



Sleep deprivation and adverse health effects in United States Coast Guard responders to Hurricanes Katrina and Rita

Timothy Bergan, DO, MPH ^{a,1}, Dana Thomas, MD, MPH ^b, Erica Schwartz, MD, MPH ^c, Jodi McKibben, PhD ^d, Jennifer Rusiecki, PhD ^{a,*}

^a Department of Preventive Medicine Biostatistics, Uniformed Services University, Bethesda, MD

^b Centers for Disease Control and Prevention, Office of Public Health Preparedness and Response, Division of State and Local Readiness, San Juan, Puerto Rico

^c Directorate of Health, Safety, and Work Life (CG-11), United States Coast Guard Headquarters, 2701 Martin Luther King Jr Ave, SE, Washington, DC 20593

^d Department of Psychology, West Chester University, 700 S High St, West Chester, PA 19382

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ABSTRACT

Objective: Disaster responders are increasingly called upon to assist in various natural and manmade disasters. A critical safety concern for this population is sleep deprivation; however, there are limited published data regarding sleep deprivation and disaster responder safety.

Design: We expanded upon a cross-sectional study of 2695 United States Coast Guard personnel who responded to Hurricanes Katrina and Rita. Data were collected via survey on self-reported timing and location of deployment, missions performed, health effects, medical treatment sought, average nightly sleep, and other lifestyle variables. We created a 4-level sleep deprivation metric based on both average nightly reported sleep (≤ 5 hours; > 5 hours) and length of deployment (≤ 2 weeks; > 2 weeks) to examine the association between sustained sleep deprivation and illnesses, injuries, and symptoms using logistic regression to calculate odds ratios (ORs) and 95% confidence intervals.

Results: The strongest, statistically significant positive ORs for the highest sleep deprivation category compared with the least sleep-deprived category were for mental health and neurologic effects, specifically depression (OR = 6.76), difficulty concentrating (OR = 8.33), and confusion (OR = 11.34), and for dehydration (OR = 9.0). Injuries most strongly associated with sleep deprivation were twists, sprains, and strains (OR = 6.20). Most health outcomes evaluated had monotonically increasing ORs with increasing sleep deprivation, and *P* tests for trend were statistically significant.

Conclusion: Agencies deploying disaster responders should understand the risks incurred to their personnel by sustained sleep deprivation. Improved planning of response efforts to disasters can reduce the potential for sleep deprivation and lead to decreased morbidity in disaster responders.

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Introduction

First responders have been increasingly called upon in recent years to assist in various natural and man-made disasters, including hurricanes, earthquakes, wildfires, tornadoes and oil spills. The largest and costliest natural disaster in US history was Hurricane Katrina. On August 29, 2005, Hurricane Katrina made landfall over the Mississippi-Louisiana border as a category 3 storm, with sustained winds greater than 125 mph. Its path of destruction extended as far east as Mobile, AL, and west as New Orleans, LA. There were more than 1300 fatalities

and tens of thousands of people driven from their homes.¹ Only a few weeks later, on September 24, 2005, the Gulf Coast was once again struck by another major hurricane, Rita. Approximately 5600 Coast Guard personnel responded in the wake of these 2 storms.¹

Sleep deprivation is often a significant problem among first responders, particularly in a scenario where the response can last for weeks or months. In occupational studies (not related to disaster response), sleep deprivation has been associated with poor job performance and risk of adverse health or safety outcomes, such as industrial accidents and traffic accidents.^{2,3} The majority of research on sleep deprivation has historically involved the aviation community, and it has been reported that approximately 20% of aviation mishaps are related to fatigue.⁴ Other occupational groups which have been the focus of sleep deprivation studies include physicians,⁵ shift work nurses,⁶ and student midwives,⁷ among whom there are increased risks for a variety of psychological and physiological illnesses.

* Corresponding author at: Department of Preventive Medicine and Biostatistics, Uniformed Services University, 4301 Jones Bridge Rd, Bethesda, MD 20814. Tel.: +1 301 295 3712.

E-mail address: Jennifer.rusiecki@usuhs.edu (J. Rusiecki).

¹ Department of Preventive Medicine and Biostatistics, Uniformed Services University, 4301 Jones Bridge Rd, Bethesda, MD 20814. Tel.: +1 301 295 3712.

To date, a handful of studies have examined the relationship of disordered sleep patterns and risk of occupational injury. In 2010, a Finnish group of researchers conducted a prospective study examining the relationship of disordered sleep and association with injury on the job. They found a significant association between problems with initiating sleep and subsequent on-the-job injuries.² In a US-based study, researchers conducted telephone surveys to query workers about work performance in relation to several sleep disorders, including insomnia, obstructive sleep apnea, and shift-work sleep disorder. They reported that workers who reported difficulty sleeping were more likely to report difficulty with concentration and organization at work.⁸ More concerning is a report from another study among American workers 18 years and older working 30 or more hours per week; workers in that study who reported suffering from insomnia had a 2-fold increase in occupational injuries.⁸

Our study is an extension of a cross-sectional analysis that reported exposures and health outcomes among a cohort of Hurricane Katrina and Rita disaster responders in the United States Coast Guard.⁹ That study reported that responders sleeping 5 hours or less per night on average had a positive association with depression as well as physical injury from slips, trips, and falls compared with those sleeping more than 5 hours per night on average.⁹ The assessment of sleep as a dichotomous variable did not take into account sustained sleep deprivation by length of deployment. In the current study, we further explore the association between sleep and adverse health effects in the same cohort by constructing a sleep deprivation variable, which takes into account both average hours slept per night and length of deployment and is categorized into 4 levels, enabling assessment of dose-response. We also investigate the association between sleep deprivation and medical treatment sought during deployment.

Participants and methods

Study population

The population included in this cross-sectional study was comprised of all Coast Guard members who responded to Hurricanes Katrina and Rita from 27 August 2005 through 12 November 2006 and who completed an Internet-based responder exit survey developed by the Directorate of Health, Safety, and Work-Life. The exit survey has been described in detail previously.⁹ Briefly, data were collected on timing of deployment (start and end deployment), missions performed, health effects experienced, medical treatment sought, average sleep, and other lifestyle variables (tobacco use, days off during deployment). The intention of the Directorate of Health, Safety, and Work-Life was that responders would complete the survey upon completion of their deployment/response work as part of their checkout process. This occurred for about 20% of responders, but 865 (32%) completed the survey within 1 month of completion of their deployment. Another 25% completed the survey between 30 and 60 days post-deployment completion, whereas another 12% completed it between 60 and 90 days; the remaining 30% completed it between 90 days and 1 year post-deployment completion. Although the Coast Guard mandated that all Coast Guard Katrina/Rita responders complete the survey (via a message sent out to all Coast Guard members: ALCOAST 546-05), there was no mechanism to ensure 100% compliance, and the response rate among Katrina/Rita responders was approximately 51% ($n = 2834$). This is approximate because the exact number of Coast Guard Katrina/Rita responders is unknown but was estimated by a Government Accountability Office Report to be approximately 5600.¹ Our analyses included only those responders ($n = 2695$ of 2834 [95%]) who indicated that they participated in 1 deployment. Approval for this study was granted by the Institutional Review Boards at the Uniformed Services University of the Health Sciences and the Coast Guard.

Assessment of sleep deprivation

Sleep deprivation was ascertained via the combination of 2 factors measured in the responder exit survey: average sleep per night and length of deployment. Responders indicated their average nightly sleep during deployment (in hours) in categories of 1 to 3 hours per night, 4 to 5 hours per night, 6 to 7 hours per night, or 8+ hours per night. Our sleep deprivation metric combined average nightly sleep with reported deployment length (in weeks) to classify responders into 1 of 4 levels of sleep deprivation. These levels were least-sleep deprived/reference (sleep >5 hours per night; deployment ≤ 2 weeks), moderate-low sleep deprived (sleep >5 hours per night; deployment >2 weeks), moderate-high sleep deprived (sleep ≤ 5 hours per night; deployment ≤ 2 weeks), and most sleep deprived (sleep ≤ 5 hours per night; deployment >2 weeks). We applied a 5-hour cut-point because of the way the survey was constructed (eg, we combined the 1-3 hours and 4-5 hours for the ≤ 5 hours category, and we combined the 6-7 hours and 8+ hours for the >5 hours category). We applied a 2-week cut-point for deployment length, which corresponds to a period of sustained sleep deprivation (eg, 6 hours in bed) reported to result in cognitive deficits equivalent to those found after 1 night of total sleep deprivation.^{10–12}

Assessment of health effects

The health effects we focused on in this study included injuries, illnesses, and symptoms reported by the responders in the exit survey that were experienced during deployment. Specifically, the health effects of interest were as follows: diarrhea; digestive symptoms (reporting any of nausea, vomiting, or loss of appetite); infected skin; skin rash; depression; difficulty concentrating; confusion; sinus infection; joint pain; muscle strain; injury from twists, sprains, or strains; laceration; puncture; abrasion; heat stress; and dehydration. Each health effect was reported as a dichotomous variable (yes, no), and responders reported all health effects they experienced. In addition to health effects, the exit survey also captured information on medical treatment sought by each responder. A positive response to having sought medical treatment for various exposures and/or health effects indicated that the responder sought the care of a medical professional rather than simply experienced an injury, illness, or symptom. Seeking medical treatment is an indicator for increased severity of the health effect. Health effects in this survey were self-reported by the respondents and were not confirmed by diagnosis from a medical professional.

Statistical analysis

Frequency data and χ^2 analyses were used to characterize population background characteristics and demographics. To calculate odds ratios (ORs) in this cross-sectional analysis, we used multiple logistic regression analyses in which the dependent variable was either a specific health effect or the exposure/health effect for which medical treatment was sought and the independent variable was the sleep deprivation metric described above. We adjusted models to include all baseline variables for which we found a significant difference between those reporting more average nightly sleep (>5 hours per night) and those reporting less sleep (≤ 5 hours per night): age, sex, component (eg, active duty, Reserve), officer/enlisted, days off during deployment, tobacco use, home region, and arrival month. However, to evaluate a more parsimonious model, we used a change in estimate strategy,¹³ comparing these adjusted models to models adjusted for age alone and found no appreciable difference in parameter estimates (eg, <20%). We therefore adjusted all models only for age. Because of the small number of responders who

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