngest driver in the study was 24 years old while the oldest driver was 84 years old. While the Age Discrimination Act does not allow discrimination in the employment of drivers based on their age, it would interesting to establish why the number of accidents increased with the average age of the drivers.

Implications

This study is important for transportation companies in promoting highway safety and improved savings associated with reduced number of accidents. While focusing on the 'human factor' and its role in traffic accidents, it is important that we use a holistic approach, which advocates a systems approach of reducing traffic accidents among truck drivers. Such an approach calls for identifying of traffic problems, formulation of a national strategy to address the problems and setting of targets and performance monitoring mechanisms. Transportation policy makers should shift from emphasis on the truck drivers to integration of road safety strategies with "strategic and sometimes competing goals such as those relating to environment and to accessibility and mobility" (Breen & Seay, 2004, p.12).

To focus on truck drivers to improve drivers' performance and increased revenue for the transportation company alone would be flawed thinking (Holton, 1999). The drivers operate at the individual level. But critical to the success of any organization are the individual, process and organizational performance levels. Human Resource Development experts, logistic transportation experts, public heath scholars and sociologists among many other experts in the U.S. must look at transportation and roads and their impact on rural economies and the entire U.S. economy in a holistic manner. To improve truck drivers' performance, there is an urgent need to improve the entire transportation system. The U.S. transportation system may want to examine the Vision Zero. Thus, Vision Zero is a traffic safety policy developed in Sweden and is based on four elements: ethics, responsibility, a philosophy of safety and creating mechanisms of change (Peden, et al., 2004). While this strategy may not be the panacea to road traffic accidents, its examination may provide some important insights on how to improve truck drivers' performance in the U.S.

Recommendations

Because of the low correlations and coefficient of determination obtained in this study, we recommend the need for a qualitative study that will help answer important questions, which cannot be answered by a statistic or parameter estimate. Such a study should focus on the truck drivers and what they think could make them more efficient and effective in their work. Thus, in depth interviews with the truck drivers and focus group discussions may help answer pertinent questions related to highway safety. While the quantitative figures are important, the need to conduct qualitative studies or mixed methodology studies that employ multidisciplinary approaches and involve researchers from various disciplines is compelling.

The efforts to modify hours-of-service by truck drivers (effective January 4, 2004) by the U.S. Department of Transportation was aimed at allowing more driving, but trim total on-duty time, creating the benefit of two full nights of rest and the elimination of built up fatigue. As noted, “A restart provision allows truckers to start a new weekly cycle if they take 34 consecutive hours off. The new rules allow drivers 14 hours of work, of which 11 can be driving, and then require 10 hours off. The weekly limits of 60 hours in seven days or 70 hours in eight days remain the same” (Bearth, 2003, p. 36). We recommend a study that aims at determining the effect of this new regulation on traffic accidents. Such a study should employ both quantitative and qualitative techniques as suggested in this study. Also, to be investigated should be the effect of driver fatigue on drivers’ performance as perceived by the main performers, the drivers.

We recommend a qualitative study that would focus on drivers who are above 50 years old with more than three accidents. Such a study would establish from these older and experienced drivers what they think leads to an increase in the number of accidents as the average age of the drivers increases. The results of such a study would provide more insight than the purely quantitative studies.

To ensure highway safety and improved driver performance, we recommend for additional driver incentive programs. Such programs should be initiated with input from the drivers to get buy-in and insure ownership of the programs.

References

Adams-Guppy, J., & Guppy, A. (2003). Truck driver fatigue risk assessment and management: a multinational survey. *Ergonomics, 46,* (8), 763-779.

Arboleda, A., Morrow, P. C., Crum, M. R., & Shelley, II, M.C. (2003). Management practices as antecedents of safety culture within the trucking industry: Similarities and differences by hierarchical level. *Journal of Safety Research, 34, 189-197.*

Atkinson, W. (2002). Trucking safety: Problems and progress. *Risk Management, 49,* (11), 34-48.

Belzer H. M., Rodriquez, D. & Sedo, S. (2002). Pay for safety: An economic alternative for Truck Driver Safety. Committee on Freight Transportation Regulation and Economics Task Force on Trucking Industry Research, January 16.

Barton, R., & Tardif, L.P. (2002). Implementing successful incentive programs within transport fleets. International Truck & Bus Safety Research & Safety Symposium, Knoxville, Tennessee, 45-54.

Barton, R., & Tardif, L.P. (1998). Incentive programs for enhancing truck safety and productivity, a Canadian perspective. *Canada Safety Council.*

Bearth, D. P. (2003). Trucking highway deaths fall. *Transport Topics, April 28, 2003; 3534; Research Library,* 36-37.

Belzer, M. H., Rodriguez, D., & Sedo, S.A. (2002). *Paying for safety: An economic analysis of the effect of compensation on truck driver safety* (Prime contract number DTFH 61-98-C-0061). Washington, D.C. Federal Highway Administration/Federal Motor Carrier Safety Administration.

Bernard, T. M., Bouck, L. H., & Young, W. (2000). Stress factors experienced by female commercial drivers in the transportation industry. *Professional Safety*. Park Ridge: 45, (9).

Breen, J., & Seay, A. (2004). *The fundamentals.* In M. Peden, R. Scurfield, D. Sleet, D. Mohan, A. A. Hyder, E. Jarawan, & C. Mathers (Eds.). (pp. 1-25). *World report on traffic injury prevention.* Geneva: World Health Organization.

Bruning, E. R. (1989). The relationship between profitability and safety performance in trucking firms. *Transportation Journal, 28,* (3), 40-49.

Corsi, T. M., Fanara, Jr., P., & Roberts, M. J. (1984). Linkages between motor carrier accidents and safety regulation. *The Logistics and Transportation Review, 20,* (2), 149-162.

Cullen, D. (1999). Where there's smoke… *Fleet Owner*. 94, (1), 98.

Crum, M.R., Morrow, P.C., Olsgard, P., & Roke, P.J. (2001). Truck driving environments and their influence on driver fatigue and crash rates. *Transportation Research Record 1779, Paper No. 01-2294.*

Crum, M. R., & Morrow, P. C. (2002). The influence of carrier scheduling practices on truck driver fatigue. *Transportation Journal*, 42, (1), 20-41.

Davis, J.A. (1971). *Elementary survey analysis*. Englewood Cliffs, NJ: Prentice Hall.

Deyo, L. (2003). Training steers fleet. *Waste Age, 34,* (4), 58.

Drissel, R. J., & Spiegel, W. D. (2003). Are late-night truck drivers more dangerous? Not at one company… *Transportation Quarterly, 57,* (2), 39-46.

Fickes, M. (2000) Taking driver training to new levels. *Waste Age, 31,* (4), 238-248.

Geller, E. S. (1999) Behavior-based safety: Confusion, controversy, and clarification. *Occupational Health & Safety, (68*), (1), 40-49.

Gilbert, T. F. (1978). *Human Competence: Engineering worthy performance,* New York: McGraw-Hill.

Gilbert, T. F. (1988). 'Measuring the potential for performance improvement', *Training 25* (7), 49-52.

Hinton, E. B., & McVittie, S. (1994). Developing and testing of a screening model for predicting tractor-trailer truck driver retention. *Mack-Blackwell National Transportation Study Center and the Department of Adult and Vocational Education. University of Arkansas.*

Holton, E. F. III (1999). An integrated taxonomy of performance domains. *Advances in Developing Human Resources, 1. 29.*

International Truck & Bus Safety Research & Policy Symposium (2002). Implementing successful incentive programs within transport fleets. *International Truck & Bus Safety Research & Policy Symposium, April 3-5, 2002, Knoxville, Tennessee.*

Kamp, J. (1994). Worker psychology: Safety management's next frontier. *Professional Safety, 39,* (5), 32-36.

Khayesi, M. (1993). Rural household travel characteristics: The case of Kakamega district. Journal of Eastern African Research and Development, *23*, 88-105.

Leavitt, W. (2000). The safety mandate: Drivers. *Fleet Owner, 95,* (11), 5-7.

Lewin, K. (1936). *Principles of topological psychology*. New York: McGraw Hill.

Lewis-Beck, M. S. (1980). *Applied regression: An introduction*. Beverly Hills, London: Sage Publications.

Lyman, S., & Braver, E. R. (2003). Occupant deaths in large truck crashes in the United States: 25 years of experience. *Accident analysis and prevention, 35*, (5), 731-739.

Lyznicki, J. M., Doege, T. C., Davis, R. M., & Williams, M. A. (1998). Sleepiness, driving, and motor vehicle crashes. *JAMA, 279,* (23), 1908-1913.

Mejza, M. C., Barnard, R. E., Corsi, T. M., & Keane, T. (2003). Driver management practices of motor carriers with high compliance and safety performance. *Transportation Journal, 42,* (4), 16-29.

Mitler, M. M., Miller, J. C., Lipsitz, J. J., & Walsh, J.K. (2003). *The sleep of long-haul truck drivers, 337,* (11), 755-761. Retrieved October 28, 2003, from http://www.nejm.org at University Arkansas Libraries.

Monaco, K., & Williams, E. (2000). Assessing the determinants of safety in the trucking industry, *Journal of Transportation Statistics, 3* (1), 51-67.

Moses, L. N., & Savage, I. (1992). The effectiveness of motor carrier safety audits. *Accident Analysis & Prevention,* 24, (5), 479-496.

Moser, P. (2001). Rewards of creating a fleet safety culture. *Professional Safety, 46,* (8), 39-41.

Nafukho, F. M. & Hinton E. B. (2003). Determining the relationship between driver's level of education, training and job performance in Kenya. *Human Resource Development Quarterly, 14 (3) 265-283.*

National Safety Council (2002). Recommendations from the 2002 International Truck & Bus Safety Research and Policy Symposium, Knoxville, Tennessee. Retrieved October 28, 2003, from http://www.nsc.org/trn/trucksym.htm p.1.

Opanga, K. (1996). "These are not Accidents: They are Road Murders". Nairobi: Sunday Nation Ltd, February 11.

Orris, P., Hartman, D.E., Strauss, P., Anderson, R. J., Collins, J., Knopp, C., Yanchun, X., & Melius, J. (1997). Stress among package truck drivers. *American Journal of Industrial Medicine, 31, 202-210.*

Palmer, C. (2000) Trucking industry behind in promoting women, report says. *The Trucker, 13,* (11), 43-36.

Peden, M., Scurfield, R., Sleet, D., Mohan, D., Hyder, A. A., Jarawan, E., & Mathers, C. (Eds.). (p. 19). *World report on traffic injury prevention.* Geneva: World Health Organization.

Petty, G. (2002). Sleeping on empty. *Fleet Owner, 97*, (4), 34.

Ray, R. (1998). Life on the road driving truck drivers off: J. B. Hunt takes study to heart, raises pay to hold employees. *Mack-Blackwell Transportation Center, University of Arkansas, 4*, 2b, 1-3.

Robinson, G. D. and Robinson (1996). *Performance Consulting: Moving Beyond Training.* San Francisco. Berrett-Koehler Publishers

Schulz, J. D. (1998). Staying alive. *Traffic World, 255,* (3), 16-17.

Shanoff, B., (2003). Driving performance: New rules have CDL holders on best behavior or else. *Waste Age, 34* (1), 28.

U. S. Department of Transportation (2000). *Bureau of Transportation Statistics*, *Transportation Statistics Annual Report 2000.* Washington, D. C. Retrieved March 25, 2002, from http://www.bts.gov/publications/pocketguide/html/table.html

U.S. Department of Labor (2002). Federal Motor Carrier Safety Administration. *Data, Analysis and Statistics.* Retrieved October 28, 2003, from http://www,fmcsa.dot.gov/factsfigs/dashome.htm

U. S. Department of Labor (2003). Bureau of Labor Statistics. *Census of fatal occupational injuries.* Retrieved October 28, 2003, from http://www.bls.gov/iif/oshcfoi1.htm

U. S. Department of Labor (2003). Bureau of Labor Statistics. *Lost-work time injuries and illnesses: Characteristics and resulting time away from work, 2001*. Retrieved November 8, 2003, from http://www.bls.gov/news.release/osh2.nr-0htm

U. S. Department of Transportation (2003). Analysis Division Federal Motor Carrier Safety Administration. *Results from the 1999 drug and alcohol testing survey*. Retrieved October 28, 2003, from http://www.fmcsa.dot.gov/factsfigs/dashhome.htm

U. S. Department of Transportation (2003), Federal Motor Carrier Safety Administration. *Commercial motor vehicle/driver fatigue and alertness study, executive summary (1996*). Retrieved October 28, 2003, from http://www.fmcsa.dot.gov/safetyprogs/research/cmvfatiguestudy.htm

U. S. Department of Transportation (2003). Federal Motor Carrier Safety Administration. *Commercial driver training and performance management focus area summary.* Retrieved October 28, 2003, from http://www.fmcsa.dot.gov/safetyprogs/research/dtperfmgt.htm

U.S. Department of Transportation (2003). Analysis Division, Federal Motor Carrier Safety Administration. *Large truck crash facts 2001, FMCSA-RI-02-011*…1-56. Retrieved October 28, 2003, from http://www.ai.volpe.dot.gov/CarrierResearchResults/HTML/2001Crashfacts/2001LargeTruckCrashFacts.htm

U. S. Department of Transportation (2003). Federal Motor Carrier Safety Administration. *Research and technology program*. Retrieved October 28, 2003, from http://www.fmcsa.dot.gov/safetyprogs/research/cmvfatiguestudy.htm

U. S. Department of Transportation (1995). Federal Highway Administration, Office of Motor Carriers, Washington, D.C. Truck and Bus Safety Summit, Report of Proceedings, FHWA Docket MC-92-10.

U.S. Department of Transportation (2000). Bureau of Transportation Statistics, derived from U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business.* Washington D. C.

U.S. Department of Transportation (2000). Transportation System Extent and Use. Bureau of Economic Analysis, *Survey of Current Business*. Washington D. C.: http://www.bts.gov/publicatins/pocketguide/html/ March 29, 2002.

U.S. Department of Transportation (2002). National Transportation Statistics. Washington, D.C. Bureau of Transportation statistics. http://www.bts.gov/publicatins/pocketguide/html/ March 29, 2002.

Weinberger, L. A. (1998). Commonly held theories of human resource development. *Human Resource Development International, 1,* (1), 75-93.

Williams, E. (1999). What influences driver safety in the trucking industry? Proceedings of the 41st Annual Meeting of the Transportation Research Forum. *Transportation Research Forum, Washington, D.C.*, 132-152.

Williamson, A., Feyer, A. M., Friswell, R., & Sadural, S. (2001). Driver fatigue: A survey of professional long distance heavy vehicle drivers in Australia. *National Road Transport Commission*. CANBERRA ACT, Australian Transport Safety Bureau. .

Wylie, D., & Associates. (2000). *Driver fatigue is the number one safety issue in the truck and bus industry.* Retrieved November 8, 2003, from http://www.drivingfatigue.com/fatigue.htm