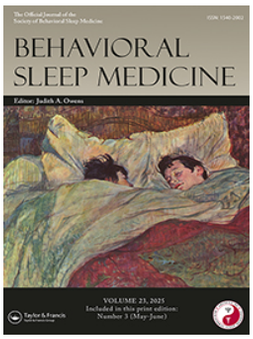

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Examining the Feasibility of an App-based Sleep Intervention for Shiftworkers Using the RE-AIM Framework

Hannah Thorne [a*], Rochelle M Sophocleous [a*], Madeline Sprajcer [a], Alexandra E Shriane [a], Mitch J Duncan [b], Sally A Ferguson [a], Corneel Vandelanotte [a], Tracy Kolbe-Alexander [c,d], Charlotte C Gupta [a], Gabrielle Rigney [a], Matthew Thomas [a], Cassie J Hilditch [e], Benjamin Peterson [f], and Grace E Vincent [a]

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ABSTRACT

Objectives: This study assessed the feasibility of Sleepfit, an app-based sleep intervention for shiftworkers, to evaluate participant reach, engagement, and interaction.

Methods: The RE-AIM framework guided the feasibility assessment. Participants from various shiftwork industries (e.g. healthcare, mining) completed a 14-day trial of the Sleepfit app, alongside baseline and post-intervention surveys. Descriptive statistics were used to evaluate participant enjoyment and engagement, including daily app usage and the number of activities completed.

Results: Among the 110 enrolled shiftworkers, 53 (48%) completed post-intervention assessments, and 34 (30.9%) adhered to the full study protocol. Of those who completed baseline surveys, 85.4% downloaded and used Sleepfit, engaging with an average of 17.3% of available activities, with shiftwork-specific modules like "Coping with Shiftwork" showing the highest engagement. Participants cited lack of time, inconvenience, and losing interest as reasons for discontinuing app use.

Conclusions: This study indicates the potential feasibility of app-based interventions like Sleepfit to improve shiftworkers' sleep health through tailored, relevant content. Future studies should consider longer durations and larger samples, incorporating wearable technology to enhance data accuracy and assess sustained effects across varied shift schedules.

Introduction

An ever-increasing demand for around-the-clock services and production necessitates a substantial workforce of shiftworkers who engage in work activity outside of the standard business hours of 9 a.m. to 5 p.m (Australian Bureau of Statistics, 2022; International Labour Organization, 2019; Ward et al., 2019). Shiftworkers make up at least 15% of the workforce in Australia (Australian Bureau of Statistics, 2022), with similar proportions in the United States

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of America (USA) (Bureau of Labor Statistics, 2019) and the European Union (Eurofound, 2019). Despite their significant contribution to service delivery, shiftworkers are impacted by a myriad of negative health, wellbeing, safety, and productivity outcomes (Costa, 2010; Crowther et al., 2021; Vincent et al., 2018). The observed effects partially arise from inadequate sleep, attributable to occupational demands necessitating shiftworkers to maintain wakefulness and sleep during periods misaligned with natural circadian rhythms (Boivin et al., 2022).

The sleep/wake pattern that shiftworkers engage in to facilitate their work commitments can disrupt natural circadian rhythms and lead to circadian misalignment (Boivin et al., 2022; Rampling et al., 2022; Shriane et al., 2023). Evidence suggests that these significant disruptions to shiftworker sleep increase the risk of developing high-burden health conditions, including but not limited to cardiovascular disease (Hege et al., 2018), cancer (Cordina-Duverger et al., 2022), diabetes (Hulsegge et al., 2021), and mental health conditions (Brown et al., 2020). In addition, inadequate sleep places shiftworkers at a greater risk of injury at work (Kecklund & Axelsson, 2016). Beyond the impacts to the individual shiftworker, inadequate sleep and its sequela are estimated to cost the Australian and USA economies AUD41.2 and USD400 billion annually, respectively (Hafner et al., 2017; Hillman et al., 2018). As such, for the benefit of individual workers, service delivery, and the economy, there is an urgent need to employ effective interventions to improve shiftworker sleep.

A range of interventions that attempt to improve shiftworker sleep have been developed. At an organisational level strategies have been trialed, such as the implementation of scheduled napping (Hilditch et al., 2017), adjustments to rosters or scheduling practices, the provision of bright light treatments (Dugdale et al., 2022), and workplace-implemented psychoeducation (Declercq et al., 2022). At an individual level, interventions include light/dark exposure (Huang et al., 2013), high/low color temperature light exposure (Young et al., 2015), and even the use of non-alcoholic beer as a placebo to induce sleep (Franco et al., 2012). However, a recent review of interventions designed to improve sleep in shiftworkers reported that only half of the strategies were successful in improving sleep health (Harrison et al., 2021). As a result, alternative interventions may be required to improve sleep health in shiftworkers, that demonstrate a high level of feasibility and efficacy.

Digital interventions are increasingly common to support sleep, health, and wellbeing for members of the general public (Glazer Baron et al., 2022). These interventions typically use self-directed education and health marker monitoring as a mechanism to achieve positive health-related outcomes (Murawski et al., 2019; Rowlands et al., 2021). If effective, they can have a significant positive impact on public health, considering the widespread adoption of smart mobile (also known as cell) phones in Australia. Despite promising evidence supporting the efficacy of digital sleep interventions in other populations (Biduski et al., 2020; Buckingham et al., 2020; Cao et al., 2021; De Korte et al., 2018), current literature indicates a lack of purpose-built smart mobile health applications (mHealth) focusing on shiftworker sleep. Given that shiftworkers face unique challenges, particularly in regard to sleep timing and opportunities to engage in other health behaviours, standard digital interventions may not be as effective in this population. As a result, any digital intervention designed for shiftworkers would need to consider this context carefully and be tailored to their unique needs. Additionally, it is critical that any digital intervention designed for shiftworkers is evaluated, to ensure relevance, useability, and engagement over time. Furthermore, recent investigations have reported mixed findings for the effectiveness of app-based sleep interventions on shiftworker sleep quality (Murray et al., 2023; Oftedal et al., 2019) and have highlighted the importance of consistent methodologies to compare outcomes within this rapidly changing digital space.

The current study used the RE-AIM framework; Reach, Effectiveness, Adoption, Implementation and Maintenance, in addition to subjective measures to assess the enjoyment and engagement metrics of an app-based sleep intervention to improve shiftworker sleep. The RE-AIM framework has been used previously to evaluate the feasibility and efficacy of other health behaviors such as the 10,000 steps physical activity program (Duncan et al., 2019) and improving education around client insomnia for psychologists (Meaklim et al., 2023). The overarching research question addressed: How do

a broad range of shiftworkers perceive and interact with an app-based sleep intervention during 14 days of use?

Methods

Intervention

This study used mobile phone application (app) *Sleepfit*, which offers tailored sleep health advice for shiftworkers in a portable, accessible manner (Figure 1). *Sleepfit* contains 52 activities, including educational articles, interactive quizzes, and guided relaxation exercises. Activities are organised into 10 modules based on theme (e.g., sleep disorders, sleep science, daily habits). All elements of *Sleepfit* are optional, in that users can engage with them as frequently as they choose. Originally, *Sleepfit* was developed for the general population, and as such, the content available in *Sleepfit* was previously tailored for shiftworkers by members of the research team (GEV, GR, SAF, AES), with tailoring based on fatigue management advice and the existing body of literature of sleep in shiftworkers. This tailoring was conducted ahead of a pilot trial intervention amongst a small sample of paramedic shiftworkers (Shriane et al., 2024). Findings from this previous investigation demonstrated *Sleepfit* ability to improve subjective sleep health and sleep hygiene outcomes. Specifically, after 14-days of *Sleepfit* use, significant reductions in Insomnia Severity Index and Sleep Hygiene Index scores were observed (Shriane et al., 2024). While promising, these findings were elucidated from a small pilot trial conducted amongst a specific cohort of shiftworkers, and this early investigation experienced high attrition. As such, further evaluation of *Sleepfit* amongst a larger, more diverse group of shiftworkers was warranted.

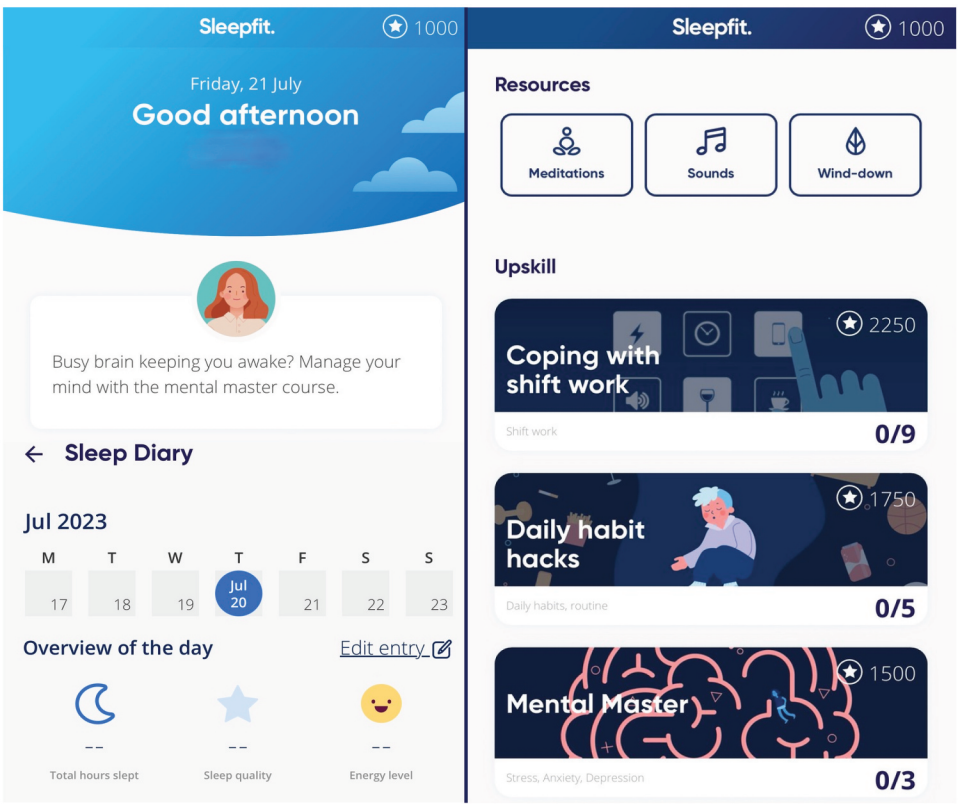

Figure 1 . Screenshot of the *Sleepfit* app.

During the intervention period (14 days), participants were able to engage with as much or as little of the content as they chose. In addition, participants could set sleep goals (e.g., cease device use 1–2 hours before bed, practice a wind-down routine 30 minutes before bed) and had the option to complete daily sleep diaries. Participants could choose to have *Sleepfit* send them a reminder notification at the same time each day to engage with the app (e.g., complete a sleep diary entry). A brief diagnostic assessment for risk of common sleep disorders was presented to participants when they first logged in to *Sleepfit*. This assessment included administration of the Regensburg Insomnia Scale (Crönlein et al., 2013) and the STOP-Bang Questionnaire (Chung et al., 2016) via chatbot functionality. This was an existing tool within the app prior to tailoring of content for shiftworkers. These data were not collected or analyzed for the purposes of this study.

Study Design

A single-arm pre-post feasibility study design was used, consisting of three subjective surveys (Baseline, Post-intervention, and Follow-up), two sleep diaries (Baseline Sleep Diary and Post-Intervention Sleep Diary), and 14-day use of an app-based sleep intervention (i.e., *Sleepfit*) as the intervention protocol. Figure 2 illustrates the study protocol and data collection timepoints. The study obtained ethics approval from the Central Queensland University Human Research Ethics Committee (reference no. HE1353).

Recruitment and Participants

The study sought to recruit participants who were engaged in regular, paid shiftwork, defined as work done outside the standard hours of 9 a.m. to 5 p.m. (Kecklund & Axelsson, 2016). Eligible participants were those who were employed either full-time, part-time, casual, or as a contractor and between 18 and 65 years of age. The study excluded Australian Defence Force members as their work arrangements are typically sustained operations rather than shiftwork. The study aimed to recruit a minimum of 30 participants, in line with feasibility study sample size recommendations (Hertzog, 2008; Lancaster et al., 2004).

Recruitment occurred between October 2022 and July 2023 (9 months) via social media (Facebook, LinkedIn, and Twitter), e-mail, and flyers placed in locations frequented by shiftworkers (e.g., hospital staff rooms, emergency service stations (with permission)). Participants were offered an incentive of 12 months free access to *Sleepfit* (normally valued at AUD$69) as compensation for their time.

Procedure

Prior to providing informed consent, participants were informed that participation was voluntary and that they could withdraw at any time. Following enrollment, participants completed the baseline survey (Week 1) which included demographics, work characteristics, and general health information (e.g., industry, schedule type, self-rated health status), as well as subjective sleep health outcomes. Participants were then immediately provided with a 7-day digital sleep diary (Baseline Sleep Diary) to measure sleep quality and the survey link sent via text message or e-mail, depending on their communication preference. Following the completion of Baseline Sleep Diary, participants were provided with instructions to download and use *Sleepfit* for the following 14 days. Participants were not permitted to download the app unless they had at least two days (out of seven) sleep diary entries. After 14 days (Week 4), participants were asked to complete a post-intervention survey of subjective sleep health outcomes (effectiveness), enjoyment of app and barriers to use (implementation), as well as continuation/recommendation of app to other shiftworkers (maintenance), following which they were provided with Post-Intervention Sleep Diary to complete for the next 7 days. A follow-up survey was sent to participants four weeks after completing the 14-day intervention period. The follow-up survey

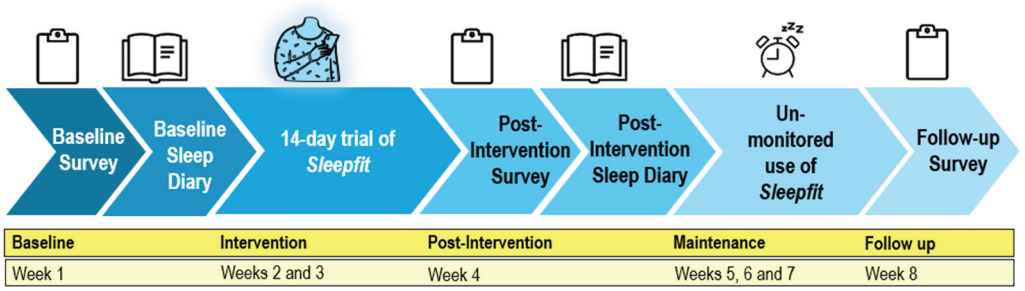

Figure 2 . *Sleepfit* feasibility study protocol.

measure self-rated sleep health (effectiveness), barriers to use (implementation) and continued use or cessation of *Sleepfit* (maintenance). Measures of engagement with *Sleepfit* via in-app metrics included number of daily in-app check-ins participants made (participants could register their sleep as a log once per day), and number of activities completed. Participants were able to continue using *Sleepfit* after the monitored intervention period. Post-intervention use of *Sleepfit* was considered maintenance (Weeks 5, 6 and 7) in between post-intervention and follow-up surveys.

Outcome Measures

The feasibility of *Sleepfit* was measured using the RE-AIM framework to examine the reach, effectiveness, adoption, implementation, and maintenance of the intervention. Table 1 describes the application of this framework to the current study.

Participants (Reach)

The proportion of participants who were willing to participate in the study from recruitment was measured and compared to the representativeness of participants who completed the intervention (including reasons for attrition or continued participation). The representativeness of shiftworkers in the study was assessed by socio-demographic information, such as employment industry and occupational status. The follow-up survey also provided data for evaluating participation; however, completion was not required to be included in the final sample. The difference between the baseline and post-intervention participant numbers were also investigated by contrasting socio-demographic and subjective sleep health outcomes.

Sleep Health (Effectiveness)

To evaluate the impact of *Sleepfit* on subjective sleep health, the 'Are you SATED? [RU-SATED]' Scale was used at baseline and post-intervention and at follow-up, which measures six dimensions of sleep associated with health outcomes: regularity of sleep, being satisfied with sleep, alertness during waking hours, timing of sleep, sleep efficiency, and sleep duration (Ravyts et al., 2021). Responses are provided on a 3-point Likert scale of '*rarely/never*', '*sometimes*' and '*always/usually*' with the total sum of scores being between 0 (poor sleep health) and 12 (good sleep health) (Buysse, 2014; Ravyts et al., 2021). The RU-SATED scale has demonstrated good reliability (Becker et al., 2018).

Sleep Quality (Effectiveness)

Subjective sleep quality was measured at baseline and post-intervention using two, 7-day sleep diaries. Sleep diaries were modeled off the 6-item (yielded as five scores) Brief Pittsburgh Sleep Quality Index scale [B-PSQI] to measure individual differences in sleep efficiency, sleep latency, sleep duration, sleep disturbances, and subjective sleep quality (as averaged over 7-days) (Sancho-Domingo et al., 2021). Total scores range from 0 to 15, with scores >5 indicating poor sleep quality (Sancho-Domingo et al., 2021). The B-PSQI demonstrates good internal consistency (α = .79) and has been shown to be a valid scale of measurement for sleep quality and identifying poor sleep across gender and age groups (Sancho-Domingo et al., 2021).

Engagement of Sleepfit (Adoption)

Engagement with *Sleepfit* was measured via usage metrics recorded by the Sleepfit database and supplied to the research team by *Sleepfit*. This included the number of daily check-ins and number of activities (out of a possible 52) participants completed during the 14-day intervention period.

Enjoyment and/or Barriers (Implementation)

Enjoyment of, and barriers to, using *Sleepfit* were measured by participants subjective responses through post-intervention and follow-up surveys. Participants were asked if they had stopped using *Sleepfit* at any point during the intervention period (yes/no). If yes, participants were presented with multiple-choice responses as to why (e.g., '*lack of time*', '*the app stopped working/lost access*') and could also provide free-text responses to explain barriers to implementation. Participants were also presented with Likert-scale questions regarding whether they enjoyed using *Sleepfit*, liked the overall presentation of the app, found it easy to navigate, and felt supported by organizational management to use it, all of which were answered on the same scale (1 = *Strongly Agree*; 5 = *Strongly Disagree*). Participants were presented with multiple-choice options to explore what they liked most (e.g., '*the content is interesting*', '*it helped my sleep*', '*it was convenient to use*') and least (e.g., '*the sleep tips were not relevant to me*', '*it was difficult to use*') about the app. In addition, open-ended questions regarding enjoyment and perceptions of effectiveness were collated for reporting. Perceived effectiveness on participant sleep health and sleep quality were measured by participant subjective responses through the post-intervention survey, where participants were asked to report whether they believed *Sleepfit* was effective in improving their sleep health. Free-text responses to questions were collated and summarized to inform understanding of enjoyment and barriers to implementation.

Continued use/Cessation of Sleepfit (Maintenance)

Continued use or cessation of *Sleepfit*, as well as whether participants would recommend the app to fellow shiftworkers, was measured at post-intervention and follow-up surveys through participant subjective responses. Participants were asked if they were still using *Sleepfit* following

Table 1. RE-AIM framework application.

Reach	The proportion and representativeness of willing participants in the study.
Effectiveness	Changes to subjective sleep health and sleep quality outcomes following *Sleepfit* use.
Adoption	The proportion of participants that downloaded and engaged with *Sleepfit*, and amount of daily app check-ins and activities completed.
Implementation	Enjoyment of *Sleepfit* and any barriers to use.
Maintenance	The likelihood of continued use/recommendation to other shiftworkers, as well as free-text comments.

conclusion of the intervention period (yes/no). Those continuing to use *Sleepfit* were asked why they had continued to use the app (multiple-choice responses, e.g., '*the content is interesting*', '*it helped my sleep*', '*it was convenient to use*'). Participants were able to provide free-text responses as to why they had continued to use *Sleepfit* to further understand implementation. Participants who reported they were no longer using *Sleepfit* were presented with multiple-choice responses to indicate why (e.g., '*lost interest*', '*it wasn't helping my sleep*', '*the app wasn't easy/convenient to use*'). Again, participants could provide free-text responses regarding these barriers to ongoing use. Participants were also presented with Likert-scale question regarding whether they were likely to continue using Sleepfit (1 = *Strongly Agree*; 5 = *Strongly Disagree*). Free-text responses to informed understanding of continued use and cessation.

Statistical Analyses

All statistical analyses and assumption tests were conducted using SPSS software (IBM, Version 29, Armonk, NY). Alpha was set at $p < .05$. All data are reported as mean ± standard deviation (M ± SD) or proportion (%). Descriptive statistics were used to collate Baseline and Post-intervention sleep outcomes, as well as Post-intervention feasibility outcomes. Independent sample t-tests were used to assess attrition rates following baseline measures and compare the baseline characteristics (socio-demographic, health outcomes, and work schedules) of participants who did ('completers') and did not complete the study ('non-completers'). Free-text responses were collated and summarized.

Results

Shiftworkers (N = 112) provided informed consent and enrolled in the study. Two participants were excluded, one due to being over 65 years old and the other for working outside of Australia. Due to participant attrition, a final cohort of 34 participants was included in data analysis. Our intention was to analyze subjective sleep health and sleep quality data; however, the final sample was underpowered to assess these outcomes. Figure 3 provides additional detail regarding participant flow through the study protocol.

Demographic, Work, and Health Characteristics

Participant demographics are presented in Table 2. The mean age of participants in the final sample was 38 years (±9.7), with 58.8% (n = 20) identifying as female. Participant employment spanned across six main industries, with most working full-time onrotating schedules (88.2%), averaging 50 work hours (± 20.2) per week. Most participants (88.2%) reported their general health as good, very good, or excellent.

Number of Participants in the Study (Reach)

The number of shiftworkers reached was (N = 110). Participation was reduced to n = 62 (56.4%) before beginning the intervention, with a high drop-out rate (43.6%) during Baseline Sleep Diary (see Figure 3). When comparing the completers (n = 34) with the non-completers (n = 76), significant differences were noted in their work schedules ($p < .05$). The completers were mostly made up of participants working rotating shifts (88.2%), while the attrition group had a significantly higher proportion of participants working day shift (13.2%), evening/night shift (9.2%) and on-call (1.3%) (M = 1.71, SD = 0.94; t (33) = - 2.95, p = .006). There was also a greater proportion of part-time workers within the attrition group (21.1%), compared with the final sample (8.8%). Though there was notably a greater proportion of participants aged over 51 years in the attrition group (25.0%) than in the final sample (8.9%), there was no significant difference between the final sample overall age (M = 38.4, SD = 9.6) and the

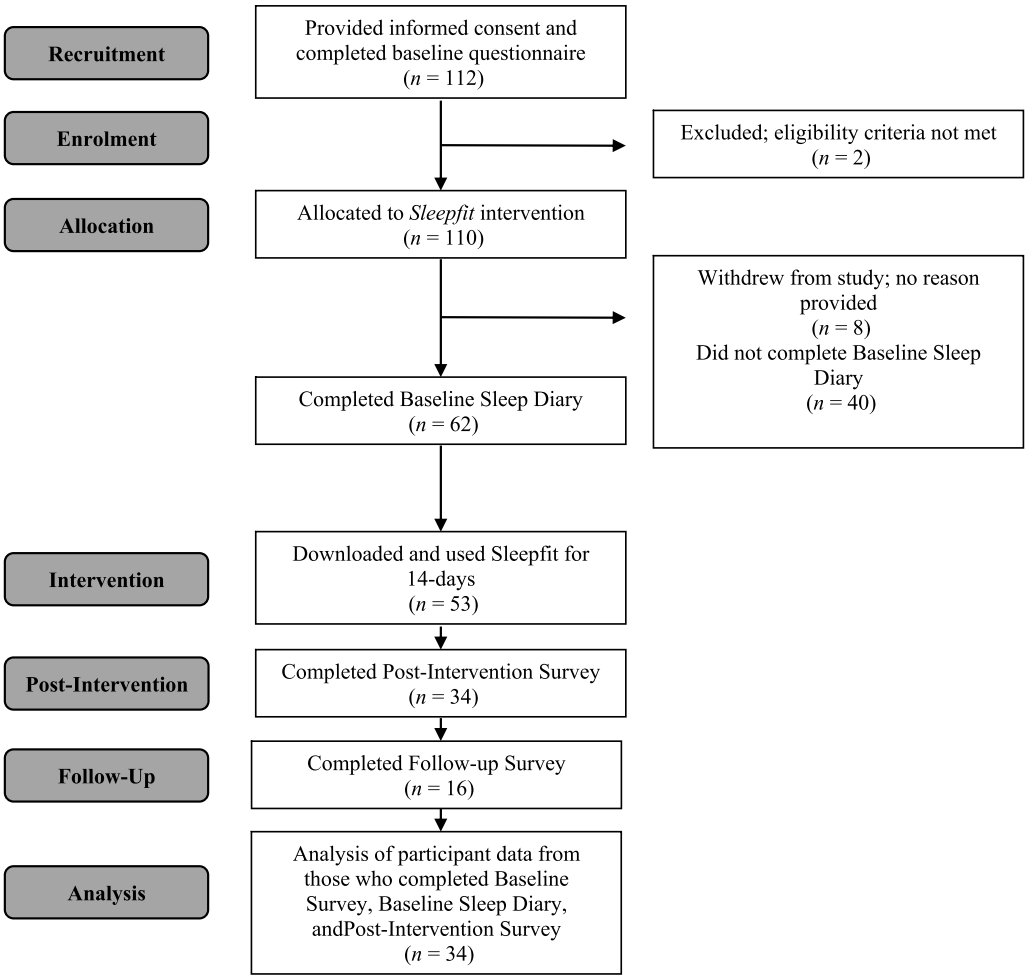

Figure 3. Consort flowchart of participants through study.

attrition group (M = 40.91, SD = 11.0, t (33) = -1.10, p = .277). There were no other differences between the two groups for any other sociodemographic or health outcomes.

Sleepfit Engagement (Adoption)

Of those that completed the Baseline Sleep Diary (85.4%) downloaded and engaged with *Sleepfit*, with over half of these participants (61.8%) logging daily check-ins during the 14-day intervention period (n = 34). *Sleepfit* included 10 modules with a total of 52 activities, with participants completing an average of 9 (17.3%) activities during the 14-day intervention period. The most frequently completed modules were *Coping with Shiftwork*, *Daily Habit Hack*, and *Sleep Disorders and Concerns*, as presented in Table 3. The most frequently completed activities included topic areas of sleep drivers, napping, circadian rhythm education, fatigue management strategies, scheduling physical activities, sleep inertia, and shiftwork disorder. Participants demonstrated least frequent engagement with activities focusing on ageing and sleep needs, weight-loss and sleep, and sleep apnea.

Table 2. Demographic, work, and health characteristics of participants at baseline.

	Completers (*n*=34)		Non-completers[a] (*n*=76)		Full Sample (*n*=110)	
	n	%	*n*	%	*n*	%
Gender						
Female	20	**58.8**	46	**60.5**	66	**60.0**
Male	14	41.2	30	39.5	44	40.0
Age group (y)						
18–34	12	35.3	28	36.8	38	34.6
35- 50	19	**55.9**	29	**38.2**	47	**42.7**
>51	3	8.9	19	25.0	25	22.7
General health						
Poor	0	0.0	3	3.9	3	2.7
Fair	4	11.8	14	18.4	18	16.4
Good	17	**50.0**	37	**48.7**	54	**49.1**
Very Good	12	35.3	18	23.7	30	27.3
Excellent	1	2.9	4	5.3	5	4.5
Highest level of education						
High School	6	17.6	12	15.8	18	16.4
Certificate III or higher	16	**47.1**	23	30.3	39	35.4
Bachelor's degree or higher	12	35.3	41	**53.9**	53	**48.2**
Industry						
Maritime	1	2.9	1	1.3	2	1.8
Manufacturing	0	0.0	2	2.6	2	1.8
Mining	10	29.4	18	23.7	28	24.5
Healthcare & Social Services	15	**44.2**	34	**44.7**	49	**44.6**
Public Administration & Safety	3	8.8	10	13.2	13	11.8
Transport, postal & warehousing	3	8.8	8	10.5	11	10.0
Energy Sector	2	5.9	3	3.9	5	4.5
Occupational Status						
Casual/Contractor	1	2.9	6	7.9	5	4.5
Part-time	3	8.8	16	21.1	19	17.3
Full-time	30	**88.2**	54	**71.1**	84	**76.4**
Work schedule						
Rotating Shift	30	**88.2**	58	**76.3**	88	**80.0**
Regular Night/Evening Shift	2	5.9	7	9.2	9	8.2
Regular Day Shift	2	5.9	10	13.2	12	10.9
On call	0	0.0	1	1.3	1	0.9
Average total hours worked per week						
0- 40	16	**47.0**	45	**59.2**	61	**55.5**
41- 55	10	29.4	19	25.0	29	26.4
56- 84	4	11.8	10	13.2	14	12.7
85- 105	4	11.8	2	2.6	6	5.4
Injured at work or commute[b]						
Yes	0	0.0	4	5.3	5	4.5
No	34	**100**	72	**94.7**	105	**95.5**
Regularly sleeps in a bed with another person						
Yes	21	**61.8**	48	**66.2**	69	**62.7**
No	13	38.2	28	36.8	41	37.2

NB: Bold text indicates the largest group per demographic. A Certificate III or higher is an Australian vocational education qualification, indicating completion of specific skills and training above a basic level.

[a]Attrition after baseline group includes participants who were enrolled at baseline but did not complete post-intervention surveys and sleep diaries.

[b]Within 14 days prior to baseline.

Sleepfit Enjoyment and Barriers to Use (Implementation)

Implementation was measured by subjective participant enjoyment following *Sleepfit* use, as presented in Table 4 (n = 34). More than half (58.8%) of participants reported enjoying *Sleepfit*, and that it was easy to navigate the app (52.9%). Most participants also reported that they liked the layout (75.5%).

Continuation/Cessation of Sleepfit (Maintenance)

Maintenance was measured by subjective participant cessation or continued use of *Sleepfit* after the intervention period, as presented in Tables 4 and 5 (n = 34). Recommendation of *Sleepfit* to other shiftworkers was largely neutral, with half of participants (50%) stating that they were unsure as to whether they would recommend the app. Continued use and cessation of *Sleepfit* at post-intervention was also reported by equal numbers, with 50% of participants reporting that they would continue to use *Sleepfit*. Some participants (50%) provided free-text feedback that was collected and summarized regarding cessation and described a lack of time, inconvenience, or losing interest in the app as main reason for ceasing to use it. Common suggestions for improvement included wanting connectivity to participant smart watches and less manual reporting. Reasons for continued use included enjoyment, benefit of use, ease of use, and finding it helpful.

Discussion

This study evaluated the feasibility of an app-based sleep intervention for shiftworkers using the RE-AIM framework. Overall, of those that used the app, most reported enjoying using *Sleepfit*, with minimal barriers to use reported. Participants were divided regarding the likelihood of continuing to use *Sleepfit* long-term, with the inclusion of automation and/or linkage with other devices reported as incentives to maintain engagement. The recommendation for integrating advanced digital health tools, such as the Sleepfit app with wearable devices, aims to enhance accuracy by reducing reliance on self-reported data. These recommendations align with the growing preference among shiftworkers

Table 3. *Sleepfit* engagement by individual activity completed.

		Participants completed				Participants completed	
Module	Activity Topic	*n* = 34	%	Module	Activity Topic	*n* = 34	%
Sleep Disorders and Concerns	Insomnia	3	8.8	Coping with Shiftwork	Circadian rhythm education	15	44.1
	Sleep apnoea	1	2.9		Fatigue management strategies	13	38.2
	Shiftwork disorder	**12**	**35.3**		Napping	**16**	**47.0**
	Jetlag	1	2.9		Sleep inertia	12	35.3
	Sleep medications	1	2.9		Caffeine	10	29.4
	Parasomnias	1	2.9		Physical activity	9	26.5
	REM sleep disorder	1	2.9		Daytime sleeping	11	32.4
	Dreams and nightmares	1	2.9		Scheduling physical activity	13	38.2
	Restless legs syndrome	2	5.9		Nutrition	10	29.4
	Narcolepsy	1	2.9	Daily Habit Hacks	Sleep drivers	**20**	**58.8**
	Bruxism	1	2.9		Cognitive processes	6	17.6
	Delayed sleep phase disorder	1	2.9		Lifestyle factors	6	17.6
Sleep Science	Neurological activity	**2**	**5.9**		Daily habits	6	17.6
	Ageing and sleep needs	1	2.9		Sleep problems	6	17.6
	Dreaming	1	2.9	Mental Master	Stress	**4**	**11.8**
	Role of genetics	1	2.9		Unhelpful thoughts	3	8.8
Sleep and Physical Health	Disease risk	**2**	**5.9**		Anxiety and worry	3	8.8
	Weight loss & sleep	1	2.9	Bedroom Makeover	Technology use	5	14.7
	Pain and sleep	1	2.9		Noise, temperature & light	5	14.7
	Pregnancy & sleep	1	2.9		Mattress and bedding	5	14.7
Sleep and Mental Health	Stress, anxiety & depression	4	11.8		Bedroom atmosphere	4	11.8
	Thoughts impact sleep	**5**	**14.7**	Relaxation Relay	Guided meditation	3	8.8
	Thinking patterns & insomnia	2	5.9		Progressive muscle relaxation	3	8.8
Sleep Health	Long-term outcomes	2	5.9		Autogenic training	3	8.8
	Daily habits	2	5.9		Visualisation activity	3	8.8
	Bedroom impacts	2	5.9		Sleep sounds	3	8.8

NB. Bold indicates highest completed activity topic in that module.

Table 4. Enjoyment and barriers to use of *Sleepfit*.

	Post-Intervention (n = 34)					
	Agree/Strongly Agree		Neutral		Disagree/Strongly Disagree	
	n	%	*n*	%	*n*	%
How much do you agree with the following statements:						
I enjoyed using the *Sleepfit* app	20	**58.8**	10	29.4	44	11.8
I like the overall presentation of the *Sleepfit* app	25	**73.5**	7	20.6	2	5.9
I was able to easily find my way around the app	18	**52.9**	10	29.4	6	17.7
I would recommend *Sleepfit* to other shiftworkers	7	20.6	17	**50.0**	10	29.4
Likelihood to continue using *Sleepfit*	14	**41.2**	12	35.3	8	23.5
What did you like/dislike about the *Sleepfit* app?[a]						
The content is interesting	12	**35.3**	–		1	2.9
It gave me relevant sleep tips	12	**35.3**	–		6	17.6
It gave me relevant physical activity tips	9	**26.5**	–		5	14.7
It helped me sleep	4	11.8	–		0	0.0
It was easy to use	14	**41.1**	–		6	17.6
It was convenient to use	4	11.8	–		8	**23.5**
The notifications were not annoying	21	**61.8**	–		13	38.2

Note: – indicates no option to select as it was not compulsory for participants to select multiple options.
[a]Response was not compulsory for these questions and therefore elicited numbers less than that of the final sample number.

for sophisticated technological interventions to improve sleep, a trend supported by recent qualitative studies (Richa et al., 2023).

There is considerable variation in how feasibility is determined across behavioral app-based intervention studies, with methodologies often differing significantly (De Cocker et al., 2015; Murray et al., 2023; Oftedal et al., 2019; Schoeppe et al., 2022). The present study utilized the RE-AIM framework to evaluate the feasibility of Sleepfit. While similar in design to previous research, our study is novel in its use of RE-AIM to assess multiple dimensions of feasibility, including Reach, Implementation, Maintenance, and Adoption. In the context of the subsequently reported findings, it is important to note that no specific thresholds were defined a priori to establish feasibility in this study. However, comparable studies provide some insights when determining overall feasibility.

In terms of Reach, the study demonstrated there was a large and representative sample of shiftworkers willing to participate. This participation rate is comparable to other intervention studies, for example, 63% of those invited expressed willingness to participate in a digital physical activity intervention (De Cocker et al., 2015). For Implementation, participant enjoyment of the intervention was consistent with findings from previous studies on app-based interventions for shiftworkers and non-shiftwork populations (Murray et al., 2023; Oftedal et al., 2019). Maintenance, measured as continued use and recommendation to others, yielded mixed results, while certain features of *Sleepfit*, such as its presentation, received positive feedback, only 20% of participants indicated they would recommend the app, suggesting limited potential for broader endorsement. Finally, Adoption, measured through app engagement, was low, highlighting the need for adjustments to improve usability and sustained interaction. These findings align with prior research (Oftedal et al., 2019; Rayward et al., 2021) which reported similar challenges with low engagement in app-based interventions for shiftworkers despite consistent use among a subset of users. Our study also incorporated backend data from *Sleepfit* to compare objective measures of engagement with participants' subjective perceptions. Notably, the shiftwork-specific modules were the most frequently accessed, reinforcing the value of tailored content for enhancing relevance and engagement in sleep health interventions. Despite limitations in sample size and the absence of predetermined feasibility criteria, our findings indicate the potential feasibility for app-based interventions like *Sleepfit* to support shiftworkers' sleep health.

It is well-documented that shiftworkers are more prone to poor health outcomes, when compared to non-shiftworkers (Kecklund & Axelsson, 2016). Shiftworkers who seek medical

Table 5. Reasons for continued use or cessation of *Sleepfit*.

	Post-intervention		Follow-up	
	n = 34		*n* = 16	
	n	%	*n*	%
At any point, I did stop using the *Sleepfit* app	17	50.0	8	50.0
Why did you stop using the *Sleepfit* app?				
Lost interest	4	11.8	3	18.8
Lack of time	7	20.6	4	25.0
It was not helping me sleep	3	8.8	2	12.5
The app stopped working/lost access	0	0.0	0	0.0
The app wasn't convenient to use	4	11.8	4	25.0
Other	4	11.8	2	12.5

attention for symptoms attributed to sleep loss (e.g., low mood, anxiety, impaired cognition) often refer to the disruption of their sleep/wake cycle secondary to shiftwork (Brown et al., 2020). Assessing the feasibility of a digital health intervention such as *Sleepfit* has clinical significance, as it considers shiftworker needs to improve sleep and reduce the likelihood of negative health outcomes associated with shiftwork (Perez-Pozuelo et al., 2020). The rapid development of digital health interventions has resulted in clinicians and their patients more frequently using app-based interventions as a management strategy for poor sleep health (Perez-Pozuelo et al., 2020). As such, this study demonstrates the importance of feasibility testing of app-based sleep interventions, given their use in managing sleep problems. Future investigations into app-based sleep intervention feasibility for shiftworkers should consider the diversification of outcomes, to incorporate variables applicable to shiftworker health, such as diet and physical activity.

This study has several limitations that offer avenues for future research. First, the low uptake and high attrition rates indicate that the participant task burden, particularly the time-intensive pre- and post-surveys, may have been onerous, especially for those in demanding, front-line roles. Anecdotal feedback from participants highlighted survey burden as a primary factor deterring participation, rather than a lack of enjoyment of the app. However, the high attrition rates also make it challenging to make strong conclusions regarding the feasibility of *Sleepfit*. It is worth noting, however, that comparable attrition rates have been seen in prior digital intervention trials of the same duration (2-weeks) (Shriane et al, 2024; Vandelanotte et al., 2017). In future studies, linking the app to validated wearable technology, such as smartwatches that objectively measure sleep, could improve usability and engagement by reducing the need for time-intensive surveys. Second, the sample size restricted the ability to conduct detailed comparisons across industries, shift types, and working hours. Expanding the sample size in future research will enable more nuanced analyses and comparisons, thereby enhancing the study's applicability to various work settings. While we collected self-reported data on sleep disorders, variability between diagnoses, and the likely high prevalence of undiagnosed cases limited our ability to assess their impact on app uptake, attrition, and outcomes. Future studies with larger samples and using validated pre-screening tools could stratify by sleep disorder status. Data show that clinically significant sleep disorders affect 18% of shiftworkers with up to 80% undiagnosed (Reynolds et al., 2022, 2024), highlighting the need for targeted screening in future research. Fourth, the study period was relatively short (14 days), and we did not collect detailed shift information from participants during this time. Future studies should consider monitoring changes in sleep and behavior over an extended period (3–12 months), taking into account-specific work schedules (e.g., number and timing of night shifts, days off) to better understand any long-term effects on sleep health. Finally, all measures employed were subjective in nature. Future research could explore incorporating objective data collection methods, such as integration with wearable technology – indeed as an outcome of this project Sleepfit has now integrated the application with most sleep tracking devices (e.g., Fitbit, Garmin, Oura, Withings, Google Fit, Apple Healthkit, Polar). This approach could align

with participant preferences for digital health tools and improve data accuracy, addressing both the scientific need for objective data and user preference for advanced digital health interventions.

Conclusion

In conclusion, within the limitations of current sample size, this study indicates the potential feasibility of app-based interventions like *Sleepfit* to support shiftworkers' sleep health, particularly through tailored and relevant content. Future research should utilize longer study durations with larger a larger sample size, and incorporate objective measures such as through wearable technology, to more effectively capture long-term impacts and engagement patterns across diverse shiftwork schedules.

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Data availability statement

The de-identified data that supports the findings of this study are available from the corresponding author upon reasonable request.

References

Australian Bureau of Statistics. (2022). *Working arrangements*. https://www.abs.gov.au/statistics/labour/earnings-and-working-conditions/working-arrangements/latest-release

Becker, N. B., Martins, R. I. S., de Neves Jesus, S., Chiodelli, R., & Rieber, M. S. (2018). Sleep health assessment: a scale validation. *Psychiatry Research*, *259*, 51–55. https://doi.org/10.1016/j.psychres.2017.10.014

Biduski, D., Bellei, E. A., Rodriguez, J. P. M., Zaina, L. A. M., & De Marchi, A. C. B. (2020). Assessing long-term user experience on a mobile health application through an in-app embedded conversation-based questionnaire. *Computers in Human Behavior*, *104*, 106169. https://doi.org/10.1016/j.chb.2019.106169

Boivin, D. B., Boudreau, P., & Kosmadopoulos, A. (2022). Disturbance of the circadian system in shift work and its health impact. *Journal of Biological Rhythms*, *37*(1), 3–28. https://doi.org/10.1177/07487304211064218

Brown, J. P., Martin, D., Nagaria, Z., Verceles, A. C., Jobe, S. L., & Wickwire, E. M. (2020). Mental health consequences of shift work: an updated review. *Current Psychiatry Reports*, *22*(2), 1–7. https://doi.org/10.1007/s11920-020-1131-z

Buckingham, S. A., Morrissey, K., Williams, A. J., Price, L., & Harrison, J. (2020). The physical activity Wearables in the police force (PAW-force) study: acceptability and impact. *BMC Public Health*, *20*(1), 1–16. https://doi.org/10.1186/s12889-020-09776-1

Bureau of Labor Statistics. (2019). *Job flexibilities and work schedules summary*. https://www.bls.gov/news.release/flex2.nr0.htm

Buysse, D. J. (2014). Sleep health: can we define it? Does it matter? *Sleep: Journal of Sleep Research & Sleep Medicine*, *37*(1), 9–17. https://doi.org/10.5665/sleep.3298

Cao, J., Lim, Y., Sengoku, S., Guo, X., & Kodama, K. (2021). Exploring the shift in international trends in mobile health research from 2000 to 2020: bibliometric analysis. *JMIR mHealth and uHealth*, *9*(9), e31097. 10.2196/31097

Chung, F., Abdullah, H. R., & Liao, P. (2016). STOP-Bang questionnaire: a practical approach to screen for obstructive sleep apnea. *Chest*, *149*(3), 631–638. https://doi.org/10.1378/chest.15-0903

Cordina-Duverger, E., Uchai, S., Tvardik, N., Billmann, R., Martin, D., Trédaniel, J., Wislez, M., Blons, H., Laurent-Puig, P., Antoine, M., Guénel, P., & Radoï, L. (2022). Sleep Traits, Night Shift Work and Lung Cancer Risk among Women: Results from a Population-Based Case-Control Study in France (The WELCA Study). *International Journal of Environmental Research and Public Health*, *19*(23), 16246. https://doi.org/10.3390/ijerph192316246

Costa, G. (2010). Shift work and health: current problems and preventive actions. *Safety and Health at Work*, *1*(2), 112–123. https://doi.org/10.5491/SHAW.2010.1.2.112

Crönlein, T., Langguth, B., Popp, R., Lukesch, H., Pieh, C., Hajak, G., & Geisler, P. (2013). Changes in self-reported and parent-reported health-related quality of life in overweight children and adolescents participating in an outpatient training: findings from a 12-month follow-up study. *Health and Quality of Life Outcomes*, *11*(1), 1–8. https://doi.org/10.1186/1477-7525-11-1

Crowther, M. E., Ferguson, S. A., Vincent, G. E., & Reynolds, A. C. (2021). Non-Pharmacological interventions to improve chronic disease risk factors and sleep in shift workers: a systematic review and meta-analysis. *Clocks & Sleep*, *3*(1), 132–178. https://doi.org/10.3390/clockssleep3010009

Declercq, I., Van Den Eede, F., Roelant, E., & Verbraecken, J. (2022). SHIFTPLAN: a randomized controlled trial investigating the effects of a multimodal shift-work intervention on drivers' fatigue, sleep, health, and performance parameters. *Trials*, *23*(1), 662. https://doi.org/10.1186/s13063-022-06573-6

De Cocker, K., De Bourdeaudhuij, I., Cardon, G., & Vandelanotte, C. (2015). Theory-driven, web-based, computer-tailored advice to reduce and interrupt sitting at work: development, feasibility and acceptability testing among employees. *BMC Public Health*, *15*(1), 1–17. https://doi.org/10.1186/s12889-015-2288-y

De Korte, E. M., Wiezer, N., Janssen, J. H., Vink, P., & Kraaij, W. (2018). Evaluating an mHealth app for health and well-being at work: mixed-method qualitative study. *JMIR mHealth and uHealth*, *6*(3), e6335. 10.2196/mhealth.6335

Dugdale, Z., Eiter, B., Chaumont Menendez, C., Wong, I., & Bauerle, T. (2022). Findings from a systematic review of fatigue interventions: What's (not) being tested in mining and other industrial environments. *American Journal of Industrial Medicine*, *65*(4), 248–261. https://doi.org/10.1002/ajim.23334

Duncan, M. J., Caperchione, C. M., Corry, K., Van Itallie, A., & Vandelanotte, C. (2019). A RE-AIM evaluation of a workplace physical activity microgrant initiative: The 10, 000 steps workplace challenge. *Journal of Occupational and Environmental Medicine*, *61*(9), 718–723. https://doi.org/10.1097/JOM.0000000000001653

Eurofound. (2019). *6th European Working Conditions Survey*. Update https://www.eurofound.europa.eu/publications/report/2016/working-conditions/sixth-european-working-conditions-survey-overview-report

Franco, L., Sanchez, C., Bravo, R., Rodríguez, A. B., Barriga, C., Romero, E., Cubero, J., & Chapouthier, G. (2012). The sedative effect of non-alcoholic beer in healthy female nurses. *PLOS ONE*, *7*(7), e37290. 10.1371/journal.pone.0037290

Glazer Baron, K., Culnan, E., Duffecy, J., Berendson, M., Cheung Mason, I., Lattie, E., & Manalo, N. (2022). How are consumer sleep technology data being used to deliver behavioral sleep medicine interventions? A systematic review. *Behavioral sleep medicine*, *20*(2), 173–187. https://doi.org/10.1080/15402002.2021.1898397

Hafner, M., Stepanek, M., Taylor, J., Troxel, W. M., & Van Stolk, C. (2017). Why sleep matters-the economic costs of insufficient sleep: a cross-country comparative analysis. *Rand Health Quarterly*, *6*(4).

Harrison, E. M., Schmied, E. A., Yablonsky, A. M., & Glickman, G. L. (2021). Implementation of interventions designed to promote healthy sleep and circadian rhythms in shiftworkers. *Chronobiology International*, *38*(4), 467–479. https://doi.org/10.1080/07420528.2020.1845190

Hege, A., Lemke, M. K., Apostolopoulos, Y., Sönmez, S., & Useche, S. A. (2018). Occupational health disparities among US long-haul truck drivers: the influence of work organization and sleep on cardiovascular and metabolic disease risk. *PLOS ONE*, *13*(11), e0207322. https://doi.org/10.1371/journal.pone.0207322

Hertzog, M. A. (2008). Considerations in determining sample size for pilot studies. *Research in Nursing & Health*, *31*(2), 180–191. https://doi.org/10.1002/nur.20247

Hilditch, C. J., Dorrian, J., & Banks, S. (2017). A review of short naps and sleep inertia. *Sleep Medicine*, *32*, 176–190. https://doi.org/10.1016/j.sleep.2016.12.016

Hillman, D., Mitchell, S., Streatfeild, J., Burns, C., Bruck, D., & Pezzullo, L. (2018). The economic cost of inadequate sleep *Sleep: Journal of Sleep Research & Sleep Medicine*, *41*(8), zsy083. https://doi.org/10.1093/sleep/zsy083

Huang, L.-B., Tsai, M.-C., Chen, C.-Y., & Hsu, S.-C. (2013). The effectiveness of light/dark exposure to treat insomnia in female nurses undertaking shift work during the evening/night shift. *Journal of Clinical Sleep Medicine*, *9*(7), 641–646. https://doi.org/10.5664/jcsm.2824

Hulsegge, G., Proper, K. I., Loef, B., Paagman, H., Anema, J. R., & van Mechelen, W. (2021). The mediating role of lifestyle in the relationship between shift work, obesity and diabetes. *International Archives of Occupational and Environmental Health*, *94*(6), 1287–1295. https://doi.org/10.1007/s00420-021-01662-6

International Labour Organization. (2019). *Working conditions in a global*. perspectivehttps://www.ilo.org/global/publications/books/WCMS_696174/lang-en/index.htm

Kecklund, G., & Axelsson, J. (2016). Health consequences of shift work and insufficient sleep. *BMJ*, *355*, i5210. https://doi.org/10.1136/bmj.i5210

Lancaster, G. A., Dodd, S., & Williamson, P. R. (2004). Design and analysis of pilot studies: recommendations for good practice. *Journal of Evaluation in Clinical Practice*, *10*(2), 307–312. https://doi.org/10.1111/j.2002.384.doc.x

Meaklim, H., Meltzer, L. J., Rehm, I. C., Junge, M. F., Monfries, M., Kennedy, G. A., Bucks, R. S., Graco, M., & Jackson, M. L. (2023). Disseminating sleep education to graduate psychology programs online: A knowledge translation study to improve the management of insomnia. *Sleep: Journal of Sleep Research & Sleep Medicine*, *46* (10). https://doi.org/10.1093/sleep/zsad169

Murawski, B., Plotnikoff, R. C., Rayward, A. T., Oldmeadow, C., Vandelanotte, C., Brown, W. J., & Duncan, M. J. (2019). Efficacy of an m-health physical activity and sleep health intervention for adults: a randomized waitlist-controlled trial. *The American Journal of Preventive Medicine*, *57*(4), 503–514. https://doi.org/10.1016/j.amepre.2019.05.009

Murray, J. M., Magee, M., Giliberto, E. S., Booker, L. A., Tucker, A. J., Galaska, B., Sibenaller, S. M., Baer, S. A., Postnova, S., Sondag, T. A., Phillips, A. J. K., Sletten, T. L., Howard, M. E., & Rajaratnam, S. M. W. (2023). Mobile app for personalized sleep–wake management for shift workers: A user testing trial. *Digital Health*, *9*, 20552076231165972. https://doi.org/10.1177/20552076231165972

Oftedal, S., Burrows, T., Fenton, S., Murawski, B., Rayward, A. B., & Duncan, M. J. (2019). Feasibility and preliminary efficacy of an m-health intervention targeting physical activity, diet, and sleep quality in shift-workers. *International Journal of Environmental Research and Public Health*, *16*(20), 3810. 10.3390/ijerph16203810

Perez-Pozuelo, I., Zhai, B., Palotti, J., Mall, R., Aupetit, M., Garcia-Gomez, J. M., Taheri, S., Guan, Y., & Fernandez-Luque, L. (2020). The future of sleep health: a data-driven revolution in sleep science and medicine. *NPJ Digital Medicine*, *3*(1), 42. https://doi.org/10.1038/s41746-020-0244-4

Rampling, C. M., Gupta, C. C., Shriane, A. E., Ferguson, S. A., Rigney, G., & Vincent, G. E. (2022). Does knowledge of sleep hygiene recommendations match behaviour in Australian shift workers? A cross-sectional study. *BMJ Open*, *12* (7), e059677. https://doi.org/10.1136/bmjopen-2021-059677

Ravyts, S. G., Dzierzewski, J. M., Perez, E., Donovan, E. K., & Dautovich, N. D. (2021). Sleep health as measured by RU SATED: a psychometric evaluation. *Behavioral sleep medicine*, *19*(1), 48–56. https://doi.org/10.1080/15402002.2019.1701474

Rayward, A. T., Plotnikoff, R. C., Murawski, B., Vandelanotte, C., Brown, W. J., Holliday, E. G., & Duncan, M. J. (2021). Erratum to: Efficacy of an m-health physical activity and sleep intervention to improve sleep quality in middle-aged adults: The Refresh Study randomized controlled trial. *Annals of Behavioral Medicine*, *55*(10), 1043–1043. https://doi.org/10.1093/abm/kaab067

Reynolds, A. C., Lechat, B., Melaku, Y. A., Sansom, K., Brown, B. W. J., Crowther, M. E., Wanstall, S., Maddison, K. J., Walsh, J. H., Straker, L., Adams, R. J. T., McArdle, N., & Eastwood, P. R. (2022). Shift work, clinically significant sleep disorders and mental health in a representative, cross-sectional sample of young working adults. *Scientific Reports*, *12* (1), 16255. https://doi.org/10.1038/s41598-022-20308-2

Reynolds, A. C., Loffler, K. A., Grivell, N., Brown, B. W., & Adams, R. J. (2024). Diagnosis and management of sleep disorders in shift workers, with patient informed solutions to improve health services research and practice. *Sleep Medicine*, *113*, 131–141. https://doi.org/10.1016/j.sleep.2023.11.027

Richa, M., Pulman, A., Dogan, H., Murphy, J., & Bitters, F. (2023). A Tailored mHealth App for Improving Health and Well-Being Behavioral Transformation in UK Police Workers: Usability Testing via a Mixed Methods Study. *JMIR Human Factors*, *10*, e42912. https://doi.org/10.2196/42912

Rowlands, A., Gillies, C., Chudasama, Y., Davies, M., Islam, N., Kloecker, D., Lawson, C., Pareek, M., Razieh, C., Zaccardi, F., Yates, T., & Khunti, K. (2021). Association of working shifts, inside and outside of healthcare, with severe COVID– 19: an observational study. *BMC Public Health*, *21*(1), 1–7. 10.1186/s12889-021-10839-0

Sancho-Domingo, C., Carballo, J. L., Coloma-Carmona, A., & Buysse, D. J. (2021). Brief version of the Pittsburgh Sleep Quality Index (B-PSQI) and measurement invariance across gender and age in a population-based sample. *Psychological Assessment*, *33*(2), 111. https://doi.org/10.1037/pas0000959

Schoeppe, S., Salmon, J., Williams, S., Power, D., Waters, K., Alley, S., Rebar, A. L., Hayman, M., Duncan, M. J., & Vandelanotte, C. (2022). Feasibility of using activity trackers and apps to increase physical activity in whole families: The Step it Up Family intervention. *Digital Health*, *8*, 20552076221129083. https://doi.org/10.1177/20552076221129083

Shriane, A. E., Rigney, G., Ferguson, S. A., Bin, Y. S., & Vincent, G. E. (2023). Healthy sleep practices for shift workers: consensus sleep hygiene guidelines using a Delphi methodology. *Sleep: Journal of Sleep Research & Sleep Medicine*, *46*(12), zsad182. https://doi.org/10.1093/sleep/zsad182

Shriane, A. E., Vincent, G. E., & Ferguson, S. A., et al. (2024). Improving sleep health in paramedics through an app-based intervention: A randomised waitlist control pilot trial. *BMC Public Health*, *24*, 2395. https://doi.org/10.1186/s12889-024-19823-w

Vandelanotte, C., Kolt, G. S., Caperchione, C. M., Savage, T. N., Rosenkranz, R. R., Maeder, A. J., Van Itallie, A., Tague, R., Oldmeadow, C., Mummery, W. K., & Duncan, M. J. (2017). Effectiveness of a web 2.0 intervention to increase physical activity in real-world settings: A randomized ecological trial. *Journal of Medical Internet Research*, *19*(11).

Vincent, G. E., Aisbett, B., Wolkow, A., Jay, S. M., Ridgers, N. D., & Ferguson, S. A. (2018). Sleep in wildland firefighters: what do we know and why does it matter?. *International Journal of Wildland Fire*, *27*(2), 73–84. 10.1071/WF17109

Ward, E. M., Germolec, D., Kogevinas, M., McCormick, D., Vermeulen, R., Anisimov, V. N., Aronson, K. J., Bhatti, P., Cocco, P., Costa, G., Dorman, D. C., Fu, L., Garde, A. H., Guénel, P., Hansen, J., Härmä, M. I., Kawai, K., Khizkhin, E. A., & Guyton, K. Z. (2019). Carcinogenicity of night shift work. *The Lancet Oncology*, *20*(8), 1058–1059. https://doi.org/10.1016/S1470-2045(19)30455-3

Young, C. R., Jones, G. E., Figueiro, M. G., Soutière, S. E., Keller, M. W., Richardson, A. M., Lehmann, B. J., & Rea, M. S. (2015). At-sea trial of 24-h-based submarine watchstanding schedules with high and low correlated color temperature light sources. *Journal of Biological Rhythms*, *30*(2), 144–154. https://doi.org/10.1177/0748730415575432