



ELSEVIER

Contents lists available at ScienceDirect

Air Medical Journal

journal homepage: <http://www.airmedicaljournal.com/>

Original Research

Causes and Management of Sleepiness Among Pilots in a Norwegian and an Austrian Air Ambulance Service—A Comparative Study

Erik Zakariassen,^{1,2*} Siri Waage,^{1,3} Anette Harris,⁴ Pia Gatterbauer-Trischler,⁵ Bernd Lang,⁵ Wolfgang Voelckel,⁶ Ståle Pallesen,^{3,4} Bjørn Bjorvatn,^{1,3}

¹ Department of Global Public Health and Primary Care, University of Bergen, Bergen, Norway

² The Norwegian Air Ambulance Foundation, Drøbak, Norway

³ Norwegian Competence Center for Sleep Disorders, Haukeland University Hospital, Bergen, Norway

⁴ Department of Psychosocial Science, Faculty of Psychology, University of Bergen, Bergen, Norway

⁵ Air Rescue College, Christophorus Flugrettungsverein, Vienna, Austria

⁶ Medical Department, Christophorus Flugrettungsverein, Vienna, Austria



A B S T R A C T

Objective: We compared subjectively reported sleepiness and fatigue as well as causes and management strategies for combating sleepiness among pilots working in 2 different helicopter emergency medical services operating with different shift systems.

Methods: Pilots from the Norwegian Air Ambulance (NAA) and Christophorus Flugrettungsverein (CFV) in Austria participated. NAA performs flight missions 24/7, whereas at the time of the study the participating CFV bases did not fly after sunset. The pilots are on duty for 1 week in both services. NAA and CFV used an identical research protocol, including questionnaires about sleep, sleepiness (Epworth Sleepiness Scale and Karolinska Sleepiness Scale), coping strategies, and work-related causes of fatigue.

Results: CFV pilots kept busy, whereas NAA pilots slept and did physical exercise as strategies to prevent sleepiness. The majority in both groups used napping and coffee consumption as strategies. CFV pilots reported more frequently than NAA pilots that administrative duties and environmental factors were reasons preventing napping.

Conclusion: Some differences existed between the 2 pilot groups regarding strategies for managing sleepiness and causes that prevented pilots from napping. Pilots in both groups were healthy, physically active, and had normal Epworth Sleepiness Scale and Karolinska Sleepiness Scale scores.

© 2018 The Authors. Published by Elsevier Inc. on behalf of Air Medical Journal Associates. This is an open access article under the CC BY-NC-ND license. (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

Both working hours that overlap with usual sleeping time and extended working hours influence biological rhythms and social life. Shift work, and especially night work, usually involve activity when the circadian rhythm promotes sleep and sleep when the circadian rhythm promotes wakefulness. This causes misalignment between the endogenous circadian timing system and the external 24-hour timing system. Accordingly, shift work has consistently been shown to be associated with health problems. Most common are sleep

disturbances such as prolonged sleep onset, reduced sleep duration, and excessive sleepiness.^{1,2}

Sleepiness is not equivalent to fatigue. Sleepiness refers to a state of increased sleep propensity³ and is distinguished from fatigue, which is frequently differentiated into muscular and mental fatigue. Muscular fatigue refers to an exercise-induced reduction in maximal voluntary muscle force,⁴ whereas mental fatigue comprises a psychological state caused by prolonged periods of demanding cognitive activity and is characterized by subjective feelings of “tiredness” and “lack of energy.”⁵ In aviation, fatigue and sleepiness have long been identified as occupational hazards.^{6,7} However, relevant research on emergency medical service providers, air ambulance, helicopter emergency medical service (HEMS), and shift work is scarce.^{8–11}

Anette Harris received salary for 6 months from The Norwegian Air Ambulance Foundation.

* Address for correspondence: Erik Zakariassen, Department of Global Public Health and Primary Care, PO Box 7810, 5020 Bergen, Norway.

E-mail address: erik.zakariassen@uib.no (E. Zakariassen).

1067-991X/\$36.00

© 2018 The Authors. Published by Elsevier Inc. on behalf of Air Medical Journal Associates. This is an open access article under the CC BY-NC-ND license.

(<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

<https://doi.org/10.1016/j.amj.2018.11.002>

Different shift systems and different methods used in research render it difficult to compare data between different systems across countries and services. Research on how pilots in HEMS manage sleepiness and what they consider as work-related causes of sleepiness is very limited. Nevertheless, the International Civil Aviation Organization manual has suggested some personal fatigue mitigation strategies, such as what to do when sleep at home is disturbed by a new baby or in the case of extended commuting before duty period.¹² To address the aforementioned limited research and knowledge, the main aim of this study was to compare the pilots' general/overall perception of subjectively reported sleepiness, causes of sleepiness, and management strategies for combating sleepiness in a Norwegian and an Austrian HEMS service.

Material and Methods

In 2014, the Norwegian Air Ambulance (NAA) established a fatigue risk management system (FRMS). Therefore, to meet the need for baseline data, a larger research project was initiated. At that time, the NAA operated 8 bases in Norway, with 9 helicopters.

The NAA pilots are on duty 7 days and off duty 14 days followed by 7 days on duty and 21 days off duty. They perform helicopter missions 24/7 while on duty throughout the year. During the duty week, they live together with the other crewmembers at the base in single bedrooms. As part of the safety policy, there are duty time limitations and rest requirements. For the Norwegian pilots, the maximum allowable flight time (measured from takeoff and landing on base on return + 1 hour) for crewmembers amounts to 7 hours within a consecutive 24-hour period, 12 hours in a consecutive 48-hour period, and maximum of 30 hours during a consecutive 7-day period. During 6 summer weeks, 30 NAA pilots performed 483 missions, 10% of the missions between midnight and 6 AM. The mean time spent on missions per duty week was 1,424 minutes with a 95 % confidence interval between 1,207 and 1,642 minutes.

To be able to compare causes and management strategies for sleepiness and fatigue between Austrian and Norwegian pilots, the Norwegian research group invited the Austrian air ambulance Christophorus Flugrettungsverein (CFV) to participate and to perform a similar study using the same research protocol. The normal schedule for the CFV pilots included 7 days on duty followed by 7 days off duty. At that time, the crews in Austria only performed missions that started at daylight. During the work period, the crews mainly live together at the base in single bedrooms. However, if the pilots live close to the base (eg, < a 30-minute drive), they may spend the night at home.

The maximum hours on duty and the respective maximum time for HEMS operations for the Austrian pilots is 16 hours on duty with 7 hours as the maximum allowable flight time (measured from take-off at the base to landing on base on after return) and 112 hours on duty within 7 successive days. The minimum rest period for HEMS operations is 8 hours between 2 HEMS duty days, and 36 hours of rest time between 2 HEMS duty periods (7 successive days on duty). During 7 summer weeks, 21 CFV pilots performed 576 missions. The mean time spent on missions per duty week was 1,539 minutes with a 95% confidence interval between 1,331 and 1,793 minutes.

An identical research protocol was used in both Norway and Austria. All pilots in NAA (n = 30) and half of the pilots in CFV (n = 24) were invited to participate. In order to obtain a balance between urban and busier bases and rural and less busy bases, the pilots in Austria were selected based on geographic differences and numbers of missions per year on the different HEMS bases. The pilots completed a questionnaire about sleep and sleepiness while at work. The questionnaire included items about demographic and background variables like sex, age, marital status, children, years in present work, health and different questions about sleep, work-related sleepiness, and management of sleepiness. Management of sleepiness was

divided into 15 different strategies, and the pilots could tick off as many as applicable. Response options to a question about what prevented pilots from napping were divided into 10 different causes, and the pilots could tick off as many as applicable. Work-related causes of fatigue were divided into 8 different potential fatigue-triggering situations. For each situation, the pilot could choose between does not cause fatigue, low fatigue, moderate fatigue, high fatigue, and not applicable.

Epworth Sleepiness Scale

The Epworth Sleepiness Scale (ESS) is considered a trait measure of subjective sleepiness and was completed once. ESS assesses the subject's general tendency to fall asleep or doze off in 8 different situations. Each item is scored from 0 (no probability) to 3 (high probability), yielding a total score between 0 and 24. The scale has shown high validity and reliability. ESS > 10 indicates excessive daytime sleepiness.^{13,14} Cronbach alpha based on categorical principal analysis in the CFV pilot group was 0.89, and in the NAA pilot group, it was 0.87.

Karolinska Sleepiness Scale

The Karolinska Sleepiness Scale (KSS) comprises a 1-item 9-point scale measuring subjective sleepiness rated from 1 = very alert, 3 = alert, 5 = either alert or sleepy, 7 = sleepy but no problems staying awake to 9 = very sleepy, fighting sleep, effort to stay awake.^{15,16} When awake, the pilots were instructed to complete the KSS every second hour during the workweek.

Statistics

Statistical analyses were conducted with SPSS, Version 20 (IBM Corp, Armonk, NY). Standard descriptive data analyses were used to characterize the sample. The response options in work-related causes of fatigue were merged before statistical analyses. Does not cause fatigue and low fatigue were merged into no fatigue, and moderate fatigue and high fatigue were merged into fatigue. The response alternative not applicable was excluded from statistical analyses. The scores on the ESS and KSS are presented in terms of mean, standard deviation (SD), and range (minimum-maximum). The distribution of data concerning age, number of years in same occupational position, and sleep need (hours) were skewed and were thus presented as a median with interquartile range; *t*-tests to compare statistical differences between means and the Mann-Whitney *U* test to compare statistical differences between median values were used to evaluate differences between the 2 pilot groups. For other comparisons, the Pearson chi-square was used, and the Fisher exact test was used when tables had cells with a frequency of less than 5. A *P* value of .05 or below was considered statistically significant.

Ethics

The Regional Committee for Medical and Health Research Ethics, Health Region West (no. 2014/593) approved the Norwegian part of the study. In Austria, Ethikkommission, Land Salzburg informed CFV that ethical approval was not needed (415-EP/73/671-2016).

Results

Eighty-eight percent of the CFV pilots (n = 21) and 80% (n = 24) of the NAA pilots responded to the questionnaire. There were no statistical differences between the pilots from the CFV compared with the NAA pilots in regard to background variables like marriage/cohabitation, children at home, age, and hours of sleep needed (Table 1). The pilots from CFV had been in the same position as a pilot longer than NAA pilots (*P* = .04). Regarding physical health, the majority in both groups reported this to be "very good" or "good." The majority of all pilots in both groups reported that they got sufficient sleep both on and off duty.

Table 1

Background and Sleep Characteristic in the 2 Pilot Groups: The Norwegian Air Ambulance (NAA) and the Christophorus Flugrettungsverein (CFV)

Continuous Variables	CFV (n = 21)	NAA (n = 24)	Statistic	P Value
	Median (IQR)	Median (IQR)		
Age	43 (40–48)	45 (39–48)	−0.16 ^a	.87 ^b
Years in same position	11 (5–16)	6 (3–9)	−2.20 ^a	.03 ^b
Hours need of sleep	7 (7–8)	7 (7–8)	−0.19 ^a	.85 ^b
Categoric variables	n (%)	n (%)	—	1.00 ^d
Male	21 (100)	23 (96)	—	1.00 ^d
Married/cohabitant	17 (81)	22 (92)	—	.40 ^d
Children at home	14 (67)	19 (79)	0.37 ^c	.50 ^d
Physical health			2.67 ^e	.24 ^d
Very good	14 (67)	11 (46)		
Good	7 (33)	11 (46)		
Average	0 (0)	2 (8)		
Poor	0 (0)	0 (0)		
Sleep problems related to work schedule			4.89 ^e	.07 ^d
No	11 (50)	17 (71)		
Little	6 (27)	7 (29)		
Some	4 (23)	0 (0)		
Often	0 (0)	0 (0)		
Very often	0 (0)	0 (0)		
Sufficient sleep off duty			4.67 ^e	.19 ^d
Always	10 (48)	10 (42)		
Almost always	11 (52)	9 (38)		
Sometimes	0 (0)	4 (16)		
Seldom	0 (0)	1 (4)		
Sufficient sleep on duty			3.31 ^e	.26 ^d
Always	7 (34)	10 (42)		
Almost always	11 (52)	14 (58)		
Sometimes	3 (14)	0 (0)		
Seldom	0 (0)	0 (0)		

IQR = interquartile range.

^a z value.^b P value based on the Mann-Whitney U test.^c Continuity correction.^d P value based on the Fisher exact test.^e Fisher value.

There were some statistical differences between the pilots in terms of strategies to prevent sleepiness (Table 2). A higher number of CFV pilots kept themselves busy compared with the NAA pilots, whereas a larger number of NAA pilots slept and did physical exercise as strategies to prevent sleepiness compared with the CFV pilots. The majority in both groups used napping and coffee consumption as strategies. About half of the pilots in both countries drank water, and less than half ate food as a strategy. Energy drinks, with or without caffeine and herbal stimulants, were not used.

There were statistically significant differences between the 2 services in terms of reported causes that prevented the pilots from napping during duty time. Administrative duties, phone calls, and environmental factors were reported more often among the CFV pilots as reasons for not napping, whereas among the NAA pilots, HEMS missions were most commonly reported. Both pilot groups reported “not tired enough” as an important factor for not napping (Table 2).

Among the pilots who did not choose not applicable, the majority in both countries responded no fatigue to most of the potential work-related fatigue-triggering situations, with only 1 statistically significant difference between Austrian and Norwegian pilots (Table 3). Inadequate sleep environment was reported to cause fatigue by 38% of the CFV pilots compared with 17% among the NAA pilots ($P = .04$). There were no statistical differences between the 2 services with regard to commuting, night HEMS missions, sleep loss, or administrative duties.

The CFV pilots' mean ESS score was 7.2 (SD = 2.6; range, 3–13), whereas the corresponding value for the NAA pilots was 6.9

Table 2

Sleepiness Management Strategies Used by the Pilots and Factors That Prevent Pilots From Napping

Sleepiness management strategies	CFV (n = 21)		NAA (n = 24)		Statistic	P Values
	n	%	n	%		
Napping	17	81	21	88		.69 ^a
Keep busy	13	61	5	21	6.25 ^b	.01
Drink coffee	11	52	17	71	0.93 ^b	.23
Drink water	10	48	14	58	0.18 ^b	.56
Talking to people on base	9	43	8	33	0.12 ^b	.55
Sleeping	5	24	17	71	8.12 ^b	<.01
Physical exercise	4	19	15	63	6.98 ^b	0.01
Listening to music	4	19	4	17		1.00 ^a
Eating food	3	14	9	38	2.01 ^b	.10
I do not use any strategies	1	5	2	8		1.00 ^a
Drink tea	1	5	1	4		1.00 ^a
Drink energy drinks without caffeine	0	0	0	0		—
Using nicotine	0	0	2	8		.49 ^a
Using herbal stimulants	0	0	0	0		—
Drink caffeinated soft drinks	0	0	0	0		—
Causes that prevent pilots from napping						
Administrative duties	14	67	7	29	4.91 ^b	.02
Phone calls	14	67	3	13	11.77 ^b	<.01
Do not feel tired enough	10	48	15	63	1.64 ^b	.14
HEMS missions	8	38	17	71	3.63 ^b	.04
Environmental factors ^c	8	38	2	8		.03 ^a
I feel napping is unprofessional	3	14	0	0		.09 ^a
I do not think naps are beneficial	0	0	1	4		1.00 ^a
Base culture does not encourage napping	0	0	0	0		—

CFV = Christophorus Flugrettungsverein; HEMS = helicopter emergency medical service; NAA = Norwegian Air Ambulance.

^a P value based on the Fisher exact test.^b Continuity correction.^c For example, uncomfortable bed, light, noise, and temperature.

(SD = 2.2; range, 1–12) ($t_{39,10} = -0.38$, $P = .71$). In CFV, 3 pilots had excessive daytime sleepiness (2 pilots scored 11 and one 13), whereas in NAA 1 pilot had excessive daytime sleepiness (scored 12).

The CFV pilots' mean KSS score during the workweek was 2.85 (SD = 0.8; range, 2.7–2.9), whereas the corresponding value for the NAA pilots was 2.07 (SD = 0.9; range, 1.9–2.3) ($t_{12,0} = 10.5$, $P < .001$). For both pilot groups, the maximum score given at 1 registration point during a workday was 8.

Discussion

Overall, the pilots reported that they got sufficient sleep during both on- and off-duty weeks. Napping was an important strategy preventing sleepiness for both groups. Administrative duties, phone calls, and environmental factors prevented the Austrian pilots from napping more often than the Norwegian pilots. The mean ESS scores for the vast majority fell within normal values. The findings support the notion that the pilots did not suffer from sleep debt.

Overall, small differences existed between the 2 pilot groups related to family situation, age, and need of sleep. Almost all of the pilots found themselves to be healthy and reported sufficient sleep, both on and off duty. In all, 6 (29%) of the 21 CFV pilots who participated in the study slept at home during duty weeks.

Both groups used several management strategies to prevent sleepiness. A vast majority in both groups, as a strategy to prevent sleepiness, used napping. Naps reduce sleepiness and help to increase alertness. Short naps (10 minutes) seem to have an immediate beneficial effect.^{17,18} The downside of naps is sleep inertia that may occur when naps last for some time (eg, ≥ 30 minutes), causing impaired performance compared with the state before nap or no nap.¹⁹ Naps of

Table 3
Work-related Causes of Fatigue Among Christophorus Flugrettungsverein (CFV) and Norwegian Air Ambulance (NAA) Pilots

Work-related causes of fatigue	CFV (n = 21)		NAA (n = 24)		Statistic	P Value
	n	%	n	%		
Time spent commuting to/from base						.11 ^a
No fatigue	15	71	15	63		
Fatigue	1	5	7	29		
7 consecutive 24-h HEMS duties						.33 ^a
No fatigue	18	86	23	96		
Fatigue	3	14	1	4		
Inadequate sleep environment ^c						.04 ^a
No fatigue	7	34	18	75		
Fatigue	8	38	4	17		
Long HEMS missions (> 2 h)						.67 ^a
No fatigue	18	86	20	83		
Fatigue	2	10	4	17		
Night HEMS missions					1.16 ^b	.28
No fatigue	9	43	12	50		
Fatigue	3	14	12	50		
Multiple (> 3) HEMS missions per day					0.89 ^b	.32
No fatigue	13	62	19	79		
Fatigue	8	38	5	21		
Administrative duties						.09 ^a
No fatigue	15	71	21	88		
Fatigue	5	24	1	4		
Sleep loss					1.67 ^b	.17
No fatigue	3	15	11	46		
Fatigue	12	57	13	54		

^a P value based on the Fischer exact test.

^b Continuity correction.

^c For example, sleep disturbed by uncomfortable bed, light, noise, and temperature.

a 15- to 20-minute duration may have no immediate effect on alertness and performance, probably because of mild sleep inertia.¹⁹

One important positive safety aspect was that all pilots worked within a culture that was positive toward napping. However, the CFV pilots reported that administrative duties, phone calls, and environmental factors were the most frequent causes that prevented them from napping. These factors are preventable and should not be causes for not napping if pilots urgently need rest. The Norwegian shift system with 7 days and nights at the HEMS base might have established a stronger culture for both napping and sleeping at daytime and a mutual understanding that administrative duties can wait.

Other interesting differences in sleepiness management strategies were noted. More CFV pilots than NAA pilots kept themselves busy as a sleepiness management strategy. Activity may be a way to counteract sleepiness.²⁰ Fewer CFV pilots used physical exercise as a strategy compared with the NAA pilots. One possible explanation could be lack of time because some CFV pilots return home in the evening during the duty week. All HEMS bases operated by the NAA have a training facility that makes it easy to exercise. This is not standard in CFV, and 1 consequence is less of an opportunity to perform physical exercise. It is important to keep in mind that good physical condition is reported to decrease the negative effects of shift work and increase alertness.^{21,22} Still, physical exercise performed close to bedtime may delay sleep.²³

A higher percentage of CFV pilots reported inadequate sleep environment as a work-related cause of fatigue compared with NAA pilots. CFV pilots also reported environmental factors as reasons that prevented them from napping. Environmental factors preventing sleep can be easily corrected. More CFV pilots answered that administrative duties and phone calls prevented them from napping compared with NAA pilots (Table 2). Interestingly, in the questions about work-related causes of fatigue, there was no statistical difference between the 2 pilot groups in terms of administrative duties. The

majority in both groups answered “no fatigue.” Still, some pilots in both groups reported fatigue because of administrative duties.

ESS scores in norm populations are reported to be approximately 6 to 7.^{13,24,25} In a study about predictors of negative effects, nurses reporting no negative effects had a mean ESS score of 7.7.²⁶ Emergency medical service workers in the United States reported a mean ESS score of 7.9 (SD = 5.2).¹¹ The majority of these had ≥ 12 -hour shifts and worked on average 13 (SD = 9.1) shifts per month.¹¹ In the present study, the pilots from both groups scored within the normal range of ESS scores. CFV pilots are allowed to be on duty for 16 hours, including 7 hours flight time, compared with NAA pilots with 7 hours flight time within 24 hours. Furthermore, CFV pilots are allowed to commute between home and base. This could decrease sleep hours for CFV pilots even though no differences in ESS score between the services were found. In total, 3 pilots in CFV and 1 in NAA scored above 10. A functional FRMS is important to avoid high ESS scores.

The mean KSS scores show that the pilots in both groups are within the “alert” area with good margin although a statistically significant difference in the mean score between the 2 pilot groups was found. This indicates that the pilots get enough rest during a workweek. Still, for pilots, the KSS score did reach high levels on certain days, which underlines the importance of continuous focus on FRMS, as mentioned earlier.

The strengths of the present study were the high response rate and the use of a validated instrument for the measurement of sleepiness (ESS and KSS). Another asset was that pilots from 2 different countries and HEMS services who differ in terms of night flights were part of the data collection using the same data collection protocol.

However, some limitations of the present study should be noted. The differences between the 2 pilot groups regarding night missions (NAA) versus no night missions (CFV) seem to be less evident than expected because more than half of the CFV pilots seemed to perform night flights. Although the response rate was high, a relatively limited number of pilots participated in the study, which limited the statistical power. The external validity must be interpreted with caution. All data are based on self-reports, introducing possible biases (such as common method bias, social desirability bias, and memory bias). Fluctuation in sleep loss and sleepiness among the different pilots during duty weeks warrant further investigation.

The results overall suggested that excessive sleepiness was reported with a very low frequency in both services, which may reflect similarities between the 2 pilot groups in terms of workload and rest opportunity. Still, some differences between services were reported, which probably are results of different shift systems but also different culture and differences in base facilities. Studies have in general found cross-cultural differences concerning heavy work investment, the latter being most common in societies where survival values are important.²⁷ There may also be differences between the 2 services in terms of safety culture,²⁸ which could have influenced the findings. These factors should be taken into consideration when interpreting the findings of the present study.

Further research is needed to isolate the effect of shift systems. Analyses of data collected during duty weeks, sleep diaries, sleepiness scores across time of day, objective measurements with actigraphy, reaction time tests, and the pilots' workload are natural next steps. In other air ambulances services, like in the United States, 8- and 12-hour shifts are common. Thus, similar studies as the present one should be conducted among pilots working those types of shifts.

Conclusion

Despite different shift systems, there were few differences between the 2 nations' pilots regarding causes and management of sleepiness. However, some statistically significant differences did exist within management strategies of sleepiness, factors that prevent pilots from napping and work-related causes of fatigue. Pilots in both groups were healthy and physically active. Although a whole week on duty and

some long shifts that normally cause elevated sleepiness,²⁹ both trait (ESS) and state measures of sleepiness (KSS) during a workweek were within normal values. Good sleep facilities and an accepting culture for napping and sleep at daytime seem to be important factors ensuring low levels of sleepiness among the pilots.

References

- Costa G. The impact of shift and night work on health. *Appl Ergon*. 1996;27:9–16.
- Harma M, Kecklund G. Shift work and health - how to proceed? *Scand J Work Environ Health*. 2010;36:81–84.
- Hossain JL, Ahmad P, Reinish LW, Kayumov L, Hossain NK, Shapiro CM. Subjective fatigue and subjective sleepiness: two independent consequences of sleep disorders? *J Sleep Res*. 2005;14:245–253.
- Gandevia SC. Spinal and supraspinal factors in human muscle fatigue. *Physiol Rev*. 2001;81:1725–1789.
- Akerstedt T, Wright Jr KP. Sleep loss and fatigue in shift work and shift work disorder. *Sleep Med Clin*. 2009;4:257–271.
- Sallinen M, Sihvola M, Puttonen S, et al. Sleep, alertness and alertness management among commercial airline pilots on short-haul and long-haul flights. *Accid Anal Prev*. 2017;98:320–329.
- Holmes A, Al-Bayat S, Hilditch C, Bourgeois-Bougrine S. Sleep and sleepiness during an ultra long-range flight operation between the Middle East and United States. *Accid Anal Prev*. 2012;45(suppl):27–31.
- Guyette FX, Morley JL, Weaver MD, Patterson PD, Hostler D. The effect of shift length on fatigue and cognitive performance in air medical providers. *Prehosp Emerg Care*. 2013;17:23–28.
- Nix S, Gossett K, Shepherd AD. An investigation of pilot fatigue in helicopter emergency medical services. *Air Med J*. 2013;32:275–279.
- Patterson PD, Weaver MD, Frank RC, et al. Association between poor sleep, fatigue, and safety outcomes in emergency medical services providers. *Prehosp Emerg Care*. 2012;16:86–97.
- Patterson PD, Buysse DJ, Weaver MD, Callaway CW, Yealy DM. Recovery between work shifts among emergency medical services clinicians. *Prehosp Emerg Care*. 2015;19:365–375.
- International Civil Aviation Organization. *Fatigue Risk Management Systems Manual for Regulators*. Available at: <https://www.icao.int/safety/fatiguemanagement/frms%20tools/doc%209966%20-%20frms%20manual%20for%20regulators.pdf>. Accessed December 6, 2018.
- Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. *Sleep*. 1991;14:540–545.
- Broderick JE, Junghaenel DU, Schneider S, Pilosi JJ, Stone AA. Pittsburgh and Epworth sleep scale items: accuracy of ratings across different reporting periods. *Behav Sleep Med*. 2013;11:173–188.
- Akerstedt T. Psychological and psychophysiological effects of shift work. *Scand J Work Environ Health*. 1990;16:67–73.
- Kaida K, Takahashi M, Akerstedt T, Nakata A, Otsuka Y, Haratani T. Validation of the Karolinska sleepiness scale against performance and EEG variables. *Clin Neurophysiol*. 2006;117:1574–1581.
- Hartzler BM. Fatigue on the flight deck: the consequences of sleep loss and the benefits of napping. *Accid Anal Prev*. 2014;62:309–318.
- Driskell JE, Mullen B. The efficacy of naps as a fatigue countermeasure: a meta-analytic integration. *Hum Factors*. 2005;47:360–377.
- Hilditch CJ, Dorrian J, Banks S. A review of short naps and sleep inertia: do naps of 30 min or less really avoid sleep inertia and slow-wave sleep? *Sleep Med*. 2017;32:176–190.
- Eriksen CA, Akerstedt T, Kecklund G, Akerstedt A. Comment on short-term variation in subjective sleepiness. *Percept Mot Skills*. 2005;101:943–948.
- Akerstedt T. Shift work and disturbed sleep/wakefulness. *Occup Med (Lond)*. 2003;53:89–94.
- Harma MI, Ilmarinen J, Knauth P, Rutenfranz J, Hanninen O. Physical training intervention in female shift workers: II. The effects of intervention on the circadian rhythms of alertness, short-term memory, and body temperature. *Ergonomics*. 1988;31:51–63.
- Atkinson G, Fullick S, Grindley C, Maclaren D. Exercise, energy balance and the shift worker. *Sports Med*. 2008;38:671–685.
- Johns MW. Sleepiness in different situations measured by the Epworth Sleepiness Scale. *Sleep*. 1994;17:703–710.
- Pallesen S, Nordhus IH, Omvik S, Sivertsen B, Tell GS, Bjorvatn B. Prevalence and risk factors of subjective sleepiness in the general adult population. *Sleep*. 2007;30:619–624.
- Waage S, Pallesen S, Moen BE, et al. Predictors of shift work disorder among nurses: a longitudinal study. *Sleep Med*. 2014;15:1449–1455.
- Snir R, Harpaz I. Cross-cultural differences concerning heavy work investment. *Cross Cult Res*. 2009;43:309–319.
- Choudhry RA, Fang DP, Mohamed S. The nature of safety culture: a survey of the state-of-the-art. *Saf Sci*. 2007;45:993–1012.
- Sallinen M, Kecklund G. Shift work, sleep, and sleepiness – differences between shift schedules and systems. *Scand J Work Environ Health*. 2010;36:121–133.