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FinnHEMS

Well-being at work among helicopter emergency medical service personnel in Finland

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Extended summary

Introduction

Personnel engaged in emergency medical services (EMS) and in helicopter emergency medical services (HEMS) perform challenging missions 24/7. This underlines the importance of overall well-being at work among these personnel. Only healthy personnel can successfully perform challenging HEMS missions in the long run.

Fatigue due to an imbalance between overall strain and recovery is an occupational hazard that may compromise both well-being at work and operational and patient safety in HEMS settings. However, there are no evidence-based recommendations available on how to mitigate fatigue at HEMS work. For this reason, it is important to create a comprehensive picture of HEMS personnel's overall well-being at work, including on-duty fatigue, at the national level.

The research aim of the present study was to assess the overall well-being at work among HEMS personnel in Finland, with the main emphasis on fatigue and the balance between strain and recovery. To make the results as useful as possible for development actions, different occupational groups, duties, and task load levels were considered in the assessment.

The development aim of the present study was to a) identify the main development needs to promote the overall balance between strain and recovery in HEMS professionals and b) introduce a future improvement plan to achieve this goal.

Methods and materials

The study was carried out at all FinnHEMS bases in Finland: Vantaa, Turku, Tampere, Kuopio, Oulu, and Rovaniemi. The data comprised questionnaire, field, register, and workshop data. All active HEMS personnel in Finland were invited to participate in the questionnaire and field studies and the workshop. The study was approved by the ethics committee of the Finnish Institute of Occupational Health.

The questionnaire data was collected from 29th March to 3rd June 2017 via Internet. A total of 45 HEMS physicians (DOCs) (response rate 65 %), 16 helicopter pilots (PICs) (32 %), and 17 HEMS crew members and flight assistants (HCM and FA) (48 %) answered the questionnaire that included items on health, work ability, fatigue, general well-being at work and cognitive functioning, well-being at HEMS work, sleep and alertness.

The field data was collected from two six-week periods, from 31st May to 12th July 2017 (summer) and from 30th November 2017 to 11th January 2018 (winter) at FinnHEMS bases using tablets. A total of 34 DOCs (49 %), 13 PICs (26 %), and 17 HCMs/FAs (41 %) participated in the summer measurements. The respective figures for the winter measurements were 33 (48 %), 18 (36 %), and 13 (35 %).

The register data was obtained from the FinnHEMS database (FHDB) for the same two six-week field data collection periods. This data included detailed information on the missions performed and DOCs' estimations on how demanding the missions were cognitively and mentally.

The workshop data was collected at the HEMS Education Days on 15th March 2018 and the study group experts analysed the workshop data afterwards.

Results

Questionnaire study

The results of general health and well-being at work showed that these outcomes were rather firm among HEMS personnel. For example, more than 90 % of HEMS personnel assessed their workability, job satisfaction, and work engagement good. In addition, more than 80 % of HEMS personnel were satisfied with their working hour arrangements, estimated rapport among employees good, and did not report strong need for recovery from work.

There were, however, differences between the HEMS personnel. One main difference was that DOCs reported more frequently cognitive failures at work than the other groups. Moreover, the general status of DOCs was less optimal compared to the other HEMS personnel. This phenomenon was observed in job strain, work-life interference, the perceived negative effects of working hours, and recovery from night duties. Also, the questionnaire results of sleep and on-duty alertness tended to be poorer for DOCs than for the other HEMS personnel.

Field study

The field study results on sleep and on-duty alertness were well in line with those of the questionnaire study. DOCs obtained less on-duty sleep (4 h per 24-h duty period) and rated more often low alertness levels during overnight duties (19 % of the 24-h duties) than the other HEMS personnel (sleep time 7 h per 24-h duty period, low alertness levels in 2 % - 3 % of the 24-h/48-h duties). Self-rated on-duty stress remained at low levels in all occupational groups in all duty types.

Duty duration did not prove a significant factor in terms of sleep, alertness or stress during overnight duties. However, the time of day played a role in alertness. The lowest level of alertness was reached within the 03:00h - 09:00h time window of the overnight duties, independent of the occupational group or duty duration.

Register study

The register study data seemed to support the assumptions on DOCs' task-related fatigue factors on missions that are related to critical patients. Their self-estimates indicating cognitively moderately to highly demanding missions seemed to be associated with high HEMS benefit scores, intubation of a patient, escorting a patient to hospital, and patient's death. The self-estimates indicating moderately to highly mentally demanding missions seemed to be associated with treatment of an underage patient, intubation of a patient, escorting a patient to hospital, and patient's death.

Workshop

Based on the above-mentioned results, HEMS personnel identified the main development needs and based on these an expert group, comprising the researchers of the project, made a proposal on feasible and effective actions to meet them. The needs were arranged into three main categories: working conditions, activities while on duty, and personal means off-duty.

Within the main category of working conditions, the development actions, considered both feasible and effective, mainly addressed the issue of DOCs' workload during night duties and long total working hours. Example of these actions were i) organising consultation calls so that HEMS physicians would no longer be responsible for them (in the night time), ii) limiting HEMS physicians' total working hours by applying the same regulations to them as to aircrew personnel's working hours, and iii) limiting HEMS physicians' working hours prior to and following a night duty.

There were also other development actions of the same nature. These actions emphasised i) optimising sleeping and resting conditions, ii) reducing unnecessary dispatches and obligations, and iii) creating a favorable climate for on-duty recovery measures through educational and managerial operations models. Moreover, some of the proposed actions focused on the use of stardardised methods and protocols to assess and enhance on-duty alertness.

Discussion and conclusions

This study showed that general health, well-being at work, and work ability are at a fairly good level among HEMS personnel. This provides a good basis for meeting the identified development needs to further improve the balance between strain and recovery.

The main development needs concern fatigue risk mitigation. This is a relevant issue to all HEMS personnel during their night duties due to the downswing of circadian-regulated alertness. The need for development fatigue mitigation is emphasised among DOCs due to frequent consultation calls and probably, to some extent, also other job demands, such as a large amount of total working hours and the cognitive demand and mental burden caused by treating the most critical patients. The highest priority is to provide also the DOCs with opportunities for protected sleep during their overnight duties.

To implement the proposed actions, it is essential to develop a fatigue risk management system (FRMS). This system would cover all HEMS personnel, not just pilots and HEMS crew members, as it is currently the case. The full coverage is of special importance, given the role of multi-professional teamwork in HEMS.

1. Introduction

Personnel engaged in emergency medical services (EMS) and especially in helicopter emergency medical services (HEMS) perform challenging missions. Patients treated by HEMS in Finland are the most critical ones and external conditions for demanding procedures can be far from optimal. Also, air and road transport operations themselves can be challenging because of darkness, difficult weather or traffic conditions, long distances and decision making. In all, HEMS missions can be considered as critical duties with regard to patient and traffic safety.

An additional factor to be reckoned with is on-duty fatigue. It has been considered as a hazard to both patients and employees, which is not surprising, for EMS missions are conducted on a 24/7 basis. (see Patterson et al. 2018; Patterson et al. 2012).

Fatigue can be defined as a biological need for recuperative rest and consequently it is a sign of an imbalance between strain and recovery. According to a model by Williamson et al. (2011) there are three main sources of fatigue: unfavorable time of day (circadian factor), short prior sleep and/or prolonged prior wake (homeostatic factor), and task-related factors (e.g., physical and mental task demands) (Figure 1.1.). Fatigue may also take several forms, such as sleepiness (difficulty staying awake) and mental fatigue (e.g., difficulty continuing task performance due to prolonged cognitive load).

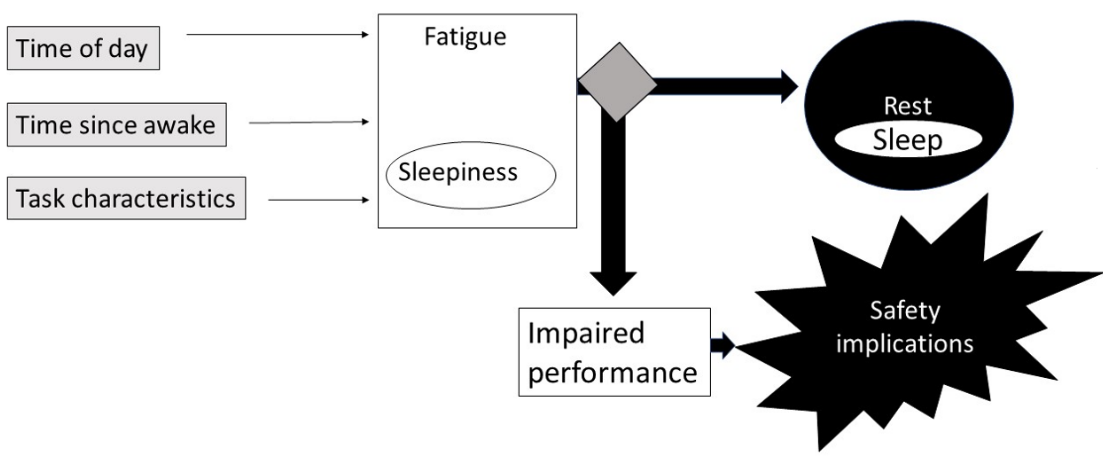


Figure 1.1. A modified version of the model of fatigue and its links to performance and safety outcomes by Williamson et al. (2011).

Working hour arrangements as a whole are a significant determinant of on-duty fatigue in every 24/7 industry (Sallinen & Hublin 2015). The main reason for their significance is that they create a misalignment between the required and natural sleep-wake cycles. In consequence, both the circadian and homeostatic factors may promote sleep instead of wakefulness while on duty. This joint effect of these two factors occurs especially while working at night when the circadian cycle of alertness reaches its lowest point and the time elapsed since the prior night sleep is significantly extended.

The duration of a duty is an issue often addressed in the context of on-duty fatigue in EMS personnel. In general, research evidence suggests that there is an association between extended duties and negative safety outcomes, which can be explained by increased on-duty fatigue (Wagstaff & Sigstad 2011). A recent systematic review on EMS personnel concluded that the quality of existing evidence on the association of duty duration with fatigue is, however, low or very low (Patterson et al. 2018).

In addition to the working hour arrangements, rest opportunities during work shifts play a significant role. Previous research has shown that especially strategic napping effectively reduces sleep pressure in EMS personnel and similar shift workers (Martin-Gill et al. 2018; Caldwell 2009). Thus, it is difficult to assess the true fatiguing effects of working conditions unless on-duty rest and sleep opportunities are taken into consideration.

When studying on-duty fatigue in HEMS settings it is also important to pay attention to possible differences between professions. In Finland, the HEMS team members have quite different working conditions. In short, helicopter pilots (PIC) work long duties, 48 h in duration, but their actual time of working within a duty is limited by the regulations on flight time limitations. If the limit of active working time is reached, their duty is interrupted, and they are replaced by a new pilot. HEMS crew members (HCM) work 24 h or 48 h duties also under flight regulations, so the same applies for them, too. On the contrary, health personnel's working hours are not regulated. HEMS paramedics of Rovaniemi base usually work 24 h duties, whereas HEMS physicians' (DOCs) duties vary between 7 h and 24 h. It is also worth noting that the actual time of working within a duty is unlimited for the health personnel. DOCs also answer consultation calls regardless of time of the day, which understandably further restricts their opportunities for recovery within a duty.

In addition to working hour arrangements and rest and sleep opportunities during a duty, there are other work-related factors underlying on-duty fatigue and recovery in (H)EMS personnel. One such factor is the overall level of task load. For example, a high number of patients has been linked to low levels of safety climate and job satisfaction, and poor perceptions of working conditions in EMS personnel (Patterson et al. 2010). There are, however, not yet solid research evidence on the effectiveness of the on-duty fatigue interventions where task load has been modified in EMS personnel (Studnek et al. 2018).

Individual differences in response to long and irregular working hours are also important to take into account when assessing and mitigating on-duty fatigue in shift work in general (Van Dongen 2006; Saksvik et al. 2010; Sallinen et al. 2018). For example, a recent study on commercial airline pilots showed that one-fourth of the pilots reported increased fatigue on each eastward long-haul flight during a two-month measurement period, whereas one-fourth did not report increased fatigue on any of these flights (Sallinen et al. 2018). Amongst the main individual characteristics explaining these individual differences are sensitivity to sleep restriction, flexibility of sleep habits, and chronotype (morningness-eveningness) (Saksvik et al. 2010). In practice, also the general health status and life situation, such as having small children, play a role in on-duty fatigue and recovery between duties.

To summarize, on-duty fatigue can be considered as a safety hazard in HEMS settings. However, strong evidence-based recommendations for on-duty mitigation in EMS personnel are not available (Patterson et al. 2018). For this reason, it is important to first create a comprehensive picture of HEMS personnel's overall well-being at work, recovery, sleep, stress, and fatigue at a base on the national level. To optimize the usefulness of the data it is essential to pay attention to different occupational groups and variations in their working hour arrangements, task load, and in possibilities for recovery during and between duties. Moreover, from the viewpoint of a future improvement action plan it is important to learn about HEMS personnel’s own views on how they would develop their working conditions in light of the results of a mapping study targeted at their work and well-being. One important aspect in this connection is teamwork, as HEMS personnel with different expertise operate as teams.

The present mapping study focuses on the HEMS personnel of Finland. To create a comprehensive picture of how well the personnel copes with their demanding job and what are the main development needs, especially with respect to the balance between strain and recovery, multiple sources of data are used: field, questionnaire and register data. The workshop method is applied to collect data on HEMS personnel’s views on the main results of the mapping study. Based on all these data, a plan for the future development of the working conditions of the HEMS personnel is introduced.

2. Aims

The research aim of the present study was to assess the overall well-being at work among HEMS personnel in Finland, with the main emphasis on fatigue and the balance between strain and recovery. To make the results as useful as possible for future development actions, different occupational groups, duties, and task load levels were considered in the assessment.

The development aim of the present study was to a) identify the main development needs to promote the overall balance between strain and recovery in HEMS personnel and b) introduce a future improvement plan to achieve this goal.

3. Materials and Methods

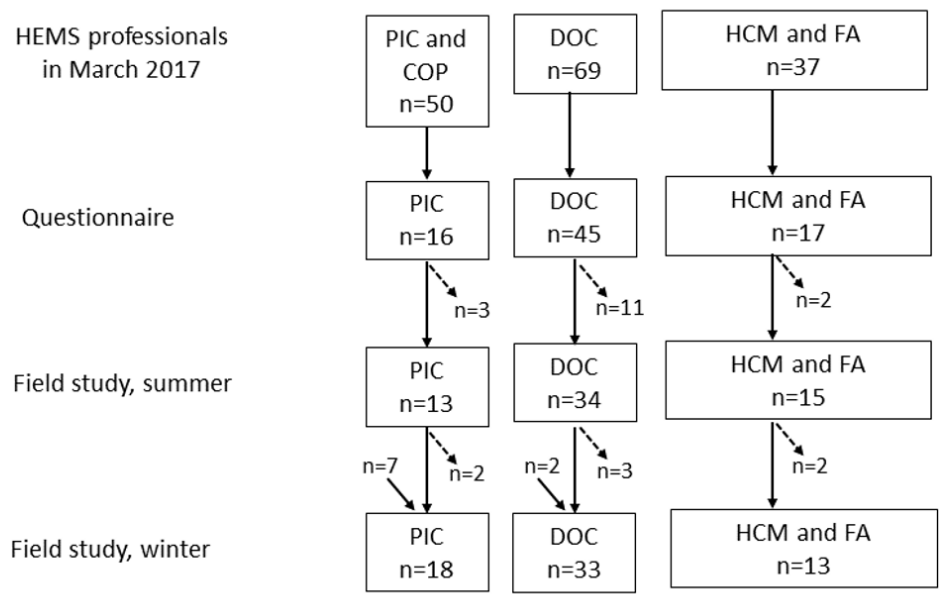
3.1. Study design and setting

The study was carried out at all FinnHEMS bases in Finland: Vantaa, Turku, Tampere, Kuopio, Oulu, and Rovaniemi. The data comprised questionnaire, field, register, and workshop data. The questionnaire data was collected from 29th March to 3rd June 2017 via Internet. The field data was collected from two six-week periods, from 31st May to 12th July 2017 (summer) and from 30th November 2017 to 11th January 2018 (winter) at FinnHEMS bases using tablets. The register data was obtained from the FinnHEMS database (FHDB) for the same two six-week periods after finishing the winter field study period. The workshop data was collected at the HEMS Education Days on 15th March 2018. The study was approved by the ethics committee of the Finnish Institute of Occupational Health.

3.2. Participants

All active HEMS personnel in Finland were invited to participate in the questionnaire and field studies. The HEMS team differs between bases: Vantaa FH10, Turku FH20, Tampere FH30, Oulu FH50 and Kuopio FH60 have a pilot (PIC), HEMS crew member (HCM) and physician (DOC), whereas the team in Rovaniemi FH51 base is composed of PIC, co-pilot (COP), flight assistant (FA) and a specially trained advanced paramedic.

In this study, due to their low number, FAs have been combined with HCMs as their roles in the HEMS team is very similar. The number of FH51 paramedics is also very low and to avoid recognition of participants their results are not presented here. However, their results are presented in a separate attachment, distributed only to the participants themselves and internally in the HEMS team. No COPs participated in the study. Figure 3.2.1. presents the number of participants by sub-study and role.



Note. PIC = helicopter pilot; COP = co-pilot; DOC = HEMS physician; HCM = HEMS crew member; FA = flight assistant. HCMs and Rovaniemi base FAs were combined in one group due to similar roles in the team.

Figure 3.2.1. Flow chart on participation by role. Field studies: those with at least one marking are included in the chart.

3.3. Questionnaire study

Participants completed an online questionnaire including items **on** age**,** sex**,** base**,** role in HEMS team**,** work experience in HEMS (years), and weekly working hours in HEMS duty and in other jobs. Total weekly working hours were calculated as the sum of aforementioned working hours. Chronotype was rated on a five-point scale that was dichotomised to 'morning type' (1 = absolutely morning type to 3 = neither) and 'evening type' (4 = more evening type to 5 = absolutely evening type) (Horne & Ostberg, 1976).

Health

Physical symptoms were rated on a six-items including symptoms of 1) digestive system, 2) arrhythmia or chest pain, 3) headache, 4) lower back pain, 5) neck or shoulder pain, and 6) other pain in the body using a five-point scale. The ratings were dichotomised to 'rarely' (all the six symptoms occurred 1 = never/less than once a month to 2 = less than once a week) and 'often' (at least one of the six symptoms occurred 3 = at least once or twice a week to 5 = almost daily/daily) (Barton et al 1995). Subjective health compared with age peers, was rated on a five-point scale that was dichotomised to 'good' (1 = very good to 2 = good) and 'not so good' (3 = average to 5 = very bad) (Idler et al, 1997). Fatigue**,** physical exhaustion, and mental fatigue were each rated on six-point scales that were dichotomised to 'rarely' (1 = never to 3 = some occasions a month) and 'often' (4 = once or twice a week to 6 = five times a week or more often).

Work ability

Work ability was rated on an 11-point scale (0 to 10) that was dichotomised to 'good' (eight to ten) and 'not so good' (zero to seven) (Tuomi et al. 1997).

General well-being at work (not limited to HEMS work)

General work-related stress was rated on a five-point scale that was dichotomised to 'only some' (1 = not at all to 3 = some) and 'a lot' (4 = quite a lot to 5 = very much) (Elo et al. 1992). Work engagement was rated on a nine-item questionnaire using a seven-point scale (1 = never, 4 = couple of times a month, 7 = daily). The ratings were dichotomised to 'often' (the mean of all the items ≥ 4.5) and 'not so often' (the mean of all the items < 4.5) (Schaufeli & Bakker 2003).

General cognitive functioning (not limited to HEMS work)

Cognitive failures at work, including memory**,** attention**, and** executive failures, were each rated with five items as part of a 15-item questionnaire using a five-point scale. The ratings were dichotomised to 'rarely' (all the five symptoms occurred 4 = monthly or more rarely to 5 = never) and 'often' (at least one of the five symptoms occurred 1 = several times per day to 3 = weekly) (Wallace & Chen, 2015).

Well-being at HEMS work

Job satisfaction was rated on a 15-item questionnaire using a seven-point scale (1 = extremely dissatisfied to 7 = extremely satisfied). The ratings were dichotomised to 'satisfied' (the mean of all the items ≥ 4.5) and 'not so satisfied' (the mean of all the items < 4.5) (Hackman & Oldham, 1975). Rapport among employees was rated on a five-point scale that was dichotomised to 'good' (1 = very good to 2 = moderately good) and 'not so good' (3 = neither to 5 = poor). Job strain (Karasek & Theorell, 1990) was rated on a 12-item questionnaire (nine items on job control and three items on job demand) using a six-point scale (1 = totally agree to 6 = totally disagree). The ratings were dichotomised to 'no' (if the mean of the items on job control was higher than the mean of the items on job demand) and 'yes' (if the mean of the items on job control was equal to or lower than the mean of the items on job demand).

Need for recovery from work was rated separately for all work and for night work in HEMS duty on an 11-item questionnaire using a dichotomic scale (0 = no and 1 = yes). The ratings were dichotomised to 'not so strong' (the sum of the items ≤5) and 'strong' (the sum of the items >5) (van Veldhoven et al. 2003). Time needed for recovery after a HEMS duty was evaluated using the following item: "After a HEMS duty that covers one to two nights, my alertness normalizes 1) after one day, 2) after two days, 3) after three or more days". The answer was dichotomised to 'one day is sufficient for recovery' and 'one day is not sufficient for recovery'.

Satisfaction with working time arrangements in HEMS operations was rated on a five-point scale that was dichotomised to 'good' (1 = extremely satisfied to 2 = rather satisfied) and 'not so good' (3 = not satisfied or dissatisfied to 5 = extremely dissatisfied). Consideration of shift wishes in HEMS operations was rated on a five-point scale that was dichotomised to 'considered' (4 = rather often to 5 = always) and 'not considered' (1 = not at all to 3 = sometimes).

The effects of current working time arrangements in HEMS operations on general health**,** sleep and alertness**,** life outside work**,** coping with a job**,** work performance**,** and safety at work were each rated on a five-point scale that was dichotomised to 'do not disturb/compromise' (3 = do not disturb/compromise or improve to 5 = improves a lot) and 'disturbs/compromises' (1 = disturbs/compromises a lot to 2 = disturbs/compromises to some extent) (Barton et al 1995).

Sleep and alertness

Participants estimated their daily sleep time (hours and minutes) while working in normal office hours (between 06 h and 21 h), prior to a 17-hour HEMS duty and/or prior to a 24 to 48-hour HEMS duty, and on days off. Participants also evaluated their daily sleep time (hours and minutes) during a 17-hour HEMS duty and/or during a 24 to 48-hour HEMS duty. Further participants evaluated their amount of sleep needed to feel rested the next day (sleep need; hours and minutes).

Chronic insomnia (difficulties to fall asleep, recurring awakenings or difficulties to stay asleep) during night-time sleep prior to or following a HEMS duty or while napping after a HEMS duty, and insomnia after two weeks on holiday were rated on a four-point scale that was dichotomised to 'rare' (1 = rarely/never to 2 = rather rarely) and 'frequent' (3 = rather often to 4 = often/continuously). Specifically, insomnia was assessed in association with day duty starting at 07:30 to 08:30, 12 hour duty starting at 09:00, 12 hour duty starting at 21:00, 17 hour duty starting at 15:00 to 15:30, 24 hour duty starting at 09:00, 24 hour duty starting at 12:00, 48 hour duty starting at 09:00, 48 hour duty starting at 12:00, and/or 48 hour duty starting at 14:30. If none of these duty hours matched a participant's duty hours he/she rated the items regarding the closest resembling working hours.

Participants evaluated their lowest alertness level during a duty in 6 h periods starting from the beginning of the duty and covering the whole duty (see the descriptions of the duties under 'insomnia' above). Specifically, sleepiness was rated using the nine-point Karolinska Sleepiness Scale (KSS) (Åkerstedt and Gillberg, 1990). The KSS ratings were dichotomised to 'no reduced alertness' (1 = extremely alert to 6 = some signs of sleepiness) and 'reduced alertness' (7 = sleepy, but no effort to keep awake to 9 = very sleepy, great effort to keep awake, fighting sleep) for analyses.

3.3.1. Statistical methods

Kruskal-Wallis test was conducted to compare working hours, sleep time, and sleep need between the groups. Mann–Whitney U-test was conducted to compare the questionnaire-based average greatest sleepiness between different groups. Fisher's exact test was conducted to compare the prevalence of questionnaire-based high sleepiness and frequent insomnia between different groups.

Mann–Whitney U-test (working hours, sleep time, and sleep need) and Pearson's chi-squared test (cognitive failures, effects of working hours on sleep and alertness, recovery variables, frequent insomnia, and high sleepiness) were conducted to compare DOCs between southern (Helsinki, Turku and Tampere) and northern bases (Kuopio, Oulu and Rovaniemi).

3.4. Field study

Measures before each duty period

Participants reported bed and wake-up times of their main sleep preceding each HEMS duty, and other than HEMS working hours if they had worked during the past 24 hours prior to starting their HEMS duty.

Measures during each duty period

Upon the beginning of a duty, participants rated the lowest level of alertness using the KSS and the highest level of stress from 1 (very calm and relaxed) to 9 (extremely stressed and tense) in the past five minutes. They kept a record of duty start, duty end, bed, and wake-up times, and evaluated time spent awake on each sleep period. They rated quality of each sleep period (0 = poor to 4 = good) and the lowest level of alertness and the highest level of stress within the past six hours at 09:00h, 15:00h, 21:00h, and 03:00h (as soon as they could or remembered, or if they e.g. went to bed before a target time, the rating was instructed to be made then).

The KSS ratings were dichotomised to ‘no reduced alertness’ (1 = extremely alert to 6 = some signs of sleepiness) and ‘reduced alertness’ (7 = sleepy, but no effort to keep awake to 9 = very sleepy, great effort to keep awake, fighting sleep) for analyses. The stress ratings were dichotomised to ‘no stress’ (1 = very calm and relaxed to 6 = somewhat stressed) and ‘increased stress’ (7 = lot of stress (lot of tense and pressure) to 9 = extremely stressed and tense).

The registration of sleep periods on duty differed slightly between the summer and winter periods. In the summer measurements, participants were instructed to mark each sleep period separately, but frequent interruptions due to consultation calls complicated registration of DOCs' sleep. Thus, in the winter measurements DOCs were instructed to register one sleep period even if their sleep was interrupted by consultation calls. In addition, they were instructed to take into account the calls when they estimated the time spent awake within the sleep period.

All on-duty sleep periods (from bed time to wake-up time) that were separated by less than 30 minutes from each other were combined. Sleep periods with less than 10 min of sleep were disregarded. The sleep periods were analysed in 6-h time windows (09 h – 15 h, 15 h – 21h, 21h – 03 h, and 03 h – 09 h).

Besides KSS ratings, on-duty alertness was assessed by biomathematical modeling using a method called the Sleep-Wake Predictor (Åkerstedt et al. 2008). The summer period data of duty hours and the sleep periods were used as the input data in modelings. The mean amount of sleep per each 6-h period of duty (09 h – 15 h, 15 h – 21h, 21h – 03 h, and 03 h – 09 h) was imported into the modeling tool so that the midpoint of sleep was set at the midpoint of the matching 6-h period. Sleep periods with less than 10 min of sleep, on average, were disregarded. Note that the mean amount of sleep within a 6-h period also covered cases with no sleep.

3.5. FinnHEMS database

FinnHEMS database (FHDB) is a national database where DOCs and FH51 paramedics register all HEMS missions. The database includes both mission- and patient-related information. In this study, FHDB data was used to describe the effect of task-related factors on self-rated alertness and stress of participants within a HEMS duty (DOCs and FH51 paramedics). To measure mission-related strain, two new variables were added to the database for data collection during the field study periods: the participants were asked to estimate the cognitive demand and mental burden of each mission on a scale of 0 to 10.

The analysed data comprised all missions within HEMS duties in the field study. In addition to cognitive demand and mental burden, the data contained the following information of each mission where a patient was met: HEMS benefit score, patient's age, dead at scene, escorted to hospital and airway management. Based on expert opinion these were evaluated to form the most essential variables to explain the mission-related cognitive demand and mental burden.

3.6. Workshop

HEMS personnel attended a 25-minute presentation on the results of the questionnaire and summer field study of the project. This was followed by a one-hour workshop for which the HEMS personnel participating in the HEMS Education Days had been divided into six 10 - 12 persons multi-professional groups. The participants first pointed out the most important **targets to develop** in their work (work in 2 - 4 persons groups and discussions), and then generated **solution ideas** to the identified targets (solo work and discussions).

Later, the study group experts from FIOH and FinnHEMS evaluated the **feasibility of the solution ideas** with respect to focus group's operation using a three-point scale (1 = poor, 2 = medium, 3 = good feasibility) and recommendations for **time periods for implementation**. Then, the experts evaluated the **effectiveness of the feasible** (i.e. rated 2 = medium or 3 = good feasibility) **solution ideas** with respect to the most important development targets using a four-point scale (0 = no effect to 3 = strong effect). The assessment was based on scientific literature and experiential knowledge on HEMS operation. The development targets/needs and the solution ideas to meet the targets/needs identified in the workshop were grouped under three headings: 1) working conditions, 2) activities on duty, and 3) personal means off-duty.

4. Results

Only groups with ≥10 individuals are presented in the results to avoid identifying individual participants.

4.1. Questionnaire study

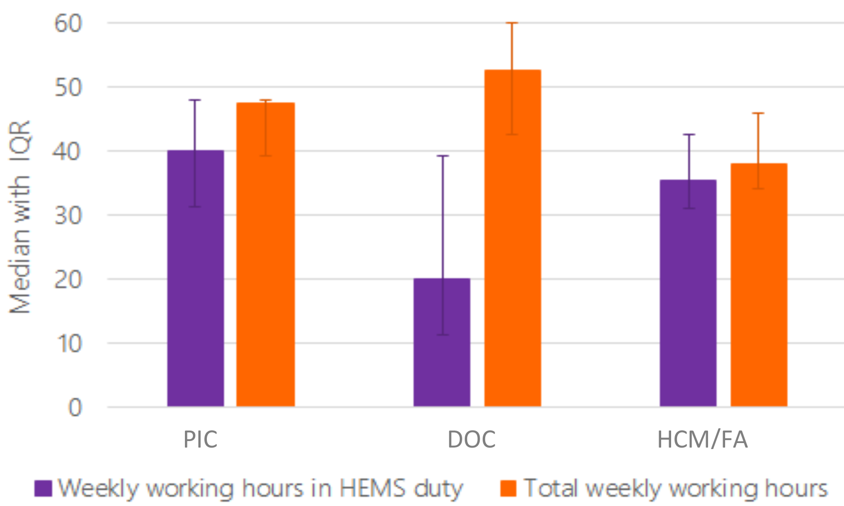
4.1.1. Sample characteristics

Table 4.1.1.1 and figure 4.1.1.1. present the sample characteristics of HEMS personnel by role. PICs, DOCs, and HCM/FAs differed in their weekly HEMS duty hours (Kruskall-Wallis -test: $p = 0.012$) and total weekly working hours (Kruskall-Wallis -test: $p < 0.001$). PICs and HCM/FAs had almost twice as much HEMS duty hours as DOCs, whereas DOCs had the longest total working hours. DOCs' working hours did not differ between the southern and northern bases.

Table 4.1.1.1. Questionnaire-based sample characteristics by role.

	PIC (n = 16)	DOC (n = 45)	HCM/FA (n = 17)
	%	%	%
Base area, South	88	62	71
Men	100	53	94
Evening chronotype	50	42	53
	Mean (SD)	Mean (SD)	Mean (SD)
Age, years	44 (6)	42 (6)	41 (4)
Work experience in HEMS operations, years	10 (7)	8 (5)	9 (6)

SD = standard deviation.

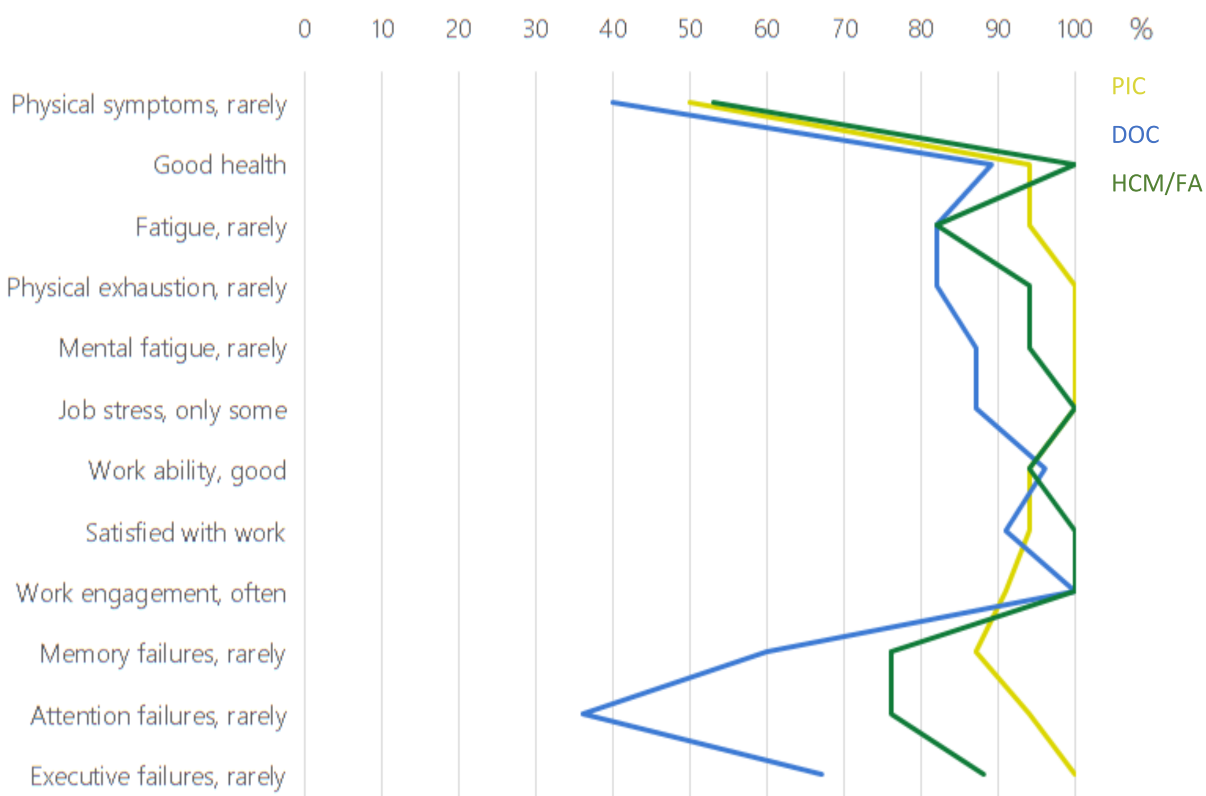


Note. PIC: n = 16, DOC: n = 45, and HCM/FA: n = 17. IQR = interquartile range.

Figure 4.1.1.1. Questionnaire-based weekly working hours by role.

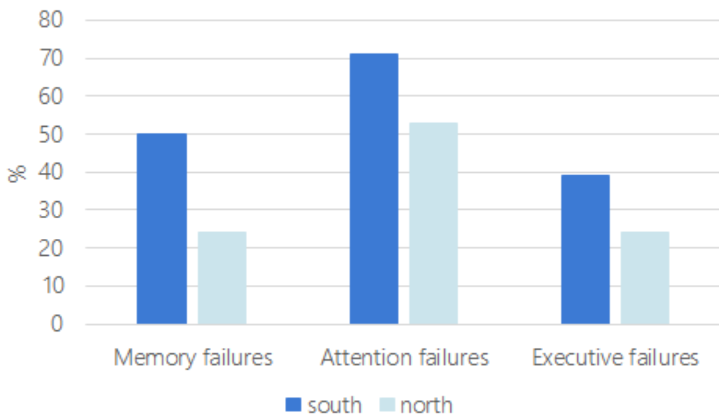
4.1.2. General health, work ability, well-being at work, and cognitive function at work

Figure 4.1.2.1. presents the prevalence of good health, work ability, and well-being and cognitive functioning at work by role. The overall results of all occupational groups indicated a good level in all these outcomes, except for cognitive functioning at work (memory, attention, and executive failures) in DOCs. 60 % of DOCs reported committing memory failures only rarely, 38 % reported the same in the domain of attention failures, and 68 % in the domain of executive failures. The corresponding results of HCM/FAs varied between 76 % and 88 % and those of PICs between 88 % and 100 %. Despite a tendency toward more cognitive failures among the DOCs of the southern bases than among their counterparts farther north, there was insufficient statistical evidence to show this difference (Figure 4.1.2.2).



Note. PIC: n = 16, DOC: n = 45, and HCM/FA: n = 17.

Figure 4.1.2.1. Health, work ability, and well-being and cognitive failures at work by role.



Note. south: n = 28, north: n = 17.

Figure 4.1.2.2. Weekly cognitive failures among DOCs by location of base

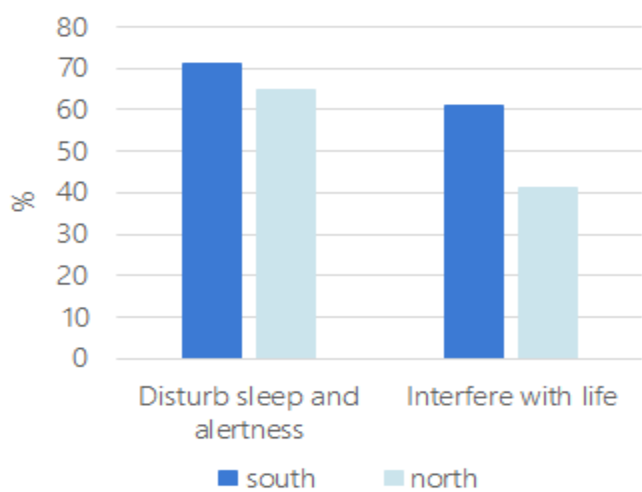
4.1.3. Well-being at HEMS work

Figure 4.1.3.1. presents the results of effects of working hours and recovery at HEMS work. The main observation was that a clear majority of HCM/FAs and PICs (73 - 100 %) reported good levels in all outcomes, whereas less than 50 % of DOCs reported good levels in several outcomes. These outcomes were recovery need after HEMS night duties and the effects of HEMS working hours on sleep, alertness, and the work-life balance. In addition, there was at least a 10 percent point difference in job strain and the effects of HEMS working hours on all presented items between the DOCs and the other HEMS personnel in favour of the latter.

Note. PIC: n = 16, DOC: n = 45, and HCM/FA: n = 17. WH = working hours.

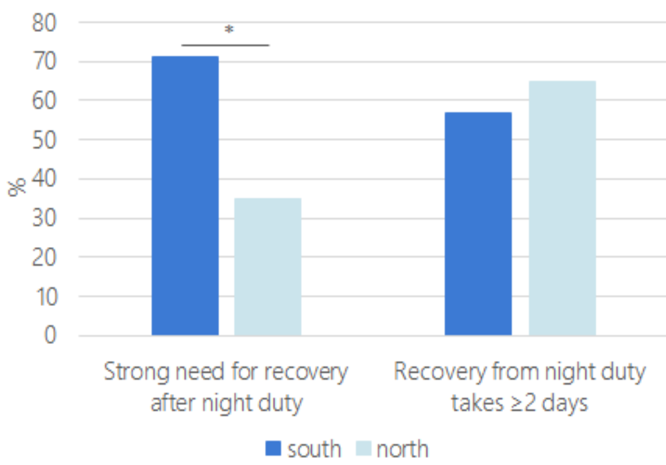
Figure 4.1.3.1. Effects of working hours and recovery by role.

Figures 4.1.3.2 and 4.1.3.3. show selected comparisons between the DOCs located in the southern and northern bases. There was insufficient evidence for a difference in the perceived negative effects of working hours on sleep, alertness and work-life balance between the southern and northern bases. However, the DOCs of the southern bases had significantly more often strong need for recovery than their counterparts in the northern bases (Mann-Whitney U-test: $p = 0.017$).



Note. south: n = 28, north: n = 17.

Figure 4.1.3.2. Perceived negative effects of working hours on sleep and alertness and work-life balance among DOCs by base location.



Note. south: n = 28, north: n = 17, * Mann-Whitney U-test: p = 0.017.

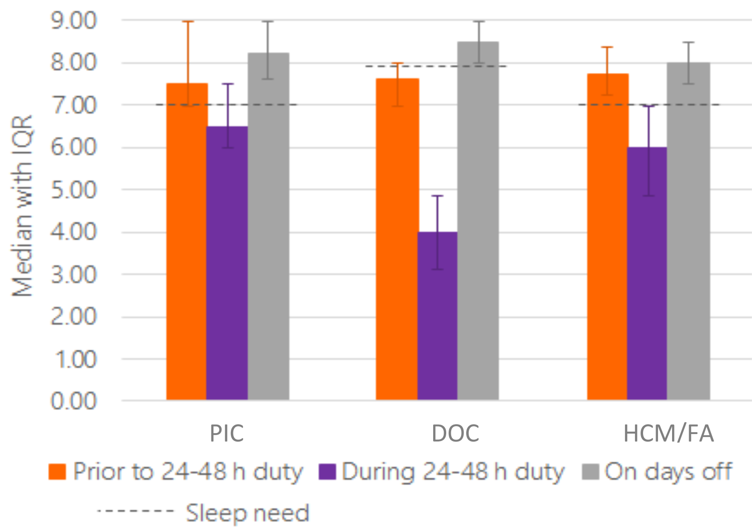
Figure 4.1.3.3. Increased need for recovery from work among DOCs by location of base.

4.1.4. Sleep

Figure 4.1.4.1. presents questionnaire-based daily sleep time and sleep need by role and timing in relation to the duty. The occupational groups differed from each other in sleep during their overnight duties (24 h, 48 h) (Kruskall-Wallis test: $p < 0.001$). DOCs reported sleeping approximately 4 h and PICs and HCM/FAs approximately 6 h per 24-h duty period. Also, DOCs' habitual sleep need was approximately an hour longer as compared to the other HEMS personnel (Mann–Whitney U-test: $p = 0.011$). Otherwise the results of sleep were rather similar for the occupational groups.

DOCs reported getting approximately the same amount of sleep prior to their day duties (median 7:15 h:mm, 1st – 3rd quartile 7:00 - 7:41) and 17-h overnight duties (7:22, 7:00 - 8:00) as prior to their 24-h duties (see Figure 4.1.4.1.). During 17-h duties, they estimated that they obtained approximately 4 hours of sleep (median value), that is, the same amount as during 24-h duties.

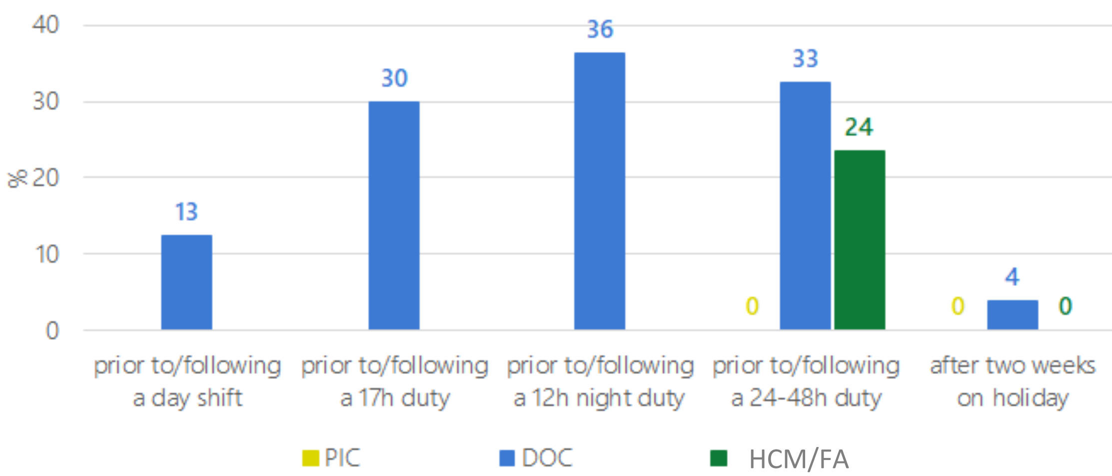
There was insufficient statistical evidence to show any difference in sleep times or sleep need between the DOCs of the southern and northern bases.



Note. PIC: n = 15/16/16, DOC: n = 40/43/45, and HCM/FA: n = 17/17/17, respectively. IQR = interquartile range.

Figure 4.1.4.1. Questionnaire-based daily sleep time and sleep need by role (prior to or following a duty/days off/sleep need.

Figure 4.1.4.2. shows the results of reporting frequent insomnia symptoms by role and duty type. DOCs and HCM/FAs reported symptoms in connection with overnight duties, whereas PICs did not. DOCs also reported symptoms in connection with day duties but to a lesser extent than in connection with overnight duties. There was insufficient statistical evidence to show any difference in insomnia between the southern and northern bases.



Note. DOC: n = 32 (day duty), n = 40 (17-h duty), n = 11 (12-h duty), n = 38 (24-h duty), and n = 45 (holiday); PIC: n = 13 (48-h duty) and n = 13 (holiday); and HCM/FA: n = 12 (24-h duty) and n = 17 (holiday).

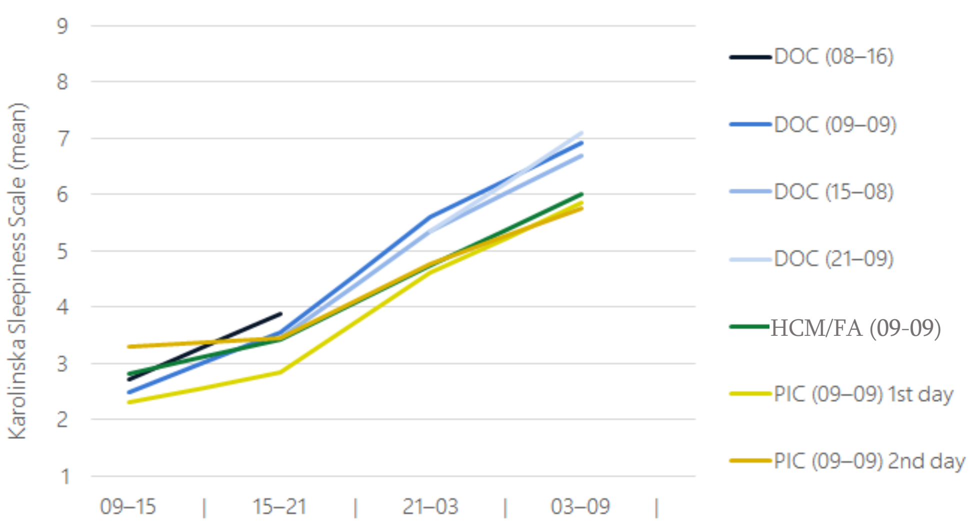
Figure 4.1.4.2. Questionnaire-based frequent insomnia prior to or following a duty by role and type of a duty/holiday.

4.1.5. Retrospective assessments of alertness

The KSS-ratings indicating the lowest level of alertness over the 24 h duty (start time 09:00h) differed between DOCs and HCM/FAs. DOCs rated higher values (mean KSS ± SEM: 6.9 ± 0.2, n = 38) than HCM/FAs (Kruskall-Wallis test: p = 0.020, n = 12), meaning that DOCs assessed their level of alertness being lower.

In DOCs, the mean KSS-rating over the day duty was 4.0 (± 0.3, n = 32), over the 17 h duty 6.7 (± 0.2, start time 15:00h, n = 40), and over the 12 h duty (start time 21:00h, n = 11) 7.1 (± 0.2). In PICs, the corresponding mean KSS-rating over the 48 h duty was 6.9 (± 0.5, start time 09:00h, n = 13).

Figure 4.1.5.1. presents an overview of the KSS-ratings indicating the lowest level of alertness in 6 h periods by duty and role. The mean level of alertness seems to increase more towards the early morning hours among DOCs than among the other occupational groups.

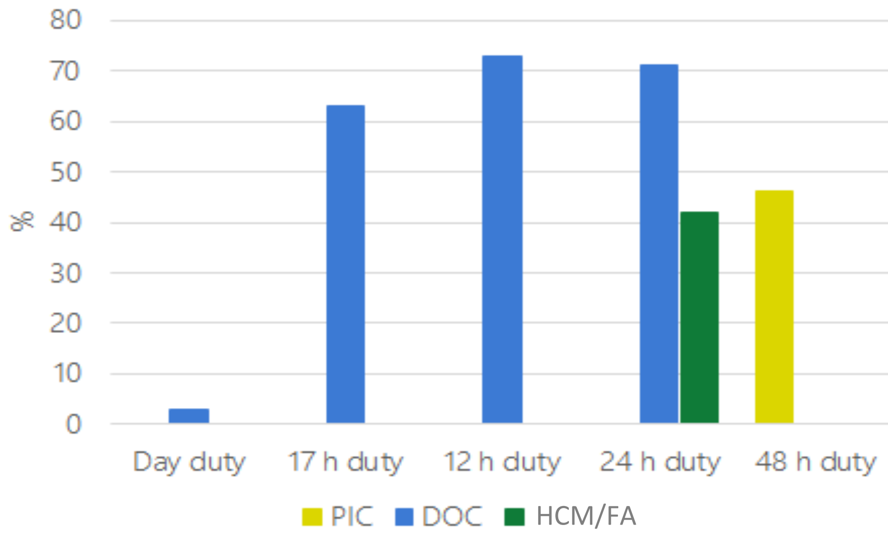


Note. DOC: n = 32 (day duty 8:00h – 16:00h), n = 38 (24-h duty 9:00h – 9:00h), n = 40 (17-h duty 15:00h – 8:00h), and n = 11 (12-h duty 21:00h – 9:00h); HCM/FA: n = 12 (24-h duty 9:00h – 9:00h); PIC: n = 13 (48-h duty 9:00h – 9:00h split into 1st and 2nd days)

Figure 4.1.5.1. The mean values of retrospective KSS ratings in 6 h time windows across HEMS duties by occupation and duty duration.

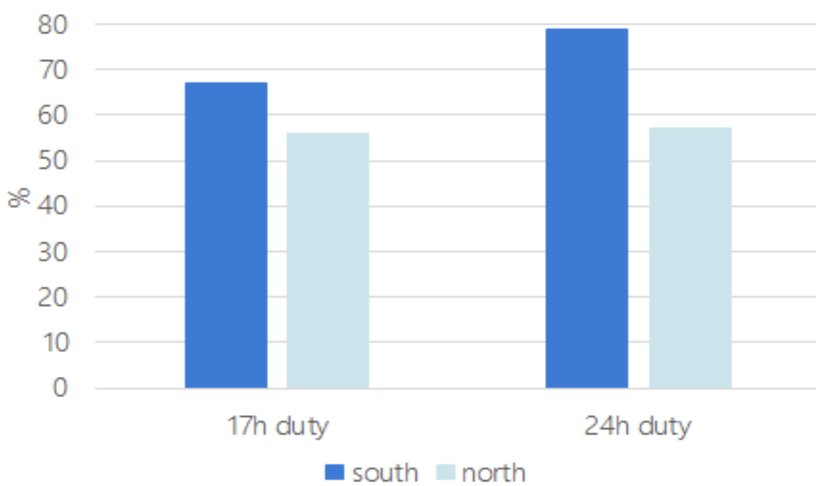
Percentage of participants with reduced alertness during the 24 h duty was higher among DOCs (71 %) than among HCM/FAs (33 %, Fisher's exact test, p = 0.04). In addition, percentage of DOCs with reduced on-duty alertness (24 h duty) was higher than that of PICs (48 h duty, the second night,31 %, Fisher's exact test: p = 0.02).

Percentage of DOCs with reduced on-duty alertness (17 h and 24 h duties) did not significantly differ between the southern and northern bases (Figure 4.1.5.3), even though there was a trend toward a higher percentage value in the southern bases.



Note. DOC: n = 32 (day duty 8:00h – 16:00h), n = 40 (17-h duty 15:00h – 8:00h), n = 11 (12-h duty 21:00h – 9:00h); n = 38 (24-h duty 9:00h – 9:00h); and HCM/FA: n = 12 (24-h duty 9:00h – 9:00h); PIC: n = 13 (48-h duty 9:00h – 9:00h)

Figure 4.1.5.2. Percentage of participants with reduced on-duty alertness (KSS ≥7) in the questionnaire by role and duty.



Note. 17 h duty, start time 15:00h: n = 24 south, n = 16 north; 24 h duty, start time 9:00h: n = 24 south, n = 14 north.

Figure 4.1.5.3. Percentage of DOCs with reduced on-duty alertness (KSS ≥7) by location of a base and duty.

4.2. Field study

4.2.1. Working hours

Table 4.2.1.1. shows the number of duties in the combined data of the summer and winter measurements broken down by duty duration and role. The highest and lowest numbers were reached for 24-h duties (n = 227) and 48-h duties (n = 99), respectively.

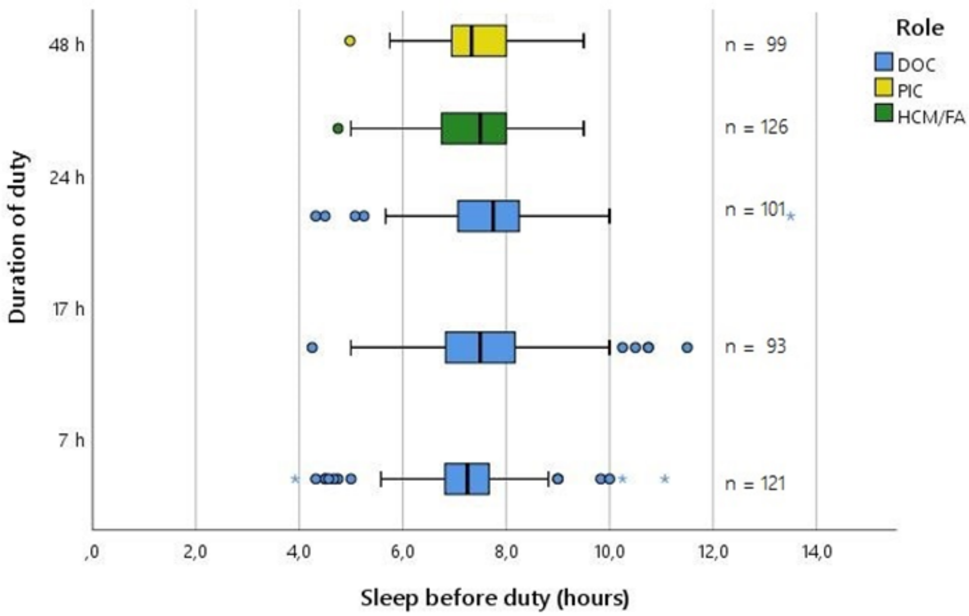
There were marked differences between the occupational groups and base areas in the number of duties collected. 58 % of all duties were collected from DOCs, 23 % from HCM/FAs, and 18 % from PICs. 81 % of all duties were collected in the southern bases and 19 % in the north ones. Note, that the number duties collected from different participants varied.

Table 4.2.1.1. The number of duties by duty duration and role in the combined data of the summer and winter measurements.

	Role			
Duration of duty	DOC	PIC	HCM/FA	Total
day 7h	121	0	0	121
17h	93	0	0	93
24h	101	0	126	227
48h	0	99	0	99
Total	315	99	126	540

4.2.2. Sleep

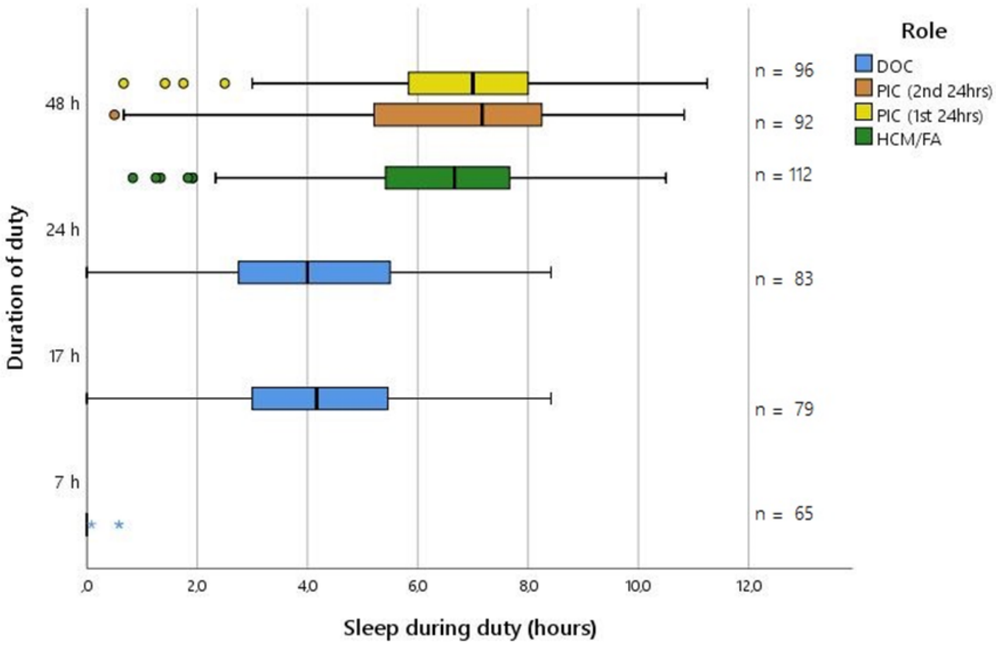
Figure 4.2.2.1. shows pre-duty sleep duration in the combined data of the summer and winter measurements broken down by duty duration and role. Median sleep time varied between 7 and 8 hours, independent of duty duration and role. The figures also show that pre-duty sleeps were only infrequently short, as at least 75 % of them were 6.5 h or longer in duration in each duty category.



Note. n = number of duties.

Figure 4.2.2.1. Pre-duty sleep by duty duration and role in the combined data of the summer and winter measurements. The box denotes median and quartiles, the outmost whiskers/circles/stars minimum and maximum.

Figure 4.2.2.2. shows on-duty sleep duration in the combined data of the summer and winter measurements broken down by duty duration and role. For DOCs, median sleep time was around 4 h during overnight duties (17 h, 24 h), which was almost 3 h less than observed for the other roles. It was also notable that practically only DOCs had overnight duties with no or virtually no sleep. In PICs and HCM/FAs, median sleep time was quite similar for the first and second 24 h period of the 48-h duty.



Note. n = number of duties.

Figure 4.2.2.2. On-duty sleep by duty duration and role in the combined data of the summer and winter measurements. The box denotes median and quartiles, the outmost whiskers/circles/stars minimum and maximum.

Table 4.2.2.1. shows the mean duration of on-duty sleep in 6 h time windows across duties in the combined data of the summer and winter measurements broken down by duty duration and role. The amount of on-duty sleep varied between 4 min and 33 min during the daytime and between 71 min and 361 min during the nighttime hours (21 h – 09 h). The main difference between DOCs and the others occurred in the 03:00h – 09:00h time window. DOCs reported obtaining, on average, 116 min less sleep than the other HEMS personnel. The results of sleep quality are not presented due to a low number of observations per 6 h time window.

Table 4.2.2.1. The mean values of on-duty sleep duration (min) in 6-h time windows in the combined data of the summer and winter measurements broken down by role and duty duration. Note that also cases with no sleep (0 min of sleep) are included in the mean values.

Role	Duty duration	9h - 15h		15h - 21h		21h - 03h		03h - 09h	
		n	min	n	min	n	min	n	min
DOC	17h or 24 h	87	12	167	9	163	98	149	212
HCM/FA	24 h	120	13	119	10	114	121	105	283
PIC	48 h/1st 24 hrs	98	10	98	8	97	71	97	361
PIC	48 h/2nd 24 hrs	95	14	94	13	83	77	83	340

n = number of duties.

4.2.3. Alertness

Table 4.2.3.1. shows the number and percentage of duties with and without reduced levels of on-duty alertness (KSS 7 - 9). The results are broken down by role and duty duration. Of these factors, role was the main one when comparing overnight duties. DOCs rated reduced levels of alertness in 16 - 19 % of their overnight duties both having 95 % confidence interval above zero, while the other occupational groups rated reduced alertness very rarely (2 % - 3 %). The result of DOCs' 7-h day duty was comparable to that of PICs' and HCM/FAs' overnight duties. Within DOCs' overnight duties, the results of 17 h and 24 h duties were quite similar.

The 95 % confidence intervals presented in Table 4.2.3.1. show that the lower limit of the interval for DOCs' overnight duties was higher than the upper limit of the interval for PICs' and HCM/FAs' overnight duties. This observation further stresses the difference between DOC and the other roles in on-duty alertness.

Table 4.2.3.1. On-duty KSS ratings classified into two categories (no reduced alertness: 1 - 6; reduced alertness: 7 - 9) by role and duty duration in the combined data of the summer and winter periods. Note that the individual KSS ratings indicated the lowest level of alertness.

		KSS 1- 6	KSS 7-9				
Role	Duration	n	n	%	95 % CI	Total	Missing
DOC	24h	79	19	19.4	11.6; 27.2	98	3
DOC	17h	72	14	16.3	8.5; 24.1	86	7
DOC	7h (day)	62	3	4.6	-0.5; 9.7	65	56
PIC	48h	96	3	3.0	-0.3; 6.4	99	0
HCM/FA	24h	121	3	2.4	-0.3; 5.1	124	2
Grand total		430	42			472	68

n = number of duties, CI = confidence interval.

Figures 4.2.3.1. (DOCs) and 4.2.3.2. (HCM/FAs and PICs) show the mean values of all self-ratings of alertness in consecutive 6-h time windows across duties. Note that each self-rating indicated the lowest alertness level the participant in question had experienced in a given 6-h time window.

The overnight duties of DOCs showed a clear pattern, with the highest values occurring in the 21:00h – 03:00h and 03:00h – 09:00h windows. The difference in the mean values between nighttime and daytime was approximately 2 steps on the nine-step KSS. For day duties, the mean value was indicative of relatively good alertness, whereas for overnight duties it was indicative of lowered alertness.

The overnight duties of HCM/FAs and PICs also showed a pattern, with the highest values occurring in the 21:00h – 03:00h and 03:00h – 09:00h windows. However, as opposed to DOCs, the highest mean values were mainly not indicative of lowered alertness.

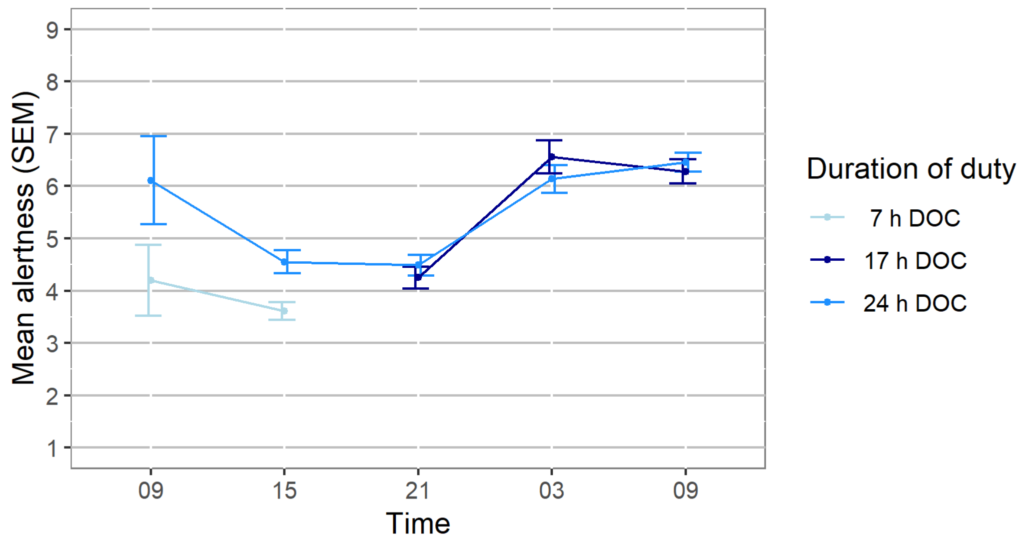


Figure 4.2.3.1. The mean values of the KSS ratings given by DOCs in 6-h time windows in the combined data of the summer and winter measurements by duty duration. Note that the ratings indicate the lowest level of alertness.

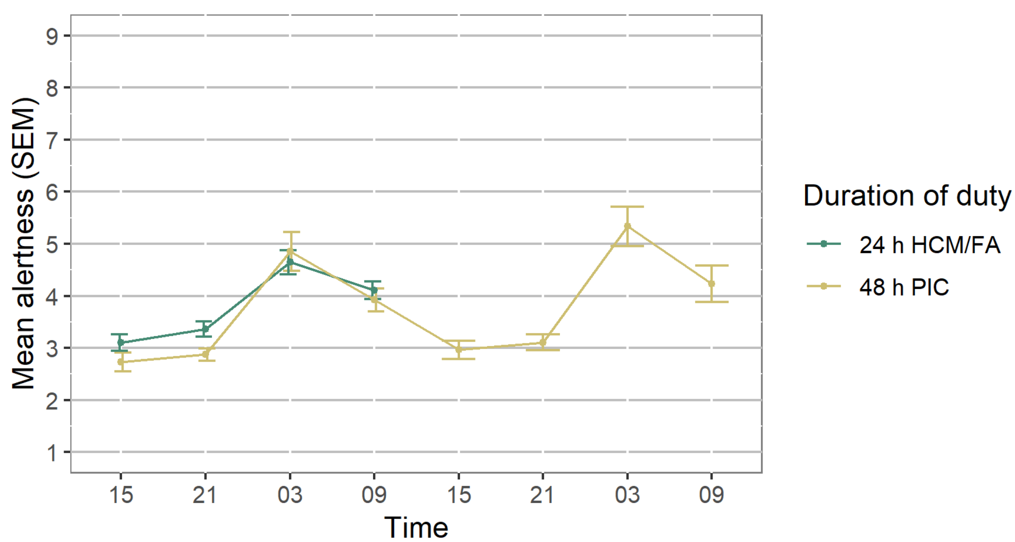


Figure 4.2.3.2. The mean value of the KSS ratings given by PICs and HCM/FAs in 6-h time windows in the combined data of the summer and winter measurements by duty duration. Note that the ratings indicate the lowest level of alertness.

Figure 4.2.3.3 presents *predicted* alertness during DOCs' and HCM/FAs' 24-h duties and PICs' 48 h duties. These predictions created with the Sleep-Wake Predictor used the pre- and on-duty sleep data collected during the summer and winter measurements. The on-duty sleep data, collected by a diary at 6-h intervals, is presented in Table 4.2.2.1. The pre-duty sleep data used in the predictions is given in Table 4.2.3.2.

Note that the black line in Figure 4.2.3.3 represents a scenario with 7.5 hours of sleep (start time 22:58) prior to a 24-h duty but no sleep at all during the duty. The pre-duty sleep was based on DOCs' sleep prior to their overnight duties. This scenario was created because DOCs had overnight duties with no or very little on-duty sleep.

One of the main findings was that the predictions showed reduced alertness levels (KSS hourly mean ≥ 6.5) during the night-time hours of all roles. In PICs, the levels of predicted on-duty alertness were quite similar during the first and second night.

The main difference between DOCs and the other two roles was observed between 05:00h and 09:00h. During that period, DOCs' predicted alertness was, on average, 0.6 KSS steps higher than HCM/FAs' and 0.5 steps higher than PICs'.

Note that this analysis gives too positive picture of DOCs' alertness in comparison to HCM/FAs' and PICs', as the sleep periods per 6-h interval used in the predictions were all completely consolidated. In the real world, especially DOCs' sleep periods are fragmented due to consultation calls.

The scenario with no on-duty sleep demonstrates the significance of on-duty sleep for on-duty alertness. In this scenario, the hourly mean values indicate reduced alertness (KSS ≥ 6.5) for 9 h, between 01:00h and 09:00h.

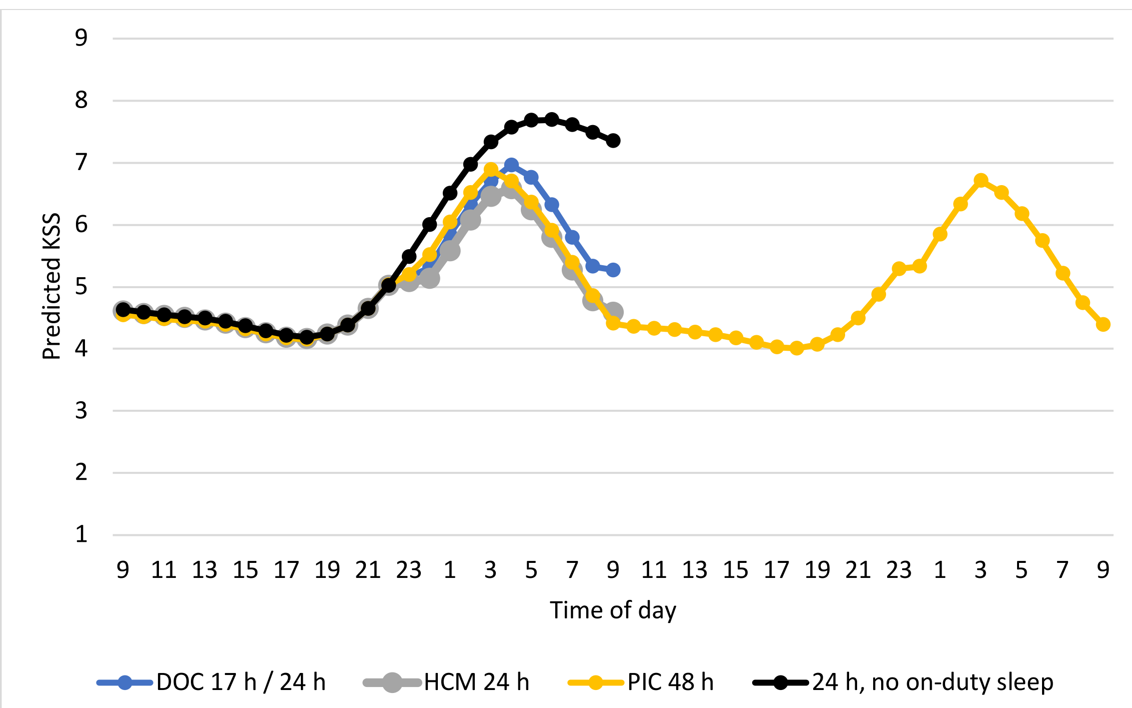


Figure 4.2.3.3. Predicted KSS values by the Sleep-Wake Predictor for DOCs' 17-h/24-h, HCM/FAs' 24-h, and PICs' 48-h duties. The black line denotes a scenario without any on-duty sleep. Each data point represents a mean KSS value per duty hour.

Table 4.2.3.2. The mean values of pre-duty sleep start time and duration in the combined data of the summer and winter measurements by role and duty duration.

Role	Duty duration	n	Start time Mean	Duration Mean
DOC	17h or 24 h	194	22:58	7 h 31 min
HCM/FA	24 h	126	23:15	7 h 25 min
PIC	48 h	99	23:22	7 h 26 min

n = number of duties.

4.2.4. Stress

Table 4.2.4.1. shows the number and percentage of duties with and without increased on-duty stress (STRESS-scale 7 - 9). The results are broken down by role and duty duration. The main observation was that duties involving increased stress were very infrequent for all roles and duty types. The highest percentage value of duties with increased stress was observed for DOCs' 24 h duty but even then, only 2 % of the duties showed this phenomenon.

Table 4.2.4.1. On-duty stress ratings classified into two categories (no stress: 1 - 6; increased stress: 7 - 9) by role and duty duration in the combined data of the summer and winter measurements. Note that the individual ratings indicated the highest level of stress.

		Stress 1 - 6	Stress 7 - 9					
Role	Duration	n	n	%	95 % CI		Total	Missing
DOC	24h	96	2	2,0	-0,8	4,8	98	3
DOC	day 7h	64	1	1,5	-1,5	4,5	65	56
DOC	17h	85	1	1,2	-1,1	3,4	86	7
HCM/FA	24h	123	1	0,8	-0,8	2,4	124	2
PIC	48h	99	0	0,0			99	0
Grand total		467	5				472	68

n = number of duties, CI = confidence interval.

Figures 4.2.4.1. (only DOCs) and 4.2.4.2. (HCM/FAs and PICs) show the mean values across all self-ratings of stress in consecutive 6-h time windows within a duty. Note that each self-rating indicated the highest stress level the participant had experienced in a given 6-h time window.

There was a tentative pattern of stress being higher during the second part of a duty than during the first part in DOCs, independent of duty duration. During overnight duties, the highest levels were reached in the 21:00h - 03:00h time window. The difference between the highest and lowest levels was, however, only about one step on the 9-step STRESS scale and the mean value never exceeded a value of 5 (neither some stress, nor a lot of stress).

The stress levels of HCM/FAs and PICs remained low (1 - 3; extremely little stress – only some stress) throughout their 24-h and 48-h overnight duties.

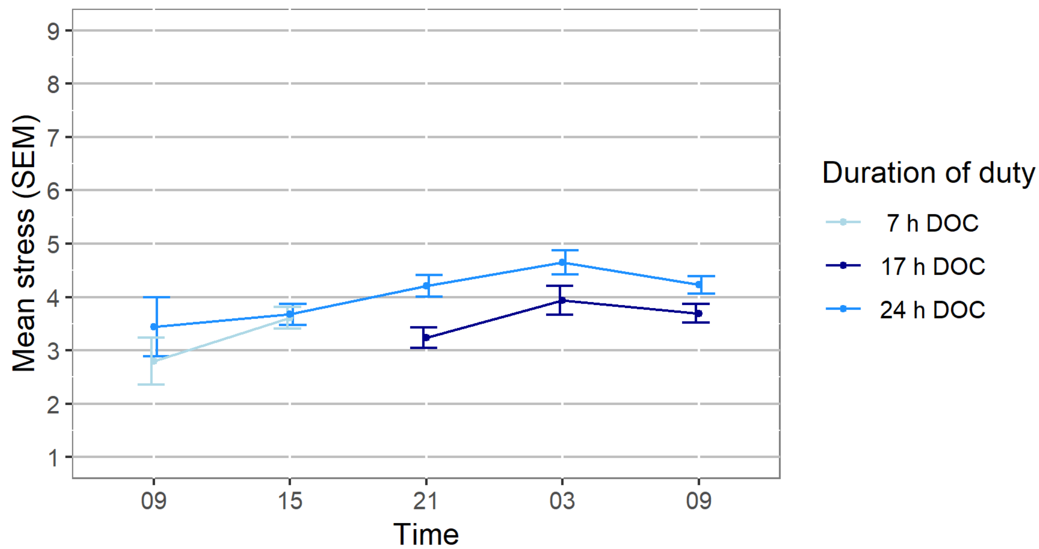


Figure 4.2.4.1. The mean values of the stress ratings given by DOCs in 6-h time windows in the combined data of the summer and winter measurements by duty duration. Note that the ratings indicate the highest level of stress.

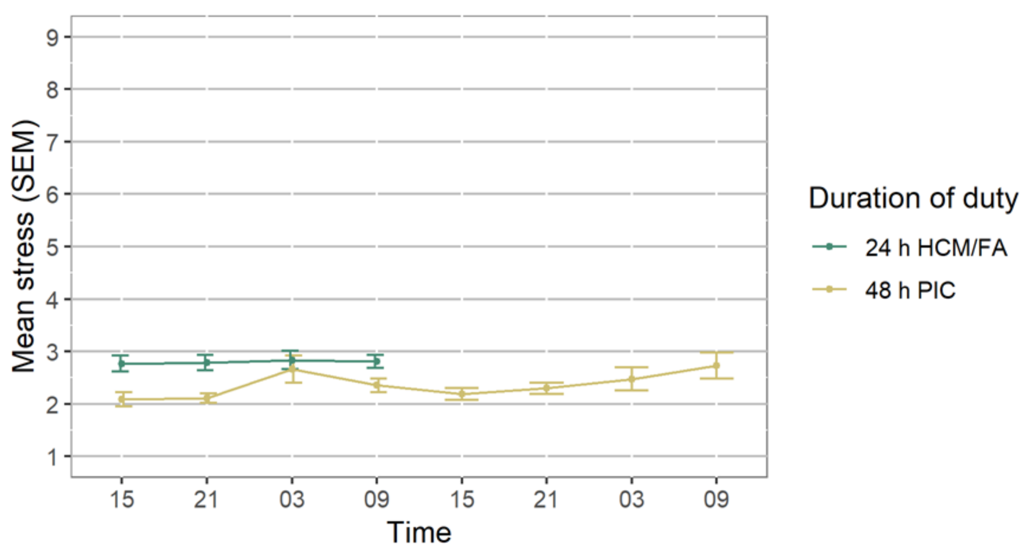


Figure 4.2.4.2. The mean values of the stress ratings given by PICs and HCM/FAs in 6-h time windows in the combined data of the summer and winter measurements by duty duration. Note that the ratings indicate the highest level of stress.

4.3. DOCs cognitive demand and mental burden during missions

DOCs registered for each mission their cognitive demand and mental burden in the FHDB. Table 4.3.1. presents the cognitive demand and mental burden experienced by DOCs in relation to patients' HEMS benefit score (HBS). Cognitive demand was medium or high for 60.8 % of missions where the patient's HBS was 6 - 8, representing the most difficult patients that benefit the most from the HEMS unit's care. For lower HBS ratings the percentage of medium or high cognitive demand was below 40 %. Mental burden was mainly low for all categories of HBS.

Table 4.3.1. DOCs' self-estimates of cognitive demand and mental burden in relation to patients' HEMS Benefit Score.

	HEMS Benefit Score			
	0 - 2 (n = 132)	3 - 5 (n = 181)	6 - 8 (n = 171)	Total, % (N = 484)
Cognitive demand				
Low (0-3), %	62.1	64.1	39.2	54.8
Medium (4-6), %	31.1	31.5	52.6	38.8
High (7-10), %	6.8	4.4	8.2	6.4
Total, %	100.0	100.0	100.0	100.0
Mental burden				
Low (0-3), %	63.6	75.6	64.9	68.6
Medium (4-6), %	30.3	22.7	31.0	27.7
High (7-10), %	6.1	1.7	4.1	3.7
Total, %	100.0	100.0	100.0	100.0

n = number of missions.

Table 4.3.2. presents DOCs' self-estimates of cognitive demand and mental burden in relation to patient's age. Younger patients added to mental burden: 27.8 % of the missions where DOCs' treated an underage patient were estimated highly mentally burden. Also, the median age of patients was the lowest for the missions where mental burden was estimated high. Patient's age was not similarly associated with DOCs' self-estimates of cognitive demand.

Table 4.3.2. DOCs' self-estimates of cognitive demand and mental burden in relation to patients' age.

	Patient's age				
	<18 yrs, %	median	mean	95 % CI of mean	n
Cognitive demand					
Low (0-3)	9.1	54.0	51.0	48.2; 53.9	265
Medium (4-6)	11.2	58.9	52.9	49.3; 56.5	188
High (7-10)	12.9	53.4	49.6	40.6; 58.6	33
Mental burden					
Low (0-3)	8.7	56.5	52.1	49.5; 54.6	332
Medium (4-6)	11.2	59.5	52.3	48.0; 56.6	134
High (7-10)	27.8	46.8	39.8	26.1; 53.6	18

n = number of missions.

Table 4.3.3. presents cognitive demand and mental burden in relation to different types of missions. There was a trend of cancelled missions adding to mental burden. Escorting a patient to a hospital and patient's death were both related to higher scores in both cognitive demand and mental burden. Cognitive demand was at its highest for the missions where the patient was escorted to hospital. This score was quite similar to the missions with HBS 6 - 8 and to the missions with intubation of a patient. It can be assumed that the same patients belonged to all of these categories, as all of them describe the most critical patients.

Table 4.3.3. DOCs' self-estimates of cognitive demand and mental burden in relation to mission type (denied, cancelled) and patient status (escorting to hospital, death).

	Patient			Mission	
	dead at scene (n = 80)	escorted to hospital (n = 216)	not escorted (n = 188)	denied or cancelled (n = 737)	Total (N = 1221)
Cognitive demand					
Low (0-3), %	56.2	41.7	69.1	92.0	77.3
Medium (4-6), %	35.0	50.9	26.6	7.3	19.8
High (7-10), %	8.8	7.4	4.3	0.7	2.9
Total, %	100.0	100.0	100.0	100.0	100.0
Mental burden					
Low (0-3), %	50.0	64.8	80.8	89.8	81.4
Medium (4-6), %	40.0	31.5	18.1	9.5	16.7
High (7-10), %	10.0	3.7	1.1	0.7	1.9
Total, %	100.0	100.0	100.0	100.0	100.0

n = number of missions.

Table 4.3.4. presents cognitive demand and mental burden in relation to airway management performed on the patient. Cognitive demand was clearly higher for the missions where a patient was intubated. The missions without the need of airway management had the highest percentage value for low cognitive demand. A similar trend was observed in mental burden. Patients in the need of airway management are the most critical patients.

Table 4.3.4. DOCs' self-estimates of cognitive demand and mental burden in relation to airway management.

	Airway management			
	intubation (n = 145)	other (n = 48)	none (n = 288)	Total (N = 481)
Cognitive demand				
Low (0-3), %	37.9	47.9	63.9	54.5
Medium (4-6), %	52.4	43.8	31.6	39.1
High (7-10), %	9.7	8.3	4.5	6.4
Total, %	100.0	100.0	100.0	100.0
Mental burden				
Low (0-3), %	54.5	60.4	76.8	68.4
Medium (4-6), %	40.0	29.2	21.5	27.9
High (7-10), %	5.5	10.4	1.7	3.7
Total, %	100.0	100.0	100.0	100.0

n = number of missions.

4.4. Results of the workshop and expert assessment

Based on the development proposals of the HEMS personnel, the study group experts identified 10 target areas and related solution ideas that were further arranged under the following three categories: working conditions, activities on duty, and personal means off-duty. Table 4.4.1. summarises the assessments of the experts.

Table 4.4.1. Study group experts' assessment of the feasibility (1 = poor to 3 = good), implementation period, and effectiveness of the development actions (0 = no effect to 3 = strong effect) to meet the targets/needs identified in the HEMS personnel workshops.

(A) Working conditions

Development targets/needs	Development actions	Feasibility	Implementation period	Effective-ness
Dispatch				
• Risk assessment • Cancelled missions disrupt everybody's sleep	Better use of mission data in operational control to balance regional and time-specific load	3	now, continuous process	2
	Create a HEMS dispatcher system in the emergency response centres	3	3 – 5 years	3
	Specify dispatch instructions according to specific regional and operational characteristics	3	1 – 2 years	2
	Develop an SOP (standard operating procedure) to allow more assessment by the HEMS unit of the true need on scene, even if it delays departure	3	now	2
Consultations				
• Consultation calls disrupt DOCs sleep	Reorganise consultations so that DOCs are not responsible for them while on HEMS duty	3	now, continuous process	3
	Develop the instructions of hospital districts and increase EMS units' autonomy to reduce the number of consultations	3	now, continuous process	3
Optimising recovery time on duty				
• To decrease strain / overload due to too many tasks • To improve systems / structures	Reduce overlapping registrations	3	1 – 3 years	2
	Reorganise the distribution of tasks and increase flexibility in the on-duty team	3	now	2

(A) Working conditions continues

Development targets/needs	Development actions	Feasibility	Implementation period	Effective-ness
Working hour arrangements				
• Off and on duty recovery is compromised (due to long total working hours) • Sufficient staffing	Limit DOCs' total working hours	3	now	3
	Limit the working hours before and after a night duty	3	now	3
	Include training in office hours	3	now	1
	Create a reserve/backup crew arrangement for all occupational groups and bases	2	now – 2022	1
	Include DOCs as flight crew members and thus under working time regulation	3	from 2022	3
Sleep hygiene on duty				
• Sleep hygiene is not optimal • More tranquility for sleep and rest	Calm sleeping areas in on-call facilities	3	now – 2 years	2
	Arrange the duty handovers so that they do not disturb rest	3	now	1
	Critically evaluate visits and limit them by base when necessary	3	now	1
	Optimise sleeping and resting conditions	3	now	2
	Renew temporary bases	3	3 – 5 years	3
Equipment of bases				
• Equipment differ at different bases which delays working	Standardize equipment at all bases to facilitate the mobility of personnel	3	0.5 – 2 years	1

(B) Activities on duty

Development targets/needs	Development actions	Feasibility	Implementation period	Effective-ness
Performance on duty				
• To improve performance and alertness • To save time when duty officers are tired	Evaluate the need for new SOPs and check lists and implement them	3	now, continuous process	2
	Develop an alertness monitoring method, both for each mission and continuously	3	now – 2 years	2
	Develop a method to increase performance on mission departure (at night)	3	now – 1 year	2
Recovery on duty				
• Breaks during duty • Resting (particularly during night time)	Develop a culture that allows rest using managerial and educational measures	3	now	3
	Avoid other than HEMS related tasks while on duty	3	now	3
Individuals as part of work community				
• Self-management • Creation of team spirit	Critically review one's own need for recovery and act accordingly	3	now	3
	Develop teamwork and create team spirit	3	now	3
	Mutual respect and courtesy	3	now	2
	Consider individual needs	3	now	2
	Try to communicate appropriately, especially at night	3	now	2
	Develop common culture: collective meals, daily rest, fitness time	3	now	2

(C) Personal means off-duty

Development targets/needs	Development actions	Feasibility	Implementation period	Effective-ness
Off-duty well-being				
• Taking care of one's own well-being off-duty	Well-rested to work, moderate alcohol consumption, and taking care of one's fitness	3	now	2

5. Discussion

5.1. Main results

The main research aim of the present study was to assess the overall balance between strain and recovery among the HEMS personnel of Finland.

In general, the questionnaire results of general health and well-being at work showed that these pillars of balance between strain and recovery were rather firm among HEMS personnel. For example, more than 90 % of participants assessed their workability, job satisfaction, and work engagement good. In addition, more than 80 % of participants were satisfied with their working hour arrangements, estimated rapport among employees good, and did not report strong need for recovery from work.

There were, however, differences between the HEMS personnel. One main difference was that DOCs reported more frequently cognitive failures at work than the other groups. Moreover, the general status of DOCs was less optimal compared to the other HEMS personnel. This phenomenon was observed in job strain, work-life interference, the perceived negative effects of working hours, and recovery from night duties. Also, the questionnaire results of sleep and on-duty alertness tended to be poorer for DOCs than for the other HEMS personnel.

The results of the field study on sleep and on-duty alertness were well in line with those of the questionnaire study. DOCs obtained less sleep and rated more often low alertness levels during overnight duties than the other HEMS personnel. Self-rated on-duty stress remained at low levels in all occupational groups in all duty types.

In the field study, duty duration did not prove a significant factor in terms of sleep, alertness or stress during overnight duties. However, the time of day played a role in alertness. The lowest level of alertness was reached within the 03:00h - 09:00h time window of the overnight duties, independent of the occupational group or duty duration.

Unfortunately, the field data collected during the summer and winter periods were not comprehensive enough for seasonal comparisons. These two periods of data had to be combined to have a sufficient number of participants per occupational group and duty type.

Next, these main results will be discussed with the main emphasis on the differences between DOCs and other HEMS personnel.

5.2. Differences between DOCs and other HEMS personnel

The results of the questionnaire and field studies suggest that well-being at HEMS work, including on-duty sleep and alertness, is reduced among the DOCs as compared to the other HEMS personnel. When looking at these results in the big picture, one can assume that the key factor is reduced sleep during overnight HEMS duties among DOCs.

In both the questionnaire and field studies, DOCs reported sleeping approximately 4 hours per 24-h duty, which was 2 - 3 hours less than the other HEMS personnel did. Importantly, all HEMS personnel reported obtaining 7 - 8 hours of sleep prior to their night duties in both the questionnaire and field studies. Thus, prior sleep cannot explain the observed differences in on-duty alertness, cognitive functioning, and recovery from night duties between DOCs and the other HEMS personnel.

The results of the alertness modelings seemed to support the presumption that the reduction in on-duty sleep among DOCs put them at an increased risk of impaired alertness during overnight duties. The group difference was, however, less pronounced in the modelings than in the self-rating data. This method-related difference may be explained by sleep continuity – or lack thereof. In the field data, especially DOCs' on-duty sleep probably comprised of more than one unbroken sleep period within a 6-h time window, whereas the mathematical modelings were based on scenarios where sleep was a single unbroken period. Interrupted on-duty sleep is especially typical for HEMS physicians because they are obliged to take consultation calls 24/7. FHDB data shows that the number of consultation calls is, on average, 17.9 per 24-h duty. Unfortunately, in the present study on-duty sleep was measured with a degree of precision that does not allow one to conclude about the role of sleep continuity.

Experimental sleep restriction studies also support the idea that the reductions in on-duty sleep among DOCs can explain their reduced on-duty alertness and possibly also increased cognitive failures at work. According to these studies, 3–5 hours of nocturnal sleep leads to progressive impairments in these outcomes also daytime across the days of sleep restriction (Belenky et al. 2003; Van Dongen et al. 2003). In addition, the modelled scenario with no on-duty sleep clearly demonstrates how high sleepiness can increase for hours if no or only very little sleep is obtained while working on an overnight duty. In the field data, DOCs had such duties, even if only infrequently.

When comparing the occupational groups in terms of self-reported cognitive failures, it is necessary to also consider differences in their job characteristics and demands. In general, DOCs' job can be considered less protocol driven compared to flight personnel in HEMS. In practice this means that DOCs' possibilities to rely on routines is more limited. Well-rehearsed routines are known to be an effective means to prevent human errors in safety-critical occupations. Thus, it is likely that besides reductions in on-duty sleep, differences in job characteristics explain why DOCs reported more cognitive failures at work. Also, it is worth noting that the DOCs are in charge of patient documentation after missions and consultation calls, which adds to their workload compared to the flight personnel.

The idea of high job demands underlying DOCs' self-reported cognitive failures is to some extent supported by the register data of the present study. It showed that DOCs self-estimated cognitive demands of their missions were either moderate or high in almost half of the cases. The high cognitive demands seemed to associate with high HEMS benefit scores, intubation of a patient, escorting a patient to hospital, and patient's death.

Another aspect of job demands, which was measured among DOCs, was the level of mental burden during missions. This aspect can be considered important especially for sleep and overall recovery between missions. In about one-third of the missions, DOCs estimated their mental burden either moderate or high. The self-estimated mentally moderately to highly demanding missions seemed to associate with treatment of an underage patient, intubation of a patient, escorting a patient to hospital, and patient's death.

Thus, the register data seemed to support the assumptions on DOCs' task-related fatigue factors on missions that are related to critical patients. However, to know to what extent, if any, these two self-estimations and missions characterized by the above-mentioned features (e.g., a high HEMS benefit score) are associate with variation in on-duty alertness, it is important to next study the distribution of these measures across duties. This further analysis may help target alertness-promoting measures in an optimal manner with respect to job demands.

Long weekly working hours were also a typical job characteristic of HEMS physicians. They reported working, on average, more than 50 hours a week. Such long working weeks have been associated with reduced mental health and higher risk for physical health problems in the long run (Milner et al. 2015; Kivimäki et al. 2015). Thus, long weekly working hours, besides frequent consultation calls during HEMS duties, may contribute to the preliminary findings of increased job strain and poorer recovery from night work among DOCs. It also worth noting that DOCs worked weekly only about 20 hours on HEMS duties and more than 30 hours on other duties. Among the other HEMS personnel, such difference was not observed and their average weekly working hours remained below 50 hours.

To conclude, short and fragmented on-duty sleep due to consultation calls probably is the main factor explaining why the DOCs – in contrast to the other HEMS personnel – reported impairments in on-duty alertness, cognitive functioning, and recovery after night duties. However, also other factors, such as differences in other job characteristics and demands, may contribute to this observation.

5.3. Role of duty duration and time of day in alertness

One of the research aims was to assess strain and recovery in different types of HEMS duties. The questionnaire results of the effects of HEMS working hours on sleep and alertness showed that DOCs experienced these effects more negatively than the other HEMS personnel. This suggests that duty duration is not the most crucial factor, as DOCs mostly worked at least 50 % shorter nighttime duties than the other HEMS personnel (e.g., 17 h, 24 h vs 48 h).

This above-mentioned finding of the questionnaire study was replicated and specified in the field study. First, DOCs rated lower alertness levels during their 24 h duties than did the flight personnel during their 48 h duties. Second, alertness levels did not differ between 17 h and 24 h overnight duties among DOCs. Third, alertness levels were quite similar during the first and second 24-h period of a 48-h duty among PICs and HCM/FAs. The main explanation for the third result probably lies in fairly long on-duty sleep especially during the nighttime. Together these findings suggest that adjustments to the duration of overnight duties are not the key factor for improving on-duty alertness.

The results of the field study and the predictions of on-duty alertness by the Sleep-Wake Predictor indicate that in HEMS duties the time of day is a much stronger determinant of alertness than on-duty time. The influence of the time of day on alertness was observed in all occupational groups during overnight duties, with the lowest alertness occurring in the 03:00h – 09:00h time window. This time window largely covers a period that is, especially in aviation, called the Window of Circadian Low (WOCL, 02:00h - 06:00h) (Commission regulation (EU) No 83/2014). Within this period, the downswing of the circadian-regulated alertness takes place.

In HEMS work, working during the WOCL is impossible to avoid. Thus, the main solutions should be based on alertness management strategies, such as protected on-duty sleep. The nighttime KSS ratings of DOCs in the present study correspond well with those seen among employees who are not permitted to sleep during their night duties (Åkerstedt et al. 2014). The ratings of the other HEMS personnel tended to remain at markedly better levels. Thus, the main concern about on-duty alertness relates to HEMS physicians during the nighttime. To improve the situation, allowing DOCs a protected sleep period between HEMS missions would be a primary solution.

5.4. On-duty stress versus on-duty sleepiness

In comparison to on-duty sleepiness, on-duty stress was only marginally increased. For example, only 2 % of DOCs' 24-h duties involved increased stress, whereas 19 % of the same duties involved reduced alertness.

There are at least two explanations for the observed difference. It is possible that the methods used to measure alertness and stress differ in their validity. The Karolinska Sleepiness Scale is a well-validated method, while the stress scale, which is analogous to the KSS, is not equally validated for its purposes. The other explanation is that on-duty stress really is of less concern than on-duty sleepiness. This explanation would be comprehensible. High expertise, well-rehearsed team work, and well-defined protocols can all be considered buffers against high stress, but not against possible reductions in alertness.

On-duty stress showed a tendency to be at higher levels among the DOCs than the other HEMS personnel. This finding tentatively adds to the idea of DOCs' working conditions being less optimal as compared to the other team members.

In the future, it would be important to collect not just subjective evaluations but also stress biomarkers and cardiac autonomic data in field settings to get an accurate and comprehensive picture of on-duty stress and recovery.

5.5. Role of base area in strain and recovery

In addition to occupation and duty type, the role of base location was addressed in the questionnaire study results, when appropriate. As a whole, the results seemed to be less positive for the southern bases than the northern ones, even though statistical power was lacking. Of the conducted comparisons, only need for recovery after a night duty did this.

The division of the bases into the southern (Vantaa, Tampere and Turku) and northern ones (Kuopio, Oulu and Rovaniemi) was an attempt to assess the role of workload in strain and recovery. Based on FHDB mission data in 2018 the three southern bases had on average 7523 and the three northern bases 6539 missions. Thus, the above-mentioned preliminary results tentatively suggest that a higher workload is associated with reduced cognitive functioning at work, on-duty alertness, and recovery from night duties. As such this conclusion makes sense, but first it is important to consider at least two factors. First, the southern and northern bases represent quite rough proxies for higher and lower workload levels. Second, the present study showed only tendency-like associations, which calls for a replication before anything conclusive can be inferred.

5.6. Main development needs and how to meet them

The development aims of the present study were first to identify the main needs and then to make an improvement plan to promote the overall balance between strain and recovery among HEMS personnel. The positive questionnaire results of general health, well-being at work, and work ability provide a good starting point for this development job.

Based on the results of the present study, HEMS personnel and the study group experts first identified the main development needs and then made a proposal on feasible and effective actions to meet them. The needs were arranged into three main categories: working conditions, activities while on duty, and personal means off-duty. Under each category, there were one to six sub-categories.

Within the main category of working conditions, the development actions considered both feasible and effective mainly addressed the issue of DOCs’ workload during night duties and long total working hours. Example of these actions were i) re-organising consultation calls so that HEMS physicians would no longer be responsible for them (in the night time), ii) limiting HEMS physicians’ total working hours by applying the same regulations to them as to aircrew personnel’s working hours, and iii) limiting HEMS physicians’ working hours prior to and following a night duty. These actions are quite straightforward responses to the results of DOCs’ reduced cognitive functioning, alertness, and recovery opportunities around night duties.

There were also other development actions of the same nature. These actions emphasized i) optimising sleeping and resting conditions, ii) reducing unnecessary dispatches and obligations, and iii) creating a favorable climate for on-duty recovery measures through educational and managerial operations models. Moreover, some of the proposed actions focused on the use of standardised methods and protocols to assess and enhance on-duty alertness.

These development actions are well in line with recent recommendations of fatigue mitigation in EMS work (Table 5.6.1) (Patterson et al. 2018). According to these recommendations, the main mitigation measures are the use of sleepiness monitoring instruments, restriction of duty duration below 24 hours, the use of caffeine to stay alert, having nap opportunities during duties, and providing education on fatigue mitigation. Only the recommendation of restricting duty duration below 24 hours was not supported by the results of the present study, even if a comparison between DOCs' 17-h and 24-h HEMS duties is complicated by the fact that DOCs often worked a regular day duty at the hospital before they started a 17-h HEMS duty. Thus, that sort of recommendation was not included in the development needs plan summarized in Table 4.4.1.

Table 5.6.1. Evidence-based recommendations for fatigue risk management in EMS by Patterson et al. (2018).

PICO	Recommendation statement	Relevance CVI Clarity CVI	Total Round of Voting
1	Recommend using fatigue / sleepiness survey instruments to measure and monitor EMS personnel. (strong recommendation, very low certainty in evidence	1.0	1
2	Recommend that EMS personnel work shifts shorter than 24 hours. (weak recommendation in favor, very low certainty in effect)	1.0	1
3	Recommend that EMS personnel have access to caffeine as a fatigue countermeasure. (weak recommendation in favor, low certainty in effect)	1.0	1
4	Recommend that EMS personnel have the opportunity to nap while on duty to mitigate fatigue. (weak recommendation in favor, very low certainty in effect)	1.0	1
5	Recommend that EMS personnel receive education and training to mitigate fatigue and fatigue-related risks. (weak recommendation in favor, low certainty in effect)	1.0	1

PICO = the Population, Intervention, Comparison, Outcome framework; Relevance CVI = the Content Validity Index.

It is worth noting that Table 4.4.1 set responsibilities for both the organisations involved in HEMS work (i.e., employers of the HEMS personnel and an organisation responsible for HEMS services) and the HEMS personnel themselves. This accords with the concept of shared responsibility, often used in civil aviation when talking about fatigue risk management. It holds that responsibility for fatigue risk management is shared between airline management, pilots, and support staff (ICAO 2015). The concept stems from the fact that fatigue is a whole-of-life issue that is determined by all waking activities and behaviours, not just by work demands.

To implement the development actions presented in Table 4.4.1, it is worth considering the possibility of having a system and procedure that collects all actions under the same umbrella and supports this kind of development in the long-run. Perhaps the most suitable option for this purpose is a fatigue risk management system (FRMS) that covers all HEMS personnel (Gander et al. 2011). It has especially been used in the aviation sector. With an FRMS, it is possible to apply a wide range of fatigue countermeasures in an optimal manner (Dawson & McCulloch 2005).

An FRMS is a data-driven means of continuously monitoring and managing fatigue-related safety risks, based upon scientific principles, knowledge, and operational experience that aims to ensure relevant personnel are performing at adequate levels of alertness (IATA, ICO, IFALPA 2015, p. 46). This system stands on the following four pillars: FRM policy and documentation, FR management, FRM assurance, FRM promotion (Figure 5.6.1).

An FRMS is already in use in HEMS work among pilots and HEMS crew members, but not among physicians and FH51 paramedics. This difference between the HEMS personnel may partly explain why their results differed especially in on-duty alertness in the present study.

Figure 5.6.1. Four pillar model of Fatigue Risk Management System.

A crucial phase in developing an FRMS is its implementation in the workplace. Table 5.6.2. summarises the milestones and actions of the FRMS implementation process (IATA, ICO, IFALPA 2015). This process is characterized by careful planning and training followed by the first attempt to apply an FRMS to certain operations. Based on the experiences of these two milestones, an FRMS can be put into effect, monitored, and improved on continuous basis. To further facilitate the implementation process, it is good to have a model of fatigue mitigation strategies. For this purpose, a worthy option is so called Fatigue Risk Trajectory (FRT) model (Dawson & McCulloch 2005). The model divides mitigation strategies into five levels, starting from working hour regulations and ending with an investigation of fatigue-related incidents.

In all, the implementation of the development actions 44ummarized in Table 4.4.1 calls for well-defined plan, processes and responsibilities. This approach also supports a long-term development of FRM in HEMS work.

Table 5.6.2. Milestones and actions of FRMS implementation.

Milestone	Actions
Preparation	- identification of existing and needed FRMS elements and processes - identification of needed human and financial resources - personnel training - FRMS policy statement - implementation plan
Trial	Definition of - operations where the trial takes place - outcomes used to monitor fatigue risk - FR mitigation strategies - documentation and modifications
Launch	- putting FRMS into effect in operations to which it applies - monitoring functionality of FRMS
Maintain and improve	- making FRMS a routine - reviewing and improving continuously through the FRM assurance process

5.7. Strengths and weaknesses

A main strength of the study was the use of data collected from multiple sources. This made it possible to compare results collected from different sources and thus cross-check most of the results. Second, the participation of all six HEMS bases of Finland in the study was a clear strength, ruling out the possibility that the results would be applicable to specific bases only. Third, workshops and the data collected in them can be considered very valuable for the development efforts, as the HEMS personnel of Finland were able to have their say on the main results of the study and innovate real-world solutions and future developments.

The main weakness of the present study was a low number of participants in the other occupational groups than DOCs. This lack of representativeness makes it difficult to draw highly generalizable conclusions from the data. In addition, the low number of participants did not enable us to statistically test the differences between the groups as planned. It is also worth mentioning that it would have been good to collect also objective data on sleep, alertness, and stress to make the results even more reliable.

5.8. Overall picture of HEMS personnel's strain and recovery and its development in the future

The main results of the present study indicate that general health, well-being at work, and work ability are at a fairly good level among HEMS personnel. This provides a good basis for meeting the identified development needs to improve the balance between strain and recovery.

The main development needs concern fatigue risk mitigation. According to the present study, this is a relevant issue to all HEMS personnel during their night duties due to the downswing of circadian-regulated alertness. The need for development around fatigue mitigation is pronounced among DOCs due to frequent consultation calls and probably, to some extent, also other job demands, such as a large amount of total working hours and a high number of cognitively and mentally demanding missions. To implement the proposed actions, it is essential to develop an FRMS. This system would cover all HEMS personnel, not just pilots and HEMS crew members, as it is currently the case. The full coverage is of special importance, given the role of multi-professional teams in HEMS work.

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