Working Multiple Consecutive Shifts: How Many Is Too Much?

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Certification Statement

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

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Abstract

The problem is that the Redondo Beach Fire Department (RBFD) does not know the impact on firefighter performance associated with an increase in overtime shifts. There is no limit to the number of consecutive shifts that firefighters work. It is common for personnel to work five or six consecutive 24-hour shifts. The purpose of this applied research project was to identify the impact on RBFD firefighter performance associated with an increase in overtime shifts. Descriptive research methodology was used to identify laws and standards related to employees working consecutive shifts and how other fire departments are addressing this issue. Research also described the effect that sleep deprivation and fatigue had on firefighter performance. Performance issues were identified by other departments as well as specifically for the RBFD. Research procedures included an internet survey, personal interviews, and a cognitive computer test to identify performance issues from firefighters working multiple consecutive shifts. The results of this study reflect a significant decrease in cognitive performance after 96 hours of consecutive work. Fatigue and sleep deprivation were the main causes, which also affected mood and motivation. In order to improve firefighter safety and reduce the potential risk of injuries and accidents, this study will culminate with recommendations for sleep management strategies. Strategies included identifying the signs and symptoms of fatigue, napping, rotating firefighters from busy to slower units, and developing healthy sleep habits. With labor's input, policies should be developed to limit the number of consecutive shifts that firefighters will be allowed to work.

Table of Contents

Certification Statement……. 2

Abstract…… 3

Table of Contents……. 4

Introduction……. 7

Background and Significance…….. 8

Literature Review…… 13

Laws and Standards…… 13

Airline Pilots and Air Traffic Controllers…… 14

Truck Drivers…… 15

Marine Officers…… 15

Railroad Workers……. 16

Medical Residents…… 16

Firefighters…….. 16

Staffing Restrictions of Other Fire Departments…… 17

The Importance of Sleep and the Effects of Fatigue…….. 18

The Effects of Sleep Deprivation on the Fire Department……. 25

The Effects of Sleep Deprivation on the Individual Firefighter……. 26

Fire Department Administration Responsibilities……... 28

Redondo Beach Firefighter Performance Issues……. 30

Literature Review Summary Statement…….. 31

Procedures…….. 32

Limitations……. 37

Definition of Terms…… 38

Results…… 39

Summary of Data…….. 50

Discussion…….. 53

Recommendations……. 58

Short Term……. 58

Long Term……. 59

References……. 62

Acknowledgements……... 66

Appendix A…… 67

Figure 1: Fire Department Survey Information……..…… 68

Figure 2: Fire Department Shift Schedule from Survey…… 72

Figure 3: Limit of Consecutive Shifts that Personnel Can Work…….. 74

Figure 4: Maximum Number of Shifts that Personnel Can Work Consecutively……. 75

Figure 5: Fire Department Approximate Call Volume…….. 77

Figure 6: Laws and Standards that Reference Personnel Working Consecutive Shifts… 78

Figure 7: Hours that Personnel are required to be off prior to Returning to Work…… 80

Figure 8: Effects on Firefighter Performance Observed…… 81

Figure 9: Changes in Performance or Productivity…… 83

Figure 10: On-duty Injuries Resulting from Working Consecutive Shifts……. 85

Figure 11: Firefighter Mind Power Test Results……. 86

Figure 12: Mind Power Subjective Questions by Consecutive Shift…….. 89

Figure 13: Mind Power Test Scores by Consecutive Shift…….. 90

Figure 14: Mind Power Test Scores by Consecutive Shift (≥5 Shift Participants)……. 91

Working Multiple Consecutive Shifts: How Many Is Too Much?

Due to the current economic recession, the City of Redondo Beach has placed a freeze on personnel hiring and promotion. As a result of attrition, multiple vacancies have occurred with the greatest impact in the Firefighter and Paramedic ranks. Currently, approximately 10% of RBFD's operations workforce is vacant. Personnel are working overtime to fill these vacancies as required by the minimum staffing portion of the memorandum of understanding (MOU) with the Redondo Beach Firefighters Association (RBFA). In addition to these overtime shifts, personnel routinely work overtime due to holiday, vacation, sick leave, and compensatory time off (CTO) coverage. The regular work schedule consists of a 48/96 shift. Operations personnel work two days in a row, followed by four days off.

The problem for the Redondo Beach Fire Department (RBFD) is that it does not know the impact on firefighter performance associated with an increase in overtime shifts. There is currently no limit to the amount of consecutive shifts that firefighters can work. It is common for personnel to work five or six consecutive 24-hour shifts. The purpose of this applied research study is to identify the impact on RBFD firefighter performance associated with an increase in overtime shifts. Descriptive research methodology was used to answer the following research questions:

1. What are the laws and standards that apply to employees working consecutive shifts?
2. How are other fire departments addressing firefighters working consecutive shifts?
3. What effect does sleep deprivation have on firefighter performance?

4. What performance issues are affected when RBFD firefighters work consecutive shifts?

Background and Significance

The Redondo Beach Fire Department (RBFD) is a full service agency that provides fire suppression, emergency medical, code enforcement, and marine safety services (City of Redondo Beach Website - Redondo Beach Fire Department, 2011, para. 1). The City of Redondo Beach is a coastal community located approximately 20 miles from downtown Los Angeles and seven miles south of Los Angeles International Airport (LAX) in the County of Los Angeles (City of Redondo Beach Website - Redondo Beach Fire Department, 2011, para. 2)

Redondo Beach is primarily a residential community with a population of 66,711 (estimated 2009) (U.S. Census Bureau, 2010, p. 2). The City encompasses approximately 6.2 square miles, and is bordered by the cities of Hermosa Beach, Manhattan Beach, El Segundo, Torrance, and the Palos Verdes Peninsula. Redondo Beach contains significant industrial and commercial properties in addition to its residential neighborhoods. Additionally, the City has its own recreational and commercial harbor, which boasts approximately 1,500 slips. A pier and approximately two miles of bathing and surfing beaches are attractions for residents and tourists alike.

The City of Redondo Beach is a charter city governed by a council-manager form of government. The Mayor is elected at large and there are five Council Members. In addition, a City Manager is appointed by the Mayor and Council as the chief administrative officer to guide day to day operations. The City's budget (General Fund appropriations) for Fiscal Year 2010-11 is $ 66,872,426. The Fire Department budget is $ 15,775,598 (City of Redondo Beach, 2010, p. 200).

The Redondo Beach Fire Department employs 60 full-time operations and seven administrative personnel. There are two land-based fire stations and one harbor patrol station in the city. The headquarters station houses one paramedic engine, one tiller truck, one paramedic rescue, and one chief officer. Fire station two consists of two paramedic engines, an air/light unit, and a paramedic rescue. The harbor patrol station houses a rescue boat as well as a fire boat, which is cross staffed by the truck company. Harbor patrol personnel provide rescue services in and around the harbor's four marinas and open water area surrounding the harbor. A minimum staffing agreement exists that allows for 20 personnel on duty each day. The fire department responded to 5,451 calls for service in 2010. Of the total incidents, 3,779 were emergency medical aids and 1,672 were rescue and fire related (City of Redondo Beach Website - Redondo Beach Fire Department, 2011, para. 4).

The RBFD is divided into three divisions including Prevention, Operations, and EMS/Special Services. A Division Chief heads each division and also provides shift coverage on their assigned shift. The Fire Chief is in charge of the Administrative division of the department. Additional responsibilities include a hazardous material response vehicle, paramedic program, and fire investigation unit.

A 48/96 shift schedule is utilized by the RBFD. Specifically, shift personnel work 48 hours in a row (two days) followed by 96 hours (four days) off duty. Three shifts (A platoon, B platoon, and C platoon) rotate to provide continuous daily coverage. The RBFD has been utilizing this schedule for approximately 11 years. This shift schedule has gained popularity, especially in California, due to long commute times and affordable housing. The cost of real estate in many beach cities precludes many firefighters from living in the city. Consequently,

personnel often commute 50 miles or more to live in more affordable areas. The 48/96 schedule only requires five commutes instead of 10, which is common on a "Kelly" schedule.

The department utilizes "Telestaff" for daily staffing needs. The Telestaff program manages personnel work schedules and can auto-hire for upcoming vacancies. Working opportunities (overtime shifts) are managed by various lists that keep track of shifts worked, voluntarily or forced. Personnel may sign up for upcoming vacancies up to 30 days in the future. Overtime shifts are awarded to employees with the lowest amount of shifts worked. Scheduled vacancies occur for a variety of reasons including vacations, holidays, and compensatory time off (CTO). When an employee desires to take a shift (24 hours) off, he/she enters the type of time into Telestaff. The computer subsequently fills the position and notifies the employee. In addition, department initiated overtime may include vacancies, sick leave, on-duty injuries (IODs), special event, or filming details. Consequently there are a lot of opportunities for personnel to work overtime. The staffing computer program has been used for the past 10 years.

In addition to personal time off and department initiated overtime, the RBFD currently has multiple vacant positions. These vacancies are a result of retirements and promotions that have yet to be filled. Many of the vacancies are in the firefighter and paramedic ranks. Due to the economic crises that has gripped the nation over the past few years (2008 through 2011), the City of Redondo Beach has initiated a hiring freeze. Consequently, the vacant positions have been left open and are continuously being filled by overtime. While the overtime cost associated with filling the shift is less than hiring new employees to fill the position (benefits savings), a new problem emerges. Fewer personnel are available to work the increased number of vacant shifts. Over the past year, multiple RBFD employees have suffered long term on-duty injuries. Two additional employees have been placed on administrative leave due to personnel issues.

These unforeseen occurrences have also contributed to the number of shifts required to be covered. When all available overtime shifts due to injuries, vacancies, personal time, and department initiated coverage are added, the number is staggering.

Currently, there is no limit to the number of consecutive shifts that RBFD personnel can work. If an employee works an overtime shift at either the end of a 48 hour set, or right before his scheduled shift, he is automatically placed on 72 straight work hours. Due to the number of available overtime shifts, it is not uncommon for personnel to work six or seven shifts in a row. The research shows that some firefighters and paramedics have worked 12 consecutive days. For instance, there are only six firefighter positions on the department (truck company), two per shift. One of the firefighter positions is currently vacant, and another firefighter is on long term disability. Consequently, four firefighters work not only their own shifts, but are also required to cover the two vacancies and personal time shifts when one of them wants a day off. An important question is: What are the impacts on personnel resulting from working consecutive shifts?

As personnel are working consecutive days, sleep deprivation and fatigue may play a role in firefighter performance. The impact on firefighter performance is unknown and is the subject of this study. Call volume for the RBFD is significant, and it is common for each unit to respond to 5-10 calls per 24 hour shift. In addition, personnel frequently run two or three emergency responses after 10:00 PM. Sleep is therefore affected and fatigue may be compounded over multiple on-duty days. Firefighter safety is the department's primary concern. Information revealed from this research project may provide insight into best practices related to firefighters working multiple consecutive shifts.

The purpose of this applied research study is to evaluate firefighter performance due to personnel working consecutive shifts (regular and overtime). In addition, a review of applicable standards and common practices of other fire departments will help to compare and contrast current policies (or absence thereof). This issue has recently come to light as the number of overtime shifts has substantially increased, and the effects this has on firefighter safety and wellness. Various parties are involved in this issue. The firefighter's union, department administration, and the public at large all have a stake in the identification of performance effects. Both the end user of the fire department's service (external customer) and our own firefighters (internal customer) may be affected by the outcome of this research project. Safety of our personnel as well as the quality of customer service given may be adversely affected by firefighter performance attributes. The future impact of this problem may become worse as additional vacancies occur and the hiring freeze continues. Moreover, this issue should be addressed in varying degrees to other fire departments across the nation. Identification of negative performance attributes may necessitate creation of a policy to limit the number of consecutive shifts that firefighters should work.

This applied research project is a requirement of the National Fire Academy Executive Fire Officer Program. The study intends to enhance executive-level knowledge, skills, and abilities necessary to lead transformations of organizations from being reactive to proactive, conduct research, and engage in lifelong learning (Executive Fire Officer Program, 2010, p. 3). This research project is consistent with the guidelines set forth in the Applied Research Project Guidelines (Executive Fire Officer Program, 2010).

Evaluating the effects on firefighter performance from working consecutive shifts directly relates to the Executive Development course within the Executive Fire Officer Program.

Unit 7: Organizational Culture and Change describes leading change in an organizational culture. Adapting to performance issues resulting from working consecutive shifts is a significant change. Innovative ways to manage this problem are addressed in this study. This research study relates to operational goal 3 of the United States Fire Administration's strategic plan. Operational goal 3 is to improve the fire and emergency services' capability for response to and recovery from all hazards (USFA, 2010, p. 14). Response capability is hindered if firefighters are not alert or fatigued when they respond to local emergencies. A goal of this study is to identify adverse firefighter performance due to working consecutive shifts. Methods to address the results of fatigue can ensure a response ready environment and improve response capability.

Literature Review

Literature review for this study was conducted from multiple sources including: the Learning Resource Center at the National Fire Academy, web-based articles and periodicals, and personal interviews. Research will address and summarize the results of this search in the following six areas: first, laws and standards, second, staffing restrictions of other fire departments, third, the importance of sleep and the effects of fatigue, fourth, the effects of sleep deprivation on the fire department, fifth, the effects of sleep deprivation on the individual firefighter, and sixth, fire department administration responsibilities.

Laws and Standards

Firefighters are not unlike other shift workers, in that all are susceptible to fatigue due to working extended hours. The consequences of decreased performance by shift workers can be dramatic. There are numerous accounts of accidents that have occurred from sleep deprived and/or fatigued workers. Some of these events for example, include the grounding of the Exxon Valdez, the Three Mile Island nuclear disaster, and the space shuttle Challenger explosion.

The Exxon Valdez disaster occurred on March 24, 1989 near the coast of Alaska. According to the NTSB report, the probable cause of the spill was failure of the third mate to properly maneuver the vessel because of fatigue and excessive work load (Elliot & Kuehl, 2007, p. 20). The Three Mile Island overheated reactor situation occurred in 1997 at approximately 4:00 a.m. as a result of a fatigued crew failing to notice a closed cooling valve (Morgan, 2009). On January 28, 1986, the space shuttle Challenger exploded after liftoff, in part because of fatigue and poor decision making made by executives working on as little as two hours of sleep (Morgan, 2009, p. 13). As a result of these and numerous other incidents, various agencies created regulations to limit the effects of fatigue and sleep deprivation. Regulations are currently in place for airline pilots, air traffic controllers, truck drivers, marine officers, railroad workers, and medical students.

Airline Pilots and Air Traffic Controllers

According to the Federal Aviation Regulations (FAR) part 135, commercial airline pilots are restricted to the amount of hours they may fly without rest. For instance, pilots are required to have at least nine consecutive hours of rest for up to eight hours of flight time (Federal Aviation Administration, 2009). In addition, pilots are restricted to: 1,200 hours in any calendar year, 120 hours in any calendar month, 34 hours in any seven consecutive days, or eight hours during any 24 consecutive hours (single pilot) (Federal Aviation Administration, 2009). Fatigue while flying is a major concern not only for the pilots and airlines, but for the traveling public. The Federal Aviation Administration (FAA) has recommended that air carriers include fatigue training as part of their crew resource management training programs (Duquette & Dorr, 2010, p. 1). Air traffic controllers are also susceptible to fatigue. The Federal Aviation Administration (FAA) recently placed rules in effect to address controllers who have fallen asleep on the job.

Controllers are now required a minimum of nine hours off between shifts, and will no longer be able to swap shifts that would place them on duty prior to the nine hour rule (Brown & Johnson, 2011).

Truck Drivers

Vehicle crashes caused by drowsy drivers are a significant national problem. The general reduction of sleep that has occurred in recent years, combined with a greater reliance on motor vehicles has increased fatigue related crashes (Elliot & Kuehl, 2007, p. 29). The U.S. Department of Transportation (DOT) restricts the time that drivers can operate a passenger-carrying commercial motor vehicle (bus drivers). Driving time is limited to 10 hours following eight consecutive hours off duty, or for any period after having been on duty 15 hours following eight consecutive hours off duty, or having been on duty 60 hours in any seven consecutive days (Maximum Driving Time, 2005).

Marine Officers

Various marine regulations also address the maximum amount of work hours allowed without rest. Marine regulations state that Officers must be off duty for six of the 12 hours before leaving port. They are to receive a minimum of 10 hours rest per day, divided into no more than two periods. In addition, rest may be reduced to six hours for two days, while maintaining at least 70 hours rest per week. Moreover, licensed individuals may not work more than 12 of 24 hours when at sea, and for tankers not more than 15 of 24 hours (Marine Regulations, 2005).

Railroad Workers

Title 49 of the United States Transportation Code addresses work hour restrictions for railroad workers. Rail workers are limited to 12 consecutive hours of on duty time. In addition, they are not allowed to work six consecutive days unless the employee has had at least 48 consecutive hours off duty. During the employee's off duty time, he/she is unavailable for any railroad carrier service (Railroad Regulations, 2010).

Medical Residents

Analogous to firefighters, medical students often work long hours with patients at the hospital. Their ability to make quick decisions, calculate proper medication dosages, etc. can be affected by fatigue resulting from sleep deprivation. Lowenstein (2003), indicated that medical students working increased hours have a higher risk of making medication errors. As a result of the death of a woman in New York State in the 1980's, regulations were developed to limit the hours that medical students can work. The regulations dictated that residents could work a maximum of 80 hours per week, with a maximum of 24 consecutive hours of patient care, and a minimum of eight hours off duty between shifts (Agency for Healthcare Research and Quality (US) [AHRQ], 2001, p. 520). In 2002, An American Medical Association (AMA) policy was passed to increase the minimum off duty hours from eight to 10. In addition, residents are able to stay on duty an additional six hours to transfer patients, staff outpatient clinics, or maintain continuity of care. However, no new patients may be accepted after 24 consecutive hours (American Medical Association, 2011).

Firefighters

After an exhaustive search of applicable laws and standards, this study was unable to locate any that specifically addressed firefighters working consecutive shifts. NFPA 1500

Standard on Fire Department Occupational Safety and Health Program is the industry standard, but does not cover sleep deprivation, firefighter fatigue, or a maximum amount of consecutive shifts that employees can work. The United States Forest Service (USFA) limits drivers to a maximum of 10 hours within a 15 hour period (Matthews, 2000). Wildland firefighters have general recommendations which address a work to rest ratio. The National Wildfire Coordinating Group (NWCG) recommends 14 day assignments. These assignments are typically used for larger "campaign" fires. The work to rest ratio is 2:1, which means that for every two hours of work or travel, there is one hour of corresponding sleep or rest. In addition, no work shift should exceed 24 hours. Following completion of a 14 day assignment, two mandatory days off should be provided (Elliot & Kuehl, 2007, p. 54). A separate recommendation was offered by a Contra Costa Grand Jury in 2007. The grand jury recommended limiting firefighters' consecutive work time to 72 hours with a mandatory break between shifts, except in extreme emergencies (Huff, 2007, para. 5). They added that "there is no question that fatigue leads to injuries and unsafe conditions".

Staffing Restrictions of Other Fire Departments

Although no formal laws or standards were identified, various fire departments have standard operating procedures that address working multiple consecutive shifts. For instance, the Phoenix Fire Department limits employees to three consecutive 24-hour shifts. Moreover, members must be off-duty for 24 hours prior to returning to work (Phoenix Fire Department [PFD], 2008). PFD also states, in part, that fatigue caused by extended periods of inadequate rest may impair job performance. This may be the result of the employee working consecutive shifts and the level of activity, both routine and emergency that was encountered during those shifts (PFD, 2008, para. 2). Another example is the Minneapolis Fire Department (MFD) policy which

limits members to 48 continuous hours. The employees must have a mandatory 24 hour rest period before working another suppression assignment (Minneapolis Fire Department [MFD], 2010). Results of a survey conducted for this study indicated numerous other fire department policies that concentrate on limitations to the number of consecutive shifts employees can work.

The Importance of Sleep and the Effects of Fatigue

Sleep deprivation must be understood and why sleep is so important. Sleep is actually a dynamic activity, during which many processes vital to health take place (National Sleep Foundation [NSF], 2006). It is essential to helping maintain mood, memory, and cognitive performance. In addition, sleep is a vital physiological function, as critical for human survival as food, water, and oxygen, and as difficult to deprive as these basic physiological needs (Neri, Dinges, & Rosekind, 1997, p. 5). Over the past several decades, U.S. employees have worked more hours, thus time slept each night has decreased. In 1910 the average sleep time was nine hours, which had decreased to 7.5 hours in 1975, and is currently 6.8 hours per night for American adults (Elliot & Kuehl, 2007, p. 1).

The effects of sleep loss are also evident in the military. The longer a soldier goes without sleep, the more his/her thinking slows and becomes confused, and the more mistakes he/she will make. Further, lapses in attention occur and speed is sacrificed in an effort to maintain accuracy (Hegerle, 2007, p. 40). Long hours are often associated with chronic sleep loss, which may result in decreased ability to think clearly and feelings of depression, stress, and irritability. How fatigued an individual feels is not reliable, as chronically sleep deprived people frequently do not perceive their lack of sleep as a problem (Elliot & Kuehl, 2007, p. iii). The Royal Aeronautical Society identified an important phenomenon, highly relevant to operational environments. They concluded that there is a discrepancy between the subjective report of

sleepiness/alertness and physiological measures. They found that individuals on flight crews reported the highest subjective rating of alertness at a time when physiologically the individual was falling asleep within six minutes (an indicator of severe sleepiness) (Rosekind, Neri, & Dinges, 1997, p. 7.3).

An examination of the mechanisms of sleep and wakefulness is important to understand how the body recharges. The sleep-wake cycle consisting of eight hours of nocturnal sleep and 16 hours of daytime wakefulness is controlled by a combination of two internal influences: sleep homeostasis and circadian rhythms (NSF, 2006, p. 3). Homeostasis is a process by which the body maintains equilibrium of internal conditions such as blood pressure, temperature, and acid-base balance. The homeostatic drive for sleep begins when we wake up and reaches its maximum in the late evening when we fall asleep. Neurotransmitters in the brain control the body's urge to sleep. A chemical known as adenosine is present in the blood stream and is thought to rise continuously while awake, resulting in a need for sleep that becomes harder to resist (NSF, 2006, p. 3). When at sleep, the levels of adenosine decrease until we wake-up.

Circadian rhythms are cyclical changes that occur over a 24-hour period that are driven by the brain's biological clock. The 24-hour rhythms in physiology and behavior are synchronized to the outside physical environment and social/work schedules. Light and darkness are signals that set our biological clock and help determine when the body feels the need to wake up or go to sleep (NSF, 2006, p. 3). The National Sleep Foundation (2006) found that sleep quality and restfulness are best when the sleep schedule is regularly synchronized to the internal circadian rhythms. Alterations to the sleep schedule, such as working at night (shift work) or suffering from "jet lag" can have adverse consequences.

Sleep consists of multiple stages and is actually an active physiological process. The two types of sleep are: rapid eye movement (REM) and non-REM (NREM) sleep. NREM sleep consists of four stages and is characterized by slower brain waves, decreased pulse, blood pressure, and respiratory rate. Stage 1 occurs from drowsiness and transitions to falling asleep. People in stage 1 may feel sudden muscle jerks and sometimes a falling sensation. Stage 2 is characterized by a period of light sleep, during which eye movements cease and the brain waves (measured by an EEG) slow. Muscle relaxation continues, the heart slows, and body temperature decreases. Stages 3 and 4 are characterized by deeper sleep where the vital signs decrease even further, the body becomes immobile, and there is no eye movement. During stages 3 and 4, it is harder to awaken individuals. People awakened during these stages may feel groggy and/or disoriented for several minutes after they wake up (NSF, 2006, p. 5). Sleepwalking often occurs during this sleep stage.

REM sleep is an active period of sleep characterized by intense brain activity. Respiratory, pulse, and blood pressure increases while breathing is irregular and shallow. The eyes move rapidly in various directions and the arms/legs muscles become temporarily paralyzed. Most dreams occur during this sleep stage. During normal sleep, REM and NREM sleep alternate throughout the night according to a predictable pattern referred to as the "sleep architecture" (NSF, 2006, p. 5). A complete sleep cycle consists of REM and NREM cycles that alternate every 90 to 110 minutes and is repeated 4-6 times per night.

When firefighters or shift workers have disruption to their sleep, it is suggested that adverse results can develop. It is well documented that fatigue and sleep deprivation are common among medical personnel (AHRQ, 2001, p. 520). The research also indicates that shift workers have poorer quality of sleep, marked by less REM sleep, and are less likely to feel

refreshed after awaking. Sleep deprivation (getting 2 to 3 hours less sleep than optimal) is cumulative and can lead to "sleep debt". Obtaining one hour less than is required for seven consecutive nights would result in a seven hour sleep debt, or one night of lost sleep over a week. If sleep debt occurs over 5-10 days, alertness and general performance decrease, particularly cognitive performance (AHRQ, 2001, p. 520). Recovery from sleep loss is accomplished through an increase in deep sleep and not through an hour for hour payback.

The effects of sleep deprivation and fatigue take on many forms in the fire and EMS service. Some of the signs and symptoms of fatigue include: poor and careless performance, greater tolerance for error, difficulty concentrating, inattention to minor but potentially important details, increased lapses of attention, increased irritability, decreased motivation, poor decision making, slowed reaction time, difficulty communicating, forgetfulness, feeling of depression, poor morale, lethargy, complaints of headaches, loss of appetite, weight loss, stomach or other problems, and sleepiness (Sharkey, 2004, p. 7). One study indicated that an individual awake for 24 hours has the same reaction time and critical thinking ability as a well-rested person with a blood alcohol level of 0.10 percent, a level considered legally drunk in all U.S. states (Lambert, 2005, p. 33)

The Department of the Army (2007) found that sleep loss impairs the ability to quickly make decisions. This is especially true in making ethical decisions. If given enough time to think about their actions, Soldiers will tend to make the same decisions whether sleep deprived or fully rested. However, when placed in a situation in which a snap judgment needs to be made, such as deciding to fire on a rapidly approaching vehicle, sleep deprivation may negatively impact decision making (Hegerle, 2007, p. 45). In addition to the military, fatigue also affects police officers. If officers are impaired by fatigue, they become less alert, their cognitive and

physical abilities decline, their moods worsen, and they become less able to deal with stress. This reduces both public and officer safety because risks of job-related accidents, injuries, errors, and misconduct increase (Kryger, Roth, Dement, Vila, & Samuels, 2011, Chapter 72).

Fatigue directly affects cognitive and motor performance. Lorber (2006) stated that emergency workers can temporarily overcome fatigue on critical calls but not so much on routine calls. She found that tasks requiring brief, intense concentration can be performed with little impairment after sleep loss, but alertness and persistence are lost, and monotonous tasks suffer (Lorber, 2006, p. 15). A study of subjects that were sleep deprived one night revealed significantly lower scores on tests that measured judgment, simple reaction time, explicit recall, and inverse word reading (NSF, 2006, p. 7). They added that daytime alertness and memory are impaired by the loss of eight hours of sleep, especially when the sleep loss is sustained over a few nights. In addition to mental performance, University of Pennsylvania researchers found that sleep deprived subjects (allowed to sleep 4.5 hours a night for one week) reported feeling more stressed, angry, sad, and mentally exhausted (NSF, 2006, p. 7).

The military has conducted numerous studies on human performance with sleep deprivation. The question was: How long can the crew be expected to go without sleep before significant impairment? They concluded that for a crew on a typical schedule with work during the day and sleep at night, the critical wake duration after which a majority can be expected to show impairment is approximately 44 hours (midway through the second night without sleep) (Neri et al., 1997, p. 6). They added that at approximately 64 hours and more without sleep, the performance of all individuals, even the hardiest and most resistant, become seriously degraded. About 25-33% of the population shows significant impairment after as little as 20 hours without sleep. These people will likely deny the problem, but will also likely be very impaired (Neri et

al., 1997, p. 7). Additional studies of sleep deprived physicians found that after one night without sleep, they had worse language and numeric skills, retention of information, short-term memory, and concentration (AHRQ, 2001, p. 521).

In 2008, Battalion Chief Kenneth Morgan conducted a survey of the Clark County Fire Department personnel to research mental and physical fatigue. He found that 68% of the respondents at the busiest fire stations (call volume) indicated fatigue after 72 hours. At the slower fire stations, 54% of the respondents indicated that 72 hour shifts produce physical fatigue. He concluded that fire station assignment has little effect on reducing physical fatigue (Morgan, 2009, p. 25). In addition, physical and mental fatigue, as well as irritability, peaked after 48 hours, indicating that 48 hours may be the threshold for effective safe levels. He found that cognitive processes (as reported by the respondents) remained at acceptable levels to 48 hours, but rose dramatically at 72 hours. Moreover, he observed that paramedics have increased cognitive issues after 24 hours of work, in their ability to calculate drug dosages and in other general decision-making processes (Morgan, 2009, p. 32).

In 2007, members from the Mesa (AZ) Fire Department and Dr. Vaughn Becker, a cognitive psychologist at Arizona State University, conducted memory and reaction time tests of numerous firefighters. The games were conducted via a website on the internet that consisted of two cognitive task games that targeted four specific facets of cognitive functioning along with an objective description of call volume. The computerized study utilized a virtual "concentration" game that measured spatial orientation and memory. The second game measured the speed at which a target could be found. These tasks measured two of the most important cognitive abilities of a municipal firefighter: response orientation – "the ability to choose quickly and correctly between two or more movements in response to two or more signals" and flexibility of

closure – "the ability to identify or detect a known pattern (a figure, object, word, or sound) that is hidden in other distracting material" (Blackwell, Becker, & Adams, 2011, p. 3). Results of the study indicated that the overall time needed to detect targets increased with increasing call volumes. Moreover, participants who experienced a higher number of calls were therefore more likely to be cognitively fatigued. The declines in memory were not statistically significant. The conclusion of this study suggested that high call volumes have consequences that go beyond physical and emotional fatigue, affecting the memory and the speed and accuracy of decision making (Blackwell et al., 2011, p. 5).

Fatigue due to sleep deprivation is also affected by the number of emergency calls that personnel respond to, also known as call volume. Lorber (2006) states that a physically and/or mentally challenging incident that occurs early during the shift can adversely affect personnel later in the shift (Lorber, 2006, p. 32). One long incident or many incidents can have the same adverse impact. Lorber (2006) goes on to say that when personnel handle multiple incidents during a single 24-hour shift, the competence of the crews and the quality of their service may be compromised. The Park City Fire Service District encountered a 250% increase in call volume over a 10 year period. They found that the increase in call volume directly correlated to fewer nights of uninterrupted sleep. In addition, they found that as the instances of sleepless or partial sleepless nights increases, the concern over the practice of allowing employees to work 72 hour consecutive hour shifts increased (Zwirn, 2007, p. 6).

A relatively new work schedule is popular, especially in Southern California, and is known as the 48/96 shift schedule. The schedule originated because firefighters were unable to afford local housing and faced long commutes, which were reduced in half with the schedule

(Elliot & Kuehl, 2007, p. 46). One of the negative aspects of the schedule is the sleep deprivation and fatigue that may occur from high call volume fire stations.

The Effects of Sleep Deprivation on the Fire Department

Many firefighter and EMS personnel work 24-hour shifts with multiple days off in a row. The days off can be used not only for family and social activities, but to catch up on the sleep that was missed while on duty. However, the time off enables many emergency responders to work second jobs to bring in extra money to support their families (Lorber, 2010, p. 42). Lorber (2010) also explains that in the current ever-challenging economic times, many emergency responders must, in some cases, work two part time jobs to make ends meet. The effects of "moonlighting" promote sleep loss by reducing the time available to sleep when we are off shift. A vicious cycle occurs where personnel come to work fatigued and sleep deprived (Lorber, 2010). The reported "two hat syndrome", where public safety providers may work in multiple roles or multiple agencies, places them in jeopardy of working consecutive shifts requiring them to stay awake for long periods of time (Patterson, Suffoletto, Kupas, Weaver, & Hostler, 2009, p. 192).

Other adverse effects to the fire department are presenteeism and absenteeism. Presenteeism is the practice of coming to work and doing only what is absolutely necessary in order to maintain a job (Brewer & Deschamp, 2006, p. 93). This may occur as employees are too exhausted to contribute to the organization in a meaningful way. Further, it may manifest through limited interaction with patients and coworkers, poor documentation, and a stagnant learning mode, all of which detract from overall organizational performance and efficiency (Brewer & Deschamp, 2006, p. 93). Absenteeism may also occur as employees call in sick. The financial ramifications are evident by an increase in sick leave usage.

Fatigue related accidents and injuries involving firefighters are well documented. A search of the National Firefighter Near Miss Reporting System (NFNMRS) returned 358 reports in which fatigue was a contributing factor in near miss incidents (Morgan, 2009, p. 17). Morgan (2009) also found that of the contributing factors in the NFNMRS annual report, situational awareness, decision making, and human error were the top three listed in the reports. All are related to cognitive activity. The National Fire Protection Association (NFPA) found that the highest injury rates per 100 fires occurred between midnight and 6:00 AM, when about 3.9 injuries occurred per 100 structure fires attended. The report's author speculated that finding a higher injury rate during the nighttime hours could relate to lack of visibility, cold temperatures, and lower alertness of firefighters (Elliot & Kuehl, 2007, p. 51).

James Clack of the Minneapolis Fire Department conducted research within his department by reviewing historical data involving discipline, sick leave, injuries, and response times. He found that 48-hour employees were disciplined 52% more than 24-hour shift employees (Clack, 2003, p. 18). He also found that sick leave was 18.5% higher among employees assigned to the 48-hour shift as compared to a 24-hour shift. He added that work-related injuries during the second 24 hours of a 48-hour shift were 44.4% higher than the first 24-hour period (Clack, 2003, p. 19). Clack (2003) also observed that fire personnel assigned to the 48-hour shift were 6.3% slower than personnel assigned to the 24-hour shift in getting out of the station after being alerted to respond to an emergency call.

The Effects of Sleep Deprivation on the Individual Firefighter

The effects of fatigue and sleep deprivation on individual firefighters can be acute as well as chronic. Firefighters and emergency workers who respond to calls at night are most likely vulnerable to shift-worker sleep disorder (SWSD) (Reid, 2010, p. 42). These disorders are

characterized by sleep fragmentation and sleep debt. Additional sleep disorders such as: insomnia, hypersomnia, narcolepsy, restless leg syndrome, and sleep apnea can contribute to daytime sleepiness. Reid (2010) estimates that 80-90% of individuals with sleep disorders remain undiagnosed simply because people are unaware that a problem exists. The IAFC found that individuals differ in their ability to tolerate night work and adjust to shift work. Studies indicated that after a single night of work, approximately ½ of all adults can perform at acceptable levels (Elliot & Kuehl, 2007, p. 60). In addition, 1/3 sustained a moderate amount of impairment, and the remaining individuals will have moderate to marked decrement in performance.

Severe long term medical problems can result from chronic sleep deprivation. Evidence indicates that long work hours increase the incidence of, and risk factors for, heart disease and cardiovascular events (Elliot & Kuehl, 2007, p. 9). They add that the potential mechanisms for this association include lack of normal cardiovascular rest during sleep, increased inflammation associated with sleep deprivation and the unhealthy lifestyles that accompany long work hours. Shift work is thought to induce increased secretion of stress hormones and cause changes in such factors as blood pressure, heart rate, coagulation, and lipid and glucose metabolism (Brewer & Deschamp, 2006, p. 89). Sleep deprivation has been associated with a rise of blood pressure during the night that lasts throughout the following day (NSF, 2006, p. 9). In addition to heart disease, a workgroup of the France-based International Agency for Research on Cancer concluded, “Shift work that involves circadian disruption is probably carcinogenic to humans” (Johnson, 2010, p. 69).

There is a considerable impact to the individual’s social life due to sleep deprivation. Firefighters and EMS personnel are often not able to attend children’s functions or other family

activities due to the 24-hour shift schedule. NIOSH reported that there are psychological implications. Sometimes shift workers choose to spend time with family rather than get adequate sleep, which exacerbates their fatigue (Parker, 2006, p. 45). Shift workers may be prone to psychological and physiological reactions. Decreased productivity, decreased overall happiness, and decrease in overall health are a few of these adverse reactions. These side effects may also manifest themselves at home where firefighters report family and social problems as a result of 24-hour shifts (Zwirn, 2007, p. 11). Mood and motivation are other factors, which are influenced by fatigue and sleep deprivation. Mood is undeniably important to morale and to effective crew communication and resource management (Neri et al., 1997, p. 10). Neri adds that people can function physically when sleep deprived but will want to quit earlier due to feeling that they do not have the energy to continue.

Fire Department Administration Responsibilities

A key doctrine of law called *respondeat superior* holds that an employer is almost always responsible for the actions of employees when carried out while employees are on the "clock" and performing their normal duties (Swinhart, 2007, p. 33). Further, if the employer has knowledge of the employee's fatigued state, the employer is at risk for a claim that it has negligently allowed its fatigued employee to cause an accident (Elliot & Kuehl, 2007, p. 71). Maryland attorney Mike Jacobs states: "Fatigue is not an excuse. If it were, then everyone in the world who got sued for negligence would just claim that he was too tired to be thinking straight, and it wasn't his fault" (Swinhart, 2007, p. 33). A New Jersey law known as "Maggie's Law" addresses that a sleep deprived driver who causes a crash after being awake for more than 24 hours can be convicted of vehicular homicide. The law also raised the specter of corporate

liability in cases of drowsy employees who work long hours, high amounts of overtime, double-shifts, or even 24-hour on-call periods at their employer's request (Elliot & Kuehl, 2007, p. 72).

An additional court case, Faverty v. McDonald's Restaurants of Oregon Inc., addressed a McDonald's employee who had been sent home due to being "sleepy". The visibly fatigued employee was allowed to drive home after working nearly 12 hours. He subsequently caused a motor vehicle crash, resulting in the death and the critical injury of another driver. McDonald's was sued and the court concluded that the employer should have foreseen that an employee who worked three shifts in a 24-hour period would pose a risk of harm to themselves and other motorists. The court stated that the management's liability was similar to that of a bartender who serves a visibly intoxicated person who "volunteers" to pay for the drink and later causes an accident (Nugent, 2007, p. 95).

Sleep management strategies have been employed by various agencies to combat the adverse effects of sleep deprivation and fatigue. Some of the countermeasures documented in military research suggest the use of caffeine, naps, social interaction, physical activity, and diet (Neri et al., 1997, p. 12). These countermeasures can be effective while on duty to stay awake and more alert. Education of personnel is also important to address and reduce the effects of sleep debt. The keys to beating sleep debt are to recognize sleep debt, identify the optimal hours of sleep needed, develop consistent off-shift sleeping patterns, nutritional strategies, avoid caffeine and alcohol (while obtaining restorative sleep), daily exercise, and learn your circadian rhythm (Peltin, 2005, p. 69). Lorber (2010) states "as managers/leaders of our departments, there are further steps that we should take to reduce fatigue in our employees" (p.43). She includes: allowing tired employees an extra hour or two of sleep, even after shift change, to help keep them awake on the drive home; modifying work schedules to better accommodate

increasing alarm loads; rotating busy units/crews with slower units; and limiting the length of time personnel can be assigned to busy companies (Lorber, 2010, p. 44).

Napping has been a well documented activity to combat the effects of fatigue. Studies conducted by NASA and the FAA found that naps could be scheduled in anticipation of fatigue, and they did not have to wait until an individual was so fatigued that involuntary napping occurred (Elliot & Kuehl, 2007, p. 65). A separate study allowed eight male subjects only four hours of sleep at night. When the subjects took a 30 minute nap in the middle of the prior day, they had better subjective alertness, 20% improvement in vigilance performance, and less overall sleepiness than when they had not been allowed to nap (AHRQ, 2001, p. 524).

The effectiveness of napping increases when it's performed during the time of the lowest dips in your circadian rhythms. Although each person is different, this usually occurs between 1300 HRS and 1500 HRS (Peltin, 2005, p. 72). Peltin (2005) also points out that sleep research supports the effectiveness of improving mood, alertness, and performance with a nap of 30 minutes or less. An important consideration of napping is the phenomena of sleep inertia, which is a period of transitory hypo-vigilance, confusion, disorientation of behavior and impaired cognitive performance that immediately follows wakening (AHRQ, 2001, p. 525). Sleep inertia is affected by the length of the nap and the time of the nap in relation to the circadian rhythm.

Redondo Beach Firefighter Performance Issues

On July 15, 2011, as part of the research for this study, a telephone interview was conducted with Division Chief Steven Hyink of the Redondo Beach Fire Department. Chief Hyink was chosen for the interview due to his 28 years of experience with the Redondo Beach Fire Department. He has been a Division Chief for approximately five years. He has firsthand knowledge of firefighter performance, and has observed the effects of firefighters working

consecutive shifts. Chief Hyink was asked to describe in detail his observations of the effects on performance when personnel work multiple consecutive shifts.

Chief Hyink explained that most performance issues resulting from firefighters working consecutive shifts had to do with training, attitude, and communication (S. Hyink, personal communication, July 15, 2011). He stated that when firefighters work consecutive shifts, they attend training on the same topics during different shifts. This redundancy causes disinterest and participation suffers. Motivation also decreases during multiple shifts. He added that mundane station chores are not completed, because the same firefighter did them the previous shift. Often, communication suffers as personnel learn of current events, but fail to pass the information along to firefighters that come to work later during the week. They assume that the newcomers have heard the information, and a break of communication occurs. He also explained that many personnel have overextended themselves financially by working so much overtime. Some have grown accustomed to the extra income, and encounter stress when the overtime opportunities cease to exist.

Literature Review Summary Statement

A considerable amount of research has been conducted on sleep deprivation and the effects of fatigue. Studies of sleep patterns and components are also well documented. This research identified many laws and standards that apply to various employment groups such as pilots, truck drivers, and medical students. However, comparatively very little data has been collected concerning fire department personnel and the effects that fatigue has on them. Laws and standards that specifically addressed hour limits on fire or EMS personnel were not identified. Moreover, findings revealed only a few studies related to the effect on firefighter performance due to call volume or working consecutive shifts. Consequently, this research

focused on identifying what other fire departments are doing to manage fatigue and sleep deprivation. A national survey of fire departments was used to identify if there were any limits to the number of consecutive shifts that firefighters can work. Also inquired was if there were any adverse effects when their personnel worked extended hours.

An additional result of the literature review was to identify methods to measure the impact of working consecutive shifts on fire fighter performance. Dr. Vaughn Becker and the Mesa (AZ) Fire Department had previously conducted an internet study that tested cognitive performance. Correspondence with Dr. Becker gave insight on how to best conduct further research. As a result, contact was made with a leading memory researcher at UCLA named Dr. Gary Small. Dr. Small had partnered with a man named Gary Considine, who had developed an interactive game that utilized computer software to measure cognitive ability. Gary & Rita Considine and Tim Harvey assisted to develop a product that was geared toward firefighters. They filmed new video, recorded necessary voiceovers, and modified the software to meet specific needs of this study. The result was a computer flash drive which contained 13 games designed to measure cognitive and psychomotor performance of firefighters. Consequently, the literature review influenced a new research method, which was utilized in this applied research study.

Procedures

The descriptive research method was utilized for this applied research project. During March 2011, a literature review of prior research was initiated at the Learning Resource Center (LRC), which was located at the National Fire Academy (NFA) in Emmitsburg, MD. A search included subjects that were related to firefighter fatigue, sleep deprivation, working consecutive shifts, laws and standards related to working extended hours, and performance testing of sleep deprived

subjects. The search at the LRC revealed numerous applied research papers and articles that were helpful in the research. Additional internet searches were conducted on similar topics over the course of the project. Searches of Yahoo and Google provided numerous research studies and papers which contributed to this project. In addition, a search of "Uncle Sam" under the Google search engine provided a wealth of government related documents. In order to answer the four research questions, multiple instruments were utilized including review of prior research, internet survey, and a computerized performance test.

A feedback instrument entitled "*The Effects of Working Consecutive Shifts on Firefighter Performance*" was created on the website "Survey Monkey". The purpose of the survey was to determine how other fire departments address firefighters working consecutive shifts. Survey questions were developed to describe individual department data such as shift schedule, annual call volume, and specific policies utilized to address limitations on personnel working consecutive shifts. Additional questions addressed the effects on firefighter performance due to working consecutive shifts, such as productivity and on-duty injuries.

The U.S. Fire Administration Training, Resources and Data Exchange Network (TRADENET) and the California Fire Chiefs Association (CALCHIEFS) websites were utilized to request participation in the survey. The exact number of email recipients is unknown; however a cross section of fire departments across the country was achieved. TRADENET provided a national audience while CALCHIEFS was primary distributer to west coast fire departments. The survey request was sent in April 2011. Over 100 individuals responded to the survey request and completed the feedback instrument.

An additional feedback instrument entitled "*Firefighter Mind Power*" was created with Gary Considine on a computer flash drive platform. The Mind Power interactive technology

measured responses to mental questions and was originally part of a program that was designed to improve memory. Collaboration occurred with Mr. Considine to transform his program into a specialized firefighter test. Fire service specific words, content, and problem solving were added to be more fire department related (Appendix A). The purpose of the instrument was to measure cognitive performance on firefighters who worked consecutive shifts. Fifteen randomly selected Redondo Beach firefighters of various ranks (Division Chief, Captain, Engineer, Paramedic, and Firefighter (representing approximately 1/3 of the total fire suppression population) were each given an unmarked computer flash drive. They were instructed to take a test each morning that they were at the fire station. The performance was measured on various consecutive shifts such as the first, second, third, and so on. There were a total of 13 tests on each drive, with the first one being a practice test. The practice test allowed the participants to get used to the format and operation of the testing instrument. The practice test was not scored. At the end of the 13 tests or 30 days (whichever came first), the participants returned the flash drives. This feedback instrument was given during the month of July, 2011.

The firefighter mind power program consists of 13 tests that participants can only take once. The game automatically shuts off when they finish a test. When they open the application the next time, it automatically forwards to the next test. At the beginning of the first three tests, there is an instruction video to explain how to take the test. Each test begins with 5 subjective questions that pertain to their current condition. The questions are:

1. What consecutive shift are you starting this morning?
2. How many calls did you respond to after 10:00 p.m.?
3. How many of the calls lasted more than one hour?

4. How many hours of sleep did you get last night?
5. How tired are you right now?

The possible answers are limited to three selections, #1, #2, #3, which are answered by pressing the appropriate number buttons on the computer keyboard. The answer choices are:

1. (1) 1st or 2nd, (2) 3rd or 4th, (3) 5th or more.
2. (1) 0, (2) 1 or 2, (3) 3 or more.
3. (1) 0, (2) 1 or 2, (3) 3 or more.
4. (1) 0-2 hour, (2) 3-4 hours, (3) 5 or more hours.
5. (1) Not tired at all, (2) Somewhat tired, (3) Very tired.

Following the subjective questions, a word list consisting of 10 words is shown for 30 seconds. Five of the words are general knowledge and the other five are firefighter terms. Instructions are given to study the words because they will be asked about them later during the test. Multiple videos are subsequently shown, that the participants must pay attention to for the same reason. There are two types of videos that were shown throughout the 13 tests. The first type of video is referred to as "names and faces". In these videos, various people say their name as well as something else about themselves such as their occupation, favorite movie, favorite hobby, age, or number of kids. The second type of video showed personal activities such as walking, bike riding, golfing, surfing, and playing basketball as well as general items such as buses, cars, restaurants, and buildings. The video portion of the test takes approximately 2-3 minutes. Each test consists of the following objective types of questions:

General problem solving questions such as a word scramble	(3)
Firefighter specific question such as a hydraulic problem	(1)
Word list recall question (was it on the list or not)	(2)
Names and faces recall questions	(2)
What was shown or not shown in the test videos	(4)
Total test questions	12

Each objective test question is scored by the accuracy and speed of the answer given. The five subjective questions are all treated as correct with no time limit. Positive points are earned for correct answers, while negative points are assigned for errors. Various difficulty levels are assigned to harder questions as compared to easier ones. The score for each question is a function of right answer (1), wrong answer (-1) times the question difficulty, and then divided by the response time. The total game score for the participant is displayed at all times in the right side of the screen. Each computed test score is stored on the flash drive. Each test takes approximately five minutes.

The purpose of the subjective questions at the beginning of each test was to correlate the subject's performance according to how many consecutive shifts they worked, call volume, call duration, amount of sleep hours, and how tired each firefighter felt. Cognitive performance on various types of questions was also measured and correlated with the subjective questions. The types of questions included: problem solving, word recall, names/faces recall, and what was shown/not shown in the video. Test results were obtained over a one month period from 15

participants. Test results were downloaded from individual flash drives into a Microsoft Excel spreadsheet. The results from both individual test scores as well as group scores were subsequently compared and contrasted.

Limitations

The feedback instrument "*The Effects of Working Consecutive Shifts on Firefighter Performance*" (survey) was placed on the internet via two websites designed to reach a broad fire service audience. Many of the fire departments that responded worked a different shift schedule than the Redondo Beach FD. This was due to the varying shift schedules utilized across the country. However, numerous departments with the same shift schedule did respond, which allowed for a comparison. The number of recipients of the survey request is unknown; however the response was sufficient to draw conclusions to answer research questions one through three.

The *"Firefighter Mind Power"* feedback instrument was limited to the number of willing participants from the Redondo Beach FD. One fourth of the fire suppression division participated (15 firefighters of various ranks) in the test. One reason for not participating was a fear that the results of the performance tests would adversely affect the personnel. Many firefighters expressed concerns that the department would impose a maximum number of shifts that they were allowed to work, if the test showed a decrease level of performance from working multiple consecutive shifts. Although the author reassured the firefighters that the surveys were anonymous, and that the results were only to be used for this research project, many remained hesitant. They also felt that if their overtime shifts were limited, then their ability to make money would be hindered.

Of the firefighters that participated in the computer tests, it is unclear as to how accurate the results will be for the above mentioned reasons. It is possible that the participants could

"tank" the results and purposefully score worse on the first few shifts as compared to the greater number of consecutive shifts. Participants could answer slower on the earlier shifts, then quicker on the latter. This could skew the performance results as the participants may want to mask any perceived performance deficiencies. It is assumed that the firefighters answered the questions honestly.

An additional limitation was that each participant did not work the same number of multiple consecutive shifts. Some of the participants only worked their normal shifts, which was indicated by selection "1" (1st or 2nd consecutive shift). Other participants may have worked three or four consecutive shifts (selection 2), while a small number worked more than five consecutive shifts (selection 3). While some personnel took tests on various consecutive shifts, others did not. Consequently, only a small number of participants were tested on two consecutive shifts as well as five or more consecutive shifts.

Definition of Terms

Circadian Rhythm: An inherent cycle of approximately 24 hours in length that appears to control or initiate various biological processes, including sleep, wakefulness, digestive, and hormonal activity.

Homeostasis: A self-regulating process by which a biological or mechanical system maintains stability while adjusting to changing conditions.

Kelly Schedule: A rotating firefighter shift schedule that utilizes 24-hour shifts on duty separated by 24 hours off duty. Various schedules include 4 days off in a row after working 3 days on duty.

Mean: An average value of multiple quantities.

Median: The middle number in a given sequence of numbers.

Memorandum of Understanding (MOU): An agreement between two parties, often a labor union and city entity.

Moonlighting: Working at a secondary job.

Telestaff: A computer staffing program used to fill firefighter vacancies.

Results

Multiple methods were utilized to collect data that assisted with answering the four research questions. These methods included document retrieval and analysis, personal interview, internet survey, and a cognitive computerized test. Review of occupational standards as well as an internet survey answered the 1st research question: *What are the laws and standards that apply to employees working consecutive shifts*? There were many restrictions in multiple occupations that accounted for the maximum number of hours that employees could work.

The FAA (Federal Aviation Administration) states that commercial airline pilots are required to have nine hours of rest for up to eight hours of flight time. They are also restricted to 1,200 hours of flight time per year, 120 hours flight time per month, 34 hours in any seven consecutive days, or eight hours in any 24-hour period. Air Traffic Controllers are also required to have at least nine hours of rest between shifts. The DOT (Department of Transportation) limits commercial drivers to 10 hours on-duty following eight consecutive hours of rest. They cannot work any period after 15 hours on-duty following eight consecutive hours off-duty. Moreover, they can't work more than 60 hours in any seven consecutive days.

Federal marine regulations state that Officers must be off-duty for six of the 12 hours before leaving port. They must also have a minimum of 10 hours of rest per day, divided into no more than two periods. Licensed individuals may not work more than 12 of every 24 hours at sea, or more than 15 of every 24 hours while on a tanker. Rail workers are limited to 12

consecutive hours of on-duty time. In addition, they are not allowed to work six consecutive days, unless they have had at least 48 hours of consecutive time off-duty. Medical residents are limited 80 hours per week, with a maximum of 24 hours of patient care and a minimum of 10 hours off-duty between shifts. The residents are allowed to stay on-duty for an additional six hours to treat patients, staff outpatient clinics, or maintain continuity of care. No new patients are allowed to be accepted after 24 consecutive hours.

This study did not uncover any laws or standards that specifically limited work hours for firefighters. However, many of the 114 departments who answered the internet survey "*The Effects of Working Consecutive Shifts on Firefighter Performance*", noted department specific regulations. Survey question (#6) addressed this issue and read: *Please specify any laws or standards that your department references to address limitations on personnel working consecutive shifts (NFPA, Policy, Directive, etc.)*. Sixty-two of the 114 departments who replied to the survey chose "other" for question #6 (open-ended) and filled in department specific descriptions. The respective policies restricted the number of consecutive hours worked to varying hour limits of 96 hours, 72 hours, and 48 hours. For instance, the Santa Cruz (CA) FD has a 96 hour limitation by the direction of the Fire Chief, not by a policy. The Rincon Valley (CA) FPD relayed that they have a specific fatigue policy that limits consecutive shifts to 96 hours. The York County Fire and Life Safety department replied that they have a policy that limits firefighters to no longer than 72 hours on-duty. The Concord (NH) FD stated that their maximum mandatory time (duty shift & mandatory overtime) is 48 hours, and then overtime becomes voluntary. In addition, the Albany (OR) FD has an administrative policy that requires six hours of continuous rest per 24-hour shift, and no more than 48 consecutive hours per work period.

Other departments (29 total) stated that they have specific department policies, standard operating procedures (SOP), and/or standard operating guidelines that limit the number of consecutive hours worked. Ten of the 62 departments that responded to question #6 cited an MOU (memorandum of understanding) or contractual agreement that governed a limitation to consecutive shifts. For example, the Ithaca (NY) FD, Norwich (CT) FD, and Pleasantview (IL) FPD all cited collective bargaining agreements. The Mount Laurel (NJ) FD department did not have any specific policy, but just felt that "the level of attentiveness and general desire to continue to be at work would significantly decrease and result in increased tension, lack of wanting to do anything other than answer the bell, and irritability".

The survey instrument "*The Effects of Working Consecutive Shifts on Firefighter Performance*" answered the 2nd research question: *How are other fire departments addressing firefighters working consecutive shifts*? There were 114 respondents to the survey who represented a wide variety of fire departments. The first question of the survey asked the participant to identify their department. The majority of departments were located in California (27) (where the RBFD is located), followed by Illinois (10), and New Hampshire (10). The remainder of the department were located in a combination of states including: Alabama, Arkansas, Arizona, Colorado, Connecticut, Florida, Indiana, Louisiana, Massachusetts, Missouri, Mississippi, North Carolina, North Dakota, Nebraska, New Jersey, New Mexico, New York, Ohio, Oregon, Pennsylvania, Rhode Island, Texas, Utah, Virginia, Washington, and Wisconsin. One hundred percent of the respondents included their department name and city where they were located (Figure 1).

Of the 114 departments that replied to question 2 (*What shift schedule does your department utilize?*), the most popular shift schedule nationwide (33.3% (38)) was the 24/48 (1

day on followed by 2 days off). The second most popular (20.2% (23)) was the 48/96 schedule, which is utilized by the RBFD (2 days on followed by 4 days off). Following closely behind was the traditional Kelly schedule (3 alternate days on followed by 4 days off) (17.5% (20)). Twenty-one or 18.4% of the respondents answered "other" to this question, and listed variations to the above mentioned shift schedules (Figure 2).

The third question stated: *Does your department have a limit to the number of consecutive shifts that personnel can work*? All respondents (114) answered this survey question. Sixty-five percent (74) of the respondents answered "Yes" that they limit the number of shifts. Approximately 28% (32) answered "No", while 7% (8) answered "other". The "other" answers described voluntary versus mandatory overtime rules as well as an approval requirement by the Battalion Chief (Figure 3).

All 114 respondents answered the 4th question: *What is the maximum number of shifts that personnel can work consecutively*? The answers varied as 43% (49) responded "other" and described their specific rules. Twenty-six percent (30) replied that two shifts (48 hours) were the maximum number of shifts allowed. Eighteen percent (20) answered 3 shifts (72 hours), and 13% (15) stated 4 shifts (96 hours) were the limit (Figure 4). Of the 49 "other" responses, 32 indicated that there was no limit to the number of consecutive shifts that firefighters could work. Additional responses described the necessity of Battalion Chief approval if over a specified number of hours were worked such as 36, 72, or 96 hours.

The survey results included fire departments with varying call volumes. Question 5 stated: *What is your department's approximate annual call volume (total incidents for 2010)*? Approximately 44% (50) of those who responded worked for departments with 0 to 5,000 annual incidents, which was the majority of respondents. Thirty percent (34) of the replies were from

departments with 5,001 to 10,000 incidents, which is similar to the RBFD. Fire departments with 10,001 to 50,000 annual incidents accounted for 17.5% (20) of the survey results. A small percentage (1.8% (2)) of the respondents worked for departments that ran between 50,001 and 100,000 incidents. Finally, 7% (8) of the responding departments ran more than 100,000 incidents. These results reflected a cross section of slow and busy fire departments (Figure 5).

Question 6 related to *laws and standards that your department references to address limitations on personnel working consecutive shifts*. The results of this question were open-ended and answered the first research question (Figure 6).

The last survey question (# 7) which addresses the research question how other fire departments are addressing firefighters working consecutive shifts states: *How many hours are personnel required to be off duty prior to returning to work*? Many respondents (50.9% (58 of 114)) answered that there were no requirements to be off duty prior to returning to work. Twenty-four percent (27) chose 12 hours as a time requirement, 11.4% (13) chose 8 hours, and 7.9% (9) chose 24 hours. Eight percent (9) of the respondents chose "other" and wrote in their response. Respondents indicated that as little as one hour was required while others specified 4, 10, or 12 hours respectively (Figure 7).

Little research addressed the dangers of sleep deprivation on shift workers, such as firefighters. Part of the survey instrument also addressed the 3rd research question: *What effect does sleep deprivation have on firefighter performance*? The survey participants were asked multiple questions relating to various aspects of firefighter performance. Survey question # 8 asked: *What effects on firefighter performance have you observed due to personnel working consecutive shifts*? Of the 114 respondents, almost 80% chose fatigue as the greatest effect. Irritability received almost 59% of the responses, followed by a lack of concentration (48.2%).

Poor customer service (36.8%), low morale (28.9%), and impaired memory (24.6%) accounted for the other choices. Twenty-two responses to this question were "other", which accounted for 19.3% of the total answers. Additional observed effects included: complacency regarding safety, impaired situational awareness, decrease in work product, and higher incidence of illness/injury. Six of the 22 "other" answers indicated that they had not observed any significant changes (Figure 8).

Question # 9 states: *What, if any, changes in performance or productivity have you observed due to personnel working multiple consecutive shifts*? This question assumes that some degree of fatigue will occur when firefighters work consecutive shifts. No specific mention of call volume or hours slept each night was addressed, although fatigue is often a byproduct of sleep deprivation. In addition, respondents were allowed to make multiple choices. From the survey, 57% of the respondents answered that station maintenance not getting completed was the number one change in productivity. Projects not completed (35.1%) and a decrease in training classes or drills (31.6%) was the next highest responses respectively. Approximately 19% of the responses indicated driving or engine pumping mistakes while only 4.4% identified paramedics making drug dosage or other medical mistakes as a change in performance. In addition, 22.8% of the responses indicated that there were no changes in performance or productivity.

In response to question #9, 13.2% indicated "other" changes in performance and/or productivity. These other observations included: sleeping, lack of motivation, and "dullness" in overall personality. Others observed a mindset that changed to "just do the basics". Poor attitude was another common description as well as sub-par decision-making. One respondent cited an increase in injuries, stress, or illness attributed to fatigue from working multiple hours.

An additional performance issue identified that it was easier "to put things off until tomorrow, and then they don't get done because of call volume" (Figure 9).

The last question of the survey (#10) states: *Have you observed any of the following on-duty injuries resulting from personnel working multiple consecutive shifts*? Respondents were allowed to make multiple choices for this question. Approximately 79% identified that they did not observe any on-duty injuries as a result of personnel working consecutive shifts. Twelve percent reported slip and/or falls occurred, and less than 1% observed needle stick injuries occurring as a result of consecutive shifts. "Other" answers accounted for 8.8% and specified fitness injuries including back strains and sprains (Figure 10).

In order to answer the 4th research question: *What performance issues are affected when RBFD firefighters work consecutive shifts*, subjective and objective data were collected from two sources. The first source of subjective data was an interview with Division Chief Steve Hyink. During the interview, conducted on July 15, 2011, Chief Hyink was asked to describe in detail his observations of the effects on performance when personnel work multiple consecutive shifts. He stated that most performance issues resulting from firefighters working consecutive shifts had to do with training, attitude, and communication. He was then asked what he noticed the most about training performance issues. He stated that when firefighters work consecutive shifts, they attend training on the same topics during different shifts. This redundancy causes disinterest and participation as well as performance suffers.

Chief Hyink was asked if attitude and/or motivation changed as a result of working consecutive shifts. He stated that motivation decreases during multiple work shifts. He added that mundane station chores are not completed, because the same firefighter did them the previous shift. The next question was: How does communication suffer when firefighters work

consecutive shifts? He relayed that communication suffers as personnel learn of current events, but fail to pass the information along to firefighters that come to work later during the week. They assume that the newcomers have heard the information, and a break of communication occurs. The last question was: Are there any other effects of RBFD firefighters working consecutive shifts. Chief Hyink explained that many personnel have overextended themselves financially by working so much overtime. Some firefighters have grown accustomed to the extra income, and encounter stress when the overtime opportunities cease to exist.

The computer testing instrument, *Firefighter Mind Power* was also utilized to objectively address firefighter cognitive and psychomotor performance. The results were analyzed according to the first five subjective questions that were asked at the beginning of each test. In addition, the test results were compared to the number of consecutive shift that the participant was working.

Data derived from all participants revealed that 53 tests were taken on either the first or second consecutive shift, 41 tests on either the third or fourth consecutive shift, and 11 tests were taken on the fifth or greater consecutive shift (Figure 11). Five questions were given at the beginning of each assessment to assess baseline conditions that might affect test results. These included: 1) the number of consecutive shifts, 2) call volume after 2200 hours (call2200), 3) duration of calls greater than one hour (call1hr), 4) number of hours slept (HRS_SLEEP), and 5) how tired the subject felt at the time of the test (TIRED).

The mean number of calls ran after 2200 hours for 1-2 consecutive shifts was 1.4 (selection **1** = zero calls, selection **2** = 1 or 2 calls, selection **3** = 3 or more calls), 1.51 for 3-4 consecutive shifts, and 1.55 for ≥ 5 consecutive shifts. The results reflect an average of zero to 2 calls after 2200 hours, the night before the test was taken. The number of calls after 2200 hours

was not statistically different in regards to the number of consecutive shifts worked. The mean number of calls after 2200 hours which lasted more than one hour for 1-2 consecutive shifts was 1.26, 1.27 for 3-4 consecutive shifts, and 1.18 for ≥ 5 consecutive shifts. The duration of calls greater than one hour after 2200 hours was not significantly different among the three consecutive shift conditions. The number of hours slept during the night before the test was 2.72 hr, 2.71 hr, and 2.82 hr for those working 1-2, 3-4, or ≥5 consecutive shifts, respectively. These test results suggest that most participants slept at least 3 hours prior to the test. In addition, many of the subjects received more than 5 hours of sleep. In addition, the amount of sleep prior to taking the test was not different when number of consecutive shifts worked was considered. The degree of perceived tiredness with selection 1 = not tired at all, selection 2 = somewhat tired, selection 3 = very tired was 1.55 for those working 1-2 consecutive shifts, 1.46 for 3-4 consecutive shifts, and 1.55 for participants working ≥5 consecutive shifts (Figure 12). The results of this subjective question indicated that most of the participants were either not tired at all, or were only somewhat tired when they took the test. There were no differences in responses due to number of consecutive shifts worked.

Summarizing the subjective baseline questions, the data indicate that the call volume, duration of the calls, amount of sleep, and degree of tiredness was independent of the number of consecutive shifts worked. Any differences, therefore, in cognitive performance on *Firefighter Mind Power* between subjects working 1-2 versus 3-4 versus ≥5 consecutive shifts would have to be explained by something other than differences in call volume after 2200 hours, duration of calls greater than one hour after 2200 hours, hours slept prior to taking the test, and degree of tiredness.

Results on each type of question as well as the total test scores were compared between participants working the different number of consecutive shifts (Figure 13). Some of the probability values between 1-2 and 3-4 consecutive shifts as well as between 1-2 and ≥5 consecutive shifts were significant on a few of the tests. What was shown / not shown video question "VID11" showed moderate significance when compared between 1-2 and 3-4 consecutive shifts (p-value 0.074). The mean score for "VID11" on shift 1-2 was 49.49, and 25.05 on shifts 3-4. These results indicate that those who worked on their 1st or 2nd consecutive shift performed 100% better than those who answered that question on the 3rd or 4th consecutive shift. There was no significant drop in performance on this question during the 5th or more consecutive shift. Another significant test question was the firefighter specific problem identified as "FF4". The results suggested a difference between shift 1-2 and shifts ≥5 (p-value 0.078). The mean score for "FF4" on shift 1-2 was 63.96, and 20 on shifts ≥5. This suggests that subjects who answered this question during their 1st or 2nd shift scored approximately 220% better than those who answered the same question on their 5th or greater consecutive shift.

The names and faces recall question "NAME7" suggested that there was a difference when compared between shift 1-2 and shifts 3-4 (p-value 0.057). The mean score for "NAME7" on shift 1-2 was 69.79, and 105.2 on shifts 3-4. This comparison indicated that people who worked during their 1st or 2nd shift scored 34% worse on this question than those who took the test during their 3rd or 4th consecutive shift. This test result was one of the few where the participants scored better during a later consecutive shift.

The names and faces recall question "NAME8" was statistically significant when compared between shift 1-2 and shifts 3-4 (p-value 0.045). The mean score for "NAME8" on shift 1-2 was 116.77, and 70.95 on shifts 3-4. Those who tested during their 1st or 2nd shift

scored 65% better on this question as compared to those who answered the same question on their 3rd or 4th consecutive shift. The word list recall question "WORD5" was also statistically significant when compared between shift 1-2 and ≥5 shifts (p-value 0.01). The mean score for "WORD5" on shift 1-2 was 70.81, and 35.73 on ≥5 shifts. This test result indicated that personnel scored 98% better during their 1st or 2nd consecutive shifts as compared to the 5th or greater consecutive shifts.

The total test score performance compared between shift 1-2 and shifts 3-4 was not significant. However, the total scores compared between shift 1-2 and ≥5 shifts was statistically significant (p-value 0.046). The mean total test score for shift 1-2 was 655.34, and 436.73 for ≥5 shifts (Figure 13). This indicated that personnel who took the test during their 1st or 2nd shifts performed 50% better than those who participated during their 5th or greater consecutive shift. Further analysis of the total test score performance that only included participants who worked at least five consecutive shifts indicated similar results. The number of tests taken by this smaller sample was 13 for 1-2 shifts and 11 for ≥5 shifts, respectively. Performance by this group of participants was measured, as the same subjects took tests on both 1-2 shifts as well as ≥5 shifts. The mean total test score for shift 1-2 was 639.92 and 436.73 for ≥5 shifts (p-value 0.0565) (Figure 14).

Overall, for the total score of all 12 variables (test questions), there was a significant drop in cognitive performance between the 1st / 2nd consecutive shifts and the 5th or more consecutive shifts. Although performance did fall between the 1st / 2nd and 3rd / 4th consecutive shifts, the relatively small decrease was not statistically significant. This finding suggests that there is a threshold relating to cognitive abilities after four shifts or 96 consecutive hours of work. Therefore, cognitive problem solving and recall are some of the performance issues that are

affected when RBFD firefighters work consecutive shifts. The four problem solving questions used in this test represent a firefighter's ability to correctly assess an emergency situation, develop a plan, and implement that plan to solve the problem at hand. Speed and accuracy play a key role in the development and implementation of the plan. The word list, names and faces, and video recall test the ability for firefighters to correctly identify and recollect details about their surroundings. During an emergency, it is imperative to quickly and accurately recall exit routes, drug dosages, or other pieces of information that can adversely affect firefighter safety.

Summary of Data

The effect on performance from firefighters working consecutive shifts is substantial. Research has identified multiple performance aspects that include diminished cognitive and psychomotor skills. Fatigue and sleep deprivation play a major role in the degree of decreased performance. In addition, other aspects of firefighter well being suffer as a result of acute as well as chronic fatigue. Attitude, motivation, various medical issues and social problems all affect the overall firefighter performance. Ultimately, the question is how well can firefighters perform their job while still providing for firefighter safety and wellness. Research data suggest that there is decreased performance when firefighters work multiple consecutive shifts.

Research question 1: *What are the laws and standards that apply to employees working consecutive shifts*? Multiple state and federal laws address various professions and their respective limitations of work hours. Professions including airline pilots, truck drivers, marine officers, railroad workers, and medical residents are all susceptible to fatigue due to working extended hours. The effects of fatigue are well documented. Many infamous disasters have been contributed to by sleep deprived and fatigued workers and their diminished performance. Regulations were created that limit the number of hours that employees can work. However, no

formal laws or statues were identified that regulate the number of hours that firefighters can work. Various fire departments utilize standard operating procedures to address firefighters working consecutive shifts. In addition, many fire departments that responded to the survey cited contractual agreements with unions and MOUs that described limitations. Of those departments who enforced a maximum number of consecutive shifts, the most common were 72 or 96 hour shift restrictions. The study concluded that there were no consistent standards that applied to all firefighters in regards to work hour restrictions.

Research question 2: *How are other fire departments addressing firefighters working consecutive shifts*? Sixty-five percent of the fire departments that responded to the survey indicated that they limited the number of shifts firefighters can work consecutively. Twenty-five percent of the departments limited the number of consecutive hours to 48. Eighteen percent indicated that 72 hours was the maximum, and 13% stated that 96 hours were their limit. One out of every three departments answered that there was no limit to the number of consecutive shifts that personnel could work. Moreover, more than half of the respondents answered that they did not require any specific hours off-duty for rest prior to returning to work. Others stated that their department required between 4 – 24 hours of rest before returning to work. It became apparent that there was no consistency nationwide to how fire departments addressed personnel working consecutive shifts. Of the departments that had maximum consecutive work hour restrictions, none referenced any standards or data to support their rules.

Research question 3: *What effect does sleep deprivation have on firefighter performance*? Some of the signs and symptoms of sleep deprivation and fatigue are: poor and careless performance, greater tolerance for error, difficulty concentrating, inattention to minor but potentially important details, increased lapses of attention, increased irritability, decreased

motivation, poor decision making, slowed reaction time, difficulty communicating, forgetfulness, feeling of depression, poor morale, lethargy, complaints of headaches, loss of appetite, weight loss, stomach or other problems, and sleepiness. Call volume exacerbated the effects of sleep deprivation and fatigue. Simply put, the more calls ran during sleep hours, the less sleep firefighters receive and consequently the more fatigued they become. As fatigue increases, performance worsens, affecting the memory as well as the speed and accuracy of decision-making.

Survey results indicated that fatigue was the single greatest effect (80%) of firefighters working consecutive shifts. Irritability, lack of concentration, poor customer service, low morale, and impaired memory were also listed as adverse effects of fatigue. Additional effects observed included complacency regarding safety, impaired situational awareness, decrease in work product, and higher incidence of illness/injury. Around the fire station, Firefighter performance and productivity were also affected as daily maintenance and projects were not getting completed. A decrease in motivation and training were also observed.

Research question 4: *What performance issues are affected when RBFD firefighters work consecutive shifts*? Results from the Mind Power computer tests revealed that there was no significant correlation between call volume, amount of hours slept and how tired firefighters were when they worked various consecutive shifts. In other words, the number of consecutive shifts worked was independent of the call volume or hours of sleep they got prior to taking the test. However, the call volume, and corresponding hours slept certainly influenced cognitive performance. It is possible that a firefighter on his 2nd shift was up all night running multiple calls the night before the test. He/she would be fatigued and score lower on the test.

Conversely, a firefighter could be working the 10th consecutive shift, obtain a full night of sleep with no calls, and perform very well on the test.

The research shows that overall, within the confines of the test, firefighters scored better on multiple cognitive questions during the 1st / 2nd shift compared to the 5th or greater consecutive shift. The ability to recall items as well as problem solve shows a significant decline as the number of consecutive shifts increases. Information gleaned from Chief Hyink (RBFD) indicates that RBFD personnel exhibit signs of fatigue and decreased motivation when they work multiple consecutive shifts. Test results inferred that the RBFD participants performed worse on later consecutive shifts even though they received more than 5 hours of sleep prior to the test.

Discussion

The results of this research project are important to the health of the Fire Service. Common sense dictates that the longer we work without quality sleep, the more fatigued firefighters become, and the worse firefighters perform. Firefighters on shift work and personnel in the EMS industry have experienced fatigue the morning after numerous calls and minimal sleep. How many calls, how much sleep, and how many consecutive shifts are an acceptable risk to us, the citizens and overall firefighter safety? In 2007, a grand jury in Contra Costa recommended limiting firefighters' consecutive work time to 72 hours with a mandatory break between shifts, except in extreme emergencies (Huff, 2007, para. 5). They added that "there is no question that fatigue leads to injuries and unsafe conditions".

Morgan (2009), documented many catastrophes such as the Challenger and Three Mile Island, that occurred as a result of lack of attention due to fatigue. In fact, many of the laws that limit the number of hours employees can work resulted from an accident or occurrence that was contributed to by a fatigued worker. Similar to firefighters, medical students often work long

hours with patients at the hospital. Their ability to make quick decisions, calculate proper medication dosages, and problem solve can be affected by fatigue resulting from sleep deprivation. (Lowenstein, 2003) indicated that medical students working increased hours have a higher risk of making medication errors. This condition can be compared to fire department paramedics who treat patients in the field and must recall drug dosages, treatment modalities, as well as various algorithms. Work hours limit medical students, but not fire or EMS personnel.

Numerous studies detailed the effects of fatigue and sleep deprivation. The National Sleep Foundation [NSF] (2006) found that sleep is essential to helping maintain mood, memory, and cognitive performance. The military found that the longer a soldier goes without sleep, the more his thinking slows and becomes confused, and the more mistakes he will make (Hegerle, 2007, p. 40). Consistent with these previous studies, this study found that firefighter's cognitive performance decreased when they worked numerous consecutive shifts. How fatigued an individual feels is not reliable, as chronically sleep deprived people frequently do not perceive their lack of sleep as a problem (Elliot & Kuehl, 2007, p. iii). This was evident as test participants did not report that they were very tired, however their performance after multiple shifts decreased.

During the literature review, it was found that sleep deprivation is cumulative and can lead to "sleep debt". Obtaining one hour less than is required for seven consecutive nights would result in a seven hour sleep debt, or one night of lost sleep over a week. If this sleep debt occurs over 5-10 days, alertness and cognitive performance decrease (AHRQ, 2001, p. 520). This sleep debt was a profound effect on firefighters when they work multiple consecutive shifts. The problem with working multiple days without a break is that the firefighters do not have a chance to return home to make up their sleep. Each duty day, firefighters often have to wake up early

instead of "sleeping in". Therefore, even if they sleep five or six hours at night, they are never able to make up the sleep debt they accumulate when they work the consecutive shifts. Time off shift enables many emergency responders to work second jobs to bring in extra money to support their families. The effects of "moonlighting" promote sleep loss by reducing the time available to sleep when we are off shift. A vicious cycle occurs where personnel come to work fatigued and sleep deprived (Lorber, 2010).

Research revealed that approximately 65% of the fire departments who responded utilize standard operating procedures and/or MOUs to limit the number of consecutive hours that firefighters can work. For instance, the Phoenix Fire Department limits employees to three consecutive 24-hour shifts (PFD, 2008). Approximately 50% of the departments limited the number of consecutive shifts between two and four. No specific standard was identified to substantiate the hour restriction. However, my research indicated that there was a statistically significant drop in cognitive performance after 96 hours, or four consecutive shifts. In 2008, Battalion Chief Kenneth Morgan conducted a survey of the Clark County Fire Department personnel to research mental and physical fatigue. He found that 68% of the respondents at the busiest fire stations (call volume) indicated fatigue after 72 hours. In addition, physical and mental fatigue, as well as irritability, peaked after 48 hours, indicating that 48 hours may be the threshold for effective safe levels. He found that cognitive processes (as reported by the respondents) remained at acceptable levels to 48 hours, but rose dramatically at 72 hours (Morgan, 2009). These studies may indicate a maximum number of shifts that is appropriate for firefighters to work consecutively. Although Morgan (2009) concluded that 72 hours should be a maximum shift limit, my findings of 96 hours is not considerably different.

In 2007, members from the Mesa (AZ) Fire Department along with Dr. Vaughn Becker conducted memory and reaction time tests on numerous firefighters. Results of the study indicated that the overall time needed to detect targets increased with increasing call volumes. Moreover, participants who experienced a higher number of calls were therefore more likely to be cognitively fatigued. The declines in memory were not statistically significant. The conclusion of this study suggested that high call volumes have consequences that go beyond physical and emotional fatigue, affecting the memory and the speed and accuracy of decision making (Blackwell et al., 2011, p. 5). These findings are consistent with my Mind Power test, in that recall and speed of answering the questions correctly diminished, in relation to the greater number of consecutive shifts worked. Overall performance dropped significantly when firefighters worked five consecutive shifts or greater as compared to the 1st or 2nd shift.

Mood and motivation are other factors, which are influenced by fatigue and sleep deprivation. Mood is important to morale and to effective crew communication and resource management (Neri et al., 1997, p. 10). An interview with Chief Hyink revealed that poor attitude and decreased motivation are two signs that personnel have been working too many consecutive shifts. A decreased desire to train and complete routine station maintenance are also symptoms of fatigue. This is readily apparent as disinterest and apathy occur because firefighters may be tired of working and need time away from the fire station.

Fire departments operate based on risk management. Liability may be assumed by a fire department administration if they fail to address firefighter fatigue due to sleep deprivation. A doctrine of law called *respondeat superior* holds that an employer is generally responsible for the actions of employees when carried out while employees are on the "clock" and performing their normal duties (Swinhart, 2007, p. 33). If an employer has knowledge of the employee's fatigued

state, the employer is at risk for a claim that it has negligently allowed its fatigued employee to cause an accident (Elliot & Kuehl, 2007, p. 71). Not only are fire department administrators responsible for employees when they are on duty, the responsibility extends when personnel leave the station and drive home. Effective sleep management is essential for firefighter well being. Two methods to combat fatigue are napping and limiting the number of consecutive shifts that firefighters can work.

Lorber (2010) states "as managers/leaders of our departments, there are further steps that we should take to reduce fatigue in our employees". She includes: allowing tired employees an extra hour or two of sleep, even after shift change, to help keep them awake on the drive home; modifying work schedules to better accommodate increasing alarm loads; rotating busy units/crews with slower units; and limiting the length of time personnel can be assigned to busy companies (Lorber, 2010, p. 44). Napping has been a well documented activity to combat the effects of fatigue. Studies conducted by NASA and the FAA found that naps could be scheduled in anticipation of fatigue, and they did not have to wait until an individual was so fatigued that involuntary napping occurred (Elliot & Kuehl, 2007, p. 65). A separate study allowed eight male subjects only four hours of sleep at night. When the subjects took a 30-minute nap in the middle of the prior day, they had better subjective alertness, 20% improvement in vigilance performance, and less overall sleepiness than when they had not been allowed to nap (AHRQ, 2001, p. 524). It is a common practice that fire departments allow firefighters to nap after lunch, usually until 1330 hours. For stations with high call volumes, allowing personnel to nap for 20-30 minutes can be very beneficial.

The organizational implications of these results are decreased cognitive performance when firefighters work more than four consecutive shifts. To what degree the performance

declines may be the subject of additional studies. No specific work injuries or accidents were found to have been contributed to by firefighters working consecutive shifts. The risk of an unsafe condition or other life safety hazard certainly exists as firefighters are not as alert or mentally acute as compared to the start of the 1st or 2nd shift. Sleep management techniques and a limit to the number of consecutive shifts that firefighters should work needs to be examined. It appears that firefighters may be reluctant to limiting the number of consecutive shifts that they can work. The risk to firefighter safety exceeds the monetary benefits. The ability to work overtime should not overshadow the safety of our personnel and/or the citizens we are sworn to protect.

Recommendations

As a result of this research, it appears that cognitive performance decreases with an increase of consecutive shifts worked. Sleep deprivation and fatigue are the most significant causes, and are affected by the call volume and amount of sleep that emergency personnel obtain. Sleep debt is another factor that is exacerbated when firefighters are unable to have days off to recuperate. Three areas have been identified that need to be addressed as a result of firefighter fatigue. They are: first, firefighter safety and well-being; second, customer service to our citizens, and third, risk reduction to the department and/or jurisdiction. The following are short and long term recommendations and action items that address each area.

Short term

1. Personnel need to be trained concerning the importance of sleep and the consequences of not getting enough. Awareness of the signs of fatigue will improve firefighter health. An information sheet distributed department wide as well as company training can achieve this action item.

2. Personnel need to receive didactic training on healthy lifestyles, including proper diet, exercise, and sleep habits. Once aware of the problem (fatigue), firefighters need to be trained in specific ways to stay healthy and combat the effects of sleep deprivation.
3. Supervisors need to be trained to identify if their crew members exhibit signs and symptoms of fatigue and take action accordingly. A checklist can be developed and distributed during a supervisor meeting and followed up with a special notice so that all personnel are aware of the issue. Firefighters need to be measured for improvement as well as an increase in level of service.
4. Sleep management strategies need to be employed by the department, which may include short naps during the day and rotating crew members from busy units to slower ones. Prophylactic sleep during the day will improve performance at night.
5. If necessary, allow personnel to sleep prior to driving home after a busy shift. Safety of personnel and the general public, as well as limiting liability to the department will occur if fatigued drivers are not allowed on the road.

Long term

1. Develop policies to limit the number of consecutive shifts that firefighters can work. Limiting the number of consecutive shifts will increase firefighter performance, raise motivation to train, and improve overall morale. The exact number of consecutive shifts to limit will need to be discussed. Research data supports 96 hours (4 shifts) as the maximum.
2. Develop policies that address working consecutive mandatory and voluntary overtime shifts, consistent with operational requirements. Many fire departments employ a constant staffing model where positions must be filled each shift. There are benefits

to both firefighters and fire department administration with new policies. Limits on the number of mandatory shifts imposed will be positive to operations personnel and concurrently provide for staffing requirements.

3. Consider further research to address on-duty injuries and use of sick leave as they relate to firefighters working consecutive shifts. Additional changes need to be made based on future research.
4. Conduct evaluations of firefighter performance after implementing consecutive shift restrictions.
5. It is recommended to duplicate this study to further validate these results and to continue to add to the body of knowledge.

The Redondo Beach Fire Department does not currently have a restriction on the number of consecutive shifts that firefighters work. Observation as well as test results indicate that some RBFD firefighters suffer from fatigue and sleep deprivation. The department constant staffing system as well as an increased number of vacancies has created an environment where working multiple shifts in a row is the norm. Implementation of the above recommendations will improve firefighter's well being and motivation. It will reduce the potential for a firefighter injury, substandard patient care, or preventable vehicle accident. There are currently no laws or regulations that limit the number of consecutive shifts that firefighters work. A cooperative effort between administration and firefighter unions is imperative to develop policies to prevent injuries, accidents, or fatalities.

Continued scientific cognitive and psychomotor testing is necessary to validate findings. Future research needs to include a larger population of firefighters. Studying specific firefighters at both busy stations as well as slower ones will provide more accurate data. In addition, adding

specific fields to department record management systems (RMS) will allow for data collection on incidents and/or accident and injury reports. Future studies will enable fire administrators and labor groups to operate departments that provide a safer working environment as well as managing resources more effectively.

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Appendix A

Firefighter Mind Power Problems

1. One 3/4" Hose Line (150 gpm) flowing for 5 min. How many total gallons have been used?
   1. 112.5 gallons 2. 150 gallons **3. 750 gallons**

2. Two 1/2" Hose line (200 gpm) flowing for 8 minutes. How many total gallons have been used?
   1. 800 gallons ***2. 1600 gallons*** *3. 2400 gallons*

3. Apartment ceiling height is 12' per floor. How high is the 5th floor ceiling from the street?
   1. ***60 feet*** *2. 72 feet 3. 84 feet*

4. Apartment ceiling height is 12' per floor. How high is the 8th floor ceiling from the street?
   1. *12 feet 2. 60 feet 3.* ***96 feet***

5. Apartment ceiling height is 12' per floor. How high is the 8th floor ceiling?
   1. **12 feet** 2. 60 feet 3. 96 feet

6. Water weighs 8.35 lbs. per gallon. How much does 10 gallons of water weigh?
   1. 35 pounds 2. ***83.5 pounds*** *3. 835 pounds*

7. Dispatch time: 1345 hours, Last unit cleared: 1510 hours. How long did the incident last?
   1. 25 minutes 2. ***1 hour 25 min*** *3. 2 hours 25 mins*

8. Dispatch time: 1828 hours, 1st unit arrived: 1834 hours. What was the response time?
   1. ***6 mins*** *2. 8 mins 3. 4 mins 30 secs*

9. Firefighter Jones worked a trade for Firefighter Smith from 0730 hours to 1500 hours. How many hours did Firefighter Jones work?
   1. 3 hours 30 mins 2. 7 ***hours 30 min****. 3. 17 hours 30 min*

10. Firefighter Johnson enters a structure with 4,500 psi. in his breathing apparatus bottle. When he comes out, he has 1,700 psi. How much air did he use?
    1. 1700 psi 2. 2500 psi ***3. 2800 psi***

11. Firefighter White enters a structure with 4,200 psi. in her breathing apparatus bottle. When she comes out, she has 1,500 psi. How much air did she use?
    1. ***2700 psi*** *2. 2800psi 3. 2900psi*

12. Dinner groceries cost $ 28.00. 7 people are eating dinner. How much per person does dinner cost?
    1. $2,80 2. ***$4.00*** *3. $7*

13. Dinner cost $ 30.00. 4 people are eating dinner. How much per person does dinner cost?
    1. $3 2. $4.30 3. **$7.50**

Figure 1: Fire Department Survey Information

The Effects of Working Consecutive Shifts On Firefighter Performance

Please enter the following information:		
Answer Options	**Response Percent**	**Response Count**
Name:	100.0%	114
Fire Department:	100.0%	114
Address:	98.2%	112
City/Town:	100.0%	114
State:	100.0%	114
ZIP:	99.1%	113
Email Address:	97.4%	111
Phone Number:	91.2%	104
	answered question	**114**
	skipped question	**0**

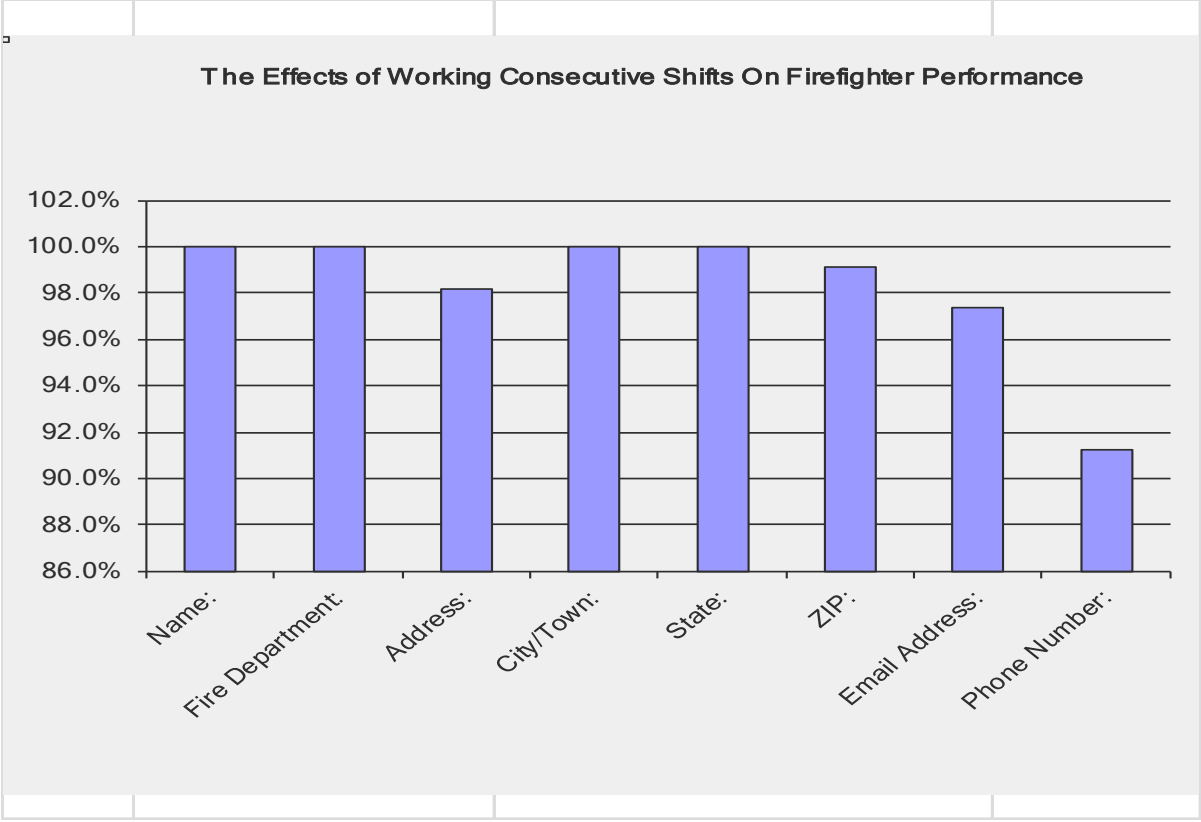


Figure 1. Listing of Fire Department demographic information.

Number	Name:	Fire Department:	City/Town:	State:
1	Lee Y. Lamar Jr.	Auburn FD	Auburn	AL
2	B Gale	Not needed	Not needed	AL
3	Blake Holte	Springdale Fire Department	Springdale	AR
4	David Staub	Pine-Strawberry Fire District	Pine	AZ
5	Gary Bynum	Drexel Heights Fire District	Tucson	AZ
6	Dave Haney	Arcadia	Arcadia	CA
7	Scott Stephens	Beverly Hills Fire Department	Beverly Hills	CA
8	Roger Sprehn	Corte Madera	Corte Madera	CA
9	Jason Beach	Emeryville fire Department	Emeryville	CA
10	Michael Lowry	Escondido	Escondido	CA
11	Ken Woods	Humboldt No. 1 Fire Protection District	Eureka	CA
12	Paul Tualla	French Camp McKinley Fire District	French Camp	CA
13	Thomas Cope	Fresno City Fire	Fresno	CA
14	Jerry Funk	Nevada County Consolidated	Grass Valley	CA
15	Mike Vetti	La Verne FD	La Verne	CA
16	Steve Prziborowski	Santa Clara County Fire Department	Los Gatos	CA
17	Tim A. Wessel	Montebello	Montebello	CA
18	Jodi Martin	Rescue Fire Protection District	Rescue	CA
19	Michael Banks	Richmond Fire Department	Richmond	CA
20	Christian J Adams	City of Riverside Fire	Riverside	CA
21	mike olsen	running springs fire	running springs	CA
22	john wagner	sacramento metro fd	sacramento	CA
23	Rudy Castellanos	San Francisco	San Francisco	CA
24	Eric Aasen	Santa Cruz FD	Santa Cruz	CA
25	Phillip Garcia	SVFRA	Sonoma	CA
26	Robert Freitas	City of Vacaville Fire Dept	Vacaville	CA
27	Don Shellhammer	Vista Fire Department	Vista	CA
28	Jim Rudroff	West Covina Fire Department	West Covina	CA
29	Doug Williams	Rincon Valley FPD	Windsor	CA
30	Dan Ghiorso	Woodside Fire Protection District	Woodside	CA
31	Emil Picchi	Woodside Fire Protection District	Woodside	CA
32	Janelle	Yuba City Fire Dept	Yuba City	CA
33	Steven Dubay	Colorado Springs (CO) FD	Colorado Springs	CO
34	Michael Lee	Cunningham Fire Prot. District	Denver	CO
35	Rick Davis	Loveland Fire Rescue	Loveland	CO
36	Doug Hall	City of Westminster	Westminster	CO
37	Joseph Hebert	Norwich Fire Department	Norwich	CT

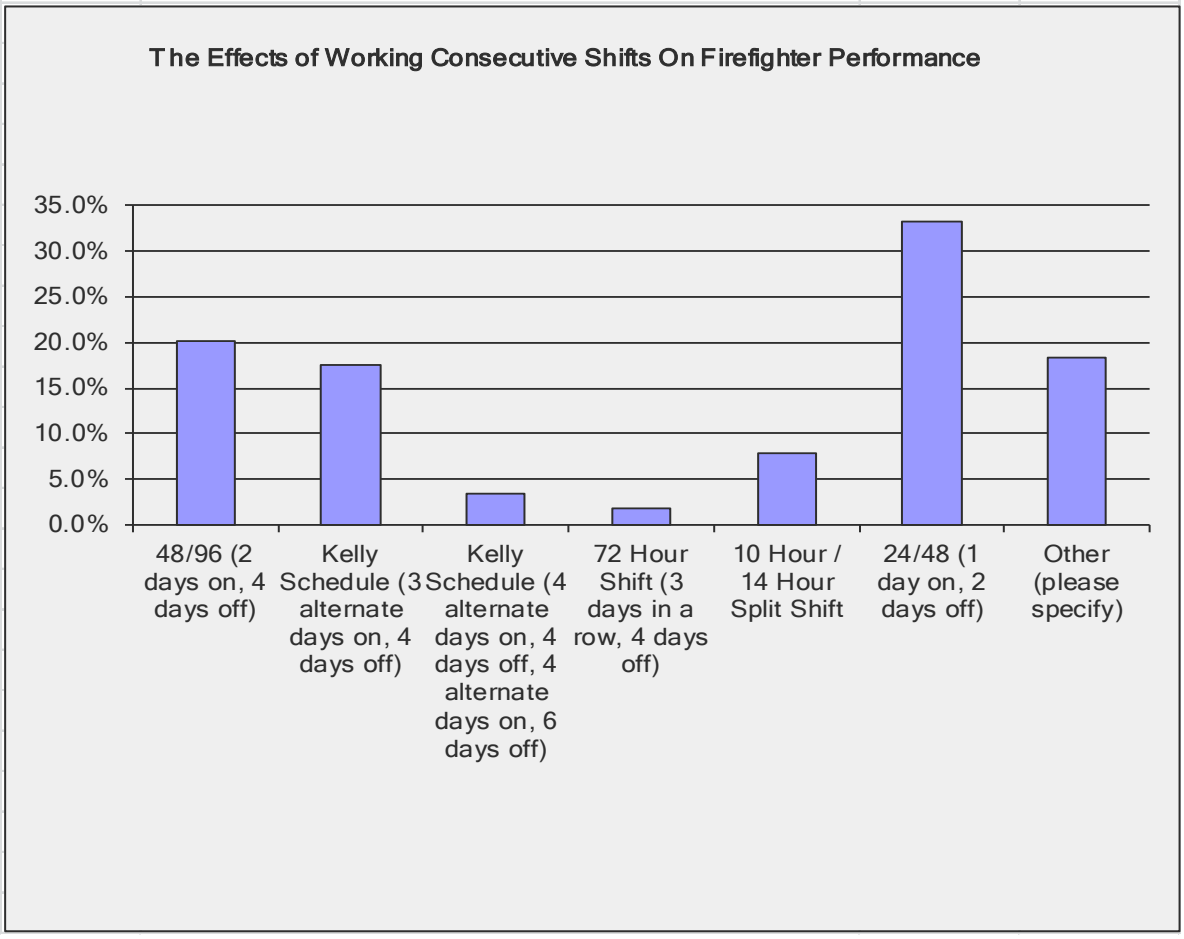
38	Marc Scrivener	Willimantic Fire Department	Willimantic	CT
39	Steven Page	Apopka Fire Department	Apopka	FL
40	Mark Miceli	BSO Fire Rescue	Fort Lauderdale	FL
41	John Meizoso	Miami Dade Fire Rescue	Miami	FL
42	Andrew Thompson	Greater Orlando Aviation Authority	Orlando	FL
43	Rick Sullivan	Plant City Fire Rescue	Plant City	FL
44	Dick Cummings	Elgin Fire Department	Elgin	IL
45	Jeff Dees	Roberts Park Fire Dept	Justice	IL
46	Rick Griffin	La Grange Fire Department	La Grange	IL
47	John Buckley	Pleasantview Fire Protection District	LaGrange	IL
48	Joe Cirelli	Mokena Fire Protection District	Mokena	IL
49	Tim Leidig	Mundelein Fire Department	Mundelein	IL
50	Jeffrey A Newbury	Ottawa Fire Department	Ottawa	IL
51	D/C Bruce Ziegle	Park Forest Fire Department	Park Forest	IL
52	Tim Norton	Park Ridge Fire Dept.	Park Ridge	IL
53	Drew Smith	Prospect Heights Fire District	Prospect Heights	IL
54	Steven Frye	Carmel Fire Department	Carmel	IN
55	Joe Squier	New Albany Fire Department	New Albany	IN
56	Joe Tomczek	New Iberia	New Iberia	LA
57	David Emswiler	Walpole Fire Department	Walpole	MA
58	Sal Scarpa	N. Kansas City FD	N. Kansas City	MO
59	DAVID LEWIS	ST CHARLES FIRE DEPARMT ENT	ST CHARLES	MO
60	Michelle Crowley	Biloxi Fire Dept.	Biloxi	MS
61	Stephen Benson	Southaven Fire Department	Southaven	MS
62	Benjamin Lunsford	Forsyth County Emergency Services	Greensboro	NC
63	Kevin Zorc	Nags Head Fire Rescue	Nags Head	NC
64	Frankie Hobson	City of Raleigh	Raleigh	NC
65	Joshua Smith	Statesville Fire	Statesville	NC
66	Robbie Cox	City of Washington Fire/Rescue/EMS	Washington	NC
67	Steve Mason	Wilmington	wilmington	NC
68	Dane Carley	Fargo Fire Department	Fargo	ND
69	Lee Soeth	Fargo Fire Department	Fargo	ND
70	Todd Walton	Kearney Volunteer Fire Department	Kearney	NE
71	Dan	Andrus	Concord	NH
72	Merle	Concord	Concord	NH
73	Daniel Fisher	Concord Fire	Concord	NH
74	John McAuliffe	Concord Fire Department	Concord	NH
75	Mark Hebert	Concord Fire Department	Concord	NH

76	Guy Newbery	Concord Fire Dept	Concord	NH
77	Ken Folsom	Concord NH	Concord	NH
78	Chris Johnson	Concord, NH	Concord	NH
79	Cory Clark	Concord, NH	Concord	NH
80	Gary Courtney	Sanbornton	Sanbornton	NH
81	Todd Evans	Mount Laurel Fire Department	NJ	NJ
82	Ted Sweetser	Las Cruces Fire Department	Las Cruces	NM
83	Brian Wilbur	Ithaca Fire Department	Ithaca	NY
84	Timothy S. Cowan	City of Oneida	Oneida	NY
85	David Whiting	Columbus Fire Department	Columbus	OH
86	Chris Blair	Columbus, Ohio	Columbus	OH
87	Jim	Davis	Columbus	OH
88	Lt. James Carter	Copley Twp. Fire Dept	Copley	OH
89	Richard Mascarella	City of Monroe	Monroe	OH
90	Steve Agenbroad	Clearcreek Fire District	Springboro	OH
91	Jon Cameron	Strongsville, Ohio	Strongsville	OH
92	A/C Ron Likley	Wadsworth Fire Department	Wadsworth	OH
93	Mark Bernt	Albany Fire	Albany	OR
94	Mark Havener	Tualatin Valley Fire & Rescue	Tigard,	OR
95	Vance Duncan	City of Erie, Bureau of Fire	Erie	PA
96	martin	walsh	phila	PA
97	Philadelphia Fire Department	Philadelphia Fire Department	Philadelphia	PA
98	Bob Gaetano	Mt. Lebanon	Pittsburgh	PA
99	Lt. John Egan	Woonsocket	Woonsocket	RI
100	Thomas Sanders	KBR US GOV Contract Iraq	Baghdad	TX
101	Tom Linnenkugel	Harris County Hazmat	Humble	TX
102	Russell Sander	Missouri City Fire & Rescue	Missouri City	TX
103	Jaime Ponce De Leon	Missouri City Fire & Rescue Services	Missouri City	TX
104	Travis	Carter	Sunset	UT
105	Marc Timbrook	Alexandria Fire Department	Alexandria	VA
106	Larry Spencer	Henrico County (VA) Division of Fire	Henrico	VA
107	Michael Jurgens	York County Fire and Life Safety	Yorktown	VA
108	Doug Baier	Bremerton Fire Department	Bremerton	WA
109	Mark Correira	Snohomish County Fire District #1	Everett	WA
110	Brian McMahan	Mukilteo Fire Department	Mukilteo	WA
111	Ryan Scharnhorst	Pullman Fire Department	Pullman	WA
112	Mark Crowley	Tukwila Fire Department	Tukwila	WA
113	Hallie McCurdy	West Pierce Fire & Rescue	University Place	WA
114	Charlie Myers	City of Brookfield Fire Dept	Brookfield	WI

Figure 2: Fire Department Shift Schedule from Survey

The Effects of Working Consecutive Shifts On Firefighter Performance

What shift schedule does your department utilize?		
Answer Options	**Response Percent**	**Response Count**
48/96 (2 days on, 4 days off)	20.2%	23
Kelly Schedule (3 alternate days on, 4 days off)	17.5%	20
Kelly Schedule (4 alternate days on, 4 days off, 4 alternate days on, 6 days off)	3.5%	4
72 Hour Shift (3 days in a row, 4 days off)	1.8%	2
10 Hour / 14 Hour Split Shift	7.9%	9
24/48 (1 day on, 2 days off)	33.3%	38
Other (please specify)	18.4%	21
answered question		**114**
skipped question		**0**



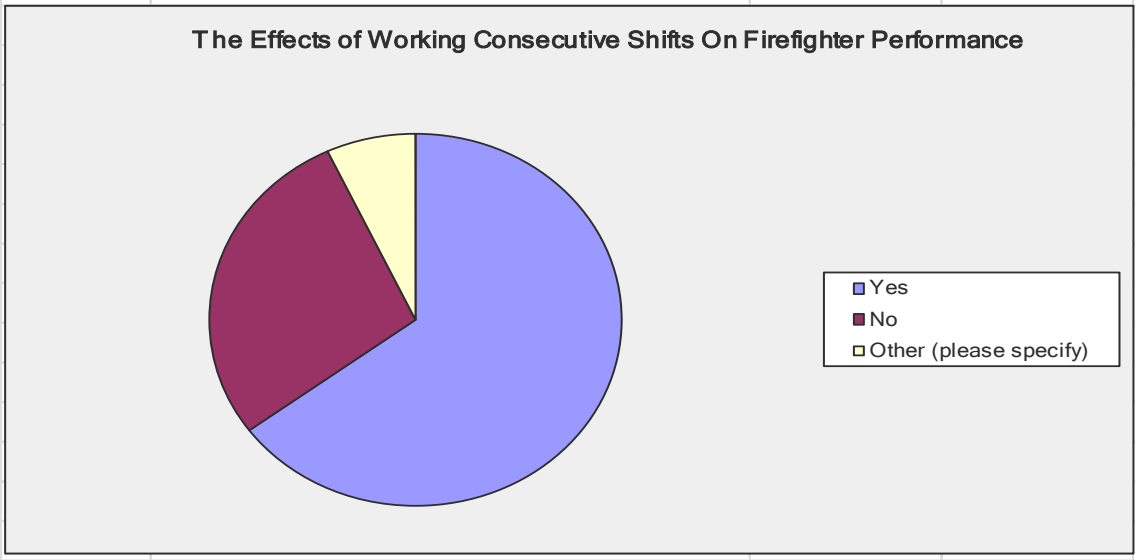
Number	Other (please specify)
1	5 alternate days on, 6 days off
2	11/13 splits 2-2-4
3	48 Hour week, 2-11 Hour Days, 2-13 Hour Nights, 4 days off
4	11 Hour/13 Hour Split Shift
5	11 Hr. days 13 Hr. nights-2 days, 2 nights, 4 off
6	one day on, one day off, one day on, 5 days off.
7	24 on, 2 days off, 24 on, 4 days off
8	2 10-hr days followed by 2 14-hr nights
9	It is actually an 11 hour day, 13 hour night shift.
10	2 days 11 hrs, 2 nights 13 hrs, 4 days off
11	Your 72 hour shift is in violation of FLSA. Think you may be looking for 24-on/72-off.
12	8 or 10 hour perdiem day only
13	24 hr on, 72 hr off--4 Plt system
14	Two 24/48 per week with Saturdays covered by part time drivers
15	3 alternating shifts, then 4 days off (9 day cycle)
16	4 plattoon- 1 (24) on, 1 off, 1 on, 5 off with a Debit Day every 32 days
17	24 on 72 off
18	5/6 schedule 24 on 24 off for 5 shifts then 6 days off
19	7/21 Plan
20	Mdified LA Shcedule
21	Kday is every 3 weeks

Figure 2. Listing of various fire department shift schedules by response percentage and specific descriptions.

Figure 3: Limit of Consecutive Shifts that Personnel Can Work

The Effects of Working Consecutive Shifts On Firefighter Performance

Does your department have a limit to the number of consecutive shifts that personnel can work?		
Answer Options	**Response Percent**	**Response Count**
Yes	64.9%	74
No	28.1%	32
Other (please specify)	7.0%	8
answered question		**114**
skipped question		**0**



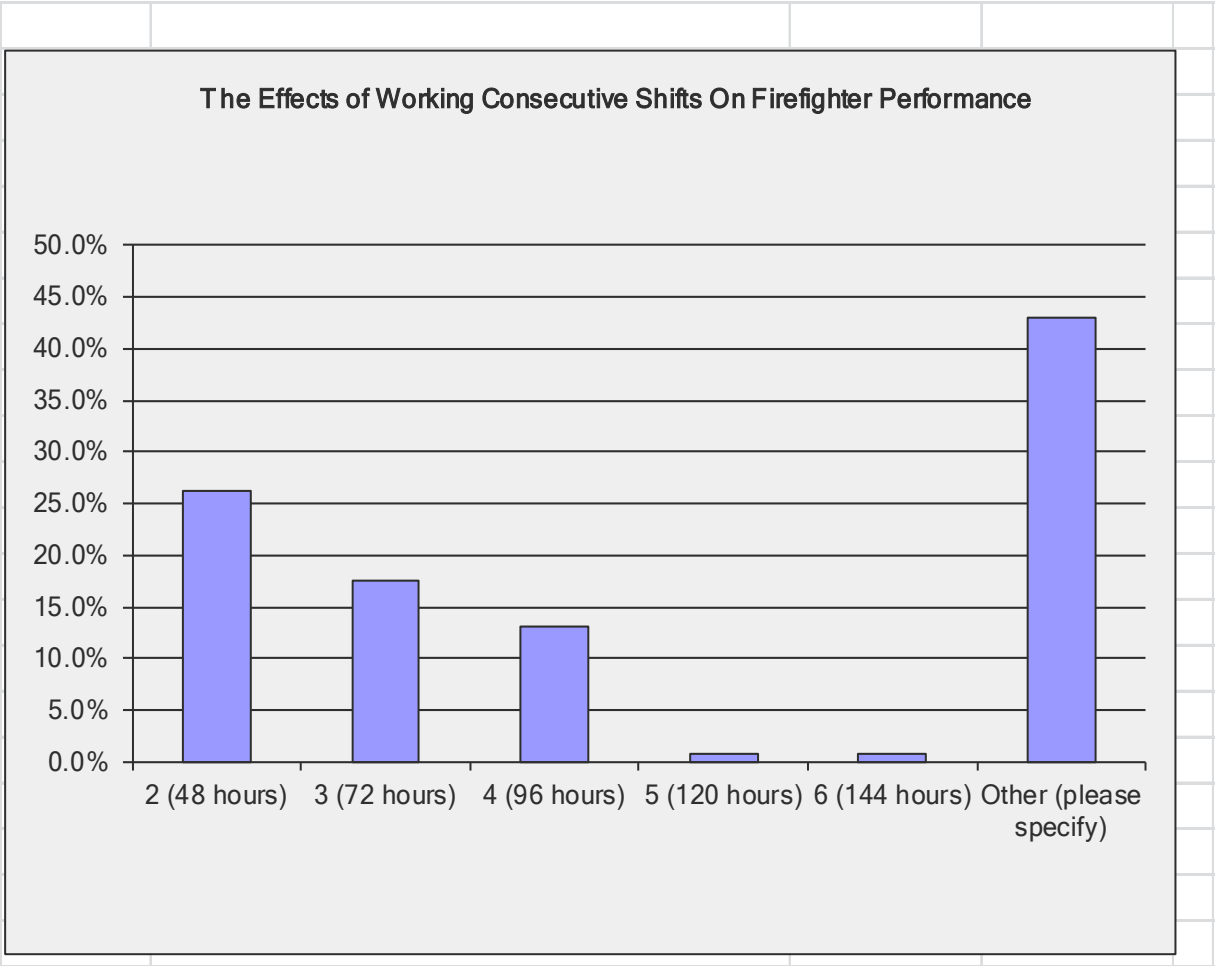
Number	Other (please specify)
1	Can refuse OT after 48 hrs.
2	Mandatory up to 48 hours, then voluntary
3	You can opt out of mandatory overtime after 48 hours
4	No more than 48 consecutive hours, unless emergency holdover (Employee can not voluntarily accept greater than 48 hours)
5	96 hrs requires BC approval
6	Yes, 72 hours but has never been enfirced
7	We will not force hire a FF to work longer than 96 consecutive hours, but the FF can chose to work longer than 96 consecutive hours.
8	Informal 96 hour limit

Figure 3. Depicts fire departments that have a consecutive shift limit and specific rules.

Figure 4: Maximum Number of Shifts that Personnel Can Work Consecutively

The Effects of Working Consecutive Shifts On Firefighter Performance

What is the maximum number of shifts that personnel can work consecutively?		
Answer Options	**Response Percent**	**Response Count**
2 (48 hours)	26.3%	30
3 (72 hours)	17.5%	20
4 (96 hours)	13.2%	15
5 (120 hours)	0.9%	1
6 (144 hours)	0.9%	1
Other (please specify)	43.0%	49
answered question		**114**
skipped question		**0**



Number	Other (please specify)
1	No formal limit
2	No Max
3	36 hour maximum
4	Infinite
5	Not specified
6	See #3
7	internal department policy only, depending on if it is a declared distaster or special situation.
8	Battilion Chief decision regarding being fit for duty
9	They can work 52 consective hours before being relieved
10	2 (24hr)
11	No limit
12	Cap was lifted about 5 years ago
13	24 hours
14	36 hours
15	24 hours
16	36 hours and then chief's authorization takes into consideration downtime during the shifts.
17	not specified
18	5 shifts or 62 hours
19	N/A
20	No set limit
21	No limit. We have had personnel work 7 shifts in a row before.
22	no restriction
23	No limit
24	no limit
25	One 24 hour shift
26	NO limit allowed, but cannot force someone over 72hrs
27	No pilicy
28	To work more than 72 hours, a person needs an 8 hour break at the end of the 72 hours.
29	2 shifts + 4 hours (52 hours)
30	No written rule
31	60
32	no maximum, usually 48 is most common
33	none
34	60 hours
35	36 hours straight
36	currently, no limit
37	no limit
38	There is none
39	no maximum
40	No limit
41	96 up to 120 with BC approval
42	no maximum
43	no limit on engines. no more than 24 hours on ambulance
44	n/a
45	none
46	No maximum
47	Informal 96 hour limit
48	We have no maximum
49	none

Figure 4. Maximum number of shifts personnel can work (percentage) and specific descriptions.

Figure 5: Fire Department Approximate Call Volume

The Effects of Working Consecutive Shifts On Firefighter Performance

What is your department's approximate annual call volume (total incidents for 2010)?		
Answer Options	**Response Percent**	**Response Count**
0 to 5,000 Incidents	43.9%	50
5,001 to 10,000 Incidents	29.8%	34
10,001 to 50,000 Incidents	17.5%	20
50,001 to 100,000 Incidents	1.8%	2
More than 100,000 Incidents	7.0%	8
	answered question	**114**
	skipped question	**0**

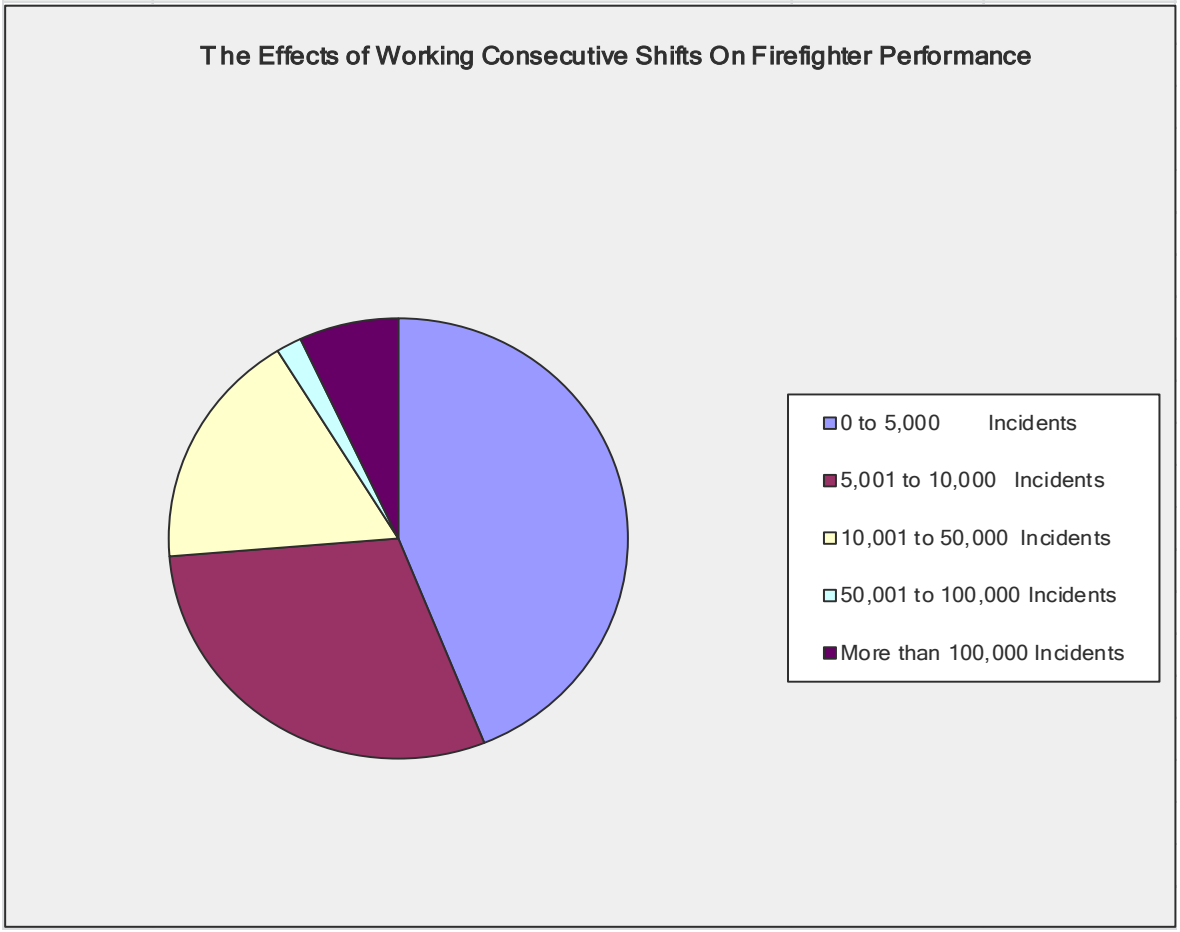


Figure 5. Depicts call volume by fire department of survey respondents (percentage).

Figure 6: Laws and Standards that Reference Personnel Working Consecutive Shifts

The Effects of Working Consecutive Shifts On Firefighter Performance

Please specify any laws or standards that your department references to address limitations on personnel working consecutive shifts (NFPA, Policy, Directive, Etc.).	
Answer Options	**Response Count**
	62
answered question	**62**
skipped question	**52**

Number	Response Text
1	Department Policy states an employee can not work for longer the 72 hours straight.
2	Policy: Maximum mandatory time (duty shift & mandatory OT) is 48 hrs, then OT becomes voluntary. Hours worked on swap do not count toward 48 hr mandatory maximum.
3	Organizational policy restricting working more than 72 hours consecutive w/o the B/C approval.
4	None, Personnel can opt out after 3 consecutive mandatory shifts. Does not include swaps.
5	OT hiring policy
6	Internal department directives.
7	Policy, union contract.
8	Administrative regulations
9	Department policy and the union contract.
10	We created or own policy for this.
11	No laws, but a 72 hour shift rolls into a 96 hour shift because you have to work your own day again when your shift comes up. So we limit the consectutive days unless is is convenient for management to have you work a 96 hour shift, then there is no limit.
12	Internal policy
13	Collective bargaining agreement
14	Policy
15	No laws, just a feeling that the level attentiveness and general desire to continue to be at work would significantly decrease and result in increased tension, lack of wanting to do anything other than answer the bell, and irritability.
16	Department Policy
17	Contractual agreement
18	None - internal policy decision.
19	N/A
20	None.
21	N/A
22	none
23	Chiefs' preference
24	NFPA
25	none
26	x
27	None

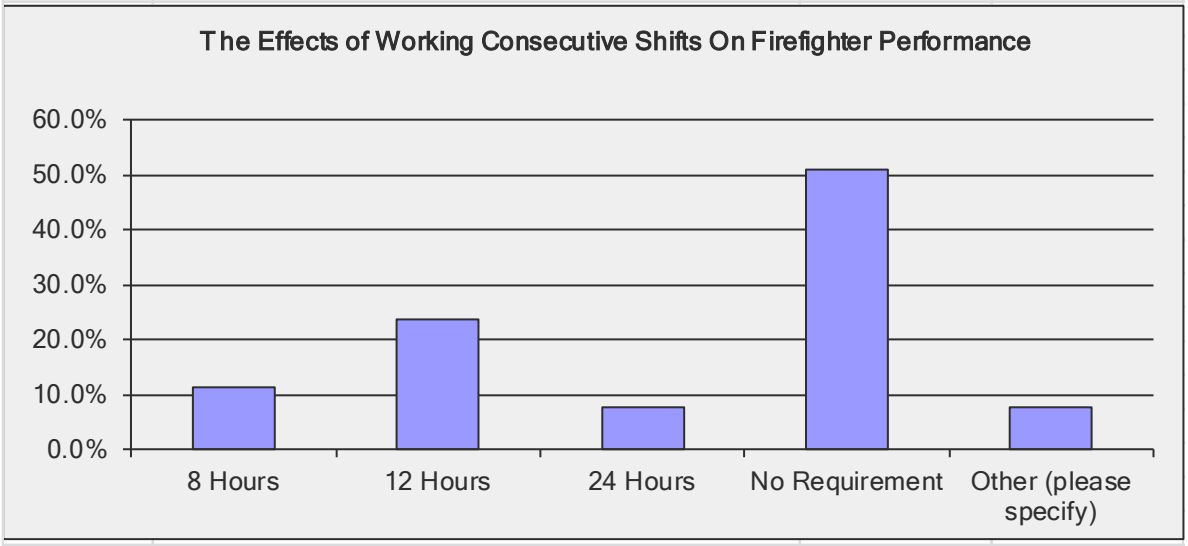
28	As far as I know it is just a policy of ours and an I believe it is included in the labor agreement
29	MOU and probationary FF Contracts state the limitations
30	Department Policy
31	Department Rules and Regulations.
32	unaware of any formal laws or standards we follow, we just have a admnentment to our CBA
33	In place in the Union Contract for nearly 20 years.
34	None
35	None
36	None referenced.
37	Not set in policy, but at the direction of the Fire Chief personnel cannot work more than 96 consecutive hours unless it is attributed to a ntural disaster.
38	Department policy
39	WAC 296-305
40	FSLA
41	Internal policy is no one can work no more than 72 hrs in a 96 hour period
42	None
43	Divisional policy. We restrict as a preventative measure. it may be set aside in the event of widespread disaster adn crews would be assigned to shorter work periods (12 hours/ 12 hours off).
44	Contract - Any personnel that works a regullar scheduled shift, and over-time shift, or shift exchance totaling 36 hours or more hours shall not work additional over-time until said employee has 24 hour off duty.
45	None,
46	Administrative Policy that requires 6 hours of continuous rest per 24 hour shift and no more than 48 consecutive hours per work period
47	n/a
48	NC labor law
49	None. This is internal to our agency but can be violated for emergency situations.
50	Department Policy
51	None.
52	n/a
53	Policy (Mutually agreed to by Labor and Management)
54	FLSA
55	MOU
56	SOP
57	FD SOG - OT policy
58	n/a
59	Utilization of fatigue policy.
60	none
61	KBR/US Gov contract stipulates no more than 72 hours worked consecutively. FF's must have a minimum 12 break prior to return to duty unless directed by SFO.
62	Policy & Ops

Figure 6. Description of laws or standards referenced to limit working consecutive shifts.

Figure 7: Hours that Personnel are required to be off prior to Returning to Work

The Effects of Working Consecutive Shifts On Firefighter Performance

How many hours are personnel required to be off duty prior to returning to work?		
Answer Options	**Response Percent**	**Response Count**
8 Hours	11.4%	13
12 Hours	23.7%	27
24 Hours	7.9%	9
No Requirement	50.9%	58
Other (please specify)	7.9%	9
	answered question	**114**
	skipped question	**0**



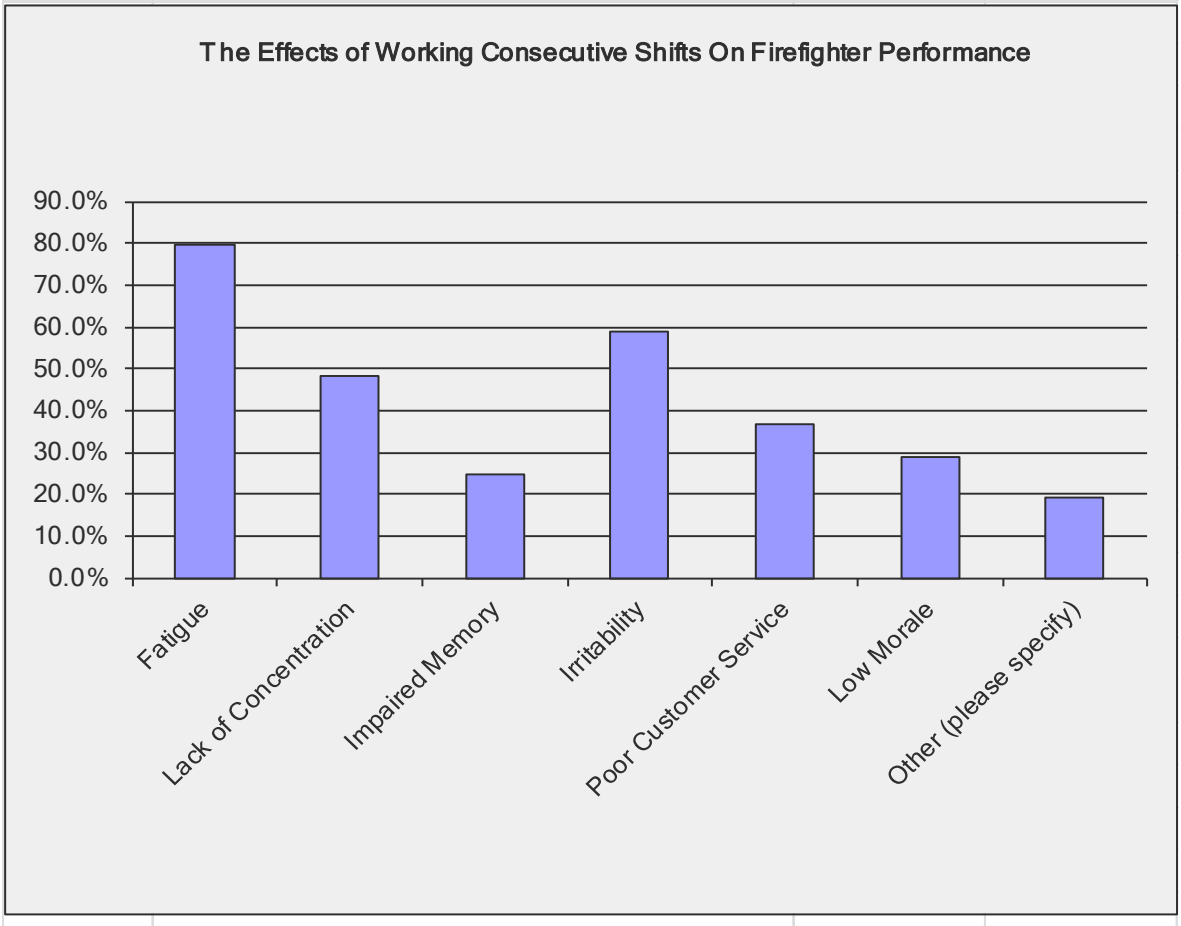
Number	Other (please specify)
1	48 hours if changing between shift schedule and day schedule
2	10
3	Unknown
4	Four hours
5	No specific requirement, generally overnight or equivalent
6	10 hours
7	can be as little as 1 hour and then do back to back 96hrs
8	we look at 12 hours as a reasonable time to "reset the clock"
9	No rules

Figure 7. Depicts the number of hours required to be off-duty prior to returning to work.

Figure 8: Effects on Firefighter Performance Observed

The Effects of Working Consecutive Shifts On Firefighter Performance

What effects on firefighter performance have you observed due to personnel working consecutive shifts?		
Answer Options	**Response Percent**	**Response Count**
Fatigue	79.8%	91
Lack of Concentration	48.2%	55
Impaired Memory	24.6%	28
Irritability	58.8%	67
Poor Customer Service	36.8%	42
Low Morale	28.9%	33
Other (please specify)	19.3%	22
	answered question	**114**
	skipped question	**0**



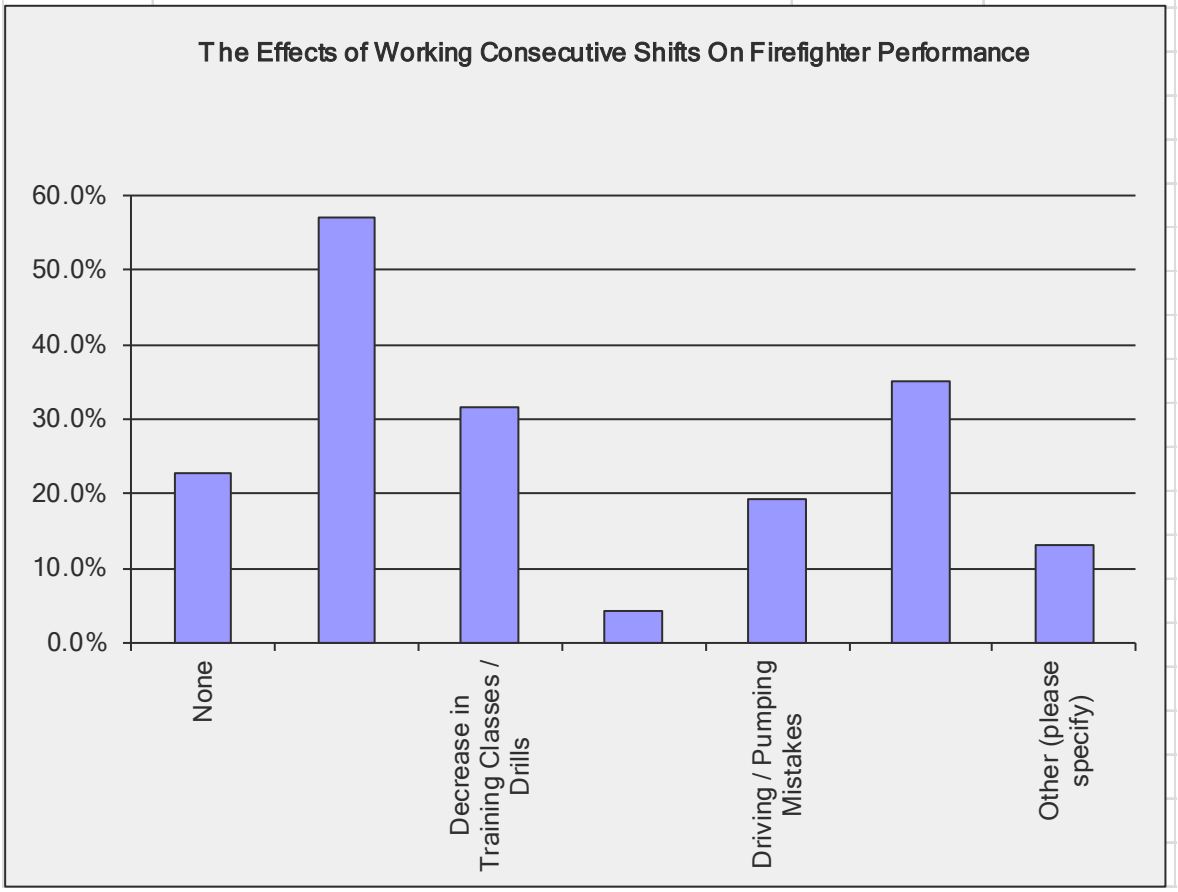
Number	Other (please specify)		
1	Complacency regarding safety		
2	I have seen all of these in our department, but I cannot say for sure if it is directly related to our personnel working consecutive shifts. I can only speak from my experiences.		
3	reduction in sick leave usage when 48/96 adopted (compared to 24/48 previous schedule)		
4	None noted		
5	late reporting for scheduled shift		
6	Based on part time jobs		
7	Impaired situational awareness		
8	Decrease in work product		
9	None, exceptfor occasional fatigue if they ran a lot of calls the previous night.		
10	Higher incidence of illness / injury		
11	Decreased productivity		
12	did not witness any		
13	None		
14	increase chance of injury after 36 hours		
15	declining productivity		
16	When you are tired.... you do not perform as well. PERIOD.		
17	Can be all of the above		
18	Unaware of any effects		
19	No real quantifiable data availalbe		
20	Have not observed any changes		
21	Occasional effects as noted above		
22	Still too new to determine.		

Figure 8. Depicts firefighter performance effects from working consecutive shifts (percentage) and other specific descriptions.

Figure 9: Changes in Performance or Productivity

The Effects of Working Consecutive Shifts On Firefighter Performance

What, if any, changes in performance or productivity have you observed due to personnel working multiple consecutive shifts?		
Answer Options	**Response Percent**	**Response Count**
None	22.8%	26
Station Maintenance Not Completed	57.0%	65
Decrease in Training Classes / Drills	31.6%	36
Drug Dosage or Paramedic Mistakes	4.4%	5
Driving / Pumping Mistakes	19.3%	22
Projects Not Completed	35.1%	40
Other (please specify)	13.2%	15
	answered question	**114**
	skipped question	**0**



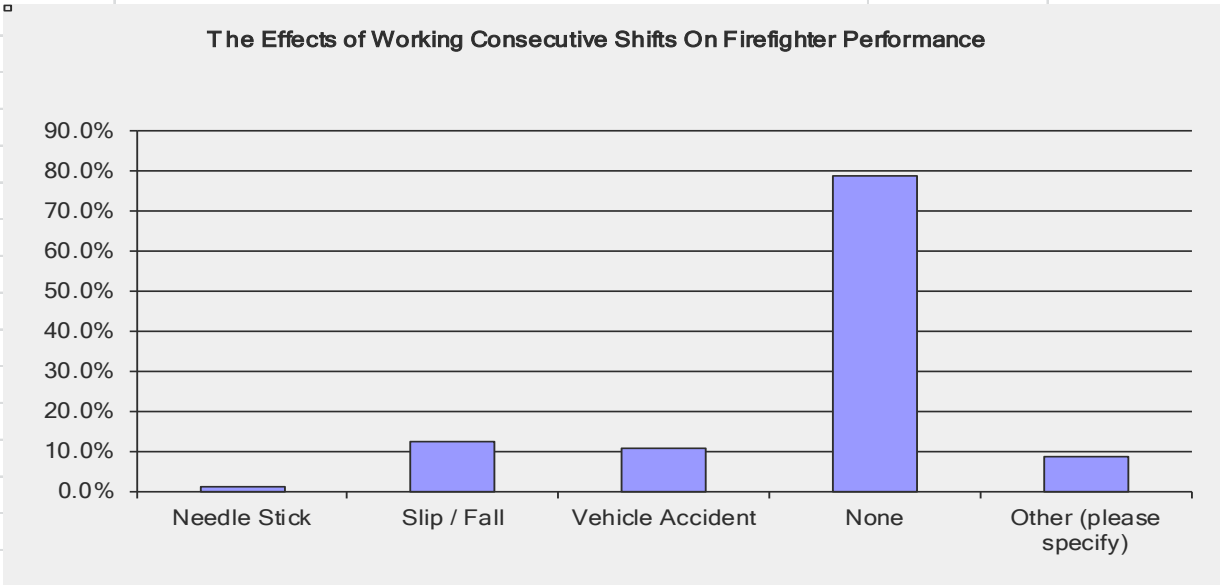
Number	Other (please specify)
1	sleeping - lack of motivation - dullness in overall personality
2	Mind set changed to just do the basics
3	None - but not specifically studied/researched.
4	Again, these are personal observations of myself. I have seen all of the above from others, but again I can't directly relate it to this.
5	Subpar decision making
6	Poor attitude
7	apparatus checks are 100%, concern for admin...
8	did not witness any
9	An increase in injuries, stress, or illness attributed to fatigue from working multiple hours.
10	needing more sleep during day time hours specially at busy stations
11	Not wanting to pull their work load
12	Easier to "put things off" until tomorrow.. and then they don't get done because of call volume
13	On scene performance is less sharp.
14	Communication between shifts and with Chief. Can go almost 2 weeks without working a weekday. Still tend to "weekend schedule"
15	Still too new to determine.

Figure 9. Depicts performance or productivity effects observed when working multiple consecutive shifts (percentage) and specific descriptions.

Figure 10: On-duty Injuries Resulting from Working Consecutive Shifts

The Effects of Working Consecutive Shifts On Firefighter Performance

Have you observed any of the following on-duty injuries resulting from personnel working multiple consecutive shifts?		
Answer Options	**Response Percent**	**Response Count**
Needle Stick	0.9%	1
Slip / Fall	12.3%	14
Vehicle Accident	10.5%	12
None	78.9%	90
Other (please specify)	8.8%	10
	answered question	**114**
	skipped question	**0**



Number	Other (please specify)
1	Shortcuts being taken such as not doing 360's around the apparatus prior to moving; equipment not secured
2	None - but not specifically studied/researched.
3	Fitness injuries
4	maintenance injury
5	None at this time
6	Hi Rob, hope all is well!
7	did not witness any
8	Back injurys as well as other strains and sprains
9	Uncertain if any injuries are related to personnel working consecutive shifts
10	None

Figure 10. Types of injuries and specific descriptions when firefighters work consecutive shifts.

Figure 11: Firefighter Mind Power Test Results

SUBJECT #	TEST #	DATE TAKEN	# OF CONSECUTIVE SHIFTS	# CALLS > 2200 HRS.	# CALLS > 1 HR.	HOURS OF SLEEP PER NIGHT	HOW TIRED	GEN. PROB SOLVING #1	GENERAL PROB. SOLVING #2	GENERAL PROB. SOLVING #3	GENERAL PROB. SOLVING #4	WORD RECALL #5	WORD RECALL #6	NAME/FACE #7	NAME/FACE #8	VIDEO MEMORY #9	VIDEO MEMORY #10	VIDEO MEMORY #11	VIDEO MEMORY #12	TOTAL SCORE
1	1	7/7/2011	1	1	1	3	2	83	98	138	138	78	81	170	201	93	86	117	86	1369
1	2	7/7/2011	1	1	1	3	2	28	48	-98	138	72	72	68	170	45	66	-47	62	624
1	3	7/8/2011	1	2	1	3	1	62	-25	-79	76	97	78	89	77	111	70	-49	70	577
1	4	7/9/2011	2	2	2	3	2	64	-36	-24	98	67	-72	116	124	75	64	-57	38	457
1	5	7/25/2011	1	1	1	3	2	42	-39	88	-119	81	81	77	159	41	68	34	51	564
1	6	7/26/2011	1	2	2	2	1	-48	-39	34	60	72	24	117	50	-49	-53	53	30	251
1	7	7/27/2011	2	1	1	3	1	18	32	30	65	56	52	30	-39	36	45	39	35	399
1	8	7/28/2011	2	1	1	3	1	21	58	28	93	78	78	50	139	60	53	47	-46	659
1	9	7/31/2011	1	1	1	3	1	32	55	27	39	78	59	33	47	60	56	-28	-52	406
2	1	7/13/2011	1	1	1	3	2	37	-38	67	52	75	75	70	-123	74	74	-62	-52	249
2	2	7/13/2011	1	1	1	3	2	49	29	49	79	-33	72	-86	111	62	56	64	51	503
2	3	7/15/2011	2	2	2	2	2	42	-33	79	41	78	48	-83	68	80	60	59	70	509
2	4	7/20/2011	1	1	1	3	1	32	67	64	58	75	-78	101	123	70	-53	54	-32	481
2	5	7/21/2011	2	2	1	3	1	32	-34	23	-99	70	81	130	139	83	83	86	70	664
3	1	7/8/2011	1	1	1	3	2	33	-38	104	76	108	-31	-64	-123	41	123	51	-18	262
3	2	7/8/2011	1	1	1	3	2	88	52	58	128	78	97	-131	123	-62	-64	117	-39	445
3	3	7/9/2011	2	1	1	3	1	28	-18	83	98	70	102	77	89	86	-50	38	53	656
3	4	7/10/2011	2	1	1	3	1	38	20	76	84	72	-59	35	68	56	56	-62	52	436
3	5	7/23/2011	1	1	1	3	1	36	-14	88	-98	81	93	139	159	106	111	72	64	837
3	6	7/25/2011	1	1	1	3	3	-83	-33	46	88	-38	93	131	139	44	53	57	-22	475
4	1	7/6/2011	2	1	1	3	2	50	-9	33	54	59	38	-56	80	37	52	-35	0	303
4	2	7/7/2011	2	2	2	2	2	12	46	29	37	34	38	53	116	77	65	42	-45	504
4	3	7/8/2011	3	2	1	2	2	32	22	-93	13	31	48	-70	55	47	36	-32	59	148
4	4	7/16/2011	1	1	1	3	2	79	15	52	67	39	-56	53	68	50	-56	-33	-17	261
4	5	7/18/2011	2	2	2	3	2	23	9	-99	51	53	93	171	37	72	39	-42	0	407
4	6	7/19/2011	2	1	1	3	2	-64	-29	33	63	31	75	171	83	-66	39	40	-25	351
4	7	7/23/2011	1	1	1	3	2	32	34	138	98	22	49	80	59	41	139	44	62	798
4	8	7/24/2011	1	2	2	3	2	0	-44	92	36	42	-33	68	123	55	64	52	27	482
4	9	7/25/2011	2	2	2	2	2	46	48	-27	17	-39	-37	70	93	86	86	29	-44	328
4	10	7/29/2011	1	3	3	2	2	104	60	48	93	59	51	184	80	80	54	-31	-39	743
4	11	7/30/2011	2	2	2	2	2	98	-88	165	70	67	65	-83	203	68	62	68	101	796
4	12	7/31/2011	2	3	1	2	2	20	16	48	84	97	70	93	60	50	66	-31	26	599
5	1	7/6/2011	2	1	1	3	2	67	51	104	70	108	108	97	123	101	77	64	93	1063
5	2	7/10/2011	1	1	1	3	1	128	76	105	-148	81	88	203	171	60	198	203	94	1259
5	3	7/11/2011	1	1	1	3	1	58	11	103	118	72	81	-101	124	-62	75	80	68	627
5	4	7/12/2011	2	2	1	2	2	44	165	79	98	75	75	118	140	105	59	46	75	1079
5	5	7/13/2011	2	1	1	3	2	41	-34	77	-152	108	103	183	183	70	85	89	-62	691
5	6	7/17/2011	1	1	1	3	1	-98	-49	-24	45	59	49	201	201	56	-93	62	33	442
5	7	7/18/2011	1	2	2	2	2	62	47	64	138	97	93	158	139	66	74	106	51	1095
5	8	7/23/2011	1	1	1	3	1	58	64	69	84	121	97	93	140	101	83	59	93	1062

SUBJECT #	TEST #	DATE TAKEN	# OF CONSECUTIVE SHIFTS	# CALLS > 2200 HRS.	# CALLS > 1 HR.	HOURS OF SLEEP PER NIGHT	HOW TIRED	GEN. PROB SOLVING #1	GENERAL PROB. SOLVING #2	GENERAL PROB. SOLVING #3	GENERAL PROB. SOLVING #4	WORD RECALL #5	WORD RECALL #6	NAME/FACE #7	NAME/FACE #8	VIDEO MEMORY #9	VIDEO MEMORY #10	VIDEO MEMORY #11	VIDEO MEMORY #12	TOTAL SCORE
5	9	7/24/2011	1	2	2	3	2	62	39	16	98	72	-54	45	118	53	77	124	-35	615
5	10	7/25/2011	2	1	1	3	1	128	45	20	119	108	93	221	170	62	83	56	123	1228
5	11	7/28/2011	1	2	2	2	3	62	-38	41	104	88	51	159	200	54	93	60	62	936
5	12	7/29/2011	1	2	2	2	3	62	-9	128	81	53	117	148	54	64	66	42	0	806
5	13	7/30/2011	2	1	1	3	2	70	104	-67	45	81	93	117	171	77	59	66	68	884
6	1	7/8/2011	2	2	1	2	2	58	60	184	111	114	114	-106	-101	-60	74	-38	83	493
6	2	7/14/2011	1	2	1	2	2	64	62	-150	104	67	108	-111	171	77	101	86	-64	515
6	3	7/15/2011	2	2	1	3	1	76	99	128	104	103	122	124	93	111	80	101	116	1257
6	4	7/16/2011	3	3	2	2	2	67	105	98	56	47	-120	105	171	101	-94	83	53	672
6	5	7/17/2011	3	2	1	3	1	34	-45	30	-138	81	78	203	171	107	89	68	-58	620
6	6	7/20/2011	1	1	1	3	1	-83	49	60	88	115	-56	123	243	-89	68	-64	-64	390
6	7	7/21/2011	2	2	1	3	1	98	-58	49	138	49	67	170	-221	101	117	-106	77	481
6	8	7/27/2011	1	2	2	2	2	70	28	141	105	122	122	124	183	-124	107	78	64	1020
6	9	7/31/2011	1	1	1	2	1	70	64	-28	104	114	97	101	93	123	82	106	77	1003
7	1	7/6/2011	1	1	1	3	1	79	69	148	138	67	54	183	86	111	83	89	86	1193
7	2	7/6/2011	1	1	1	3	1	118	76	138	118	97	78	171	171	-64	93	111	93	1200
7	3	7/7/2011	2	1	1	3	1	60	21	126	131	102	-88	175	167	101	55	52	85	987
7	4	7/8/2011	2	1	1	3	1	46	70	138	131	80	65	148	160	77	77	42	78	1112
7	5	7/11/2011	1	1	1	2	2	58	29	61	80	61	93	128	175	89	89	89	-83	869
7	6	7/12/2011	1	1	1	3	1	-34	-41	37	87	96	99	-133	107	53	50	74	38	433
7	7	7/13/2011	2	1	1	3	2	46	41	82	36	96	102	167	167	54	104	124	82	1101
7	8	7/16/2011	1	1	1	3	1	50	44	49	126	108	108	53	133	94	72	-110	-54	673
7	9	7/17/2011	1	1	1	3	1	42	47	32	52	102	71	82	-70	78	54	75	63	628
7	10	7/18/2011	2	1	1	3	1	42	64	39	107	78	86	183	104	85	94	94	-65	911
7	11	7/19/2011	2	1	1	3	2	70	-74	70	93	78	69	124	183	-94	70	110	65	764
7	12	7/23/2011	1	1	1	3	1	42	26	-31	138	125	96	154	183	70	85	104	-46	946
7	13	7/24/2011	1	1	1	3	2	61	-42	126	126	135	108	-167	203	78	104	133	154	1019
8	1	7/23/2011	1	1	1	3	1	26	-41	105	66	89	104	184	-164	69	74	-55	-58	399
8	2	7/23/2011	1	1	1	3	1	76	44	-117	105	100	104	-114	148	78	80	67	69	640
8	3	7/28/2011	1	1	1	3	2	62	34	88	84	45	61	106	86	-47	42	50	-72	539
8	4	7/29/2011	2	1	1	2	1	23	-23	44	79	42	-47	93	70	-66	-38	-30	31	178
8	5	7/30/2011	2	1	1	3	1	-34	18	84	-92	67	72	130	111	52	86	33	46	573
9	1	7/25/2011	2	1	1	3	1	17	-13	76	50	75	72	-85	-40	51	-39	-27	-32	105
9	2	7/26/2011	2	1	1	3	1	52	39	-65	84	40	88	89	107	49	64	-33	-51	463
9	3	7/27/2011	2	2	1	3	1	22	12	70	70	72	28	52	-39	63	62	-29	70	453
9	4	7/30/2011	1	1	1	2	2	60	-16	85	70	67	36	43	77	26	29	-38	50	489
9	5	7/31/2011	1	3	2	2	2	63	14	70	-76	70	102	85	175	27	67	33	61	691
10	1	7/5/2011	1	3	1	2	2	27	-31	138	28	89	93	54	-70	66	43	-30	55	462
10	2	7/6/2011	1	1	1	3	1	37	28	-67	104	67	108	131	171	68	54	64	62	827
10	3	7/23/2011	1	1	1	3	1	40	20	88	88	78	51	148	83	83	-37	38	70	750

SUBJECT #	TEST #	DATE TAKEN	# OF CONSECUTIVE SHIFTS	# CALLS > 2200 HRS.	# CALLS > 1 HR.	HOURS OF SLEEP PER NIGHT	HOW TIRED	GEN. PROB SOLVING #1	GENERAL PROB. SOLVING #2	GENERAL PROB. SOLVING #3	GENERAL PROB. SOLVING #4	WORD RECALL # 5	WORD RECALL # 6	NAME/FACE #7	NAME/FACE #8	VIDEO MEMORY #9	VIDEO MEMORY #10	VIDEO MEMORY #11	VIDEO MEMORY #12	TOTAL SCORE
10	4	7/24/2011	2	3	2	3	1	33	28	32	26	44	-59	77	-171	-55	-28	56	93	76
10	5	7/25/2011	2	2	1	3	2	20	-24	76	-20	67	78	117	171	51	80	-32	56	640
11	1	7/6/2011	3	1	1	3	2	59	-33	152	-64	90	108	-60	-111	124	-89	111	85	372
11	2	7/7/2011	3	1	1	3	1	138	60	-161	-82	66	116	183	183	-101	56	101	116	675
11	3	7/8/2011	3	1	1	3	2	67	128	151	119	108	114	-245	-101	64	93	106	123	727
11	4	7/9/2011	3	1	1	3	2	83	-119	-45	119	-78	97	170	-139	-123	-123	123	86	51
11	5	7/23/2011	1	1	1	3	1	45	64	49	-69	81	139	186	241	111	169	77	106	1199
12	1	7/7/2011	2	1	1	3	1	62	60	104	138	70	67	131	123	101	86	80	62	1084
12	2	7/7/2011	2	1	1	3	1	93	56	-60	128	80	85	111	117	-53	-86	-89	45	427
12	3	7/8/2011	3	1	1	3	1	76	-93	-88	80	-49	70	-116	80	111	74	77	64	286
12	4	7/9/2011	3	1	1	3	1	46	-76	-52	151	-65	59	-77	131	-83	62	93	-62	127
12	5	7/10/2011	3	1	1	3	1	-37	-34	64	-98	78	97	-54	148	68	77	75	72	456
12	6	8/1/2011	1	1	1	3	1	-76	-63	48	126	88	-93	94	-101	-120	77	-41	77	16
12	7	8/2/2011	1	1	1	3	1	56	46	93	87	88	-69	-124	65	104	101	116	60	623
12	8	8/3/2011	2	1	1	3	1	52	-44	65	103	78	88	116	-193	60	89	62	107	583
13	1	7/6/2011	2	1	1	3	1	33	-44	93	-41	82	51	77	-56	62	68	42	-49	318
13	2	7/11/2011	1	1	1	3	1	98	-32	65	46	78	92	-116	130	-34	56	44	31	458
13	3	7/12/2011	1	2	1	3	2	56	21	-118	65	67	53	-124	80	107	45	-45	-101	106
13	4	7/18/2011	1	2	2	2	1	33	-36	60	29	-65	-40	86	68	45	-64	56	-40	132
13	5	7/19/2011	2	2	2	2	1	73	-40	26	-119	93	57	159	184	117	97	51	-106	592
13	6	7/20/2011	2	1	1	3	1	-67	-46	32	119	44	43	201	200	50	60	56	29	721
13	7	7/24/2011	1	3	2	2	2	51	26	40	-23	25	72	56	56	43	47	59	56	508
13	8	7/25/2011	2	2	2	2	2	47	-40	-40	41	59	-11	70	-431	-62	-537	-124	-83	-1111
13	9	7/26/2011	2	2	2	2	1	45	60	-24	88	75	61	-66	-60	68	80	53	38	418
14	1	7/8/2011	1	2	1	3	1	98	93	150	128	78	121	201	131	89	86	60	93	1328
14	2	7/9/2011	2	1	1	3	1	88	-42	62	119	81	81	68	89	77	86	89	64	862
14	3	7/10/2011	2	2	2	3	2	37	17	98	84	93	81	74	93	77	49	-60	89	732
14	4	7/12/2011	1	1	1	3	1	41	26	58	62	89	36	106	117	64	39	60	62	760
14	5	7/17/2011	1	1	1	3	1	47	-38	34	-99	51	96	203	171	130	86	66	93	840
14	6	7/18/2011	1	2	1	2	2	-99	46	27	98	78	81	124	107	76	83	-51	-45	525
14	7	8/1/2011	1	1	1	3	1	32	46	18	21	88	65	148	-142	78	80	50	53	537
14	8	8/2/2011	1	1	1	2	2	111	131	93	170	-48	33	107	89	37	101	53	-38	839
14	9	8/3/2011	2	2	1	3	2	76	39	26	64	99	44	94	-70	66	52	55	-43	502
15	1	7/5/2011	1	1	1	2	2	47	-41	120	39	93	82	75	83	107	82	60	62	809
15	2	7/31/2011	1	3	2	3	2	79	-47	-62	48	97	102	123	158	93	-70	111	-106	526
15	3	8/1/2011	2	1	1	3	2	62	-104	-44	93	93	114	201	106	139	-83	-52	89	614
15	4	8/2/2011	3	2	2	3	2	56	-47	111	138	72	102	106	-201	93	-68	60	77	499
15	5	8/3/2011	3	2	1	3	2	-67	33	34	-138	102	114	201	221	0	0	-50	93	543
15	6	8/5/2011	1	2	2	3	2	-64	60	44	63	99	102	77	183	89	66	77	-53	743
15	7	8/6/2011	2	1	1	1	2	-82	-49	46	52	70	-73	167	128	80	104	91	60	594

Figure 11. Computer test results by subject, test number, and scores on individual questions.

Figure 12: Mind Power Subjective Questions by Consecutive Shift

Shift	Variable	N	Mean	STD	Median	Q1	Q3	P Value 1st or 2nd Vs. 3rd or 4th	P Value 1st or 2nd Vs. 5 or More
1st or 2nd	call2200	53	1.4	0.63	1	1	2	0.496	0.324
	call1hr	53	1.26	0.49	1	1	1	0.823	0.639
	HRS_SLEEP	53	2.72	0.45	3	2	3	0.981	0.558
	TIRED	53	1.55	0.61	1	1	2	0.36	0.851
3rd or 4th	call2200	41	1.51	0.6	1	1	2		
	call1hr	41	1.27	0.45	1	1	2		
	HRS_SLEEP	41	2.71	0.51	3	2	3		
	TIRED	41	1.46	0.5	1	1	2		
≥5 shifts	call2200	11	1.55	0.69	1	1	2		
	call1hr	11	1.18	0.4	1	1	1		
	HRS_SLEEP	11	2.82	0.4	3	3	3		
	TIRED	11	1.55	0.52	2	1	2		

Figure 12. Test results by subjective questions, between # of consecutive shifts. Probability value (P Value) compared between the $1^{st}/2^{nd}$ and $3^{rd}/4^{th}$ shifts and between the $1^{st}/2^{nd}$ and ≥5 shifts.

Figure 13: Mind Power Test Scores by Consecutive Shift

Shift	Variable	N	Mean	STD	Median	Q1	Q3	P Value 1st or 2nd Vs. 3rd or 4th	P Value 1st or 2nd Vs. 5 or More
1st or 2nd Shift	GP1	53	38.74	53.64	51	32	62	0.905	0.706
	GP2	53	19.3	43.15	28	-25	48	0.285	0.168
	GP3	53	40.38	67.13	49	27	88	0.941	0.114
	FF4	53	63.96	69.26	84	48	104	0.811	0.078
	WORD5	53	70.81	41.35	78	61	97	0.764	0.01
	WORD6	53	59.98	56.85	78	49	97	0.412	0.588
	NAME7	53	69.79	101.8	94	53	131	0.057	0.344
	NAME8	53	116.77	74.06	123	80	171	0.045	0.167
	VID9	53	46.96	60.54	62	41	80	0.57	0.304
	VID10	53	57.36	58.62	68	50	85	0.361	0.151
	VID11	53	49.49	59.46	59	38	78	0.074	0.438
	VID12	53	21.79	61.87	51	-39	64	0.249	0.099
	TOTAL	53	655.34	277.39	624	482	837	0.708	0.046
3rd or 4th Shift	GP1	41	39.98	42.79	44	23	64		
	GP2	41	7.1	56.03	16	-36	45		
	GP3	41	39.34	58.93	44	23	77		
	FF4	41	60.27	68.1	84	41	98		
	WORD5	41	70.46	26.67	75	59	81		
	WORD6	41	50.02	57.13	70	43	86		
	NAME7	41	105.2	71.25	116	70	167		
	NAME8	41	70.95	131.13	106	68	160		
	VID9	41	54.27	54.54	68	51	80		
	VID10	41	41.17	103.73	64	52	83		
	VID11	41	25.05	62.85	46	-31	62		
	VID12	41	35.63	59.63	53	0	77		
	TOTAL	41	599.44	383.06	594	453	764		
5 or More Shifts	GP1	11	45	56.3	56	32	76		
	GP2	11	-6	81.34	-34	-76	60		
	GP3	11	4.45	98.84	30	-88	98		
	FF4	11	20	113.97	56	-98	119		
	WORD5	11	35.73	67.89	66	-49	81		
	WORD6	11	70.45	67.26	97	59	114		
	NAME7	11	36.91	154.43	105	-77	183		
	NAME8	11	65.36	145.68	131	-101	171		
	VID9	11	25.82	88.56	64	-83	101		
	VID10	11	18.36	78.19	56	-68	77		
	VID11	11	64	55.09	77	60	101		
	VID12	11	56.64	61.69	72	53	93		
	TOTAL	11	436.73	244.2	499	148	672		

Figure 13. Test results by test questions, between # of consecutive shifts. Probability value (P Value) compared between the $1^{st}/2^{nd}$ and $3^{rd}/4^{th}$ shifts and between the $1^{st}/2^{nd}$ and ≥5 shifts.

Figure 14: Mind Power Test Scores by Consecutive Shift (≥5 Shift Participants)

Shift	Variable	N	Mean	STD	Median	Q1	Q3	P Value 1st or 2nd Vs. 3rd or 4th	P Value 1st or 2nd Vs. 5 or More
1st or 2nd Shift	GP1	13	28.92	64.07	56	0	70	0.7478	0.5216
	GP2	13	25.23	46.33	46	15	60	0.2231	0.2693
	GP3	13	40.38	80.21	49	44	92	0.713	0.3106
	FF4	13	73.08	49.58	88	63	104	0.8578	0.085
	WORD5	13	79.46	31.65	88	59	99	0.4325	0.0197
	WORD6	13	35.62	84.35	51	-56	102	0.421	0.2427
	NAME7	13	75.23	94.43	94	68	123	0.3082	0.4019
	NAME8	13	120.46	92.37	123	68	183	0.1716	0.2805
	VID9	13	37.69	88.32	77	41	93	0.4853	0.7208
	VID10	13	69.38	66.98	77	64	101	0.4631	0.0868
	VID11	13	44.46	63.98	77	-31	86	0.1803	0.4605
	VID12	13	10	69.59	27	-53	64	0.1575	0.1452
	TOTAL	13	639.92	327.14	623	482	798	0.848	0.0565
3rd or 4th Shift	GP1	12	36.17	59.16	49	16	84.5		
	GP2	12	-8.17	63.24	-10	-53.5	47		
	GP3	12	27.75	75.92	39.5	-35.5	57		
	FF4	12	78.33	36.63	77	51.5	103.5		
	WORD5	12	59.67	38.92	68.5	41.5	86.5		
	WORD6	12	58.92	58.17	72.5	51.5	90.5		
	NAME7	12	113.67	76.89	120	81.5	170.5		
	NAME8	12	51.83	127.56	93	48.5	116.5		
	VID9	12	60.42	60.93	74.5	55	93.5		
	VID10	12	48.17	66.15	65.5	39	87.5		
	VID11	12	9.42	70.5	34.5	-47	65		
	VID12	12	42.25	59.1	52.5	-12.5	95		
	TOTAL	12	578.42	250.73	543.5	417	606.5		
5 or More Shifts	GP1	11	45	56.3	56	32	76		
	GP2	11	-6	81.34	-34	-76	60		
	GP3	11	4.45	98.84	30	-88	98		
	FF4	11	20	113.97	56	-98	119		
	WORD5	11	35.73	67.89	66	-49	81		
	WORD6	11	70.45	67.26	97	59	114		
	NAME7	11	36.91	154.43	105	-77	183		
	NAME8	11	65.36	145.68	131	-101	171		
	VID9	11	25.82	88.56	64	-83	101		
	VID10	11	18.36	78.19	56	-68	77		
	VID11	11	64	55.09	77	60	101		
	VID12	11	56.64	61.69	72	53	93		
	TOTAL	11	436.73	244.2	499	148	672		

Figure 14. Test results by test questions (participants of ≥5 shifts), between # of consecutive shifts. Probability value (P Value) compared between the $1^{st}/2^{nd}$ and $3^{rd}/4^{th}$ shifts and between the $1^{st}/2^{nd}$ and ≥5 shifts.