ASSOCIATION BETWEEN POOR SLEEP, FATIGUE, AND SAFETY OUTCOMES IN EMERGENCY MEDICAL SERVICES PROVIDERS

by

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University of Pittsburgh, 2012

Objective: To determine the association between poor sleep quality, fatigue, and self-reported safety outcomes among Emergency Medical Services (EMS) workers.

Methods: We used convenience sampling of EMS agencies and a cross-sectional survey design. We administered the 19-item Pittsburgh Sleep Quality Index (PSQI), 11-item Chalder Fatigue Questionnaire (CFQ), and 44-item EMS Safety Inventory (EMS-SI) to measure sleep quality, fatigue, and safety outcomes, respectively. We used a consensus process to develop the EMS-SI, which was designed to capture three composite measurements of EMS worker injury, medical errors and adverse events (AE), and safety-compromising behaviors. We used hierarchical logistic regression to test the association between poor sleep quality, fatigue, and three composite measures of EMS worker safety outcomes.

Results: We received 547 surveys from 30 EMS agencies (a 35.6% mean agency response rate). The mean PSQI score exceeded the benchmark for poor sleep (6.9, 95%CI 5.5, 7.2). Greater than half of respondents were classified as fatigued (55%, 95%CI 50.7, 59.3). Seventeen percent of respondents reported an injury (17.8%, 95%CI 13.5, 22.1), forty-one percent a medical error or AE (41.1%, 95%CI 36.8, 45.4), and 89% (95%CI 87, 92) safety compromising behaviors. After controlling for confounding, we identified 1.9 greater odds of injury, 2.2 greater odds of medical error or AE, and 3.7 greater odds of safety compromising behavior among fatigued respondents versus non-fatigued respondents.

Conclusions: In this sample of EMS workers, poor sleep quality and fatigue is common. We provide preliminary evidence of an association between sleep quality, fatigue, and safety outcomes.

Public Health Significance: Some level of EMS care covers every community in the U.S. Every minute of every day EMS workers transport 35 patients to hospital Emergency Departments (EDs). The health and safety of EMS workers may impact health and safety of the public – thereby making fatigue and sleep of EMS workers an issue of public health significance.

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PREFACE

On May 19, 2011, the editor of the Journal of Prehospital Emergency Care (PEC) provided his acknowledgement that portions of this Thesis are analogous to portions of a manuscript submitted to PEC on April 28, 2011.

Date: May 19, 2011; 12:34pm EDT

From: menegazzijj@upmc.edu

To: pattersond@upmc.edu

Daniel,

I acknowledge this, as you and I discussed this issue prior to your submission of the paper to PEC. From our perspective, this is not an issue of concern as we frequently have individuals submit manuscripts that are derived from theses and dissertations.

You have our permission, and this will not interfere with potential publication in PEC.

Sincerely,
Jim

James J. Menegazzi, PhD
Editor-in-Chief
Prehospital Emergency Care

1.0 INTRODUCTION

1.1 Emergency Medical Services

Every minute of every day Emergency Medical Services (EMS) workers transport 35 patients to hospital Emergency Departments (EDs).[1] Our nation's EMS systems respond to emergency and non-emergency events and serve as the de facto U.S. public health safety net.[2] The EMS system is often referred to as the 3rd level of public safety, following police protection and fire services.[3] Some level of EMS service covers every community across the U.S. The level of care and service provided varies across communities and is often based on socio-economic factors of the community served. Rural and frontier areas often lack resources to support advanced levels of EMS care and service.[4]

The modern EMS industry was founded in the mid-1960s in response to motor vehicle crashes on our nation's roadways.[5-7] The now seminal document, *Accidental Death and Disability: The Neglected Disease of Modern Society* stimulated a public and policy-level response to improve emergency care for victims of motor vehicle crashes.[5,6,8-10] A federal office of EMS was established in the 1970s within the Department of Health Education and Welfare (now U.S. Department of Health and Human Services) to provide guidance and technical assistance to EMS systems nationwide.[6] Prior to 1970, funeral homes and police departments provided the majority of EMS response.[6,8] The Omnibus Budget Reconciliation Act of 1981 eliminated the lead federal EMS agency and delegated authority for EMS to states and local governments.[8,10,11] Preferences of local populations and decision makers have shaped the development of EMS systems over the past 50 years to include a diverse collection of EMS delivery models. Today, EMS is delivered out of hospitals, fire departments, private not-for-profit organizations, large for profit consortiums, and stand-alone entities supported by local taxes (also known as third service models).

Numerous federal offices play a role in supporting small grant programs and initiatives to improve EMS care delivery.[12] The National Highway Traffic Safety Administration's (NHTSA) Office of EMS (OEMS) is widely viewed as the nation's leading federal authority in EMS. The OEMS provides technical assistance and support for state and local EMS officials. The OEMS also provides funding for the National EMS Information System (NEMSIS), a project designed to develop a national repository of EMS transports in the U.S.[13]

Several seminal documents that outline challenges and future directions for improving EMS nationwide have been developed with support from the NHTSA OEMS. The 1996 EMS Agenda for the Future was the first in a series of such documents that identified deficits in critical components of EMS care delivery.[14] These deficits include, but are not limited to, a lack of adequate medical oversight for EMS workers, lack of adequate financing, lack of research to support clinical procedures and operations, and lack of public education on what EMS is and does for the public.[14]

In 2010, the NHTSA OEMS funded a new initiative to develop a nationwide culture of safety strategy for EMS. This initiative safety in EMS was born from increased reports of ambulance crashes, EMS worker injury and death, medical errors and adverse events, the 1999 publication *To Err is Human* by the Institute of Medicine, and recommendations from the National EMS Advisory Council (NEMSAC).[15-20] Fatigue and sleep have emerged as widespread and potentially modifiable threats to patient and provider safety in EMS.[21-25]

1.2 Emergency Medical Technicians

The Emergency Medical Technician (EMT) is a health professional certified by a state and/or nationally accredited program. There are two main levels of EMT certification: the EMT-Basic and EMT-Paramedic. The EMT-Basic may deliver emergent or non-emergent care to stabilize a patient's airway, breathing, or circulation. In most areas, the EMT-B cannot deliver medication, establish Intravenous Access (IV), or use invasive procedures such as endotracheal intubation. The EMT-Basic education includes 110 hours of didactic and clinical instruction and training. Certification is granted following a standardized written examination and skills practicum administered by state officials.[26] The EMT-Paramedic is the advanced level of EMT capable of administering medications and use invasive procedures to stabilize patients. Common educational requirements for EMT-Paramedic certification include 1,000 to 1,300 hours of didactic and clinical education and training.[26] Less common levels of EMS certification include the EMT-Intermediate, First Responder, and Critical Care Paramedic. The National Registry of EMTs (NREMT) is the principle organization for certification in the U.S.

There is no uniform repository of all certified EMTs in the U.S. The NHTSA OEMS estimates that greater than 700,000 EMTs work full-time, part-time, or as a volunteer.[27] Studies of Nationally Registered EMTs determine that certified EMTs are mostly white, male, with a mean age of 35.[28] Most EMTs work as volunteers with the median compensation of $23,500 for paid EMT-Basics and $37,282 for paid EMT-Paramedics.[4,28] Health status indicators of EMTs include a mean Body Mass Index (BMI) of 27.7 kg/m^2 with 50% of female EMTs and 21% of male EMTs classified as normal weight.[29] Most (75.3%) of EMTs report they do not meet recommendations for physical activity and 34.7% report they currently smoke or are former smokers.[29] Rates of injury and occupational related mortality among EMTs exceed that of the general working public.[30,31] Exposure to violence and hazardous materials is common.[32-35] A recent study of 119 EMT-Basics and EMT-Paramedics determined that poor sleep quality was common and 44.5% were classified as severely fatigued while at work.[36]

1.3 Sleep Quality

Between 29% and 35% of adults do not receive adequate sleep (>7 hours per night).[37,38] Females and non-Hispanic African Americans are more likely to report insufficient sleep in previous 30 days than males and other racial groups.[37] The proportion of adults that report insufficient sleep decreases with age.[37] There is additional evidence that the proportion of adults with insufficient sleep varies by employment status, marital status, and educational attainment.[37]

Standards for measuring sleep quality are limited because what constitutes good or bad sleep quality varies between individuals.[39] The Pittsburgh Sleep Quality Index (PSQI) is a widely used survey tool for measuring subjective sleep quality across seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medications, and daytime dysfunction.[39] Sleep latency refers to the amount of time taken to fall asleep. Sleep duration refers to the total amount of sleep within a 24-hour period. School-aged children (6-12 years of age) may average 10-11 hours of total sleep while adults may average 7-8 hours within a 24-hour period.[40] Habitual sleep efficiency refers to the ratio of sleep time to time in bed. Sleep disturbances refers to frequency of disruption in sleep. Daytime dysfunction refers to sleepiness during daytime.[41]

Cross-sectional surveys are the most commonly used measurement methodologies for capturing sleep quality.[41] Polysomnography and clinical assessment are resource intensive, yet objective methods for diagnosing sleep quality. Poor sleep quality has been linked to poor health status, risk of psychiatric disorders, depression, and work performance (i.e. absenteeism).[42]

1.4 Fatigue

Fatigue is a condition distinct from sleep quality or sleepiness.[43] Fatigue has been referred to as an uncomfortable feeling associated with a lack of energy that may not be resolved by sleep.[43] Acute fatigue may occur in healthy individuals, be linked to a specific event (cause), and may dissipate or disappear with rest and sleep.[44] Chronic fatigue is defined as “self-reported persistent or relapsing fatigue lasting six or more consecutive months,” may not resolve with rest, and may not be associated with an acute event (i.e., physical exertion).[45]

Acute and chronic fatigue have been linked to performance among healthcare workers. Barker and Nussbaum studied 745 registered nurses and linked higher levels of mental and physical fatigue to decreased performance.[46] Josten and colleagues highlighted an inverse association between fatigue and performance.[47] Investigators linked higher (worse) fatigue to lower performance among nurses that worked ≥9 hour shifts compared to nurses that worked 8-hour shifts.[47] A recent study of medical residents determined higher rates of medical error among fatigued versus non fatigued.[48]

1.5 Rationale for this study

Poor sleep quality and fatigue among health care workers contributes to poor safety outcomes such as error and injury.[48] Annually, medical errors and adverse events (AE) affect hundreds of thousands of patients and contribute to as much as $28 billion in additional healthcare costs.[15] The World Health Organization (WHO) identified fatigue as a leading factor in medical error and injury in healthcare.[49] The Accreditation Council for Graduate Medical Education has twice recommended reductions in work time for medical trainees due in part to concerns about fatigue.[50] Little is known about the linkage between fatigue, sleep, and safety in Emergency Medical Services (EMS); a high-risk environment for patients and providers.

The risk of negative outcomes for the EMS worker and patient is high. The EMS worker delivers patient care in a fast-paced and uncertain environment. Alertness and vigilance are needed at all times to prevent negative outcomes. Commonly identified errors in EMS care include deviating from protocol, failure to secure a patient's airway, dropping a patient from a stretcher, and mistakes in administration of medication.[17,20,51,52] Threats to the EMS worker's personal safety include violent patients and bystanders, high-speed ground or air-medical transports, lifting and moving patients, and exposure to hazardous materials and contaminated substances and needles.[18] Rates of EMS worker injury and death while on the job exceed that of the general public.[18,30,53,54] Many EMS workers hold multiple public safety jobs, routinely working 50 hours or more per week.[36,55-57] Unlike resident physicians, the U.S. EMS worker faces few restrictions on hours worked or number of agencies employed.

A recent study determined that a high proportion of EMS workers suffer severe fatigue while at work and generally have poor sleep quality.[36] There is no known research of the link between sleep, fatigue, and patient and EMS safety outcomes. The purpose of this study was to use previously tested and psychometrically sound surveys to examine the association between sleep quality, fatigue, self-reported injury, adverse events or medical errors, and safety-compromising behaviors.

2.0 METHODS

2.1 Recruitment of Study Sample

This study was approved as exempt from human subjects research, waiving the requirement of obtaining consent from EMS agencies or individual EMTs. We recruited EMS agencies connected to an EMS management group with a total membership of 2,253 EMS agencies (The National EMS Management Association). We distributed a standard recruitment letter and study flyer on the member email Listserv. This letter and flyer directed agencies to a designated study website (www.EMSARN.org). The site was populated with information about the research study. Agencies willing to participate contacted the study team.

2.2 Survey Sampling of EMTs

At baseline, agencies provided limited demographic data on potential EMS worker respondents employed at the agency. We used a secure online survey system developed and maintained by the University of Pittsburgh Center for Research on Health Care Data Center. Agency administrators used this system to distribute a standard email from the University of Pittsburgh to EMS workers. The email contained standardized text and information about the study and a link to the secure online survey. The EMS worker completed the survey, selected the "opt-out" option, or took no action. The survey link was available from January to June 2010. Completed survey data were stored on a secure server. We received a coded dataset with agency ID#s linked to randomly generated survey ID#s and survey responses at the end of the study period. We gave a $100 gift card to the agency with the highest response rate.

2.3 Survey Instruments

We measured sleep quality with the 19-item Pittsburgh Sleep Quality Index (PSQI).[58] The PSQI evaluates the respondents sleep quality across seven constructs: Subjective Sleep Quality, Sleep Latency, Sleep Duration, Habitual Sleep Efficiency, Sleep Disturbances, Use of Sleeping Medications, and Daytime Dysfunction. Respondent answers to each question were weighted from 0-3 and possible scores ranged from 0-21. A score of >5 indicates poor sleep quality.[58]

We measured fatigue at work with the 11-item Chalder Fatigue Questionnaire (CFQ) adapted for the EMS work environment.[36] The CFQ evaluates both physical and mental fatigue.[59] Adapted items reference EMS work (i.e. "Do you feel weak?" was modified to, "Do you feel weak during your EMS shifts?"). Respondents recorded their answers on a 4-point Likert scale: Always, Sometimes, Rarely, or Never. We scored responses as Always=1, Sometimes=1, Rarely=0, and Never=0. Respondents with scores ≥4 are classified as fatigued. Both the PSQI and CFQ have been widely used in clinical and occupational populations – including EMS workers.[36]

We reviewed the literature and identified limited standards for capturing safety outcomes in EMS. We developed a new 44-item survey tool to elicit safety outcomes data using self-report by EMS personnel, the EMS Safety Inventory (EMS-SI). The development process began with assembling a panel of EMS medical directors, EMTs and paramedics, and epidemiologists. This panel developed a list of draft candidate items for the EMS-SI.[60] We used a D elphi-like (consensus driven) iterative process to review and eliminate or endorse each item based on content and face validity. Panelists grouped items into composite measures of safety analogous to the Patient Safety Indicator (PSI) tool developed by the Agency for Healthcare Research and Quality (AHRQ).[61] Items were grouped into three composite measures of provider injury (n=2-items; i.e., "I was injured during a shift."), medical errors or adverse events (n=25-items; i.e., "I accidentally dislodged an ET tube."), and safety-compromising behaviors (n=17-items; "I have greatly exceeded the speed limit while responding lights and sirens.").

We used the same consensus driven process to develop two nominal 7-point Likert scales to capture EMS-SI responses. Response options included on the first scale include: "definitely not," "probably not," "I'm not sure," "probably yes," "definitely yes," "do not wish to answer," or "not applicable to me." Response options on the second scale include: "ran out of time," "forgot to perform," "not part of protocol," "did not think it necessary," "contraindicated," "do not wish to answer," and "not applicable to me." The expert panel considered five responses credible indicators of negative patient or provider safety outcomes: "Probably Yes," "Definitely Yes," "Ran Out of Time," "Forgot to Perform," and "Did Not Think it was Necessary." See Appendix A for a list of EMS-SI items and response options.

Respondents completed a 15-item demographic survey that included: sex, age in years, certification (EMT-Basic or EMT-Paramedic), years of EMS experience, employment status (full time, part time, volunteer only), total shifts worked last month, type of shift most commonly worked (24hr, 12hr, ≤8hr), status of working at more than one EMS agency (yes, no), rating of general health (excellent, good, fair, poor), ever told by physician to have (diabetes, high blood pressure, heart problems, sleep apnea, breathing problems, arthritis, weight problems, migraines, depression), race and ethnicity, smoking status, alcohol consumption, and height and weight.

2.4 Analysis of Data

We calculated standard measures of reliability and instrument validity to evaluate the psychometric properties of the CFQ in this study sample. We calculated Cronbach's coefficient Alpha and Pearson product moment score-total coefficients to test the internal consistency / reliability of our survey tools. Cronbach's Alpha values above 0.70 are interpreted as a positive sign for instrument reliability.[62] We used Confirmatory Factor Analysis (CFA) to test model fit and determine if the items used to measure fatigue actually measured the hypothesized constructs of mental and physical fatigue.[63] We report a standard set of measures of model fit and construct validity: the Goodness of Fit Index (GFI), the Standardized Root Mean Square Residual (SRMR), Bentler's Comparative Fit Index (CFI), the Bentler & Bonett's Non-Normed Fit Index (NNFI), Bentler & Bonnett's Normed Index (NI), item-construct Pearson correlation coefficients, and Pearson construct-to-construct correlation coefficients. A SRMR less than 0.08, GFI, CFI, NNFI, and NI approaching 0.9, and item-scale Pearson correlations ≥0.40 and construct-to-construct Pearson correlation coefficients that are less than construct Cronbach's alpha coefficients are considered acceptable indices of instrument validity and model fit.[63-67] We did not perform CFA on PSQI constructs. The PSQI score calculations require use of multiple similar items across constructs. We did not perform CFA on the EMS-SI because it was not designed to measure latent constructs of safety outcomes.

We calculated frequencies and percentages to describe agency-level and individual-level demographic information. We used Wald chi-square tests to evaluate differences between the proportions of EMS workers classified as fatigued, with poor sleep quality, injured, having committed an error, and perceiving compromised safety across agency and respondent factors while accounting for within-agency clustering. We selected the Wald chi square test over the Rao-Scott chi-square because the latter test assumes random and non-complex sampling. Alpha was set at 0.05 for all comparisons. We used cluster-adjusted odds ratios to quantify the association between exposure to sleep and/or fatigue and the designated outcomes. We used cluster-adjusted (hierarchical) logistic regression to adjust for agency and respondent factors that may alter variations observed in bivarate analyses. The cluster-adjusted hierarchical logistic regression models accounts for the lack of independence that groups of respondents have with a particular agency. We followed conventional model building guidelines and included only those variables significant in bivariate analyses. We used chi-square tests to check for collinearity prior to model building. When collinearity was detected we specified a model with variables most strongly associated with fatigue, sleep, and the outcome of interest. We included the variable 'shift length most commonly worked' in all models because of interest in the association between extended work hours and safety outcomes in healthcare.[68,69] The EMS-SI survey may capture a h igher frequency of safety outcomes from paramedics versus EMT-Basics. We repeated our final hierarchical logistic models on study data stratified by level of certification. These additional models address an important question: "Given that EMT-Basics work at a lower scope of practice, is there a possibility that the associations identified in the logistic models differ across level of certification?" We performed all analyses with SAS Version 9.2 (Cary, North Carolina).

3.0 RESULTS

3.1 Sample Demographics

We received 547 surveys from all four US census regions with most participating agencies and respondents located in the Midwest and Northeast (Table 1). The mean agency response rate was 35.6% (range 4.9% to 78.1%). Complete data was present for 511 surveys. The most common type of agency self-classification was Other (40%) and greater than two-thirds self-identified ownership as private non-profit (83%). Three-quarters of agencies (73%) employed between 21 and 100 EMS workers. Most respondents (93%) self-identified as white and 74% as male (Table 2). The mean age of respondents was 37 years (SD 10.6). Greater than half of respondents were certified as an EMT-Paramedic (59.5%) and had less than 10 years of EMS experience (51.5%). The largest stratum for employment status was full-time (75%) and most respondents reported working between nine and 15 shifts per month (44%). Half of respondents reported regular shift lengths of 24-hours (48%) and one-third of respondents (34%) were actively working at more than one EMS agency. Three quarters of subjects were classified as overweight or obese and more than half reported one or more health problems.

Table 1. Agency Demographics

Study Sample	**N=30 (100%)**
Census Region	
Midwest	16 (53.3%)
Northeast	9 (30.0%)
West	3 (10.0%)
South	2 (6.7%)
Agency Classification	
Hospital Based	4 (13.3%)
Fire Based	1 (3.3%)
3rd Service/Government	11 (36.7%)
Rescue Squad	2 (6.7%)
Other	12 (40%)
Agency Ownership	
Private For-Profit	1 (3.3%)
Private Non-Profit	25 (83.4%)
Government Funded	2 (6.7%)
Member Supported	1 (3.3%)
Other	1 (3.3%)
Number of Employees	
1-20 Employees	5 (16.7%)
21-50 Employees	12 (40.0%)
51-100 Employees	10 (33.3%)
101-400 Employees	3 (10%)

3.2 Sleep Quality

Psychometric tests confirmed that, in this study sample, the PSQI had positive reliability and internal consistency in this study sample (α=0.72). The component score-total Pearson correlation coefficients ranged from 0.53 ($p<0.0001$) for the Use of Sleeping Medications component to a high of 0.70 ($p<0.0001$) for the Sleep Duration component. The mean component score to total PSQI score Pearson correlation (0.61) was comparable to prior studies.[58]

The mean PSQI score was 6.9 (95% CI 6.6, 7.2) and ranged from 0–20. Greater than half of PSQI scores exceeded the 6.0 benchmark for poor sleep quality (n=304, 59.5%; 95% CI 55.2-63.8%). The proportion of respondents with poor sleep scores was highest among full-time workers, respondents that commonly worked 24-hour shifts, and among those that worked at more than one EMS agency ($p<0.05$; Table 2). The mean sleep quality score among fatigued respondents was 3.1 points higher than the non-fatigued ($p<0.0001$, Figure 1).

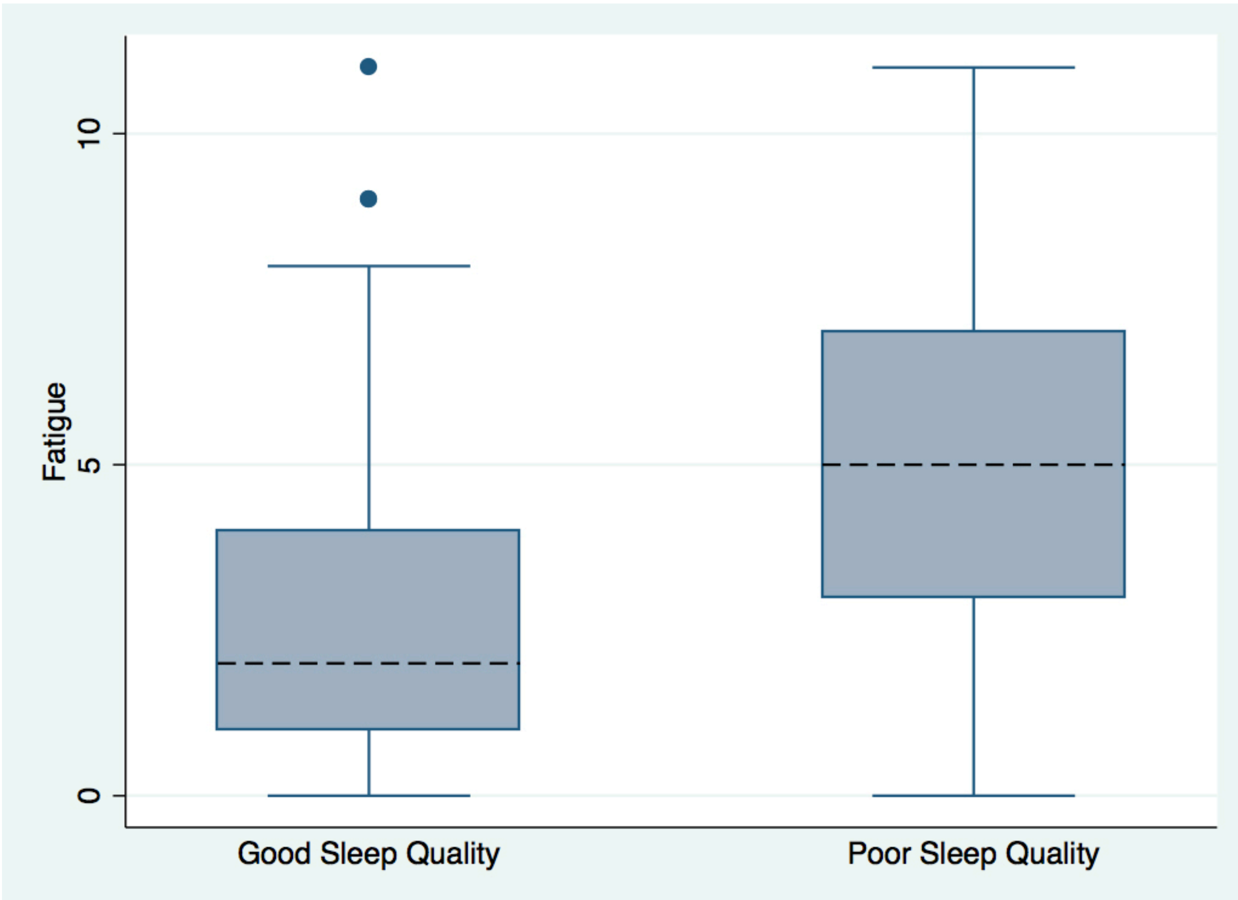

Figure 1. Association between poor sleep quality scores and fatigue

Figure 1 Notes: This box plot illustrates medians (dashed lines), the 25th and 75th percentiles, and range of PSQI scores in relation to CFQ fatigue scores (0-11) stratified by Good Sleep Scores (PSQI <6) and Poor Sleep Quality Scores (PSQI ≥ 6).

Table 2. Summary of associations between respondent demographics and poor sleep quality, fatigue, injury, errors and adverse events, and safety compromising behaviors

	Study Sample (Respondents) n(%)	Poor Sleep n(%)	Severe Fatigue n(%)	Injury n(%)	Error or Adverse Event n(%)	Safety Compromising Behaviors n(%)
	N=511 100%	N=304 59.5%	N=281 55%	N=91 17.8%	N=210 41.1%	N=458 89.6%
Age					*	
17-25 years	80 (15.7)	49 (61.3)	41 (51.3)	10 (12.5)	38 (47.5)	73 (91.3)
26-35 years	163 (31.9)	92 (56.4)	89 (54.6)	29 (17.8)	74 (45.4)	152 (93.3)
36-45 years	156 (30.5)	93 (59.6)	96 (61.5)	38 (24.4)	70 (44.9)	138 (88.5)
≥ 46 years	112 (21.9)	70 (62.5)	55 (49.1)	14 (12.5)	28 (25.0)	95 (84.8)
Sex						
Male	378 (74.0)	216 (57.1)	209 (55.3)	65 (17.2)	155 (41.0)	338 (89.4)
Female	133 (26.0)	88 (66.2)	72 (54.1)	26 (19.5)	55 (41.4)	120 (90.2)
Race					*	
White	478 (93.5)	284 (59.4)	263 (55.0)	85 (17.8)	203 (42.5)	431 (90.2)
African American	5 (1.0)	20 (60.6)	18 (54.5)	6 (18.2)	7 (21.2)	27 (81.8)
Other	28 (5.5)					

Table 2 Notes: *=indicates a Wald chi square test of statistical significance at $p<0.05$. Race African American was collapsed with the Other stratum due to low cell numbers. With exception of the study sample column all percentages appearing in parentheses represent "row percentages" and not column percentages. For example, 61.3% of subjects aged 17-25 years were classified as having poor sleep quality whereas 38.7% aged 17-25 were classified as having good sleep quality. Three (n=3) respondents were missing data required for the BMI calculation. No statistical comparisons for poor sleep, fatigue, injury, error or adverse events, or compromised safety across health conditions (i.e., diabetes, depression, etc) due to low cell frequencies (n<30) and the likelihood for unstable chi-square statistics and corresponding p-values.

Table 2 (continued): Summary of associations between respondent demographics and poor sleep quality, fatigue, injury, errors and adverse events, and safety compromising behaviors

	Study Sample (Respondents) n(%)	Poor Sleep n(%)	Severe Fatigue n(%)	Injury n(%)	Error or Adverse Event n(%)	Safety Compromising Behaviors n(%)
Certification				*	*	*
EMT-Paramedic	304 (59.5)	181 (59.4)	178 (58.6)	65 (21.4)	165 (54.3)	284 (93.4)
EMT-Basic	207 (40.5)	123 (59.5)	103 (49.8)	26 (12.6)	45 (21.7)	174 (84.1)
Years of EMS Experience					*	
0-10 years	263 (51.5)	161 (61.2)	131 (49.8)	45 (17.1)	123 (46.8)	235 (89.4)
11-20 years	148 (29.0)	84 (56.8)	95 (64.2)	31 (20.9)	59 (39.9)	134 (90.5)
≥ 21 years	100 (19.6)	59 (59.0)	55 (55.0)	15 (15.0)	28 (28.0)	89 (89.0)
Employment Status		*	*			
Full-Time	387 (75.7)	245 (63.3)	234 (60.5)	79 (20.4)	169 (43.7)	355 (91.7)
Part-Time	79 (15.5)	39 (49.4)	40 (50.6)	10 (12.7)	30 (38.0)	69 (87.3)
Volunteer	45 (8.8)	20 (44.4)	7 (15.6)	2 (4.4)	11 (24.4)	34 (75.6)
Number of Shifts per Month			*	*	*	
0-5 shifts	74 (14.5)	36 (48.6)	26 (35.1)	3 (4.1)	11 (14.9)	54 (73.0)
6-15 shifts	301 (58.9)	176 (58.5)	191 (63.5)	62 (20.6)	140 (46.5)	280 (93.0)
≥16 shifts	136 (26.6)	92 (67.6)	64 (47.1)	26 (19.1)	59 (43.4)	124 (91.2)
Shift Most Commonly Work		*	*		*	*
24 hours	248 (48.5)	153 (61.7)	154 (62.1)	54 (21.8)	109 (44.0)	228 (91.9)
12 hours	196 (38.4)	112 (57.1)	105 (53.6)	31 (15.8)	87 (44.4)	177 (90.3)
≤ 8 hours	67 (13.1)	39 (58.2)	22 (32.8)	6 (8.9)	14 (20.9)	53 (79.1)
Actively working at more than 1 EMS agency		*			*	
Yes	175 (34.3)	119 (68.0)	102 (58.3)	26 (14.9)	86 (49.1)	163 (93.1)
No	336 (65.8)	185 (55.1)	179 (53.3)	65 (19.3)	124 (36.9)	295 (87.8)
BMI						
Normal	112 (21.9)	58 (51.8)	48 (42.9)	19 (17.0)	46 (41.1)	97 (86.6)
Overweight/Obese	396 (77.5)	244 (61.6)	231 (58.3)	72 (18.2)	164 (41.4)	359 (90.7)

Table 2 Notes: We do not report (label) results of tests for differences in individual health conditions (i.e. Diabetes) across poor sleep, fatigue, and the three composite safety outcomes. Comparisons involving low cell frequencies produce unstable estimates. We focused on the composite measure “Any of the above conditions” as a more stable indicator for statistical modeling inclusive of individual health status.

Table 2 (continued): Summary of associations between respondent demographics and poor sleep quality, fatigue, injury, errors and adverse events, and safety compromising behaviors

	Study Sample (Respondents) n(%)	**Poor Sleep n(%)**	**Severe Fatigue n(%)**	**Injury n(%)**	**Error or Adverse Event n(%)**	**Safety Compromising Behaviors n(%)**
Smoking Status						
Do not smoke	432 (84.5)	256 (59.3)	237 (54.9)	79 (18.3)	183 (42.4)	389 (90.0)
Smoke	79 (15.5)	48 (60.8)	44 (55.7)	12 (15.2)	27 (34.2)	69 (87.3)
Alcoholic Drinks per Week					*	
0 drinks	182 (35.6)	104 (57.1)	90 (49.5)	30 (16.5)	59 (32.4)	161 (88.5)
1-3 drinks	185 (36.2)	111 (60)	101 (54.6)	36 (19.5)	82 (44.3)	162 (87.6)
4-10 drinks	110 (21.5)	69 (62.7)	69 (62.7)	18 (16.4)	48 (43.6)	101 (91.8)
>10 drinks	34 (6.7)	20 (58.8)	21 (61.8)	7 (20.6)	21 (61.8)	34 (100)
Self-Rated General Health			*			
Excellent	139 (27.2)	65 (46.8)	57 (41.0)	18 (12.9)	53 (38.1)	121 (87.1)
Good	325 (63.6)	200 (61.5)	187 (57.5)	59 (18.2)	137 (42.2)	294 (90.5)
Fair or Poor	47 (9.2)	39 (83.0)	37 (78.7)	14 (29.8)	20 (42.6)	43 (91.5)
Ever told by a physician						
Diabetes	26 (5.1)	15 (57.7)	17 (65.4)	5 (19.2)	7 (26.9)	22 (84.6)
Hypertension	112 (21.9)	71 (63.4)	72 (64.3)	24 (21.4)	41 (36.6)	99 (88.4)
Heart Problems	26 (5.1)	15 (57.7)	17 (65.4)	4 (15.4)	12 (46.2)	23 (88.5)
Sleep Apnea	52 (10.2)	32 (61.5)	30 (57.7)	13 (25.0)	19 (36.5)	45 (86.5)
Breathing Problems	35 (6.8)	24 (68.6)	24 (68.6)	12 (34.3)	22 (62.8)	31 (88.6)
Arthritis	28 (5.5)	21 (75)	19 (67.9)	5 (17.8)	9 (32.1)	24 (85.7)
Weight Problems	150 (29.4)	102 (68)	95 (63.3)	34 (26.7)	68 (45.3)	137 (91.3)
Migraines	43 (8.4)	31 (72.1)	30 (69.8)	11 (25.6)	17 (39.5)	40 (93.0)
Depression	73 (14.3)	56 (76.7)	48 (65.8)	18 (24.7)	39 (53.4)	66 (90.4)
Any of the above conditions	290 (56.8)	194 (66.9)*	179 (61.7)*	60 (20.7)	129 (44.5)	262 (90.3)

Table 2 Notes: We do not report (label) results of tests for differences in individual health conditions (i.e. Diabetes) across poor sleep, fatigue, and the three composite safety outcomes. Comparisons involving low cell frequencies produce unstable estimates. We focused on the composite measure "Any of the above conditions" as a more stable indicator for statistical modeling inclusive of individual health status.

3.3 Fatigue

Psychometric tests confirm the CFQ had positive reliability and construct validity properties in this study sample. Cronbach's coefficient alpha was acceptable for both physical and mental fatigue constructs (0.88 and 0.69, respectively). Component score-total Pearson correlation coefficients for physical and mental fatigue were 0.94 ($p<0.001$) and 0.78 ($p<0.001$). The CFA findings confirm the data fit the hypothesized two construct model: SRMR=0.05, GFI=0.91, CFI=0.92, NNFI=0.88, and NFI=0.91. Item-construct Pearson correlations ranged from 0.45 to 0.76 and construct-to-construct Pearson correlation was 0.53.

Greater than half of respondents were classified as fatigued while at work (n=281, 55.0%; 95% CI 50.7, 59.3%). The proportion of respondents classified as fatigued was highest among full-time workers, persons working 6-15 shifts monthly, respondents that commonly worked 24 hour shifts, and respondents with fair or poor self-rated general health ($p<0.05$; Table 2).

3.4 Injury

Seventeen percent of respondents reported being injured in previous three months (n=91, 17.8%, 95% CI 13.5, 22.1%; Table 2). The proportion of EMS workers injured was higher among paramedics and respondents working 6-15 shifts monthly than among respective reference groups ($p<0.05$; Table 2). Odds of injury were 2.3 times higher among respondents with poor sleep than respondents with good sleep (OR=2.3, 95%CI 1.3, 3.9; Table 3, Figure 2). Odds of injury were 2.9 times higher among fatigued respondents than non-fatigued (OR=2.9, 95%CI 1.8, 4.6; Table 3, Figure 2).

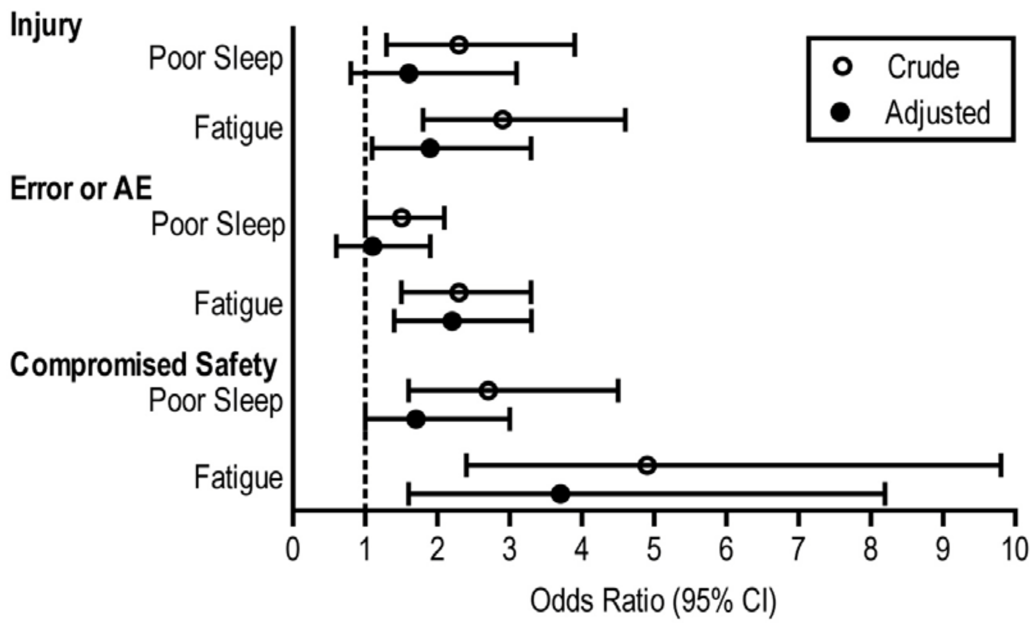

Figure 2. Odds of safety outcomes associated with poor sleep and fatigue (crude ORs and adjusted ORs)

Figure 2 Notes: Adjusted odds ratios from Table 3. These ORs were adjusted for clustering within agencies and confounding.

Table 3. Safety Outcomes Adjusted for Confounding and Clustering at the Agency Level

	Injury Model OR (95%CI)	Error or Adverse Event Model OR (95%CI)	Compromised Safety Model OR (95%CI)
(Unadjusted) Poor Sleep	2.3 (1.3, 3.9)	1.5 (1.0, 2.1)	2.7 (1.6, 4.5)
(Unadjusted) Fatigue	2.9 (1.8, 4.6)	2.3 (1.5, 3.3)	4.9 (2.4, 9.8)
(Adjusted) Poor Sleep	1.6 (0.8, 3.1)	1.1 (0.6, 1.9)	1.7 (1.0, 3.0)
(Adjusted) Fatigue	1.9 (1.1, 3.3)*	2.2 (1.4, 3.3)*	3.7 (1.6, 8.2)*
Age			
17-25 years		REF	
26-35 years		0.6 (0.3, 1.2)	
36-45 years		0.6 (0.3, 1.3)	
≥46 years		0.4 (0.2, 1.1)	
Race		*	
White		REF	
African American & Other		0.4 (0.2, 0.9)	
Alcohol Intake per Week			
Do not drink alcohol		REF	
1-3 drinks		1.3 (0.8, 2.1)	
4-10 drinks		1.2 (0.7, 1.9)	
>10 drinks		2.0 (1.0, 3.8)	
Self-Rated General Health			
Excellent	REF		
Good	1.3 (0.8, 2.1)		
Fair or Poor	2.0 (0.7, 5.8)		
Certification		*	*
EMT-Basic	REF	REF	REF
EMT-Paramedic	1.6 (1.0, 2.5)	5.3 (3.1, 9.1)	2.5 (1.6, 3.8)
Years Experience		*	
0-10 years		REF	
11-20 years		0.5 (0.3, 0.9)	
≥21 years		0.3 (0.2, 0.6)	
Employment Status			
Full-Time	REF		
Part-Time	1.1 (0.4, 2.5)		
Volunteer	0.7 (0.07, 7.2)		
Number of Shifts per Month		*	
0-5 shifts	REF	REF	
6-15 shifts	3.8 (1.1, 12.7)	3.2 (1.6, 6.3)	
≥16 shifts	4.0 (1.1, 14.0)	2.9 (1.4, 6.0)	
Shift Most Commonly Work			
≤12 hours	REF	REF	REF
24 hours	1.4 (0.8, 2.5)	0.8 (0.5, 1.3)	1.2 (0.7, 1.9)

Table 3 Notes: *=indicates the variable was statistically significant at p<0.05 in the full cluster and confounding adjusted model. REF = reference stratum.

3.5 Medical Error and Adverse Events

Four of every 10 respondents reported one or more medical errors or AEs in the previous three months (n=210, 41.1%, 95% CI 36.8, 45.4%; Table 2). The proportion of respondents reporting a medical error or AE was highest among the youngest age stratum (17-25 years), white respondents, certified paramedics, persons with fewer years of EMS experience, respondents working 6-15 shifts monthly, and among respondents that work longer shift hours and at more than one EMS agency ($p<0.05$; Table 2). Odds of reporting an error or AE in previous three months were 50% higher among respondents with poor sleep than respondents with good sleep (OR=1.5, 95%CI 1.0, 2.1; Table 3, Figure 2). Odds of error and AE were 2.3 times higher among fatigued respondents than non-fatigued respondents (OR=2.3, 95%CI 1.5, 3.3; Table 3, Figure 2).

3.6 Safety Compromising Behaviors

Ninety percent of respondents perceived that their safety or the safety of their patients was compromised during the prior three months of work (89%, 95%CI 87%, 92%; Table 2). The proportion of respondents with perceptions of compromised safety was highest among certified paramedics and among respondents that commonly worked longer shift hours ($p<0.05$, Table 2). Odds of perceived compromised safety were 2.7 times higher among respondents with poor sleep than respondents with good sleep (OR=2.7, 95%CI 1.6, 4.5; Table 3, Figure 2). Odds of perceived compromised safety were 4.9 times higher among fatigued respondents than the non-fatigued (OR=4.9, 95%CI 2.4, 9.8; Table 3, Figure 2).

3.7 Association Between Poor Sleep, Fatigue, and Safety Outcomes Adjusted for Confounding and Clustering at Agency Level

The odds that a respondent with poor sleep or fatigue would report an injury were attenuated after adjusting for poor sleep and fatigue simultaneously and all possible confounders (Table 3, F igure 2). The association between poor sleep and injury was reduced to non-significance while odds of injury related to fatigue remained statistically significant (OR=1.9, 95% CI 1.1, 3.3; Table 3, Figure 2). Similar to the adjusted model for injury, odds of error or AE were reduced after controlling for poor sleep, fatigue, and possible confounders. Odds of an error or AE are highest among whites, paramedics, respondents with the least years of EMS experience, and respondents that work 6-15 shifts monthly (Table 3, Figure 2). Finally, the odds that a respondent with poor sleep or fatigue perceived his or her personal or patient safety as compromised in previous three months was reduced after controlling both poor sleep and fatigue and possible confounders (Table 3, Figure 2).

The model fit statistics highlighted in Table 4 suggests that full models for injury, error and adverse events, and safety compromising behaviors (see Table 3) fit the data well. The Akaike Information Criterion (AIC) and Schwarz Criterion (SC) are commonly listed statistics of model fit for logistic regression models with smaller values of AIC and SC indicating better the model fit. The change in values of AIC and SC is insignificant for reduced models of all three outcomes indicating the full model is an adequate fit of study data. Other commonly cited model fit statistics include the R^2, Likelihood Ratio Chi-Square Test, Score Chi-Square Test, and Wald Chi-Square Test. The higher the R^2 value, the greater the proportion of variance the fitted model has explained in the data. The Likelihood Ratio Chi-Square, Score Chi-Square, and Wald Chi-Square test the null hypothesis that all variables in the model are equal to zero, with the alternative that at least one variable is not equal to zero. For all three outcomes, the three chi-square tests were reduced but remained statistically significant following a reduction in the number of variables in the models. For all three outcomes, the R^2 statistics were reduced following a reduction in the number of independent variables in the models. Taken together, these statistics suggest that while the three full fitted models can be improved, the specified full models fit the data well and a reduction in independent variables has an insignificant impact on model fit (Table 4).

Table 4. Model Fit Statistics for the Multivariable Logistic Fitted Models

	Fit Statistics			Global Tests			
Specified Model	**AIC**	**SC**	**-2Log L**	**Likelihood Ratio**	**Score**	**Wald X^2**	**Adj R^2**
Injury Full Model	460.8	507.4	438.8	40.0	34.7	36.9	0.1239
Injury Reduced Model 1	460.1	502.4	440.1	38.7	33.3	28.4	0.1199
Injury Reduced Model 2	461.9	495.8	445.9	32.8	29.7	32.9	0.1023
Injury Reduced Model 3	461.1	486.6	449.1	29.6	28.3	34.9	0.0927
Injury Reduced Model 4	459.7	476.6	451.7	27.1	25.5	33.3	0.0850
Injury Reduced Model 5	461.3	473.9	455.3	23.5	22.3	22.9	0.0739
Err.AE. Full Model	597.5	665.3	565.5	126.6	111.4	173.7	0.2959
Err.AE. Reduced Model 1	595.9	659.5	565.9	126.1	111.1	166.7	0.2948
Err.AE. Reduced Model 2	592.9	643.7	568.9	123.2	108.7	161.2	0.2889
Err.AE. Reduced Model 3	591.8	629.9	573.8	118.3	105.7	119.3	0.2786
Err.AE. Reduced Model 4	589.8	623.7	573.8	118.3	105.7	116.4	0.2785
Cmp.Safy Full Model	312.8	333.9	302.8	37.7	36.8	47.3	0.1464
Cmp.Safy Reduc. Model 1	311.1	328.0	303.1	37.4	36.5	41.8	0.1452
Cmp.Safy Reduc. Model 2	311.7	324.4	305.7	34.8	33.9	29.2	0.1354

Table 4 Notes: AIC=Refers to the Akaike Information Criterion which is calculated as -2Log L + 2((k-1)+s), where k is the number f levels of the dependent variable and s is the number of predictors in the model. The model with the smallest AIC is considered best. SC=Refers to the Schwarz Criterion and is calculated as -2 Log L + ((k-1)+s)*log(sigma f_i), where f_i is the frequency of values of the i^{th} observation, and k and s are defined as described in the AIC description. Analogous to AIC, the SC is inflated (penalized) when the model includes additional predictor (independent variables), thus the smaller the better the fitted model. The -2 Log L = Refers to the negative two times the log-likelihood and the value is not meaningful by itself, but in interpreted in concert with the SC and AIC measures. The Likelihood Ratio = Refers to likelihood ratio chi-square, which is a test that at least one of the predictor coefficients is NOT equal to zero in the model. We report the value associated with the Intercept and Covariate values from the output. Score = Refers to the score chi-square test that at least one of the predictor coefficients is NOT equal to zero in the model. Wald = Refers to the wald chi-square test that at least one of the predictor coefficients is NOT equal to zero in the model. The Adj R^2 = Refers to the max-scale R-square in the output. This value is a scaled version of the R^2 that reportedly does not reach 1.0 in some models. Injury Full Model = Refers to the full model reported in Table 3. Injury Reduce Model 1 = Refers to the full model minus the Shift Most Commonly Worked variable. Injury Reduced Model 2 = Refers to the full model minus variables (Shift Most Commonly Worked and Number of Shifts per Month). Injury Reduced Model 3 = Refers to the full model minus variables (Shift Most Commonly Worked, Number of Shifts per Month, and Employment Status). Injury Reduced Model 4 = Refers to the full model minus variables (Shift Most Commonly Worked, Number of Shifts per Month, Employment Status, and Self-Rated General Health). Injury Reduced Model 5 = Refers to the full model minus variables (Shift Most Commonly Worked, Number of Shifts per Month, Employment Status, and Poor Sleep). Err.AE. Full Model = Refers to the full model reported in Table 3. Err.AE. Reduced Model 1 = Refers to the full model minus the variable Shifts Most Commonly Worked. Err.AE. Reduced Model 2 = Refers to the full model minus variables (Shifts Most Commonly Worked and Alcohol Intake per Week). Err.AE. Reduced Model 3 = Refers to the full model minus variables (Shifts Most Commonly Worked, Alcohol Intake per Week, and Age). Err.AE. Reduced Model 4 = Refers to the full model minus variables (Shifts Most Commonly Worked, Alcohol Intake per Week, Age, and Poor Sleep). Cmp.Safy Full Model = Refers to the full model reported in Table 3. Cmp.Safy Reduc. Model 1 = Refers to the full model minus the variable Shifts Most Commonly Worked. Cmp.Safy Reduc. Model 2 = Refers to the full model minus variables (Shifts Most Commonly Worked and Poor Sleep).

Findings from the modified full models stratified by certification (EMT-Basic and EMT-Paramedic) provide no new insights in addition to the fitted models in Table 3. These additional models address an important question: “Given that EMT-Basics work at a lower scope of practice, is there a possibility that the associations identified in the logistic models differ across level of certification?” Findings from the stratified full models appear in Table 5. In a comparison of findings in Table 3 to Table 5 we observed an insignificant difference in odds ratios and corresponding 95% confidence intervals. Portions of the models specified in Table 5 are not interpretable given a concentration of measured outcomes (i.e. injury) in one stratum of independent variables (i.e. all injured fell into full time employment status with no injured in part-time or volunteer stratums). This lack of distribution of outcomes across stratums for select independent variables rendered interpretation of these stratified fitted full models impractical.

Table 5. Safety Outcomes Adjusted for Confounding and Clustering at the Agency Level in Table 3

Stratified by Level of Certification (EMT-P and EMT-B)

	Injury Model OR (95%CI)		Error or Adverse Event Model OR (95%CI)		Compromised Safety Model OR (95%CI)	
	EMT-P	**EMT-B**	**EMT-P**	**EMT-B**	**EMT-P**	**EMT-B**
(Unadjusted) Poor Sleep	1.9 (1.0, 3.6)	4.4 (1.7, 11.3)	1.7 (1.05, 2.8)	1.2 (0.6, 2.4)	2.3 (1.1, 4.8)	3.1 (1.6, 5.9)
(Unadjusted) Fatigue	2.9 (1.8, 4.6)	2.5 (1.07, 6.0)	2.0 (1.3, 3.1)	2.8 (1.4, 5.5)	3.6 (1.1, 11.3)	5.7 (2.9, 10.9)
(Adjusted) Poor Sleep	1.2 (0.6, 2.6)	3.0 (1.0, 9.0)	1.3 (0.8, 2.4)	0.6 (0.3, 1.2)	1.5 (0.6, 4.1)	1.9 (0.9, 3.8)
(Adjusted) Fatigue	2.5 (1.5, 4.1)	1.4 (0.5, 4.1)	1.7 (1.08, 2.8)	3.6 (1.6, 8.0)	3.1 (0.8, 12.0)	4.2 (2.1, 8.5)
Age						
17-25 years			REF	REF		
26-35 years			1.0 (0.4, 2.8)	0.3 (0.1, 0.6)		
36-45 years			1.4 (0.5, 3.5)	0.2 (0.1, 0.7)		
≥46 years			0.8 (0.3, 2.2)	0.3 (0.1, 1.2)		
Race						
White			REF	REF		
African American & Other			0.7 (0.2, 2.3)	0.1 (0.01, 0.6)		
Alcohol Intake per Week						
Do not drink alcohol			REF	REF		
1-3 drinks			1.3 (0.7, 2.6)	1.4 (0.6, 3.2)		
4-10 drinks			1.0 (0.6, 1.7)	1.8 (0.6, 5.4)		
>10 drinks			2.6 (1.5, 4.5)	0.6 (0.1, 3.3)		
Self-Rated General Health						
Excellent		REF				
Good		3.9 (0.7, 21.7)				
Fair or Poor		2.8 (0.2, 35.0)				

Table 5 Notes: *=indicates the variable was statistically significant at $p<0.05$ in the full cluster and confounding adjusted model. REF = reference stratum. Unstable = refers to the beta coefficients and corresponding odds ratios as being unstable due to a concentration of outcomes in one stratum of the predictor variable.

Table 5 (continued): Safety Outcomes Adjusted for Confounding and Clustering at the Agency Level in Table 3 Stratified by Level of Certification (EMT-P and EMT-B)

	Injury Model OR (95%CI)		**Error or Adverse Event Model OR (95%CI)**		**Compromised Safety Model OR (95%CI)**	
	EMT-P	**EMT-B**	**EMT-P**	**EMT-B**	**EMT-P**	**EMT-B**
Years Experience						
0-10 years			REF	REF		
11-20 years			0.4 (0.2, 0.7)	0.8 (0.3, 2.1)		
≥21 years			0.3 (0.1, 0.6)	0.4 (0.1, 1.9)		
Employment Status						
Full-Time	Unstable	REF				
Part-Time	Unstable	1.0 (0.3, 3.5)				
Volunteer	Unstable	0.9 (0.1, 15.0)				
Number of Shifts per Month						
0-5 shifts	Unstable	REF	REF	REF		
6-15 shifts	Unstable	1.5 (0.3, 6.6)	3.4 (1.3, 8.9)	3.2 (1.03, 10.0)		
≥16 shifts	Unstable	1.9 (0.3, 10.8)	3.3 (1.2, 9.4)	3.0 (0.7, 13.6)		
Shift Most Commonly Work						
≤12 hours	Unstable	REF	REF	REF	REF	REF
24 hours	Unstable	1.8 (0.6, 5.2)	1.0 (0.6, 1.7)	0.6 (0.2, 1.6)	0.9 (0.4, 1.9)	1.5 (0.7, 3.2)

Table 4 Notes: *=indicates the variable was statistically significant at $p<0.05$ in the full cluster and confounding adjusted model. REF = reference stratum. Unstable = refers to the beta coefficients and corresponding odds ratios as being unstable due to a concentration of outcomes in one stratum of the predictor variable.

4.0 DISCUSSION AND CONCLUSION

4.1 Discussion

In this study sample of EMS workers, we identified associations between sleep quality, fatigue, and self-reported safety outcomes. More than half of respondents had poor sleep quality or severe fatigue while at work. Fatigue was associated with all three composite measures of safety outcomes after controlling for confounding variables. Our findings are early evidence that poor sleep quality and fatigue may jeopardize patient and provider safety in the EMS setting.

In this study sample, the number of shifts worked monthly was linked to reported errors and AEs but not injury or perceptions of compromised safety. Longer shift hours (24 vs. ≤12 hours) were not associated to higher odds of negative safety outcomes. In contrast, nurses working shifts≥ 12.5 hours commit more medical err ors than those working shorter shifts.[70] Medical interns experience a su bstantial reduction in errors when extended work shifts were eliminated and the number of weekly work hours was reduced.[71] Extended-duration work shifts may contribute to fatigue and impair performance and safety.[69] Long periods without rest can impair cognitive and motor performance, even to the degree of alcohol intoxication.[72] Shift length for EMS workers can be long and interrupt normal circadian sleep periods resulting in detrimental effects on EMS worker performance and patient care quality.[69,73]

The lack of association between shift length and safety outcomes in this study sample may be explained by an unmeasured factor in this study: varying amounts of workload during shifts. An EMT's workload is variable and influenced by many factors. Dispatch timing and the amount of work required for a given response are often unpredictable. Workload depends on call volume, proximity to receiving facilities, crowding in the Emergency Department, and a host of other factors. Many EMS workers may be busy the entire shift while others may have time to include a nap or rest during downtime to curb fatigue and sleepiness.

High workload during shift work is associated with higher odds of negative safety outcomes in other settings.[74,75] In a study hospital-based nursing care, a higher rate of pneumonia and urinary tract infections was linked to increased workload and limited staffing.[76] We did not capture workload at the individual level. It may be that respondents that traditionally work 24-hour shifts rest and reduce odds of a negative outcome. Our finding higher odds of a medical error or AE among respondents that work 6-15 shifts per month is provocative and deserves further study involving an individual or team-level measure of workload.

Research subsequent the release of the Institute of Medicine's (IOM) 2008 report on resident hours resulted in aggressive action adopted by the Accreditation Council for Graduate Medical Education (ACGME).[77] A parallel effort targeting EMS workers may lead to new studies and research to improve our understanding of the causal relationships between fatigue, sleep, shift hours, and safety outcomes. These data suggest that number of shifts and total fatigue may be important targets for intervention in EMS workers in place of shift length.

4.2 Limitations

Our findings may not generalize to all EMS workers. This study utilized a convenience sample of EMS providers that resemble EMS workers across the U.S. (Table 6). Our response rate is comparable to prior multi-agency studies of EMS workers and other survey-based research of health care professionals.[78,79] Several differences between respondents and non-respondents may impact study findings. The proportion of non-respondents certified at the EMT-Paramedic level was lower than respondents (48% vs. 59%, $p<0.0001$). The proportion of non-respondents that work full-time was lower than the proportion among respondents (57% vs. 76%; $p<0.0001$). Non-respondents had fewer median years of agency service than respondents (4 vs. 5; $p<0.05$).

We developed our own measure of safety outcomes given a lack of standardized measurements for safety outcomes in EMS. We used a modified Delphi consensus-driven approach and a multidisciplinary panel in light of known limitations with independent reviews and ratings of outcomes by medical oversight physicians.[80,81] The EMS-SI tool is unique to EMS, but comparable to a patient safety indicator tool developed by AHRQ and tested in prior large scale safety studies.[61]

The self-report nature of our safety outcome measures is a strength and weakness. We adopted a three-month period of recall in recognition that occupational epidemiologists consider the accuracy of recall to diminish several months post event.[82,83] In prior research, EMTs under report medical errors and adverse events by an estimated 4%.[84-86] There is additional evidence that between 11% and 32% of occupational injuries and accidents are not voluntarily reported.[87,88] Under reporting may be attributed to an unwillingness to report, particularly in agencies where a fear of retribution may result from a poor safety culture.

We believe our findings do not highlight the true strength, but underestimate the association between sleep quality, fatigue, and safety outcomes. Our findings provide preliminary evidence that in one subset of the EMS population, sleep quality and fatigue are important indicators of safety.

Table 6. Characteristics of study sample compared to other research studies of EMS workers

Characteristic	Study Sample: Respondents	Study Sample: Non-Respondents	LEADS Sample	High Response EMS Sample	NHTSA Workforce Report **	Resuscitation Outcomes Consortium Agencies	Longitudinal Study of EMS Turnover	National Survey of EMS Safety Culture
Individual Characteristics								
Sex								
Male	74%	---	72.9%	71.8%	71-77%	---	---	73.2%
Female	26%	---	27.1%	28.2%	23-29%	---	---	26.8%
Certification								
EMT-Basic	40.5%	52%	58.1%	50.7%	#72%	58.2%	---	19.4%
EMT-Paramedic	59.5%	48%	34.6%	49.3%	#22%	34.2%	---	62.1%
Mean Age in Years	37.2	---	---	---	35	---	---	---
Race								
White	93.5%	---	---	---	75-81%	---	---	---
Non-White	6.5%	---	---	---	19-25%	---	---	---
Employment Status								
Full-Time	75.7%	56.9%	---	---	$89%	---	---	77.6%
Part-Time	15.5%	33.6%	---	---	$11%	---	---	20.6%
Volunteer	26.6%	9.5%	---	---		---	---	1.8%
Agency Affiliation *(EMT unit of measurement)*					+Includes county/3rd			
Fire-Based	9.6%	7.4%	34.1%	---		---	---	---
County/3rd Service	50%	60%	12.1%	---	+30%^^	---	---	---
Hospital	15%	14%	9.9%	---	20%^^	---	---	---
Other	25.4%	18.6%	43.8%	---	50%^^	---	---	---
Mean Years of Service at Agency	7.1	6.2	---	---	---	---	---	---
Mean Percentage of Work devoted to Clinical Field Work (not administrative)	61%	69%	---	---	---	---	---	---
Smoking Status								
Never / Do not smoke	84.5%	---	83.0%	---	---	---	---	---
Smoke	15.5%	---	17.0%	---	---	---	---	---
BMI								
Normal weight	21.9%	---	28.8%	---	---	---	---	---
Overweight/Obese	77.5%	---	71.2%	---	---	---	---	---

Table 6 (continued): Characteristics of study sample compared to other research studies of EMS workers

Characteristic	Study Sample	LEADS Sample	High Response EMS Sample	NHTSA Workforce Report **	Resuscitation Outcomes Consortium Agencies	Longitudinal Study of EMS Turnover	National Survey of EMS Safety Culture
Agency Characteristics *(Agency Unit of Measurement)*							
Agency Affiliation							
Fire-Based	3.3%	---	---	---	62.5%	10.0%	11.5%
County/3rd Service	36.7%	---	---	---	25.7%	22.5%	19.7%
Hospital	13.3%	---	---	---	N/A	27.5%	29.5%
Other (i.e. private)	46.7%	---	---	---	11.8%	40.0%	39.3%

Table 6 Notes:
** The NHTSA Workforce report includes statistics based on data from the 2003 and 2005 Current Population Survey (CPS), the 2007 National Registry of EMTs (NREMT) registration database, the 2004-05 Edition of the Bureau of Labor Statistics Occupational Outlook Handbook.
#=indicates source was the 2007 NREMT database statistics cited within the NHTSA Workforce report and excludes statistics from EMT-Intermediates.
$=is used to indicate data from this source does not stratify EMTs by volunteer status and automatically labels an EMT as Full-Time based on the EMT working greater than or equal to 35 hours per week.
^^Categories reported in the NHTSA Workforce report are not completely analogous to the stratums defined in this study. We collapsed several categories in the NHTSA Workforce report deemed similar to stratums in this study (e.g. 50% Other includes "private ambulance services and 'other' in the Workforce Report; and 30% County/3rd service includes all types of local government types).
@=The mean of medians reported in Table 2 of the Davis et al, 2007 publication.
For the ROC agency affiliation, the categories are Fire-Based, Non-fire government (county/3rd service), and Private (other).

4.3 Conclusions

In this sample of EMS workers, poor sleep quality and fatigue is common. We provide preliminary evidence of an association between sleep quality, fatigue, and safety outcomes.

5.0 PUBLIC HEALTH SIGNIFICANCE

Some level of EMS care covers every community in the U.S. Every minute of every day EMS workers transport 35 patients to hospital Emergency Departments (EDs). The health and safety of EMS workers has a profound impact on the health and safety of the public – thereby making fatigue and sleep of EMS workers an issue of public health significance.

APPENDIX A

COPY OF IRB APPROVAL

Memorandum

To:	Daniel Patterson
From:	Christopher Ryan, Vice Chair
Date:	12/14/2009
IRB#:	PRO09110229
Subject:	The EMS Agency Research Network (EMSARN)

The above-referenced project has been reviewed by the Institutional Review Board. Based on the information provided, this project meets all the necessary criteria for an exemption, and is hereby designated as "exempt" under section

45 CFR 46.101(b)(2) Tests, surveys, interviews, observations of public behavior
45 CFR 46.102(f) No human subject

Please note the following information:

- If any modifications are made to this project, use the " **Send Comments to IRB Staff**" process from the project workspace to request a review to ensure it continues to meet the exempt category.
- Upon completion of your project, be sure to finalize the project by submitting a "**Study Completed**" report from the project workspace.

APPENDIX B

THE EMS SAFETY INVENTORY TOOL (EMS-SI)

Item Stem: ***In the previous 3 months....***	**Scale**	**Category**
.I was injured during a shift.	A	Injury
...I received a needle stick injury.	A	Injury
I did not establish an IV after two attempts because	B	Error or AE
... I did not use a secondary treatment device when the preferred failed (e.g. IO instead of IV access, king airway instead of ET tube) because	B	Error or AE
I did not check a glucose level in a patient with altered mental status because	B	Error or AE
.I did not check a glucose level in a diabetic patient with nausea and vomiting because	B	Error or AE
I did not perform an airway intervention (e.g. BVM, Intubation, King/Combitube) on a patient with Congestive Heart Failure while enroute to the hospital because	B	Error or AE
I did not intubate a patient in respiratory arrest because	B	Error or AE
I did not place a patient on the monitor because	B	Error or AE
I did not perform a 12-Lead EKG on a patient with chest pain because	B	Error or AE
I did not perform a 12-Lead EKG on a patient with STEMI because	B	Error or AE
I confirmed a STEMI but did not administer aspirin when warranted because	B	Error or AE

Appendix B (continued)

Item Stem: ***In the previous 3 months....***	**Scale**	**Category**
I administered the wrong medication by not checking the label because	B	Error or AE
I administered the wrong dose of medication by not confirming the dose because	B	Error or AE
I transferred a patient at the Emergency Department (ED) with an unrecognized esophageal intubation (ET tube placed in esophagus rather than trachea) because	B	Error or AE
I did not secure an embedded object in a wound instead of securing the object with bandages and accidently removed it because	B	Error or AE
I did not print and properly interpret a 6 inch EKG strip because	B	Error or AE
I did not properly size a piece of equipment and then used it on a patient (e.g. ET tube, C-Collar, Airway Adjunct, IV Catheter) because	B	Error or AE
.I did not transport a specialty care patient to a specialty care facility (i.e. Trauma, Stroke, Pediatric) because	B	Error or AE
I accidentally started an IO in a location outside of protocol.	A	Error or AE
I made a patient with chest pain ambulate instead of using a stretcher.	A	Error or AE
I did not administer the necessary treatment for a specific condition/malady.	A	Error or AE
I accessed a dialysis port or other vascular device outside of protocol.	A	Error or AE
I accidentally dislodged an ET tube.	A	Error or AE
I placed an IV into an artery instead of into a vein.	A	Error or AE
I accidentally dropped a patient while on a transportation device (i.e. stretcher, stair chair).	A	Error or AE
I accidentally caused physical injury to a patient moving the patient.	A	Error or AE
I was overly stressed during a shift.	A	Safety-Compromising Behavior
I found myself at an unsafe scene.	A	Safety-Compromising Behavior

Appendix B (continued)

Item Stem: ***In the previous 3 months....***	**Scale**	**Category**
I may have been contaminated with copious amounts of patient bodily fluids.	A	Safety-Compromising Behavior
I was involved in a collision involving one of my agency's vehicles.	A	Safety-Compromising Behavior
I have reported for my shift without getting adequate rest beforehand.	A	Safety-Compromising Behavior
I have reported for my shift after drinking alcohol within the previous 8 hours.	A	Safety-Compromising Behavior
.I did not complete a pre-shift check of equipment and medications because	B	Safety-Compromising Behavior
I did not restock the ambulance before a call or shift because	B	Safety-Compromising Behavior
I have "fudged" information on a patient care report (i.e. vitals, chronology of events).	A	Safety-Compromising Behavior
I felt vulnerable to harm due to lack of appropriate PPE (i.e. BSI, Turnout Gear, etc).	A	Safety-Compromising Behavior
I felt that ***a patient's*** safety was jeopardized because my agency did not provide me with updated equipment.	A	Safety-Compromising Behavior
I felt that ***my*** safety was jeopardized because my agency did not provide me with updated equipment.	A	Safety-Compromising Behavior
I felt that ***a patient's*** safety was jeopardized because my agency did not provide me with updated protocols/policies/procedures.	A	Safety-Compromising Behavior
I felt that ***my*** safety was jeopardized because my agency did not provide me with updated protocols/policies/procedures.	A	Safety-Compromising Behavior
I have exceeded the speed limit while routinely driving the unit in a non-emergency mode.	A	Safety-Compromising Behavior
I have greatly exceeded the speed limit while responding lights and sirens (i.e. more than 15 mph over the posted speed limit).	A	Safety-Compromising Behavior
My "Chute Time" (Time from call received to rolling) was greater than 1 minute.	A	Safety-Compromising Behavior

Appendix B (continued)

Scale	Response	Negative Safety Outcome
A	Definitely Not	
	Probably Not	
	I'm Not Sure	
	Probably Yes	Yes
	Definitely Yes	Yes
	Do Not Wish to Answer	
	Not Applicable to Me	
B	Ran Out of Time	Yes
	Forgot to Perform	Yes
	Not Part of Protocol	
	Did Not Think it was Necessary	Yes
	Contraindicated	
	Do Not Wish to Answer	
	Not Applicable to Me	

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