



NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

CREW ENDURANCE TRAINING PROGRAM

FOR THE US NAVY

by

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ABSTRACT

The Crew Endurance Training program was designed to provide fleet-wide support to the US Navy on the successful implementation of circadian-based watchbills, and guidance on sleep management and crew endurance best practices. The first phase of the study included the evaluation of existing educational programs and the analysis of training needs. Combining information from studies conducted by the Naval Postgraduate School Crew Endurance team on USN ships, the expertise of the Sleep Matters Initiative (SMI), and feedback from active-duty service members (ADSMs), we developed the first version of training materials in 2019. The second phase of the project included the delivery of the training program, its assessment, and the analysis and refinement of the training. This iterative procedure was repeated throughout the second phase of the project.

The training was provided to more than 1,160 ADSMs, both USN Sailors and Marines. Overall, the responses from all audiences were positive with a high level of satisfaction with the training provided in terms of understanding the importance of sleep, sleep hygiene practices, the effect of sleep on operational performance and endurance, how best to implement circadian-based watchbills, and with the instructors, course content, and training duration. In general, trainees asked for more in-depth information, but operational commitments limited the time available to answer all questions.

Also, we updated the Crew Endurance website to support sharing of lessons learned and best practices for the individual and the command. The website includes references, tools, and training materials for use by the warfighter and shipboard leaders, as well as templates for shipboard watchbills and instructions to support circadian-based watchbills. Based on the findings from this study and the expressed need for training on crew endurance and guidance regarding the efficient application of circadian-based watchbills, we recommend the continuation of the Crew Endurance Training project.

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TABLE OF CONTENTS

I.	INTRODUCTION.....	1
A.	BACKGROUND	1
B.	PROBLEM STATEMENT	2
C.	STUDY AIM AND OBJECTIVES.....	2
D.	REPORT STRUCTURE	2
II.	LITERATURE REVIEW	5
A.	SLEEP DEFICIENCY COMPROMISES OPERATIONAL READINESS	5
B.	FATIGUE MANAGEMENT/SLEEP HEALTH EDUCATION AND TRAINING PROGRAMS IMPROVE HEALTH AND SAFETY IN SAFETY-SENSITIVE OCCUPATIONAL GROUPS.....	6
C.	WHAT SHOULD SLEEP HEALTH EDUCATION TRAINING PROGRAM PROVIDE?	10
D.	UNIQUE CHALLENGES OF THE MILITARY	11
E.	SCIENCE AND EDUCATION CAN AFFECT CHANGE	13
F.	CONCLUSIONS	14
III.	METHODS.....	15
A.	DEVELOPMENT OF THE INITIAL VERSION OF THE TRAINING PROGRAM	15
B.	DELIVERY OF TRAINING, ASSESSMENT, AND REFINEMENT	18
1.	Participants.....	18
2.	The training assessment questionnaire	19
3.	Procedures	20
4.	Statistical analysis.....	21
IV.	PROJECT OUTCOMES.....	23
A.	TRAINING DELIVERY	23
B.	TRAINING ASSESSMENT.....	25
1.	Responses from Marines	25
2.	Responses from USN senior leaders.....	27
3.	Responses from SWOS students.....	29
C.	OTHER ACCOMPLISHMENTS	34
1.	Crew Endurance website.....	34
2.	Crew Endurance Handbook	35
V.	CONCLUSIONS	37
1.	Study limitations	38
VI.	RECOMMENDATIONS.....	39
	APPENDIX A: ASSESSMENT QUESTIONNAIRES.....	41
A.	9-ITEM VERSION OF THE ASSESSMENT QUESTIONNAIRE.....	41
B.	6-ITEM VERSION OF THE ASSESSMENT QUESTIONNAIRE.....	42
C.	19-ITEM VERSION OF THE ASSESSMENT QUESTIONNAIRE.....	43
	APPENDIX B: LIST OF PRODUCTS DEVELOPED UNDER THIS PROJECT.....	45

A. REFEREED CONFERENCE PAPERS	45
B. CONFERENCE POSTERS	45
C. PRESENTATIONS.....	45
D. OTHER PRODUCTS	46
LIST OF REFERENCES.....	47
INITIAL DISTRIBUTION LIST	55

LIST OF FIGURES

Figure 1.	Responses from shore-based Marine Corps Security forces.....	26
Figure 2.	Responses regarding length of training.....	26
Figure 3.	Responses regarding pace of training.	26
Figure 4.	Responses regarding adequacy of training.	27
Figure 5.	Responses from US Navy senior leadership.....	27
Figure 6.	Level of agreement with statements related to the training.	29
Figure 7.	Responses to the question: “In terms of the duration of the training session, did you feel the training was...”. Vertical lines denote the standard error of proportion.....	30
Figure 8.	Responses to the question: “In terms of the pace of the training session, did you feel the pace was...”. Vertical lines denote the standard error of proportion.....	30
Figure 9.	Responses to the question: “Do you feel you currently received enough training on these topics?” Vertical lines denote the standard error of proportion.....	31
Figure 10.	Responses to the question: “Please rate your level of satisfaction with the sleep and fatigue training, overall.” Vertical lines denote the standard error of proportion.....	31
Figure 11.	Responses to the question: “How confident are you that you can apply what you learned to you work?” Vertical lines denote the standard error of proportion.	32
Figure 12.	Responses to the question: “Are there any topics you would like to pursue learning further?”	33
Figure 13.	Responses to the question: “Responses to the question: “Are there any topics you would like to pursue learning further?”	34

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LIST OF TABLES

Table 1.	Number of trainees by occupational group.....	23
Table 2.	Training sessions.....	24
Table 3.	Delivery of Crew Endurance Handbooks.	36

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I. INTRODUCTION

A. BACKGROUND

Having a well-rested crew is essential to mission success, operational safety, and readiness. Sleep and performance data from US Navy Sailors have been collected over many years and from different types of watch schedules. This information provides a rich and comprehensive understanding of how both the individual Sailor and the team onboard are affected by lack of sleep opportunities originating from excessive workload, rotating non-circadian shifts, and long deployment cycles. Numerous research reports and studies have demonstrated the benefits of using a circadian-based watchbill onboard US Navy ships (Brown, Matsangas, & Shattuck, 2015; Gabehart et al., 2015; Shattuck & Matsangas, 2014, 2015a, 2015b, 2019a; Shattuck, Matsangas, & Brown, 2015; Shattuck, Matsangas, & Powley, 2015; Shattuck, Matsangas, & Waggoner, 2014; Shattuck, Waggoner, Young, Smith, & Matsangas, 2014). Circadian-based watchbills not only allow the individual crewmember to maintain his/her circadian rhythms, but also improve individual performance and mood (Brown et al., 2015; Shattuck, Matsangas, & Brown, 2015).

Multiple factors determine whether individual Sailors and crews can obtain adequate amounts of quality sleep. Sailors are exposed to various onboard stressors and environmental factors – and each of these can potentially influence sleep. These factors include noise, smells, light, vibration, ship motion, sleep interruptions, additional onboard duties, drills/training exercises, and social and family commitments (Shattuck, Matsangas, & Dahlman, 2018). In addition, Sailors also bring or develop habits onboard that affect their sleep and the possibility of obtaining adequate rest. In recent years, reports have warned about excessive consumption of energy drinks and caffeinated beverages (Matsangas & Shattuck, 2015; Shattuck & Matsangas, 2015b; Shattuck, Matsangas, & Brown, 2015) and also exposure to high-energy visible light (HEV) blue light (Boivin, Duffy, Kronauer, & Czeisler, 1996; Cajochen, Chellappa, & Schmidt, 2014). This HEV light surrounds us throughout daylight hours but is also emitted from artificial sources such as television, tablets, smartphones, etc. Exposure to HEV light suppresses the release of melatonin, which is essential for falling and staying asleep.

B. PROBLEM STATEMENT

Following a decision by the Commander of Naval Surface Forces, all US Navy ships were told to adopt circadian-based watchbills by the end of 2017 (COMNAVSURFOR, 2017). The decision did not mandate a specific circadian-based watch schedule but instead, left it up to each ship to decide on which one to adopt depending on crew size, type of ship, etc. Implementing circadian-based watchbills fleet-wide is a major step forward in the effort to improve operational readiness and crew endurance. It is essential that such a policy must be implemented correctly. Implementation is not *a one size fits all* solution and special consideration of operational needs and appropriate training must be taken to ensure its effectiveness and operational sustainability.

C. STUDY AIM AND OBJECTIVES

The overarching aim of this project was to provide fleet-wide support (e.g., SURFOR, SURFLANT, SURFPAC, SWOS) for the successful implementation of circadian-based watchbills, and appropriate guidance on sleep management and crew endurance best practices. Under this aim, the project has three objectives.

- Analyze the training needs and develop the training program,
- Deliver the training, and
- Assess the effectiveness of the training.

D. REPORT STRUCTURE

The Literature Review chapter provides an overview of the existing literature detailing how sleep deficiencies compromise operational readiness, the utility of fatigue management/sleep health programs, and other relevant topics. The Methods chapter section of this report describes the phases of the project and the various procedures we used. The Project Outcomes chapter describes the training throughout of the project and findings from the training assessments. The Conclusions chapter provides an overview of our findings and the limitations of this project. The Recommendations chapter proposes

potential routes for the future continuation of the project. Lastly, this report includes the following Appendices.

- Appendix A: Training assessment questionnaires.
- Appendix B: List of products developed under this project.

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II. LITERATURE REVIEW

A. SLEEP DEFICIENCY COMPROMISES OPERATIONAL READINESS

Since September 11, 2001, United States military forces have operated at an exceedingly high tempo with a high number of overseas deployments. The Department of Defense (DOD) is continually challenged to maintain an edge in front of revolutionary changes in the warfare environment. Sustained operations and extended missions are increasingly common in today's battlefield, and more is being asked of each military service member. These conditions, combined with a variety of other factors in the military, especially in a combat environment, such as extreme temperatures, heavy mental and physical workload, long-term exposure to enclosed environments and isolation from family and loved ones, undermine the ability to obtain sufficient sleep necessary for optimal performance, productivity, safety, and health (Lieberman et al., 2005). In such conditions, it is challenging for the DoD to maintain the training, readiness, and the physical and mental health of military service members (Pickup, 2008; Seelig et al., 2016).

Sufficient quantity and quality of sleep are required for optimal performance. Although technology has made substantial advances in weapons systems, human performance remains a limiting factor in today's military. Undeniably, military personnel face many situations in which accurate performance of complex tasks during extended durations of wakefulness is required. A few examples include standing watch or sentry duty, radar and sonar monitoring, maintenance of nuclear power generators aboard ships and submarines, submarine duty, emergency air transport, long-range flights, air traffic control, maintenance of aircraft and other vital equipment, and providing surveillance data to the battlefield and combat. The seemingly simple task of firing a weapon requires alertness, pattern recognition to identify a target, logical reasoning to decide if the target should be fired upon according to the current rules of engagement, and short-term memory of the friendly force locations. Even top-level commanders in all branches of service are subject to the pressures of fatigue generated by round-the-clock operations. Further, it has been suggested that decision-making under conditions of uncertainty may be particularly vulnerable to sleep loss (Killgore, Balkin, & Wesensten, 2006).

Sleep deficiency compromises operational readiness in active-duty personnel in all branches of the service and the results can be catastrophic. In a survey of military service members, almost two-thirds of respondents reported obtaining inadequate sleep (Troxel et al., 2015). An analysis of U.S. Army data indicated that fatigue was a contributing factor in 628 Army accidents and 32 deaths between 2010 and 2014 (Haushild, 2017). During Operation Desert Storm, an M1 tank crew lost battlefield awareness and the ability of crewmembers to integrate information in a time-critical situation, resulting in a friendly fire incident (Belenky, 1997). Sleep deficiency increases the risk of injuries, errors, and accidents. Accidents have been the leading cause of death among active-duty service members for 25 out of the past 30 years (De Bruyne & Leland, 2015). In the past two decades, fatigue has claimed more deaths among military pilots than combat duty (Wingelaar-Jagt, Wingelaar, Riedel, & Ramaekers, 2021). In 2017, multiple collisions and one grounding involved U.S. Navy ships in the Western Pacific (i.e., USS John S. McCain, USS Fitzgerald, USS Antietam, and USS Lake Champlain). Tragically, 17 US Navy Sailors were killed in these accidents. In the Navy's comprehensive review of those recent incidents, it was determined that fatigue or ineffective fatigue/rest management was embedded in all of the mishaps in the Western Pacific, and it was recommended that the Navy should establish a comprehensive fatigue management policy (Department of the Navy, 2017).

B. FATIGUE MANAGEMENT/SLEEP HEALTH EDUCATION AND TRAINING PROGRAMS IMPROVE HEALTH AND SAFETY IN SAFETY-SENSITIVE OCCUPATIONAL GROUPS

Commercial aviation requires fatigue education and awareness training programs (Federal Aviation Administration, 2012). Similar programs have been instituted in other industries, such as railroad and trucking (Meuleners, Fraser, Govorko, & Stevenson, 2017; Quan, 2015). Some research has been conducted to evaluate such programs in these and other safety-sensitive occupations (Barger et al., 2018). A systematic literature review and meta-analysis were recently conducted to evaluate this research and identify the impact of fatigue education and training on safety and related outcomes in shift working occupations (Barger et al., 2018). Because that review was limited to shift workers, who have much in common with military work schedules, it is highly relevant.

In that review, searches of five research publication databases and one website (the publications section of the National Institute of Justice – NIJ), for literature published between January 1980 and September 2016 yielded 18 relevant studies of fatigue education and training in shift workers (Barger et al., 2018; Patterson, Higgins, Weiss, Lang, & Martin-Gill, 2018). This review was updated with a search of the PubMed database for literature published between September 2016 and June 2019. The updated review generated 1,928 potentially relevant publications. Of those, seven new studies of fatigue management/ sleep health education training programs were identified and reviewed. Of note, it is difficult to conduct double-blind, randomized controlled trials of these programs in operational settings; therefore, much of this research used quasi-experimental designs. We report the relevant publications from these combined reviews.

The fatigue training and education programs we reviewed were highly varied in format, delivery, and focus. Programs ranged from one-hour lectures (Arora, Georgitis, Woodruff, Humphrey, & Meltzer, 2007; Scott, Hofmeister, Rogness, & Rogers, 2010) to a one-day workshop, to more extended programs, such as 8 weeks of 2+ hour weekly classes (Christopher et al., 2016; Poulsen, Sharpley, Baumann, Henderson, & Poulsen, 2015). Program delivery included: in-person; led by experts (Steffen et al., 2015; Sullivan et al., 2017); team-based / peer-led (Kuehl et al., 2016); email-based (Smith & Wallace, 2016); and digital (Rosekind, Gregory, & Mallis, 2006). In addition to fatigue education, some programs emphasized topics such as mindfulness (Christopher et al., 2016), self-care practices (Poulsen et al., 2015), and exercise prescription (Atlantis, Chow, Kirby, & Singh, 2006; Spiotta, Fargen, Patel, Larrew, & Turner, 2019). Countermeasures such as scheduling interventions (Hardaway & Gregory, 2005; Rosekind et al., 2006) and an electronic handover tool (Fabreau et al., 2013) were included in some programs.

These wide variations demonstrate that there is no standardized approach, prevent pooling results from many studies, and introduce complexities in distinguishing what aspect of the program was effective. Nonetheless, fatigue management/sleep health education training programs improved patient safety, personal safety, and ratings of acute fatigue and reduced stress and burnout (Barger et al., 2018). A review of more general workplace interventions to promote sleep suggests that sleep and sleep-related outcomes can be improved by employer-sponsored programs (Redeker et al., 2019). A 2016 study

of sleep health education in nurses showed improvement in sleep quality (Morimoto et al., 2016) as did a meta-analysis of five studies that included sleep quality as an outcome (Barger et al., 2018).

A series of studies in firefighters revealed the benefits of a sleep health education program that screens for common sleep disorders. Nearly 7,000 firefighters in 66 fire departments across the US participated in sleep health education, and sleep disorders screening, with 37.2% screening at risk. Firefighters who screened positive for a sleep disorder were twice as likely to report a motor vehicle crash or falling asleep while driving, compared to firefighters who did not screen positive for a sleep disorder (Barger et al., 2015). Those who screened positive for a sleep disorder also had an increased risk for cardiovascular disease and diabetes, and were more than three times as likely to experience depression or anxiety (Barger et al., 2015). Thus, screening for sleep disorders may help identify those at greater risk for adverse safety events as well as poor physical or mental health. In military service members, insomnia is a frequent and rapidly increasing complaint (Caldwell, Knapik, Shing, Kardouni, & Lieberman, 2019; Simkins, 2019). The treatment of insomnia in military service members proved successful in reducing depressive symptoms and suicidal ideation. This treatment is particularly important because suicide is the third leading cause of death in the US Armed Forces (Germain, 2015).

Following a 60-minute sleep health education program in nurses, drowsiness, motor vehicle crashes, and errors decreased (Scott et al., 2010). In addition, police officers reported significantly lower levels of fatigue, sleep disturbance, and burnout following an 8-week program focusing on mindfulness (Christopher et al., 2016). Members of Navy flight crews reported that the awareness about sleep and circadian rhythms that they gained from a sleep health education program helped them be better prepared for the operational challenges inherent in their job (Hardaway & Gregory, 2005). Members of the wellness workforce at a hospital showed significant improvement in several measures following an 8-week worksite-based health sleep program. The measures included a more positive overall quality of life, fewer attentional failures during the workday, and a reduction in the number of days work performance was affected by poor sleep (Steffen et al., 2015). Resident physicians showed improvement in anxiety,

quality of life, and sleepiness measures following an almost year-long program of exercise and sleep health education (Spiotta et al., 2019). In post-program focus groups, 42% of firefighters reported making positive changes in sleep-related behavior (Barger et al., 2016). A minority of studies also reported mixed results or little change in sleep, health, safety, and performance measures (Arora et al., 2007; Fabreau et al., 2013; Lee, Gay, & Alsten, 2014; Pylkkonen et al., 2018).

In a cluster-randomized trial of sleep health education with screening for sleep disorders in one mid-sized fire department, firefighters assigned to stations receiving the sleep health education program reported half the number of disability days on average than those assigned to control stations, as recorded by payroll records (Sullivan et al., 2017). Firefighters who attended education sessions were 24% less likely to file at least one official injury report during the study interval (Sullivan et al., 2017). In this department of approximately 1200 active firefighters, it was estimated that the reduction in disability day usage observed in the sleep health education cohort would translate into annual direct-payroll savings of \$2.1 million (Bureau of Labor Statistics, 2022; Sullivan et al., 2017).

Firefighter and police sleep health education programs significantly improved understanding of sleep. The mean score on a knowledge assessment significantly increased post-education as compared to the pre-test education score (Barger et al., 2016; Holbrook, White, & Hutt, 1994). The greatest knowledge improvements in firefighters were in the expert-led trainings, followed by train-the-trainer and then online training methodologies (Barger et al., 2016). The majority of firefighters in the study indicated that a sleep health education program was important and informative, and was recommended for their colleagues in other fire departments, independent of the method of delivery (Barger et al., 2016). Similarly, 94% of employees and spouses enrolled in a study at a large mid-western children's hospital reported satisfaction with Sleep Smart educational program (Smith & Wallace, 2016). A majority of night shift nurses reported Sleep Enhancement Training System for Shift Workers to be "very useful" or "essential" (Lee et al., 2014). Resident physicians viewed a program combining weekly exercise with sleep health education positively (Achermann, Werth, Dijk, & Borbély, 1995). Truck drivers, dispatchers, and safety directors all reported significantly improved safety

culture following fatigue training (Arboleda, Morrow, Crum, & Shelley, 2003). The wide acceptance of fatigue management/sleep health education programs across occupations is encouraging and suggests that a similar program will be well-received by military service members.

C. WHAT SHOULD SLEEP HEALTH EDUCATION TRAINING PROGRAM PROVIDE?

Recommendations about what should be included in fatigue management/sleep health education programs are somewhat varied. Wesensten and Balkin (2013) recommended three components for an optimally effective sleep health program: sleep health education; objective measurement of sleep (e.g., actigraphy); and an estimated mental effectiveness model (Wesensten & Balkin, 2013). Czeisler states the key components of a comprehensive fatigue risk management program are education, caffeine re-education, actionable recommendations for fatigue and health mitigations of shift work, scheduling policies, and screening and management of sleep disorders (Czeisler, 2013). Arguably, the most important element of any fatigue management program is targeted sleep health education as the foundation to provide scientifically valid information, dispel common myths (Robbins et al., 2019), and provide actionable suggestions to change sleep behaviors. Sleep health education programs also need to be tailored to the specific needs and challenges of each occupational group. Education must emphasize the health and safety consequences of poor sleep habits and must provide resources to support behavior change so that recipients of the education can implement the recommendations and obtain healthy quantity and quality of sleep. Lentino and colleagues concluded that targeted educational interventions and resources focused on modifiable behaviors are required to improve sleep health in military personnel (Lentino, Purvis, Murphy, & Deuster, 2013). Mysliwicz and colleagues further believe fatigue management/sleep health education confers a tactical advantage in military mission success (Mysliwicz, Walter, Collen, & Wesensten, 2016).

D. UNIQUE CHALLENGES OF THE MILITARY

The association between sleep deficiency and adverse performance, safety, and mental and physical health consequences has been well-established (Czeisler, 2015; Good, Brager, Capaldi, & Mysliwiec, 2019; Troxel et al., 2015). A recent analysis of the *2011 Health Related Behavior Survey of US Active-Duty Personnel* showed that short sleep duration was associated with increased odds of hypertension, high cholesterol, hyperglycemia, and overweight/obesity (Hruby, Lieberman, & Smith, 2018). In a study of more than 14,000 US Army service members from the Active, Reserve, and National Guard, poor sleep was associated with lower scores on the Comprehensive Soldier and Family Fitness Assessment Global Assessment Tool scores in emotional, social, family, and spiritual fitness (Lentino et al., 2013). Importantly to the military, poor sleep has also been associated with impaired decision-making (Killgore et al., 2006) and reduced ability to detect threats (Basner et al., 2008). Analysis of data from military service members enrolled in the Millennium Cohort Study showed that insomnia symptoms were significantly associated with lower odds of deployment, greater health care utilization, and early discharge from the military (Gehrman et al., 2013). Additionally, pre-deployment sleep disturbance is predictive of post-deployment mental health problems (Gehrman et al., 2013).

Sleep deficiency often starts early in the career of military officers. In a longitudinal study at the US Military Academy at West Point, cadets averaged less than 5.5 hours of sleep on school nights throughout their 4 years (Miller, Shattuck, & Matsangas, 2010). In the military academies and basic training programs, recruits are in their late teens or early twenties. At this age, their circadian system is physiologically delayed (there is a physiologic drive for later bedtimes and waketimes) in conflict with the very early morning awakenings that are required in the military. Education and recognition of this biology, moving training start times from 0430 to 0700, resulted in improved sleep and marksmanship (Miller, Tvaryanas, & Shattuck, 2012).

There is a growing recognition that sleep is a modifiable risk factor for operational resilience (Hruby et al., 2018; Seelig et al., 2016). Promoting healthy sleep is a goal of the US Department of Health and Human Service campaign, Healthy People 2020 (Seelig et al., 2016). The US Army Surgeon General recognized the importance of

sleep, giving it equal billing with exercise and nutrition in the “Performance Triad” (Lentino et al., 2013). Interventions designed to promote healthy sleep in military service members, including sleep health education, are now imperative (Hruby et al., 2018; Seelig et al., 2016). Fatigue management/sleep health education should be instituted at the early stages and continue throughout one’s military career, covering fatigue mitigation and health sleep recommendations for all military situations including training, pre-deployment, combat, and post-deployment (Troxel et al., 2015).

The results of a study of US Army physicians suggest that leadership, especially that of the immediate supervisor, is important to healthy sleep behaviors (Hsu, Hansen, Roberts, Murray, & Mysliwiec, 2018). The multi-faceted goals of a comprehensive fatigue management/sleep health education training program are for military leaders to acknowledge and embrace the role of sufficient sleep for mission success and incorporate healthy sleep practices in mission planning. In short, all military service members should prioritize sleep (Wesensten & Balkin, 2013). Any fatigue management/sleep health education program in the military should also address the culture that often glorifies short sleep durations. In highly elite professions (e.g., astronauts, surgeons, military service members), short sleep can be seen as a sign of toughness (Seelig et al., 2016). Appropriate education may dispel this myth to begin to collectively change the attitudes of military leadership and service members regarding this issue.

The military has unique challenges that can limit the opportunity to obtain sufficient sleep and maintain operational readiness. Moreover, a military service member’s sleep deficiency not only affects his/her performance, but could endanger fellow soldiers, compromise the unit’s mission, and perhaps even national security (Wesensten & Balkin, 2013). Similarly, the advantage that adequate sleep duration and good sleep quality affords to alertness, reaction time, judgment, and creative solutions could be critical to mission success (Wesensten & Balkin, 2013). Therefore, fatigue management/sleep health education training programs need to be specifically designed to resonate with military service members. Although the broad training topics are identical to those necessary for other civilian occupational groups (e.g., sleep, circadian rhythms, fatigue countermeasures); customized application to address the unique military challenges is required. Just as training should be tailored to address extended-duration

shifts in resident physicians and firefighters; early morning starts for aviators, and overnight shifts for nurses, fatigue management/sleep health education training in the Navy must address 24-hour and non-24-hour watchbills, and split sleep schedules. Additional factors that affect sleep in the military that must be addressed include time zone changes, isolation, close living conditions, noise, light, smell, and temperature in the sleep environment. The language used in the program may also differ from that in civilian programs (Matsangas & Shattuck, 2018), e.g., the use of military-specific terminology such as resiliency, crew endurance, and operational readiness.

It may also be useful to extend sleep health education to the families of military service members, who are exposed to the unique stressors of military life. When their husbands were deployed, Army wives commonly sought treatment for sleep-related disorders (Mansfield et al., 2010) and rates of depression and anxiety in spouses were similar to returning combat veterans (Eaton et al., 2008). In the RAND Deployment Life Study, 44% of military wives reported a short sleep duration of fewer than seven hours. Sleep problems were also associated with poor physical and mental health (Holliday, Haas, Shih, & Troxel, 2016). Family resilience is an important priority for the military (Holliday et al., 2016; Meadows et al., 2015). Incorporating sleep health into existing military family programs or developing sleep health education programs for military families may improve the health and wellness of military service members and their families.

E. SCIENCE AND EDUCATION CAN AFFECT CHANGE

The Comprehensive Fatigue and Endurance Management Policy (CFEMP) in 2017 mandated the use of circadian-based watchbills on all US Navy surface ships. The policy is a success story aligned with the findings of this review. The Crew Endurance Team at the Naval Postgraduate School collected data that showed poor sleep and performance were associated with the traditional “five and dime” and non-24 hour schedules (Matsangas & Shattuck, 2016; Shattuck & Matsangas, 2016, 2019a; Shattuck et al., 2018; Shattuck, Matsangas, Mysliwiec, & Creamer, 2019; Shattuck, Matsangas, & Powley, 2015). Incorporating the scientific evidence into educational programs for Naval Leadership resulted in Vice Adm. Tom Rowden, Commander, Naval Surface Forces

(CNSF) to direct implementation of circadian rhythm watchbills on all surface ships in 2017 (LaCrosse, 2017). A sustained effort to educate military leadership can lead to further improvement in policies governing sleep.

F. CONCLUSIONS

It is imperative to develop a targeted, comprehensive fatigue management/sleep health education program for military service members (Caldwell, Caldwell, Thompson, & Lieberman, 2019; Lentino et al., 2013; Mysliwiec et al., 2016). To ensure engagement and impact, multiple versions should be created to address specific concerns of enlisted personnel and officers. For example, whereas Naval enlisted personnel are interested in how to adjust their sleep and circadian rhythms to ensure alertness during their watchbill, officers need to understand circadian rhythms to design appropriate schedules and ensure the safety and operational readiness of the entire unit. Although fatigue management and sleep health education can be deployed in an expert-led presentation, in a train-the-trainer format, or in an online program, expert-led training may be more motivating, at least for the initial training (Barger et al., 2016; Lerman et al., 2012). To be most effective, training will need to reoccur periodically (e.g., annual training) (Lerman et al., 2012). A robust sleep health education program may contribute to improved health, safety, and performance of military service members and may confer longer-term benefits of more efficient use of military training dollars and increased operational readiness of the more than 2.2 million US active and reserve military service members (Osgood, Finan, Hinman, So, & Quartana, 2019; Seelig et al., 2016).

III. METHODS

Conceptually, the project was divided into two phases. The first phase took place in the first year of the project and included a) the evaluation of relevant, existing educational programs, and b) the analysis of needs and development of the initial version of the training program.

The second phase included the delivery of the training program, the assessment, and, lastly, the analysis and refinement of the training. This iterative procedure was repeated throughout the second phase of the project.

A. DEVELOPMENT OF THE INITIAL VERSION OF THE TRAINING PROGRAM

During the first year of the project, we conducted a literature review regarding the efficacy of sleep hygiene training offered in a variety of settings. The scope of this review was to contribute to the development of a crew endurance training program tailored and optimized for members of the United States Navy. Also, we identified characteristics of the multiple US Navy audiences for which training would be developed. These include training designed to be delivered to senior leadership and junior Sailors both on ships and in shore-based facilities.

Based on a preliminary needs analysis, it was decided that the training program would first be delivered to the fleet as an instructor-led course. Then we would develop online information to be readily available on the Crew Endurance website. The first training materials developed built upon lecture materials the Naval Postgraduate School Crew Endurance Team had been using previously to educate Sailors about sleep and watchbills used within the US Navy. To further improve the training materials, we collaborated with the Sleep Matters Initiative (SMI), housed in the Division of Sleep and Circadian Disorders at Brigham and Women's Hospital and the Division of Sleep Medicine at Harvard Medical School. The SMI group has extensive experience in developing sleep health education and sleep disorders screening programs for safety-sensitive occupational groups.

Based on a preliminary needs assessment, we identified the core topics to be covered in the training materials. In addition to information on healthy sleep, fatigue, and circadian rhythms, the training materials included modules on operational scheduling of watchbills, environmental challenges of US Navy personnel; sections on stress and resilience were also included because these factors are frequently related. Special consideration was taken to include operational requirements and adjusting to the specific demands of the different ships and duties onboard. We leveraged the SMI content to customize the sleep disorders information to be Navy-specific. The module also included content on fatigue countermeasures, e.g., sleep banking and strategic use of caffeine. Overall, these materials included information on topics that improve individual operational performance. The following list shows the topics that were considered important to be included in the training materials.

- Operational consequences of fatigue
 - Fatigue is endemic in society and the military
 - Special challenges and sleep deficiency in the Navy
 - Safety risk—this section should be emphasized in training to officers and senior enlisted
- What sleep is and why normal sleep is important
 - Sleep is for the brain and the body
 - Duration, timing, and quality
- Benefits of optimal sleep - in contrast to the effects of sleep deficiencies on operational performance
 - Benefits of optimal sleep
 - Effects of sleep deficiencies on operational performance
- Determinants of operational performance
 - Hours awake
 - Sleep debt and recovery from sleep debt
 - Time of day [circadian]
 - Sleep inertia

- Sensitivity of work duties (duration, complexity, manual/cognitive) to sleep loss/irregular sleep
- Inter-individual differences to vulnerability to sleep loss
- Fatigue mitigation recommendations: General
 - Make healthy sleep a priority
 - Try to maintain a consistent sleep schedule
 - Maintain anchor sleep
 - Napping
 - Take into account your morningness-eveningness preference
 - Use of caffeine
 - Use of nicotine
 - Use of OTC medications (sleep-promoting agents)
 - Use of alcohol
 - Dietary patterns
 - Physical fitness
 - Light management
 - When to avoid light, e.g.
 - Light-emitting devices before sleep
 - Gaming and gadgets before sleep, etc.
 - When to be exposed to light, e.g.
 - To fight sleep inertia
 - To stay alert, etc.
 - Work stress (leading to insomnia)
 - Obstructive Sleep Apnea (OSA): Make sure that you can breathe during sleep
 - Habitability in the bunk (noise, light, temperature)
 - Commuting to and from work
- Fatigue mitigation recommendations: Operational [emphasis on Deployments, Continuous Operations, NightOps, etc.]
 - Circadian-based watchbills
 - What are they? How do they differ from previous watchbills?

- Strengths and weaknesses
- How to use them effectively
- Workload management
- Optimization of work hours
- Timing of all-hands evolutions
- Light management
- Strategic use of HEV lighting
- Rack curtains to enable darkness
- How to respond effectively to unplanned events
 - Sleep banking
 - Policies and procedures that kick in when unplanned events require extended work hours
 - Strategic use of caffeine
- Napping policy
- Food services

B. DELIVERY OF TRAINING, ASSESSMENT, AND REFINEMENT

In the second phase of the project, we delivered the training to multiple audiences of active-duty service members. The program was delivered primarily as an adjunct to ongoing training at existing schoolhouses and educational initiatives prior to deployments, e.g., Department Head School Students at Surface Warfare Officers School (SWOS) and Prospective Commanding Officers (PCOs)/Prospective Executive Officers (PXOs) Course. The training program was delivered by the NPS Crew Endurance Team both in-person and virtually. After each training session, an individual course evaluation took place to ensure the quality of the course and its content.

1. Participants

In total, training was provided to more than 1,160 active-duty service members. Detailed information regarding the delivery of training can be found in the Project Outcomes chapter. The Naval Postgraduate School Institutional Review Board (IRB)

determined that the assessment of training under this project was not human subjects research (IRB determination 2019.0038-DD-N; IRB determination 2020.0036-DD-N).

2. The training assessment questionnaire

To assess satisfaction with the training, we used three short questionnaires. All three were focused solely on whether participants reacted favorably to the training session, i.e., level one of the four levels needed to holistically assess a training program according to Kirkpatrick's training evaluation model (Kirkpatrick & Kirkpatrick, 2006).

The first tool was a 9-item questionnaire that the Crew Endurance Team developed to assess responses from Marines at the Strategic Weapons Facility Pacific (SWFPAC). Five items ("Training was relevant"; "Training was understandable"; "I would recommend the training to others"; "The trainer was easy to understand"; "I am satisfied with the training I received today") were rated based on a 5-point Likert scale (Strongly disagree; disagree; neither agree nor disagree; agree; strongly agree). The item "In terms of how long the training session was, did you feel the training was..." was rated with a 4-point Likert scale (too short; about right; too long; not sure). The item "In terms of the pace of the training session, did you feel the pace was..." was rated with a 4-point Likert scale (too slow; about right; too fast; not sure), and one item ("Do you feel you currently receive enough training on sleep and fatigue?") with a 3-point Likert scale (Yes, it is about right; No, it is too little training; No, it is too much training). The last item was open-ended ("What would make you more satisfied with the training?").

The second tool was a 6-item questionnaire. Trainees were asked to rate the following statements on a 5-point Likert scale (1-poor, 2, 3-Neutral, 4, 5-Outstanding): "Objectives were clearly explained by the speaker," "The objectives of the presentation were achieved," "Content of this module is relevant/useful to my current/future job," "The speaker's style was effective for presenting these concepts," "The speaker interacted effectively with the participants." The questionnaire also included an open-ended item for participants to provide comments and recommendations. This 6-item questionnaire had been developed and used by the Navy Senior Leadership group to assess training effectiveness.

However useful, though, both the 9-item and the 6-item tools were limited in terms of the number of satisfaction components that they addressed. For this reason, we developed an expanded 19-item tool that included extra items relevant to trainee satisfaction. Eight items (“The objectives of the training were clearly explained by the speaker,” “The objectives of the training were achieved,” “The speaker was easy to understand,” “The speaker's style was effective for presenting the training concepts,” “The speaker interacted effectively with the participants,” “The content of the training was relevant/useful to my current/future job,” “I was satisfied with the training I received today,” “I would recommend the training to others”) were rated based on a 5-point Likert scale (strongly disagree to strongly agree). Two items (“In terms of the duration of the training session, did you feel the training was...”; and “In terms of the pace of the training session, did you feel the pace was...”) were rated with 4-point Likert scales. Five items focused on topics covered in the training using a 5-point Likert scale. Specifically, attendees were asked to rate whether they received enough training on these topics (sleep basics, effects of sleep deprivation, consequences of fatigue on human performance, sleep-promoting medications and stimulants (e.g., caffeinated beverages, energy drinks, nicotine, medications), and tips for healthy sleep in the military environment. A 5-point Likert scale (very dissatisfied to very satisfied) was used to assess the overall level of satisfaction with the training, whereas confidence that what was learned can be applied to work was assessed with a 4-point scale (not confident at all to very confident). The last two items were open-ended (“Are there any topics you would like to pursue learning further?” and “What would you recommend to improve the training?”).

3. Procedures

Each individual attended only one training session. Before the COVID-19 pandemic (March 2020), the training was provided in person by a member of the NPS Endurance Team. At the end of the session, attendees were handed printed questionnaires to assess satisfaction with the training.

Later, however, the training was provided virtually by a member of the NPS Endurance Team. At the end of the session, attendees were provided a link or a QR code to complete the web-based assessment questionnaire (in LimeSurvey and Qualtrics). The

web-based 19-item questionnaire required 150 seconds to complete (median with an interquartile range of 129 seconds; data from Officers attending the Surface Warfare Officers School).

4. Statistical analysis

All data were screened for erroneous/anomalous entries and underwent descriptive statistical analysis. Statistical analysis was conducted with JMP statistical software (JMP Pro 16; SAS Institute; Cary, NC).

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IV. PROJECT OUTCOMES

A. TRAINING DELIVERY

In total, the training was provided to more than 1,160 active-duty service members in 38 separate training sessions. Trainees included three different occupational groups, i.e., more than 100 Marines stationed in a shore-based unit performing security duties, attendees of the US Navy senior leadership course at the Naval Postgraduate School (n = 760), and 300 USN students attending the Surface Warfare Officers School (58 prospective Commanding and Executive officers – PCOs/PXOs; 242 officers attending the Department Head School Classes). The training was provided in-person to 535 service members and virtually to 625 service members. Detailed information regarding the number of trainees is shown in Table 1.

Table 1. Number of trainees by occupational group.

Occupational Group		Training delivery		
		In-person	Online	Total
SWFPAC	Marines	>100	-	>100
SWOS	USN PCOs/PXOs	-	58	58
	USN Department Heads	-	242	242
NLS	USN senior leaders	435	325	760
Total		>535	625	>1160

In terms of training duration, Navy Senior leaders and Marines attended a 60-minute training session, whereas prospective Commanding/Executive officers and USN officers attending Department Head School Classes attended a 90-minute session. Each service member participated in only one training session. All 60- and 90-minute sessions included the same training materials. In longer sessions, however, there was more time available for in-depth discussion and questions. Detailed information regarding the training sessions is shown in Table 2.

Table 2. Training sessions.

Date	Month	Training location	Attendees	Training duration (minutes)	Assessment Questionnaire	Response rate
2018	February	NSLS	Navy Leaders	60	6-item	100%
2018	April	SWFPAC	Marines	60	9-item	~44%
2018	April	SWFPAC	Marines	60	9-item	~44%
2018	April	SWFPAC	Marines	60	9-item	~44%
2018	April	NSLS	Navy Leaders	60	6-item	100%
2018	June	NSLS	Navy Leaders	60	6-item	96.8%
2018	July	NSLS	Navy Leaders	60	6-item	93.6%
2018	August	NSLS	Navy Leaders	60	6-item	77.4%
2018	October	NSLS	Navy Leaders	60	6-item	90.0%
2019	January	NSLS	Navy Leaders	60	6-item	96.8%
2019	February	NSLS	Navy Leaders	60	6-item	80.7%
2019	April	NSLS	Navy Leaders	60	6-item	100%
2019	June	NSLS	Navy Leaders	60	6-item	100%
2019	July	NSLS	Navy Leaders	60	6-item	55.6%
2019	August	NSLS	Navy Leaders	60	6-item	82.8%
2019	November	NSLS	Navy Leaders	60	6-item	86.7%
2019	December	NSLS	Navy Leaders	60	6-item	90.3%
2020	February	NSLS	Navy Leaders	60	6-item	86.2%
2020	April	NSLS	Navy Leaders	60	6-item	85.7%
2020	May	NSLS	Navy Leaders	60	6-item	94.1%
2020	June	NSLS	Navy Leaders	60	6-item	100%
2020	July	NSLS	Navy Leaders	60	6-item	81.8%
2020	August	SWOS	Department Heads	90	19-item	51.0%
2020	August	SWOS	PCOs/PXOs	90	6-item	71.4%
2020	August	NSLS	Navy Leaders	60	6-item	100%
2020	October	NSLS	Navy Leaders	60	6-item	96.6%
2020	October	SWOS	Department Heads	90	19-item	93.1%

2020	December	NSLS	Navy Leaders	60	6-item	83.3%
2021	January	SWOS	Department Heads	90	19-item	50.0%
2021	January	SWOS	PXOs	90	19-item	33.3%
2021	February	NSLS	Navy Leaders	60	6-item	93.3%
2021	March	NSLS	Navy Leaders	60	6-item	35.7%
2021	May	NSLS	Navy Leaders	60	6-item	82.8%
2021	June	NSLS	Navy Leaders	60	6-item	75.0%
2021	August	NSLS	Navy Leaders	60	6-item	88.5%
2021	August	SWOS	Department Heads	90	19-item	21.6%
2021	October	SWOS	Department Heads	90	19-item	27.5%
2021	October	NSLS	Navy Leaders	60	6-item	93.1%

Navy Senior Leaders Seminar (NSLS); Strategic Weapons Facility Pacific (SWFPAC)

B. TRAINING ASSESSMENT

Training assessment was based on 845 questionnaires (with an estimated average response rate of 72.8%). Detailed information on response rates by training session can be found in Table 2. Next, we will present satisfaction with training by occupational group.

1. Responses from Marines

Most of the Marines found the training relevant (~89%) and understandable (~93%), about right in length (~86%) and pace (~91%), and the trainer easy to understand (~93%). Consequently, ~84% of the participants were satisfied with the training, and ~80% would recommend it to others. Of note, 71% of the participants felt that the amount of training they received was “about right”, but 29% responded that the amount of training received was not enough. These results are shown in Figures 1 to 4.

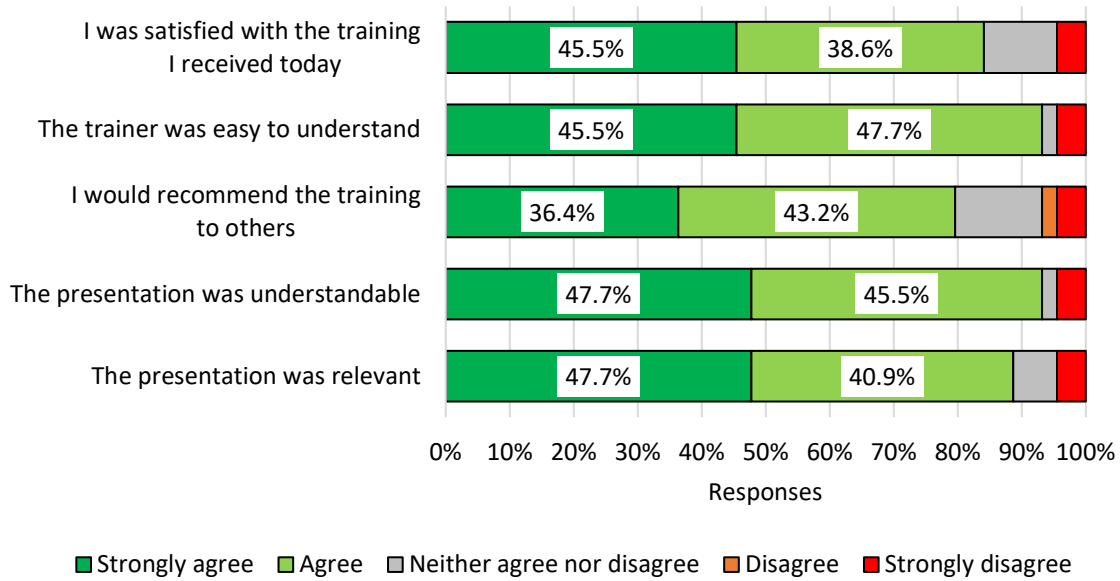


Figure 1. Responses from shore-based Marine Corps Security forces.

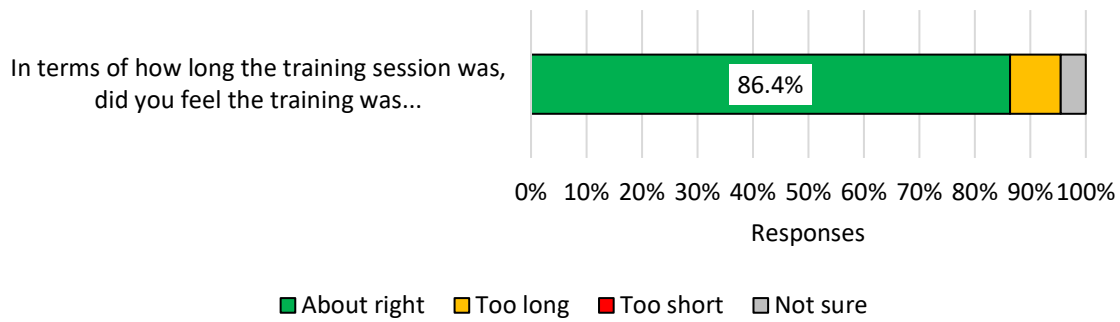


Figure 2. Responses regarding length of training.

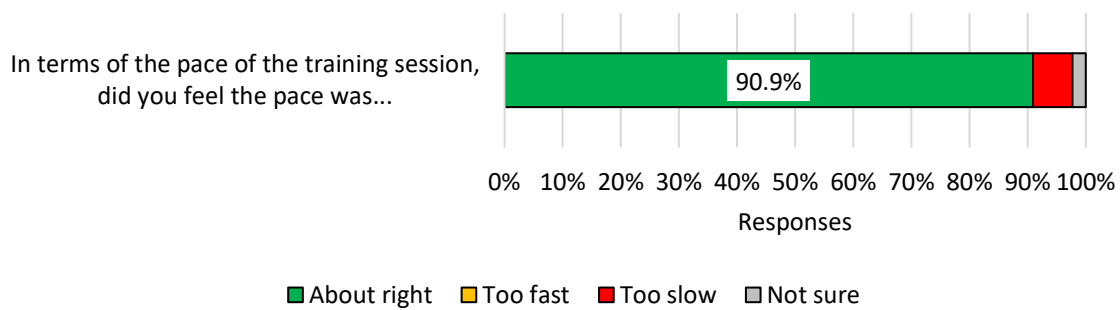


Figure 3. Responses regarding pace of training.

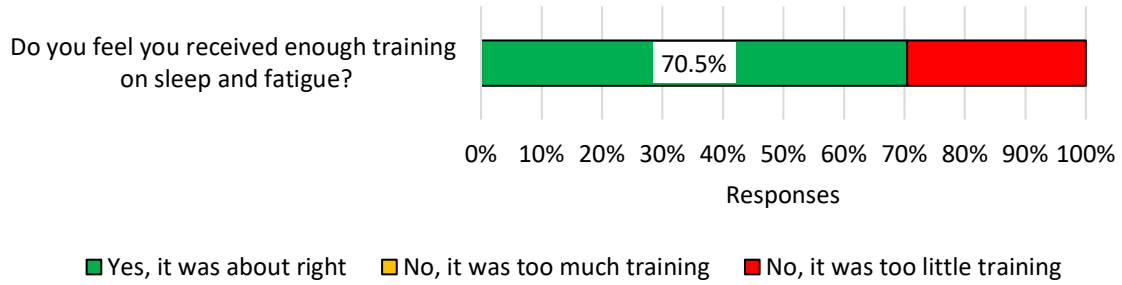


Figure 4. Responses regarding adequacy of training.

2. Responses from USN senior leaders

Approximately 98% of the USN senior leaders responded that the training objectives were clearly explained and that the objectives were achieved (ratings 4 and 5 on the Likert scale). Responses showed that the audience was satisfied with the speaker's style (~97%) and with the speaker interacting with the participants (~96%). The content of the training was found to be both relevant and useful for the participants' current or future job (~94%). These results are shown in Figure 5.

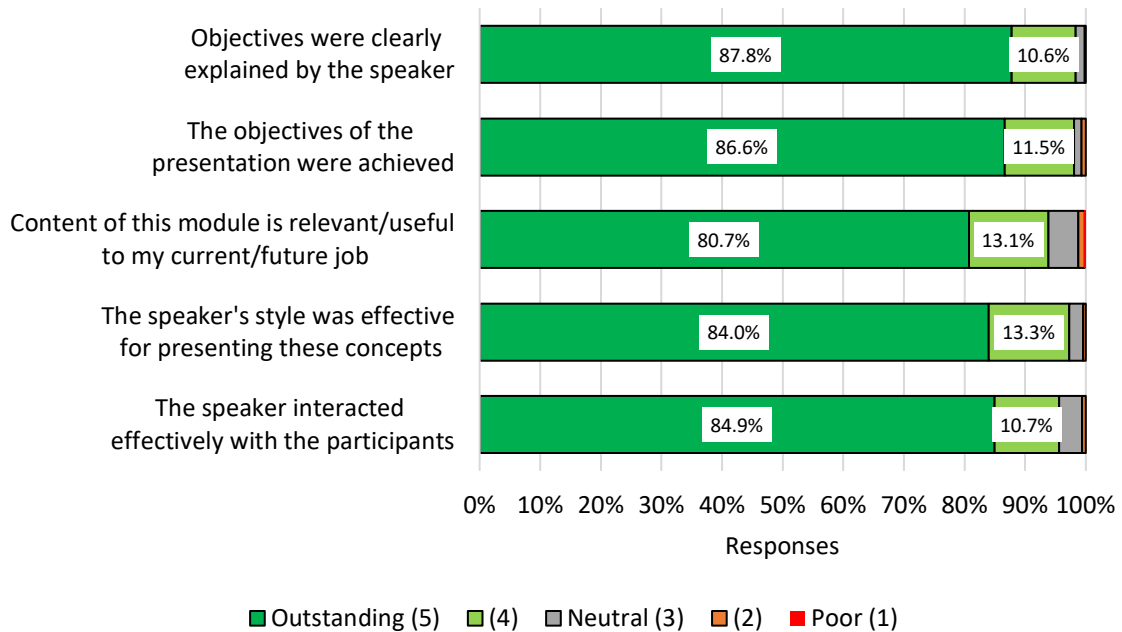


Figure 5. Responses from US Navy senior leadership.

Almost all responses in the open-ended item were overwhelmingly positive and clearly showed that the audience was satisfied with the training. Some examples:

“EYE-OPENING!!! Keep this brief in all future NSLS.”

“Hands down the best presentation I've received so far at NSLS. Dr. Shattuck really opened my eyes and I will never be the same.”

“Absolutely foundational topic for leadership that has done this wrong their entire careers. This is a must-change in our culture. We are making great progress but have many years of education and cultural learning to achieve before we have successfully changed this critical area of readiness and responsible nurturing of the individual Sailor (physical and mental health).”

“Awesome / informative brief! Should be mandatory for PCO/PXO/COB/CMC Schools!”

“After over 25 years in the Navy, this was the first presentation ever about how poor sleeping habits affect me as a whole...great information. Very helpful!”

Also, there were several comments recommending improving the information provided in the training by adding information on sleep disorders and sleep hygiene. These recommendations were taken into account and used for revising the materials presented.

“Would like to see the topics of snoring and apnea included, which both seem to be issues with people in our age group.”

“The topic of sleep deprivation is well documented and known....what is more applicable to this group are tips and techniques to counter....address...assist...”

3. Responses from SWOS students

As shown in Figure 6, most of the respondents found that the objectives of the training were clearly explained (~99%) and achieved (~99%). Focusing on the speaker, respondents found that the speaker was easy to understand (~99%), had an effective style (~97%), and interacted effectively with the attendees (~97%). Most importantly, though, attendees found that the content of the training was relevant/useful to their current/future job (~93%), they were satisfied with the training (~91%), and they would recommend it to others (~96%).

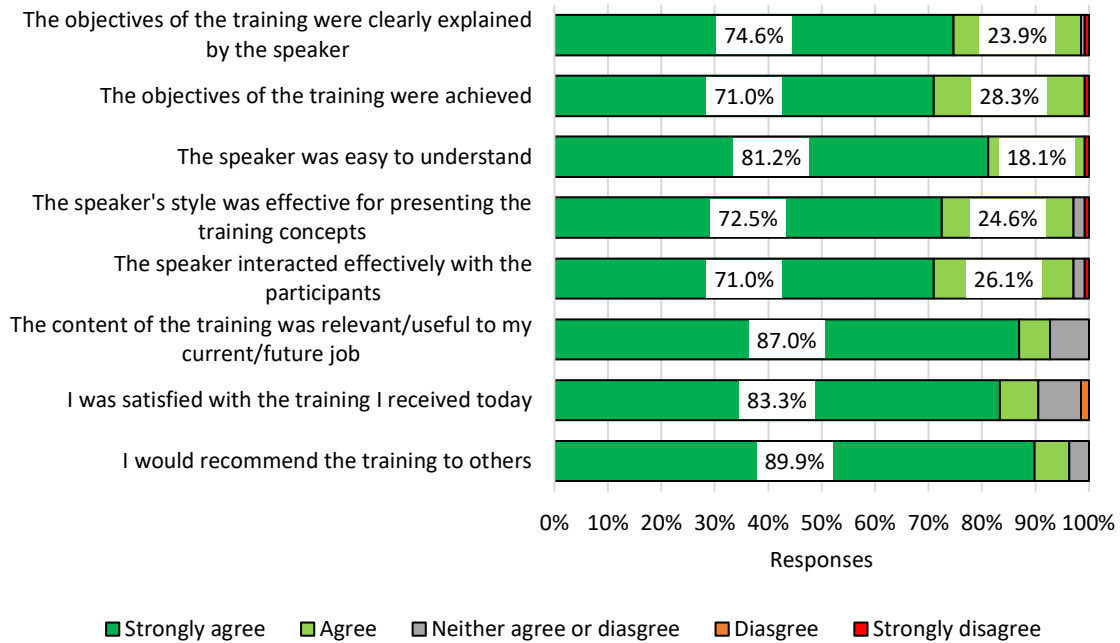


Figure 6. Level of agreement with statements related to the training.

Also, 92.8% of the trainees felt that the amount of training they received was “about right,” and 95.7% responded that the pace of the training session was “about right.” These results are shown in Figures 7 and 8.

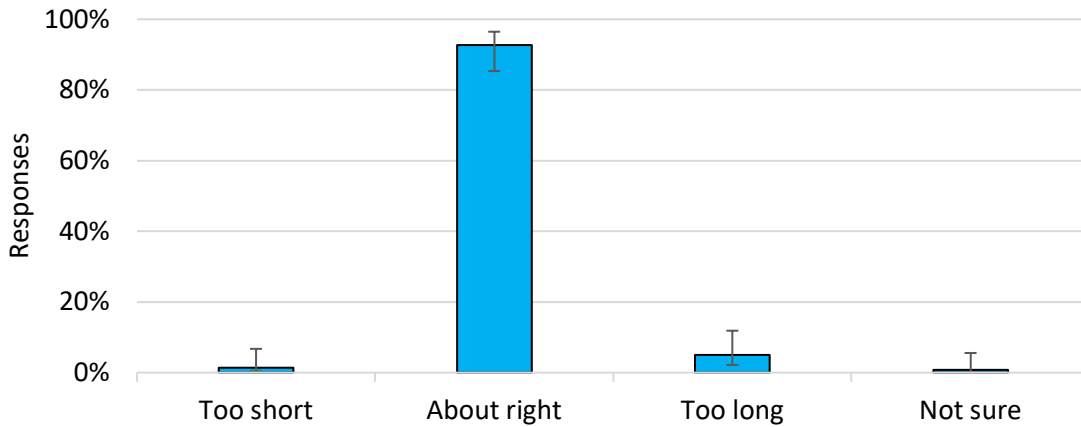


Figure 7. Responses to the question: “In terms of the duration of the training session, did you feel the training was...”. Vertical lines denote the standard error of proportion.

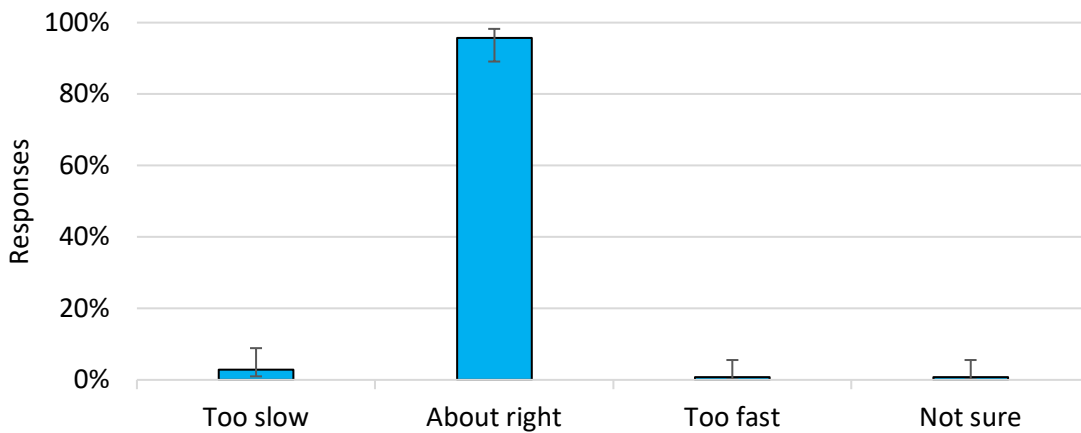


Figure 8. Responses to the question: “In terms of the pace of the training session, did you feel the pace was...”. Vertical lines denote the standard error of proportion.

Next, attendees were asked whether the information provided in five topics of the training sessions was sufficient. Results showed that officers received sufficient information on sleep basics (89.9%), the effects of sleep deprivation (91.3%), and the consequences of fatigue on human performance (87.0%). Even though approximately two-thirds of the participants found that the information provided was sufficient, 33.3% asked for more information on stimulants and sleep-promoting medications, whereas 35.5% asked for more information on tips for healthy sleep in the military environment. These results are shown in Figure 9.

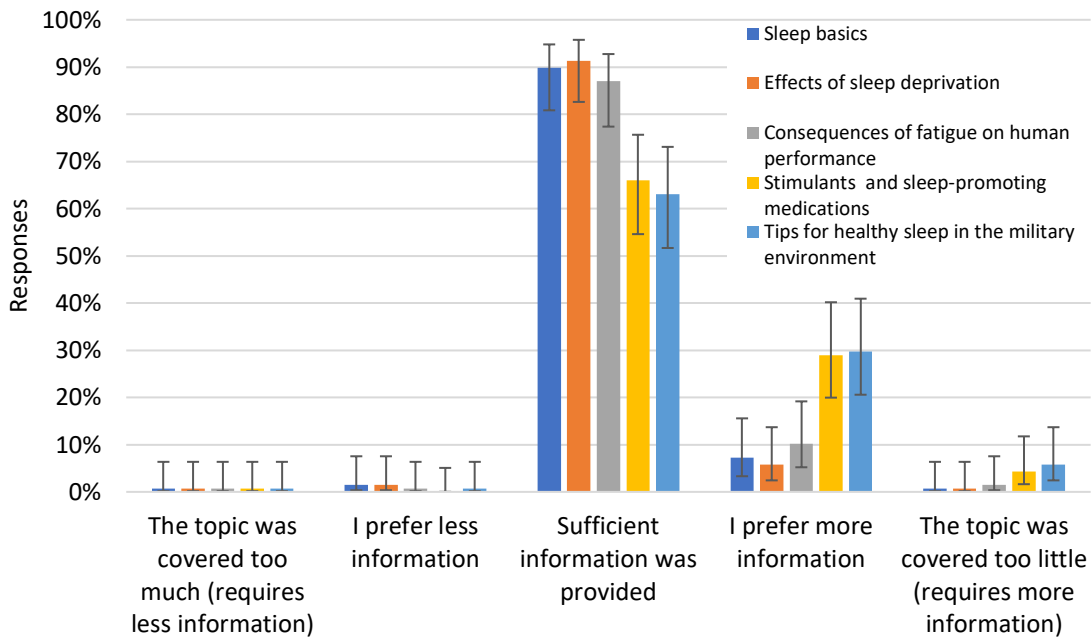


Figure 9. Responses to the question: “Do you feel you currently received enough training on these topics?” Vertical lines denote the standard error of proportion.

Overall, 92.0% of the respondents were satisfied with the sleep and fatigue training (37.0% satisfied and 55.1% very satisfied). Also, 80.4% of the respondents were confident that they can apply what they learned to their work (40.6% moderately confident and 39.9% very confident). These results are shown in Figures 10 and 11.

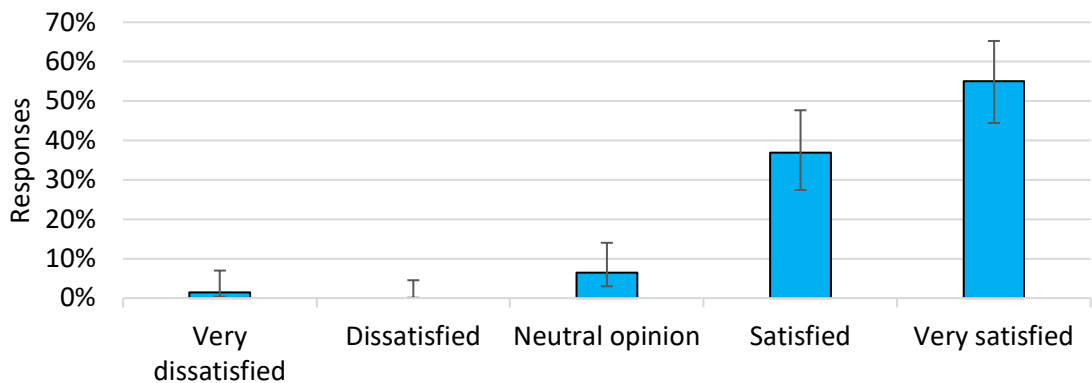


Figure 10. Responses to the question: “Please rate your level of satisfaction with the sleep and fatigue training, overall.” Vertical lines denote the standard error of proportion.

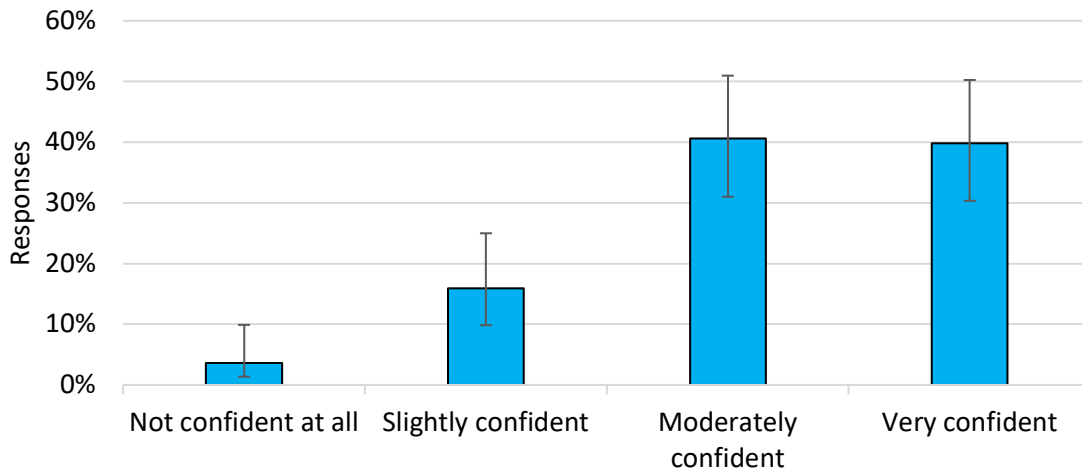


Figure 11. Responses to the question: “How confident are you that you can apply what you learned to you work?” Vertical lines denote the standard error of proportion.

Next, attendees were asked whether there were any topics they would like to pursue learning further. Responses showed that trainees emphasized two areas. First, trainees asked for more information on various circadian watchbills by sections available, how these watchbills can be implemented on ships, and problems in their implementation. Second, trainees asked for more details on how to equitably distribute various duties, tasks, and commitments (e.g., meetings, drills, flight operations, operational commitments) using the daily schedule of circadian-based watchbills. Detailed results are shown in Figure 12.

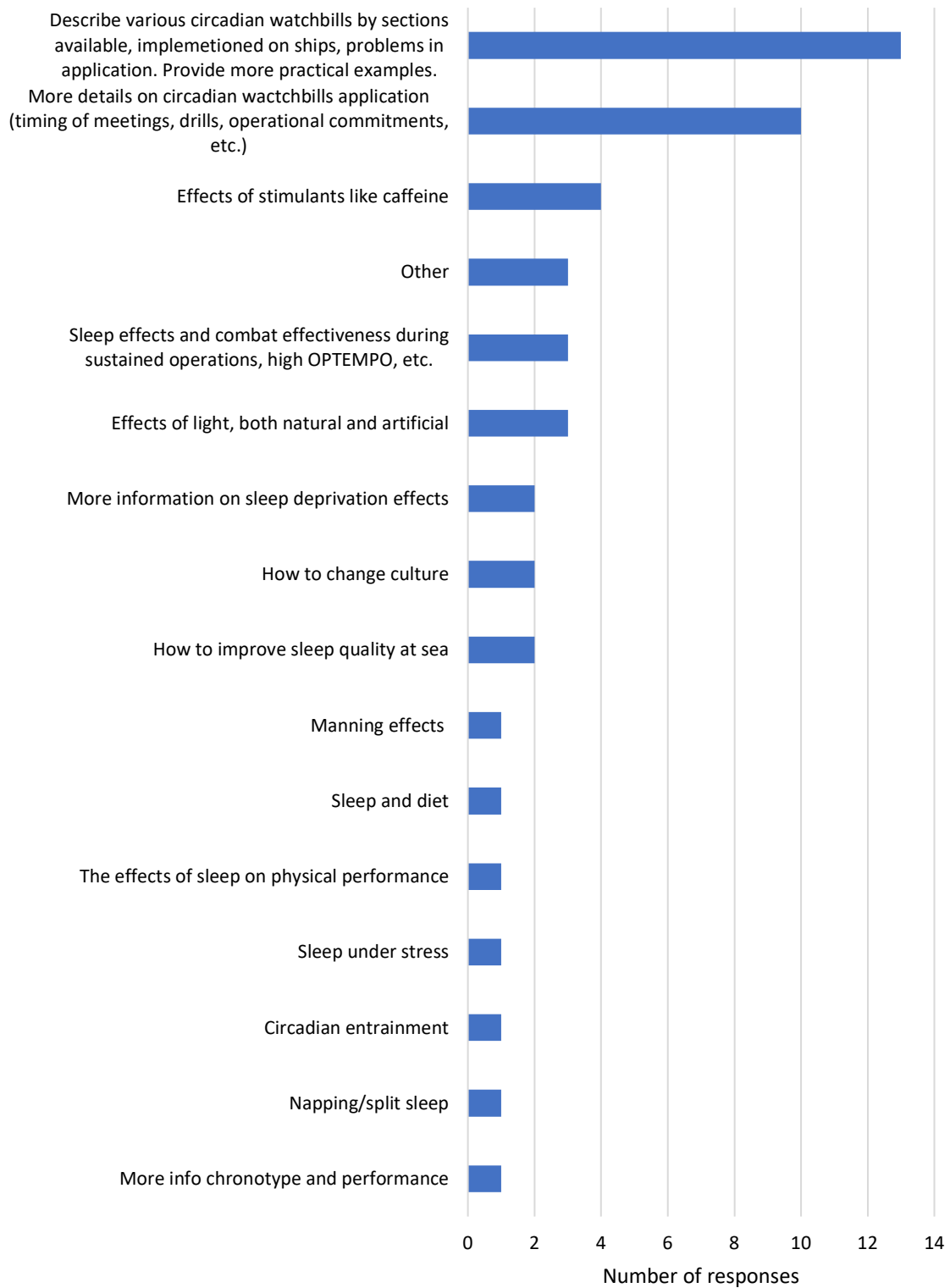


Figure 12. Responses to the question: “Are there any topics you would like to pursue learning further?”

Lastly, trainees were asked to provide recommendations to improve the training. Ten trainees asked for more examples on watchbills and battle rhythms, and more practical examples. Detailed results are shown in Figure 13.

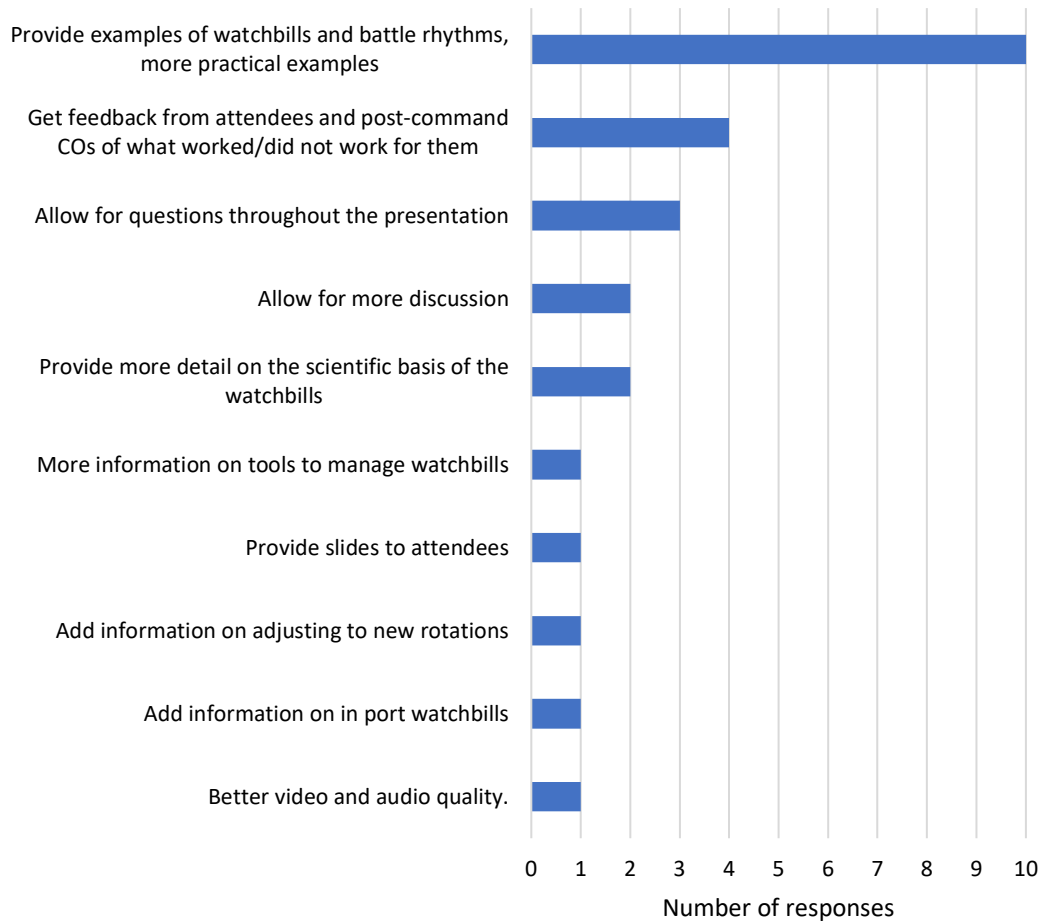


Figure 13. Responses to the question: “Responses to the question: “Are there any topics you would like to pursue learning further?””

C. OTHER ACCOMPLISHMENTS

1. Crew Endurance website

The Crew Endurance Team had previously developed a website as part of the online presence of the team. Under the aims of this project, however, we identified that significant room for improvement existed along three axes: aesthetics, navigation, and context. By improving the website, the overarching goal was to reach a wider audience

and to increase virtual engagement with the target audience and potential key stakeholders within leadership and ship commands.

To improve the Crew Endurance website, we identified stakeholders and US Navy audiences to which the Crew Endurance website should appeal. These audiences included varying levels of warfighters and leadership on ships and shore-based duty. Based on lessons learned from the Crew Endurance Team experience with USN Sailors and information provided by the website users, it was decided that providing a basic understanding of sleep and basic sleep hygiene was just as important as disseminating knowledge on circadian-based watchbills and their implementation. Therefore, the website was updated to support sharing of lessons learned and best practices for the individual and the command. It includes references, tools, and training materials for use by the warfighter and shipboard leaders, as well as templates of shipboard watchbills and instructions to support Crew Endurance programs. Based on an initial preliminary needs analysis combined with an iterative design/implement/assess procedure, the basic structure of the website was refined.

The new website was launched in November 2019 and has been updated periodically. In the initial months of launching the redesigned website, marketing was conducted via social media platforms including Facebook, LinkedIn, and Twitter pages of the Naval Postgraduate School Crew Endurance Team, as well as key players within Navy leadership. The website address was added to hard-copy outreach materials and was included in presentations and in-person training to various commands around the country, as well as Navy senior leadership symposiums at the Naval Postgraduate School.

2. Crew Endurance Handbook

Various units and commands have requested the revised version of the Crew Endurance Handbook. As shown in Table 3, we delivered a total of 2,090 handbooks in the last two months.

Table 3. Delivery of Crew Endurance Handbooks.

Date	Location	Count
11/12/2021	SWOS – Department Head students	300
11/15/2021	SWOS – Prospective Commanding Officers	150
11/15/2021	Commander, Naval Surface Force Pacific (CNSP)	150
11/19/2021	SWOS – Prospective Executive Officers	180
11/23/2021	LCS-19	300
11/24/2021	SWOS - Basic Division Officer Course (BDOC)	600
11/18/2021	MCO	120
11/18/2021	Commander, Naval Surface Forces Atlantic (SURFLANT)	120
11/18/2021	Naval Advanced Medical Development (NAMD)	50
11/18/2021	Various Sailors	20
12/2/2021	Senior Enlisted Academy	30
1/10/2022	1-52 General Aviation Support Battalion, Ft. Wainwright, AK	40
12/16/2021	LCS-19	20
1/28/2022	Senior Enlisted Academy	10

SWOS: Surface Warfare Officers School

V. CONCLUSIONS

The Crew Endurance Training program was designed to provide fleet-wide support (e.g., SURFOR, SURFLANT, SURFPAC, SWOS) on the successful implementation of circadian-based watchbills, and appropriate guidance on sleep management and crew endurance best practices. Combining information from studies conducted by the Naval Postgraduate School Crew Endurance Team on USN ships, the expertise of the Sleep Matters Initiative (SMI), and feedback from active-duty service members, we developed the appropriate training materials. The training was provided to more than 1,160 active-duty service members, both USN Sailors and Marines.

Overall, the responses from all audiences were positive with a high level of satisfaction with the provided training in terms of understanding the importance of sleep, sleep hygiene practices, the important effect of sleep on operational performance and endurance, how best to implement circadian-based watchbills, and with the instructors, course content, and training duration. In general, trainees asked for more in-depth information, but operational commitments limited the time we had available to answer all questions being asked.

Overall, the trainees we surveyed believed that the Crew Endurance training program was successful and beneficial. We should note, however, that the assessment of the crew endurance program was focused solely on whether participants reacted favorably to the learning event, i.e., Kirkpatrick's Level one of the four levels needed to holistically assess a training program according to the Kirkpatrick model (Kirkpatrick & Kirkpatrick, 2006). Due to operational commitments which limited the additional access to the trainees, we were unable to assess participants' level of learning from the program, changes in their behavior, or tangible results from the training program. Especially the latter two (behavior and results) may be difficult to assess in the military operational environments (Salas, Milham, & Bowers, 2003; Shobe & Curtis, 2007). Verified by the literature review, observations from several of our field studies showed that changing sleep behavior is challenging and providing training alone may not be sufficient to effect a change. Tailoring training materials for a specific audience may also not be enough to change behavior. Crew endurance training must be strongly endorsed and supported by

the group's leadership and it must be accompanied by appropriate changes in the work hours and work conditions.

Along these lines, another multi-year project by the NPS Crew Endurance Team focuses on assessing the effective implementation of circadian-based watchbills in the USN surface naval vessels, identifying problems, and providing potential solutions. We believe that the optimal implementation of circadian-based watchbills, combined with training Sailors on the benefits of crew endurance, will eventually improve crew operational performance, reduce mishaps, and result in better health outcomes (Shattuck & Matsangas, 2019b).

We plan to continue providing training to military audiences to improve awareness of the importance of sleep hygiene and the association between healthy sleep and operational performance and resilience. Further, we will continually assess the effectiveness of the program, and adapt to the needs of the attendees and the Navy as a whole.

1. Study limitations

An important caveat of our assessment is that it is focused on Level One of Kirkpatrick's model, i.e., the reaction of attendees to the training (Kirkpatrick & Kirkpatrick, 2006). Unfortunately, assessment of higher levels on the Kirkpatrick scale differences in behavior resulting from the training; and overall evaluation of the effect of training in the operational environment remain challenging.

COVID-19 affected the delivery of training by limiting in-person activities after March 2020. The travel restrictions, however, did not seem to negatively affect the delivery of training. Contrary to our initial expectation, restricted traveling seems to have increased the opportunity to provide virtual presentations and has enhanced our ability to reach some audiences. Also, responses from the Navy senior leaders did not change between the in-person and online delivery of the training (Fisher's exact test, $p > 0.05$).

VI. RECOMMENDATIONS

Based on the findings from this study and the expressed need for training on crew endurance and guidance regarding the efficient application of circadian watchbills, we recommend the continuation of the Crew Endurance Training project. In particular, the following tasks should be considered:

- Continue providing training to military audiences to improve awareness of the importance of sleep hygiene and the association between healthy sleep and operational performance and resilience.
- Continue improving/revising existing tools and develop new tools that will assist leadership to determine appropriate watch schedules based on individual vessel attributes.

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APPENDIX A: ASSESSMENT QUESTIONNAIRES

A. 9-ITEM VERSION OF THE ASSESSMENT QUESTIONNAIRE

Response to Training

CONFIDENTIALITY & PRIVACY: Any information that is obtained during this survey will be kept confidential to the full extent permitted by law. All efforts, within reason, will be made to keep any personal information in your responses confidential but total confidentiality cannot be guaranteed. All data from this survey will be kept on a secure server and/or locked facility and only the research team will have access to the data.

1. Please indicate if you agree or disagree with the following statements about the training you just received.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Training was relevant.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Training was understandable.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I would recommend the training to others.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The trainer was easy to understand.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was satisfied with the training I received today.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

2. In terms of how long the training session was, did you feel the training was... (select one)

- Too short
- About right
- Too long
- Not sure

3. In terms of the pace of the training session, did you feel the pace was... (select one)

- Too slow
- About right
- Too fast
- Not sure

4. Do you feel you currently receive enough training on sleep and fatigue? (select one)

- Yes, it is about right
- No, it is too little training
- No, it is too much training

5. What would make you more satisfied with the training? (comment below)

B. 6-ITEM VERSION OF THE ASSESSMENT QUESTIONNAIRE

Training Assessment Questionnaire

1. Please rate the following statements.

	Poor (1)	(2)	Neutral (3)	(4)	Outstanding (5)
Objectives were clearly explained by the speaker	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The objectives of the presentation were achieved	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Content of this module is relevant/useful to my current/future job	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The speaker's style was effective for presenting these concepts	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The speaker interacted effectively with the participants	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

2. Please provide comments and recommendations

C. 19-ITEM VERSION OF THE ASSESSMENT QUESTIONNAIRE

Training Assessment Questionnaire (K1/2)

CONFIDENTIALITY & PRIVACY: Any information that is obtained during this survey will be kept confidential to the full extent permitted by law. All efforts, within reason, will be made to keep any personal information in your responses confidential but total confidentiality cannot be guaranteed. All data from this survey will be kept on a secure server and/or locked facility and only the research team will have access to the data.

1. Please indicate if you agree or disagree with the following statements.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
The objectives of the training were clearly explained by the speaker	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The objectives of the training were achieved	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The speaker was easy to understand	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The speaker's style was effective for presenting the training concepts	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The speaker interacted effectively with the participants	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

2. In terms of the duration of the training session, did you feel the training was... (select one)

Too short
 About right
 Too long
 Not sure

3. In terms of the pace of the training session, did you feel the pace was... (select one)

Too slow
 About right
 Too fast
 Not sure

4. Please rate your level of agreement with the following statements.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
The content of the training was relevant/useful to my current/future job	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was satisfied with the training I received today	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I would recommend the training to others	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

5. The following is a list of the topics covered in your training. Do you feel you currently received enough training on these topics?

	The topic was covered too much (requires less information)	I prefer less information	Sufficient information was provided	I prefer more information	The topic was covered too little (requires more information)
Sleep basics	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Effects of sleep deprivation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Consequences of fatigue on human performance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stimulants (caffeinated beverages, energy drinks, nicotine, medications, etc.) and sleep-promoting medications	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tips for healthy sleep in the military environment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

6. Please rate your level of satisfaction with the sleep and fatigue training, overall. (select one)

Very dissatisfied	Dissatisfied	Neutral opinion	Satisfied	Very satisfied
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

7. How confident are you that you can apply what you learned to you work? (select one)

Not confident at all	Slightly confident	Moderately confident	Very confident
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

8. Are there any topics you would like to pursue learning further? (comment below)

9. What would you recommend to improve the training? (comment below)

APPENDIX B: LIST OF PRODUCTS DEVELOPED UNDER THIS PROJECT

A. REFEREED CONFERENCE PAPERS

Shattuck, N.L., Matsangas, P., Clifton, H., Hart, J., Czeisler, C., & Barger, L. (2020). Crew endurance training in the United States Navy: Interim assessment of a 3-year project. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, 64(1), 841-845. Doi: 10.1177/1071181320641195.

Shattuck, N.L., & Matsangas, P. (2021). Crew endurance training in the United States Navy: Lessons learned from senior leadership, prospective commanding/executive officers, and department heads. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, 65(1), 1470-1474. Doi: 10.1177/1071181321651076.

B. CONFERENCE POSTERS

Shattuck, N.L., Matsangas, P., Chawinga, Z., Clifton, H., Geiger, L., Hart, J., Weaver, M., Czeisler, C., & Barger, L. (2019, 18—22 August). Enhancing crew endurance in the United States Navy: Progress from the first year of a 3-year training project. Poster presented at the Military Health System Symposium (MHSRS), Kissimmee, FL.

Shattuck, N.L. & Hancock, M.L. (2020). Enhancing Crew Endurance in the United States Navy: Virtual Public Engagement and Training. Poster presented at the Military Health System Symposium (MHSRS), Kissimmee, FL

Shattuck, N.L. and Matsangas, P. (in review) “Satisfaction with Crew Endurance Training: Results from US Navy Senior Leaders and Surface Warfare Officers”

C. PRESENTATIONS

- Updated Sleep Hygiene & Crew Endurance Presentation
- Updated Virtual Sleep Hygiene & Crew Endurance Brief
- Sleep Hygiene & Crew Endurance Brief developed for US Army and US Marine Corps
- Basic Division Officer Course – BDOC, Special Operations Command - SOCOM

D. OTHER PRODUCTS

- Virtual Brochure
- Sleep Tip Cards
- Website Promotional Cards
- The Crew Endurance website is here: <https://nps.edu/web/crewendurance>
- SMART tool instruction video
- Sleep and Immunity Video
- Crew Endurance Team Research Directory

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