

Effects and implementation of an intervention to improve sleep, fatigue and recovery among healthcare workers with night shifts: A pre- and post-test study

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ABSTRACT

Background: Previous intervention studies among night workers mainly focused on single interventions and found inconclusive evidence for effectiveness. A comprehensive intervention approach that includes individual and environmental components has been argued as important. Gaining insight into contributing factors for the implementation of interventions for night workers and effectiveness is important to distinguish between theory and programme failure.

Objectives: To evaluate the effects and implementation of the PerfectFit@Night intervention to improve sleep, fatigue and recovery of night workers in healthcare, using the RE-AIM framework, which assesses reach, effectiveness, adoption, implementation and maintenance of interventions.

Design: A prospective pre-post study design, with two measurements before and three and six months after the intervention.

Setting: Twelve different departments of a university hospital in the Netherlands.

Participants: Healthcare workers working night shifts ($n = 210$).

Methods: PerfectFit@Night consisted of environmental (provision of a powernap bed and healthy food, and workshop healthy rostering) and individual elements (e-learning and sleep coaching) and was implemented for three months in a phased manner. Questionnaires, logbooks and interview data were used. Effects of the intervention on sleep, fatigue and recovery were evaluated with mixed-effects models, and implementation factors of reach, adoption, implementation and maintenance were evaluated.

Results: Night shift-related insomnia (-11% -points, 95% CI: -19% , -4% at three months), need for recovery (β : -2.45 , 95% CI: -4.86 , -0.03 at six months) and fatigue (OR: 0.46 , 95% CI: 0.25 , 0.86 at six months) decreased significantly after the intervention. No changes were found for subjective sleep quality and sleep duration. Barriers and facilitators for implementation were identified for each intervention element at individual (e.g., dietary preferences), organisational (e.g., responsibilities at work) and workplace levels (e.g., location of power nap bed), and for the intervention itself (e.g., useful information in e-learning). Although satisfaction was high and continuation was preferred, embedding of the intervention in the daily routine was limited. Facilitators for future implementation include a positive attitude towards the intervention, clear guidelines regarding intervention elements, appointment of night workers as ambassadors, and suitable conditions in terms of work demands and for the intervention elements.

Conclusions: The multi-faceted PerfectFit@Night intervention reduced insomnia, fatigue and need for recovery in night workers in healthcare. The most important facilitators to improve the implementation of PerfectFit@Night exist at the organisational level (e.g., positive attitude within the culture and suitable work demands). Combining effect and implementation evaluation is crucial to identify barriers and facilitators that hamper or enhance intervention effects.

Trial registration: The study was registered in the Netherlands Trial Register on 17 January 2021 (trial number NL9224).

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What is already known

- Night work can negatively impact health due to circadian disruption and impaired sleep–wake cycles, and night workers experience worse sleep outcomes than day workers.
- Previous studies among night workers mainly focused on single interventions, such as napping, physical activity, healthy meals, adjusted shift schedules or education, and showed inconclusive results regarding the effectiveness of these interventions.
- It is important to gain insight into both the effects and implementation of workplace interventions to distinguish between theory and programme failure.

What this paper adds

- The effect evaluation showed that a multi-faceted intervention consisting of individual and environmental elements resulted in a statistically significant decrease in night shift-related insomnia, fatigue and need for recovery.
- The implementation evaluation showed that the most important facilitators for future successful implementation exist at the organisational level and include factors such as a positive attitude within the culture towards the intervention, clear guidelines regarding the use of the intervention, appointment of night workers as ambassadors, and suitable working and intervention conditions.

1. Background

Night work can negatively impact health due to circadian disruption and impaired sleep–wake cycles (Arendt, 2010; Rosa et al., 2019), yet night work is necessary for 24/7 patient care in healthcare. Sleep, fatigue and recovery after night shifts play a key role in the health consequences of night work. In general, night workers experience more sleep problems than day workers (Chang and Peng, 2021a), their sleep is of shorter duration (Hulsegge et al., 2019) and they experience worse sleep quality (McDowall et al., 2017; Chang and Li, 2022; Chang and Peng, 2021b). Poor sleep has severe consequences for the health, wellbeing and safety of healthcare workers, and impacts patient safety (Mansukhani et al., 2012; Parry et al., 2018). Poor sleep quality has been found to predict fatigue of night-shift nurses compared with day-shift nurses (Chang and Li, 2022). Furthermore, hospital night-shift workers experienced increased fatigue (Härmä et al., 2018). Systematic reviews show that fatigue may negatively impact the health and wellbeing of physicians (Michelle et al., 2018). Additionally, prolonged fatigue and inadequate recovery are related to lower performance and more critical incidents at work (Niu et al., 2011). Shift work has been found to be an important risk factor for longer recovery compared with day workers (Jansen et al., 2003; Sun et al., 2021). Improving sleep and reducing fatigue and need for recovery could be an effective way to improve the employability of night workers (Fleuren et al., 2018) as shift work is associated with lower sustainable employability (in terms of factors such as work ability, self-perceived health, and fatigue) (Peters et al., 2015). Shift work is also associated with poor sleep hygiene (Ramin et al., 2015), and changes in timing, quantity and quality of food intake (Souza et al., 2019), pointing to the need to improve night-shift worker lifestyle behaviours.

Effective interventions that reduce the adverse effects of poor sleep quality and fatigue due to night work are important at the individual level (e.g., health consequences) as well as organisational and societal levels (e.g., ensuring continuous delivery of quality healthcare). In recent decades, various interventions aiming to improve the health of night workers have been developed, implemented and tested for effectiveness (Lassen et al., 2018; Patterson et al., 2021; Robbins et al., 2021;

Hulsegge et al., 2023). These studies span a range of intervention programmes, including bright light exposure, napping during night shifts, promotion of physical activity, provision of healthy meals, adjustment of shift schedules, and provision of sleep education (Lassen et al., 2018; Patterson et al., 2021; Robbins et al., 2021; Hulsegge et al., 2023). The results regarding the effectiveness of the different interventions are generally inconclusive. This might be explained by the high heterogeneity in study design (e.g., randomised controlled trials, pre-post design studies), study population (e.g., healthcare workers, construction workers, transportation workers), implementation and outcome measures (e.g., sleep quality, fatigue, performance at work). Promising interventions focus on sleep hygiene and include sleep education (Robbins et al., 2021; Zhang et al., 2023) and napping. One review showed that napping during night shifts improved recovery after work among nurses. However no significant effects were found for fatigue (Li et al., 2019).

Previous studies among night workers mainly focused on one specific intervention, which might explain the inconclusive evidence for the effectiveness of several interventions in the literature. A recent editorial argued the importance of a comprehensive intervention approach that takes into account both individual and environmental conditions (Robroek et al., 2021). Therefore, we developed a multi-faceted intervention programme (PerfectFit@Night), integrating individual (i.e., e-learning and sleep coaching) and environmental (i.e., power nap beds, healthy food supply and a workshop on healthy rostering) elements to improve sleep and recovery, and reduce fatigue in night workers in healthcare.

When implementing interventions in occupational settings, it is important to gain insight into both effects and implementation to distinguish between theory and programme failure (Robroek et al., 2021). To date, research on factors that contribute to successful implementation of interventions is underrepresented for workplace health promotion programmes (Proper and van Oostrom, 2019), yet workers with higher compliance to interventions showed larger intervention effects (Coenen et al., 2020). Finding factors that contribute to effective implementation is especially important among night workers as it is known that shift workers are less likely to be reached by workplace interventions than day workers (Nabe-Nielsen et al., 2015). The aims of the current study are therefore to evaluate both the effects and the implementation of PerfectFit@Night using mixed methods.

2. Methods

2.1. Study design and study sample

A single-group pre–post study design was used to evaluate the intervention, with each participant moving from the control to the intervention condition. The intervention was implemented for three months in a phased manner in twelve different departments of a university medical centre in the Netherlands between June 2021 and February 2023. The inclusion criterion was having worked night shifts in the month before the start of the study. Generally, recruitment consisted of emails to the employees, short presentations by researchers, and face-to-face promotion by project group members or intervention ambassadors. Participants were able to ask the researchers questions about the study.

The final study sample consisted of 210 healthcare workers who filled out at least the first measurement and one of the post-intervention measurements. The participating healthcare workers were nurses and physicians at the hospital. A sample size calculation was based on sleep quality as measured with the Bergen Shift Work Sleep Questionnaire (BSWSQ), with a mean sleep quality of 1.75 and a standard deviation (SD) of 1.26 (Flo et al., 2012). The calculation showed that a total of 100 participants were needed to identify a medium effect size (at least 0.27) with a power of 0.80. Allowing for a loss-to-follow-up of 30 %, 204 night workers were needed at baseline (Van Elk et al., 2022).

2.2. Intervention

The PerfectFit@Night intervention was based on a needs assessment informed by a literature review and interviews with shift workers in healthcare about their challenges during night shifts and their needs and preferences in addressing these challenges. The intervention consisted of three environmental and two individual intervention elements. The environmental elements were i) provision of a power nap bed in the workplace, ii) provision of healthy food in the workplace, and iii) a workshop on healthy rostering. The individual elements consisted of iv) interactive e-learning, and v) individual sleep coaching.

Environmental elements were arranged as follows: a bed was provided at a specific location near the participating departments to encourage power naps during night shifts. Healthy food was supplied free of charge, with information about basic principles and the best timing of consumption. There is no consensus on the best foods to consume or how to time food intake during night shifts, however general chrononutrition principles were recommended. These included: follow the normal daily dietary pattern as much as possible, divide 24 h food intake into three meals and eat small portions during the night (Lowden et al., 2010; Potter and Wood, 2020). Participants were advised to consume vegetables, wholegrain products and relatively high-protein products, and avoid convenience, high-carbohydrate, non-fibre carbohydrate and sugar-rich foods and drinks (Lowden et al., 2010; Potter and Wood, 2020). An example of a night menu offered to the participants was plain yoghurt with granola, vegetable soup or green salad, a cracker with cheese and some vegetables for snacking. The workshop on healthy rostering was delivered by an expert at the level of the department to those involved in creating the rosters. The aim of the workshop was to inform roster coordinators about healthy rostering and motivate them to initiate conversations about healthy rostering within their department.

Individual elements were arranged as follows: the interactive e-learning was designed to increase knowledge and awareness of healthy lifestyle habits during night shifts. The e-learning focused on the effects and possible risks of night work and offered advice on how to reduce these risks, concentrating on sleep, power naps, nutrition, and physical activity. Sleep coaching was only offered to workers who reported sleep problems and high fatigue at baseline. They were offered a maximum of three coaching sessions by licensed psychologists using evidence-based forms of cognitive behavioural therapy for insomnia.

For implementation, a project group consisting of managers, senior staff of the departments, a researcher and an expert from the Occupational Health Service was formed in each (cluster of) department(s). The project groups met approximately once per 2–3 weeks during the preparation phase to prepare the implementation in accordance with the needs and preferences of their departments (e.g., where to store the healthy food, which bed to purchase for power naps and where to locate it, and when to schedule the workshop on healthy rostering). Additionally, in all but one of the departments, around 3–4 workers acted as ambassadors, informing their colleagues about the intervention elements before and during the intervention period. Several weeks before implementation, night workers were informed about the intervention through live, online or video-recorded presentations. PerfectFit@Night kicked-off with a week of activities such as presentations about the intervention, webinars on healthy eating during night shifts and how to take a power nap. Night workers also received a goodie bag with information materials on how to eat and sleep when working night shifts. The participants were encouraged to use all individual and environmental intervention elements but participation was strictly voluntary. The use of a sign-up sheet was recommended for power naps. Project group members and ambassadors encouraged workers to experience a power nap on the bed. Sleep coaching was only offered to night workers who reported poor sleep quality and high fatigue at the first baseline measurement. They were contacted by a

sleep coach but participation was voluntary. During the intervention period, the project group met regularly, and ambassadors provided input on questions and problems reported within the departments. The project group discussed the actions needed to improve implementation and participant experience.

The needs assessment, programme objectives, outcomes, and the intervention itself are described in more detail elsewhere (Van Elk et al., 2022).

2.3. Data collection procedure

The RE-AIM framework was used to evaluate the PerfectFit@Night intervention considering both effects and implementation (Glasgow et al., 1999). Results are presented according to the five dimensions of the RE-AIM framework: reach (the number or proportion of individuals that participated in the intervention), effectiveness (the impact of the intervention on outcomes), adoption (the number/proportion of departments willing to implement the intervention and their characteristics), implementation (the fidelity to the intervention protocol and participant adherence) and maintenance (the extent to which the intervention is embedded) (Glasgow et al., 1999).

For the effect evaluation (RE-AIM dimension effectiveness), questionnaire data were collected at the four measurement points: two baseline measurements (two months and just before the start of the intervention) and two measurements after the intervention period (three months and six months after the start of the intervention). Participants who completed the first baseline measurement received all follow-up questionnaires. Participants were lost-to-follow up if they did not respond from a specific questionnaire onwards, or non-responders if they did not respond to a specific questionnaire but did respond to one or more subsequent questionnaires. Data were pseudonymised and collected digitally and on paper, depending on the preference of the department.

For the implementation evaluation (RE-AIM dimensions reach, adoption, implementation and maintenance), quantitative and qualitative data were used. Questionnaire data on participation and satisfaction with the intervention elements were collected at the third measurement. Qualitative data consisted of logbook records from the researchers, and interview data. These semi-structured interviews were held directly after the intervention period with 21 nurses, one nurse in training and one physician from eleven departments. The interviewees worked an average of five night shifts per month. The interviews focused on use of and the experience with power naps, healthy food and e-learning, and sought to gain a better understanding of the successes and failures of the intervention elements.

2.4. Outcome measures

2.4.1. Primary outcomes

Sleep, fatigue and need for recovery were measured at four time points, using validated questionnaires.

Sleep was operationalised into three outcomes: night shift-related insomnia, subjective sleep quality and sleep duration after night shifts. Night shift-related insomnia was measured using the Bergen Shift Work Sleep Questionnaire (BSWSQ), in which we focused exclusively on sleep problems related to night shifts (Flo et al., 2012). The BSWSQ consists of seven items on insomnia and fatigue/sleepiness that can be answered on a five-point scale ranging from “never” to “always”. Night shift-related insomnia was dichotomised and defined as an unfavourable score for at least one insomnia item and one fatigue/sleepiness item. The BSWSQ demonstrates good reliability (interclass correlation of 0.69–0.75) as well as convergent and discriminant validity with other scales (Flo et al., 2012). Overall subjective sleep quality in the past month and sleep duration after night shifts were both measured with the Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989). Overall subjective sleep quality could be indicated on a four-

point scale and was dichotomised into good (very good/good) and poor (very poor/poor) sleep quality. Sleep duration was expressed in hours. The PSQI shows high reliability ($\alpha = 0.80$) and good construct validity ($r = 0.69$) (Carpenter and Andrykowski, 1998).

Need for recovery was assessed with the Need for Recovery Scale from the Dutch Questionnaire on the Experience and Evaluation of Work (Van Veldhoven and Broersen, 2003), which consists of six items that can be answered on a four-point scale ranging from “never” to “always”. The scale shows good reliability ($\alpha = 0.86$ – 0.88) as well as construct validity and sensitivity to change in the Netherlands (Van Veldhoven and Broersen, 2003; Van Veldhoven and Sluiter, 2009; De Croon et al., 2006). A higher standardised sum score indicated greater need for recovery.

Fatigue. The Short Fatigue Questionnaire (SFQ) consists of four items scored on a seven-point scale, ranging from 1, meaning “yes that is true” to 7, meaning “no, that is not true” (Alberts et al., 1997), and shows high reliability ($\alpha = 0.72$ – 0.90) (Penson et al., 2020). The total score was calculated (range of 4–28) and divided into three categories: low or below average (score 4–8), above average (score 9–14) and high (score 15 or higher) fatigue.

2.4.2. Secondary outcomes

Dietary intake, sleep hygiene, work ability and self-perceived health were assessed as secondary outcomes at baseline and both post-intervention measurements.

Dietary intake (caffeine intake and food intake) was assessed with a self-constructed questionnaire based on the revised version of the Fat List (Van Assema et al., 2001). For caffeine intake, participants were asked to indicate the number of units of coffee, tea or energy drinks consumed. The score was divided into three categories of total number of units of caffeinated drinks consumed during a night shift: 0 units, 1–3 units and 4 or more units. For food intake, participants were asked to indicate intake per type of food (e.g., fruit, vegetables, dairy, and sweet and savoury snacks) on a four-point scale ranging from “never” to “always”, with a higher sum score indicating healthier food intake.

Sleep hygiene in relation to night shifts was assessed by four self-constructed items that are in congruence with published sleep guidelines for shift workers (Shriane et al., 2023), such as taking power naps and considering food and drink intake during night shifts. These items were answered on a four-point scale ranging from “never” to “always” and the total score was calculated, with a higher score reflecting better sleep hygiene.

Work ability was measured with the single-item first dimension of the Work Ability Index (WAI) (Ilmarinen et al., 1997), which shows acceptable test–retest reliability (De Zwart et al., 2002). The single item is highly correlated with the total WAI ($r = 0.71$ – 0.87) (Ahlstrom et al., 2010). Work ability is a continuous scale ranging from 0 to 10, with higher values indicating greater work ability.

Self-perceived health was measured using a single item of the RAND 36-item Health Survey (RAND-36) (Van der Zee and Sanderman, 2012), with five answer options ranging from “very good” to “very bad”. Internal ($\alpha = 0.71$ – 0.92) and test–retest ($r = 0.51$ – 0.82) reliability are both high (Van der Zee and Sanderman, 2012). Self-perceived health was dichotomised into poor (fair, poor and very poor) and good health (good and very good).

2.4.3. Covariates

Demographics, chronotype, occupation and working hours were collected at baseline and included as covariates in the analyses based on previous literature describing the possible confounding effects of these factors on sleep (Philippens et al., 2022; Booker et al., 2018). Age was included as a continuous variable, sex was dichotomised into female and male, and living situation was divided into three categories: living without a partner with or without

child(ren), living with a partner without child(ren), and living with a partner with child(ren). Chronotype was measured using a validated single item (Roenneberg et al., 2003), and was divided into morning type, no specific type and evening type. Occupation was categorised into nurse and physician and working hours were based on actual working hours (including extra hours) and included as a continuous variable.

2.4.4. Implementation outcomes

Reach refers to the number or proportion of individuals that participated in the intervention. Reach was defined based on questionnaire data to quantify the use of each intervention element, supplemented by record data on the use of sleep coaching (individual level).

Adoption refers to the number or proportion of hospital departments willing to implement the intervention, including the reason for implementation. Adoption by the departments was described in logbook data at the organisational level.

Implementation refers to fidelity to the intervention protocol and participant adherence to and experience of the intervention. Implementation was assessed with logbook and questionnaire data to evaluate the dose of the intervention elements delivered (organisational level) and received (individual level), and whether the intervention was implemented following the protocol (organisational level). Interview data were used to identify barriers and facilitators of the intervention itself and at individual, organisational and workplace levels.

Maintenance refers to the extent to which the intervention was embedded in the daily routine of the participating departments after the intervention period. Questionnaire data were used to evaluate satisfaction with and individual preferences for maintenance of the intervention (individual level). Additionally, we asked the project managers of the intervention to indicate the extent to which the intervention continued after the intervention period (organisational level).

2.5. Statistical analysis

Baseline characteristics were summarised using descriptive statistics. Only participants who participated in the baseline and at least one follow-up measurement were included in the analyses. Univariate regression analyses were conducted to detect selection bias by analysing loss-to-follow up after baseline. Confounders were chosen based on evidence from existing literature (Philippens et al., 2022; Booker et al., 2018) and checked with univariate regression analyses by analysing differences in the magnitude of associations between individual characteristics and the primary outcome measures over time. The associations with the primary outcomes did change over time for sex, household composition and chronotype.

The effects of the intervention were evaluated with mixed-effects models, adjusting for clustering at individual and department levels by including a nested random effect in the models. The first measurement was used as reference for the second, third and fourth measurements. The first and second measurements were performed before the intervention; the third and fourth were performed after. Linear mixed models were performed for sleep duration and need for recovery. Generalised linear mixed models with a dichotomous outcome variable were used for night shift-related insomnia and subjective sleep quality. The advantage of this approach is that the estimate of the independent variable presents the changes in the prevalence of insomnia and poor sleep quality over time. For fatigue, ordinal mixed models were applied, with the estimates representing the likelihood of being in a less favourable fatigue category. The analyses were corrected for seasonal effects (starting month) and covariates.

Supplementary analyses performed to evaluate the effects of the intervention on the secondary outcomes were similar to the fully adjusted models of the primary outcomes. Here, the third and fourth measurements were compared with the first, as secondary outcomes were not assessed at the second measurement.

Additionally, in the fully adjusted models, we analysed whether the effects depended on the degree of implementation of the intervention. First, we checked whether a specific intervention element explained the effects by comparing participants that used the intervention elements with no or limited usage. Second, we analysed whether the effects depended on an accumulation of intervention elements by including the number of elements used. Here, sleep coaching was not taken into account because of the selective participation (as only persons with sleep problems were offered coaching). For these analyses, use of the bed for power naps and consumption of healthy food on at least half of the night shifts were used as the cut-off. All analyses were performed using R-Studio version 4.2.1.

2.6. Ethical considerations

The study was approved by the Medical Ethical Review Committee of the Erasmus University Medical Center (MEC-2020-0959) and is registered in the Netherlands Trial Register (trial number NL9224). Participants signed an informed consent form after receiving written information about the study.

3. Results

3.1. Study population

The total study population consisted of 210 night workers in the healthcare sector at baseline (Table 1). Most of the night workers were female (81.0 %) and had no specific chronotype (49.5 %), the mean age was 36 and the majority lived alone or as a single parent (37.1 %) or with a partner and children (36.2 %). The majority were nurses (92.4 %) working, on average, 32.6 h per month.

3.2. Effect evaluation

A statistically significant decrease in the prevalence of night shift-related insomnia was found, with reductions of 11 % points (95 % CI: -0.19 , -0.04) and 13 % points (95 % CI: -0.22 , -0.05) at the third and fourth measurements respectively, compared with the first measurement (Table 2). Need for recovery reduced statistically significantly by -2.45 points (95 % CI: -4.86 , -0.03) and the likelihood of greater fatigue decreased statistically significantly with an odds ratio of 0.46 (95 % CI: 0.25, 0.86; Table 2) at the fourth measurement. These results indicate that after the intervention period, fewer participants had insomnia after working night shifts and participants had less need for recovery after work, and were less fatigued in general. No effects were found for overall sleep quality or sleep duration after night shifts. Physicians, participants with poor sleep quality and those who lived with a partner but without children living at home were less likely to be lost-

to-follow up after baseline. Participants with more years of night work were more likely to be lost-to-follow up. No statistically significant interaction effects were found for measurements with chronotype, except for a slightly significant interaction effect for sleep quality (β : -0.03 , 95 % CI: -0.07 , -0.00).

In terms of secondary outcomes, food intake was statistically significantly healthier and sleep hygiene was statistically significantly better at the third and fourth measurements (Supplementary Table 1).

No specific intervention element showed statistically significant effects on the outcomes, except for the provision of healthy food in the workplace, which reduced the prevalence of night shift-related insomnia by 12 % points (95 % CI: -0.23 , -0.01 ; Table 3). Additionally, no clear cumulative effect of intervention elements was found for intervention effects (Supplementary Table 2). For participants using two intervention elements, the prevalence of night shift-related insomnia significantly decreased by 16 % points (95 % CI: -0.25 , -0.08) and fatigue improved, with an odds ratio of 0.49 (95 % CI: 0.26, 2.53). The use of a single intervention element significantly decreased the need for recovery by -2.72 points (95 % CI: -5.45 , -0.00). The use of three intervention elements did not show significant effects.

3.3. Implementation evaluation

3.3.1. Reach

A total of 1070 night workers in twelve departments were invited to complete the first questionnaire. The response was 64 % ($n = 681$; Fig. 1). Of these 681 night workers, a total of 210 participants (31 %) were eligible for the analyses, as they also responded to at least one of the post-intervention questionnaires. More specifically, 180 (26 %) of the participants at baseline responded to the third questionnaire and 125 (18 %) of the participants at baseline responded to the fourth questionnaire.

3.3.2. Adoption

All but two of the departments approached by the Occupational Health Service agreed to participate, resulting in twelve participating departments (86 %). Department characteristics differed in terms of patient care and organisational structure. Main reasons to participate were awareness of the importance of worker wellbeing (especially during the COVID-19 pandemic) and the need to intervene to reduce the adverse health effects of night work.

3.3.3. Implementation

Fig. 2 shows the number and percentage of night workers who used the intervention elements available to all participants (i.e., e-learning, power nap bed and healthy food provided in the workplace). Of the 146 night workers, 41 % used only one of the intervention elements and 45 % used a combination of two elements. Ten of the 33 night workers (30 %) who were eligible for and offered sleep coaching made use of it. The workshop on healthy rostering was given in all departments.

The e-learning was completed by the majority of the participants (80 %), mostly out of curiosity. Both positive (e.g., new and useful information, and the possibility of changing dietary habits) and negative (e.g., no new or useful information) experiences were reported in relation to the e-learning content.

The majority (76 %) of the participants rarely used the bed for power naps, 7 % took a power nap on the bed on half of their night shifts and 15 % did it on most or all of their night shifts. Reasons for and positive experiences of using the power nap bed were to reduce fatigue and improve alertness, the convenience and comfort of the location (e.g., close to department, quiet location), and the comfort of the bed. Reasons against and negative experiences of using the power nap bed included social and ethical concerns (e.g., does not feel right to leave the department), workplace demands (e.g., no time, responsibilities at work), and the inconvenience of the location.

Table 1
Demographic characteristics of hospital workers with night shifts ($N = 210$) at baseline.

	n (%)
Sex	
Female	170 (81.0 %)
Male	40 (19.0 %)
Living situation	
Living without partner with or without child(ren) ^a	78 (37.1 %)
Living with partner without child(ren)	56 (26.7 %)
Living with partner with child(ren)	76 (36.2 %)
Occupation	
Nurse	194 (92.4 %)
Physician	16 (7.6 %)
Self-reported chronotype	
Morning type	47 (22.4 %)
No specific type	104 (49.5 %)
Evening type	59 (28.1 %)

^a Participants who live alone or as a single parent.

Table 2

Estimates from mixed models for night shift-related insomnia, subjective sleep quality, sleep, need for recovery, and fatigue among healthcare workers with night shifts (N = 210).

	n	%	Model adjusted for clustering ^a %-point (95 % CI ^c)	Model adjusted for clustering ^a and confounders ^b %-point (95 % CI ^c)
Night shift-related insomnia (yes/no) ^d		% yes		
Baseline measurement 1	201	52 %	Ref	Ref
Baseline measurement 2	155	47 %	− 5 % (− 12 %, 3 %)	− 4 % (− 12 %, 3 %)
Post-intervention after 3 months	160	39 %	− 11 % (− 19 %, − 4 %)	− 11 % (− 19 %, − 4 %)
Post-intervention after 6 months	104	39 %	− 13 % (− 22 %, − 4 %)	− 13 % (− 22 %, − 5 %)
Subjective sleep quality (good/poor) ^d		% poor		
Baseline measurement 1	198	18 %	Ref	Ref
Baseline measurement 2	157	20 %	2 % (− 4 %, 8 %)	2 % (− 4 %, 8 %)
Post-intervention after 3 months	157	16 %	− 1 % (− 7 %, 5 %)	− 1 % (− 7 %, 5 %)
Post-intervention after 6 months	102	12 %	− 2 % (− 9 %, 6 %)	− 2 % (− 9 %, 6 %)
	n	Mean (SD)	Model adjusted for clustering ^a β (95 % CI ^c)	Model adjusted for clustering ^a and confounders ^b β (95 % CI ^c)
Sleep duration after night shifts (h) ^e				
Baseline measurement 1	204	6.60 (1.61)	Ref	Ref
Baseline measurement 2	156	6.41 (1.57)	− 0.15 (− 0.34, 0.03)	− 0.16 (− 0.35, 0.03)
Post-intervention after 3 months	158	6.59 (1.49)	− 0.02 (− 0.21, 0.17)	− 0.02 (− 0.21, 0.17)
Post-intervention after 6 months	106	6.66 (1.52)	− 0.08 (− 0.30, 0.14)	− 0.06 (− 0.29, 0.16)
Need for recovery (0–100) ^e				
Baseline measurement 1	198	36.06 (17.77)	Ref	Ref
Baseline measurement 2	156	35.26 (16.96)	− 0.94 (− 2.94, 1.06)	− 0.88 (− 2.89, 1.13)
Post-intervention after 3 months	155	34.55 (18.42)	− 1.20 (− 3.22, 0.83)	− 1.08 (− 3.11, 0.95)
Post-intervention after 6 months	100	31.83 (15.00)	− 2.57 (− 4.98, − 0.17)	− 2.45 (− 4.86, − 0.03)
	n	%	Model adjusted for clustering ^a OR ^g (95 % CI ^c)	Model adjusted for clustering ^a and confounders ^b OR ^g (95 % CI ^c)
Fatigue ^f		% low/medium/high ^h		
Baseline measurement 1	198	16/27/57	Ref	Ref
Baseline measurement 2	157	21/25/54	0.75 (0.43, 1.29)	0.77 (0.44, 1.33)
Post-intervention after 3 months	157	21/28/51	0.63 (0.36, 1.08)	0.65 (0.38, 1.12)
Post-intervention after 6 months	102	21/39/39	0.42 (0.23, 0.78)	0.46 (0.25, 0.86)

Numbers depicted in bold are statistically significant.

^a Clustering is based on the individual within working department.^b Adjusted for seasonal effect (starting month of the intervention), age, sex, household composition, chronotype, occupation and working hours.^c 95 % CI = 95 % confidence interval.^d Dichotomous outcome measures, analysed with generalised linear mixed models, presenting %-points.^e Continuous outcome measures, analysed with linear mixed models.^f Ordinal outcome measure, analysed with ordinal mixed models.^g OR = odds ratio.^h Low fatigue (4–8), medium fatigue (9–14), and high fatigue (15+).

The majority (61 %) of the participants mostly or always consumed the healthy food provided in the workplace during night shifts, 10 % consumed the food on half of their night shifts, and 30 % rarely or never consumed it. Reasons for and positive experiences of consuming the healthy food provided involved convenience, a reduction in abdominal complaints, the dietary advice, and the nature of the food provided (e.g., appealing). Reasons against and negative experiences of consuming the healthy food provided included individual preferences and experiences (e.g., preferring food from home, no or limited health effects), and the nature of the food provided (e.g., unappealing, no list of ingredients and expiration date).

Fidelity to the intervention differed across the departments. Two departments did not receive the e-learning, three other departments were not provided with healthy food in the first month, and the beds used for power naps in two of these departments were temporarily stored during the last weeks of the intervention period. However, when the departments that had most implementation problems were excluded from the analyses, similar results were found (see Supplementary Table 3).

3.3.4. Maintenance

Almost all interviewees (96 %) recommended PerfectFit@Night to other departments. Average satisfaction scores on a scale of 1 to 10 were: powernap bed 8.1, healthy food 7.5, e-learning 7.0, and sleep coaching 8.0. The majority of the night workers preferred continued use of the bed for power naps (67 %) and healthy food (63 %). Some

considerations for future implementation were related to facilitators, such as a positive attitude towards the intervention within the culture of the department, clear guidelines regarding the use of the intervention elements, appointment of night workers as ambassadors for PerfectFit@Night, enabling circumstances for the intervention (e.g., adequate staffing, less work demands), and suitable conditions for the intervention elements (e.g., appropriate location for power naps).

After the intervention period, the e-learning and power nap beds remained available, but the delivery of food to the departments was discontinued. However, during this period the e-learning and power nap beds were not or infrequently used. Delivery of healthy food was not reinstated in any of the departments, and only three departments offered sleep coaching, but it was rarely used. However, all but two of the departments expressed a preference for further implementation of some or all intervention elements. They mentioned the need for more attention to the intervention, including project-based guidance, creation of support within the department, and a suitable location for power naps.

4. Discussion

The current study showed that night shift-related insomnia, need for recovery and fatigue decreased significantly after the PerfectFit@Night intervention, whilst sleep quality and duration showed no change. The effect size for reduced night shift-related insomnia is substantial (11–13 % points) and the percentage of participants with high fatigue

Table 3

Estimates from mixed models for differences across specific intervention elements in night shift-related insomnia, need for recovery, and fatigue among healthcare workers with night shifts (n = 210).

	n (%)	%-point (95 % CI ^a)
Night shift-related insomnia		
Pre-intervention measurements		Ref
Power nap bed used on at least half of the night shifts	34 (23.0)	10 % (−4 %, 24 %)
Healthy food consumed on at least half of the night shifts	103 (69.6)	−12 % (−23 %, −1 %)
Use of e-learning	114 (67.1)	−4 % (−15 %, 7 %)
Use of sleep coaching	10 (6.7)	−11 % (−37 %, 15 %)
	n (%)	β (95 % CI ^a)
Need for recovery		
Pre-intervention measurements		Ref
Power nap bed used on at least half of the night shifts	33 (22.3)	−1.17 (−5.02, 2.69)
Healthy food consumed on at least half of the night shifts	102 (68.9)	0.34 (−2.68, 3.36)
Use of e-learning	112 (65.9)	−0.77 (−3.82, 2.28)
Use of sleep coaching	10 (6.7)	−2.15 (−9.49, 5.19)
	n (%)	OR ^b (95 % CI ^a)
Fatigue		
Pre-intervention measurements		Ref
Power nap bed used on at least half of the night shifts	33 (22.3)	1.50 (0.53, 4.24)
Healthy food consumed on at least half of the night shifts	102 (68.9)	0.71 (0.32, 1.57)
Use of e-learning	112 (65.9)	0.66 (0.29, 1.49)
Use of sleep coaching	10 (6.7)	7.73 (0.49, 122.76)

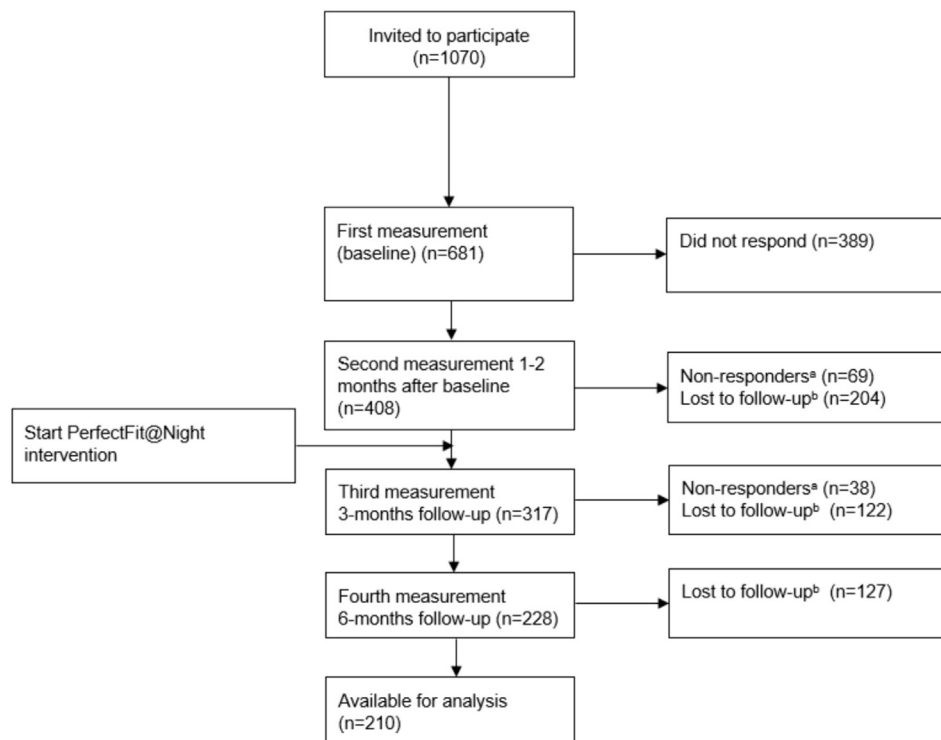
Numbers depicted in bold are statistically significant; the models are adjusted for clustering based on the individual within working department and confounders' seasonal effect (starting month of the intervention), age, sex, household composition, chronotype, occupation and working hours.

^a 95 % CI = 95 % confidence interval.

^b OR = odds ratio.

decreased from 57 % to 39 %, but the effect size for need for recovery is small (0.16). Whilst implementation of PerfectFit@Night during the intervention period was generally successful, maintenance was limited. Barriers and facilitators for implementation of the intervention

elements were identified at individual (e.g., dietary preferences), organisational (e.g., responsibilities at work) and workplace levels (e.g., location of the powernap bed), and for the intervention itself (e.g., useful information provided through e-learning).



*Non-responders was defined as workers that did not complete a particular follow-up measurement and who will return in another follow-up measurement.

^bLost to follow-up was defined as workers that ended participation in follow-up measurement.

Fig. 1. Flow chart of the study population.

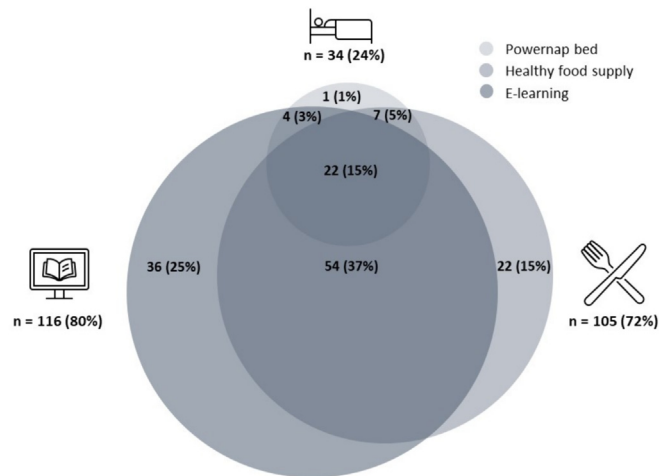


Fig. 2. Use of the intervention elements available to all participants (i.e., bed for power naps, healthy food and e-learning). Participation numbers are based on the third measurement and do not include all participants.

The multi-faceted nature of PerfectFit@Night, focusing on both the individual and environmental levels, might explain the positive effects on night shift-related insomnia, need for recovery and fatigue rather than a single intervention element. This is in line with a recent systematic review, which found that multi-faceted interventions seem promising in improving nurses' sleep (Zhang et al., 2023). Furthermore, our results are in line with the promising results of sleep education (Robbins et al., 2021; Zhang et al., 2023) and napping, which was previously found to improve recovery but not fatigue (Li et al., 2019). However, the latter has been contradicted by a meta-analysis of studies on emergency medical services personnel, which showed a modest statistically significant effect of napping during night shifts on acute fatigue (Martin-Gill et al., 2018). This discrepancy can be explained by the different types of napping interventions in these studies, for example differences in duration (Patterson et al., 2021), or different definitions of fatigue. The effects of the intervention could significantly improve the employability of healthcare workers, given that fatigue and need for recovery are inverse indicators of sustainable employability (Fleuren et al., 2018), and sleep disturbances and fatigue are identified risk factors for sickness absence from work (Amiri and Behnezhad, 2020; Sagherian et al., 2019). The lack of intervention effects on subjective sleep quality and sleep duration could be due to the fact that sleep consists of multiple components (Van Elk et al., 2023), with differences in the underlying mechanisms, and interventions can have different effects on each component. Additionally, the provision of beds for power naps and healthy food (universal prevention) focused less on sleep at home, and sleep quality and duration were measured over the past month rather than after night shifts, which would have been more precise.

Using the RE-AIM framework, we were able to evaluate the effects and the implementation of PerfectFit@Night, and identify factors that hampered or enhanced the effects of the intervention (Kristensen, 2005). Indicators of successful implementation were compliance with the e-learning and healthy food, high satisfaction with the intervention (individual level), and high fidelity to the intervention protocol in most departments (organisational level). Indicators of unsuccessful implementation were lack of compliance with the recommended use of the bed for power naps and low take-up of sleep coaching (individual level), and delayed implementation of some intervention elements in certain departments and work demands that made it difficult to take time for the intervention elements (organisational level). Remarkably, even though night workers were highly satisfied with the intervention and night workers and project members recommended continuation, several intervention elements were discontinued after the intervention period. The evaluation of both the effectiveness and the implementation

of the current study allowed for a comprehensive understanding of the intervention's success and highlighted the need for more attention to embedding the intervention in the daily workplace routine. This can be achieved by addressing barriers and facilitators at the organisational level, such as creating a positive attitude towards the intervention within the workplace culture, appointing night workers as ambassadors of the intervention, and providing clear guidelines regarding the intervention elements and workplace demands to increase compliance. The barriers and facilitators identified in the current study are congruent with those reported in other implementation studies among night workers (in healthcare) (Ledikwe et al., 2017; Huggins et al., 2022). An added benefit of the implementation evaluation was the possibility of analysing whether a specific intervention element contributed to the effects or whether the effects depended on an accumulation of intervention elements used. This was especially important given that use of the different intervention elements was voluntary, which meant that each participant used a different set of intervention elements. However, no one specific intervention element was found to have clear effects, nor did we find a clear accumulation effect of the intervention elements. Despite the value of implementation evaluation, these evaluations of health promotion programmes for healthcare workers are scarce. The current evaluation is therefore an important addition to the literature.

4.1. Strengths and limitations

A major strength of this study is the evaluation of both the effects and implementation of PerfectFit@Night using quantitative and qualitative methods.

However, some limitations also need to be considered. Firstly, individual randomisation was not possible due to implementation at the department level, and randomisation at the department level was not possible due to the COVID-19 pandemic, which meant that the departments most impacted by the pandemic (i.e., the intensive care unit, the emergency department, and the recovery room) wanted to start implementing the intervention earlier than planned to show appreciation and provide extra care and support for their employees. Therefore, we applied a pre-post design. However, it is difficult to draw conclusions about causality with a pre-post study design. The fact that the two pre-intervention measurements showed no changes between the first and second measurements of primary outcomes increased the likelihood of attributing the positive effects to the intervention programme. The different departments started the intervention in a phased manner and were differently exposed to the consequences of the pandemic. We lack information on the precise influence of the pandemic on the departments, however, with the differences in the timing of the implementation, this probably did not affect our results. Secondly, night workers with poor sleep quality were less likely to drop out of the study after baseline, meaning that fewer participants with good sleep quality remained in the study. Though this suggests selection bias, it did not affect the intervention effects. Sensitivity analyses addressing potential confounders associated with sleep quality revealed no substantial alteration in the robustness of the intervention effects. Thirdly, the current data on sleep, fatigue and need for recovery were measured over the past month, which could induce recall bias, and the data were self-reported and therefore subjective. We recommend more precise, repetitive and objective measurement of these variables in future research. Lastly, internal validity may have been affected by the testing effect (the questionnaire influenced the response to the follow-up questionnaire) or the Hawthorne effect (modification of behaviour due to awareness of being studied).

5. Conclusion

An integrated multi-faceted intervention programme targeting different aspects at both individual and environmental levels improved night shift-related insomnia, fatigue and recovery among night workers in healthcare, but not subjective sleep quality or sleep duration.

Although positive effects were found, combining effect and implementation evaluation is crucial, as the implementation of the intervention could be improved by careful consideration of barriers and facilitators.

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CRediT authorship contribution statement

Fleur van Elk: Writing – original draft, Visualization, Validation, Software, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Heidi M. Lammers-van der Holst:** Writing – review & editing, Validation, Supervision, Methodology. **Suzan J.W. Robroek:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Alex Burdorf:** Writing – review & editing, Validation, Supervision, Methodology, Funding acquisition, Conceptualization. **Karen M. Oude Hengel:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Funding acquisition, Conceptualization.

Data availability

Data are stored at the Department of Public Health, Erasmus University Medical Center, Rotterdam, The Netherlands. Data are available from the last author upon reasonable request.

Declaration of Competing Interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijnurstu.2024.104881>.

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