Enhancing Sleep and Mental Health: Real-World Evidence from a Digital Mental Health Platform

Kristen M. Van Swearingen, Komal Kumar, Benyetta High, Sara M. Levens, Neha Chaudhary, Jessica Watrous, Sara J. Sagui Henson

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Kristen M. Van Swearingen[1] MA; Komal Kumar[2] MS; Benyetta High[2] MPH, LPC; Sara M. Levens[1] PhD; Neha Chaudhary[2] MD; Jessica Watrous[2] PhD; Sara J. Sagui Henson[2] PhD

[1] University of North Carolina at Charlotte Charlotte US
[2] Modern Health San Francisco US

Corresponding Author:
Kristen M. Van Swearingen MA

University of North Carolina at Charlotte
9201 University City Blvd
Charlotte
US

Abstract

Background: Poor sleep is closely linked to mental health and workplace burnout, and many struggle to get enough restorative sleep.

Objective: This study examined how engagement with a multi-modal employer-sponsored digital mental health platform impacted perceived sleep quality over time, and whether improvements were associated with changes in mental health and burnout.

Methods: Working adults (N = 578, 61.1% women, Mage = 33.9 years, 40.3% people of color) newly registered for the platform completed measures of self-rated sleep quality, depression, anxiety, and burnout, at baseline, 3-months, and 12-months. Participants engaged with at least one care modality (virtual therapy, coaching, or digital resources). We examined baseline associations, changes in sleep quality, and longitudinal associations with mental health and burnout.

Results: At baseline, 42% reported poor sleep quality and were more likely to have higher depression, anxiety, and burnout. Each month of platform use increased the odds of good sleep quality by 3.73% (p = .02). Higher sleep quality over time was associated with improvements in depression, anxiety, and burnout (ps < .001). The 44% of participants who improved their sleep from baseline to 12-months showed reduced depression (-48.25%) and anxiety (-38.33%), and increased cynicism burnout, though cynicism levels remained below the cut-off for high burnout (+24%; ps < .01).

Conclusions: Use of a digital mental health platform was associated with meaningful improvements in sleep quality over 12-months. These gains were linked to reductions in depression, anxiety, and burnout, highlighting broader well-being benefits of integrated mental health care.

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Kristen M. Van Swearingen[1], Komal Kumar[2], Benyetta High[2], Sara M. Levens[1], Neha Chaudhary[2], Jessica Watrous[2], & Sara J. Sagui Henson[2]

[1] Health Psychology Doctoral Program, University of North Carolina at Charlotte, Charlotte, NC

[2] Modern Health, San Francisco, CA

Correspondence to: Kristen M. Van Swearingen, MA, University of North Carolina at Charlotte, 9201 University City Blvd, Charlotte, NC 28223, USA; email: kvanswea@charlotte.edu

Abstract

Background:
Poor sleep is closely linked to mental health and workplace burnout, and many struggle to get enough restorative sleep. This study examined how engagement with a multi-modal employer-sponsored digital mental health platform impacted perceived sleep quality over time, and whether improvements were associated with changes in mental health and burnout.

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Working adults (N = 578, 61.1% women, M_{age} = 33.9 years, 40.3% people of color) newly registered for the platform completed measures of self-rated sleep quality, depression, anxiety, and burnout, at baseline, 3-months, and 12-months. Participants engaged with at least one care modality (virtual therapy, coaching, or digital resources). We examined baseline associations, changes in sleep quality, and longitudinal associations with mental health and burnout.

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At baseline, 42% reported poor sleep quality and were more likely to have higher depression, anxiety, and burnout. Each month of platform use increased the odds of good sleep quality by 3.73% (p = .02). Higher sleep quality over time was associated with improvements in depression, anxiety, and burnout (ps < .001). The 44% of participants who improved their sleep from baseline to 12-months showed reduced depression (-48.25%) and anxiety (-38.33%), and increased cynicism burnout, though cynicism levels remained below the cut-off for high burnout (+24%; ps < .01).

Conclusion:
Use of a digital mental health platform was associated with meaningful improvements in sleep quality over 12-months. These gains were linked to reductions in depression, anxiety, and burnout, highlighting broader well-being benefits of integrated mental health care.

Keywords: anxiety; depression; sleep; burnout; digital mental health; well-being; employee health

Introduction

Sleep is a fundamental process for regulating our overall health and well-being [1–3]. Consequences of poor sleep include daytime impairment [4], diminished ability to manage challenges effectively [5], and negative impacts on mental health [6]. As such, poor sleep is commonly linked to a range of mental health challenges [7,8], and is often noted as a prominent, distressing symptom of conditions like anxiety and depression [8,9].

Poor sleep quality and mental health concerns share a bidirectional relationship. For instance, getting poor sleep due to a variety of environmental, situational, social, and psychological factors [10–12], can negatively impact mood and increase worry the following day [13,14]. Additionally, it can impair attention, decision-making, and concentration, all of which are essential for navigating daily challenges [15]. Consequently, poor sleep quality can reduce one's capacity to effectively cope with stressors [5,16] and regulate the negative emotions that may result from impaired coping [17,18]. At the same time, individuals with elevated mental health symptoms tend to experience racing thoughts that can disrupt their sleep [19–23]. This bidirectional cycle can contribute to the development or exacerbation of mental health challenges [24].

Poor sleep quality not only impacts mental health, but the impact also extends to well-being in the workplace. Sleep supports the restoration of cognitive and emotional resources that are essential for tackling workplace challenges [15,17,25]. Consequently, poor sleep quality is linked to greater workplace stress across a range of occupations [26]. When workplace stress is not adequately managed, it can intensify to burnout [25]. Burnout encompasses a range of symptoms including emotional exhaustion, detachment from one's work, and a diminished sense of accomplishment [27]. Improving sleep quality can help individuals to better manage their workplace stress, and protect against feelings of burnout [28].

As sleep is interconnected with mental health and burnout, addressing either part of this

relationship may help to effectively break the harmful cycle. For example, when people feel more mentally well and engaged at work, their sleep quality may improve, and when they achieve better quality sleep, they may better regulate their mood and contribute to productive and meaningful work. Mental health interventions, such as Cognitive-Behavioral Therapy [29] and mindfulness-based therapies [30] have shown promise in improving sleep quality, even when sleep was not the primary focus of treatment. However, only around a quarter adults in the United States (US) receive the necessary treatment for a mental health condition [31].

Digital mental health solutions offer a promising approach to increasing access to evidence-based interventions to improve sleep quality. Digital mental health is an umbrella of services, such as telehealth, digital therapeutics, online group therapy, chat-based care, and digital self-guided content, that are delivered through online platforms, mobile apps, or wearables [32–35]. There are currently several digital health solutions available specifically for sleep, such as Digital Cognitive-Behavioral Therapy for those with clinical insomnia (d-CBTi) [36]. However, many individuals experience subclinical sleep issues, and even the mere perception that our sleep quality is poor can have a significant negative effect on emotional well-being and daily functioning [37–39]. Therefore, solutions beyond d-CBTi that effectively improve sleep may have broader public health implications.

Digital health platforms that offer comprehensive mental health services and are multi-modal (e.g., offer services across multiple care modalities) may improve sleep outcomes by addressing the underlying mental health factors that can affect sleep. For instance, one study found that adolescents receiving non-sleep related digital mental health services experienced improvements in sleep quality as their mental health symptoms improved [40]. This evidence is promising, but more research is needed to evaluate the broader impact among the general population. Additionally, it is essential to examine digital mental health platforms that take a holistic care approach, expanding the range of services and care modalities to support users with varying health and well-being needs.

The current study addresses a significant gap in the literature by examining the influence of

engagement in multi-modal employer-sponsored digital mental health services on sleep quality and associated mental health and burnout outcomes over time. The platform uses technology and a stratified care model that takes into account employees' clinical needs and preferences and connects them with the right level of care. This care includes a global network of licensed clinicians and certified coaches delivering one-on-one telemental health care, support, and group psychoeducation sessions, and an extensive on-demand library of digital resources. All care modalities are evidence-based, culturally centered, and focus on five domains of health and well-being: emotional, physical, social, professional, and financial health. Evaluating the impact of a platform that addresses multiple dimensions of well-being through scalable, evidence-based multi-modal care, could provide insights for population-level sleep solutions.

In the present study, we investigated how changes in sleep quality after engagement with a comprehensive digital mental health platform for 3- and 12-month periods were associated with changes in mental health concerns (depression and anxiety). Additionally, we investigated how changes in sleep quality across these time-points influenced aspects of organizational burnout, including exhaustion, cynicism, and professional efficacy.

Our first aim was to analyze baseline associations between sleep quality, mental health, and workplace burnout among employees newly registered for the platform to understand the risk factors and correlates of poor sleep. Given the bidirectional relationships among these variables, we hypothesized that poor sleep quality would be associated with worse depression and anxiety symptoms, and higher levels of burnout. Our second aim was to examine longitudinal changes in sleep quality over time among employees engaging with the digital mental health platform across 3- and 12-months. We hypothesized that individuals would improve their sleep quality after engaging with the platform. Our third aim was to explore whether changes in sleep quality over time were associated with concurrent changes in mental health symptoms and workplace burnout. We hypothesized that as an individual's sleep quality improved, they would also experience

improvements in their depression and anxiety symptoms and reduce their feelings of burnout.

Methods

Study Design

This was a 12-month prospective, observational study of adults from multiple workplace organizations who had newly registered for an employer-sponsored digital mental health benefits platform [Modern Health, San Francisco, CA]. Participants were eligible if they 1) were 18 years or older, 2) had access to a smartphone, tablet, or computer, 3) were employed by companies partnered with the mental health platform, 4) and had indicated they were planning to start care (by either matching with a therapist or coach, or engaging with one piece of digital content). Data were collected at three time points: baseline (after registering), and at 3- and 12-months following registration. Data were collected between September 2021 and March 2023. The study protocol was reviewed and approved by Western Clinical Group Institutional Review Board.

Procedure

Upon onboarding with the platform, individuals who met the specified inclusion criteria were invited by email to fill out a screening questionnaire. This questionnaire gathered additional demographic information to ensure a balanced sample that was representative of the broader US population and the commercial population who had access to this employer-sponsored benefit. Those who successfully completed the screening were subsequently directed to a consent form. Participants who provided their informed consent to join the study received a baseline survey via email, which took approximately 30-45 minutes to complete. Throughout the study period, participants received two follow-up surveys at 3- and 12-months. Participants were offered a $25 digital gift card as compensation for completing each survey. All questionnaires and surveys were conducted using Qualtrics' online survey platform.

Digital Mental Health Services

The digital mental health platform is an employer-sponsored mental health benefit, offering employees no-cost access to a range of mental health services such as one-on-one care with a therapist or coach, group psychoeducation sessions, and self-guided digital resources. Eligible individuals registered for an account with the platform via a mobile app or website. Through the platform, participants completed clinical assessments using validated measures such as the PHQ-9 and GAD-7 to determine clinical need. Individuals also specified their preferred care delivery method, such as ‘on my own’, ‘one-on-one’, or ‘unsure’, and selected their desired area of focus from the following domains: emotions, physical well-being, professional life, relationships, and finance. From these selections, a proprietary algorithm provided them with an initial care recommendation (e.g., to start with coaching for a member with mild clinical need who preferred one-on-one support) and individuals were able to engage in this recommendation or self-refer and use any combination of multi-modal care, including one-on-one care, group psychoeducation, and self-guided resources as they desired. For eligibility in this study, all participants accessed at least one therapy or coaching session, or engaged with at least one piece of digital content.

Teletherapy and Telecoaching

Participants had access to 50-minute one-on-one teletherapy sessions provided via Zoom by licensed therapists holding advanced psychology or related degrees (e.g., PhD, PsyD, LCSW, LMFT, or LPC). Additionally, participants had access to 30-minute telecoaching sessions provided via Zoom by International Coaching Federation certified coaches [41]. All coaches had at least 100 hours of coaching experience plus at least 6 additional hours of training from the digital mental health company on topics of culturally centered care and identifying high-risk situations that may require crisis or higher-level support. All therapists and coaches were vetted carefully for offering evidence-based practices such as Motivational Interviewing, Cognitive Behavioral Therapy, Acceptance and Commitment Therapy, and Dialectical Behavior Therapy. Ongoing provider quality monitoring was

conducted by a team of legal, compliance, provider operations, and clinical experts to ensure rigorous clinical standards were upheld.

Participants were either recommended to these one-on-one services after their initial intake assessment, or they could opt to self-refer. In both cases, a proprietary algorithm matched participants with a list of providers who were most relevant to their clinical needs, spoke their desired language, and had session availability within a few days. The matching algorithm also took into account provider specializations in the participant's domain of focus. For example, if a participant wanted to work on their physical well-being and sleep quality, they were provided a list of therapists or coaches who specialized in sleep-related issues and could provide personalized strategies and support to help improve sleep habits. In this health domain, providers have the opportunity for individualized care, in which they could provide psychoeducation around how sleep and mental health are related, build routines around sleep hygiene and rest, implement techniques for cognitive restructuring to disrupt worrying and maladaptive thoughts at bedtime, and utilize Motivational Interviewing to support behavior changes necessary for sleep and mental health improvement. The amount and frequency of sessions that participants attended depended on their personal preferences, employer coverage, and individual needs.

Self-Guided Digital Resources and Group Psychoeducational Sessions

Participants had unrestricted access to an on-demand digital library featuring mental health programs and resources available to them. These included brief daily exercises, interactive programs, educational podcasts, mindfulness practices, and self-paced educational courses designed with the support of mental health experts including an in-house team of clinical psychologists, covering topics like emotions, relationships, and professional life. In addition to ample content aimed at improving mental health, the digital library also contained several resources specific to sleep. These included a self-paced, structured 6-session course called "Tools for Better Sleep, Rest, and Movement Throughout Your Day" and a 6-episode podcast covering elements of CBTi including sleep hygiene,

bedtime stimulus control, relaxation techniques, sleep restriction, and cognitive restructuring. There were also guided meditations, body scans, progressive muscle relaxations, breathing exercises, and calming sounds designed to help with sleep. Providers could recommend self-guided resources that were relevant to participant's concerns or goals. Participant use of self-guided resources was recorded, however specific content selection was not.

Finally, participants could join live group psychoeducation sessions led by therapists and coaches. Sessions covered topics such as dealing with challenges in the workplace, processing stressful world events, and building emotional resilience. Several regularly featured sessions were specific to improving sleep quality (e.g., "Sleep: A Beginner's Guide" and "Sleep: A Deep Dive", both 1-hour long sessions). Group sessions were provided in a variety of formats, such as webinar style learning, skill-building workshops, and informal discussions to support different user preferences. Participation in the group sessions was anonymous.

Measures

Demographics. Participants provided information on their age (by typing a number in years in an open-text box) and selected their gender identity, race/ethnic identity, and level of education from preset dropdown menus which also had the option to include another category.

Sleep quality. Perceived sleep quality was measured by a single item ("During the past month, how would you rate your sleep quality overall?") from the Pittsburgh Sleep Quality Index (PSQI) [42]. Participants could choose one of four response options: (3) 'very good', (2) 'fairly good', (1) 'fairly bad', or (0) 'very bad'. A binary variable was created, such that 'very bad' or 'fairly bad' responses were categorized as 'poor sleep', while 'fairly good' or 'very good' responses were categorized as 'good sleep.' We defined improvement in sleep quality as a participant being categorized as having 'poor sleep' at baseline, and 'good sleep' at a follow-up time-point. Single item self-rated health measures are increasingly being utilized in clinical practice and health research due

to their feasibility and strong predictive validity [43,44]. In real-world settings, lengthy questionnaires are not always practical, especially when examined at multiple time-points. As such, this single-item measure of sleep quality was chosen to capture a relatively accurate perception of one's sleep. Single-item sleep quality measures have been used in previous studies [20,45,46], and research suggests that one's perception of their sleep quality can be more predictive of well-being and daytime functioning than objective measures [37–39].

Depression. Depression severity was measured by the 9-item Patient Health Questionnaire (PHQ-9) [47]. Participants reported how often they were bothered by a number of depression symptoms over the past two weeks, on a 4-point scale (0= 'Not at all', 3= 'Nearly every day') with higher total scores indicating greater symptomatology. A positive screen for depression symptoms was indicated by a score of ≥ 10 [47].

Anxiety. Anxiety severity was measured by the 7-item Generalized Anxiety Disorder Questionnaire (GAD-7) [48]. Participants reported how often they were bothered by a number of anxiety symptoms over the past two weeks, on a 4-point scale (0= 'Not at all', 3= 'Nearly every day') with higher total scores indicating greater symptomatology. A positive screen for anxiety symptoms was indicated by a score of ≥ 8 [49].

Workplace Burnout. Burnout was measured by the 16-item Maslach Burnout Inventory (MBI-GS-16) [50], which examines three different subscales of burnout (exhaustion, cynicism, and professional efficacy). Participants reported how often they experienced a number of feelings about their job on a 7-point scale (0= 'Never', 6= 'Every Day'). An average was taken from the total score of each subscale. Higher average scores on the exhaustion subscale indicate greater feelings of fatigue and emotional exhaustion from work. Higher average scores on the cynicism subscale indicate greater indifference towards one's work. Higher average scores on the efficacy subscale indicate greater feelings of competence and achievement in one's work; thus, lower scores on this subscale indicate higher burnout. Higher levels of burnout were categorized by a frequency of "once

a week" or more for exhaustion and cynicism subscales (≥4), and a frequency of "a few times per month" or less for the efficacy subscale (≤3).

Platform engagement. To assess engagement in the platform, we reported average utilization for coaching, therapy, and self-guided digital resources. We included participants in this study who had used at least one service during the study timeframe. We did not have access to data on group psychoeducation sessions engagement as participation was anonymous.

Statistical Analyses

All analyses were conducted using R version 4.4.1 [51]. We conducted descriptive statistics for demographic variables, baseline sleep quality, mental health, and burnout. We also calculated the percent of participants categorized as having 'poor sleep' or 'good sleep' at baseline, as well as those screening positive for depression symptoms, anxiety symptoms, or high levels of burnout in the overall sample.

Our first aim was to evaluate whether baseline sleep quality was associated with mental health (depression and anxiety) and workplace burnout (exhaustion, cynicism, and professional efficacy). For this aim, chi-square tests examined if there were differences in the proportions of positive screens for depression, anxiety, or high burnout between participants with poor sleep quality versus those with good sleep quality.

Our second aim was to evaluate longitudinal changes in sleep quality among employees engaging with the digital mental health platform across 3- and 12-months. First, a generalized linear mixed-effects model was conducted to assess if time since initiation of mental health services predicted the odds of reporting good sleep quality. In this model, the outcome variable was sleep quality (coded as binary (0 = poor sleep, 1 = good sleep)). The model included a fixed-effect for time since initiation of platform services (baseline = 0, 3-month follow-up = 3, 12-month follow-up = 12), and random intercepts for participants to account for different baseline sleep quality levels. Second,

we calculated the proportion of participants categorized as having poor sleep at baseline who were categorized as having good sleep at follow-up time-points (indicating improved sleep).

Our third aim was to evaluate whether changes in sleep quality over time (between baseline, 3-months, and 12-months follow-up) were associated with concurrent changes in mental health symptoms and burnout. First, we conducted a series of linear mixed effects-models with the overall sample to examine the relationship between sleep quality and outcomes over the course of using the digital mental health services. Five models were constructed, one for each of the five mental health and burnout outcomes, all of which were continuous. The models included fixed effects for time since initiation of platform services (baseline = 0, 3-month follow-up = 3, 12-month follow-up = 12) and sleep quality (coded as binary (0 = poor sleep, 1 = good sleep)). Time was also nested within participants to account for individual differences in baseline mental health or burnout levels and their changes over time. Second, we conducted paired samples t-tests within participants who improved their sleep quality (i.e., reported poor sleep quality at baseline and good sleep quality at 3- or 12-month follow-ups) to examine the change in mental health and burnout outcomes from baseline to the 3-month or 12-month follow-ups.

Results

Study Participants and Baseline Descriptive Data

The sample included 578 participants who engaged in at least one service, and provided their sleep quality score at baseline and at least one of the follow-up time points. Participants were, on average, 33.88 years old (*SD* = 8.73), 61.07% identified as women, and 40.31% identified as a person of color (see Table 1 for sample demographics and characteristics). Of this group, 527 participants provided follow-up data at 3-months and 343 provided follow-up data at 12-months.

At baseline, 42.04% (*n* = 243) of participants indicated their sleep quality over the past month was either ‘very bad’ (*n* = 24) or ‘fairly bad’ (*n* = 219), categorizing them as baseline ‘poor sleepers.’

The remaining 57.96% (*n* = 335) of participants indicated their sleep quality as either ‘fairly good’ (*n* = 289) or ‘very good’ (*n* = 46), categorizing them as baseline ‘good sleepers.’

For mental health symptoms at baseline, average depression (*M* = 8.35, *SD* = 5.63) and anxiety scores (*M* = 7.63, *SD* = 5.37) were below the clinical cut-offs of ≥10 for the PHQ-9 and ≥8 for the GAD-7. Additionally, 36.85% (*n* = 213) of participants had a positive baseline screen for depression symptoms and 42.91% (*n* = 248) of participants had a positive baseline screen for anxiety symptoms.

For burnout symptoms at baseline, average exhaustion (*M* = 2.08, *SD* = 1.67) and cynicism (*M* = 2.03, *SD* = 1.59) were below the high burnout cut-offs of ≥4 for high exhaustion and cynicism on the MBI-GS-16. Average professional efficacy (*M* = 4.58, *SD* = 1.05) was above the high burnout cut-off of ≤3 for low professional efficacy. Additionally, 26.91% (*n* = 155) of participants were above the cut-off indicating high exhaustion, 16.12% (*n* = 93) of participants were above the cut-off indicating high cynicism, and 8.70% (*n* = 50) of participants were below the cut-off indicating low professional efficacy.

Regarding platform engagement during the 12-month study period, 42.86% used therapy, attending an average of 6.3 virtual therapy sessions, 67.49% used coaching, attending an average of 3.4 virtual sessions, and 77.26% accessed self-guided digital content, engaging with an average of 10.9 resources. The majority of participants (64.43%) used at least two modalities of care, and 19.24% used all three modalities of care at least once.

Table 1

Baseline Demographic Characteristics and Descriptive Statistics in the Overall Sample and by Baseline Sleep Quality

	Overall Sample (*n* = 578)	**Poor Sleepers** (*n* = 243)	**Good Sleepers** (*n* = 335)
Age, *M* (*SD*)	33.88 (8.73)	33.95 (8.36)	33.82 (9.00)
Gender Identity, *n* (%)			

Woman	353 (61.1)	160 (65.8)	194 (57.9)
Man	197 (34.1)	74 (30.5)	124 (37.0)
Gender non-binary	28 (4.8)	9 (3.7)	17 (5.1)
Race/Ethnicity, *n* (%)			
Asian or Asian American	109 (18.9)	45 (18.5)	64 (19.1)
Black or African American	36 (6.2)	20 (8.2)	16 (4.8)
Hispanic, Latino, or Spanish Origin	47 (8.1)	20 (8.2)	27 (8.1)
Non-Hispanic White	345 (59.7)	138 (56.8)	207 (61.8)
More than 1 race/ethnicity	39 (6.7)	19 (7.8)	20 (6.0)
Education, *n* (%)*			
<Bachelors	72 (12.5)	40 (16.5)	32 (9.6)
Bachelors	348 (60.2)	141 (58.0)	207 (61.8)
>Bachelors	158 (27.3)	62 (25.5)	96 (28.7)
Platform Engagement Over 12 Months, *M* (*SD*)			
Therapy Sessions	6.3 (5.4)	5.6 (4.4)	6.8 (6.1)
Coaching Sessions	3.4 (3.1)	3.5 (3.3)	3.3 (3.0)
Digital Resources	10.9 (18.4)	10.2 (13.8)	11.5 (21.1)

Note. *M* = mean, *SD* = standard deviation.
*Difference is statistically significant ($p < .05$)

Baseline Associations Between Sleep Quality, Mental Health, and Burnout

Average depression and anxiety scores were below clinical cut-offs for those with good sleep quality (depression: $M = 6.18$, $SD = 4.73$; anxiety: $M = 6.03$, $SD = 4.62$), and above clinical cut-offs for those with poor sleep quality (depression: $M = 11.30$, $SD = 5.41$; anxiety $M = 9.82$, $SD = 5.57$). Chi-squares indicated a higher proportion of participants with poor sleep at baseline screened positive for depression ($\chi^2(1, n = 578) = 102.47$, $p < .001$, $\phi = 0.42$) and anxiety ($\chi^2(1, n = 578) = 61.97$, $p < .001$, $\phi = 0.33$) than those with good sleep at baseline (see Table 2). For example, 60.9% of poor sleepers screened positive for depression at baseline versus 19.4% of good sleepers.

Average burnout exhaustion and cynicism were below the high burnout thresholds for both individuals with both good sleep quality (exhaustion: $M = 2.49$, $SD = 1.59$; cynicism: $M = 1.84$, $SD =$

1.50) and poor sleep quality (exhaustion: M = 3.23, SD = 1.69, cynicism: M = 2.28, SD = 1.68). Additionally, average professional efficacy was above the low professional efficacy threshold for individuals with both good sleep quality (M = 4.72; SD = 0.99) and poor sleep quality (M = 4.40; SD = 1.10). However, chi-squares indicated a higher proportion of participants with poor sleep at baseline had high burnout for exhaustion ($\chi^2(1, n = 576) = 23.34$, $p < .001$, $\phi = 0.20$), cynicism ($\chi^2(1, n = 577) = 8.00$, $p = .005$, $\phi = 0.12$), and low professional efficacy ($\chi^2(1, n = 575) = 7.88$, $p = .005$, $\phi = 0.12$) than those with good sleep at baseline (see Table 2). For example, 37.6% of poor sleepers were classified as having high exhaustion at baseline versus 19.2% of good sleepers.

Table 2

Positive Screens for Mental Health and High Burnout in the Overall Sample and by Baseline Sleep Quality

	Overall Sample (n = 578)	**Poor Sleepers** (n = 243)	**Good Sleepers** (n = 335)
Mental Health Symptoms			
Depression Screen, n (%)*			
Negative Screen	365 (63.2)	95 (39.1)	270 (80.6)
Positive Screen	213 (36.9)	148 (60.9)	65 (19.4)
Anxiety Screen, n (%)*			
Negative Screen	330 (57.1)	92 (37.9)	238 (71.0)
Positive Screen	248 (42.9)	151 (62.1)	97 (29.0)
Burnout Symptoms			
High Exhaustion, n (%)*			
Negative Screen	421 (73.1)	151 (62.4)	270 (80.8)
Positive Screen	155 (26.9)	91 (37.6)	64 (19.2)
High Cynicism, n (%)*			
Negative Screen	484 (83.9)	191 (78.6)	293 (87.7)
Positive Screen	93 (16.1)	52 (21.4)	41 (12.28)
Low Professional Efficacy, n (%)*			
Negative Screen	525 (91.3)	212 (87.2)	313 (94.3)
Positive Screen	50 (8.7)	31 (12.8)	19 (5.7%)

Note. A positive screen for depression or anxiety was defined as baseline depression or anxiety scores above the clinical cut-off (≥ 10 for depression, ≥ 8 for anxiety). High burnout was

defined as exhaustion and cynicism scores ≥ 4, and professional efficacy scores ≤3.
*Difference is statistically significant ($p < .05$)

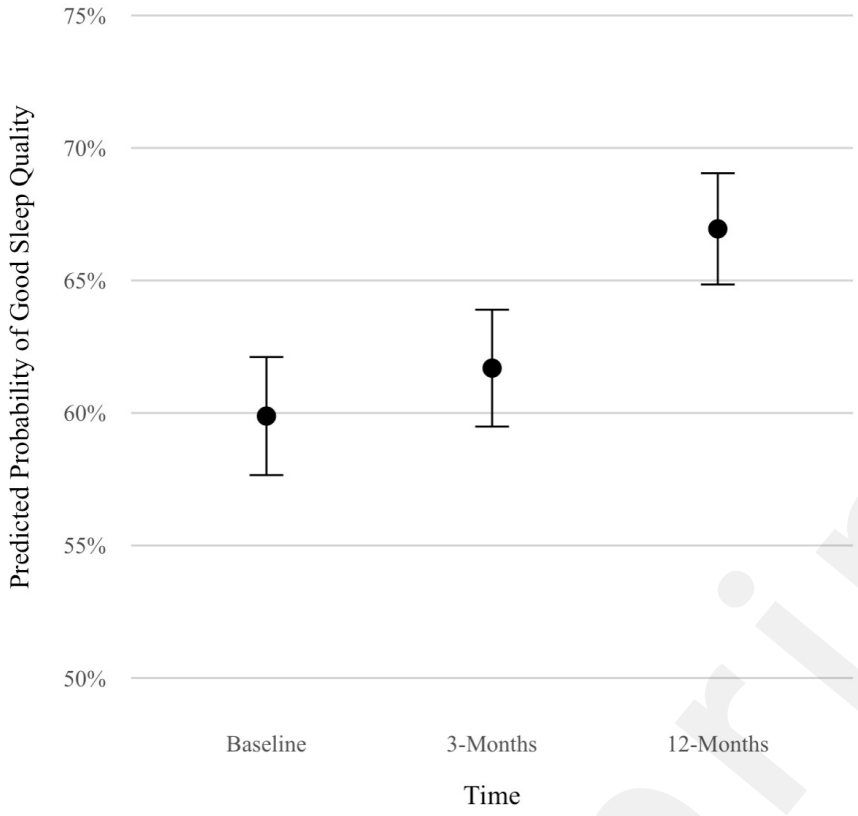
Longitudinal Changes in Sleep Quality

A generalized linear mixed-effects model was constructed to predict the odds of good sleep quality over time (see Figure 1). The model included a fixed effect of time, and random intercept for participants. The model indicated that time since initiation of services had a small but statistically significant association with sleep quality ($\beta = 0.04$, $SE = 0.02$, $t = 2.29$, $p = .022$). The beta of 0.0366 for time translates to an odds ratio of 1.0372, indicating that for each month of platform use, the predicted odds of having good sleep quality increased by 3.73%. The model predicted that compared to baseline, the odds of having good sleep quality were 11.6% higher at 3-months and 55.1% higher at 12-months. Based on this model, Figure 1 depicts the predicted probability of having good sleep quality at each time-point.

Descriptively, the proportion of participants categorized as poor sleepers was the following at each time-point: 42.04% ($n = 243$) at baseline, 38.14% ($n = 201$) at 3-months, and 35.29% ($n = 123$) at 12-months. We examined the proportion of participants categorized as having poor sleep at baseline who were categorized as having good sleep at follow-up time-points. Accordingly, 34.84% ($n = 78$) of poor baseline sleepers reported good sleep at 3-month follow-up and 43.97% ($n = 62$) reported good sleep at 12-month follow-up.

Figure 1

Predicted Probability of Good Sleep Quality by Time-Point



Note. The predicted probability of good sleep quality is 59.88% at baseline, 61.69% at 3-months, and 66.95% at 12-months. Error bars represent 95% confidence intervals.

Relationships Between Sleep Quality, Mental Health, and Burnout Over Time

A series of linear mixed-effects models (see Table 3) were constructed to examine the impact of time since initiation of platform services and sleep quality on five mental health and burnout outcomes across the three study time-points. In the model predicting depression, time since initiation of services was significantly associated with depression symptom reduction (β = -0.16, p < .001). Sleep quality significantly predicted depression symptoms when controlling for time (β = -3.55, p < .001), such that a 1 unit increase in sleep quality (moving from poor sleep to good sleep) was associated with a 3.55 point reduction in depression scores. Given the intercept was 9.73 (close to the cut-off of ≥10 for a positive depression screen), a 3.55 point reduction associated with improved sleep quality indicates that average depression scores reduced to 6.18, which are approaching the mild range (<5). Similarly, for anxiety, time since initiation of services was significantly associated

with anxiety symptom reduction (β = -0.12, p < .001). Sleep quality significantly predicted anxiety symptoms when controlling for time (β = -2.80, p < .001), such that a 1 unit increase in sleep quality was associated with a 2.80 point reduction in anxiety scores. The intercept in this model was 8.83 (above the cut-off of ≥8 for a positive anxiety screen); thus, a 2.78 point reduction associated with improved sleep quality indicates average anxiety scores reduced to 6.05, which are approaching the mild range (<5).

In the model predicting burnout exhaustion, time since initiation of services was significantly associated with an exhaustion score increase (β = 0.04, p < .001). Sleep quality significantly predicted exhaustion when controlling for time (β = -0.46, SE = 0.07, t = -6.20, p < .001), such that a 1 unit increase in sleep quality was associated with a 0.46 point reduction in exhaustion scores. For cynicism, time since initiation of services was significantly associated with a cynicism score increase (β = 0.07, p < .001). Sleep quality significantly predicted cynicism when controlling for time (β = -0.28, p < .001), such that a 1 unit increase in sleep quality was associated with a 0.28 point reduction in cynicism scores. For professional efficacy, time since initiation of services was significantly associated with an efficacy score decrease (β = -0.01, p = .003). Sleep quality significantly predicted professional efficacy when controlling for time (β = 0.22, p < .001), such that a 1 unit increase in sleep quality was associated with a 0.22 increase in professional efficacy scores.

Table 3

Fixed Effects Estimates of Time and Sleep Quality on Mental Health and Burnout Outcomes

Outcome Variable	Predictor	*β*	*SE*	*t*	*p*
Mental Health					
Depression	(Intercept)	9.73	0.23	41.66	< .001
	Time	-0.16	0.02	-7.64	< .001
	Sleep Quality	-3.55	0.24	-14.56	< .001
Anxiety	(Intercept)	8.83	0.24	36.45	< .001

	Time	-0.12	0.02	-5.45	< .001
	Sleep Quality	-2.78	0.25	-11.17	< .001
Burnout					
Exhaustion	(Intercept)	3.05	0.08	38.25	< .001
	Time	0.04	0.01	5.80	< .001
	Sleep Quality	-0.46	0.07	-6.20	< .001
Cynicism	(Intercept)	2.22	0.08	27.93	< .001
	Time	0.07	0.01	10.00	< .001
	Sleep Quality	-0.28	0.08	-3.53	< .001
Professional Efficacy	(Intercept)	4.43	0.05	85.50	< .001
	Time	-0.01	0.01	-3.05	.002
	Sleep Quality	0.22	0.05	4.10	< .001

Note. Time is coded as 0 for baseline, 3 for 3-month follow-up, and 12 for 12-month follow-up. Sleep quality is coded as 0 for “poor sleep” and 1 for “good sleep.”

Next, we conducted paired sample t-tests within the subset of participants who improved their sleep from baseline to 3- or 12-month follow-ups (Table 4) to better understand how mental health symptoms and burnout changed between the study time-points (from baseline to 3-month, or from baseline to 12-month). Participants with poor sleep at baseline who reported good sleep at 3-month follow-up (n = 78), showed significant reductions in depression (-42.77%) and anxiety (-30.54%; ps < .001) between baseline and 3-month follow-up. Participants with poor sleep at baseline who reported good sleep at 12-month follow-up (n = 68) showed significant reductions in depression (-48.25%) and anxiety (-38.33%; ps < .001) at 12-month follow-up. None of the three burnout domains changed over 3- or 12-months in the samples of participants who improved their sleep quality at 3- or 12-month follow-up, with the exception of a significant increase in cynicism at 12-month follow-up (+24%, p < .01), though it remained below the cut-off for high burnout.

Table 4

Paired Sample T-tests of Outcomes Among Participants Who Improved Their Sleep from Baseline to Follow-Up Time-Points

Variable	*n*	Range	Baseline *M*(*SD*)	3-Month Follow-up *M*(*SD*)	*t*	*p*
Baseline to 3-month follow-up						
Depression	78	0 - 27	10.17 (5.29)	5.82 (4.10)	-7.05	< .001
Anxiety	78	0 - 21	8.94 (5.94)	6.21 (4.70)	-4.86	< .001
Exhaustion	78	0 - 6	2.93 (1.75)	2.85 (1.79)	-0.51	.61
Cynicism	78	0 - 6	2.17 (1.61)	2.33 (1.77)	1.14	.26
Efficacy	78	0 - 6	4.53 (1.11)	4.54 (1.06)	0.05	.96
Variable	***n***	**Range**	**Baseline *M*(*SD*)**	**12-Month Follow-up *M*(*SD*)**	***t***	***p***
Baseline to 12-month follow-up						
Depression	62	0 - 27	11.40 (5.96)	5.90 (4.21)	-7.35	< .001
Anxiety	62	0 - 21	9.60 (5.92)	5.92 (4.91)	-5.55	< .001
Exhaustion	58	0 - 6	3.26 (1.70)	3.06 (1.46)	-0.54	.59
Cynicism	59	0 - 6	2.38 (1.74)	2.95 (1.64)	2.55	.01
Efficacy	59	0 - 6	4.39 (1.03)	4.40 (1.05)	0.28	.78

Note. M = mean, SD = standard deviation.

Discussion

To date, sleep research has primarily focused on the treatment of insomnia, instead of taking a broader public health perspective to sleep treatment. Given the impact of sleep perception on mental health and well-being outcomes, a broader focus on sleep among the general population may offer critical insights into public health interventions to address sleep. We evaluated the real-world effectiveness of an employer-sponsored digital mental health platform for improving sleep quality, and whether improved sleep quality was associated with changes in mental health and burnout. As predicted, we found that engagement with the mental health platform was associated with improved

sleep quality. Additionally, when sleep quality was higher, individuals tended to show reduced mental health and burnout symptoms. This study is important as it assessed the impact of a multi-modal mental health platform within a broad population.

The large percentage of participants who registered for the mental health platform who reported poor sleep quality at baseline (42%) supports a plethora of research showing that many people struggle to achieve restful and restorative sleep at night. This finding mirrors an American Psychological Association statistic from 2013, where 42% of adults reported fair or poor quality sleep [20]. For such individuals, especially those who experience sleep issues but do not reach the threshold for a sleep disorder diagnosis, there is a clear need for services that can help to improve sleep problems. Our findings suggest that multi-modal digital mental health platforms, though not explicitly a sleep intervention, can offer support beyond just mental health, playing a valuable role in other health behaviors and domains of well-being known to influence mental health.

When examining correlates of poor sleep before starting care, we found that individuals with poor sleep quality at baseline were more likely to report higher depression and anxiety symptoms, greater exhaustion and cynicism at work, and lower professional efficacy for their job. These associations align with past research showing that maintaining quality sleep is crucial for sustaining the cognitive resources needed to tackle daily challenges [15,17] and managing negative emotional experiences [5,18]. As such, sleep disturbances may make it difficult to manage and recover from daily challenges, leading to exhaustion, feelings of burnout, and greater mental health symptoms. Given the bidirectional relationship between these variables, the opposite may also be true. Experiencing greater mental health and workplace concerns could lead to greater sleep disturbances. Individuals may lie awake at night with intrusive thoughts or worry about work-related challenges [20–22]. Additionally, the body's physiological response to stressors, such as greater cortisol in the body, can disrupt the wake-sleep cycle [52]. While this study cannot determine the directionality of these baseline relationships, our findings strongly underscore the complex interplay between these

variables. Given that the population studied here was seeking mental health support from a digital platform, these baseline findings highlight the range of health and well-being needs of these individuals beyond care for depression or anxiety.

Although the services in the digital mental health platform primarily focused on emotional health, the platform also leveraged multiple modalities of care (therapy, coaching, self-guided resources) to support people with their physical well-being and sleep habits. Thus, for aim 2, we explored whether sleep quality improved over the course of using digital mental health services. We found that 38.14% of participants who initially reported poor sleep at baseline improved to good sleep by 3-month follow-up, and 43.97% improved to good sleep by 12-month follow-up. Additionally, our model examining change in sleep quality across all three time-points, while accounting for repeated measurement within participants and missing data, predicted that the odds of reporting good sleep quality consistently increased over time. Specifically, the odds of experiencing good sleep quality rose by 3.73% for each month of utilizing platform services, indicating a 55.1% increased odds of good sleep after 12-months. Overall, this finding is in line with previous research showing that mental health treatment can also lead to welcomed improvement in sleep quality [29,30,40].

The improvement in sleep quality observed in our study underscores the potential for digital mental health interventions to support sleep-related concerns. These platforms provide a unique opportunity to reach individuals with subclinical sleep issues or those who may not present or have access to sleep treatments like CBTi. Given the high rate of sleep concerns in the general public, sleep problems have become somewhat normalized. As a result, many individuals may overlook these concerns, fail to seek support for their sleep outside of the traditional medical system, or face barriers when they do [53]. Additionally, gold standard interventions like CBTi can be time intensive, and research on these interventions has focused primarily on clinical populations. This leaves a gap in our understanding of the impact of less intensive, but still evidence-grounded interventions that

could have broad public health implications. Digital mental health platforms can serve as an accessible entry point for sleep support, offering an alternative to standard treatments for sleep that may be less accessible, limited in availability, or not well-known. As services for these mental health platforms are carefully developed, they may consider taking a holistic care approach to support the diverse and interconnected health and well-being needs of their users.

Given the strong link between sleep quality, mental health, and burnout, for aim 3, we explored whether changes in sleep quality over time were associated with changes in depression, anxiety, and all three domains of burnout. Between our two analyses, we found that improved sleep quality was associated with improved mental health symptoms and to some extent, workplace burnout. Examining mental health across time, our regression models predicted a significant reduction in depression and anxiety symptoms. Additionally, when one's sleep quality was good, depression and anxiety were significantly lower by 3.55 points and 2.80 points respectively. These models showed that at baseline, depression and anxiety were close to or above the cut-offs for a positive screen and moderate symptoms, and that when sleep quality improved, average scores dropped to around 6, which is closer to mild levels of symptoms.

In our second analysis for this aim, we found that among participants who reported poor sleep at baseline and improved to good sleep by the 3-month follow-up, their average depression scores statistically significantly improved by 43%. This change of 4.35 points was also close to the threshold to be considered clinically significant change, which is a 5-point reduction in depression [54]. At 12-months, people who improved their sleep quality reported a 48% improvement in depression and a clinically significant point reduction of 5.5 points, on average. Regarding anxiety, those who improved their sleep quality by 3-months reported a 31% improvement at 3-month follow-up and those who improved their sleep quality by 12-months reported a 38% improvement in symptoms at 12-month follow-up. It is possible that mental health improvements directly contributed to individuals experiencing better sleep quality. Alternatively, as the relationship between sleep and

mental health is bidirectional [55], improvements in sleep quality may have had positive downstream effects on mental health. The digital mental health platform provided comprehensive services aimed at enhancing overall well-being, including physical health, with some resources specific to sleep hygiene and psychoeducation. Improvement in either sleep quality or mental health likely contributed to positive change in the other.

Regarding the association between changes in sleep quality and changes in the three domains of burnout, we first found that over time, exhaustion and cynicism significantly increased while professional efficacy decreased. However, burnout scores were already low at baseline, and this amount of change was not enough to move scores over the threshold to be considered high burnout at any time-point. Sleep quality seemed to act as a kind of buffer against these increases. When one's sleep quality was good, exhaustion and cynicism were statistically significantly lower by 0.46 points and 0.28 points respectively, and professional efficacy was higher by 0.22 points. These point reductions in exhaustion and cynicism and increase in efficacy associated with good sleep quality across study time points put participants' burnout scores even further into the category of lower burnout.

The buffering impact of good sleep quality was also partially supported by our paired sample t-test analyses. While the regression analyses showed that burnout slightly increased over time, our t-tests indicated that the subsample of participants who improved their sleep quality from baseline to either follow-up time-point, maintained their low levels of burnout. Directionally, exhaustion scores were lower at follow-up (though not statistically significant), cynicism scores were higher at follow-up (and significantly so at 12-months, but remained below the high burnout cut-off), and professional efficacy did not change (directionally or statistically). Because burnout was low at baseline, and remained below cut-offs throughout the study, there was limited room for further reduction. The slight increase in cynicism between baseline and 12-months may reflect a floor effect. However, the overall observed maintenance of low burnout over time, especially for those with good and

improving sleep quality is a positive outcome.

The study findings related to burnout may reflect additional contributing factors. Burnout may be attributed to aspects of organizational culture, job demands, and workplace policies [56,57] that remain unchanged despite individual improvements in sleep and mental health. This could account for the fact that burnout slightly declined over time, yet sleep quality and mental health tended to improve. It is also possible that burnout has a larger influence on sleep quality than the reverse. Individuals experiencing burnout may be facing work-related stressors such as working long hours and dealing with emotional exhaustion, which can disrupt their ability to maintain a consistent bed-time routine or mentally wind down before bed [25]. As burnout decreases, sleep quality may improve from the reduced stress and demands. Of note, only a small portion of participants had elevated burnout at baseline, and we did not stratify the sample by baseline burnout severity. It is possible that individuals with higher initial burnout experienced improvements in sleep quality as their burnout decreased. For the majority of participants who started out with low levels of burnout, their treatment goal may have been to maintain their lower levels, a pattern that aligns with the study findings.

Improvements in sleep alone may not address the organizational factors that likely have a more significant impact on burnout. The complex nature of burnout may require more targeted interventions, starting in the workplace itself with strategies such as systemic improvements, to see significant changes. However, improving sleep quality may still have a positive impact. Overall, burnout tended to be lower at time points when individuals reported good sleep quality. When sleep improved from poor to good, burnout levels remained low. Improving sleep through mental health interventions may help to buffer against the exacerbation of workplace stress and burnout. Therefore, it is worth investing in solutions that target sleep and mental health, as they can also affect how someone shows up at work, even when burnout may be increasing due to other organizational factors, improved sleep may attenuate this increase.

Limitations

There are several notable limitations of the study. First, this was an observational study using real-world data collected between 2021-2023. World events, such as the COVID-19 pandemic, could have impacted sleep quality during the study period. Additionally, with no control group for comparison, we are unable to make causal claims that the mental health services provided caused changes in sleep quality. However, several studies have demonstrated improvements in mental health following use of this digital mental health platform [58–60], and there is mounting evidence that individuals often experience enhanced sleep quality following improvements in their mental health [29,30,40]. Nonetheless, future studies could incorporate a comparison group in their design to further validate the effectiveness of digital mental health services in improving sleep.

Second, participants were eligible for the study if they attended at least one therapy or coaching session, or engaged with at least one self-guided digital resource. Many of our participants used a combination of one-on-one care and self-guided resources. Therefore, we were unable to stratify sleep quality improvements by care modality. Future studies may explore how factors such as service type, content, and level of engagement may influence the magnitude of sleep quality improvement. This could help determine the most effective strategies for improving sleep quality with digital mental health services. Third, all participants were employees of organizations sponsoring the digital mental health platform. Therefore, the results of the study may not generalize to non-working adults or employees that were not represented on the platform. For instance, factors such as job-related workload or financial stress may have impacted sleep quality, and these particular stressors may vary in other populations.

Finally, all data collected in this study were self-reported by participants, and individuals may not have accurately evaluated themselves or remembered their experiences. Furthermore, we used a single item to measure sleep quality perception. We did not assess objective measures of sleep quality, such as actual sleep duration, latency, and efficiency. However, research has shown that one’s

perception of their sleep quality can strongly influence emotional well-being and cognitive performance, sometimes even more so than objective sleep metrics [37–39].

Conclusion

This study examined how the use of an employer-sponsored digital mental health platform impacted perceived sleep quality and correlates of poor sleep over time. At baseline, poor sleep was related to higher symptoms of depression, anxiety, and burnout, highlighting the multifaceted nature of challenges experienced by a sample of participants motivated to engage in mental healthcare and support. Results suggest that digital mental health solutions offering a comprehensive, holistic approach to well-being can support sleep improvement. Sleep quality improved while participants engaged with services, and this improvement in sleep was associated with improvements in mental health symptoms and maintenance of burnout below cut-off levels. Given the strong connection between sleep and emotional well-being, the study demonstrates that sleep and mental health can be addressed simultaneously with digital mental health services, with improvements supporting other positive outcomes such as management of workplace burnout.

Declarations

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Conflicts of Interest

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Data Availability Statement

Individual de-identified data that underlie the results reported in this manuscript can be shared privately for research purposes upon receipt of a methodologically sound proposal, and whose proposed use of the data from the study related to this article are approved by the authors. To gain access, requesters will need to submit a proposal to the corresponding author and sign a data access agreement that includes a commitment: (1) to using the data only for research purposes; (2) to not attempt to, or actually, re-identify any individual; (3) to securing the data using appropriate safeguards; and (4) to destroying or returning the data after analyses are completed.

References

1. Nollet M, Franks NP, Wisden W. Understanding sleep regulation in normal and pathological conditions, and why it matters. *J Huntingtons Dis*. 2023;12(2):105-119. doi:10.3233/JHD-230564

2. Baranwal N, Yu PK, Siegel NS. Sleep physiology, pathophysiology, and sleep hygiene. *Prog Cardiovasc Dis*. 2023;77:59-69. doi:10.1016/j.pcad.2023.02.005

3. Medic G, Wille M, Hemels ME. Short- and long-term health consequences of sleep disruption. *Nat Sci Sleep*. 2017;9:151-161. doi:10.2147/NSS.S134864

4. Altena E, Ellis JG. How sleep affects daytime functioning: The latest insights from different patient and age groups. *Brain Sci*. 2021;11(9):1163. doi:10.3390/brainsci11091163

5. Li ZQ, Qin Y, Cai WP, et al. Sleep deprivation impairs human cognitive reappraisal ability: A randomized controlled trial. *Nat Sci Sleep*. 2023;15:729-736. doi:10.2147/NSS.S414962

6. Baglioni C, Nanovska S, Regen W, et al. Sleep and mental disorders: A meta-analysis of polysomnographic research. *Psychol Bull*. 2016;142(9):969-990. doi:10.1037/bul0000053

7. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*. American Psychiatric Association; 2013. doi:10.1176/appi.books.9780890425596

8. Benca RM, Okawa M, Uchiyama M, et al. Sleep and mood disorders. *Sleep Med Rev*. 1997;1(1):45-56. doi:10.1016/s1087-0792(97)90005-8

9. Pandina GJ, Garibaldi GM, Revicki DA, et al. Psychometric evaluation of a Patient-Rated Most Troubling Symptom Scale for Depression: findings from a secondary analysis of a clinical trial. *Int Clin Psychopharmacol*. 2010;25(2):51-59. doi:10.1097/YIC.0b013e3283320667

10. Johnson DA, Billings ME, Hale L. Environmental determinants of insufficient sleep and sleep disorders: Implications for population health. *Curr Epidemiol Rep*. 2018;5(2):61-69. doi:10.1007/s40471-018-0139-y

11. Altun I, Cınar N, Dede C. The contributing factors to poor sleep experiences in according to the university students: A cross-sectional study. *J Res Med Sci*. 2012;17(6):557-561. Accessed April 3, 2025. https://pubmed.ncbi.nlm.nih.gov/23626634/

12. Grandner MA, Jackson NJ, Izci-Balserak B, et al. Social and behavioral determinants of perceived insufficient sleep. *Front Neurol*. 2015;6:112. doi:10.3389/fneur.2015.00112

13. Triantafillou S, Saeb S, Lattie EG, Mohr DC, Kording KP. Relationship between sleep quality and mood: Ecological momentary assessment study. *JMIR Ment Health*. 2019;6(3):e12613. doi:10.2196/12613

14. Palmer CA, Bower JL, Cho KW, et al. Sleep loss and emotion: A systematic review and meta-analysis of over 50 years of experimental research. *Psychol Bull*. 2024;150(4):440-463. doi:10.1037/bul0000410

15. Khan MA, Al-Jahdali H. The consequences of sleep deprivation on cognitive performance. *Neurosciences (Riyadh)*. 2023;28(2):91-99. doi:10.17712/nsj.2023.2.20220108

16. Arora T, Grey I, Östlundh L, et al. A systematic review and meta-analysis to assess the relationship between sleep duration/quality, mental toughness and resilience amongst healthy individuals. *Sleep Med Rev*. 2022;62(101593):101593. doi:10.1016/j.smrv.2022.101593

17. Goldstein AN, Walker MP. The role of sleep in emotional brain function. *Annu Rev Clin Psychol*. 2014;10(1):679-708. doi:10.1146/annurev-clinpsy-032813-153716

18. Vanek J, Prasko J, Genzor S, et al. Insomnia and emotion regulation. *Neuro Endocrinol Lett*. 2020;41(5):255-269. https://pubmed.ncbi.nlm.nih.gov/33315339/

19. Pillai V, Drake CL. Sleep and repetitive thought. In: Babson KA, Feldner MT, eds. *Sleep and Affect*. Elsevier; 2015:201-225. doi:10.1016/b978-0-12-417188-6.00010-4

20. American Psychological Association. Stress in America: Are teens adopting adult's stress habits? 2014. Accessed March 9, 2025. https://www.apa.org/news/press/releases/stress/2013/stress-report.pdf

21. Lichstein KL, Rosenthal TL. Insomniacs' perceptions of cognitive versus somatic determinants of sleep disturbance. *J Abnorm Psychol*. 1980;89(1):105-107. doi:10.1037/0021-843x.89.1.105

22. Pillai V, Roth T, Mullins HM, Drake CL. Moderators and mediators of the relationship between stress and insomnia: stressor chronicity, cognitive intrusion, and coping. *Sleep*. 2014;37(7):1199-1208. doi:10.5665/sleep.3838

23. Vandekerckhove M, Wang YL. Emotion, emotion regulation and sleep: An intimate relationship. *AIMS Neurosci*. 2018;5(1):1-17. doi:10.3934/Neuroscience.2018.1.1

24. Cheng P, Kalmbach DA, Hsieh HF, Castelan AC, Sagong C, Drake CL. Improved resilience following digital cognitive behavioral therapy for insomnia protects against insomnia and depression one year later. *Psychol Med*. 2023;53(9):3826-3836. doi:10.1017/S0033291722000472

25. Toker S, Melamed S. Stress, recovery, sleep, and burnout. In: Cooper CL, ed. *The Handbook of Stress and Health*. Vol 704. John Wiley & Sons, Ltd; 2017:168-185. doi:10.1002/9781118993811.ch10

26. Mao Y, Raju G, Zabidi MA. Association between occupational stress and sleep quality: A systematic review. *Nat Sci Sleep*. 2023;15:931-947. doi:10.2147/NSS.S431442

27. Maslach C, Leiter MP. Burnout. In: Fink G, ed. *Stress: Concepts, Cognition, Emotion, and Behavior*. Elsevier; 2016:351-357. doi:10.1016/b978-0-12-800951-2.00044-3

28. Moser CM, Tietbohl-Santos B, Laskoski PB, Hauck S. Beyond the pandemic: Longitudinal lessons on social support, sleep quality, and burnout among healthcare workers: Longitudinal lessons on social support, sleep quality, and burnout among healthcare workers. *J Occup Environ Med*. 2024;66(11):874-879. doi:10.1097/JOM.0000000000003194

29. Belleville G, Cousineau H, Levrier K, St-Pierre-Delorme ME, Marchand A. The impact of cognitive-behavior therapy for anxiety disorders on concomitant sleep disturbances: a meta-analysis. *J Anxiety Disord*. 2010;24(4):379-386. doi:10.1016/j.janxdis.2010.02.010

30. Peters AL, Saunders WJ, Jackson ML. Mindfulness-based strategies for improving sleep in people with psychiatric disorders. *Curr Psychiatry Rep*. 2022;24(11):645-660.

doi:10.1007/s11920-022-01370-z

31. National Institute of Mental Health. Mental illness. National Institute of Mental Health. September 2024. Accessed February 6, 2025. https://www.nimh.nih.gov/health/statistics/mental-illness

32. Center for Devices, Radiological Health. What is digital health? U.S. Food and Drug Administration. December 5, 2024. Accessed March 18, 2025. https://www.fda.gov/medical-devices/digital-health-center-excellence/what-digital-health

33. Dang A, Arora D, Rane P. Role of digital therapeutics and the changing future of healthcare. *J Family Med Prim Care*. 2020;9(5):2207-2213. doi:10.4103/jfmpc.jfmpc_105_20

34. Bond RR, Mulvenna MD, Potts C, O'Neill S, Ennis E, Torous J. Digital transformation of mental health services. *Npj Ment Health Res*. 2023;2(1):13. doi:10.1038/s44184-023-00033-y

35. Wies B, Landers C, Ienca M. Digital mental health for young people: A scoping review of ethical promises and challenges. *Front Digit Health*. 2021;3:697072. doi:10.3389/fdgth.2021.697072

36. Espie CA, Kyle SD, Williams C, et al. A randomized, placebo-controlled trial of online cognitive behavioral therapy for chronic insomnia disorder delivered via an automated media-rich web application. *Sleep*. 2012;35(6):769-781. doi:10.5665/sleep.1872

37. Windmill H, Dyer A, Smith AD, Roser ME, Dhanda A, Hall SD. Characterising the inconsistency between perceived and actual sleep and its impact upon cognition and mood. *Sci Rep*. 2024;14(1):29342. doi:10.1038/s41598-024-80683-w

38. Rahman SA, Rood D, Trent N, Solet J, Langer EJ, Lockley SW. Manipulating sleep duration perception changes cognitive performance - An exploratory analysis. *J Psychosom Res*. 2020;132(109992):109992. doi:10.1016/j.jpsychores.2020.109992

39. Gavriloff D, Sheaves B, Juss A, Espie CA, Miller CB, Kyle SD. Sham sleep feedback delivered via actigraphy biases daytime symptom reports in people with insomnia: Implications for insomnia disorder and wearable devices. *J Sleep Res*. 2018;27(6):e12726. doi:10.1111/jsr.12726

40. Lawrence-Sidebottom D, Huffman LG, Beam A, et al. Improvements in sleep problems and their associations with mental health symptoms: A study of children and adolescents participating in a digital mental health intervention. *Digit Health*. 2024;10:20552076241249928. doi:10.1177/20552076241249928

41. International Coaching Federation. ICF accreditation: Become an ICF-accredited coach. Accessed July 10, 2025. https://coachingfederation.org/for-coach-educators/icf-accreditation/

42. Buysse DJ, Reynolds CF 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res*. 1989;28(2):193-213. doi:10.1016/0165-1781(89)90047-4

43. Schnittker J, Bacak V. The increasing predictive validity of self-rated health. *PLoS One*. 2014;9(1):e84933. doi:10.1371/journal.pone.0084933

44. Ahmad F, Jhajj AK, Stewart DE, Burghardt M, Bierman AS. Single item measures of self-rated mental health: a scoping review. *BMC Health Serv Res*. 2014;14(1):398. doi:10.1186/1472-

6963-14-398

45. Gallup, Inc. Casper-Gallup state of sleep in America 2022 report. Gallup.com. March 15, 2022. Accessed March 8, 2025. https://www.gallup.com/analytics/390536/sleep-in-america-2022.aspx

46. Ding L, Zhang L, Cui Y, et al. The association of sleep duration and quality with depressive symptoms in older Chinese women. *PLoS One*. 2022;17(3):e0262331. doi:10.1371/journal.pone.0262331

47. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. *J Gen Intern Med*. 2001;16(9):606-613. doi:10.1046/j.1525-1497.2001.016009606.x

48. Spitzer RL, Kroenke K, Williams JBW, Löwe B. A brief measure for assessing generalized anxiety disorder: the GAD-7: The GAD-7. *Arch Intern Med*. 2006;166(10):1092-1097. doi:10.1001/archinte.166.10.1092

49. Plummer F, Manea L, Trepel D, McMillan D. Screening for anxiety disorders with the GAD-7 and GAD-2: a systematic review and diagnostic metaanalysis. *Gen Hosp Psychiatry*. 2016;39:24-31. doi:10.1016/j.genhosppsych.2015.11.005

50. Maslach C, Jackson SE, Leiter MP. *Maslach Burnout Inventory (3rd Ed.)*. Consulting Psychologists Press; 1996.

51. R Core Team. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria; 2024. https://www.R-project.org/

52. Lo Martire V, Caruso D, Palagini L, Zoccoli G, Bastianini S. Stress & sleep: A relationship lasting a lifetime. *Neurosci Biobehav Rev*. 2020;117:65-77. doi:10.1016/j.neubiorev.2019.08.024

53. Koffel E, Bramoweth AD, Ulmer CS. Increasing access to and utilization of cognitive behavioral therapy for insomnia (CBT-I): a narrative review. *J Gen Intern Med*. 2018;33(6):955-962. doi:10.1007/s11606-018-4390-1

54. Löwe B, Unützer J, Callahan CM, Perkins AJ, Kroenke K. Monitoring depression treatment outcomes with the patient health questionnaire-9. *Med Care*. 2004;42(12):1194-1201. doi:10.1097/00005650-200412000-00006

55. Ali M, Viqar U. Sleep disorders and mental health: Exploring the bidirectional relationship and intervention strategies. *BioMedica*. 2024;40(1):14-17. doi:10.24911/biomedica/5-1142

56. Thompson HG, Askelson NM, Bucklin R, et al. Organization-level factors associated with burnout: Guided discussions with micropolitan public health workers during COVID-19: Guided discussions with micropolitan public health workers during COVID-19. *J Occup Environ Med*. 2023;65(7):580-583. doi:10.1097/JOM.0000000000002837

57. Smith L, Cranmer J, Grabbe L. Workplace culture: The key to mitigating burnout. *J Psychosoc Nurs Ment Health Serv*. 2023;61(1):2-3. doi:10.3928/02793695-20221207-02

58. Roos LG, Sagui-Henson SJ, Castro Sweet C, Welcome Chamberlain CE, Smith BJ. Improvement and maintenance of clinical outcomes in a digital mental health platform: Findings from a longitudinal observational real-world study. *JMIR MHealth UHealth*. 2024;12:e48298. doi:10.2196/48298

59. Sagui-Henson SJ, Prescott MR, Corcoran JB, et al. Effectiveness of evidence-based telecoaching delivered through an employer-sponsored mental health benefits platform. *Telemed J E Health*. 2022;28(4):486-494. doi:10.1089/tmj.2020.0555

60. Prescott MR, Sagui-Henson SJ, Welcome Chamberlain CE, Castro Sweet C, Altman M. Real world effectiveness of digital mental health services during the COVID-19 pandemic. *PLoS One*. 2022;17(8):e0272162. doi:10.1371/journal.pone.0272162

Abbreviations:

CBTi: Cognitive-Behavioral Therapy for those with clinical insomnia

GAD-7: 7-item Generalized Anxiety Disorder scale

PHQ-9: 9-item Patient Health Questionnaire

Supplementary Files

Figures

The predicted probability of good sleep quality is 59.88% at baseline, 61.69% at 3-months, and 66.95% at 12-months. Error bars represent 95% confidence intervals.