Sleep Study/Alternative Schedule

LT Brandon Howard
Sleep Study Objectives

- Examine the current literature
- Analyze raw data from internal partners
- Sleep and schedule survey of FFs
- Identify internal areas of opportunity

Survey (86% Response Rate)
Stakeholder Considerations

Fire Chief: < 56 hours/week for FFs

Union: hours worked

Citizens: Overall cost, impact to service

Firefighters: Impact on family, commuting, new schedule

Divisions: adverse events
Sleep
The Importance of Sleep

• Humans ideally need 7-10 hours of sleep\(^1\)
  • Minimum of 6 hours
  • Quality and quantity matter

• Circadian rhythm\(^2\)
  • Disruptions
  • Sleep cycle 1-5 stages, 4-6 per night
  • Common Sleep Cycle (90-110 minutes)

• Sleep Debt
Survey Results: Sleep

• Sleep Disorders
  • 10% of SMFR FF’s reported
  • 37% nationally

• At SMFR, contributing factors to sleep debt
  • 82% of FFs wake up between 0400-0530 to come to work
  • 60% of FFs commute 15-45 minutes average
  • 68% of FFs stated they wake up to calls that their unit is not assigned to
Hours of Sleep Off-Duty vs. On-Duty

5% FFs under 6 hours

52% FFs under 6 hours
Summary of Sleep

• Drastic difference from on-duty vs. off-duty hours slept

• SMFR could based on the Literature:
  • Look at instituting a sleep disorder screening
  • Create ways to limit sleep debt in FFs
  • Investigate issues resulting in sleep loss other than call volume
  • Start time impact
Shift Work
Shift Work

• Call volume increasing year over year
  • 2020 = 41,225 vs. 2025 = 43,200 (SMFR Data Analysis)

• Night calls drastically impact sleep
On-duty return to sleep after a night-call

- 0-15 min: 14% (26% of total)
- 16-30 min: 26% (52% of total)
- 31-45 min: 28% (56% of total)
- 46-60 min: 23% (46% of total)
- 61+ min: 10% (20% of total)

Total: 100%
**Call Volume**

- **Total Calls per Year**:
  - Station 21: 1.48 calls per night average
  - Station 11: 1.25 calls per night average
  - Station 12: 1.04 calls per night average
  - Total Night calls (2200-0600): 0.12 calls per night average

**Graph Details**:
- **Y-axis**: Calls per Year
- **X-axis**: Station
- **Legend**:
  - Blue bars for Total Calls
  - Orange bars for Total Night calls (2200-0600)
Summary of Shift Work

- Large variations between busiest and slowest stations
- Most FFs are impacted if there is a night call
Firefighter Injury and Wellness
FFs are 37% more likely to have sleep disorder

Those with sleep disorders are TWICE as likely to have a MVA

SMFR FFs have to commute to work

Denver possibly less affordable

Being sleep deprived for 24 hours = .10 ETOH

SMFR’s in-house Wellness program is effective at a drastic reduction in long-term injuries

Continue to leverage Wellness resources
Results Firefighter Injury and Wellness

175 FFs stated sleep deprivation has affected their drive home (35%)

SMFR had 93 MVAs involving fire apparatus and medic units in a 1½ year time period.

In 2020 we had 69 on-duty workers comp claims by SMFR FFs

11 FFs stated they had a MVA when driving home after shift (2%)

More accidents first 24 hours

50/50 split on shift
Summary of Firefighter Injury and Wellness

• SMFR ≠ National Trends

• Off duty behavior could be investigated
  • Education on sleep hygiene
  • Best practices to prepare for work

• Sleep deprivation = largest concern for FF MVAs
  • Units out of service to sleep

• More accidents on day 1 of 48-hour shift
  • Additional investigation into accidents could occur
Fleet Data

- From 1/4/19– 5/12/21 SMFR had 93 MVA involving apparatus
- 45% of accidents occurred on the way to calls
  - This included emergent and non-emergent responses
• 20% of accidents occurred at the station
Wellness Data

- 33 (48%) of injuries involved the torso or upper extremities
Wellness Survey Results

Workouts on-duty

- 91% of FFs responded that they workout on day 1 of shift.
- 86% of FFs workout on day 2 of shift.

Wellness and Employee services is now offering “better together” workouts at the stations

- Goal is to improve crew fitness
- Group workouts with a cognitive training
EMS Data

EMS study from January 1\textsuperscript{st} – March 31\textsuperscript{st} 2021

Occurrences- Protocol violation, inter-agency relationship issue, medication errors

- Self reported or outside reported
  - 18 occurrences, 50\% split

QM errors

- Found through 3\textsuperscript{rd} party dictation group
  - 657 errors, 57\% on 1\textsuperscript{st} day
Physiological Risk
Physiological Risk

• Cardiac heart disease = #1 killer of FFs
  \[\text{7}\]

• 56 hours/week \uparrow \uparrow \text{cardiac heart disease and stroke (males)}
  \[\text{8}\]

• Exposure risks
  \[\text{9}\]

• \textit{Sleep debt is the new FF cancer}
  \[\text{1}\]

• Sleeping 6 or less hours/night \uparrow \text{cancer risk by 40%}
  \[\text{1}\]

• Sleep deprived FFs attempt to stay awake for off-duty responsibilities
  \[\text{10}\]
Naps and Caffeine
Naps

• Naps are paramount when sleep cannot be guaranteed\textsuperscript{10}

• The fire service has been very slow to adapt
  • Promote naps
  • Up to 45-minutes improves alertness and cognitive performance\textsuperscript{10}

• Time is a rare commodity\textsuperscript{11}
  • Station tours, engine demos, certifications, pre-plans, calls, cooking, etc.
  • Decrease in training or public events
Caffeine

- Caffeine should be a **secondary option** to napping

- Caffeine provides a physical and mental stimulation \(^{12}\)

- 100mg-600mg of caffeine helps maintain cognitive ability even during times of heavy sleep deprivation \(^{12}\)
  - Negative effects \(^{13}\)
  - Not a replacement for sleep
Survey Results of Naps

**SURVEY DATA: NAPPING**

- % Allowed to Nap
- % Who Napped

<table>
<thead>
<tr>
<th>Day 1</th>
<th>Day 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>71</td>
<td>89</td>
</tr>
<tr>
<td>51</td>
<td>71</td>
</tr>
</tbody>
</table>
Summary Naps and Caffeine

• SMFR could change culture around naps

• SMFR could offer education surrounding naps and caffeine

• SMFR could seek a reduction in workload (certifications, public education, pre-plans, etc.)

• Caffeine is a short-term fix, quality sleep and naps are the long-term goals
Schedule
Schedule

• Survey Schedule options were:
  • Seattle
  • Denver (K)
  • 48/96
  • Denver 24/48
  • Kelly schedule
Kelly Day:
Kelly Days are mandatory days off within a firefighter’s schedule.

Debit Day:
An additional day each month that you will be regularly scheduled to work to facilitate a D-shift.
## August 2021

<table>
<thead>
<tr>
<th>Sunday</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
<td>19</td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>22</td>
<td>23</td>
<td>24</td>
<td>25</td>
<td>26</td>
<td>27</td>
<td>28</td>
</tr>
<tr>
<td>29</td>
<td>30</td>
<td>31</td>
<td></td>
<td>48/96</td>
<td>48/96</td>
<td>48/96</td>
</tr>
</tbody>
</table>

www.calendaroptions.com
Schedule

- Sleep quality and quantity should drive discussion \(^{14}\)

- Statistically very little difference between 24/48 and 48/96 \(^{14}\)
  - Both resulted in 73% FFs rating poor quality sleep
  - Sufficient time between shifts is necessary to restore circadian rhythm
  - At least 2 but as many as 4 days could be needed to recover

- Family well-being rated as #1 factor \(^{15}\)
  - 24/48 FF active in family only 33% of time
  - Impact on family could be considered
Night calls impact on sleep deprivation

1 call = mild sleep deprivation
2 calls = moderate sleep deprivation
3 calls = severe sleep deprivation
Frequency of 3+ night calls

<table>
<thead>
<tr>
<th>Unit</th>
<th>A Shift</th>
<th>B Shift</th>
<th>C Shift</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine 21</td>
<td>2019</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>Medic 32</td>
<td>2019</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>Engine 33</td>
<td>2019</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>E19, E39, E47</td>
<td>2019</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
Call Volume

1.48 1.25 1.04

.12 calls per night average

Calls per Year

Station

Total Calls

Total Night calls (2200-0600)
Schedule 24/48

Work/Rest ratio = key to quality sleep\textsuperscript{10}

1-2 consecutive nights is \textbf{MINIMUM} recovery time after working 24 hours\textsuperscript{10}

May not allow 2 quality nights of sleep at home

OT/Trades may cause a 48-hour shift and then only allow one rest day
Work/Rest ratio = key to quality sleep

- Allows 4 recovery days after every shift
- Working 48 hours may cause severe sleep deprivation if a FF can’t sleep or nap
- Overtime on a 48/96 may cause a 72-hour shift or interrupted recovery days
SMFR (Seattle) Schedule

Work/Rest ratio = key to quality sleep

- Allows 4 recovery days every other shift
- Best work/rest cycle of the shifts currently being evaluated
- More opportunities to work overtime/trades and not be on a 48-hour shift
Schedule

• Shift start time
  • Research has shown an early start time for shift work is detrimental to employee health \(^{11}\)

• 3 negative factors with early start times \(^{16}\)
  - Reduce sleep before work
  - Increase risk of errors and accidents
  - Increase morning fatigue
• Shift start time by preference
  • **0800 60%**
  • **0900 41%**
  • 1000 33%
  • 1100 26%
  • 0700 26%
• Shift schedule preferences by shift *
  • **Seattle schedule** 98%
  • 48/96 schedule 66%
  • Denver with a Kelly day 13%

* Indicates percentage of respondents based on those who supported a shift change
Years Worked in a Career (46 hour/wk baseline)

- Seattle (46h): 47,840 Hours
- Denver (K) (48h): 49,920 Hours
- 48/96 (56h): 87,360 Hours

Total Hours:
- 47,840 Hours
- 49,920 Hours
- 58,240 Hours
- 71,760 Hours
- 74,880 Hours
- 87,360 Hours
Summary of Schedule

• On a 48/96
  • Longer shifts can cause worse sleep deprivation
  • 56 Hour work week
  • Longer time away from family during shift
  • OT/Mando and trades could cause imbalance of work/rest cycles

• On a 24/48
  • Limited days off could make it difficult to achieve full sleep recovery
  • 48 Hour work week
  • Family well-being is diminished
  • OT/Mando and trades could cause imbalance of work/rest cycles

• Only 13% of SMFR membership supports a 24/48 schedule
Summary of Schedule

- On a SMFR (Seattle) Schedule
  - Four days of recovery after every other shift
  - 48 Hour work week
  - Best work/rest cycle
  - More opportunity for trades/overtime
  - 98% of the membership support this shift
<table>
<thead>
<tr>
<th>Schedule</th>
<th>4 Days of Recovery</th>
<th>48-hour Work Week</th>
<th>Firefighter Preference</th>
<th>Meets Goal of Chief</th>
<th>Not Requiring addition FTEs</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMFR (Seattle)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>48/96</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Denver</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
</tr>
</tbody>
</table>
Summary of Start Time

• Move start time back to decrease sleep deprivation, errors, and fatigue

• SMFR membership supports a shift change time to later in the morning

• Our current start time was rated 5th by the membership in desirability
Limitations

• Limited sleep data on 24/48 (K) and Seattle

• Cross-sectional study

• Limited data analysis on survey data

• Survey was self-reported

• Internal data was limited
Considerations
Top 5 Considerations

Based on Literature, Internal Data, and Line Survey SMFR could:

1. Move to a shift that works as few hours as financially feasible
2. Identify schedule that maximizes sleep recovery
3. Change the shift start time to later in the morning
4. Change the culture of napping on-duty
5. Investigate opportunities to provide sleep disorder screenings for FFs
Questions?


References


References


The effects of shift work on firefighting: a literature review

Brandon T Howard

Introduction
Is shift work contributing to early death in career firefighters? Since the start of the fire service over 200 years ago, the job has changed drastically. In the early times of the fire service, volunteers were called by a local bell system in their communities, responding to fires and fires alone. As time progressed, the fire service added Emergency Medical Services (EMS) into its response policies. The United States has seen a drastic increase in EMS calls. In 1985, there were 5 million EMS calls; in 2010, there were 20 million calls (Peterson, 2016). After EMS, various other response specialties were established into the fire service, including hazardous materials response, wildland firefighting, technical rescue, dive rescue, and confined space. Due to this diversification, we have seen a rise in the number of career firefighters (National Fire Protection Association, 2021). The current generation of firefighters responds to more calls annually than any other time in history (Federal Emergency Management Agency, 2019). In response to this increase in call volume and diverse service demands, fire departments have moved to an all-hazard response model.

Ample research has linked the job demands of the fire service to an increased risk for cancer and cardiovascular disease (Billings & Focht, 2016; Daniels et al., 2014; Yang et al., 2013; Soteriades, Smith, Tsismenakis, Baur, & Kales, 2011; National Sleep Foundation, 2006). Specifically, it has been shown that firefighters working in environments of fire, heat, combustion, and smoke are at a higher risk of cancer and cardiovascular disease due to job exposure (Burke, 2017). To address these concerns, firefighter safety equipment has changed, health-conscious policies and procedures have improved, cultural beliefs are changing, and cancer prevention from combustion products is standard practice (Burke, 2017). However, one area that may be undervalued is sleep quality and quantity under the constraints of shiftwork. Is this generation of firefighters being lulled into a false sense of security that carcinogens are the only cancer-causing concern?

Commonly firefighters think staying awake, or loss of sleep is a badge of honor (Toomey & Toomey, 2018). Conversely, and although sleep is still in its infancy stage of being understood, it is well known that sleep is a biological necessity (National Sleep Foundation, 2016). Additionally, loss of sleep has been linked to a decline in mental and physical health and performance; examples include an increase in risk of cardiac disease (Pega et al., 2021), diabetes (Peterson, 2016), stroke (National Sleep Foundation, 2006), and cancer rates (Peterson, 2016) and more (Barger et al., 2015) Moreover, the longer one goes without sleep, the harsher its effects (Walker, 2016). Because shift work is an integral part of the fire service, a better understanding of how shift work and sleep can coexist is imperative to explore.

While many professions have moved away from shift work, firefighting has continued to implement shift schedules. Fire stations are staffed 24 hours a day, seven days a week. It is common for a firefighter to work at least 24 hours straight, and some departments have moved to 48-hour shifts (Brewer & Deschamp, 2006). Firefighters and the public have become accustomed to 24-hour availability to respond to every
[perceived] emergency (Geering, 2016), resulting in increased demand. Studies have attempted to find the ideal shift schedule, yet inherently there is not a one size fits all solution (Billings, 2016; Cohen, 2005; Knauth, 1996). However, efforts to improve the relationship between sleep quality and quantity regarding shift work schedules should continue to be investigated.

This paper synthesizes pertinent information about firefighting while working shiftwork as it pertains to sleep quality and quantity.

Methods
A literature review summarizes the critical information and theories around a given topic through books, scholarly articles, and other sources (Fink, 2019). Databases utilized in this review include JSTOR, EBSCO, Google Scholar, and the Colorado University of Denver Auraria Library. Search terms included shiftwork, shift work, shift schedule, firefighting, firefighter, sleep, sleep loss, sleep deprivation, and sleep quality. Because thousands of articles were found, search criteria were created to limit articles only involving firefighting. Inclusion criteria included human studies, firefighting, firefighters, English language, published between 1996 and 2021, and structural firefighting. Studies specific to wildland firefighting, organizational impacts and studies that minimally discussed shiftwork and firefighting were excluded.

Sleep
Sleep is a function of the circadian system (National Sleep Foundation, 2016). Humans are wired to wake in the mornings and then sleep at night to allow the body to recover from the day’s activities by working through the stages of sleep (Walker, 2017; Siegel, 2005). While a review of sleep is not the emphasis of this paper, general practices and research of sleep is needed to understand its impact on shiftwork. Consistent findings and literature suggest 7-10 hours of sleep is optimal for the healthy adult (LaMotte, 2019; Rosekind et al., 1996). Due to the high call volume in the fire service, interruptions in sleep cycle commonly occur causing decreased alertness, decreased performance, and increased fatigue (Rosekind et al., 1996). The nature of shiftwork as it pertains to the firefighting profession leads to unpredictable disruptions of the sleep cycle and sleep debt.

Sleep debt refers to sleep loss as a cumulative issue (Miller, 2012; Rosekind et al., 1996). Research shows that if an individual slept only six hours per night for five days, they would have accumulated 10 hours of sleep debt. By looking at overall cumulative sleep (i.e. not only on a nightly basis), Rosekind et al. (1996) found the long-term effects of sleep debt included uncontrolled sleep episodes, decreased performance, and increased sleepiness. Additionally, the study found that people who lose sleep during the week will sleep in on weekends in effort to reduce sleep debt (Rosekind et al., 1996). Miller and Rucas (2012) found that more sleep is linked to decreased impulsivity. Furthermore, they proposed that firefighters are at a high risk for sleep loss as shift work makes it borderline impossible to have a predictable night sleep (Miller & Rucas, 2012).

Firefighter Vehicular Injury & Accidents
Multiple studies have found that firefighters are at 37% higher risk for having a sleep disorder when compared to the general population (Sullivan, et al., 2017; Bakalar 2014). Further, those firefighters who have a sleep disorder are twice as likely to get into a vehicle accident due to sleep loss (Czeisler, Barger, & O’Brein, 2019; Bakalar 2014). Firefighters commuting more often, due to varying shift schedules, are inherently
at additional risk (Brewer & Deschamp, 2006). Other studies have found that being sleep deprived for 24 hours can lead individuals to respond as though they are intoxicated (Grossman 2007; Brewer & Deschamp, 2006; Rosekind & Gander, 1996). Sleep deprivation that results from a busy 24-hour shift are comparable to an individual performing with a blood alcohol content of 0.10% (Dawson & Reid, 1997). A possible solution to these issues has been to educate those working in the fire service on effective sleep hygiene tactics (Peterson, 2016). One of the most extensive studies on firefighters and sleep disorders found that simply offering sleep disorder screenings and having an in-house wellness program drastically decreased injuries and work loss (Sullivan et al., 2017).

Physiological Risk
Cardiovascular health and risk have been studied in regard to shift work (National Sleep Foundation, 2016) and primarily focus on the long-term adverse effects of shift work (Billings & Focht, 2016). The World Health Organization (2021) published a report that stated working at least 55 hours a week can lead to a 17% increase in ischemic heart disease and a 35% increase in stroke risk. Another study found that firefighters working 24-hour shifts have an increased diastolic blood pressure increase of 5.0mmHg (Wolcow et al., 2015). Any increase in blood pressure can indicate possible hypertension, which can contribute to several cardiac diseases (Nor et al., 2019). Yang et al. (2013) found cardiac heart disease is the top contributor to early death in firefighters. Further, they acknowledged past research in identifying cardiac arrest as the top killer of US firefighters. Roughly 45% of all deaths among on-duty firefighters are cardiovascular in nature (Soteriades, Smith, Tsismenakis, Baur, & Kales, 2011). Moreover, the National Fire Protection Association (2018) reports that 92% of the fire service is male. This is particularly relevant as the World Health Organization’s report (2021) concluded that almost three-quarters of those affected with heart disease and stroke were male. Thus, sleep loss due to shift work in the fire service must be accounted for in understanding the cardiovascular health of firefighters.

Cancer
Members of the fire service experience exposure risks that the general public does not including diesel exhaust, chemical flame retardants, and synthetic toxins (Burke, 2017). A longitudinal study concluded that firefighters are at an increased risk of cancer due to the nature of their work (Daniels et al., 2014). The study also found that asbestos is a significant contributor to cancer in firefighters (Daniels et al., 2014). Interestingly, research also suggests that sleep loss is having a direct impact on cancer rates (Walker, 2017; Rosekind et al., 1996). Walker (2017) found that simply sleeping six or fewer hours per night can increase cancer risk by 40%. Inherently, the fire service is confronted with unpredictable night calls resulting in uncertainty regarding their sleep. Another reality worth noting is that once a firefighter is off-duty, responsibilities such as child-care, second jobs, and attempts to return to regular daytime schedules hinder their ability to recover (Rosekind et al., 1996). For the off-duty sleep-deprived firefighter, this can cause an issue for their circadian clock and harm their sleep cycle (Rosekind et al., 1996). Therefore, a sufficient number of recovery days and prioritizing recovering are essential for the firefighters to reduce their sleep debt.

Naps/Caffeine
The fire service is in desperate need of adopting naps into its culture. Naps have
been shown to drastically improve alertness (Rosekind et al., 1996). Ideal nap length has been identified to be less than 45 minutes or approximately 2 hours to allow for completion of one full sleep cycle (~2-2.5 hours; Rosekind et al., 1996). A possible solution to busy firehouses is to decrease training or public events and allow crews to nap on duty (Peterson, 2016). Firefighters provide many services to the public from inspections, public educations, running calls, and station tours. By decreasing such demands and allowing time for naps, this could provide a simple solution to a complex problem. If napping is not an option for the extremely busy firehouse, an alternative is caffeine.

Caffeine consumption results in increased alertness as well as physical and cognitive performance (McLellan, Bell, Lieberman, & Kamimori, 2004). Further, research shows that doses ranging from 100mg to 600mg helps maintain cognitive performance even in the heavily sleep-deprived individual (McLellan, Bell, Lieberman, & Kamimori, 2004). Another study cautioned that caffeine’s benefits come with the downside of disrupting sleep cycles (LaJambe, Kamimori, Belenky, & Balkin, 2005). Consuming caffeine can disrupt an individual’s sleep cycle and, when frequent, can have lasting effects. LaJambe, Kamimori, Belenky, and Balkin (2005) concluded that caffeine can be used as a positive tool to combat sleepiness. However, it is paramount that regular sleep cycles should resume as soon as feasible (LaJambe, Kamimori, Belenky, & Balkin, 2005). The use of naps and timely caffeine consumption can effectively mitigate the negative effects of an irregular sleep cycle in the short term.

Schedule
Currently, there are many shift variances being used in fire departments across the country. Two common schedules are the 24/48 and 48/96 (Choi et al., 2014). A 24/48 schedule means that a firefighter works a 24-hour shift and then takes 48 hours off. This schedule repeats itself and accumulates a total of 48 hours/week. A 48/96 schedule means that a firefighter works a 48-hour shift and then takes 96 hours off. Similarly, this schedule repeats itself and accumulates a total of 56 hours/week. When exploring shift schedules, the number one concern is the firefighter’s sleep quality and quantity (Billings & Focht, 2016). Billings and Focht (2016) found very little statistical difference between working a 24/48 and a 48/96 schedule. Notably, both schedules led to 73% of their surveyed firefighters reporting poor sleep quality, scoring 6 or above on a Pittsburgh Sleep Quality Index. (Billings & Focht, 2016). The authors suggest that shorter shifts and more days off between shifts could offer the best chances for quality sleep (Billings & Focht, 2016). An additional review found that family wellbeing was the most significant determinant in schedule preference (Koen, 2005). Koen (2005) defined family well-being as a firefighter being fully present and active with the family. The firefighter working a 24/48 reported only being active with their family one out of every three nights (33%) while the firefighter working a 48/96 was active three out of six nights per week (50%; Koen, 2005).

Night calls, defined as a call between 2200-0600, have been shown to have a significant impact on sleep quality in the fire service (Koen, 2005). Koen (2005) concluded that if a firefighter wakes up once for a night call, they would have only mild sleep deprivation. If two night calls occur, the firefighter will be moderately deprived of sleep and encouraged to nap. Further, a firefighter could work an additional 24-hour shift (48 hours total) with two night calls
and perform sufficiently. Finally, if a firefighter has three night calls in 24 hours, they should not work another 24-hour shift as these individuals would be suffering from severe sleep deprivation. Work rest ratios are essential when it comes to shift work. To recover from sleep debt, a firefighter needs one to two consecutive nights of unrestricted sleep (Rosekind et al., 1996). Working a 24/48 schedule does not allow two consecutive nights of unrestricted sleep as the second night is typically interrupted by firefighters waking up early and commuting to work. Most fire departments across the county have shift change around 0700. Peterson (2016) concluded that later start times allow firefighters to obtain more quality sleep at home. Knauth (1996) determined early start times were linked to reduced sleep before work, increased morning fatigue, and increased risk of errors and accidents. Conclusively, start time and shift schedules should be considered as two interrelated factors when discussing overall sleep quality and quantity.

Discussion
To date, most studies focus solely on 24/48 and 48/96-hour shifts (Billings et al., 2016). Particularly, future research will be needed in the following areas: rest vs. work cycles, sleep deprivation on different shift schedules, and the importance of recovery days between shifts. Recovery days are vital, as research shows decreased sleep quality and quantity is related to decreased alertness, cognitive and physical performance (Rosekind et al., 1996). The World Health Organization (2021) reported that approximately 75% of those affected by stroke and heart disease were male. While men account for 92% of career firefighters (National Fire Protection Association, 2018), further research is needed to determine if these same effects are seen in female firefighters (Yun et al., 2015).

Serious consideration should be placed on how different shifts affect work/family life, rest and recovery days, and sleep deprivation (Koen, 2015). Some of these findings could be utilized in other fields like nursing, police, EMS, and other 24-hour emergency services. Additionally, individuals who sleep fewer than four hours have a suicide rate 3.5 times more than those who sleep six to eight hours a day (Emet et al., 2016). Future investigations should continue to explore the possible connections between suicide and sleep, especially in relation to the fire service. Due to the number of firefighters dying of cardiac disease, stroke, suicide, and other mental or physical health issues which may be linked to sleep quality and quantity, education and prevention training across the fire service is essential.

Conclusion
This literature review is an in-depth look at how shiftwork impacts firefighter’s physical and mental health specifically related to sleep. Most of the research has analyzed the impact of environmental hazards on firefighters’ health. Until recently, there has been limited research on the impact of sleep quality and quantity on the fire service. Notably, Walker (2017) identified that sleep quality and quantity is the missing link to firefighters’ health. Career firefighters would benefit from frequent screenings for sleep disorders, heart disease, and diabetes (Sullivan et al., 2017). Access and education on sleep quality and quantity is vital to increase positive outcomes for firefighters. This review identified a gap in the research with regards to sleep quality and quantity as it pertains to shift work.
Disclosure
The author has confirmed that all authors meet the ICMJE criteria for authorship credit as follows: (1) substantial contribution to conception and design of, or acquisition of data or analysis and interpretation of data, (2) drafting the article or revising it critically for important intellectual content and (3) final approval of the version to be published.

Funding
The were no funding sources for this paper.
References


<table>
<thead>
<tr>
<th>Situation</th>
<th>Solution</th>
<th>Inputs</th>
<th>Activities</th>
<th>Outputs</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long shift hours and insufficient sleep recovery have led to an increase in cancer and other adverse health effects. Working 56 hours per week has been identified as a significant harm to firefighter health.</td>
<td>Change shift length and frequency of shifts worked by firefighters whom South Metro Fire Rescue employs to reduce the possibility of adverse health effects. This should be achieved by moving to the “D-shift” type schedule, which drastically decreases the number of shifts worked.</td>
<td>-Hiring upwards of 67 FTEs</td>
<td>-Organize educational opportunities for the public, Board of directors, union members, and Fire Chief</td>
<td>-Firefighters work roughly 17 days less per year</td>
<td>-Successful change to the “D-shift” type schedule</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Board of Directors will need to approve funding</td>
<td>-Citizens will need to approve a possible mill levy increase</td>
<td>-Over an average career, “D-shift” type schedules decrease the workload on firefighters by 7 years (over a 30-year career)</td>
<td>-Adverse events decrease on-duty</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Citizens will need to approve a possible mill levy increase</td>
<td>-Canvas for funding from citizens</td>
<td>-Firefighters work only one-night max consecutively (scheduled)</td>
<td>-Sleep deprivation decreases in firefighters</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Large amount of staff time and resources</td>
<td>-Survey current line firefighters</td>
<td></td>
<td>-Quality of life increases for firefighters</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-Literature review</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Assumptions**
- High community support from citizens
- Mill Levies typically pass
- Support of the Fire Chief
- Firefighter and Union support

**External Factors**
- Funding
- COVID-19
- Reduced reserve capital
SMFR Sleep and Alternative Schedule Survey

499 Responses
21:34 Average time to complete
Closed Status
1. South Metro Fire Rescue Informed Consent to Participate in Research Study title: Sleep Study/Schedule Change Researcher[s]: Brandon Howard/B.A /Employee Services, Nick Bartley/M.A/Employee Services We are inviting you to take a survey for research. This survey is entirely voluntary. There are no negative consequences if you do not want to take it. If you start the survey, you can always change your mind and stop at any time. What is the purpose of this study? We want to understand how firefighters at SMFR think shift schedules affect sleep quality. Moreover, to learn whether there is a connection between firefighting and sleep quality/quantity. Further, we hope to understand sleep on-duty vs. off-duty. This survey/data will help guide and inform a possible shift schedule change at SMFR. What will I do? This survey will ask questions about your sleep on and off duty, how you rate your sleep, and things you do to improve sleep. The survey includes questions about your sleep patterns, your daily habits, and how a career in the fire service has affected your sleep. The survey will take approx. 10-15 minutes.

Risks • Some questions may be personal or upsetting. You can skip them or quit the survey at any time. • Online data being hacked or intercepted: Anytime you share information online, there are risks. We are using a secure system to collect this data, but we cannot completely eliminate this risk. • Breach of confidentiality: There is a chance your data could be seen by someone who should not have access to it. We are minimizing this risk in the following ways: o Data is anonymous. *Brandon Howard and Nick Bartley will be the only individuals who have access to your individual responses. o We will store all electronic data on a password-protected, encrypted computer. o We will keep your identifying information separate from your research data. However, we will be able to link it to you. We will destroy this link after we finish collecting and analyzing the data. Possible benefits: SMFR will use the deidentified data collected to help inform a possible shift change and cultural changes.

Estimated number of participants: The hope is to have 70% or more of active line firefighters take this survey. How long will it take? 10-15 minutes Costs: None Compensation: None Confidentiality and Data Security We will collect the following identifying information for the research: Your name, email address. This information is necessary to confirm that you work at SMFR. Only active FF can complete the survey. Questions about the research, complaints, or problems: Contact Brandon Howard at Brandon.howard@southmetro.org or (720)989-2000 Questions about your rights as a research participant, complaints, or problems: Contact Brandon Howard at Brandon.howard@southmetro.org or (720)989-2000 Please print or save this screen if you want to be able to access the information later. Agreement to Participate Your participation is entirely voluntary, and you can withdraw at any time. To take this survey, you must be: • At least 18 years old • Active firefighter for SMFR If you meet these criteria and would like to take the survey, click the button below to start. If you decline the survey please hit "End Survey"
2. How old are you?

- Less than or 29 years old: 71
- 30-39 years old: 165
- 40-49 years old: 149
- 50-59 years old: 108
- 60+ years old: 5

3. Please choose your current marital status:

- Single: 88
- Married: 375
- Divorced: 34
- Widowed: 1

4. Please choose your current sleeping situation

- Sleep alone: 86
- With a bed partner: 430
- With pets: 97
- With children: 24

5. Which apparatus are you predominately assigned to?

- Medic Unit: 131
- Fire Apparatus: 337
- DC/BC/Safety: 30
6. Are you a rover?

- Yes: 112
- No: 386

7. On average, how often do you rove per month?

- Once per month: 8
- 2 Times per month: 6
- 3 Times per month: 18
- 4 Times per month: 16
- Every shift: 63

8. Can you "act" in position other than your current job description?

- Yes: 65
- No: 432

9. On average, how often do you act per month?

- Once per month: 29
- 2 Times per month: 9
- 3 Times per month: 6
- 4 Times per month: 13
- Every shift: 7
10. Do you currently track your sleep?

- YES: 115
- No: 383

11. How do you track your sleep? (ex: WHOOP, Oura Ring, Sleep journaling, mobile application, etc.)

115
Responses

12. Do you have a second job?

- Yes: 103
- No: 394

13. How many hours per week do you work at your second job, on average?

102
Responses

14. How do you think the risk of sleep disorders compares between firefighter and the general public?

- Higher Risk: 438
- Same Risk: 55
- Lower Risk: 4
15. How likely are you to doze off or fall asleep in the following situations?

- Very unlikely
- Somewhat unlikely
- Somewhat likely
- Very likely
- Neither likely nor unlikely

**Situation**

- Sitting and reading: 70% Very likely, 30% Neither likely nor unlikely
- Watching TV: 50% Very likely, 50% Neither likely nor unlikely
- Sitting, inactive, in a public place: 60% Very likely, 40% Neither likely nor unlikely
- As a passenger in a car: 50% Very likely, 50% Neither likely nor unlikely
- Lying down to rest in the afternoon: 80% Very likely, 20% Neither likely nor unlikely
- Sitting and talking to someone: 40% Very likely, 60% Neither likely nor unlikely
- Sitting quietly after a lunch without alcohol: 60% Very likely, 40% Neither likely nor unlikely

16. Have you been diagnosed with a sleep disorder?

- Yes: 47 responses
- No: 451 responses

17. Which sleep disorder were you diagnosed with?

- 47 responses

Latest Responses
18. Have you ever had medical treatment for your sleep disorder?

- Yes: 38
- No: 9

19. If so, what was the medical treatment(s)?

38 Responses

20. Do you feel you have an undiagnosed sleep disorder?

- Yes: 67
- No: 430

21. Which undiagnosed sleep disorder do you believe you have?

64 Responses

Latest Responses

“Sleep apnea/snoring”

22. Have you ever utilized neurofeedback?

- Yes: 62
- No: 434
23. Has neurofeedback improved your quality of sleep?

- Yes: 49
- No: 13

24. On average, what time do you wake up to come to work?

- Before 0400: 15
- 0400-0430: 71
- 0431-0500: 122
- 0501-0530: 219
- 0531-0600: 63
- 0600-0630: 8
- After 0630: 0

25. On average, how long is your commute to work?

- 0-15 minutes: 90
- 16-30 minutes: 187
- 31-45 minutes: 115
- 46-60 mins: 47
- 1 hour - 1.5 hours: 48
- 1.5 hours to 2 hours: 8
- More than 2 hours: 3
26. Have you ever had a motor vehicle accident while driving home from working a set?

- Yes: 11
- No: 486

27. Has a lack of sleep affected your drive home?

- Yes: 175
- No: 322

28. Do you currently live within SMFR’s district?

- Yes: 176
- No: 322

29. Why do you choose not to live within the SMFR's district?

311 Responses

Latest Responses

- "Can't afford to"
- "Can't afford too."
- "Cost of living is too great, and personal choice"
30. While on duty, how many hours do you sleep per night, on average?

- Less than 1 hour: 0
- 1 hour: 0
- 2 hours: 3
- 3 hours: 14
- 4 hours: 86
- 5 hours: 159
- 6 hours: 142
- 7 hours: 72
- 8 hours: 15
- 9+ hours: 1

31. While on duty, how long does it take you to fall asleep per night, on average?

- 0-15 minutes: 121
- 16-30 minutes: 162
- 31-45 minutes: 110
- 46-60 minutes: 67
- 61+ minutes: 38

32. While on duty and there is NO night call, how many times per night do you wake up, on average?

- 0: 95
- 1: 158
- 2: 119
- 3: 83
- 4+: 43
33. While on duty, after returning from a night call, how long does it take you to fall back asleep, on average?

- 0-15 minutes: 68
- 16-30 minutes: 127
- 31-45 minutes: 137
- 46-60 minutes: 114
- 61+ minutes: 52

34. Does your station have the “First-In” alerting system in all bedrooms?

- Yes: 455
- No: 42

35. Do you feel like you wake up when another unit is toned to a call you are not assigned to?

- Yes: 340
- No: 156

36. While on duty, how many times have you slept through a calltone over your career?

- 0: 230
- 1: 115
- 2: 99
- 3: 31
- 4+: 23
37. While on duty, do you feel like you are allowed to nap on the 1st day of your set?

- Yes: 356
- No: 142

38. While on duty, do you ever nap on the 1st day of your set?

- Yes: 253
- No: 244

39. While on duty, do you typically workout on the 1st day of your set?

- Yes: 456
- No: 42

40. While on duty, when do you typically workout on the 1st day of your set?

- 0700 to 1400: 260
- 1400 to 1600: 170
- After 1600: 25
41. While on duty, do you feel like you are allowed to nap on the 2nd day of your set?

- Yes: 446
- No: 52

42. While on duty, do you ever nap on the 2nd day of your set?

- Yes: 360
- No: 138

43. While on duty, do you typically workout on the 2nd day of your set?

- Yes: 431
- No: 67

44. While on duty, when do you typically workout on the 2nd day of your set?

- 0700 to 1400: 273
- 1400 to 1600: 138
- After 1600: 19
45. While on duty, how long do you nap, on average?

- 45 minutes or less: 348
- 45 minutes to 1.5 hours: 121
- 1.5 hours to 2 hours: 6
- 2 hours to 2.5 hours: 1
- 2.5 hours or more: 0

46. Do you carry a radio during daytime hours (0700 - 1900)?

- Yes: 202
- No: 293

47. My position requires me to carry a radio during daytime hours (0700-1900)?

- Yes: 216
- No: 279

48. On average, how many times are you required to switch stations between the 1st day and 2nd day of a set per month?

- 0: 383
- 1: 60
- 2: 34
- 3: 15
- 4: 1
- 5: 3
49. Do you typically wake up early on the 2nd day of your set in anticipation of moving stations?

- Yes: 92
- No: 403

50. On average, approximately what time do you wake up on the 2nd day of your set?

- Before 0600: 96
- 0600-0700: 193
- 0700-0800: 188
- 0800-0900: 19
- After 0900: 2

51. On average, approximately what time do you wake up on the day you will be going off shift?

- 0400-0430: 3
- 0431-0500: 36
- 0501-0530: 207
- 0531-0600: 242
- 0601-0630: 10
- After 0630: 0
52. While on duty, how many caffeinated beverages do you consume daily?

- Caffeinated coffee (8 oz cup)
- Caffeinated tea (8 oz cup)
- Caffeinated soda (12 oz can)
- Energy drinks (8 oz can)
- High caffeinated energy drinks (16 oz can)
- Other energy supplements (1 oz shot)

53. Please rate your overall satisfaction with your on-duty sleep.

498 Responses
5.3 Average Number

54. While off duty, how many hours do you sleep per night, on average?
55. While off duty, how long does it take you to fall asleep, on average?

- 0-15 minutes: 239
- 16-30 minutes: 164
- 31-45 minutes: 63
- 45-60 minutes: 17
- More than 1 hour: 11

56. While off duty, how many times per night do you wake up, on average?

- 0: 140
- 1: 215
- 2: 89
- 3: 33
- 4+:

57. How many days would you estimate it takes you to recover after working a set (48 hours)?

- None: 55
- 1 day: 314
- 2 days: 89
- 3 days: 22
- 4 days: 6
- I never fully recover: 12

58. While off duty, do you normally wake before your alarm in the morning?

- Yes: 292
- No: 206
59. While off duty, do you wake up at the same time every day?

- Yes: 292
- No: 204

60. While off duty, do you typically use anything to help you sleep?

- Yes: 122
- No: 375

61. While off duty, please indicate the frequency of using any of the following to help you sleep:

- **Alcohol**
- **Over the counter medication**
- **Prescribed medication**
- **Mechanical device (CPAP, BiPAP, etc.)**
- **Other**
62. While off duty, how many caffeinated beverages do you consume daily?

- Caffeinated coffee (8 oz cup)
- Caffeinated tea (8 oz cup)
- Caffeinated soda (12 oz can)
- Energy drinks (8 oz can)
- High caffeinated energy drinks (16 oz can)
- Other energy supplements (1 oz shot)

63. Please rate your overall satisfaction with your off duty sleep.

496 Responses

Average Number 7.33

64. While off duty, do you typically workout?

- Yes 464
- No 32

65. While off duty, how many times do you workout, on average?

- 1 13
- 2 137
- 3 177
- 4 112
- 5 or more 25
66. Do you support a shift change away from the 48/96 schedule? If you select yes, you will be given the opportunity to select which shifts you’d like to change to.

- Yes: 342
- No: 153

67. Indicate your desirability for the following schedules.

- Kelly Schedule (24 on, 24 off, 24 on, 24 off, 24 on, 96 off)
- Denver Schedule with NO Kelly day (24 on, 48 off)
- Denver Schedule with Kelly day (Kelly day is a day off once per 21 days)
- Seattle Schedule (24 on, 48 off, 24 on, 96 off)
- 48/96 Schedule (48 hours on, 96 hours off)

68. Would you support a change to the start time of shift? If you select yes, you will be given the opportunity to select which start you’d like to change to.

- Yes: 277
- No: 218
69. Indicate your desirability for the following start times

![Bar chart showing desirability for different start times]

70. During your emergency service career, have you ever worked a schedule other than the 48/96 schedule?

![Pie chart showing responses]

- Yes: 391
- No: 103
71. Which schedule(s) did you work? Select all.

- Kelly schedule (24 on, 24 off, 2... 325
- Denver Schedule - No Kelly da... 36
- Denver Schedule with Kelly da... 12
- Seattle Schedule (24 on, 48 off... 4
- 10 - 14 Schedule (2 day shifts, ... 7
- Other 62

72. Which schedule did you prefer?

- 48/96 Schedule 280
- Kelly schedule (24 on, 24 off, 2... 22
- Denver Schedule - No Kelly da... 0
- Denver Schedule with Kelly da... 3
- Seattle Schedule (24 on, 48 off... 73
- 10 - 14 Schedule (2 day shifts, ... 0
- Other 10

73. Do you have any additional comments or concerns you wish to communicate to SMFR leadership?

314 Responses

Latest Responses

"While I appreciate that the Chief wants to help safeguard our overall ..."

"Over past 30+ years (that I “personally” know of), our pay has always..."

"I do not support the shift changing. It is not fiscally responsible for the..."