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ORIGINAL ARTICLE

Pilot study on the development of digitally supported health promotion for seafarers on sea

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ABSTRACT

Background: *Seafarers are exposed to a variety of job-specific physical and psychosocial stressors. Health promotion on board is of great importance for the salutogenesis of this occupational group. Due to the difficult accessibility of seafarers, electronically supported health management can be highly valuable. However, surveys on the needs and interests of seafarers in health promotion regarding e-health applications have not yet been carried out.*

Material and methods: *This pilot study uses a cross-sectional design to assess the need for digital health promotion for seafarers on board. This need was derived from the individual responses of 73 crew members on 3 merchant ships on health as well as addictive behavior, sports, coping strategies, and the level of knowledge regarding health-related issues. Conspicuous parameters on mental health and fatigue were compared to the general population.*

Results: *It was found that 31.9% of seafarers were smokers and 80.6% were alcohol consumers. 82.4% of the seafarers practiced sport. The most common coping strategies for stress were calming down (44.6%), listening to music (32.1%), resting and sleeping (25.0%) and sports (25.0%). The evaluation of the PHQ-9 mental health questionnaires indicated that 85.4% of respondents had moderate to severe symptoms of a depressive mood. The average WHO-5 Well-Being Index resulted in level of 69.7% of the maximum possible score. Knowledge questions on health-related issues were answered correctly in less than 60% of cases. With regard to fatigue, there was an increased score for the Epworth Sleepiness Scale (ESS) in 33.8% and the Pupillary Unrest Index (PUI) was elevated in 47.7%.*

Conclusions: *Nicotine and alcohol consumption is higher among the participating seafarers compared to a reference population living on land. Various coping strategies for managing stress are already used in the daily live. However, there is a demand and interest in acquiring more knowledge about health-promoting behavior. The risk of daytime sleepiness and depression is elevated among seafarers. This leads to key issues that should be taken into account for preventive medicine, health promotion and possible digitally supported health management on board.*

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Keywords: seafarers, digitally supported health management, workplace health promotion, e-health, preventive medicine

INTRODUCTION

Seafarers on board merchant ships are confronted with many stress factors due to the special characteristics of their workplace. They are exposed to a variety of health-impairing influences at work, as has been documented in numerous recent studies [1, 2]. Long stays at sea, sometimes for

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several months, far away from shore-based medical care mean that, in the event of illness, medical treatment is only possible through the health responsible officer or through telemedical consultation. This can pose a major stressor for the ship's crew. In addition to climatic, weather-related, and physical effects, stress factors that can also affect seafarers' health include living in confined spaces, a lack of leisure activities, monotony at work and deprivation. Other stress factors in shipping are separation from family and familiar cultural structures, limited opportunities for self-management, reduced sleep quantity and quality as well as unsatisfactory sports equipment [3–5].

In view of these permanent stress factors, interventions for preventive medicine to promote health on board are particularly important and promising. In this context, digitally supported health management on board could improve the health care and wellbeing of seafarers and consequently increase the job-attractiveness in order to counteract an observed shortage of skilled workers [6, 7]. As the job-specific fields of work of ratings and officers differ in terms of health burdens, a differentiated view of possible preventive medical and health-promoting interventions seems useful.

In addition, a positive influence of the size of the shipping company seems plausible (according to the authors' experience larger shipping companies have better economic opportunities for preventive measures in the sense of health information campaigns, better equipped fitness rooms or care measures), but has not yet been scientifically investigated.

Based on the specific working conditions on board, innovative, digitally supported approaches to preventive medical care for seafarers, such as health apps, appear promising. In the shipping industry the latter currently mostly refers to telemedical support through radio medical consultation services [8].

The potential of electronic health promotion has not yet been scientifically and systematically analyzed. For this reason, the EU-funded e-healthy ship study was initiated with the aim, among other things, of conducting a pilot study to determine the specific need for health information and, if necessary, further intervention options for preventive medical treatment for seafarers [9].

In order to have an optimal effect, the intervention should be based on the interest of the crew members as well as the surveys on addictive behavior, sports activities, self-applied coping methods for stress reduction, the level of knowledge about health topics and current findings about mental health and fatigue. The aim of this pilot study is therefore to conduct an orientating multimodal analysis of needs for digital health promotion on board of three randomly selected merchant ships.

MATERIALS AND METHODS

This survey is a non-interventional pilot study that uses a cross-sectional design to descriptively assess the need for electronically based health promotion among seafarers on board. In a collective of seafarers (n = 73) the needs and intervention ideas/desires for health promotion and health management were surveyed by questionnaires. Furthermore, various biographical and standardized questionnaire tools were used to identify potential physical or mental health deficits that are frequently described in the shipping industry [4, 6, 7].

FOCUS OF THE HEALTH-RELATED TOPICS

In a recent study, the following aspects of seafarers' health were identified as being particularly relevant [10]: Mental health and addictive behavior, fitness tracking, sport and physical activity, coping, fatigue and sleep and the implementation of electronically based prevention programs — for example by means of applications for mobile devices (apps). Based on these results, the present study focused on the following topics:

1. Addictive behavior

The seafarers were asked about their tobacco and alcohol consumption behavior using a questionnaire established in the maritime sector (Hamburg Seafarer Study) [11, 12].

2. Sporting activity

Information on physical activity was collected using non standardized questions. The focus was on self-assessment of personal fitness, reasons for avoiding sport and motivational aspects.

3. Coping strategies against stress on board

Questionnaires on the coping strategies of seafarers were used to record the stress management methods already practiced on board. In addition to coping strategies, improvement measures for the working and living conditions on board were also surveyed [12].

4. Mental health

The WHO-5 Well-Being Index and the PHQ-9 questionnaire were used for the standardized assessment of mental health. The WHO-5 Well-Being Index was developed by Bech et al. [13]. It has an internal consistency (Cronbach's α) of 0.91. This questionnaire consists of 5 questions that define well-being using a score system from 0–25 (0 lowest and 25 highest well-being), which in turn is represented on a percentage value scale (0–100%) [14].

The PHQ-9 questionnaire is a screening method for detecting symptoms of depression and consists of 9 questions with scores ranging from 1–27 and 5 levels of severity

(mild symptoms to severe symptoms). The Cronbach's α of the PHQ-9 questionnaire is 0.89 [15].

5. Fatigue

The Epworth Sleepiness Scale (ESS) was used as a subjective method for the standardized assessment of daytime sleepiness. This scale uses a score of 0–24 points to depict the severity of subjective daytime sleepiness, with a score of more than 10 indicating suspected increased daytime sleepiness [16]. For the ESS, a Cronbach's α of 0.88 is described [16].

Pupillometry was performed with the "Fit-For-Duty" device from the company AmTech® to objectively assess daytime sleepiness. The pupil size and pupillary fluctuations, the so-called Pupillary Unrest Index (PUI), were calculated and measured. Pupillary Unrest Index (PUI) were calculated and expressed in mm/min. The internationally recognized standard range in a normal collective of 349 people resulted in a mean value of PUI 1.50 (SD 0.39) mm/min. From a PUI of > 1.89 mm/min there is an "abnormality" and PUI values greater than 2.28 mm/min are to be assessed as "unfit for duty" according to the manufacturer's declaration [17].

6. Seafarers' level of knowledge on health issues

To assess existing basic knowledge about health topics, 52 general questions were asked about sporting activity, healthy eating and fatigue, with correct and incorrect choices. The questions on sport included, for example, the definition of stretching, burning body fat, questions on healthy fluid intake and regeneration after jogging. Questions on the topic of nutrition covered a healthy diet consisting of fish, vegetables, fruit and water in the nutritional composition or the effect of a healthy diet on body weight and energy balance. Questions on fatigue included optimal sleeping times, power napping and aspects of sleep quality. The knowledge questions were developed by a team of four scientists from different professions and care was taken to ensure that they did not demand any specific specialist knowledge from the participants. The number of correctly answered questions was recorded and expressed in percentages.

STUDY POPULATION AND SURVEY CONDITIONS

A total of 73 crew members from three seagoing merchant ships of two shipping companies underwent occupational medical examinations and were interviewed in a standardized manner. This was carried out by four scientific medical persons during three sea voyages, each lasting approximately two weeks (corresponding to a cumulative total of around 120 survey days on board). Of 73 respondents, 72 stated their nationality, which was divided into 26 Philippines, 21 Myanmar, 7 Ukraine, 4 Romania, 4 Russia, 2 Germany, 2 Poland, 2 Lithuania, then 1 each for Peru, Slovakia, Montenegro and Ethiopia.

The English-language questionnaires were grouped into topic blocks of different lengths in advance to enable smooth integration into the everyday work of the seafarers on board. Digitizing the questionnaires in advance made it easier for the seafarers to answer the questions quickly, with few media discontinuities and in chunks. The data collection platform (QuestionPro®) was used for this purpose, which allows data to be collected even without a constant internet connection. Digital end devices (tablets) were handed out to the seafarers so that they could click on the answer options themselves. The surveys always took place in the presence of the on-board investigators so that they could provide direct support in the case of any comprehension problems. The answers to expected queries about certain terms were intensively discussed and defined by the scientists with explanations agreed upon by the team.

The participants were divided into ship collectives of roughly equal size — ship 1 (n = 23), ship 2 (n = 24) and ship 3 (n = 26). The first two ships were identical container ships of a large shipping company, the third ship was a bulk carrier provided by a small shipping company. The ships were selected so that they were representative of the large and small shipping companies in terms of crew structure, design and crew manning. Due to similar working conditions on the other ships of the two shipping companies, it is assumed that the knowledge gained on the needs analysis of the three ship crews can be transferred to the overall collective of the respective shipping company.

STATISTICS

The seafarers' responses to the questionnaire were digitally recorded directly on board via tablet PCs. The documentation of the results was implemented using a special Microsoft 2010 excel spreadsheet, the data analysis was conducted with the SPSS 24 statistics program. A descriptive comparison of the absolute and relative frequency of the collected data was carried out. A group comparison for significant differences between ratings and officers was carried out using the Chi^2 test according to Pearson.

RESULTS

DEMOGRAPHIC DATA OF THE STUDY POPULATION

The surveyed group of seafarers comprised 73 exclusively male persons (46 ratings and 27 officers). The proportion of European crew members was 80.8% for officers and 4.4% for ratings. 69.8% of all crew members were married and 66.7% had children. Officers had an average of 16.5 years and ratings an average of 12.2 years of seafaring experience (Table 1).

Table 1. Demographic and occupational data of the seafarers surveyed

	Crew ratings (n = 46)	Officers (n = 27)
Ranks, n	14 machine crews 24 deck ratings 4 galley staff 4 stewards	4 captains 10 nautical officers 3 chief engineers 10 engineers
Age, years (SD)	40.4 (11.8)	38.6 (8.0)
Origin, n (%)		
European	2 (4.4%)	21 (80.8%)
Non-European	44 (95.6%)	5 (19.2%)
Family status, n (%)		
Single	13 (28.3%)	8 (30.8%)
Married	33 (71.7%)	18 (69.2%)
Children, n (%)	33 (71.7%)	15 (57.7%)
Working time as seafarer, years (SD)	12.2 (7.2)	16.5 (10.5)
Do sports		
yes	36 (83.7%)	20 (80.0%)
no	7 (16.3%)	5 (20.0%)
Sport activity, hours/week		
Ashore		
up to 5	25 (69.4%)	8 (40.0%)
more than 5	11 (30.6%)	12 (60.0%)
On board		
up to 5	32 (88.9%)	18 (90.0%)
more than 6	4 (11.1%)	2 (10.0%)

Differences in the absolute sum of the categories are due to missing data in each case

QUESTIONS ON HEALTH-RELATED TOPICS ANSWERED

A total of 52 questions were asked on the four topics described in the methods section, which were rated by seafarers as particularly relevant to health.

1. Information on addictive behavior

Seventy-two seafarers answered the questions on nicotine and alcohol consumption. Twenty of 46 ratings (43.5%) and 13 of 26 officers (50%) were non-smokers; active smokers vs. ex-smokers were 16 vs. 10 ratings (34.8% vs. 21.7%) and 7 vs. 6 officers (26.9% vs. 23.1%).

Alcohol was consumed by 36 out of 46 ratings (78.3%) and 22 out of 26 officers (84.6%). Alcohol abstinence was reported by 10 ratings (21.7%) and 4 officers (15.4%).

2. Questions about sporting activity

Fifty-six seafarers took part in the survey to self-assess their level of fitness. On a scale of 1 (low) to 5 (extremely high), 11 out of 36 ratings (30.6%) and 7 out of 20 officers (35.0%) classified themselves as "extremely fit" at level 5, followed by 17 ratings (47.2%) and 10 officers (50.0%) at fitness level 4, 7 ratings (19.4%) and 2 officers (10.0%) at fitness level 3 and 1 rating (2.8%) and 1 officer (5.0%) at fitness level 2. None classified themselves in the lowest fitness level 1.

The following reasons were given for not taking part in sporting activities:

"Lack of time" (28 ratings (70.0%) and 19 officers (86.4%)), followed by "already high physical activity during work" (19 ratings (52.8%) and 6 officers (30.0%)), "no interest" (1 rating (2.8%) and 5 officers (5 (25.0%)) (multiple

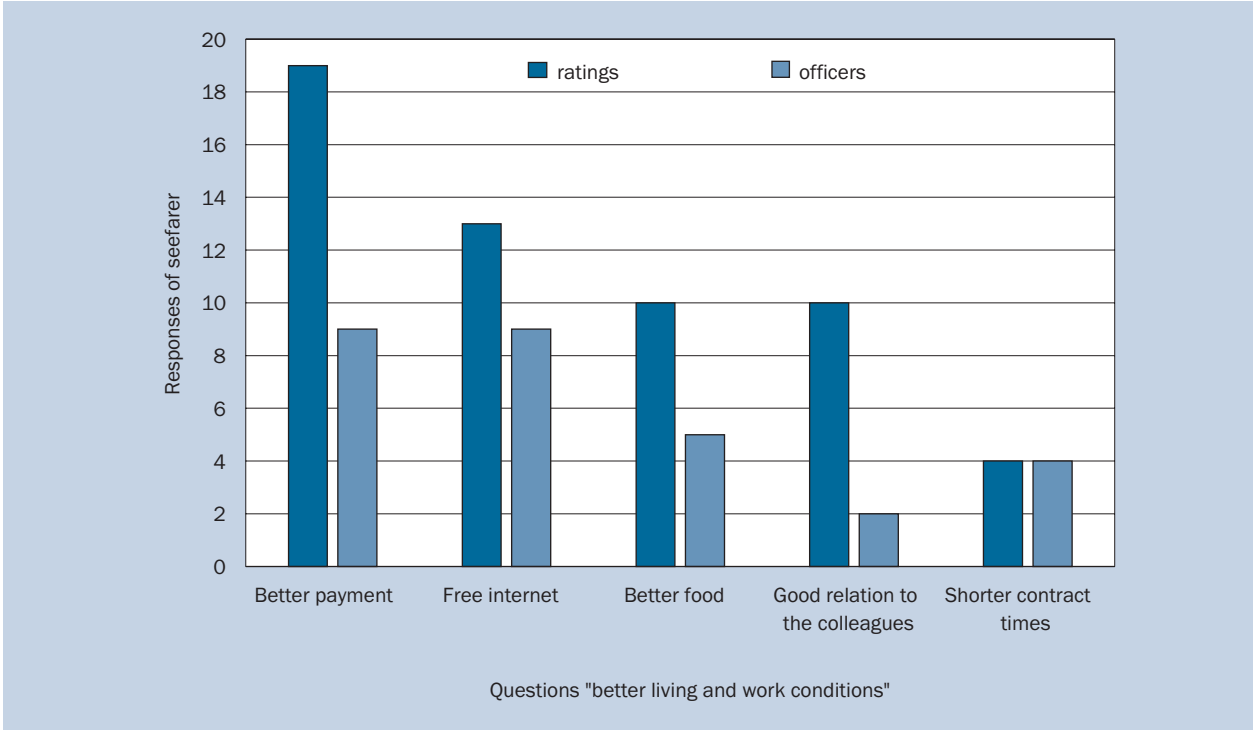

Figure 1. Responses to questions about "better living and working conditions" (n = 41). Columns indicate preferred measures to improve working and living conditions on board for ratings and officers in percent

entries were possible here and in the following three questions). There were no significant differences between ratings and officers ($p > 0.050$).

According to the seafarers, "more free time" (22 ratings (53.7%) and 11 officers (50.0%)), "organization of sport events" (20 ratings (54.1%) and 8 officers (40.0%)), "better equipment for the fitness room" (10 ratings (27.0%) and 14 officers (63.6%)) and "funny competitions between workgroups" (8 ratings (22.2%) and 5 officers (38.5%)) were beneficial for the improvement of sport on board. There were only significant differences in the evaluation of the sport equipment (Chi^2 test according to Pearson; $p = 0.006$).

3. Questions about coping strategies

Within the five questions on the preferred measures for improving working and living conditions on board, only the aspect "good working atmosphere with colleagues" was borderline significant ($p = 0.049$) between the occupational groups (10 ratings (83.3%) and 2 officers (12.5%)). For all other aspects of improvement, there were no significant differences between ratings and officers (Fig. 1).

The information provided by the seafarers on coping strategies already practiced against stress (n = 56) showed significant differences between ratings and officers only for "praying" ($p = 0.004$), other coping strategies showed no significant differences between ratings and officers (Fig. 2).

4. Mental health

The WHO-5 Well-Being Index was completed by 57 seafarers. The average Well-Being score was 17.4 points, corresponding to a level of 69.7% of the maximum possible score. The PHQ-9 questionnaire yielded 41 usable responses and showed that 35 seafarers (85.4%) had moderate to severe (10–27) symptoms of potentially impaired mental health (Fig. 3).

5. Fatigue

The sleepiness of the ship's crews was measured subjectively using the ESS and objectively using pupillometry on board. 22 (33.8%) of the 65 seafarers surveyed showed elevated values in the ESS questionnaire, 10 (15.4%) slightly elevated and 33 (50.8%) normal values. 21 (47.7%) of 44 seafarers showed slightly elevated or elevated values in the PUI (Fig. 4).

6. Seafarers' level of knowledge on health issues

Regarding the level of knowledge on health topics such as sport, nutrition and fatigue, 63 seafarers responded, giving a total of 59.0% correct answers. Questions on the topic of sports were answered correctly by 59.0%. Questions on nutrition, such as healthy nutritional composition, food components and healthy drinks, were answered correctly by 50.2%. Regarding fatigue, for example, questions were

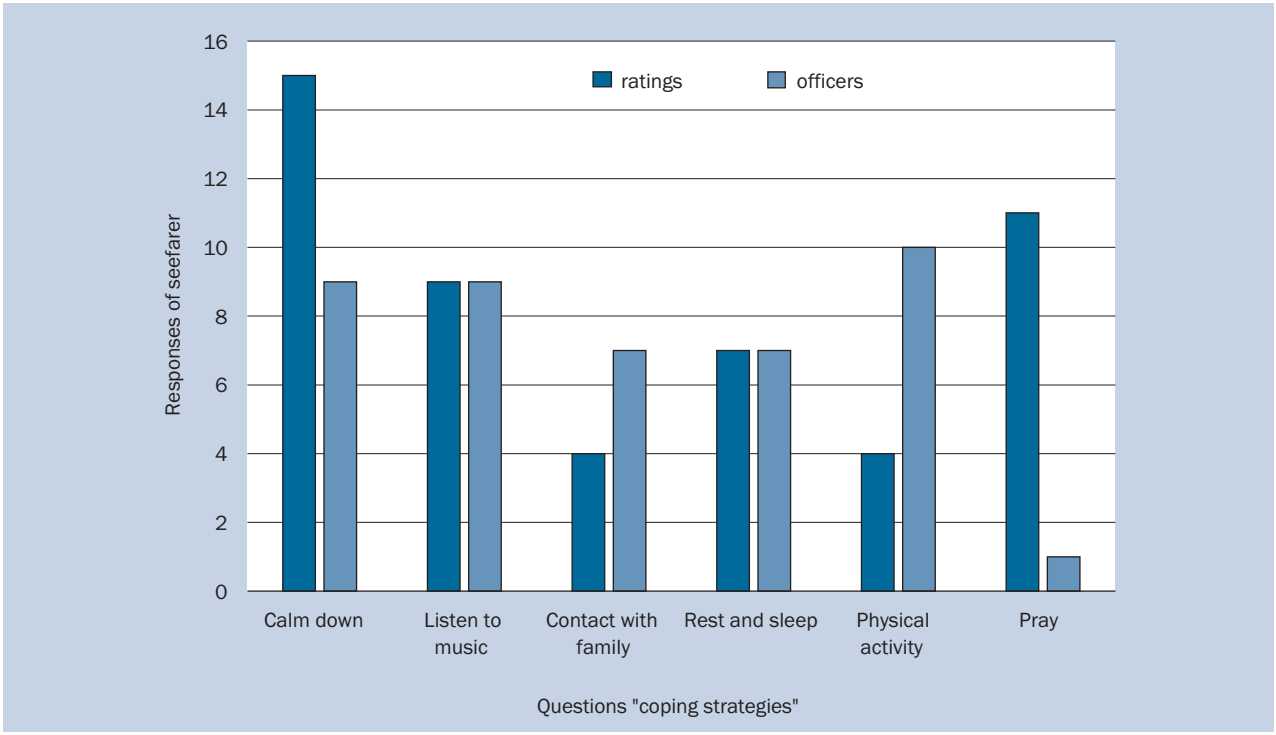

Figure 2. Responses to questions about coping strategies against stress (n = 56). Columns indicate preferred coping strategies already practiced against stress for ratings and officers in percent

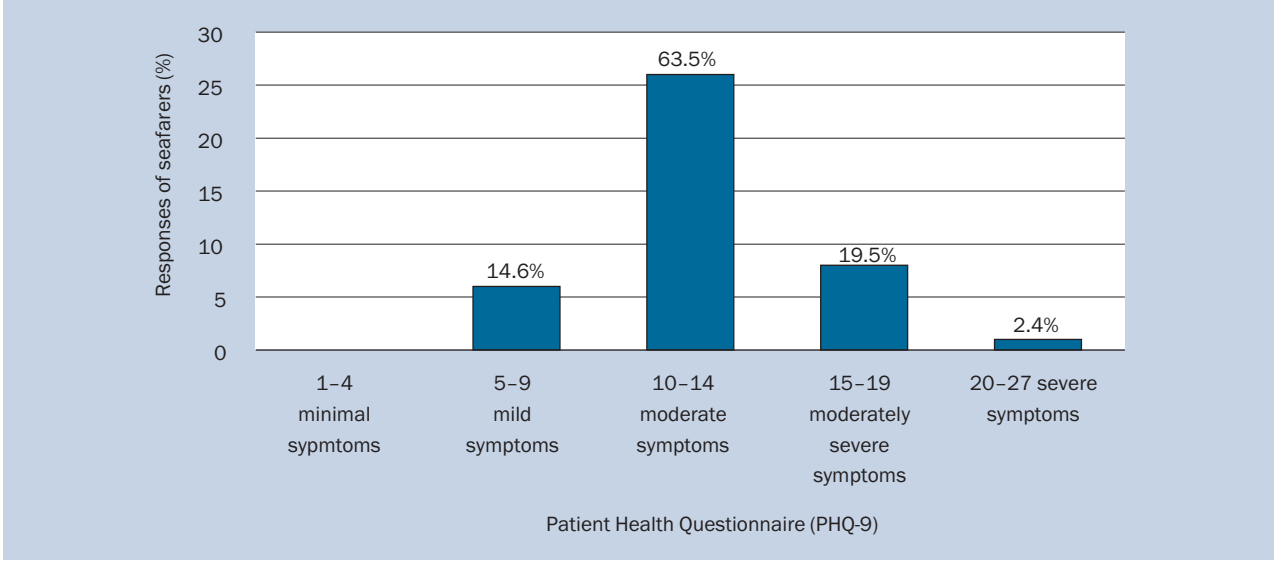

Figure 3. Responses from PHQ-9 questionnaire about mental health (n = 41)

asked about the optimum bedroom temperature, "power napping", sleep quality with alcohol consumption and other topics. The respondents answered 49.7% of these questions correctly.

A comparison of the answers collected between the two shipping companies showed that there were no significant differences in the aspects of rank, age, ethnicity, family status, children, smoking, sporting activity, PHQ-9, and ESS. There were only significant differences between the shipping companies concerning the question if alcohol is consumed (63.9% in the larger and 36.1% in the smaller company, p = 0.014). Although the PUI measurements showed no statistical relevance (p = 0.103), a relatively increased tendency for fatigue was found within the smaller shipping company.

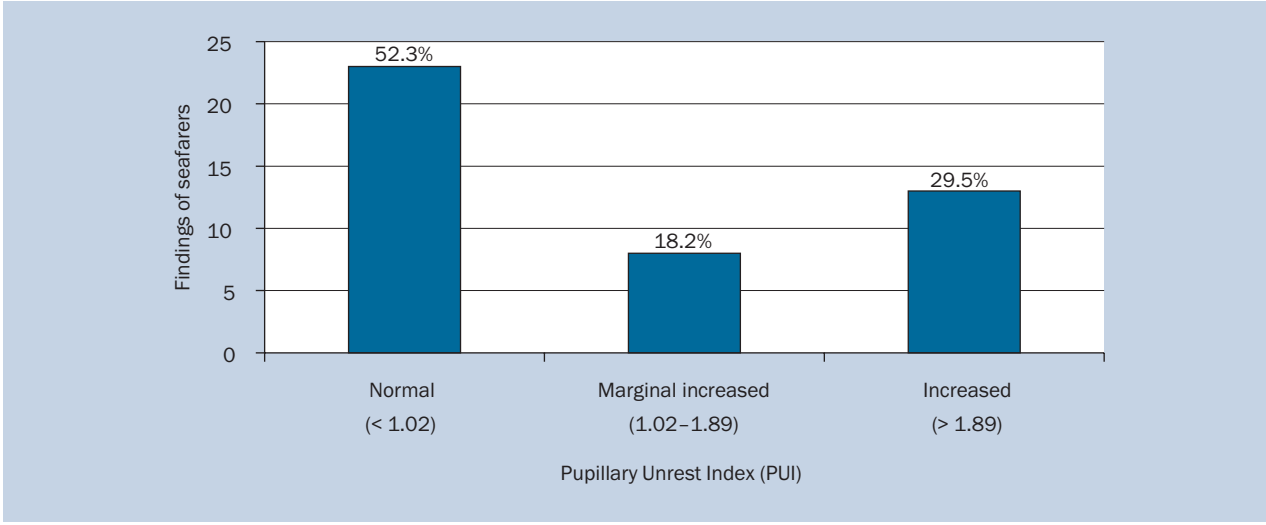

Figure 4. Objective daytime sleepiness according to pupillometry (n = 44)

DISCUSSION

This pilot study examines potentially relevant health topics for seafarers in order to identify needs and develop a future concept for a targeted digital health promotion program on board. Health and addictive behavior, sport/physical activity, coping strategies against stress, well-being and fatigue were identified as possible relevant and interesting health topics for seafarers and the seafarers were surveyed in the workplace accordingly. Stark et al. identified physical activity and nutrition as the most important topics in their review of research priorities for digital health promotion [18]. The present results should provide a basis for further evaluations and the creation of a first customized electronic health advice platform for ship crews. In the aforementioned e-healthy ship research project, a first health platform for ship crews ("crew-healthy ship") was developed.

An own recent literature review did not reveal studies on the prioritization of health topics for e-health applications in shipping, which underlines the importance of this research approach.

The evaluation of addictive behavior in this study shows that 31.9% of seafarers were active smokers and 80.6% consumed alcohol. A comparison of the frequency of active smokers from a survey conducted by the Federal Statistical Office in Germany in 2021 shows a proportion of 18.9% in the population; alcohol consumption in Germany is reported at 76.5% in a study by Atzendorf et al. [19, 20]. This indicates an elevated consumption of nicotine and alcohol among seafarers and should therefore also be a focus of future health interventions on board.

The health-promoting influence of physical activity and sport is well known. In this survey, the majority of seafarers indicated several opportunities for improving the promotion of sport on board. Significantly more than half of all ratings and officers who do more than 6 hours of sport per week ashore do five or less hours of sport on board. In total, the present study showed that sporting activity on board is relevant for seafarers and that there is potential for improvement in the opportunities for promoting physical activity at sea.

In shore-based health promotion, a recent study showed a focus on smartphones, apps, websites and virtual reality in a review on the use of "digital technology and disease prevention" [21]. These application platforms could possibly also be used on board, for example by means of VR glasses and gamification aspects or in digitally supported sporting competitions (between the ships of a shipping company). Furthermore, sports motivation could be increased through structured sporting events, improved equipment and time management for sporting activities.

The survey on preferred stress management strategies revealed that occupational group-specific differences were rather minor overall, but ratings tended to give higher priority to "calming down" "praying", "listening to music" and "resting/sleeping", while in the officers' group had a priority to "sports", "calming down", "listening to music", alongside "contact with family" and "rest/sleep".

These differences between occupational groups, even if rather minor, should also be considered when establishing a concept for digital needs-oriented health promotion. The above-mentioned aspects, but also other measures such as relaxation apps or instructions for breathing and relaxation training, should be given primary consideration when prioritizing health issues for an intervention using health apps.

The orienting knowledge test on health topics such as sport, nutrition and healthy sleeping habits indicates that

there is a need for improvement in the level of knowledge and a necessity for health advice in the areas of sport, nutrition and fatigue among seafarers, as less than 60% of all questions were answered correctly.

The data from the WHO-5 questionnaire in this study show an average Well-Being Index of 69.7%, which is almost identical to a Danish reference population (70.0%) on land [14, 22]. The results of the PHQ-9 questionnaire demonstrated that 85.4% of respondents had moderate to severe symptoms (10–27 points) of depressive mood, while in a comparison group on land only 20.8% showed moderate to severe symptoms [23]. This significant difference indicates a very high relevance for the improvement of mental health as a factor for an e-health intervention or health care measure. Psychovegetative degradation and stress are also relevant factors influencing the mental health of seafarers as described in other studies [4].

The great importance of fatigue in seafaring has already been described in several studies [5, 24]. In the ESS, a total of 22 of the seafarers examined in the current survey (33.8%) assessed themselves to have increased daytime sleepiness. Compared to a reference population on land with a frequency of 20.8%, this confirms the high significance of this issue among seafarers [25]. The frequency of daytime sleepiness was significantly higher for seafarers overall than for truck drivers, again highlighting the relevance for health interventions to improve sleep [26].

A pupillometric examination on board was added as an objectifying survey of possible exposure to fatigue in seafarers. Abnormal values (PUI of > 1.89) were found in 29.5% of the examined seafarers. A comparable study of PUI among truck drivers in 2014 indicated elevated PUI values in only 5.6% of the subjects. A recent maritime study also showed a comparable increase in daytime sleepiness of seafarers basing on elevated ESS > 10 (16.7%) and increased PUI of > 1.53 (33.3%) [27].

A non-significant, but nevertheless tendentially increased sleepiness within the crews of the smaller shipping company in the present study could possibly be explained by company-specific features like worse conditions such as less space, less comfortable economic possibilities for the equipment of the accommodation and fitness rooms.

A reliable explanation for the observed differences in alcohol consumption between shipping companies of different sizes is not possible with certainty in the absence of additional information and can possibly be assessed in follow-up studies. An only very slightly significant difference in the fitness level rating in the larger shipping company could be related to possibly better and more efficient health promotion (e.g. larger and better-equipped sports facilities, regular sports competitions and information flyers on health promotion) there. In view of the similar working conditions on the other ships of the two shipping companies, it can also be assumed that the results are transferable to the overall collective. The surveys provide valuable information for further investigations and possible prioritization, especially as no surveys on the prioritization of health issues for health promotion in maritime studies have been published to date.

Various forms of implementation are available when designing a digital health management system. Fitness trackers for activity tracking, for example, have proven their worth [28]. A review in 2018 demonstrated a positive influence of health apps in 16 out of 20 studies [29]. Battineni et al. (2019) described a high level of interest among seafarers in the use of health apps via smartphones, which makes an e-health application appear relevant in principle. The main topics identified in this study should serve as an initial guide and basis for further detailed studies on digitally based health promotion on board [30]. This pilot study reveals thematic preferences for relevant topics for digital health promotion among seafarers. In future studies, particularly questionnaires should be used to more specifically address the possibilities of preventive health measures for quitting nicotine and alcohol, promoting sport and exercise, improving sleep patterns and mental health, as well as general health behavior. A larger number of respondents could also serve to assess the generalizability of the present results. Building on this pilot study, prospective randomized intervention studies on health promotion are recommended, in which the proportion of health-promoting behavioral changes can be measured. This could also include a more detailed survey on the preferred use of electronic information media such as smart phone or computer applications.

In summary, it can be stated that the present study has provided indications for the prioritization of specific health topics for preventive medical measures. Considering the current findings (in comparison to reference groups), this survey shows a clear need on health promotion for smokers, prevention of fatigue and depression, as well as the communication of healthy lifestyle topics. Additional aspects of health promotion are sport and stress reduction. Relaxation applications, information on sleep hygiene, sleep physiology and the promotion of healthy sleep are suitable for strengthening vigilance.

CONCLUSIONS

The evaluation of the present results indicates a great importance and need for health-promoting management among seafarers on board of merchant ships. Health-related topics could include occupational group-specific prevention of addictive behavior, motivation to exercise, stress management, imparting health knowledge and promoting healthy sleeping habits. For pragmatic reasons, e-health applications appear to be a suitable and interesting medium

for seafarers for an effective communication of health topics. Building on this exploratory pilot study, further investigations in a larger collective are required for a more precise evaluation of health-promoting measures on board. Follow-up studies could also specifically investigate, validate and establish measures for electronic health promotion.

ARTICLE INFORMATION AND DECLARATIONS

Data availability statement: The datasets used and/or analyzed during the current study will be available from the corresponding author on reasonable request.

Ethics statement: The studies have been approved by the responsible ethics committee in Hamburg (Registration number PV5744-4046-BO-ff).

Author contributions: MO, LS, DD, LB, and CR analyzed the data. LS and MO wrote the manuscript, VH supervised the study. LS, MO and VH revised the manuscript. All authors read and approved the final manuscript.

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Conflict of interest: The authors declare no competing interests.

Supplementary material: None

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