EXPLORING THE SCOPE AND EVALUATION APPROACHES FOR MENTAL HEALTH APPS IMPLEMENTED IN WORKPLACE SETTINGS

By SHEILA ADDANKI, MSc

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TITLE PAGE

Exploring the scope and evaluation approaches for mental health apps implemented in workplace settings

AUTHOR: Sheila Addanki, MSc

SUPERVISOR: Dr Sandra Moll

Professor, School of Rehabilitation Science

McMaster University

SUPERVISORY COMMITTEE:

Dr Joy MacDermid

Professor, School of Rehabilitation Science

McMaster University

Dr Luciana G Macedo

Associate Professor, School of Rehabilitation Science

McMaster University

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Lay Abstract

Mental health issues in the workplace are common and can be costly for organizations and people who are struggling. Mobile applications (apps) can be used to provide mental health support to workers. Through three separate studies, this thesis explores how mental health apps can be used in the workplace. The first study was a review of the literature that indicated that studies using mental health apps look at whether and how they are used, their impact and the process of implementing them in the workplace. The second study was a review of the effects of mental health apps that indicated that apps can bring about a significant change in the symptoms of anxiety, depression, stress, burnout and improve wellbeing of workers. The third study was the implementation of a mental health app for healthcare workers, which demonstrated that introducing a mental health app in the workplace will require careful planning and consideration of the different conditions in the workplace that will influence its use. These studies together show that mental health apps have promising effects, but implementation needs to be carefully planned.

Abstract

Background: Mental health conditions are one of the leading causes of disability in Canada and worldwide, causing significant financial burdens to individuals, workplaces and the economy. This emphasizes the need to provide accessible support in the workplace to prevent, promote and manage the mental health of the workforce. Mental health apps present a promising medium to scale mental health interventions across the workplace. However, evidence related to how studies are evaluating mental health apps in complex, real-world settings requires careful examination. **Purpose:** The purpose of this program of research was to synthesize the current state of evidence on the evaluation of mental health apps in the workplace, including an assessment of their effectiveness and to systematically examine the implementation of a mental health app in a workplace as a case study. The first study was a scoping review examining the different approaches studies have used to evaluate mental health apps in the workplace. The second study was a systematic review and meta-analysis examining the effectiveness of mental health apps in the workplace. The third study was a mixed-method case study, informed by an implementation science theory to examine factors influencing the uptake and implementation of a mental health app in a mid-sized hospital. **Findings**: In total, 54 studies were included in the scoping review with main outcomes being: 1. Usage and feedback of the app, 2. Effects of mental health and workplace outcomes or 3. Implementation process. The systematic review and meta-analysis of 21 studies demonstrated the effectiveness of mental health apps in improving symptoms of distress, depression and anxiety, stress, wellbeing and burnout. mental health as compared to usual care. Findings from the case study indicated the need to carefully

consider implementation planning, contextual factors and a fit between the app and the needs of the workers. Implications: This thesis identifies the potential of mental health apps for workplaces and highlights future directions for research to optimize their use and effects.

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Dedication

I dedicate this thesis to my soul sister, **Late Ruopfuvinuo Pienyu,** who shared with me the same dream of pursuing a PhD.

Table of Contents

List of Tables

List of Figures

List of Appendices

List of Abbreviations

WHO: World Health Organization

COVID-19: Coronavirus Disease 2019

CBT: Cognitive Behavioural Therapy

RCT: Randomized Control Trial

CFIR: Consolidated Framework for Implementation Research

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

SMD: Standardized Mean Difference

CI: Confidence Interval

ROB: Risk of Bias

Declaration of Academic Achievement

This sandwich thesis consists of a general introduction, three separate manuscripts: Chapter 2, Chapter 3 and Chapter 4, and an overall discussion. All chapters were conceptualized by Sheila Addanki, who is the first author of all three manuscripts and played a key role in conducting literature reviews, selecting appropriate methodology, applying theory, collecting and analyzing data and preparing the manuscripts. Below is a summary of the contributions made to each manuscript.

Chapter 2

Addanki S, Macedo L, MacDermid J, Moll S. Mental Health Apps Implemented in the Workplace: A Scoping Review of Trends and Gaps in Evaluation Research. JMIR Preprints. 03/02/2024:57046

DOI: 10.2196/preprints.57046. This manuscript is currently under peer review. The online preprint version is made available by JMIR Publications on its website for review and ahead-of-print citation purposes only. The copyright currently is reserved with the authors, while the final peer-reviewed paper may be licensed under a cc-by license on publication; at this stage, authors and publishers expressively prohibit redistribution of this draft paper other than for review purposes.

Contributions

SA designed the scoping review under the supervision of SM. SA, ML, and SM carried out the screening process and data extraction. SA synthesized the data and wrote the manuscript. SM, LM, and JM provided valuable and constructive feedback on appraising and organizing the scoping review findings. This manuscript was previously presented at

the Canadian Association for Research on Work and Health (CARWH) Conference on September 6, 2022.

Chapter 3

Addanki S, Macedo L, MacDermid J, Moll S. Effectiveness of mental health apps among workers: A systematic review and meta-analysis of their effects on mental health and workplace outcomes.

Contributions

SA designed the systematic review and meta-analysis with guidance on the methodology and analysis from LM and JM. SA, and MP independently performed the study screening and selection with the support of SM. LM guided the quality appraisal of study outcomes. All coauthors provided constructive feedback for interpreting the results and the manuscript draft. This manuscript is prepared for submission to the *International Journal of Environmental Research and Public Health*'s call for a special issue on 'Advances in Mental Health and Wellbeing in the Workplace'.

Chapter 4

Addanki S, Macedo L, MacDermid J, Moll S. Mental Health App for Healthcare Workers: A Case Study Implementation of the Beyond Silence App. This manuscript has been submitted to the Journal WORK: A Journal of Prevention, Assessment and Rehabilitation in August 2024 and is currently under peer review.

Contributions

SA and SM were involved in the theoretical and methodological conceptualization of the implementation study and appraisal of the findings. SA, MP and LC collected the data,

and SA and MP coded the qualitative data. All co-authors provided valuable and constructive feedback on interpreting the findings and the manuscript draft.

Chapter 1: Introduction

1.1 Outline

This introduction provides an overview of the current state of mental health globally, emphasizing the need to address the growing mental health concerns in the workplace and explaining how emerging digital innovations, such as mental health apps, could be one way to address these growing needs. The chapter begins by providing a summary of the prevalence and the consequences of poor mental health in the workplace, highlighting the economic and societal costs of poor mental health. Relevant national and international policies and standards that underscore the value of supporting mental health and promoting wellbeing in workplaces are noted. Next, the chapter reviews the emergence of digital mental health innovations in the workplace by describing the different types of interventions and summarizing their evidence, including knowledge gaps. To address the gaps in the evidence, the chapter emphasizes the importance of evaluating mental health apps in the workplace through the lens of implementation science. The chapter concludes with a summary of the evidence and research aim of this thesis.

1.2 Definition, prevalence and impacts of mental health problems in the workplace

Over the last decade, mental health conditions have steadily increased, becoming a growing concern, particularly among the working population. Mental health is defined as a "state of wellbeing in which the individual realizes his or her abilities, can cope with normal stresses of life, can work productively and fruitfully, and is able to make contribution to his or her community" [1]. Keyes [2] expanded on this concept, describing mental health as a dynamic, changing state that operates on a continuum. This continuum typically ranges

from ‘healthy’ to ‘ill’, depending on various circumstances [2]. In the workplace context, one end of the continuum represents ‘healthy’ or a state of well-being, where individuals can cope with life’s stressors and work productively [2,3]. At the opposite end is a state of ‘illness,’ where individuals are in a state of crisis that could be marked by diagnosable mental health disorders potentially impairing an individual’s ability to function [2,3]. Given that nearly 60% of the world’s population is in the workforce, work can have a significant impact on mental health and vice versa [4]. Work could promote mental health by offering purpose, livelihood, and social connection [3,4]. However, it can also pose risks through exposure to psychosocial stressors at work, such as high job demands, prolonged stress, violence or harassment and poor working conditions [3,4].

Globally, nearly 210 million people are estimated to be affected by common mental health disorders such as anxiety and depression [5]. In 2019, 15% of working-age adults were estimated to have a mental health condition, with anxiety and depression being the most common [6]. These numbers have been further exacerbated by the COVID-19 pandemic, with initial estimates by the World Health Organization (WHO) suggesting a 26% and 28% increase in anxiety and depression, respectively, in just one year [7]. In Canada, one in five individuals experiences a mental health challenge each year [8], and these estimates can have a significant impact on work. Reports indicate that 21.4% of the working-age population (20-64 years of age) in Canada were living with a mental health condition, with nearly 500,000 Canadians missing work every week [9]. In fact, certain industries, such as healthcare, have higher risks where healthcare workers are 1.5 times

more likely to be off work due to illness or disability than workers from other sectors [10]
.

Even through conservative estimates, the cost of mental health conditions to workplaces and economies is significant. In 2010, poor mental health was estimated to cost the global economy approximately $2.5 trillion annually, a figure projected to rise to $6 trillion by 2030 [6]. Within Canada, the economic burden based on direct costs, such as healthcare and medication expenses, and indirect costs, such as lost productivity due to absenteeism or presenteeism, [11] is estimated to be at least $51 billion annually [9]. In fact, mental health conditions are now the leading cause of disability globally [12], accounting for approximately 30% of short-term and long-term disability claims, with more than 80% of Canadian employers rating mental health as one of the top three drivers of disability claims [8].

1.3 Emergence of policies to support workplace mental health

Reports on the economic burden of mental health in the workplace highlight the urgent and important need for evidence-based policies. These policies are critical not only for ethical reasons, to protect the health and well-being of employees, but also for practical reasons, to improve productivity and reduce the associated cost burden. Various international and national policies and standards provide guidelines to address mental health at work. Global calls to action from the WHO policy brief on mental health at work emphasize that a comprehensive approach needs to be adopted by governments, organizations and researchers [4]. The WHO Guidelines on Mental Health at Work highlighted three types of strategies to address mental health at work, including interventions that: 1. prevent work-

related mental health conditions; 2. protect and promote mental health at work by strengthening capacities to recognize and facilitate early intervention and building skills to manage stress and reduce mental health symptoms; and 3. support people with mental health conditions to participate in and thrive at work through accommodations and an inclusive environment [4].

At the international level, the recent update of the occupational health and safety global standard (ISO 45003) [13] reflected these commitments by providing guidance for organizations on how to manage and protect mental health at work. The updated standard provides guidelines for identifying and managing psychosocial risks at work- highlighting that working conditions could be an important modifiable risk factor for mental health conditions [13]. At the National level, Canada's nationwide ISO-certified resource- the National Standard of Canada for Psychological Health and Safety in the Workplace (the Standard) presents a set of voluntary guidelines, tools and resources to guide organizations in promoting mental health and preventing psychological harm at work [14]. This standard highlights 13 psychosocial factors that can influence psychological health and safety at work and provides a systematic guide for employers to improve their organization's mental health [14]. These standards together emphasize the need for researchers, organizations and policymakers to explore innovative, cost-efficient and effective workplace interventions that can be broadly deployed across workplaces.

1.4 Mental health interventions in the workplace and digital tools

Existing evidence have identified that several mental health interventions, such as Resilience Training [15], Cognitive Behavioural Therapy (CBT) [16], and mindfulness-

based interventions, [17] are effective in building knowledge and skills to reduce the negative impact of stress and improve wellbeing among workers. Reviews have also shown that organizational interventions to address psychosocial conditions in the workplace, such as organizational culture, working conditions, or processes, can reduce workers' stress and improve productivity [18]. However, most workers who could benefit from such interventions do not receive them due to poor recruitment rates for in-person interventions and/or concerns about confidentiality and stigma. Scaling such interventions to all employees can be both costly and logistically difficult in real-world organizational settings [18,19].

1.5 Access to digital mental health interventions in the workplace

Over the past decade, the advancement of digital technology-enabled tools has penetrated most aspects of life, including the delivery of mental health care [20–23]. Technology-enabled tools offer a unique possibility to address growing mental health concerns by delivering mental health interventions across workplaces through tools such as web-based or smartphone app platforms. With increasing smartphone ownership rates, mental health apps can be leveraged for large-scale delivery of mental health interventions, enabling employees to access mental health support in a personalized and anonymous manner.

Given that research in this area is still in its infancy and is continuously evolving, there are inconsistencies in the current evidence base regarding the use of terms such *as e-mental health, mobile health (mHealth), and digital mental health interventions (DHMI)* to broadly describe digital mental health innovations [24]. Due to the lack of a standard

glossary for the use of these terminologies currently [24], the term *mental health app* will be explicitly used throughout the program of research in this thesis. In this thesis, *mental health app* refers to smartphone-based software applications that can be downloaded onto smartphones or tablets, delivering a broad range of mental health interventions that vary in design and functionality [21,25].

1.6 The utility of mental health apps

Over recent years, numerous mental health apps have been developed and made available to smartphone users. While there is no one guideline for developing evidence-based mental health apps, features and functionality can be designed to target issues across the spectrum of mental health. The flexibility of mental health apps means that they can be designed to focus on any of the intervention models, enabling them to align with the WHO guidelines of mental health at work, focusing on prevention, promotion, and management [3]. Apps could include evidence-based intervention components that aim to promote skills for help-seeking, mindfulness and wellbeing, tools to monitor and track symptoms, or therapeutic components to manage common mental health issues [26]. Some mental health apps may also have features that enable connections to human support (coaching or peer support) [27]. Moreover, innovative advances in technology are enabling mental health apps to build conversational pathways, such as "chatbots," to deliver personalized support for users. Technologies within these apps can allow passive data collection related to the extent of their usage, and in some cases, prompts in the form of "notifications" can be sent to users reminding them to use the app.

1.7 Evidence for mental health apps

What we know about mental health apps is largely based upon empirical studies examining the effects of mental health apps in clinical and community settings. For instance, a meta-review by Lecomte et al. [28] identified seven meta-analyses evaluating the effectiveness of mental health apps for anxiety and depression in the clinical and general population. They found that apps had significant small to medium effects in improving symptoms of anxiety and depression, with effects sustaining until 11 weeks of follow-up [28]. With significant investments directed toward the development and scaling of mental health apps, it is essential to critically evaluate the growing evidence of their potential benefits and limitations. An umbrella review synthesizing findings from all available types of reviews (literature, scoping, systematic reviews and meta-analyses) provides support that mental health apps can 1) provide timely support with flexibility and control over how users engage; 2) be a cost-effective alternative compared to traditional treatment options; 3) provide discreet access to support, which helps combat stigma in help-seeking; and 4) improve mental health outcomes [29]. On the other hand, the review highlighted the pitfalls of mental health apps were related to 1) challenges with user engagement, since many studies reported high rates of attrition; 2) limitations in effectively assisting users through emergencies; 3) user concerns regarding risks to privacy and confidentiality breaches; and 4) insufficient use of theory and empirical approaches to intervention development and evaluation [29]. These findings identify crucial gaps that need to be considered in future studies in order to unlock the full potential of mental health apps.

Given the broader scope and benefits of mental health apps that can be accessed at any time in a confidential manner, this type of intervention can be especially beneficial to workers who may have difficulty accessing traditional mental health services. Much of the current literature on digital mental health interventions in the workplace setting is largely from web-based interventions that are delivered on a website platform, with more recent attention paid towards smartphone apps.

Several reviews have produced evidence related to the effectiveness of digital mental health interventions (including a mix of online and smartphone app interventions) in the workplace.

In 2019, a systematic review and meta-analysis by Phillips et al. identified 36 studies (31 studies examined web-based, and three studies examined app-based interventions) showing that digital tools in the workplace led to statistically significant moderate effects on stress, insomnia, and burnout, and small effects on depression, anxiety, wellbeing, and mindfulness when compared with control groups [30]. Moreover, individual-level digital mental health interventions improved mental health outcomes and also had small significant effects on workplace engagement and productivity. This indicates a clear opportunity for using digital mental health interventions in the workplace. Moreover, meta-analysis findings also showed that individual-level digital mental health interventions also had significant small effects in improving workplace engagement and productivity, moving beyond the improvement of just mental health outcomes [31].

In summary, digital mental health interventions, including mental health apps, are feasible and beneficial for workers. However, findings concerning efficacy across individual studies are heterogeneous, varying from reportedly having small or non-significant effects through to significant effects. Currently, far too few studies have attempted to identify the key factors associated with effective mental health apps.

The research described in the previous sections indicates that mental health apps have the potential to be effective; however, there is insufficient current evidence to determine how these mental health apps work and for whom. Currently, research into specific mechanisms of action in the workplace setting and the impact of the implementation process on outcomes is limited. More often, workplace mental health interventions, specifically digital innovations, were viewed as products, assuming that the intervention itself is the primary agent of change, with little or no focus on the ecosystem around digital innovation [32]. There are multiple calls among researchers to adopt a whole-systems implementation approach in evaluating these digital mental health innovations in the workplace [19,33–35].

1.8 Theoretical/Conceptual Approach: Implementation Science

To explore and understand how workplace mental health apps function in a complex, multidimensional workplace context, an implementation science perspective is recommended since it can provide a nuanced perspective to ascertain how and why mental health apps work. Implementation science is a rapidly emerging field of scientific inquiry that offers a range of methods, frameworks, and strategies to promote the uptake of innovations in the real world [36]. Seward and colleagues [37] define implementation

science as the "theories, models, frameworks and other methodologies to optimize and evaluate the implementation of evidence-informed care", while implementation research is the study of "what, why and how interventions work in the real-world settings". Central to implementation research is the context, which includes the dynamic and diverse range of forces working for or against implementation efforts, and the implementation process, which refers to the activities involved in planning and executing the implementation of the innovation. Adopting an implementation research approach by applying a theoretically informed framework can enable the identification of facilitators and barriers to implementation, guide the process of implementation, and help identify specific implementation factors to increase the likelihood of success [34].

While there are many frameworks and theories to guide the implementation of innovations, this thesis will focus on one such framework called the Consolidated Framework for Implementation Research (CFIR), which is a comprehensive framework developed by Damschroder and colleagues [38,39]. The CFIR is described as a pragmatic framework that can guide the systematic evaluation of complex innovations in multilevel implementation contexts, hence making it well-suited to evaluate mental health apps in the workplace. The framework consolidates constructs from many existing theories hypothesizing mechanisms of change. The framework consists of five domains- the innovation, the outer setting, the inner setting, the individuals, and the implementation process. The framework was recently updated since its development in 2009 [39] and consists of 48 constructs and 19 subconstructs across the five domains that provide an overarching typology for what works where and why across multiple contexts [38]. The

CFIR's five major domains (the innovation, outer setting, inner setting, the individuals involved, and the implementation process) are depicted in Figure 1, which attempts to convey the interaction between the domains to influence implementation effectiveness [38,39].

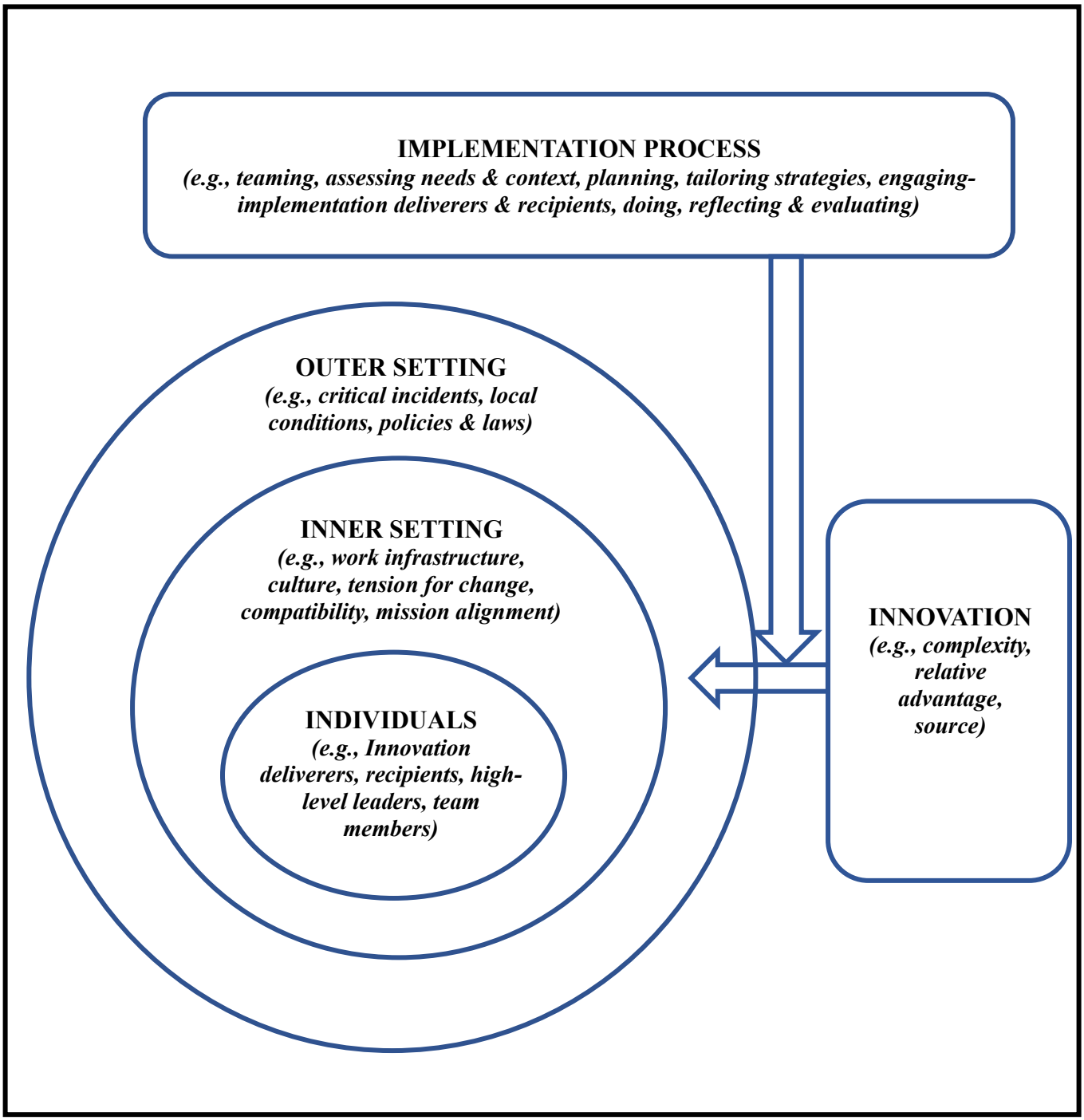

Figure 1 Overview of the CFIR domains and constructs applied to mental health apps.

The first domain, innovation, refers to the primary interventions being implemented in an organization and consists of eight constructs (e.g., innovation source, adaptability, complexity, and cost). The second domain- outer setting refers to the broader sociopolitical and economic context of workplaces and includes seven constructs (e.g., critical incidences, policies & laws, partnerships &connections). The third domain- the inner setting, refers to the workplace setting where the innovation will be implemented and includes 11 constructs (e.g., tension for change, mission alignment, culture, and work infrastructure). The fourth domain- individuals refers to the roles and characteristics of individuals, both persons leading the implementation and receiving them (e.g., roles: implementation facilitators, innovation recipients; characteristics: need, capability, opportunity and motivation). The last domain- the implementation process, refers to the activities and strategies employed to implement the innovation, and this domain consists of nine constructs representing the stages of implementation (e.g., assessing needs, planning, engaging, doing, reflecting and evaluating). CFIR offers a range of pragmatic tools to conceptualize and design implementation studies by providing researchers with tools to design data collection, analysis, and technical assistance through their website, operationalization, selection, and measurement of constructs outlined in the framework [38]. In this thesis, the CFIR will be used to guide data collection, analysis, and reporting of actionable findings related to the implementation of a mental health app that is described in Chapter 4. It has also informed critical appraisal of current research in Chapters 2 & 3.

In summary, the evidence presented in this section suggests that digital mental health innovations in the workplace have shown promise in addressing depression, anxiety,

and work engagement, however the effectiveness of mental health apps is less clear. With smartphones and apps rapidly penetrating all aspects of life, there is a need to explore the value of these innovations. Additionally, having identified some of the challenges in the existing literature of workplace mental health interventions and the complexity of implementing digital tools in multi-level real-world settings, there is a need to explore whether emerging studies of mental health apps are considering these challenges while designing and evaluating these innovations.

2. Aim of the thesis

This thesis has three primary aims that seek to address several research questions through three individual empirical papers.

1. The first aim is to describe the current state of evidence on the evaluation of mental health apps in the workplace.
2. The second aim is to evaluate the effectiveness of mental health apps for workers
3. The third aim is to examine how a case study approach adopting an implementation science lens can be used to evaluate the implementation and uptake of a mental health app in the workplace.

Subsequent chapters describe the research conducted as part of this thesis to explore the above-mentioned research aims.

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Chapter 2: Mental Health Apps Implemented in the Workplace: A Scoping Review of Trends and Gaps in Evaluation Research

Abstract

Background: Technology-based solutions to support the mental health needs of workers are on the rise, as evidenced by the growing body of research related to e-mental health applications (apps) implemented with workers or within the context of workplaces. This expanding landscape of evidence related to mental health apps underscores the necessity to summarize and consolidate the different ways in which studies are evaluating real-world technology-based interventions in a complex setting such as a workplace. **Objective**: The aim of this scoping review is to summarize the body of evidence regarding evaluation of mental health apps with workers or at workplaces. Specifically, this review will outline the current trends and gaps across the outcomes commonly assessed in studies evaluating digital mobile mental health interventions with workers.

Method: The scoping review followed the five stages outlined in Arksey and O'Mally's framework combined with Levac's recommendations. The search strategy was applied across seven databases to identify relevant studies from inception to August 2023. **Results**: From the 288 abstracts screened, 54 studies met the inclusion criteria for this review. The studies assessed apps in three ways: 1. Examining user engagement and utilization of the app 2. Investigating the effects of the app on users, and 3. Evaluating the implementation process. Most studies primarily evaluated the impact on individual mental health related outcomes as well as on workplace-related outcomes. A limited number of studies evaluated

the implementation process and its relation to the overall effectiveness of the application for workers. **Conclusion**: This scoping review provides a comprehensive overview of the ways in which studies are currently evaluating workplace mental health apps. The review highlights notable trends and gaps in the existing studies where majority of the studies focused on assessing the effects of mental health apps on individual users with a gap in assessing the ways in which the implementation of a dynamic intervention such as a mobile app in a complex workplace setting could interact and influence the overall effectiveness of the app. Future research needs to delve deeper in understanding the implementation process and consider evaluation methods that are in congruence with the goals of the intervention.

Key words: *mobile apps; work; mental health; digital health; mHealth; evaluation; mental health apps; workplace; workers*

INTRODUCTION

Mental health issues have become a significant human and financial cost for society and for workplaces. Poor mental health and loss of productivity are estimated to cost the global economy approximately $1 trillion each year [1] and this figure is projected to rise, given the COVID-19 pandemic's impact on workplace mental health. Rapid transitions and changes in workplace demand due to the pandemic have led to an increase in reports of perceived stress, depression, and anxiety among working adults, particularly for working mothers, people of minority ethnicity, and those working in front-line positions [2- 4]. Limited access to traditional mental health services, along with the longstanding stigma in seeking supports, has led to a growing need to expand access to a range of mental health supports to address unmet needs of the workforce and reduce the burden of mental health issues.

In recent years, there has been a growing interest in digital health technologies, including web-based and smartphone-based interventions, as a tool to address mental health problems. One of the main advantages of digital mental health interventions is their ability to overcome traditional barriers to accessing mental health care by providing on-demand access to quality mental health information and support [5,6]. For example, many people are reluctant to seek help due to the stigma associated with mental illness. Digital interventions, such as mental health apps, offer a private and anonymous way to access support without the fear of being judged. Digital interventions can also help to overcome geographical barriers by providing access for people who live in remote or rural areas where mental health services may be limited or non-existent [5]. In addition, digital interventions

can be accessed at any time and from anywhere, which can help to overcome the time constraints that many working adults face when trying to access traditional mental health services. Mental health apps can be used across the full spectrum of mental health care, from prevention to management. For example, there are apps that help people to assess and manage stress and anxiety, apps that provide support for people with depression, and apps that help people to improve their wellbeing.

There is a growing body of research that supports the effectiveness of mental health apps in both the general and clinical population [7,8]. A review of app-based mental health interventions was found to be effective in reducing symptoms of depression [7] and anxiety [7], as well as improving mental health literacy and wellbeing [9] in both clinical and non-clinical populations [7-9]. While a review of publicly available popular mental health apps found that only two out of the six mental health apps identified were empirically evaluated [10], underscoring the gap between mental health apps available publicly and those that are evaluated in empirical studies. There is an urgent need for high-quality studies in this field to explore mental health apps that are evidence-based, empirically supported and scale sustainability to broader users.

There is a growing interest in the use of mental health apps across different settings such as clinical, post-secondary and community settings, and more recently at workplaces. Several reviews provide evidence to support that digital mental health interventions implemented at the workplace have positive effects in improving general mental health and workplace-related outcomes [11-13]. Studies explored the effects of this intervention in improving well-being, symptoms of stress, and several workplace-related outcomes such

as work effectiveness/productivity and job satisfaction [11-13]. However, the majority of the studies in these reviews consisted of web-based interventions, with only a small percentage of them exploring mental health apps [11,12].

As the availability and use of mental health apps in workplace settings become more prevalent, there is a growing need to identify and synthesize the existing evidence related to their systematic evaluation of workers. In this paper, we aim to conduct a scoping review to synthesize and critically reflect on the body of evidence in this emerging field. Specifically, we will summarize and identify trends and gaps in the evaluation of mental health apps in workplace settings.

METHODS

In this scoping review, we used the Arksey and O'Malley (2005) methodological framework combined with the Levac et al. (2010). We also followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) guidelines to ensure consistent and transparent reporting [14]. In order to examine and summarize the breadth of evidence regarding the evaluation of mental health apps for working adults, we developed the following research questions based on the PICO framework:

1. How are mental health apps being evaluated with workers and/or in the context of a workplace?
    a. What types of mental health apps are studied?
    b. With whom are the applications being evaluated (workers/workplace sectors)?

c. What key variables are being assessed?

d. What tools are used to track implementation and outcomes?

Inclusion Criteria:

Studies were included in this review if they met the following inclusion criteria: 1) the primary study intervention was a mobile mental health app for employees, 2) study evaluated the effectiveness, implementation, impact or use of the mental health app, 3) study participants included workers currently employed in any field and/or implemented in the context of a workplace, 4) study included any quantitative or qualitative evaluation design 5) study was published in a peer-reviewed journal and 6) study was available in English. Studies were excluded if: 1) the intervention in the study was primarily a web-based/ internet-based intervention (i.e., not a mobile app) and 2) the study design only focused on app development (not evaluation) of a mental health app for workers. Conference proceedings and grey literature were not included as the key focus of this review was to present a summary of published peer-reviewed studies that systematically evaluated mental health apps.

Search Strategy

We searched the following electronic databases: PsycINFO, Embase, Medline, Cochrane database, OVID Healthstar, and OVID Emcare for peer reviewed studies from inception until August 2023. A comprehensive search strategy including search terms, subject headings and syntax requirements for the databases was adapted from a previous systematic review of digital mental health interventions for workplace [11] and was modified in consultation with a health science librarian. Search terms included a combination of

constructs such as Mental Health, Workplace, and Mobile Application. The search was conducted from May to August 2023.

Study Screening

Two independent reviewers screened and extracted data using Covidence Systematic Review Software (Covidence systematic review software, Veritas Health Innovation), an online tool that facilitates a systematic screening process. The two reviewers screened all studies independently, and any discrepancies in study selection were discussed in a review meeting. A third reviewer, SM, was consulted to resolve any disagreements between the two primary reviewers and improve clarity in decision-making when necessary.

Data Extraction and analysis

Data extraction was an iterative process aimed at developing and refining a data charting sheet in Microsoft Excel to ensure that all relevant data were captured comprehensively. The fields extracted included study characteristics, such as year, country of publication, study design, and the workplace context or industry where the study was conducted; intervention characteristics, such as the type or focus of intervention and timeframe; and evaluation approaches, including both assessment tools and the outcomes explored in the study. The initial extraction chart was piloted with five studies and was subsequently revised to capture additional information relevant to our research questions. The analysis of this data included a summative review of trends in study characteristics, intervention characteristics, and evaluation approaches.

RESULTS

We searched seven electronic databases and identified 288 studies after removing duplicates. After screening titles and abstracts, 85 studies were eligible for full-text screening. Subsequently, 54 studies met our inclusion criteria for this scoping review (see Figure 2 for the Prisma Flow Diagram). Data from these studies were extracted and charted to generate a comprehensive summary of the breadth and trends in the body of evidence regarding mental health app evaluation in the workplace. Of these 54 studies, 11 were protocols for studies in progress, meaning no results were available for them at the time of the review. Upon careful consideration of the protocols and clinical trial registrations, we gathered relevant information related to the key outcomes being evaluated and the process through which the study was conducted, deemed sufficient to answer our research question: 'How are mental health apps evaluated with workers and/or in the workplace context?' As a result, we decided to report these ongoing studies in our review.

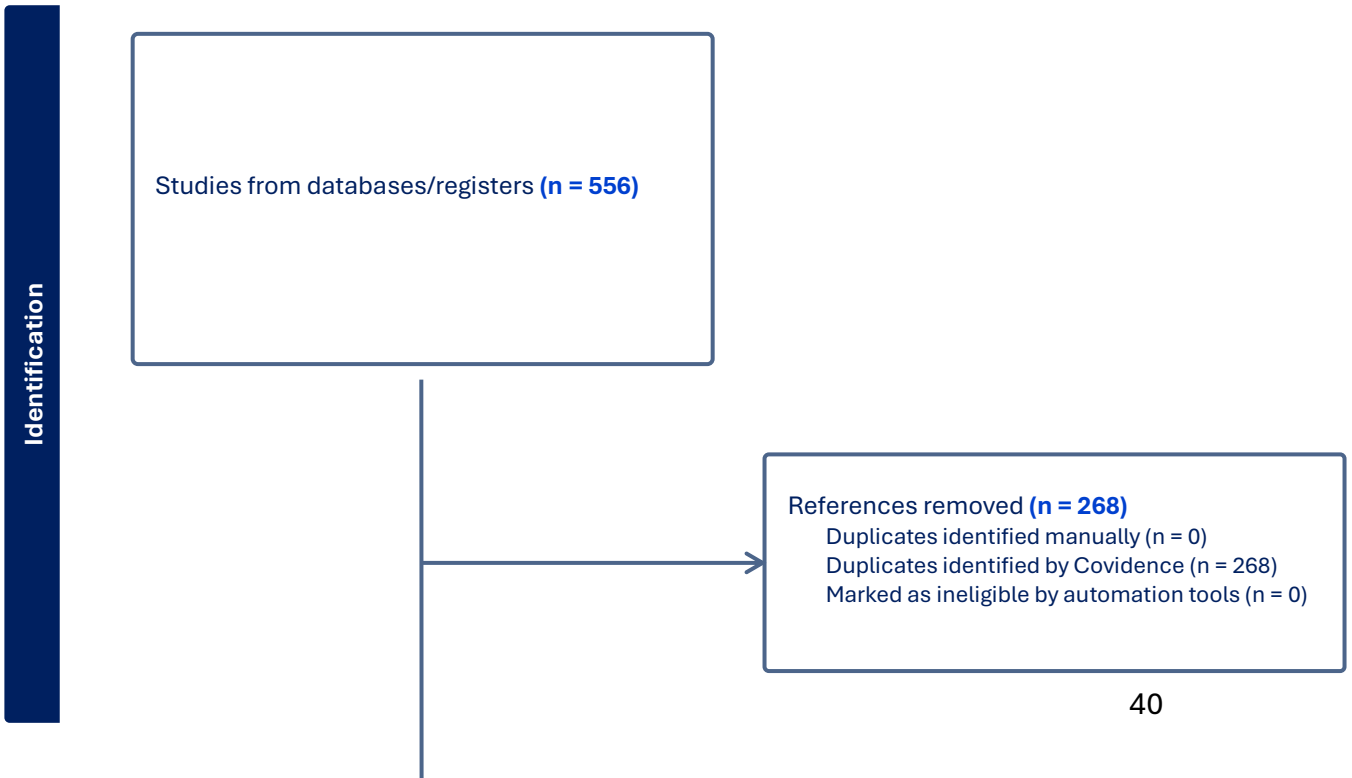

Figure 2. PRISMA Flowchart for study screening process for the scoping review

Summary of Study characteristics

Table 1 provides a summary of the key characteristics of all included studies. Among the 54 studies, over two-thirds were randomized controlled trials (RCTs) (Protocols/trial registrations [15-25]= 11; Completed RCTs [26-47]= 22; Pilot RCTs [48-51]= 3). A smaller subset of studies used methodologies such as pre/post one-arm non-randomized studies [52-63] (n=13), mixed-method studies [64-67] (n=4), and qualitative studies [68-69] (n=2).

Nearly 70% of studies (37/54) were published since the COVID-19 pandemic in 2020, with a quarter of the studies published in the year 2022 alone (14/54, 25%).

The participant demographics varied significantly across the studies. Some studies targeted the implementation of the intervention towards specific gender groups, focusing on individuals with mental health symptoms and/or in specific workplace sectors. For instance, one study targeted male participants experiencing mild to moderate symptoms of stress and/or depression to assess the feasibility of a multicomponent, technology-based (*P4Well*) intervention [49]. Two other studies specifically recruited individuals from male-dominated industries to evaluate the effectiveness of a therapeutic app (*HeadGear*) [60, 67]. One study focused on evaluating the effectiveness of a well-being and stress management app for working women [29]. Study participants worked in a range of industries including Health and Social Services (n=23), Large Corporations/Consumer-based Industry (n=5), Information Technology (n=5), Education (n=2), Agriculture (n=1), Apprenticeships (n=1), and Construction (n=1). A subset of studies implemented their interventions across multiple industries (n=7), and a few studies did not explicitly specify the contextual setting (n=10) in which the research was conducted.

Table 1 Summary of study characteristics

Characteristics	Number of studies (n) per characteristic
Manuscript availability	Full text= (43) Ongoing (registered) clinical trial/ protocols= (11)
Study Research Design	Protocols (11), Pilot RCT (3), RCT (21), Cross-Sectional Pre/Post Design (13), Mixed-Method Studies (4), Qualitative (2)
Year of Publication	2010 (1), 2013 (1), 2014 (1), 2016 (2), 2018 (8), 2019 (5), 2020 (9), 2021 (7), 2022 (13), 2023 (7)
Location of Study	United States (13), Australia (12), United Kingdom (4), South Korea (5), Finland (3), Japan (2), Brazil (1), Europe (2), Italy (1), Sweden (1), Germany (1), Spain (1), Canada (1), Malaysia (1), Netherlands (1), Slovenia (1), Taiwan (1), Vietnam (1), England (2)
Organizational Sector	Across multiple industries (7), Healthcare and Social Services (23), Information and Technology (4) Educational (2), Agriculture (1), Construction (1), Apprentice (1), Large Corporations/ Consumer-based Industry (5), Unspecified (10)
Focus of Intervention	Wellness/Preventative Apps (18), Self-Monitoring (2), Therapeutic (25), Multicomponent (9)

Summary of Intervention Characteristics

Mental health apps were standalone interventions in the majority of studies (50/54, 90%). However, three studies included an in-person intervention component [18, 20, 40], and two studies involved interventions with wearable devices linked to the mental health app [33, 59]. Wearable devices included a wristband [33] that tracked users' respiratory patterns and brain-sensing eyeglasses to non-invasively collect users' EEG activity. This data was shared with users in real time to enable self-regulation and promote relaxation [33,59]. Thirty-nine unique apps were evaluated across the studies included in this review. The most commonly evaluated apps were the *HeadGear* App (n=6, 11%)

[23,37,46,51,60,67] and the Headspace App (n=4, 9%) [17,26,39,70], both of which were 30-day interventions aimed at reducing symptoms of depression. Other commercially available apps evaluated in these studies included *Unmind* [46, 19] and *Calm* [44]. There was wide variability among the goals, functions, and duration of the interventions identified in this review. To understand the nature of the diverse types of mental health apps, we categorized them according to their overall aim and function, which was done by mapping the apps across a stepped model of care (See Figure 2). Mental health apps were either: 1) Preventative (aim to 1) Promote mental well-being, resilience, and education on managing mental health; 2) Self-help/Self-monitoring (prompts users to track mood, behavior, symptoms, and provides self-management tools); 3) Therapeutic (aims to reduce or address mental health concerns and symptoms of common disorders); 4) Multi-component (combines multiple approaches to address the user's mental health needs).

In this review, most studies focused on therapeutic mental health apps (see Table 1) designed to alleviate symptoms of common mental health disorders, such as anxiety, depression, and perceived stress (25/54, 47%). These apps included activities or modules informed by evidence-based therapies and theories, including Behavioral Activation, Mindfulness [23, 37, 47, 52, 61, 68], Acceptance and Commitment-Based Therapy [67, 36, 41, 42], and principles of Cognitive Behavior Therapy [31, 58]. Among the studies evaluating therapeutic apps, mindfulness-based apps were the most common, guiding users through evidence-based mindfulness techniques [22, 29, 34, 41, 44-46, 48, 49, 63], including breathing exercises [26, 70].

While many studies profiled therapeutic apps, a considerable number (18 out of 54, or 34%) focused on upstream wellness and prevention, evaluating apps that provided psychoeducation and information on common mental health concerns in workplaces [30, 67, 32, 59, 33, 60, 38]. For instance, one study assessed a stress management app recommended for hospital employees during their annual medical examinations. This app offered lifestyle management information, a forum to share resources for accessing psychological support, and a tool to find nearby mental health professionals [59]. Two studies examined self-monitoring apps that included features for tracking and monitoring mental health, mood, and screening for symptoms of common mental health disorders [16, 32]. Another set of studies (n=9) evaluated multi-component apps that served various functions, such as therapeutic strategies, mental health resource information, and well-being monitoring options [66, 59, 50, 38, 55, 43, 15, 25, 18]. In terms of the duration of the interventions, most studies (n=38) consisted of a fixed intervention period that typically ranged between 2 weeks and 8 weeks, with the most common being a 4-week intervention. Studies usually assessed outcomes at baseline and at the end of the interventions, with some studies consisting of a longer follow-up period, the longest being a 12-month follow-up [37]. While all studies provided a brief summary of the app to facilitate an understanding of the type of intervention, many studies lacked standardized information regarding the app's purpose, development, and testing standards, making it difficult to make systematic comparisons.

Evaluation Approaches

We identified three primary ways studies evaluated mental health apps for workers: 1) App Evaluation; 2) Impact Evaluation (Mental Health, Mental Distress, Workplace Performance); and 3) Process Evaluation. See Table 2 for a comprehensive summary of all studies included in this review and their evaluation approaches.

Table 2. Summary of all studies included in the review.

Author (Year)	Intervention Name and Description	Methodology (Research Design, Sample Size & Measurement Timepoints)	Type of Mental Health App[a]
Coelhoso et al. (2019) [29]	***Well-Being Mobile App*** (Official name not found): 8-week program (4 lessons/week) with content focused on techniques to reduce stress and promote well-being (breathing techniques, relaxation techniques, guided meditation)	**Design**: Randomized Controlled Trial (RCT) **Sample size:** 490 **Measurement Timepoints:** Baseline, mid-intervention (1-month), and post-intervention (2-months)	Therapeutic
Collins et al. (2020) [52]	***Anchored App*** (Adapted from HeadGear App): Consists of evidence-based techniques (behavioural activation, mindfulness, and coping skills training) delivered using multiple formats such as videos, exercise, goal setting.	**Design**: Pilot RCT **Sample size:** 81 **Measurement Timepoints:** Baseline, post-intervention (5 weeks)	Therapeutic
Ravalier et al. (2020) [65]	***Information App*** (no official name) co-created as a part of the HOW (Healthier Outcomes at Work) consists of psychoeducational elements, that could be updated and tailored to the needs of the organization, information regarding wellbeing events, access to Vocational Rehabilitation Assistant (VRA), option to provide feedback (via app) to management.	**Design:** Mixed Method design **Sample size:** Interviews: 19, Focus Group: 8 (4 groups), Pre survey: 503, Post survey: 154 **Measurement Timepoints:** Baseline Surveys, app development interviews & focus groups, follow-up surveys & evaluation interviews (6-months implementation period; 1-year from baseline)	Wellness/ Preventative
Hwang et al., (2019) [30]	***Stress Management app*** (No official name): The app consists	**Design: RCT**	Wellness/ Preventative

	of mental health information, and techniques/ strategies to promote mental health such as music focused on healing, meditation, breathing etc.	**Sample Size**= 56 nurses (I=26; C=30) **Measurement Timepoints**: Pre and Post-test (4 weeks)	
Morris et al. (2010) [66]	***The Mood Map:*** App enables mood monitoring (happiness, sadness, anxiety, and anger) throughout the day at regular intervals and offers other therapeutic strategies such as series of cognitive reappraisal exercises, breathing, and relaxation techniques.	**Design:** Mixed-method design (Case Studies & Experience sampling data) **Sample**: Individuals= 5 **Measurement Timepoints:** Four weekly interviews	Multicomponent
Birney et al. (2016) [31]	***The MoodHacker****:* A clinically validated depression self-management mobile app, based on the principles of CBT.	**Design:** RCT **Sample size**= 300 (I=150; C=150) **Measurement Timepoints:** Baseline, follow-up at 6 weeks, and 10 weeks	Therapeutic
Muuraiskangas et al., (2016) [67]	***Oiva:*** was based on Acceptance and Commitment Therapy to promote stress management and wellbeing. App consists of short skills building sessions with options to read or listen.	**Design:** Mixed Method **Sample size** Surveys= 43 Interviews=13 **Measurement Timepoints:** Baseline, 2 months, and 4 months	Therapeutic

Mistretta et al., (2018) [32]	***Smartphone Resiliency Training:*** Monitoring and awareness for sleep and mood, happiness and positivity, energy, and focus, and productivity. Users were prompted to select a goal (one of the topics) to work on for the next few weeks.	**Design: RCT** [3 groups: Control, In person Training, and Smartphone] **Sample size** = 60 **Measurement Timepoints:** Baseline, Follow up at 6-weeks and 3-months	Self-monitoring
Baek, J. H., et. al., (2018) [59]	***Stress Management App:*** The app initial primarily consisted of 4 main elements- mental health and lifestyle assessment, daily lifestyle management, forum for sharing their sources of trouble and getting psychological support among participants, a tool for searching nearby mental health professionals and relaxation training (added based on feedback)	**Design:** Pre/Post Non-Experimental **Sample size**= 68 **Measurement Timepoints:** Baseline, and 4 weeks	Multicomponent
Smith, E. N., et. al., (2020) [76]	***Spire Stone wearable device and mobile App:*** Monitoring of respiratory patterns and real-time biofeedback. The app consists of modules for mindfulness and relaxation.	**Design:** RCT **Sample size**= 169 **Measurement Timepoints:** Baseline and post-intervention (4 weeks)	Therapeutic
Crivelli et al., (2019) [60]	***Brain-sensing eyeglasses and a corresponding mobile App:*** Users were asked to sit in a quite space and practice mindfulness.	**Design: Pre/Post** **Sample size**= 16	Therapeutic

	The eyeglasses non-invasively collected EEG activity and transferred the data to the app. The app provided real-time acoustic feedback based on the data to promote relaxation	**Measurement Timepoints:** pre and post intervention (2-weeks)	
Jukic, et.al., (2020) [51]	***24alife App****:* A holistic app designed to guide user to build healthy lifestyle habits for three months. The app provides customization of activities after initial data regarding age, height, weight, neck, and waist measurements are entered. The activities are divided into relaxation activities, exercise training, nutrition advice and physiological responses to stress.	**Design: Pilot RCT** **Sample size**= 17 **Measurement Timepoints:** Baseline, 1-month, 2-months and 3-months	Wellness/ Preventative
Hsieh, et.al., (2020) [34]	***Smartphone-Delivered Biofeedback Training****:* (6-week program) The app consists of MP4 files for short mindfulness practices	**Design: RCT** [3 groups- Biofeedback Training (BT), Smartphone Delivered Biofeedback Training (SDBT), and Control] **Sample Size**= 135 **Measurement Timepoints:** Baseline and Post-intervention (6-weeks)	Wellness/ Preventative
Sasaki, et.al., (2021) [35]	***Two Programs (A &B)*** ***Program A:*** Multimodule program (6-modules) focused on stress management. ***Program B:*** A similar multimodule program (6-modules) with fixed-sequential order adapted from iCBT	**Design:** RCT [Control and 2 Intervention groups- CBT stress management programs] **Sample size**= 951 **Measurement Timepoints:** Baseline, post-intervention (3-months) and follow-up (7-months)	Therapeutic
Ly, et. al., (2014) [36]	***Acceptance and Commitment Therapy (ACT) based App:*** (6 weeks) The app consists of step-by-step modules based on ACT principles to manage stress. The app consists of 6 modules (one/week) with a provision for reflection that is accessible by a	**Design: RCT** **Sample size**= 73 **Measurement Timeline:** Baseline and post-intervention (6-weeks)	Therapeutic

	therapist from the back end who could send encouraging personal messages to the user.		
Lappalainen, et al., (2013) [50]	***P4Well:*** This study utilized three mobile apps. 1. Nokia Wellness Diary: mobile wellness dairy 2. Firstbeat Mobile Coach: fitness training program 3. SelfRelax: A mobile relaxation assistant that offers personalized relaxation programs	**Design: Pilot RCT** Intervention, waitlist control] **Sample size**= 24 (I= 12; C=12) **Measurement Timeline:** Pre and Post intervention (6-Months)	Multicomponent
Deady, et.al., (2022) [37]	***HeadGear:*** 30-day therapeutic intervention (one challenge/ day). App content is based on Behavioural Activation Therapy (BAT) and mindfulness-based therapies. Features also include mood monitoring and access to technical helpline.	**Design: RCT** [Intervention and Attention Control App] **Sample size**= 2271 **Measurement Timeline**: baseline, post-intervention (5 weeks after baseline), 3- and 12-month follow-up.	Therapeutic
Weber, et. al (2019) [38]	***Kelaa Mental Resilience App:*** (4-weeks) The app aims to reduce stress and promote wellbeing specifically in the workplace context by providing options for self-monitoring of behaviours, cognitions and emotions and providing psychoeducational modules.	**Design: RCT** **Sample size=** 532 (I=210, C= 322) **Measurement Timeline:** Baseline, mid-intervention (2 weeks), post-intervention (4-weeks), follow-up (6-weeks)	Multicomponent
Deady, et. al., (2020) [68]	***HeadGear Apprentice App:*** (30-days) Modified version of the HeadGear app. Modifications include changes to wording of content, navigation and	**Design: Mixed-Method** **Sample size** Study one= 26 participants across four focus groups	Therapeutic

	customization to apprentice support service guidance, ability to skip challenges and addition of gamification features.	**Measurement Timeline:** Baseline, post-intervention (5-weeks), and follow-up (3-months)	
de Korte, et. al., (2018) [69]	***Brightr App:*** developed for workers in a tech company to promote health and wellbeing by enabling them to monitor behaviour, sleep, physical activity, nutrition, and shift work. The app uses an algorithm to provide tailored feedback based on responses to short in app questionnaires and tracking of sleep and physical activity.	**Design: Qualitative** **Sample size** Interviews with users= 22 3 Focus Group with users= 4, 5 & 6 respectively 1 Focus Group with experts = 6 **Measurement Timeline:** Baseline and post-intervention (3-months) interviews	Wellness/ Preventative
Deady, et.al., (2018) [23]	***HeadGear:*** 30-day therapeutic intervention (one challenge/ day). App content is based on Behavioural Activation Therapy (BAT) and mindfulness-based therapies. Features also include mood monitoring and access to technical helpline.	**Design: Pre/Post** **Sample size** Stage 2: n= 84 **Measurement Timepoints:** Baseline, post-intervention (5-weeks), follow-up (3-months)	Therapeutic
Jesuthasan, et al. (2022) [53]	***Naluri App:*** Behavioural Intervention Technologies delivered to employees to improve psychological wellbeing through psychoeducation and skills training.	**Design:** Retrospective Study **Sample Size: 88** **Measurement Timepoints:** Baseline, 3-weeks	Wellness/ Preventative
Xu, et al. (2021) [70]	***Headspace:*** is a commercially available app provided free of cost to study participant includes guided mindfulness sessions.	**Design:** Descriptive Qualitative Study **Sample Size:** 24 **Measurement Timepoints:** Interviews at post-intervention (4-weeks)	Therapeutic
Counson, et al. (2021) [54]	***Shift App:*** Content and features of HeadGear app was modified to meet the needs of physician population.	**Design**: Pre/Post Non-randomized Pilot study **Sample Size:** 22 **Measurement Timepoints:** Baseline and	Therapeutic

		post-intervention (4-weeks)	
Ravalier (2022) [55]	***HOW*** [See above study id #3]	**Design:** Pre/Post Non-randomized study **Sample Size:** **Measurement** **Timepoints:** Baseline follow-up surveys (1-year from baseline)	Multicomponent
Xu, et al. (2021) [26]	***Headspace*** [See above Study ID #23]	**Design:** RCT **Sample Size:** 148 **Measurement** **Timepoints:** Baseline and post intervention (Four-weeks)	Therapeutic
Golden, et al. (2021) [56]	***The Wellness Hub App:*** consists of mental health, resilience related content and resources along with connections to local resources	**Design:** Pre/Post Non-randomized experimental design **Sample Size:** 231 **Measurement** **Timepoints:** Built into the app to take any number of times	Wellness/ Preventative
Hirshberg, et al. (2022) [27]	***The Healthy Minds Programs:*** A smartphone-based meditation intervention constructed around awareness, connection, insight, and purpose model of wellbeing	**Design: RCT** **Sample Size:** 666 **Measurement** **Timepoints:** Baseline, 1-Week, 2-Week, 3-Week, 4-Week, and 3-month Follow-up	Wellness/ Preventative
Dubord, et al. (2022) [57]	***Listen Leon:*** informed by the VIA-Classification of strength classifications, the app encourages employees to share feedback with one another.	**Design:** Pre/Post Non-randomized Experimental design **Sample Size:** 198 **Measurement** **Timepoints:** Baseline and 4-Weeks	Wellness/ Preventative
Hamamura, et al. (2018) [58]	***A Self-Record App*** **[No Name Found]** Psychoeducation & section on concepts of CBT	**Design:** Pilot Non-randomized Controlled Trial **Sample size:** 1396	Wellness/ Preventative

		Measurement Timepoints: Baseline and 4-Weeks	
Hwang, et al., (2022) [30]	***BetterLife:*** Guided self-help therapy informed by the principles of CBT and Problem-solving therapy for addressing Stress, Depression, Anxiety and Sleep Disorders.	**Design:** RCT **Sample size:** 126 **Measurement Timepoints:** Baseline and 10-Weeks	Therapeutic
Taylor, et al. (2022) [39]	***Headspace:*** [See above study id #]	**Design:** RCT **Sample Size:** 2182 **Measurement Timeline:** Baseline, 1.5 months, 4.5 months	Therapeutic
Robbins, et al. (2022) [40]	***Dayzz:*** This app is an extension to an online sleep educational program SHAW. The app is a personalized training program to address sleep issues.	**Design:** RCT **Sample Size:** 1355 **Measurement Timeline:** Baseline, Monthly and Follow-up (10-Months)	Wellness/ Preventative
Sanatkar, et al. (2022) [41]	***Shift App:*** aims to reduce symptoms of depression and anxiety by employing the components of CBT, ACT, Mindfulness and psychoeducational material	**Design:** Pre/Post Non-randomized Experimental design **Sample Size:** 222 **Measurement Timepoints:** Baseline and Post-intervention (4-weeks)	Therapeutic
Gnanapragasam, et al. (2023) [42]	***Foundations App:*** aims to promote wellbeing, manage stress and improve sleep	**Design:** RCT **Sample Size:** 1002 **Measurement Timepoints:** Baseline, 4-week and 8-week	Wellness/ Preventative

Gbeddy, et al. (2022) [63]	***VA Mindfulness Coach App:*** consists of gradual, mindfulness-based exercises and content	**Design:** Pre/Post Non-randomized Experimental design **Sample Size:** 14 **Measurement Timepoints:** Baseline and Four-weeks	Therapeutic
Lee (2023) [43]	***Mobile based Stress Management Intervention (mSMI):*** is a combination of three modules that include interventions for relaxation, self-management and counseling.	**Design:** RCT **Sample Size:** 82 **Measurement Timepoints:** Baseline and Six-Weeks	Multicomponent
Huberty, et al. (2022) [44]	***Calm App:*** The app uses mindfulness components, breathing techniques and body scans to promote practice of mindfulness and reduce stress	**Design:** RCT **Sample Size:** 1029 **Measurement Timepoints:** Baseline, every 2-weeks, and 8-weeks (post intervention)	Therapeutic
Pace et al. (2022) [64]	***Smartphone-based Mediation App:*** created by Healthy Minds Innovation consists of 10 distinct 10-mins sessions conducted for 10 days	**Design:** Pre/Post Non-randomized Experimental design **Sample Size:** 35 **Measurement Timepoints:** Baseline and post-intervention (16-days)	Wellness/ Preventative
Yoon, et al. (2022) [45]	***InMind:*** is a Mobile Mindfulness Training program to cope with stress	**Design:** RCT **Sample size:** 45 **Measurement Timepoints:** Baseline and Four-weeks (post-intervention, Eight Weeks (Follow-up)	Wellness/ Preventative
Pratt et al. (2023) [49]	***Lift Intervention:*** is a self-directed mindfulness program with tips and contents for integrating mindfulness into daily life	**Design:** Pilot RCT **Sample Size:** 102 **Measurement timepoints:** Baseline and post-intervention (4-weeks)	Wellness/ Preventative

Taylor et al. (2023) [46]	***Unmind App:*** consists of self-guided sessions based on principles of CBT and Act to manage and improve mental health and wellbeing	**Design:** Pilot RCT **Sample Size:** 2003 **Measurement Timepoints:** Baseline, post-intervention (21-days) and follow-**up (28 days)**	Wellness/ Preventative
Deady et al. (2023) [47]	***Anchored App:*** consists of therapeutic content based on behavioural activation, mindfulness and cognitive behavioural therapy.	**Design:** RCT **Sample Size:** 2112 **Measurement Timepoints:** Baseline, One month follow-up, Three months follow-up and 6-month follow-up	Therapeutic
Protocols and clinical trial registrations			
Bellón, et al. (2021) [15]	***e-pD-Work intervention:*** A self-guided intervention with a biopsychosocial approach. It is multi-component (9 modules: physical exercise, improve sleep, expand relationships, solve problems, improve communication, assertiveness, decision making, manage thoughts and reduce work stress).	**Design:** RCT Protocol **Estimated Sample size:** 720. **Measurement Timepoints:** Baseline, follow-up (3-months, 6-months, 9-months, 12-months)	Multicomponent
Shimazu et al., (2022) [16]	***Work engagement monitoring:*** App facilitates daily self-monitoring of achievements at work for two weeks.	**Design:** RCT Protocol **Estimated Sample size:** 600. **Measurement Timepoints:** [Data not found]	Self-monitoring
Sweeny et al., (2018) [17]	***Headspace:*** [See above for description]	**Design:** RCT Protocol **Estimated Sample size:** 200. **Measurement Timepoints:** Baseline, Mid-intervention (4-weeks), post-intervention (8-weeks), 4-months and 12-months	Therapeutic

Economides, et al. (2023) [19]	***Unmind:*** App aims to address mental health and improve sleep. The study evaluated two types of interventions tools: Night waves and Sleep tales.	**Design:** RCT Protocol **Estimated Sample size:** 300. **Measurement Timepoints:** Baseline, post-intervention (3-weeks), follow-up (7-weeks)	Therapeutic
Metcalf et al. (2021) [18]	***The Skills For Life Adjustment and Resilience (SOLAR-m):*** Developed as an extension of in-person training, the app is a module based intervention that aims to promote recovery after stressful interventions and promote wellbeing.	**Design:** RCT Protocol **Estimated Sample size:** 240. **Measurement Timepoints:** Baseline, post-intervention (7-Weeks), and follow-up (3-month)	Multi-Component
Milner, et al. (2019) [20]	***MATESmobile program:*** The app is developed as an extension of an in-person program focused on reinforcing training on suicide prevention, help-seeking behaviour and psychological distress.	**Design:** RCT Protocol **Estimated Sample size:** 844. **Measurement Timepoints:** Baseline, post-intervention (8-weeks), follow-up (3,6 and 12-months)	Therapeutic
Nicolson, et al. (2018)	***WorkingWell:*** App is deigned for individuals with severe mental health issues to cope on the job while dealing with illness/treatment related issues, lifestyle and work expectations.	**Design:** Mixed-method Protocol **Estimated Sample size:** 40 **Measurement Timepoints:** Baseline, post-intervention (8-weeks)	Therapeutic
Kosenkranius, et al. (2020)	***Everydaily App:*** App consists pf short daily activities based on techniques such as mindfulness, goal setting, gratitude. Users are presented with three options to chose pathways based on the Detachment, relaxation, autonomy, master, meaning, affiliation needs (DRAMMA) model.	**Design:** RCT Protocol **Estimated Sample size:** 200 **Measurement Timepoints:** Baseline, post-intervention (4-weeks), Follow-up (6-weeks & 8-weeks)	Therapeutic

Deady, et al. (2018)	***Headgear:***	**Design:** RCT Protocol **Estimated Sample size:** 851 **Measurement Timepoints:** Baseline, post-intervention (5-weeks), 3-month follow up	Therapeutic
Smythet, al. (2020)	***Holidaily:*** App aims to promote recovery behaviour and mental detachment from work to extend the beneficial effects of vacation into their daily work life through daily prompts based on behavioural activation strategies.	**Design:** RCT Protocol **Estimated Sample size:** 77 **Measurement Timepoints:** Six timepoints -Two weeks pre-vacation, last working day, mid vacation, first working day, two weeks post-vacation, four weeks post-vacation	Therapeutic
Olaya, et al. (2022)	***EMPOWER:***	**Design:** RCT Protocol **Estimated Sample size:** 77 **Measurement Timepoints:** Six timepoints -Two weeks pre-vacation, last working day, mid vacation, first working day, two weeks post-vacation, four weeks post-vacation	Therapeutic

[a]Classification of the mental health apps employed in each study was done by review authors based on the intervention description provided in the respective studies.
[b]Outcomes are organized by the three categories of evaluation approaches discussed in the review.

1) **App Engagement and Utilization**

a) **Usage patterns:** Over a third of studies (n=18) reported user engagement with the intervention by tracking app usage, indicated through objective analytics from the app technology or subjective reports of usage patterns. Objective app utilization reports were usually gathered through built-in analytics that highlighted aggregate usage patterns, which provided limited exploration of user-specific data. Subjective app usage reports were primarily collected through survey questions or qualitative interviews prompting users to recall their usage. Usage evaluation included various methods such as tracking the number of app downloads, the number of times the app was opened, time spent in the app, and pathways involving the different features within the app.

b) **User Feedback:** Fifteen studies included in this review tracked user feedback on the app. Typically, the follow-up evaluation explored perceptions of the app's key features, such as usability, acceptability, quality, perceived benefits, perceived impact, and overall satisfaction, providing an opportunity for suggestions for improvement. Standardized measures, such as the Mobile App Rating Scale (MARS) [78], were used in four studies [46, 19, 68, 52], and the Systems Usability Scale was employed in three studies [31, 61, 54].

2) **Impact Evaluation**

Most of the research on the impact of mental health apps for workers focused on multiple primary and secondary outcomes, from the mental health and well-being to the

work performance of individual app users. The following section highlights the most common outcomes that were evaluated in the studies reviewed, providing an overview of the tools that were used to track outcomes as well as the trends in research.

a) **Impact on Mental Health:** Tracking improvements in positive mental health was one of the most common outcomes evaluated across 22 studies by assessing wellbeing (n=22), resilience (n=11) and quality of life (n=3), self-compassion (n=2) and mindfulness (n=4). In studies evaluating the outcome of improving wellbeing, the 5-item World Health Organization Wellbeing Index (WHO-5) [72] and the 14- item Warwick-Edinburgh wellbeing scale [78] were the most commonly used scales. Some studies specifically tracked mental health outcomes specifically related to work-context self-efficacy [21, 20] and social support/social community in the workplace [21, 18]. While most studies employed standardized tools to measure positive mental health-related outcomes, one study explored app users' and experts' experiences and feedback related to engaging in healthier behaviours as a result of using the app [69]. By assessing participants' engagement in healthy behaviours as a result of app usage, this study was able to extend measuring the effects of the app not just in latent constructs but towards behavior change.

b) Impact on Mental Distress: Another common group of outcomes across ten studies looked at evaluated the impact of mental health apps on mental distress, including outcomes such as perceived stress, and symptoms of common mental

disorders such as depression, anxiety, sleep disorders and burnout. Standardized screening and diagnostic tools such as the Perceived Stress Scale (PSS) [71], the Generalized Anxiety Disorder (GAD-7) [74], and the Patient Health Questionnaire (PHQ-9) [73], Maslach Burnout Inventory [75] were frequently used to assess these outcomes. Five studies assessed mental distress outcomes specific to workplace setting such as occupational-related stress [9, 34, 30, 59, 34] and Burnout [32, 51, 50, 26, 36, 64, 49, 47]. While most studies evaluated mental distress through standardized measures that were subjectively reported by participants, four studies attempted to assess distress through objective evaluation of biological indicators such as respiratory patterns indicating a state of stress [10], glucose levels [12], Cortisol levels [12, 64] and non-invasive measures of cardiovascular activity [11].

c) Impact on Work performance: A relatively small proportion of studies (n=20) discussed the impacts of mobile health apps on work-related outcomes. Common work-related outcomes identified across studies were either user's work performance, or subjective perceptions regarding their working conditions. Studies employing work performance related outcomes assessed if the use of the mental health app had an effect on the users' performance/ productivity [52, 31, 68, 47, 23, 37, 38, 40, 44], presenteeism or absenteeism rates [52, 31, 68, 47, 23, 37, 38, 40, 25, 42]. Studies also evaluated whether using the mental health app could change users' perceptions of their working conditions [30, 38, 65, 69, 41, 42, 46, 47, 16] including their perception of

leadership [36], job satisfaction [55, 16, 22], job strain [17], perceived social support/support from co-workers [21, 16]. Many of these studies found limited evidence of a positive change in workplace related outcomes, attributing the reason to the limited timepoints at which these outcomes were evaluated, while underscoring the importance of continuing to evaluate these outcomes in ongoing studies.

3. Process of Implementation

While most studies evaluated summative outcomes assessing the overall effectiveness of the mental health app on individual and work-related outcomes, only a limited number of studies (n=5) focused on evaluating process-related factors that could affect the uptake and overall impact for users. Protocol studies included in this review proposed to examine the relationship between user characteristics, such as different levels of digital literacy [21], and users with varying levels of usage [22] in terms of their influence on the overall effectiveness of the intervention. Implementation outcomes in two other studies involved evaluating individual, contextual, and implementation-related barriers and facilitators that influenced the uptake, use, and overall impact of the mental health intervention [67, 69, 23]. Assessment of these outcomes led studies to generate recommendations and guidelines for optimizing the utilization and effectiveness of the mental health app.

DISCUSSION

Principal results

The results of this review profiled 54 current studies evaluating the impact of mobile health interventions among a working population. A previous systematic review, published

in 2019, of e-mental health interventions in the workplace identified 22 studies, but only 3 of those included apps as a primary intervention. The pandemic and post-pandemic era have precipitated a rapid increase in app-related research involving workers, with 41 studies conducted in the past 5 years. This trend may reflect a shift toward mobile health approaches to support the growing mental health needs of employees. The number of completed randomized clinical trials—24 out of 55—is promising, reflecting high-quality research designs to evaluate impact. Furthermore, this review included 12 trial registrations or published protocols, showing that the research is ongoing. The rise of digital technology and the associated research on mental health apps for employees highlights the importance of summarizing current evaluation practices and identifying gaps in the evidence.

Although studies in this review were conducted across a range of sectors, the highest proportion (42%, 23/55) were in health and social services. Given the mental health crisis noted in health and social services that is leading to significant shortages in staffing, these studies indicate promising efforts to evaluate innovative strategies to support the mental health of this group of workers. Unfortunately, 10 of the studies did not specify the workplace context where the app was implemented, making it difficult to identify make relevant recommendations for specific workplace sectors. Furthermore, many studies included in this review lacked sufficient reporting details regarding the intervention, research setting, and evaluation plan, making it challenging for future reproducibility, comparability, and dissemination. There are guidelines such as the 16-item mobile health evidence reporting and assessment (mERA) checklist that can be used to improve the reporting quality of interventions and support replicability of research [82]. This checklist

provides comprehensive recommendations for study authors on adequately describing the content, context and technology infrastructure to implement the mobile health technology with a specific population group [82].

The review also highlighted diversity in the nature of mobile health interventions, with 39 different types (unique) of applications across the mental health spectrum, from promoting wellness to managing illness. Over half of the studies focused on 'therapeutic' apps (56%) designed to address mental health symptoms; only 4 studies (8%) focused on wellness/prevention apps, reflecting more of a 'downstream' focus on treatment rather than prevention. Of the studies that focused on therapeutic apps, they did not necessarily explain the mechanisms of action. Although there were a few studies that explicitly cited theories such as behavioral activation and cognitive behavioral approaches, many app interventions linked to tools and techniques that were not necessarily embedded within a therapeutic protocol or tied to a specific psychotherapy approach. Of the studies that focused on self-help and self-monitoring apps, theoretical links between mental health knowledge and mental wellness or workplace performance outcomes were rarely cited, making it difficult to identify the mechanisms of action. This is a significant gap since explicit links between app design and expected outcomes are important aspects of evidence-based interventions [83].

The review highlights three different categories of evaluations conducted by studies exploring mental health apps. User engagement and feedback was an important outcome tracked across many studies either objectively through app metrics, or subjectively through a recall of usage or standardized measures such as MARS [79] and Systems Usability

Scales [80]. Tracking user perceptions, engagement and interaction with the mental health apps is critical in establishing a relationship between usage (dose) and desired outcomes (response). Currently, there is no consensus on what constitutes optimal engagement for a mental health app to produce desired effects [84,85]. One study exploring different types of app use, features and its effect on outcomes found that the right combination of different features (i.e., learning, goal setting, self-tracking) and its use at a moderation level could lead to desired outcomes, thereby refuting the common misconception that higher usage could lead to better outcomes [86]. Additionally, with the iterative nature of updating and maintaining apps, user feedback is a crucial element in ensuring that apps remain relevant, useful and up-to-date [84].

While many studies explored changes in mental health or mental distress related outcomes, there were only a limited number of studies tracking workplace-related outcomes despite the studies being conducted in the context of workplace. There is a growing body of evidence indicating that digital mental health interventions implemented in workplaces can improve work effectiveness, and productivity [87]. However, tracking these outcomes can be complex considering that studies need to speculate when changes in these workplace performance outcomes will take place and embed appropriate follow-up timepoints to measure them [88]. Study designs need to clearly outline the components of the intervention, and the mechanisms of change, in order to define what constitutes proximal and distal outcomes and determine appropriate timepoints for measurement of these outcomes.

Even when apps are designed to be evidence-based, this does not guarantee that the expected outcomes will occur. Evaluating a complex mental health intervention in the context of workplace requires a multilevel approach [88,89]. As such, there may be many different variables influencing uptake and impact. While studies in this review acknowledged complexities of the interactions of a digital intervention in a workplace setting, there is a gap in the application of existing theories to systematically guide this inquiry. Several implementation science theories and frameworks can be useful to guide further research in understanding and unpacking the complexities of implementing technology across different contexts and achieving large-scale adoption and sustained effects. For example, the Consolidated Framework for Implementation Research (CFIR) provides a summary of evidence-based constructs across five domains; the intervention, the individual user, the inner context, the outer context, and the process of implementation [90]. These constructs can help to identify and explain the facilitators and barriers to uptake and impact of the intervention [90]. Another similar framework called the Nonadoption, Abandonment, Scale-up, Spread and Sustainability (NASSS) Framework [91] highlights six key domains which can be used to guide researchers to evaluate the success of a mobile health intervention implemented in an organization context: the condition, the technology-based intervention, the adopters of the technology, the value proposition for the users, the organization where the technology is being implemented and the wider system/society. The NASSS framework also reflects on the complex and dynamic interaction between the six domains over time which can help answer the questions related to users' engagement with apps over time. Overall, systematic evaluation of the implementation process can facilitate

exploration of key facilitators and barriers that influence the uptake and effectiveness of the intervention. While traditional healthcare interventions typically emphasize evaluation of its effects on key outcomes, mental health app-based interventions necessitate the examination of the different ways in which users engage with the intervention as well as exploring other implementation-related and contextual factors that influence the uptake and overall impact.

Limitations

To our knowledge, this review is one of the first to summarize current research regarding approaches to evaluating mental health apps specifically in the context of the workplace. While a broad objective was established at the onset of the review to sufficiently capture all relevant studies, we restricted our search to studies published in English only to ensure feasibility regarding timelines and resources. Another limitation was the focus on descriptions of the evaluation approaches outlined in the studies. There was no formal assessment of study quality or synthesis of study findings. Future systematic reviews are needed to critically evaluate the current research evidence, identify the impact of mental health apps, and profile what works for whom and in what context. This is particularly important to assist organizational leaders, policymakers, and stakeholders in deciding how to invest in and optimize the use of mental health apps with frontline workers.

Recommendations

Results from this scoping review have several recommendations for future research.

1. Future research needs to enhance transparency and consistency in study reporting. RCTs and non-RCT evaluation reports could adapt the extension of the CONSORT statement for e-mental health (the Consolidated Standards of Reporting Trials of Electronic and Mobile Health Applications and Online TeleHealth) for reporting sufficient details of the intervention to allow replication and theory-building.
2. Evaluation studies need to identify and measure appropriate outcomes by examining the congruency between intervention goals and outcomes when exploring the effectiveness of mental health apps.
3. There is a need for longitudinal studies to assess the long-term effects of mental health apps, particularly when evaluating their impact on workplace outcomes that may require a longer duration to detect meaningful changes.
4. There is a need to investigate strategies for integrating mental health apps into existing workplace setting by considering organizational factors and fostering an implementation science lens.
5. A future systematic review can be undertaken to synthesize and appraise current evidence regarding the effectiveness of mental health apps for workers.

Conclusion

The past decade has led to tremendous advancements in mobile health innovation, including applications in workplace contexts. Research on delivering mental health apps with workers has focused almost exclusively on assessing their impact on individual mental health However, mental health apps provided to workers operate in a much broader context. They should consider working conditions and user characteristics to ensure effective

delivery and maximize their potential. Future studies need to sufficiently capture the complexities of the facilitators and barriers that shape

the adoption of interventions and the sustainability of effects within diverse workplaces.

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Conflict of interest

The authors have no conflicts to declare.

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Appendix 1

Search Strategy

1. Employment/
2. employment.ti,ab.
3. (job or worker or workplace or employee* or occupation* or manager).ti,ab.
4. 1 or 2 or 3
5. smartphone.ti,ab.
6. ((mobile or digital or handheld) adj2 (device or app or application)).ti,ab.
7. 5 or 6
8. Mental Disorders/
9. Mental Health/
10. ((mental* or mood or affect*) adj2 (disorder* or health or illness)).ti,ab.
11. anxiety.ti,ab.
12. wellbeing.mp.
13. depress*.ti,ab.
14. wellbeing.mp.
15. 8 or 9 or 10 or 11 or 12 or 13 or 14
16. 4 and 7 and 15

Chapter 3: Effectiveness of mental health apps among workers: A systematic review and meta-analysis of their effects on mental health and workplace outcomes.

Abstract

With the growing use of digital mental health interventions in the workplace, the effectiveness of mental health apps in this context remains unclear. This systematic review aimed to determine the current evidence on the effectiveness of mental health apps employed in the workplace. Five electronic databases and citations from relevant studies were searched to identify randomized control trials that evaluated the effects of a mental health app for workers. The quality of evidence was appraised by GRADE. 21 trials with 13,049 participants were included. Pooled effects from 21 trials comparing mental health apps with a control group found statistically significant effects in mental health symptoms at post-intervention with low certainty in evidence (SMD= -0.30, 95% CI=-0.40 to -0.19). At post-intervention, meta-analyses of separate outcomes found low-certainty evidence with statistically significant effects between groups in perceived stress (SMD=-0.36, 95% CI -0.562 to -0.164), psychological distress (SMD=-0.38, 95% CI= -0.615 to -0.144), wellbeing, (SMD=0.17, 95% CI 0.07 to 0.279) and burnout (SMD=-0.07 95% CI= -0.12 to -0.01). While mental health apps appear to be an effective intervention for workers, the certainty of evidence was low due to the high risk of bias along the trials and large unexplained inconsistencies of trial results. Future studies need to examine the heterogeneity among studies to clarify the effects of different usage levels, characteristics of participants and workplace industry on the overall pooled effects. Additionally, high-quality RCTs that report on clinically important outcome measures while considering the

relevance of measuring workplace outcomes in the long term are needed. **Key words:** *Mental health, mHealth; mental health apps; workplace; occupational health; systematic review; randomized controlled trial; meta-analysis*

INTRODUCTION

There is increasing evidence demonstrating the substantial impacts of mental health issues within the workforce on individual's well-being, societal welfare, businesses and the economy [1–3]. Common mental health concerns, such as depression and anxiety, have been shown to negatively impact employee wellbeing and workplace productivity [2]. Global estimates indicate that nearly 12 billion working days are lost annually due to mental health issues, with depression and anxiety costing the global economy approximately US$1 trillion per year in lost productivity [4]. To address this growing mental health crisis, digital solutions, such as smartphone-based mental health applications (apps), offer an innovative approach to scale mental health support for workers and organizations [5,6].

Mental health apps encompass a wide range of interventions, from mental health promotion and prevention to the therapeutic management of mental health issues, varying in duration, intensity, and composition of content and features [5,6]. Over the years, empirically validated therapeutic strategies have been adapted to the virtual platform to deliver cost-effective interventions at a large scale [7]. By employing evidence-based techniques such as cognitive behavioural therapy, stress management and mindfulness-based techniques, as well as resources to improve mental health literacy, mental health apps could be vital tools to scale supports for mental health and wellbeing, particularly in workplace settings [8,9]. As the proliferation of mental health apps continues, research examining their effectiveness is also rapidly growing.

Several previous systematic reviews and meta-analyses of workplace digital mental health interventions demonstrate promising evidence supporting the effectiveness of these

interventions for a range of mental health outcomes. These reviews of digital mental health interventions in the workplace that typically included a mix of both web-based and mobile app-based interventions have shown small to moderate positive effects in improving symptoms of depression, anxiety, stress, and wellbeing as well as on workplace outcomes such as engagement and productivity. Reviews of digital mental health interventions in the workplace to date have not made a distinction between web-based and mobile app-based interventions. However, given the differences in the delivery platforms and usage context where web-based interventions are typically accessed from internet browsers and app-based interventions are accessed through smartphones, there could be differences in user experiences and potentially their efficacies. The existing reviews do not make a distinction between the effectiveness of web-based and mobile app-based interventions in the workplace. In fact, with smartphone access now surpassing traditional computer access, Howarth et al. [5] highlighted the need for additional research to establish the impact of mental health apps within the workplace.

Given the growing number of mental health apps being developed, implemented and evaluated in the context of work, the main objective of this review is to systematically review and assess the current state of the effectiveness of mental health apps directed at improving workers' mental health or workplace-related outcomes.

Research questions

1. What is the effectiveness of mental health applications (mHealth apps) compared to any comparator group in improving common psychosocial outcomes

(such as perceived stress, depression, anxiety, burnout, wellbeing and quality of life) among the working population?

2. What is the effectiveness of mental mHealth apps compared to any comparator group in improving common workplace-related outcomes (such as absenteeism, presenteeism, workplace engagement and workplace productivity) among the working population?

METHODS

This systematic review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [10], and the study protocol was registered with PROSPERO (International Prospective Register of Systematic Reviews; CRD42023406167). Based on the research question formed in the study protocol, a search strategy and eligibility criteria were developed using the PICO (Population, Interventions, comparator and Outcomes) format [11].

Eligibility criteria

The inclusion criteria for this review were: 1. Type of participants: studies were included if the intervention targeted workers, defined as working-age adults, currently employed in any organization, 2. Studies that employed mental health apps delivered only via smartphones and not through other digital modalities (e.g., web-based, email, telephone or wearable devices were considered separate in their functionality from smartphone-based apps and hence were not considered eligible) with no restrictions related to their timing, duration or focus of mental health intervention, 3. Trials included any comparators (e.g., wait-listed controls (WLC), or any attention-control where participants received some form

of attention in the form of information or recourses but not thought to be active), 4. Studies that were experimental (e.g., randomized controlled trials, parallel or cluster trials) or quasi-experimental studies (pre-post studies with control group). Pilot and feasibility studies were excluded, 5. Studies assessed at least one mental health (e.g., wellbeing, symptoms of depression, anxiety, stress) or workplace-related outcome (e.g., workplace productivity, engagement), 6. Study reports were published in peer-reviewed journals with full-length papers available.

Search strategy

A comprehensive and systematic literature search was conducted using electronic databases including EMBASE, MEDLINE, PsycINFO, Ovid HealthSTAR, and the Cochrane Library Trials (CENTRAL) to identify relevant peer-reviewed studies published in English from inception to April 2024. The search strategy developed based on search terms used in a previous similar study of digital mental health interventions for employees [12,13], and included search terms for '*worker*', '*mental health*', '*wellbeing*', and '*mobile app*' (see Appendix A. for the complete search strategy) combined with Boolean operators ("OR, "AND"). Additionally, a hand search of reference list of included studies and relevant systematic reviews was conducted to identify any potentially eligible studies.

Study selection process

After removing duplicates, 2 independent reviewers (SA, MP) screened all the titles and abstracts for eligible studies. The full texts of all potentially eligible studies were then

assessed by the two independent reviewers to identify eligible studies. Any disagreements during the screening process were resolved by consensus and when needed by consulting with a third reviewer (SM). The study screening and extraction process was conducted using Covidence, a web-based platform for collaboration and production of systematic literature reviews [14].

Data collection and categorization of outcomes

Data extraction was carried out on Covidence by SA and double-checked by SM using a template developed based on the criteria outlined in the Cochrane data extraction form [11]. Examples of the fields in the data extraction form were: Aim, Design, Unit of allocation, Duration of participation, Study Characteristics, Type of study, Participants (Age and Sex), Settings, Method of recruitment, Total number randomized, Detailed description of intervention groups, and outcomes. Lastly, studies measuring engagement and productivity were combined due to their focus on related work outcomes. All available data (means, standard deviations, sample sizes, effect measures, *p* values, standard errors, confidence intervals) for relevant outcomes were extracted for both intervention and control groups for all time points. Missing outcome data for one study were obtained by contacting the corresponding author via email [15].

Assessment of study quality

The quality of the included studies was assessed using the Cochrane risk-of-bias tool (RoB 2.0) [16]. The tool consists of five domains: the randomization process, deviations from intended interventions, missing outcome data, selection of reported results and the overall risk of bias for each study. Two independent reviewers conducted the assessments for each

study independently with disagreements resolved by a third reviewer (SM). The certainty of evidence for each outcome were assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach. The body of evidence was assessed on the basis of the risk of bias, unexplained heterogeneity, directness of evidence, imprecision and the probability of publication bias.

Synthesis of data

For each study's outcome variable, a between-group effect size was calculated as the standardized mean difference (SMD). Since the review included a few studies with small sample sizes, Hedges' *g,* which corrects for small samples [17], was used as a measure of SMD with a 95% Confidence Interval (CI). SMDs of 0.2 indicate small, 0.5 indicate moderate, and 0.8 indicate large effects [18]. All statistical analysis, effect size calculation and meta-analysis were performed using the random effects model in STATA V18 [19]. A separate meta-analysis was conducted for a combined mental health outcome, and each mental health outcome extracted from the study trials. Most mental health app interventions vary across studies, and the measurement of outcomes also varies, thereby leading to high heterogeneity (variation in intervention effects) [20]. To assess the presence of heterogeneity, forest plots were visually inspected to explore for possible statistical heterogeneity. Heterogeneity between studies was assessed using the Higgins I^2 test and the Chi^2 test with a significance level of $p<0.05$, which estimates the proportion of observed variance not because of sampling error. An I^2 value of 0-40% indicates heterogeneity was not important, 30-60% represents moderate heterogeneity, 50-90% represents substantial heterogeneity, and 75-100% represents considerable heterogeneity

[21]. A subgroup analysis was conducted to examine the differences in effects based on the type of mental health app used. To assess publication bias, funnel plots were generated for each outcome that was visually examined for asymmetry. To further examine the asymmetry, small study effects (in cases where at least 10 studies were available for analysis) were calculated using the Eggers regression test when more than 10 studies were available [22]. A nonparametric trim-and-fill method was used to account for publication bias by assessing the number of studies potentially missing from the meta-analysis due to publication bias and imputing for these studies by generating an overall effect size estimate with both observed and imputed studies [23].

RESULTS

Search results

The search strategy yielded 248 titles and abstracts, with an additional 17 from a hand search of citations and Google Scholar. After removing 154 duplicates (62%), 98 titles and abstracts (38%) were screened following which 38 full texts were sought for retrieval. Based on the review's eligibility criteria, 21 studies were included in the review. (See Table 1. for an overview of included studies). Detailed study screening processes, including reasons for study exclusions, are outlined in the PRISMA Flowchart (see Figure 2).

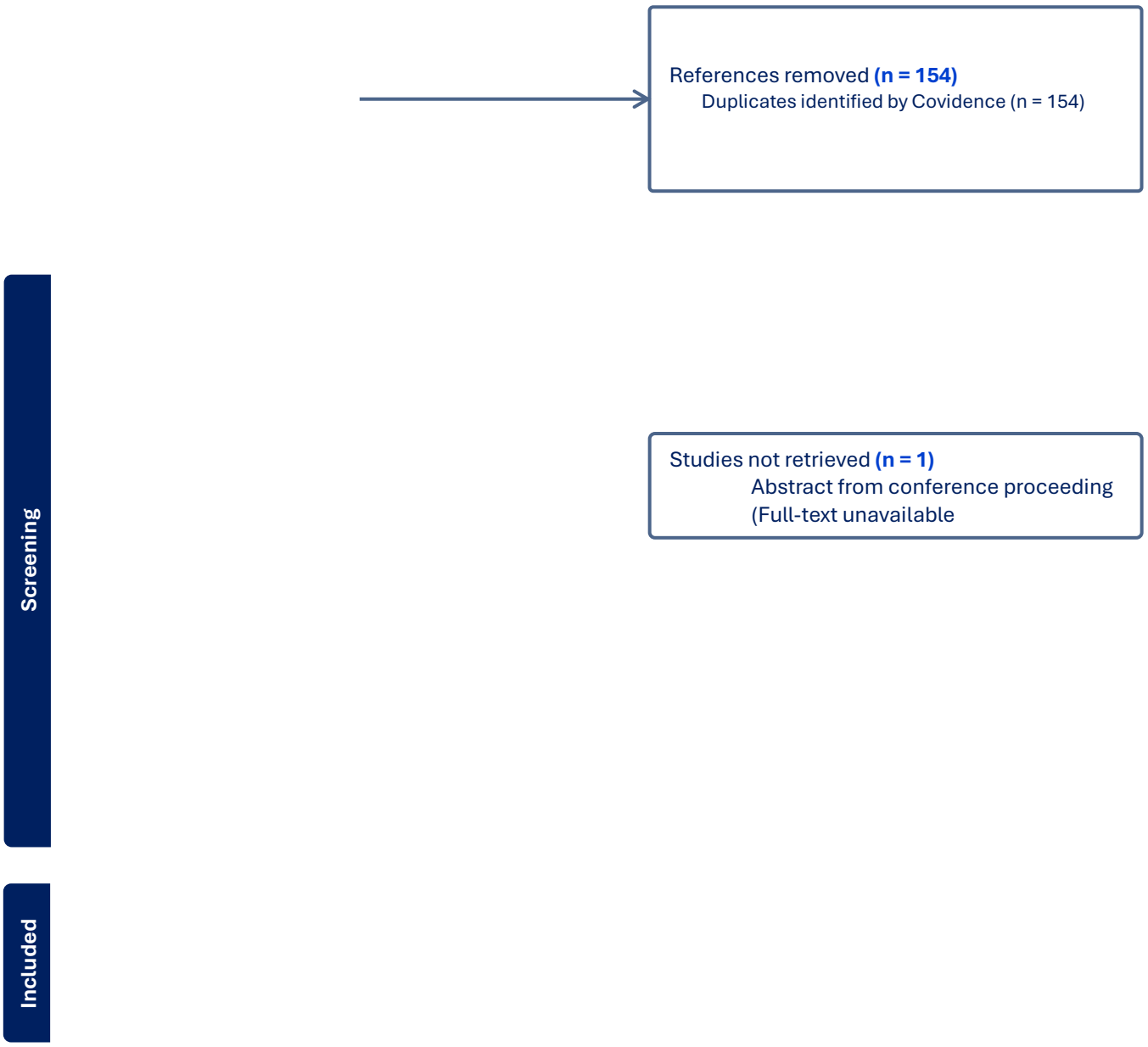

Figure 3. PRISMA Flowchart illustrating study screening

Table 3. Overview of all studies included in the systematic review and meta-analysis

Author Year Country	Study design/setting	Sample size and Participants	Recruitment	Intervention (I) & Control (C)	Guidance for Intervention use
Abbasalizadeh et al. 2024 Iran	RCT, Study setting: Healthcare, ICU Nurses	Baseline Intervention=30, Control=30 Mean age: 29.16 (SD= 4.68) Female: 36.67%	Workplace	I: Resilience app C: WLC Duration: 5-months,	Weekly reminders
Keng et al. 2022 Singapore	RCT Study setting: Healthcare, ICU Nurses	Baseline Intervention=40, Control=40 Mean age: 30.18 (SD = 6.19) Female: 90%	Community	I: Headspace app C: Active control (Lumosity app) Duration: 3 weeks	10-day basic course (complete one 10-min practice each day) and engage in daily practice using their assigned app for 3 week
Fiol-DeRoque et al. 2021 Spain	RCT, Study setting: Healthcare, workers from any medical specialty	Baseline Intervention=248, Control=234 Mean age: 41.37 (10.4) Female: 83.2%	Community	I: PsyCovidApp C: Attention-control app (general recommendations about mental healthcare) Duration: 2-weeks	Daily prompts (notifications) that included brief questionnaires to monitor mental health status, followed by short messages offering tailored information and resources based on the participants' response

Hwang et al. 2022 South Korea	RCT, Study setting: Individuals with work-related stress	Baseline Intervention=63, Control=63 Mean age: 38.6 (9.8) Female: 86%	Community	I: BetterLife C: WLC Duration: 10-weeks	Instructed to use the BetterLife program for 50 minutes per week for 10 weeks
Hsieh et al. 2020 Taiwan	RCT, Study setting: Healthcare, Psychiatric ward Nurses who experienced violence either at work or home	Baseline Intervention=47, Control=39 Mean age: 35.61 (8.18) Female: 88.1%	Workplace	I: Smartphone Delivered Biofeedback Training (SDBT) Alternative: Biofeedback Training (BT) (60-minute, weekly Biofeedback Training sessions) C: WLC Duration: 6-weeks	Weekly self-training modules for 6-weeks
Huberty et al. 2022 USA	RCT Study setting: Private consumer electronics retailer	Baseline Intervention=585, Control=444 Mean age: NA Female: 50.58%	Workplace	I: Calm App C: WLC Duration: 8-weeks	At least 10 minutes per day. Participants received weekly SMS text message reminders to use the Calm app on Sundays at noon during the intervention.
Ly et al. 2014 Sweden	RCT Study setting: Middle managers at medium and large companies	Baseline Intervention=36, Control=37 Mean age: 41.5 (7.2) Female: 42.5%	Community	I: Acceptance and Commitment Therapy based smartphone app C: WLC Duration: 6-week	Recommendation of spending 15 mins per day on the program

Deady et al. 2022 Australia	RCT Study setting: Australians from Male-dominated Industries (≥70% of workers are male)	Baseline Intervention=1128, Control=1143 Mean age: 40.26 (10.63) Female: 25.8%	Community	I: HeadGear C: Attention control (Mood tracking) Duration: 4-week	One challenge per day involving one 5–10-minute activities
Gnanapragasam et al. 2023 UK	RCT Study setting: Healthcare (clinical and non-clinical)	Baseline Intervention=502, Control=500 Mean age: 44.3 (Interquartile range (IQR) 19) Female: 84.3%	Workplace	I: Foundations App C: WLC Duration: 8-Weeks	Active use (ideally daily) is encouraged during weeks 1 and 2 to gain and develop such well-being habits and skills. Users are prompted and encouraged to continue with these behaviours via smartphone home screen notifications from the app.
Birney et al. 2016 USA	RCT Study setting: Working Adults indicating mild-to-moderate depression, recruited in partnership with several organizations (EAP and Non-EAP	Baseline Intervention=150, Control=150 Mean age: 40.6 (11.5) Female: 76.9%	Workplace	I: MoodHacker app C: Alternative Care (Email with links to online resources) Duration: 6-weeks	Daily app use was recommended, but app use milestones was not tracked

	recruitment partners)				
Hwang and Jo 2019 South Korea	RCT Study setting: Healthcare, Nurses at college Hospitals	Baseline Intervention=30 Control=30 Mean age: 53.5% between 31-40 Years Female: 94.6%	Community	I: Mind Healer app C:WLC Duration: Four weeks	Recommended to freely use the app, more than twice per week, and for at least 10 min per usage
Robbins et al. 2022 USA	RCT Study setting: Healthcare, daytime employees at a large healthcare organisation	Baseline Intervention=772 Control=544 Mean age: 36 (11) Female: 80%	Workplace	I: dayzz app C: WLC Duration: Four weeks	App delivers personalised 'just-in-time' messages to support ongoing sleep health behavioural changes
Xu et al. 2022 Australia	RCT Study setting: Healthcare, Emergency Department workers from two hospitals	Baseline Intervention=74, Control=74 Mean age: 66% <40 years old Female: 78%	Workplace	I: Headspace app C: WLC Duration: Four weeks	Advised to practice daily, 10 min of guided mindfulness meditation at their own convenience

Lee 2023 South Korea	RCT Study setting: Public Administration, Information Technology, Education, and Health Industries, Adult workers with high levels (≥22) of perceived stress	Baseline Intervention=39, Control=43 Mean age: 35.2 (8.49) Female: 78%	Community	I: Mobile app-based stress management intervention C: WLC Duration: Six weeks	Recommended to use the app for 10 minutes twice a week for 6 weeks
Hirshberg et al. 2022 USA	RCT Study setting: Employees within school system	Baseline Intervention=346, Control=320 Mean age: 44.6% between 20-40 years Female: 87.9%	Workplace	I: The Healthy Minds Program smartphone-based meditation intervention C: WLC Duration: Four weeks	No recommendations provided
Coelhoso et al. 2019 Brazil	RCT Study setting: Healthcare, only women from a Large Private Tertiary Care Hospital	Baseline Intervention=250, Control=240 Mean age: 34.6 (7.62) Female: 100%	Workplace	I: Wellbeing App C: Active Control group Duration: Eight weeks	Participants had to attend 4 classes per week; if they did not meet this deadline, they were given 4 more days to complete the classes, after which the app was blocked.
Deady et al. 2023 Australia	RCT Study setting: Australian public	Mean age: 42.96 (10.07) Female: 71.16%	Community	I: Anchored app (adapted from HeadGear) C: Active Control Duration: Four weeks	Complete one challenge (5-10 minutes) daily for 30-days

Bartlett et al. 2022 Australia	RCT Study setting: Tasmanian State Service employees	Baseline Intervention=30, Control=30 Mean age: 40.7% <44 years Female: 72.5%	Workplace	I: Smiling Mind Workplace Program app A: App+ fortnight classes C: WLC Duration: Eight weeks	Recommended minimum engagement with the app is 10 to 20 minutes mindfulness practice each weekday.
Weber et al. 2019 EU (Germany, England, and Northern Ireland)	RCT Study setting: Six different European businesses from the private and public sector	Baseline Intervention=210, Control=322 Mean age: 40.62 (11.19) Female: 75.6%	Workplaces	I: Kelaa Mental Resilience app C: WLC Duration: Four weeks	No recommendations provided

Sasaki et al. 2021 Vietnam	RCT Assessment timepoints: Study setting: Healthcare, Large public tertiary hospital	Baseline Intervention=316, Control=316 Mean age: 33.1 Female: 84.9%	Workplace	I: Stress management app. C: WLC Duration: Ten weeks	Weekly reminder messages sent to people who had not completed a weekly module on time
Taylor et al. 2022 UK	RCT, Study setting: Healthcare, Frontline workers who are in direct patient contact.	Mean age: 40.42 (10.92) Female: 83.1%	Workplace	I: Headspace C: Active control (Moodzone app: Information and guidance on how to manage stress) Duration: 4.5 months	Perform at least one 10- minute mindfulness practice daily for the duration of the study.

Study Characteristics

The 21 studies included in this review included an overall sample size of 13,049, and baseline sample sizes ranged from 60 to 2,962. In most studies (n=13), recruitment occurred within the workplace, while some studies (n=8) recruited eligible workers from the broader community across multiple workplaces. The majority of studies focused on participants from the healthcare industry (n=12), while others included participants from diverse sectors such as public and private offices, the retail industry, and male-dominated industries. Studies were mostly conducted in developed Western nations such as the United States (n=2), Australia (n=2), and the United Kingdom (n=2).

Intervention Characteristics

Studies were classified based on the intent and description of the intervention as 1. mindfulness-based apps (apps that were based on mindfulness/meditation/ relaxation techniques; n=7) [24–30], 2. psychoeducation apps (apps delivering mental health information/access to other resources, n=7) [31–37], 3. behavioural technique-based apps (apps that were based on behaviour change techniques such as behavioural activation or cognitive behavioural therapy; n=6) [15,38–42], or 4. multi component apps (study was categorized as being a multi-component mental health app that comprised self-management techniques such as music, meditation, image healing and a feature to connect to counselling, n=1) [43]. Some studies (n= 12/21, 68%) included structured interventions with components leading to the completion of the intervention, while other studies (n=9/21, 42%) included self-guided interventions that could be used as needed. In cases where the intervention was time-bound, clear instructions were provided to ensure appropriate

adherence to the interventions. In studies with self-guided apps, brief instructions were provided (13/21,62%) with regular reminders to ensure that users engage with the app sufficiently. Two studies that included self-guided interventions provided reminders or instructions to the study participants. The majority of the trials tested the intervention in comparison to a WLC group (14/21, 67%), while in other trials, an attention control was employed where participants (7/21, 33%) were provided mental health information or resources.

Outcome measures

Common outcomes across studies included perceived stress, symptoms of depression and anxiety, psychological distress, well-being, burnout, occupational stress, workplace engagement, and productivity. When studies measured more than one of these outcomes, data for all were extracted, and the study was included in the analysis for each outcome. Outcomes were combined when they measured a shared construct or mechanism supported by theoretical or empirical rationale. For example, symptoms of depression, anxiety, and psychological distress were combined as they share the common underlying construct of 'psychological distress' with overlapping symptoms [44]. Similarly, occupational stress and burnout were grouped, as chronic occupational stress is often considered a precursor to burnout [45]. For perceived stress, mental distress and burnout, a negative effect size (SMD) indicated that the levels of stress, burnout and symptoms of mental distress in the intervention group were lower than those in the control group, whereas, for wellbeing and work-related outcomes, a positive effect size (SMD) indicated that the effects were greater in the intervention group than in the control group.

The majority of studies reported more than one mental health-related outcome (20/21, 95%). The most commonly reported outcome was psychological distress (70% of studies), while workplace-related outcomes were the least commonly reported (30%). Most studies (71%) measured outcomes for at least three time points (baseline, post-intervention and follow-up); however, variability in the follow-up time points across studies made it challenging to pool follow-up data in a meaningful way for meta-analysis. Below we present the findings from the meta-analysis conducted for each outcome at a post-intervention timepoint.

Risk of Bias

Overall, three studies (14%) had a low risk of bias, 13 studies (62%) had some concerns, and five studies had a high risk of bias (24%). Figure 3 shows the ratings for the overall risk of bias and individual domains for all included studies. The highest risk of bias was observed due to the use of self-reported subjective outcome measures leading to the potential risk of response bias, followed by concerns regarding missing outcome data at post-intervention time point, which highlights the concern of high dropouts commonly seen across digital mental health intervention studies [8,13,46]. Additionally, since participants are aware of their assignment to the intervention arm by virtue of using the app or being assigned to a waitlisted control, blinding of participant's allocation to the intervention was not possible in most studies other three studies that employed another app as an active control [15,27,37].

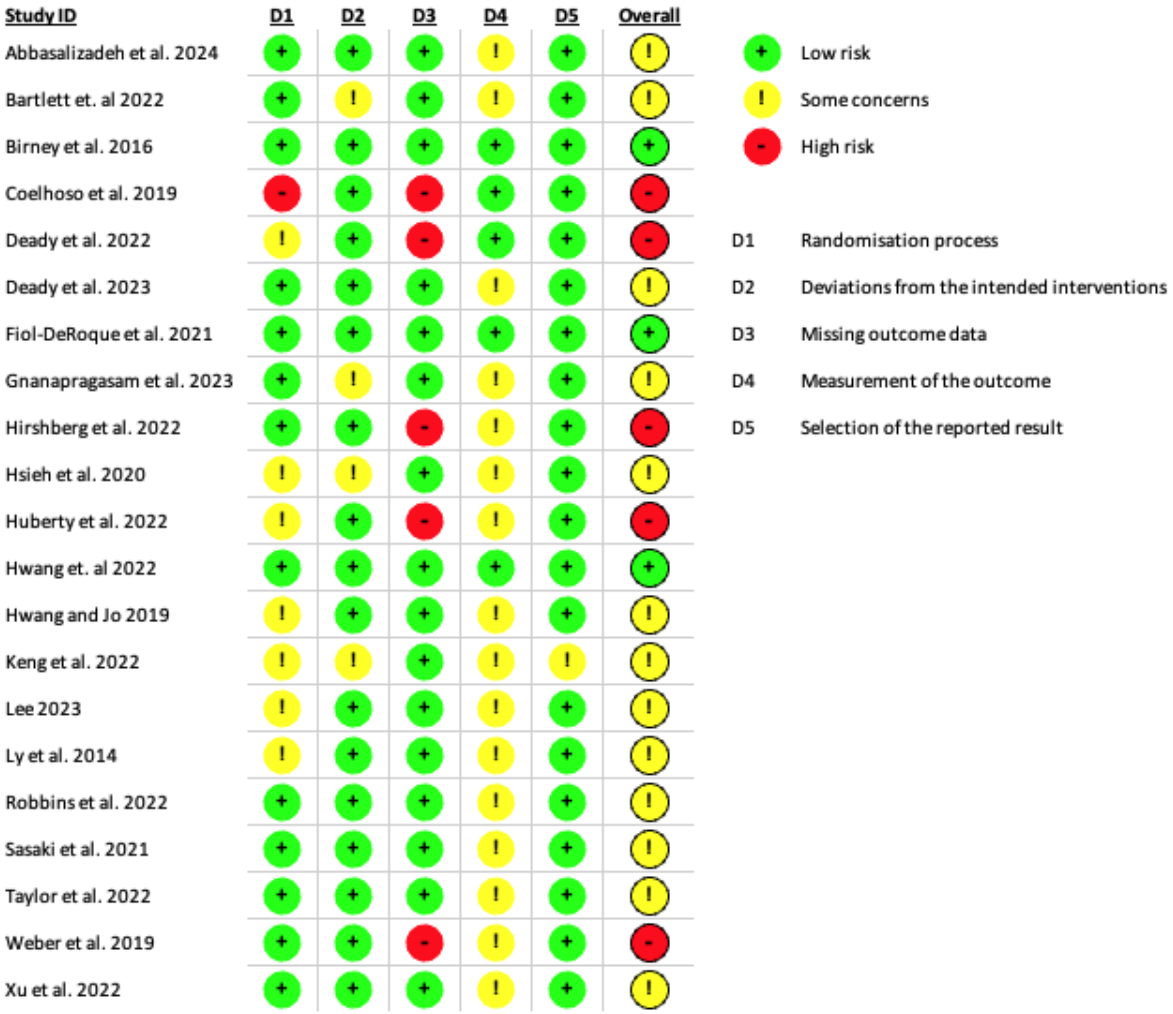

Figure 4 Risk of bias assessment of the included studies.

Effects of mental health apps

Any mental health app vs waitlisted control or attention control

A total pooled effect size was calculated by combining mental health outcomes from all 21 trials evaluating any mental health app versus any comparator. Similar outcomes reflecting psychological distress—such as perceived stress, symptoms of depression or anxiety, or distress—were selected based on the outcomes measured in each trial. When a study

measured more than one similar outcome, the primary outcome of the study was extracted. Only one study included an outcome that was not directly related to mental distress.

Table 4. Summary of findings: Mental health apps compared to control group in working adults

Certainty assessment							№ of patients		Effect	
№ of studies	**Study design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**	**Mental Health apps**	**Control Group**	**Relative (95% CI)**	
Perceived Stress (follow-up: range 2 weeks to 13 weeks; assessed with: PSS)										
9	randomised trials	serious	very serious[a]	serious[b]	not serious	publication bias strongly suspected[c]	933	1027	SMD **0.36 SD lower** (0.56 lower to 0.16 lower)	
Symptoms of Distress (follow-up: mean 4 weeks; assessed with: BDI, BAI, GAD, HADS, DASS)										
15	randomised trials	serious[d]	very serious[e]	serious[b]	not serious	publication bias strongly suspected[f]	3655	3599	SMD **0.38 SD lower** (0.61 lower to 0.14 lower)	
Wellbeing (follow-up: mean 4 weeks; assessed with: WHO-5, WEWRC)										
14	randomised trials	serious[g]	very serious[d]	serious[b]	not serious	publication bias strongly suspected[h]	3433	3575	SMD **0.17 SD higher** (0.07 higher to 0.28 higher)	
Burnout & Occupational Stress (assessed with: Maslach Burnout Inventory, Occupational Stress Scale)										

Certainty assessment							№ of patients		Effect	
№ of studies	**Study design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**	**Mental Health apps**	**Control Group**	**Relative (95% CI)**	
9	randomised trials	serious	not serious[i]	serious[b]	not serious	publication bias strongly suspected[j]	2721	2672	SMD **0.07 SD lower** (0.12 lower to 0.01 lower)	

Workplace Engagement

7	randomised trials	serious[k]	serious[l]	serious[b]	not serious	publication bias strongly suspected[m]	1204	1369	SMD **0.07 SD higher** (0.1 lower to 0.24 higher)	

Mental health outcomes combined (assessed with: PSS, GHQ-9, PHQ-9, DASS)

21	randomised trials	serious	serious[m]	serious[b]	not serious	publication bias strongly suspected[n]	4688	4798	SMD **0.30 SD lower** (0.42 lower to 0.21 lower)	

CI: confidence interval; **SMD:** standardised mean difference

Explanations

a. Downgraded by two points because the proportion of the variability in effect estimates that is due to true heterogeneity rather than chance is important (I2 = 73.82%).

b. Downgraded because the included studies consist of interventions with different therapeutic focuses and participants from different industries.

c. The search focused on only peer-reviewed papers published in English. The funnel plot for perceived stress outcome shows an asymmetrical distribution of studies, suggesting a high probability of the presence of publication bias. Due to these factors, the rating was downgraded. There were several small negative studies, but it appears that studies showing no effect or harm have not been published.

d. Due to a high risk of bias in 15% of the studies and some concerns in 60% of the studies included, confidence in the effect estimate was downgraded by one level following GRADE recommendations.

e. Substantial statistically significant heterogeneity was detected through the I^2 statistic (95.27%). There is variation in the direction of the study effect, and there is a poor overlap between the confidence intervals.

f. The search focused only on peer-reviewed papers published in English. The funnel plot of 15 randomized trials indicated that there were several small studies that showed a small significant effect, but small studies that showed no effect or harm may have been unpublished. The certainty of the evidence was lowered.

g. Downgraded because of 14 randomized trials, six did not blind participants and all trials employed self-reported measures.

h. The funnel plot of 14 randomized trials indicated trials indicated that there were several small studies that showed a small positive effect, but small studies that showed no effect or harm may have been unpublished. The certainty of the evidence was lowered.

i. Not downgraded because the proportion of the variability in effect estimates that is due to true heterogeneity rather than chance is not important (I2 = 0.01%).

j. The funnel plot indicated that there were several small studies that showed a small negative effect, but small studies that showed no effect or harm may have been unpublished. The certainty of the evidence was lowered.

k. Downgraded because out of 7 randomized trials, two trials had missing outcome data and one trial had no information about the randomization process.

l. Downgraded because the proportion of the variability in effect estimates that is due to true heterogeneity rather than chance is substantial (I2 = 75.48%).

m. Downgraded because the proportion of the variability in effect estimates that is due to true heterogeneity rather than chance is important (I2 = 75.06%).

n. The funnel plot indicated that there were several small studies that showed a small positive effect, but small studies that showed no effect or harm may have been unpublished. Egger's test results suggest that publication bias or other small-study effects may be present. The certainty of the evidence was lowered.

Table 5 Summary of findings: Types of mental health apps compared to control group in working adults in improving combined mental health outcome

Certainty assessment							No of patients		
No of studies	**Study design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**	**Multicomponent apps**	**Control Group**	**E**
Multicomponent app									
1	randomised trials	not serious	not serious	not serious	serious	publication bias strongly suspected	39	43	
Psychoeducation app									
7	randomised trials	serious	very serious	serious	not serious	publication bias strongly suspected	2369	2366	SMD **0.3 SD lower** (0.43 lower to 0.19 lower)	⊕◯◯◯ Very low[a,b]
Mindfulness based app									
7	randomised trials	serious	serious	serious	not serious	publication bias strongly suspected	864	1008	SMD **0.37 SD lower** (0.55 lower to 0.19 lower)	⊕◯◯◯ Very low[a,b]
Behavioural techniques-based app									
6	randomised trials	serious[a]	serious[b]	not serious	not serious	publication bias strongly suspected	2369	2366	SMD **0.26 SD lower** (0.54 lower to 0.01 higher)	⊕◯◯◯ Very low[a,b]

CI: confidence interval; **SMD:** standardized mean difference. **Explanations** a. Downgraded because of 6 randomized trials, four trials did not blind participants to intervention. b. downgraded because the

proportion of the variability in effect estimates that is due to true heterogeneity rather than chance is important (I2 = 94.4%).

Very low-certainty evidence showed that mental health apps, compared with a wait-listed control group or attention-control group, are more effective than comparator groups in reducing symptoms of combined mental health outcomes. A significantly small negative effect size was detected (SMD=-0.30, 95% CI -0.40 to -0.19, p=0.00) with large heterogeneity among the study effects (I^2 =80.36%) (figure 5), indicating an important reduction in mental distress, perceived stress, or symptoms of depression. The certainty of the evidence was lowered due to serious concerns with the risk of bias across studies, very serious concerns due to imprecision, serious concerns due to indirectness and strongly suspected publication bias.

A subgroup analysis assessing the differences in the effects based on the different types of mental health apps (psychoeducation, behavioural techniques, mindfulness, or multicomponent apps) indicated that the groups are not statistically different in their effects (Qb (3) = 0.70, p = 0.87) (figure 6). Examining the overall effect estimates for each group, very low certainty evidence indicated that mindfulness-based mental health apps, compared to control groups across eight trials, had higher significant effects in reducing mental distress (SMD= -0.37, 95% CI -0.55 to -0.19, p=0.00) with substantial heterogeneity (I^2 = 64.88%). Very low certainty evidence showed that across seven trials comparing psychoeducation-based mental health apps with the control group indicated a small statistically significant effect in reducing mental distress (SMD=0-.30, 95% CI -0.43 to -0.16, p=0.00) with moderate heterogeneity (I^2 = 55.97%). Very low certainty evidence from one trial indicated no evidence of a significant difference between a multicomponent app and a control group (SMD=0-.22, 95% CI -0.66 to 0.21, p=0.31), and very low certainty

evidence from six trials indicated no evidence of a significant difference between behavioural techniques based apps and a control group (SMD= -0.26, 95% CI -0.54 to 0.01, *p*=0.06). Below, results from five separate meta-analyses are presented for each outcome.

Perceived Stress

There was very low-certainty evidence from nine trials that any mental health app was effective in reducing perceived stress post-intervention when compared to any control group with a small, significant pooled effect size (SMD=-0.363, 95% CI= -0.562 to -0.164, *p*=0.00) and a large heterogeneity among the study effects (I^2 =73.82%) (figure 7). The certainty of the evidence was lowered due to serious concerns with the risk of bias across studies, very serious concerns due to imprecision, serious concerns due to indirectness and strongly suspected publication bias.

Psychological Distress

There was very low-certainty evidence from 15 trials that any mental health app was effective in reducing psychological distress, symptoms of depression and anxiety post-intervention when compared to any control group with a small, significant pooled effect size (SMD=-0.38, 95% CI= -0.615 to -0.144, *p*=0.001) and a very large heterogeneity among the study effects (I^2 =95.27%) (figure 8). The certainty of the evidence was lowered due to serious concerns with the risk of bias across studies, very serious concerns due to imprecision, serious concerns due to indirectness and strongly suspected publication bias.

Wellbeing

There was very low-certainty evidence from 14 trials that any mental health app was effective in improving wellbeing when compared to any control group with a small,

significant pooled effect size (SMD=0.17, 95% CI 0.07 to 0.279, *p*=0.00) and large heterogeneity among the study effects (I^2 =71.66%). (figure 9). The certainty of the evidence was lowered due to serious concerns with the risk of bias across studies, very serious concerns due to imprecision, serious concerns due to indirectness and strongly suspected publication bias.

Burnout

There was very low-certainty evidence from nine trials that any mental health app was effective in reducing burnout and occupational stress scores when compared to any control group with a small, significant pooled effect size (SMD =-0.07, 95% CI -0.12 to -0.01, *p*=0.01) and no significant heterogeneity (I^2 =0) (figure 10). The certainty of the evidence was lowered due to serious concerns with the risk of bias across studies, serious concerns due to indirectness and strongly suspected publication bias.

Workplace Engagement and Productivity

There was very low-certainty evidence from seven trials that any mental health app was not effective in improving workplace engagement and productivity when compared to any control group (SMD = 0.07, 95% CI -10 to 0.24, *p* = 0.42) and large heterogeneity among the study effects (I^2 =75.48%) (figure 11). The certainty of the evidence was lowered due to serious concerns with the risk of bias across studies, very serious concerns due to imprecision, serious concerns due to indirectness and strongly suspected publication bias.

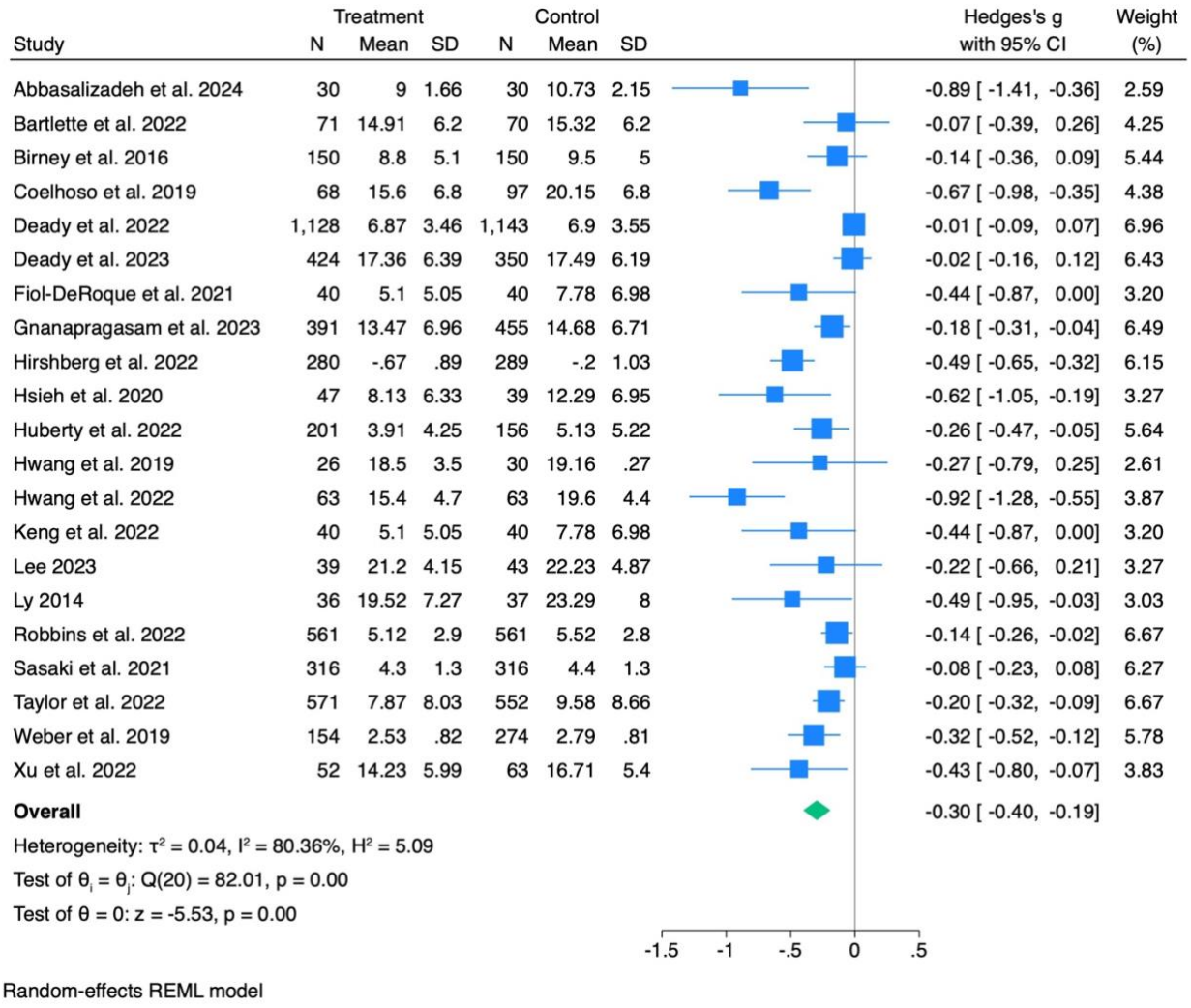

Figure 5. Forest plot of post-intervention effect size for common mental health outcomes across all 21 studies

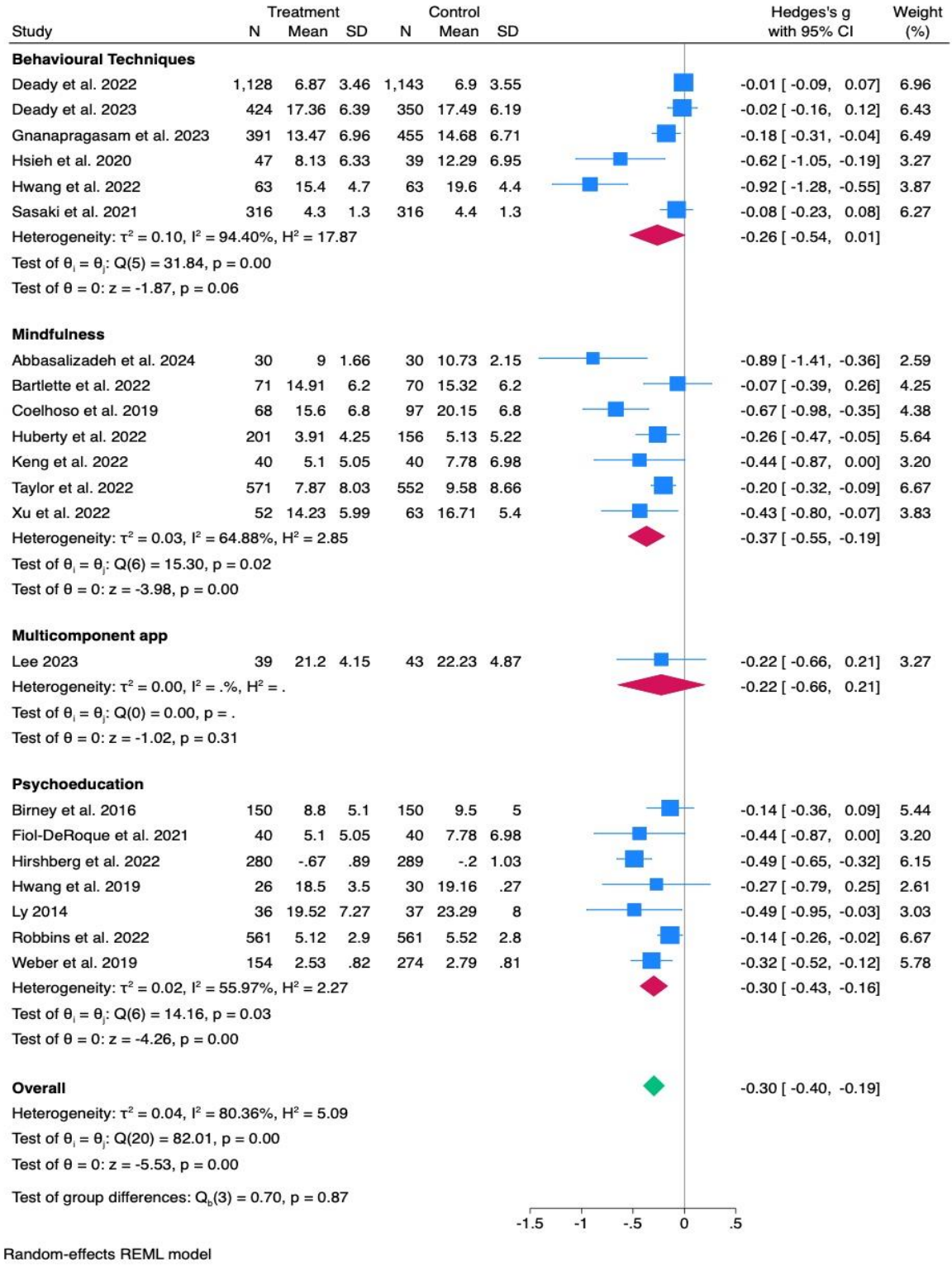
Study
Treatment N Mean SD
Control N Mean SD
Hedges's g with 95% CI
Weight (%)
Behavioural Techniques
Deady et al. 2022 1,128 6.87 3.46 1,143 6.9 3.55 -0.01 [-0.09, 0.07] 6.96
Deady et al. 2023 424 17.36 6.39 350 17.49 6.19 -0.02 [-0.16, 0.12] 6.43
Gnanapragasam et al. 2023 391 13.47 6.96 455 14.68 6.71 -0.18 [-0.31, -0.04] 6.49
Hsieh et al. 2020 47 8.13 6.33 39 12.29 6.95 -0.62 [-1.05, -0.19] 3.27
Hwang et al. 2022 63 15.4 4.7 63 19.6 4.4 -0.92 [-1.28, -0.55] 3.87
Sasaki et al. 2021 316 4.3 1.3 316 4.4 1.3 -0.08 [-0.23, 0.08] 6.27
Heterogeneity: τ² = 0.10, I² = 94.40%, H² = 17.87 -0.26 [-0.54, 0.01]
Test of θi = θj: Q(5) = 31.84, p = 0.00
Test of θ = 0: z = -1.87, p = 0.06
Mindfulness
Abbasalizadeh et al. 2024 30 9 1.66 30 10.73 2.15 -0.89 [-1.41, -0.36] 2.59
Bartlette et al. 2022 71 14.91 6.2 70 15.32 6.2 -0.07 [-0.39, 0.26] 4.25
Coelhoso et al. 2019 68 15.6 6.8 97 20.15 6.8 -0.67 [-0.98, -0.35] 4.38
Huberty et al. 2022 201 3.91 4.25 156 5.13 5.22 -0.26 [-0.47, -0.05] 5.64
Keng et al. 2022 40 5.1 5.05 40 7.78 6.98 -0.44 [-0.87, 0.00] 3.20
Taylor et al. 2022 571 7.87 8.03 552 9.58 8.66 -0.20 [-0.32, -0.09] 6.67
Xu et al. 2022 52 14.23 5.99 63 16.71 5.4 -0.43 [-0.80, -0.07] 3.83
Heterogeneity: τ² = 0.03, I² = 64.88%, H² = 2.85 -0.37 [-0.55, -0.19]
Test of θi = θj: Q(6) = 15.30, p = 0.02
Test of θ = 0: z = -3.98, p = 0.00
Multicomponent app
Lee 2023 39 21.2 4.15 43 22.23 4.87 -0.22 [-0.66, 0.21] 3.27
Heterogeneity: τ² = 0.00, I² = .%, H² = . -0.22 [-0.66, 0.21]
Test of θi = θj: Q(0) = 0.00, p = .
Test of θ = 0: z = -1.02, p = 0.31
Psychoeducation
Birney et al. 2016 150 8.8 5.1 150 9.5 5 -0.14 [-0.36, 0.09] 5.44
Fiol-DeRoque et al. 2021 40 5.1 5.05 40 7.78 6.98 -0.44 [-0.87, 0.00] 3.20
Hirshberg et al. 2022 280 -.67 .89 289 -.2 1.03 -0.49 [-0.65, -0.32] 6.15
Hwang et al. 2019 26 18.5 3.5 30 19.16 .27 -0.27 [-0.79, 0.25] 2.61
Ly 2014 36 19.52 7.27 37 23.29 8 -0.49 [-0.95, -0.03] 3.03
Robbins et al. 2022 561 5.12 2.9 561 5.52 2.8 -0.14 [-0.26, -0.02] 6.67
Weber et al. 2019 154 2.53 .82 274 2.79 .81 -0.32 [-0.52, -0.12] 5.78
Heterogeneity: τ² = 0.02, I² = 55.97%, H² = 2.27 -0.30 [-0.43, -0.16]
Test of θi = θj: Q(6) = 14.16, p = 0.03
Test of θ = 0: z = -4.26, p = 0.00
Overall -0.30 [-0.40, -0.19]
Heterogeneity: τ² = 0.04, I² = 80.36%, H² = 5.09
Test of θi = θj: Q(20) = 82.01, p = 0.00
Test of θ = 0: z = -5.53, p = 0.00
Test of group differences: Qb(3) = 0.70, p = 0.87
-1.5
-1
-.5
0
.5
Random-effects REML model

Figure 6 Sub-group analysis of the effect of post-intervention effect size for common mental health outcomes across all 21 studies

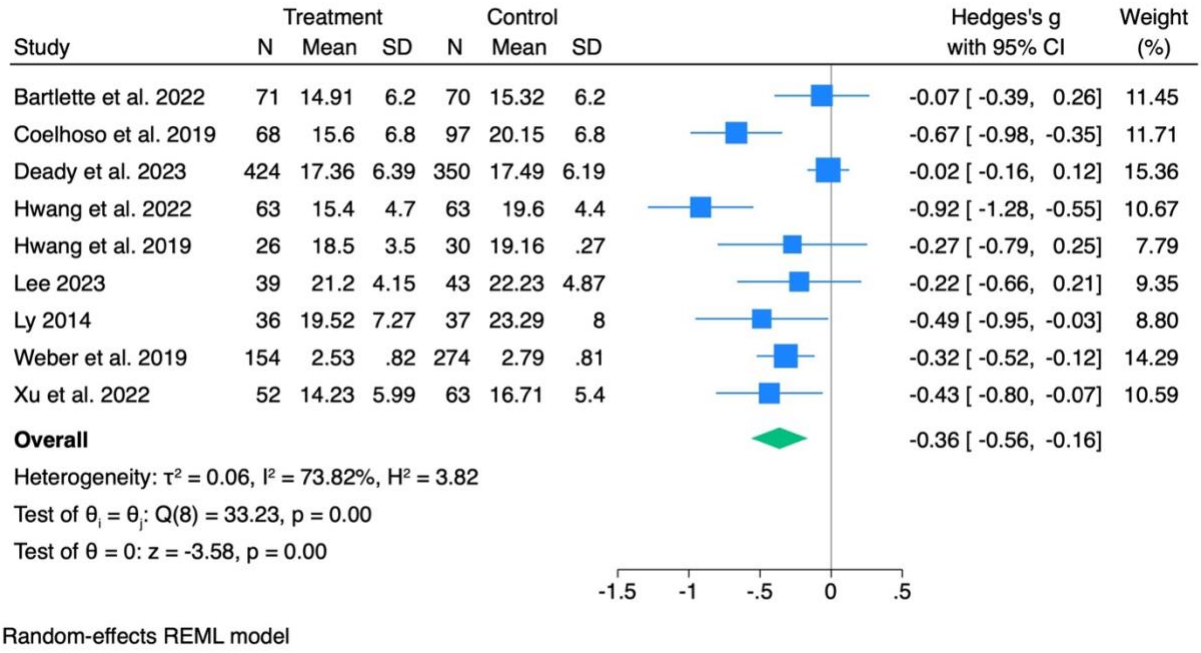

Figure 7 Forest plot of post-intervention effect size for perceived stress outcome measure across nine studies

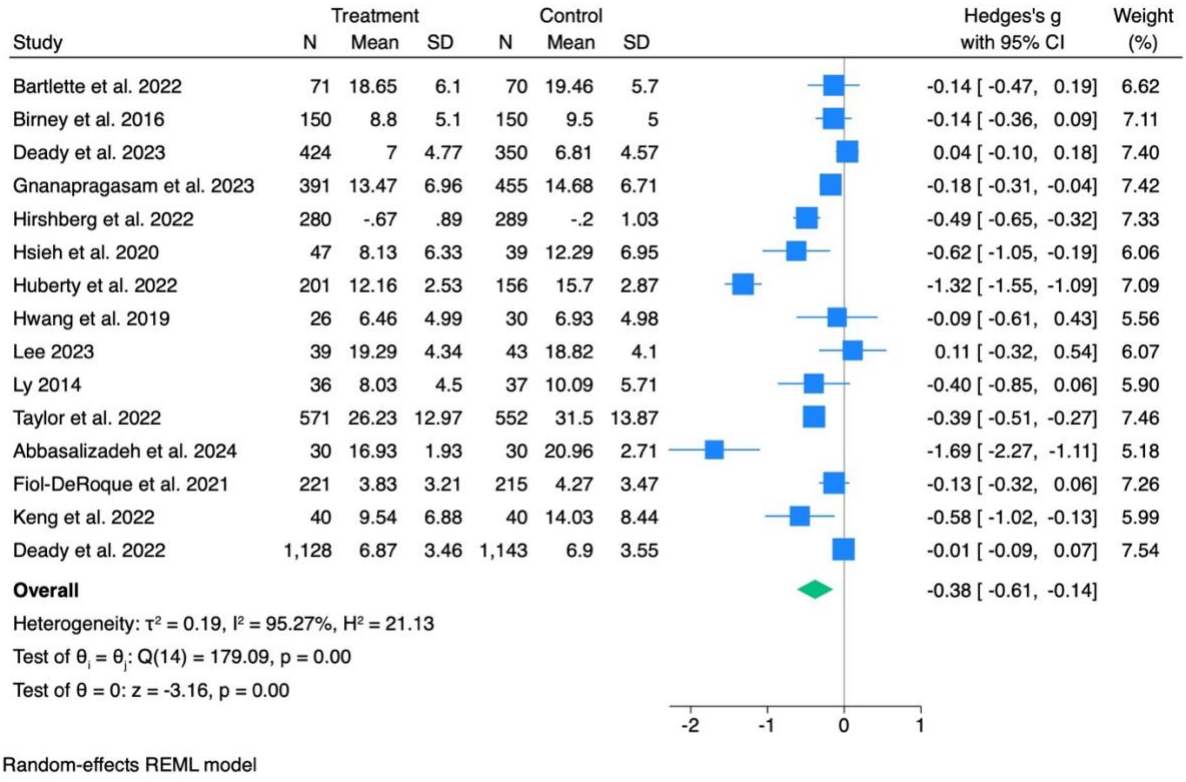

Figure 8 Forest plot of post-intervention effect size for perceived distress outcome measure across 15 studies

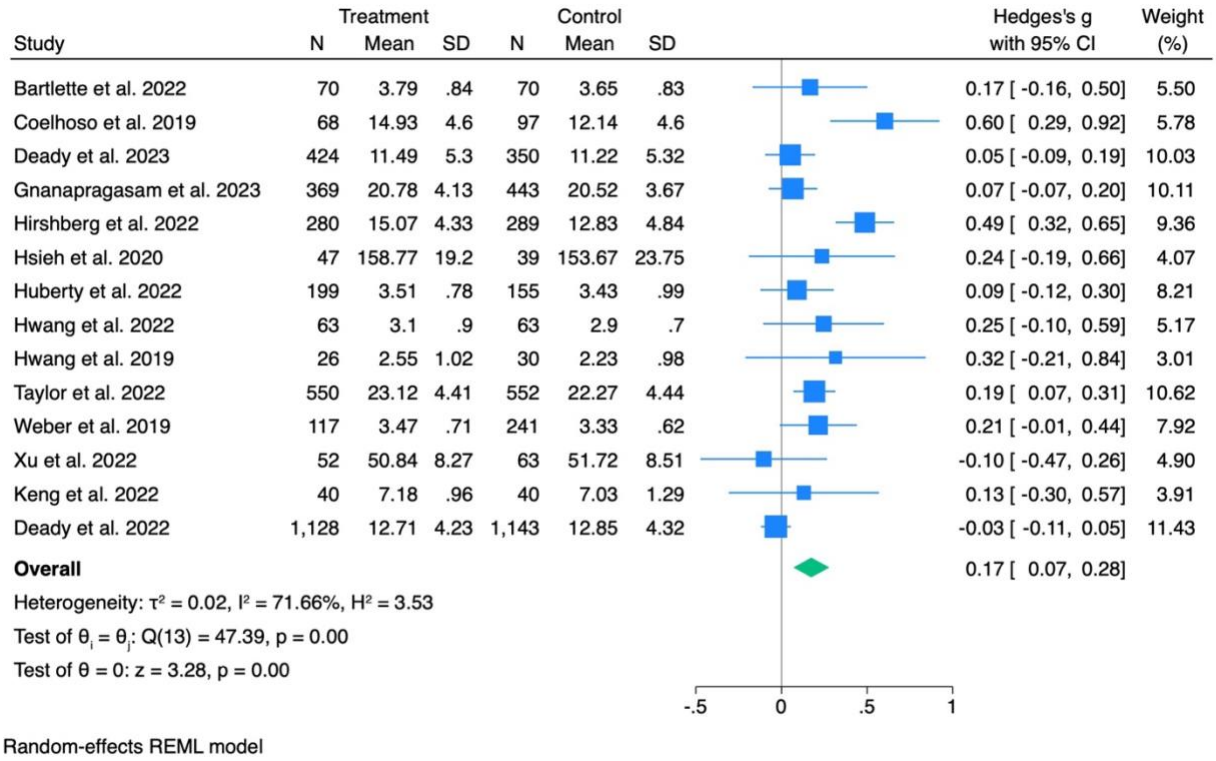

Figure 9 Forest plot of post-intervention effect size for wellbeing-related outcomes measured across 14 studies

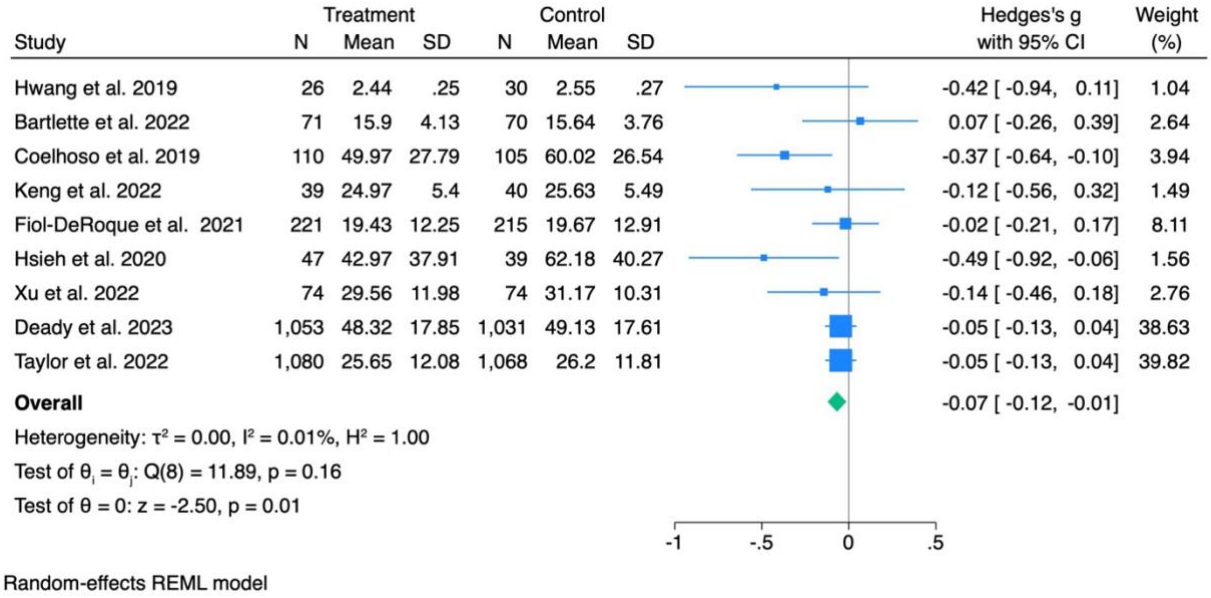

Figure 10 Forest plot of post-intervention effect size for burnout measured across nine studies

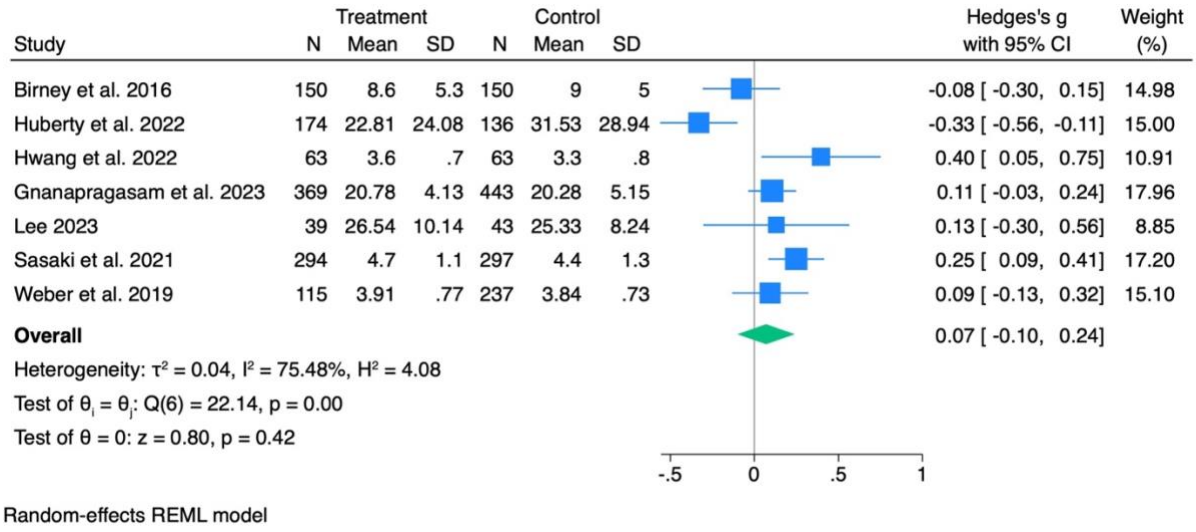

Figure 11 Forest plot of post-intervention effect size for workplace-related outcomes measured across seven studies

Small Study Effects

A funnel plot for each outcome is shown in Appendix 2. Visual examination of the funnel plot suggests that no publication bias existed for psychological distress outcomes (β=-2.12, SE = 1.471, p=0.149) and wellbeing outcomes (β=0.80, SE = 0.865, p= 0.355). However, significant asymmetry was found for the effect of mental health apps on combined mental health outcomes (β = -2.33, SE = 0.598, p < 0.0001). The trim-and-fill method suggests that eight studies with significant effects may be missing from the current literature for mental health apps (Appendix A). After adjusting for these missing studies, the imputed SMD shows evidence for the effectiveness of mental health apps in improving mental health outcomes, but the effect size is slightly reduced (SMD=-0.17, CI 95% -0.28 to -0.02).

DISCUSSION

This review aimed to synthesize the emerging body of literature on the effectiveness of app-based mental health interventions in improving workers' mental health, and workplace-related outcomes. Our systematic search identified 21 RCTs evaluating mental health apps with workers, comprising a total of sample of 13,049 participants. These participants included workers from a range of industries, with nearly half of the studies (12/21, 57%) involving healthcare workers. Studies comprised of mental health apps that were focused on mindfulness (7/12, 33%), psychoeducation (7/12, 33%), behaviour change techniques (6/21, 28%), or a combination of these techniques (1/21, 6%).

Overall, RCTs with large sample sizes provide evidence for the effectiveness of mental health apps for workers when compared to control groups in improving mental health outcomes. There are some concerns, however, about the certainty of evidence based on the GRADE criteria. The majority of the evidence comes from studies with plausible bias, which raises some doubt about the results and likely weakens confidence in the results. Major limitations that led to studies being rated as having 'Some Concerns' or 'High' risk of bias are because studies were unable to conceal study participants to the assignment of app use, use of self-rating scales, and high dropout rates. Although all the trials evaluated mental health apps, the nature of the interventions included in the meta-analyses was quite diverse. The interventions included in the meta-analyses consisted of different therapeutic focuses (psychoeducation, mindfulness, behavioural techniques-based apps) with varying levels of guidance and instructions to engage. These unexplained clinical differences across studies and very large statistical heterogeneity seen in the I^2 value demonstrated very

serious inconsistencies. There were also differences in the participants with workers recruited from different industries and in the assessment of outcomes across included studies, because of which the certainty was lowered for indirectness. Lastly, a visual inspection of funnel plots for each outcome suggested that there may have been a small study effect (that is, the potential for some publication bias) that was confirmed through the assessment of small study effects for combined mental health outcomes. It appears that studies showing no effect or harm have not been because of which the certainty was lowered.

Our result from the meta-analysis of 21 studies indicates very low certainty evidence that mental health apps for workers produced a small positive effect compared with a control group on common mental health outcomes (SMD=0.30, 95% CI -0.40 to -0.19, k=21), particularly in improving perceived stress (g=-0.363, 95% CI -0.562 to -0.164, k=9), symptoms of depression and anxiety (g=-0.379, 95% CI -0.615 to -0.144, k=15), wellbeing (g=0.174, 95% CI 0.07 to 0.279, k=14), and burnout (g=-0.07, 95% CI -0.12 to -0.01, p=0.01). However, no significant effects were found for work-related outcomes where studies evaluated effects on workplace productivity and engagement (Z=0.80, p=0.42). Subgroup analyses of different intervention types revealed no significant differences post-intervention, while individual group effects were slightly superior for mindfulness-based interventions (SMD=-0.37) and psychoeducation (SMD=-0.32) than behavioural techniques-based apps (SMD=-0.26), when compared to control groups.

The findings in this review are consistent with previous reviews of digital mental health intervention that included both web-based/ internet-based interventions and

smartphone apps delivered with workers that showed significant small to moderate effects in improving mental health outcomes [6,8,11,12,47]. In a review conducted by Phillip et al. [46] on the effectiveness of digital e-mental health interventions that included 34 studies, both web-based and app-based digital mental health interventions for workers, similar effect sizes were found in the reduction of stress (g=0.44), symptoms of anxiety (g=0.27), depression (g=0.34). In terms of wellbeing, the effect size found in our study is lower than those reported in previous reviews of digital mental health interventions. For example, Phillip et al. reported an effect size of 0.35, similar to Carolan et al., who found an effect size of 0.37. This could be likely because when web-based and app-based mental health interventions are assessed together, the size of the effect could be inflated. Additionally, the broader definition of well-being used in the review, where improvement in wellbeing constituted a reduction of symptoms of depression or anxiety, may have contributed to their larger effect sizes. In contrast to this broad definition, our meta-analysis for wellbeing included studies that measured wellbeing as an outcome using reliable and valid measures such as the 5-item World Health Organization Well-Being Index (WHO-5) [49] and the Warwick-Edinburgh Mental Wellbeing Scale [50].

For burnout, the review by Phillip et al. [46] found a moderate effect size for the reduction of burnout (g=0.51) in comparison to our findings of significant but small effect size (g=0.07) that indicates that there was little to no impact on reducing burnout. It is, however, important to note that our meta-analysis consisted of only nine studies, where burnout was often considered to be a secondary outcome among the studies included in this review. Another review specifically examining the effectiveness of digital mental health

interventions among healthcare workers found significant effects in reducing burnout, specifically within the emotional exhaustion domain, but no effects on depersonalization or personal accomplishment across five trials [51]. These differences warrant further investigation into moderating factors, such as whether workers in high-stress industries, like healthcare, experience greater reductions in emotional exhaustion. Additionally, more studies are needed to better estimate the overall pooled effectiveness of these interventions in a meta-analysis.

In terms of workplace-related outcomes, we analyzed seven studies that measured workplace productivity and engagement together and found no significant effects, which contributes to the conflicting evidence in the current literature. Previous reviews of workplace digital mental health interventions reported small positive effect sizes in workplace engagement ($g=0.19$) and productivity ($g=0.16$), with slight improvements at follow-up for both engagement ($g=0.24$) and productivity ($g=0.20$) [47]. However, a recent systematic review of 17 workplace digital mental health intervention studies whose period of intervention and assessment ranged between a span of 8-weeks to one year found no significant difference in productivity post-intervention, suggesting that the effects of digital mental health interventions on workplace outcomes may take longer to detect a meaningful and statistical difference [52]. These findings support the hypothesis that changes in workplace-related outcomes take time, and long-term follow-up is necessary to explore potential effects [52]. Future studies should prioritize long-term evaluations of workplace-related outcomes.

Strengths and Limitations

To our knowledge, this study is one of the first comprehensive systematic review and meta-analyses on the effectiveness of mental health apps for workers. This review is timely, given the growing interest in digital technology and the increasing number of mental health apps being employed in the workplace. Additionally, while our study is one of the first to critically examine the certainty in the evidence appraised using the GRADE criteria, the evidence presented in this review has low certainty.

There are several limitations that need to be noted. Despite these promising results, our analysis revealed high heterogeneity, a common issue seen within a meta-analysis of studies in this digital mental health field that requires further exploration and explanation [6,46]. When interpreting these findings, caution is warranted. One of the main considerations for downgrading GRADE judgements was concerns related to the risk of bias and very serious inconsistencies because of unexplained heterogeneity across studies. There is a wide variability in participant characteristics, study context, intervention content, and guidance. Our study was limited in its scope to explore the role of possible moderators in terms of intervention type, structured vs self-guided intervention, work industry, and presence of clinical symptoms at baseline on the intervention effects. A future study is needed to examine and explain the heterogeneity that is currently embedded in mental health app studies. Additionally, we did not analyze follow-up data, so we cannot conclude the long-term effect of mental health apps on relevant outcomes.

Conclusion

The findings from this review demonstrate very low certainty evidence that mental health apps for workers or workplaces are moderately effective in reducing symptoms of anxiety

and depression, perceived stress and improvement in wellbeing compared to a control group. This review has several implications, including the value of employing mental health apps to address workers' growing mental health needs. Key findings from this review suggest that mental health apps, which include components such as psychoeducation, mindfulness and behavioural techniques, are effective in improving mental health outcomes for workers from a range of industries, including healthcare and male-dominated industries that are often characterized by high levels of stigma and poor help-seeking. Further research is needed to explore the influence of different moderators, such as usage patterns, industry, and type of intervention that influence these effects, to optimize the impact of mental health apps in a real-world setting such as the workplace. While the existing body of evidence shows good promise, it is clear that more rigorous, diverse, and long-term studies are needed to further understand and build efficacy for mental health apps.

Author contributions

This research was primarily conceptualized and led by SA as a part of her PhD thesis. Coauthors LM, JM and SM [Lead author] were supervisors for the first author (SA). SA prepared the original draft of the manuscript with contributions from all coauthors in the form of reviewing and editing the manuscript. SM provided subject matter expertise in mental health applications. LM and JM provided methodological and statistical knowledge for conducting meta-analyses. [All authors reviewed, contributed to and approved the final version of the manuscript. All authors have read and agreed to the published version of the manuscript.]

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SA undertook the reported research as part of a PhD thesis. Research scholarships through the Public Health Agency of Canada supported MP and SA, who conducted the study screening. The funders had no role in the study design, analysis, or manuscript preparation.

Conflict of Interest

The authors declare no conflict of interest.

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List of Abbreviations

RCT Randomized Control Trial

PRISMA Preferred Reporting Items for Systematic Reviews and Meta-Analyses

Rob Risk of Bias

SMD Standardized Mean Difference

CI Confidence Interval

SD Standard Deviations

USA United States of America

UK United Kingdom

WHO-5 World Health Organization Well-Being Index

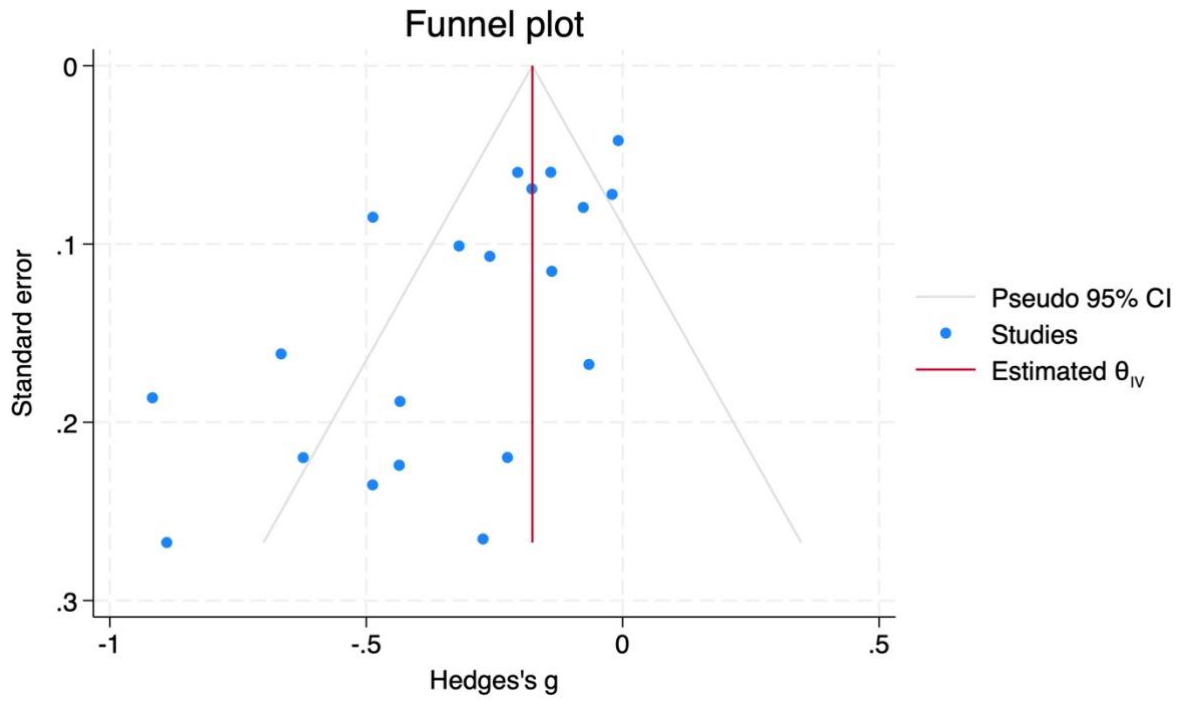
Appendix 2

A. Search Strategy

1. Employment/
2. employment.ti,ab.
3. (job or worker or workplace or employee* or occupation* or manager).ti,ab.
4. 1 or 2 or 3
5. smartphone.ti,ab.
6. ((mobile or digital or handheld) adj2 (device or app or application)).ti,ab.
7. 5 or 6
8. Mental Disorders/
9. Mental Health/
10. ((mental* or mood or affect*) adj2 (disorder* or health or illness)).ti,ab.
11. anxiety.ti,ab.
12. wellbeing.mp.
13. depress*.ti,ab.
14. wellbeing.mp.
15. Randomized control trial.mp.
16. RCT.mp.
17. Clinical trials.mp.
18. 15 or 16 or 17
19. 4 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14
20. 4 and 7 and 18 and 19

B. Funnel plots and Eggers test tables for outcomes of included studies

B.1 Funnel plot for combined mental health outcome



B.1.2 Eggers test for small-study effects for combined mental health outcome

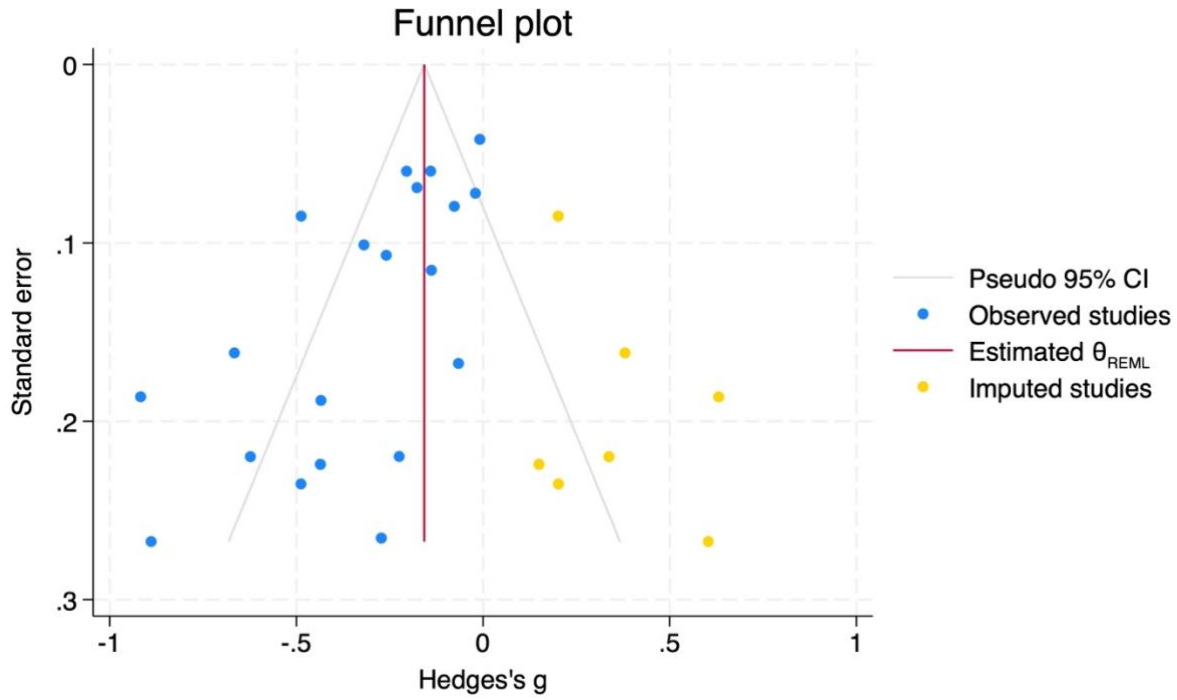
```
Regression-based Egger test for small-study effects
Random-effects model
Method: REML

H0: beta1 = 0; no small-study effects
            beta1 =     -2.33
      SE of beta1 =     0.598
                z =     -3.90
       Prob > |z| =    0.0001
```

B.1.3 Trim and Fill analysis for combined mental health outcome

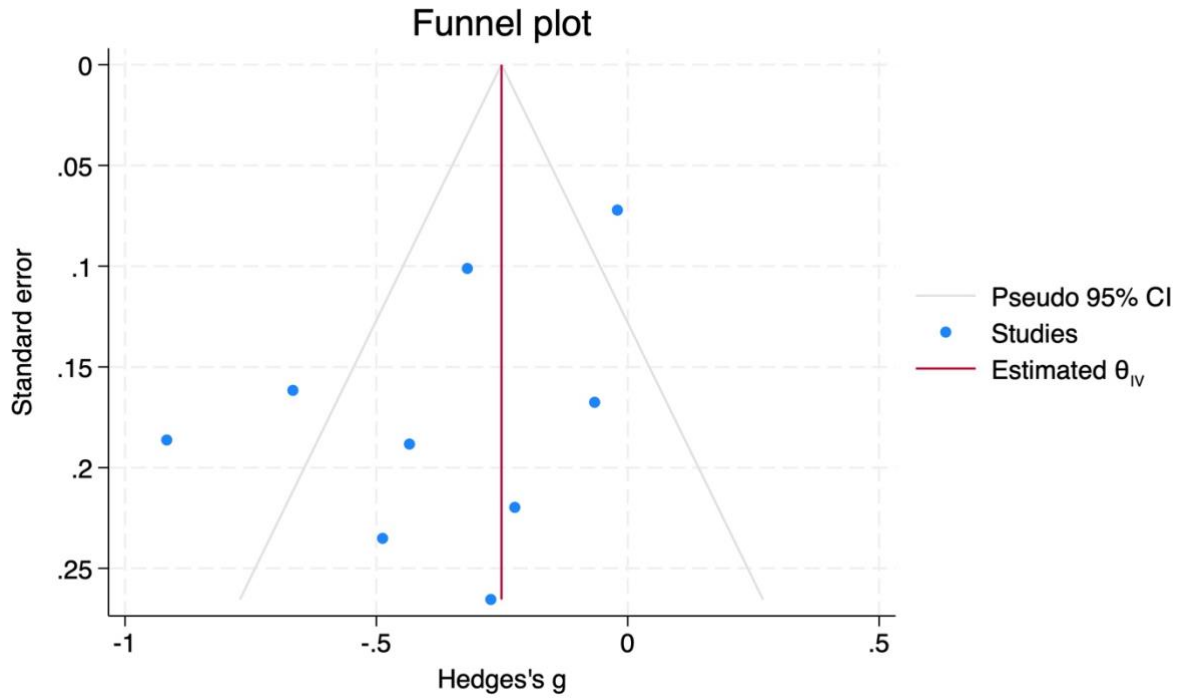
```
Iteration                              Number of studies =     29
  Model: Random-effects                         observed =     21
 Method: REML                                   imputed =      8

Pooling
  Model: Random-effects
 Method: REML
```

Studies	Hedges's g	[95% conf.	interval]
Observed	**-0.296**	**-0.401**	**-0.191**
Observed + Imputed	**-0.157**	**-0.288**	**-0.027**

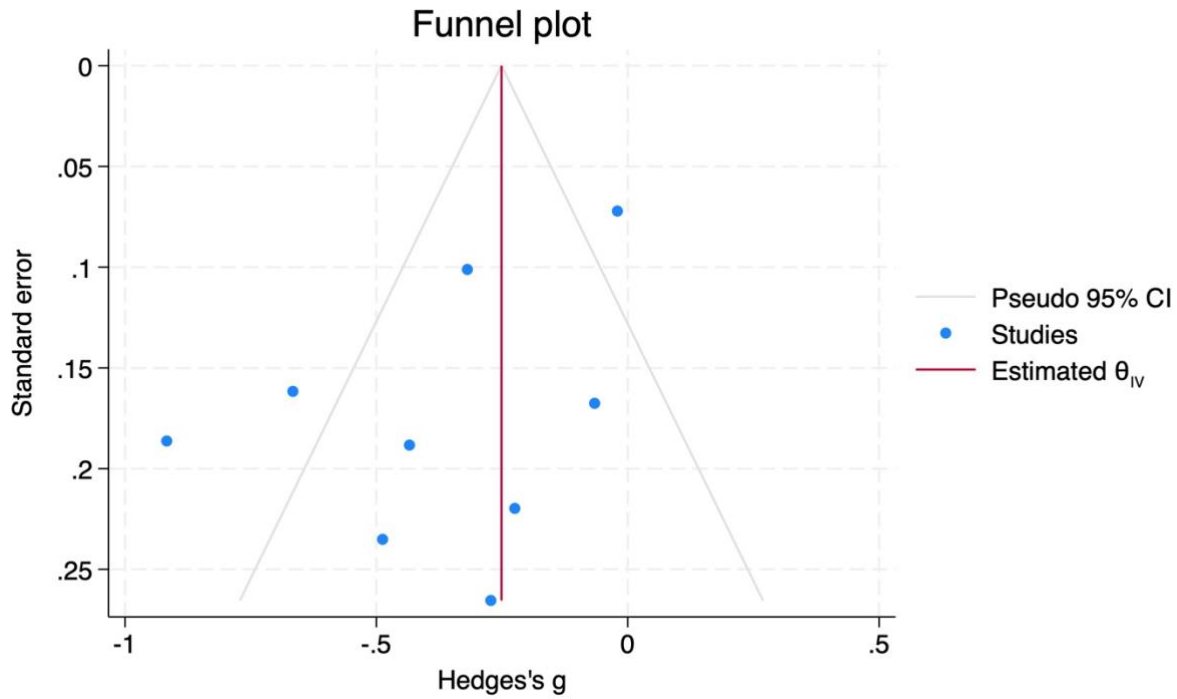
B.1.4 Funnel plot with imputed studies for combined mental health outcome



B.2 Funnel plot for perceived stress outcome



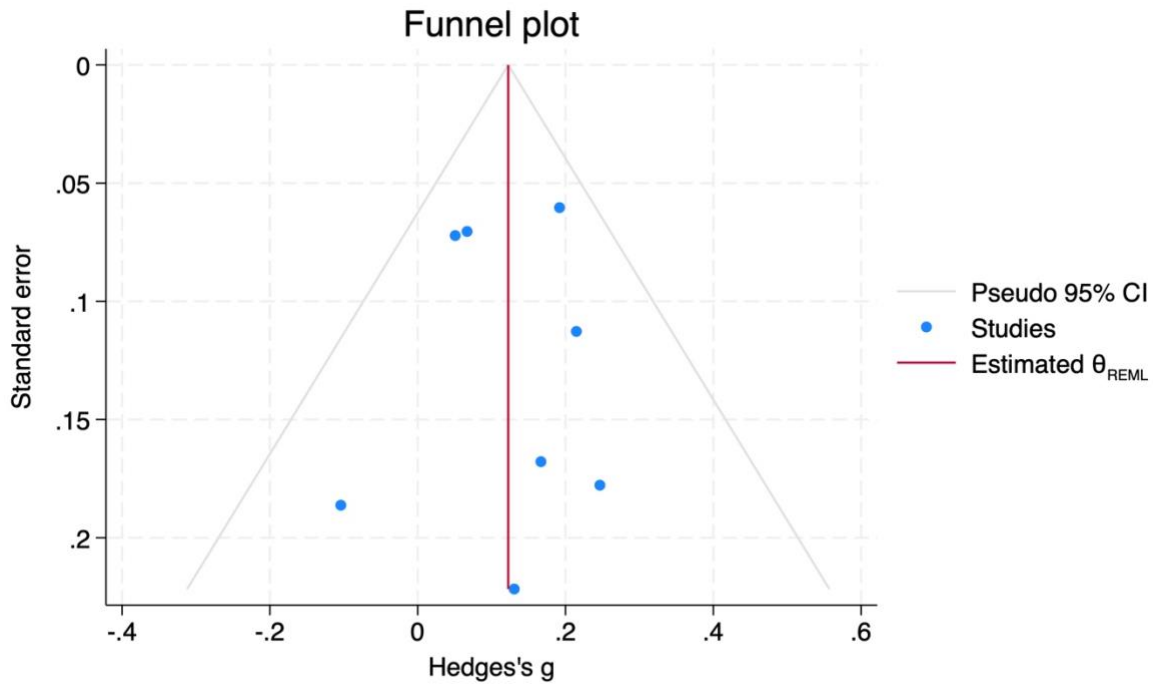
B.3 Funnel plot for psychological distress outcome



B.3.1 Eggers test for small study effects for psychological distress outcome

```
Regression-based Egger test for small-study effects
Random-effects model
Method: REML

H0: beta1 = 0; no small-study effects
            beta1 =     -2.12
      SE of beta1 =     1.471
                z =     -1.44
       Prob > |z| =    0.1499
```

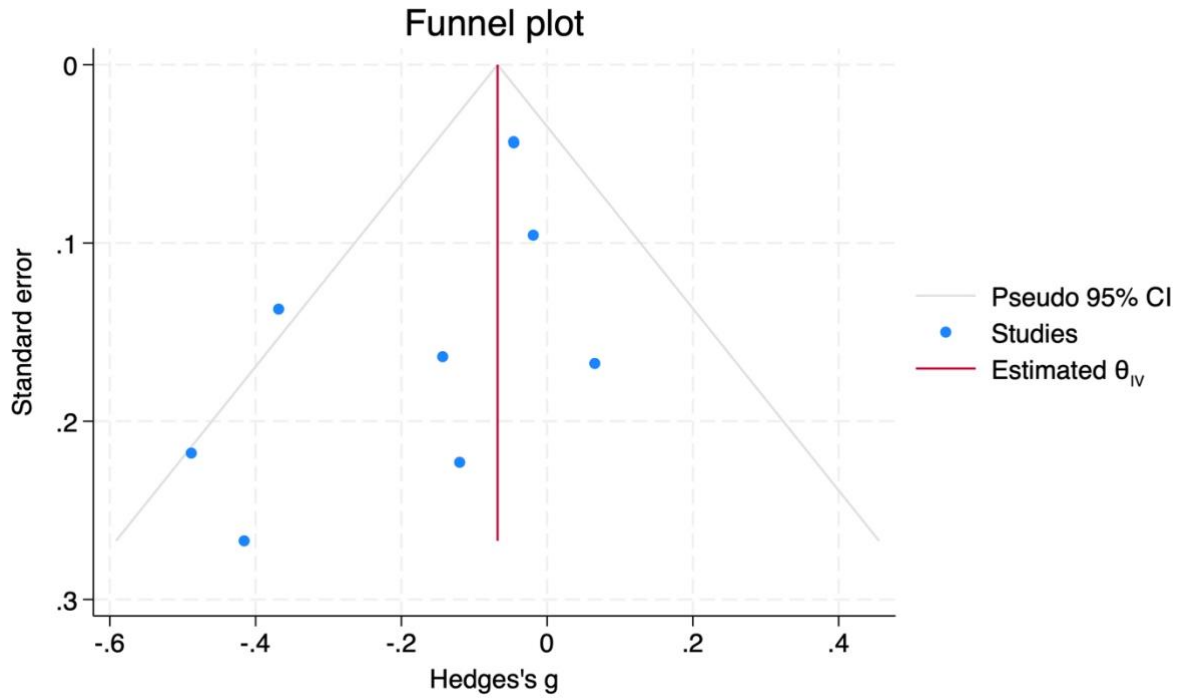
B.4 Funnel plot for wellbeing outcome



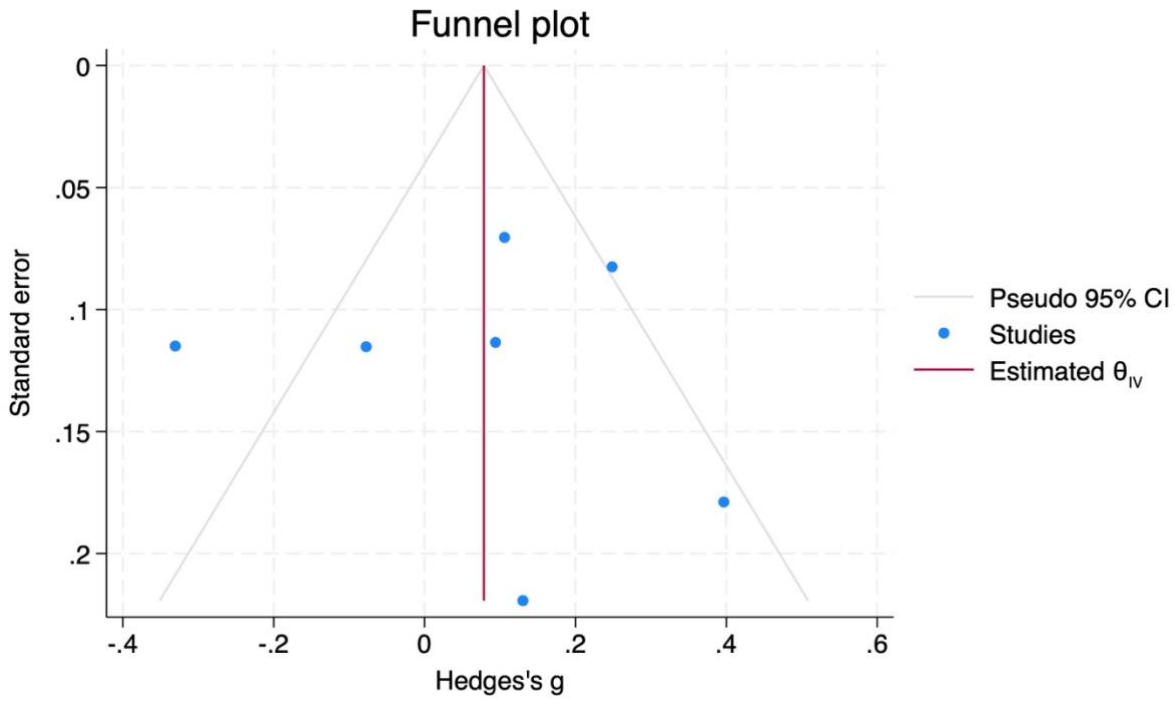
B.4.1 Eggers test for small-study effects for wellbeing outcome

```
Regression-based Egger test for small-study effects
Random-effects model
Method: REML

H0: beta1 = 0; no small-study effects
            beta1 =      0.80
      SE of beta1 =     0.865
                z =      0.92
       Prob > |z| =    0.3554
```

B.5 Funnel plot for Burnout & Occupational stress



B.6 Funnel plot for Workplace engagement


Funnel plot
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Chapter 4: Mental Health App for Healthcare Workers: A Case Study Implementation of the Beyond Silence App

Abstract

Background: Healthcare workers face high rates of mental health challenges, highlighting the urgent need for accessible support. Mental health apps are emerging as scalable tools to address workplace mental health. However, the real-world factors influencing their implementation and use within workplaces remain underexplored.

Objective: This study examined the factors shaping the implementation and use of Beyond Silence, a mental health app for healthcare workers.

Methods: A concurrent explanatory mixed-method case study design was employed. Download and usage metrics were collected for the study's implementation period (16-months). Interviews with two organizational champions (at baseline, 3-months and 16-months) and focus groups with six peer support providers (at 3-months and 16-months) were conducted to explore factors shaping implementation at a multi-site hospital and explain app usage trends. Interview and focus group data were analyzed using theory-informed thematic analysis.

Results: Usage metrics indicated a 14% download rate, 405 app openings and nine peer support appointments. Six themes across the three categories captured the key action mechanisms that shaped the implementation and use of the app: I. Contextual Factors: 1) crisis as a catalyst in normalizing seeking help; 2) culture of care and readiness for implementation; 3) tensions between espoused values and workload demands; II.

Innovation Factors 4) App onboarding complexities; 5) relative advantage of accessing in-person vs app-based supports; and III. Implementation Factors: 6) Building momentum to challenges in sustained engagement.

Conclusion: Successful implementation of workplace mental health apps requires organizational readiness, clear implementation planning, sufficient time and resources, and ongoing communication.

Keywords: *Mental health, Mhealth, Health Personnel, Mobile Applications, Workplace, Implementation Science*

INTRODUCTION

Supporting the mental health needs of healthcare workers is urgent and critical in the current healthcare climate [1]. The emotionally demanding nature of healthcare, consistent shortages in the workforce, and the long-term impacts of the COVID-19 pandemic have increased their vulnerability to isolation, burnout, and mental health issues [1]. In a national survey of over 4400 Canadian healthcare workers, 57% of respondents screened positive for anxiety and 44% for depression, with high rates of fear and concern related to their health at work [2]. To address this rising mental health crisis among healthcare workers, guidelines for supporting their needs emphasize the importance of mobilizing accessible platforms to provide access to mental health information, resources, and connections to both formal professional support and informal peer support networks [3].

With the rise of digital mental health interventions, there is substantial evidence supporting the value of mental health apps as an accessible and anonymous means of providing mental health support to healthcare workers [4]. Mental health apps that are typically accessed through personal or workplace smartphone devices offer a unique opportunity to overcome barriers to help-seeking, including geographical limitations, time constraints, or stigma— that are specially relevant in healthcare settings characterized by shift work and high work demands [5,6]. Several studies investigating the effects of mental health apps have been carried out with healthcare workers, including emergency department workers, physicians and nurses, who have reported significant improvements in well-being, self-compassion and reductions in work-related stress, depression, anxiety and burnout. However, findings related to their impact have been inconsistent. For instance,

three studies evaluating the Headspace mindfulness app showed varied outcomes- one study found significant reductions in stress, depression and anxiety over time but no improvement in burnout [7]; another study reported improvement in burnout, stress and wellbeing [8], and the third study observed no improvement in primary mental health outcomes but noted improvement in secondary outcomes such as self-compassion [9]. It has been demonstrated that transferability from one setting to another for organizational-level interventions does not guarantee that similar effects can be produced [10].

Engagement and usage rates vary widely across studies implementing digital mental health interventions in the workplace. For instance, a systematic review of such interventions found that the adherence level (i.e., completing all prescribed components of the digital intervention) ranged between 3% and 95% [11]. There is a lack of understanding of the factors that impact and influence these usage rates.

So far, studies typically performed a summative evaluation, focusing on whether the app successfully improved outcomes. However, limited studies performed a formative evaluation, exploring the practical challenges of how a mental health app functions within multidimensional and diverse healthcare settings. There is a need to conduct process evaluations to systematically explore how apps are implemented, particularly examining the complex workplace context where implementation is occurring and the individuals interacting with the app [12]. Adopting an implementation science approach within a mixed-method study can enable the systematic investigation to explore and explain factors influencing the uptake and implementation of mental health apps in the workplace.

Therefore, this study aims to explore factors that may influence the implementation and use of Beyond Silence, a new mental health app developed for healthcare workers in the context of a healthcare organization. The study methodology and synthesis of findings were informed by the Consolidated Framework for Implementation Research (CFIR), which consists of five domains (inner context, outer context, innovation, individual and implementation process) and 39 constructs that will enable the identification of barriers and facilitators to successful implementation as well as explain the trends in download and use of the Beyond Silence app [13].

METHODS

Study Design and Setting

A concurrent explanatory single-case study mixed-methods design (QUAL+ quan) was used to explore and explain the implementation and use of the Beyond Silence app within one medium-sized multi-site hospital. Given that this study focuses on both the uptake and implementation processes, mixed methods can provide a holistic understanding by combining 'how' apps are used and 'what' factors influence uptake and implementation.

The study adopted an implementation science lens by employing the CFIR [14] to collect, analyze and interpret the qualitative and quantitative data. This approach enables an in-depth exploration and illustration of the relationship between the different factors shaping the app's implementation. The study context is a medium-sized healthcare organization offering a range of services, including tertiary and long-term care services, across five different sites in a small urban centre in Northern Ontario, Canada. This

organization was recruited as an exemplary case due to its unique position as a mid-sized healthcare organization interested in building psychological health and safety at work. Ethics for this study was approved by the local ethics board. Written informed consent was obtained from all interviews and focus group participants, while app users need to agree to a privacy policy upon downloading the app. This manuscript is prepared by adhering to the guidelines outlined in the standards for reporting Implementation Studies (StaRI Statement) [15].

Recruitment

Participants in this study included organizational champions, peer support providers and app users.

The organization nominated organizational champions and peer support providers. For this study, an organization champion was defined as an employee within the participating site who was passionate about advancing mental health and work and committed to leading the implementation of the Beyond Silence app within their organization. Their responsibilities included liaising with the research team, developing an implementation plan, sharing communications about the app, and identifying any relevant internal/local resources or workplace policies to be integrated into the app. Peer support providers were employees within the organization who had undergone previous workplace peer support-related training and were recruited with the assistance of the organizational champions. Their responsibilities included volunteering six hours weekly to offer virtual peer support via the Beyond Silence app.

All employees (clinical/non-clinical, part-time/full-time) across the five sites of the organization were eligible to use the app. The app was available for download and use from December 2022 to March 2024, 16 months. To support the launch, in-person events were held at each site, guiding downloading the app, entering the unique organizational code, and navigating the app. Attendees also had the opportunity to ask the organizational champions and research team questions. In addition, instructions for downloading the app and the organizational code were distributed via internal email at the launch and twice during the implementation period. Posters were strategically placed across each site to promote the app further.

Data Collection

Qualitative data was collected through interviews with organizational champions and focus groups with peer support providers. As described above, the CFIR data collection tool (https://cfirguide.org) [13] was used to develop the interview and focus group guide by carefully reviewing and selecting constructs and subconstructs relevant to the context of this study. The guide consisted of prompts identified from each of the five domains: Inner setting (organizational context across the five sites), outer setting (broader healthcare climate/ societal context), innovation (Beyond Silence app), individual characteristics (organizational champions, peer support providers and app users) and the implementation process. Semi-structured interviews with organizational champions were conducted at baseline, 3-months and 16-months, typically lasting around 60 minutes. Focus groups with peer support providers were virtually conducted at 3 and 16 months of implementation and

typically lasted 90 minutes. Both interviews and focus groups were conducted virtually via video conferencing software (Zoom Inc.).

In the current study context, uptake was defined as the act of downloading and installing the app and the extent of usage (e.g., frequency). Quantitative data to assess uptake was collected through software usage metrics, including the number of downloads, the number of clicks per app feature, and the number and type of peer support appointments scheduled during the implementation period. Additionally, the app includes a wellness rating scale that is set up on a sliding scale from 0-20 that is colour-coded to indicate wellness levels: green (0-6, Well), yellow (7-9, Alright), orange (10-14, Struggling), and red (15-20, In Crisis).

Intervention

The Beyond Silence app aims to promote early intervention for mental health at work through evidence-based information, resources and access to peer support. This bilingual app's (available in English and French) development was informed by several years of research with healthcare workers using a co-design approach to develop culturally safe, trauma-informed information and peer support [113,114]. The goal of the app is to build mental health literacy and reduce barriers to seeking support, including peer support either within or outside the organization. The app provides a secure and anonymous platform where users are required to only enter a unique organizational access code since it is designed to be customized to each organization through embedded links to relevant organizational policies (e.g. bullying/harassment) and local resources (e.g., Employee

Assistance Program (EAP) , community supports). After downloading, users have an option to enter demographic details such as age, gender and role within the app.

There are several pathways to access help depending on the needs of the user. A check-in feature consists of pathways to explore support for themselves or a co-worker. Different pathways through the check-in leads the users to evidence-informed "information briefs" (articles, podcasts, or videos) about key mental health issues that impact healthcare workers (e.g., sleep and shiftwork, burnout, moral injury). Other features in the app include goal setting, wellness monitoring and links to local/internal resources (e.g., EAP, local community mental health resources) and relevant organizational policies (e.g., bullying/harassment policies). Another key feature is access to peer support providers from within and outside their organization; with an ability to browse profiles and availability of peer support providers by clicking on 'view their biography'.

A secure phone call or chat appointment can be booked with the peer supporter through the app. Peer supporters, whether recruited from within or outside the organization, have access to a web portal. Through this portal, they can answer calls and respond to chat appointments, review guidelines, and access information about mental health resources to share with app user as well as resources for themselves. At regular intervals, for instance when new content was uploaded, a notification was sent to users as a reminder prompts for them to explore the app and the new content.

Data analysis

Qualitative and quantitative data were analyzed concurrently. To provide a comprehensive account of the different factors influencing the implementation of the app, we combined the analysis of the interviews with organization champions and the focus groups with peer support providers. CFIR was a sensitizing framework that informed thematic analysis of qualitative data, managed through qualitative analysis software (Dedoose. Inc [18]). Thematic analysis followed the six stages outlined by Braun and Clarke [19] , which began with fully engaging with the data by reading and re-reading the transcripts. Next, initial codes informed by the CFIR constructs [13] were generated into a codebook that captured explicit and underlying meanings within the data. Preliminary coding was conducted independently by SA and MP to identify relevant data and map them into codes. Any coding discrepancy was resolved with a third reviewer (SM). Negative cases within and across the interviews and focus groups were carefully analyzed. Subsequently, through collaboration with the research team, themes were conceptualized by carefully interpreting the relationships and patterns between the codes that were further reviewed, refined and named to provide a clear, concise representation of findings. Detailed reflexive notes throughout the coding process were maintained that included rationale for coding choices, including inclusion and exclusion of specific codes.

Methodological rigor was ensured through prolonged engagement [20] with organizational champions and peer support providers during the implementation period to obtain thick and rich data. Although a typical member checking was not carried out, an end-of-implementation report was shared with organizational champions to discuss the findings in detail with opportunities to share their reflections.

Quantitative data consisted of descriptive summaries of app usage metrics. Integration of the quantitative and qualitative data was achieved by exploring how information about the organizational context of implementation informed the interpretation of the trends in app utilization [21,22]. Key findings generated by triangulating all the data sources were summarized as a 'case' with an in-depth description of the organizational context and the facilitators and barriers that influenced the uptake of the Beyond Silence App. Throughout the data analysis process, regular debrief meetings were carried out with the research project team which included a peer support expert, project coordinator, and an occupational therapist to aid in the conceptualization of the findings.

RESULTS

App Usage Metrics

During the 16-month implementation period, 108 employees (14% of all 769 employees) downloaded the Beyond Silence app, 72% of which occurred during the on-site launch events. The app was opened 405 times, with the most active user opening it 24 times. See Table 6 for the usage patterns across different app features.

Table 6. App Usage Metrics

Usage metrics	**Raw Count**
Number of downloads	108 (14% of employees)
Total App opens after download	405
Max app open by single user	25 (Median= 4, IQR=4)
Information articles	46
Wellness logs	55 (22 unique users)
Goals	26 (14 unique users)
Peer Support Appointments booked by users	9 (Completed=4; Cancelled/Missed=5)

Table 7. Theme mapped to CFIR Domains/ Constructs

Category	**Themes**
I. Contextual Factors	*1. Crisis as a catalyst in normalizing seeking help* **CFIR Domain/Constructs:** Outer Setting: Critical Incidents
	2.Culture of care and readiness for change **CFIR Domain/Constructs**: Inner Setting: Mission Alignment, Culture
	3. Tensions between espoused values and workload demands **CFIR Domain/Constructs**: Inner Setting: Work Infrastructure
II. Innovation Factors	*4. App onboarding complexities* **CFIR Domain/Constructs:** Innovation: Design, Complexity

	5. Relative advantage of accessing in-person vs app-based supports **CFIR Domain/Construct**: Innovation: Relative Advantage
III. Implementation Process	*6. Building momentum to challenges in sustained engagement* CFIR Domain/Construct: Implementation: Planning, Engaging and Implementation Deliverers

Thematic Analysis of Qualitative Data

Baseline and follow-up interviews with two organizational champions and two focus groups with six peer support providers were analyzed together to generate six key themes across three categories that illustrate different action mechanisms shaping the implementation and use of Beyond Silence. See Table 7 for categories, themes and illustrative quotes.

I. Contextual Factors

1. Crisis as a Catalyst in Normalizing Help-Seeking: This theme highlights how shared experiences of crisis among healthcare workers positively influenced the implementation and use of the app. Participants emphasized that experiencing a crisis, such as the COVID-19 pandemic, and its widespread impact on the mental health of healthcare workers likely facilitated more open discussions about mental health in the workplace and increased willingness to seek support. They noted that the recurrent outbreaks of COVID-19 across their sites subjected workers to constant stress as they struggled to meet demands that exceeded their capacity. One participant remarked that such experiences might have also led to moral injury among staff- *"Most of it's due to the pandemic; I would say at least three of the five unique cultures (across the five sites of the organization) are significantly fatigued and suffering from moral injury and mental health issues. We've been on extended outbreaks."- C01*. In this context, participants acknowledged the value of implementing the Beyond Silence app, particularly highlighting the potential of its peer support feature. They explained that an employee could benefit from speaking with someone who

understood the context of their lived experience, potentially offering a deeper understanding than a non-healthcare worker might provide.

> *"I've definitely seen more people reaching out. Whereas before, it was more... I'm going to say hush, hush in the sense that it would be discussed amongst coworkers but never really going farther than that….I think in that aspect, we're seeing more people reach out... definitely seeing some people reaching out to the Beyond Silence app and reaching out to us."* -C02.

The growing need for and urgency of mental health support for healthcare workers appeared to be a catalyst for implementation.

2. Culture of Care and Readiness: This theme relates to the potential alignment with the organizational culture and mission of supporting the mental health of its workforce, thereby positively influencing the use of the app. Participants characterized the organization's culture as one that "*embraces change*" and is "*open to new ideas."* With the introduction of new leadership, participants felt they were entering a phase of new initiatives to support workforce needs; therefore, the implementation of Beyond Silence was well-timed.

> "*I think it came at a very good time because our psychological health and wellness initiatives were occurring. Having the app helped us broaden the people involved in our peer support efforts. So, in one sense, we had a couple of resistors, but on the other hand, we added a large number of people as part of this peer support group, whereas they weren't initially included on our first run. And we actually grew, exponentially.... It really helped. And it also, I believe it also gave us momentum to do some creative things*." -C02

One participant explained how involvement in the Beyond Silence project played a critical role in working towards their organizational goal of setting up an internal peer support program. The noted that their current organizational climate, was one of caring about the mental health of their workforce, which provided momentum for implementing the app. As noted by one of the champions *"On the one hand, this is helping us launch what we plan to do. And then I think it's going to benefit you because we already have the momentum."*- C01

Overall, the organization's culture, and a strong alignment with their mission created a synergistic environment for app implementation.

3. Tensions between Espoused Values and Workload Demands: While the organization's climate created a fertile ground for implementation, participants reported pragmatic barriers to implementing and using the app. Participants highlighted working conditions where employees faced overwhelming pressure due to high workloads, understaffing and high turnover rates.

"*So the culture here is more overwhelmed, emotionally, struggling. We're short-staffed constantly, the overwhelming pressure of being here, performing, being at your 100% when you don't have 100% to give."* -PS02

As a result, frontline workers, particularly nurses, did not feel that they had time to engage with the app. There seemed to be lack of congruence between espoused values of the organization in deploying mental health resources and the realities of work demands. Furthermore, champions reported that the organizational policy restricts cell phone use during shift hours. They noted that this policy might discourage employees from using the

app during their work time. While management could be open to accommodating employees who may need to access supports during their shift, participants explained that discomfort or fear of disclosing their need for support might prevent them seeking permission to use the app.

"If you told management, 'I'm just going get some peer support for half an hour', they'll allow it. But not everyone wants to tell their managers they need peer support or they're not doing well. So that's a huge one that no, they don't have the luxury, especially a nurse, of taking 20 minutes, half an hour to put herself in a corner or in a private room, get on her telephone and not look suspicious" -C02 [T3 Follow-up interview]

II. Innovation Factors

1. **App onboarding complexities:** This theme refers to the time and effort required to find the information needed to download the app. Participants noted that finding the app on the app store, and entering the unique organizational code to access the app could be challenging for some people. They explained that many frontline workers do not use their email and/or may not notice the informational poster that contains the access code. This could be particularly difficult for those with limited digital literacy.

"I think for the most part, our nursing staff are short on time. So by the time we ask them to download, then put a confirmation code and then go to the app- And then, we've heard a lot; "I don't have time. I only have 15 minutes on this break to do so. I only have 5 minutes to do so. Patients are calling". So anything that's relatively long, they don't have time for. And it's not that they don't want to. It's just, unfortunately, not part of their work schedule. And other people are just not technologically savvy" -C02

2. Relative advantage of accessing in-person vs app-based supports: This theme highlights participants' perceptions regarding the relative advantage of accessing peer support directly from in-house peer support volunteers, as opposed to scheduling an appointment through the app. Most participants described how frontline workers who often navigate high workloads and long shift hours may not be able to schedule an appointment in advance and have access to their phones during their shifts thereby preferring to access peer support directly reaching out to the peer supporter within their site. Another advantage of in-person peer support highlighted by participants was their ability to be more effective in their role by proactively checking in with co-workers based on visual cues or prior knowledge of their working situation and related challenges. They emphasized how this can potentially reduce the burden on the worker to take the first step to reach out for support.

> *"I think because we are so conscious of the people we work with and what they may be going through, we have that a little bit more in the sense of, "You know, I've seen you for four days. In the last two days, you've been snappy. You've been a little bit more moody. Do you wanna talk about it?" Um, versus with the app, although that's great, you don't get to see that, right? You don't get to see through an app that the person's not doing well. They reach out; they reach out. They don't; they don't."* - PS01

While participants discussed the perceived benefits for their employees in accessing on-demand, in-person peer support, they expressed some tensions around directing employees to access peer support through a particular medium, considering that the implementation of

the app was part of a research study. They emphasized that their primary objective was to ensure individuals received the support they required in their preferred format.

> *"Sometimes we kind of talked about is it going to kind of screw up the study in that they know us and they might just decide to come face to face. But at the end of the day, we said like, "Well, people will use what they're most comfortable with." I would hate to say, "Don't reach out to me in person. It has to be through Beyond Silence." And I hate to do vice versa."* -PS05

They also talked about ways in which the app complemented in person peer support; either as a tool to learn about the peer support team (viewing bios etc.), or as a follow-up to an in-person session (i.e. directing help seekers to relevant content or self-management tools within the app following the in-person session).

> *"I found being able to open the app while I'm doing support to refer to the app was just a great kind of a transitional object…. Let's have a look at this. See, there are some resources here. And look, you put this here, and you have some goals, and they can measure your day and that sort of thing."* -PS06

The in-person encounters were described as a teachable moment to encourage app downloads and use over time.

III. Implementation Factors

1. ***Building momentum to challenges in sustained engagement:*** Participants reflected on the influence of different engagement strategies to promote the uptake of Beyond Silence during the implementation period. Champions described their key role as implementation leads in facilitating engagement. They explained how their existing relationship with

colleagues served to encourage staff members to download and use the app. One of the champions noted that the "therapeutic alliance" with the organizational champions was critical in establishing credibility of the technology and building trust to facilitate adoption. Participants recognized the in-person launch event as key to initial engagement.

> *"having conversations in the hall and it was a vibe we created. It was positive, and uplifting. It was about mental health..... It had the team there. It had you there, your team there, and I think that probably could happen more than once."* -C02

Ongoing engagement strategies shared by participants included promoting the app at regular work processes, including onboarding for new employees, and other wellness events. They noted that future implementation could also include collaborating with wider stakeholders, including frontline nurses, IT experts, union leaders, and social workers, who could be potential ambassadors for promoting the app with their teams.

> *"And as they came in (in house monthly wellness sessions hosted by the organization), we would remind them about the app and remind them about the different initiatives and encourage them to use it. Use it as a self-check-in....self-compassion moment.... that's some of the new language that we're using" -C01(T2 Follow-up interview)*

DISCUSSION

Of the total eligible employees (n=769), 14% (n=108) downloaded and used the Beyond Silence app. These usage rates are consistent with previous studies of health promotion and mental health apps implemented in a workplace context, where download rates of mobile health applications typically ranged between 10-15% [22,23]. For instance, in a process evaluation study of an unguided mental health app in a large Information Technology company, there was a similar download rate of 13% [22]. They noted that employees who used the app were personally motivated and used it for the right reasons [22]. This might also apply to our study, where employees who wanted to improve wellbeing or had a higher receptivity to technology—often described as early adopters—were more likely to download and use the app [24]. Additionally, the qualitative analysis of interviews with champions and focus groups with peer support providers suggest that the download and usage rates could potentially be explained by a range of contextual factors within and beyond the organization, innovation related factors as well as the implementation process.

The broader healthcare climate, marked by increasing mental health concerns stemming from the pandemic, has created an opportunity for the implementation of the *Beyond Silence* app. Several occupational mental health interventions in healthcare emphasize the post-pandemic period as a pivotal moment for introducing transformative changes aimed at addressing the mental health needs of healthcare workers [25,26]. Furthermore, several organization-specific contextual factors, such as the hospital's culture—prioritizing mental health support—and the perceived alignment between the app and the organization’s mission, positively influenced both the app's implementation and

use. These findings are consistent with existing literature, which underscores the significance of organizational context, including culture [10,27,28], perceived alignment with intervention goals, and organizational readiness [29,30], as key predictors of successful implementation. However, our study findings suggest that a supportive organizational culture alone is insufficient for successful implementation. The technology must be integrated into day-to-day workflows with providing adequate time, space, and policies that enable employees to engage with the app in the workplace. As highlighted in a scoping review of strategies for implementing workplace digital mental health interventions, offering dedicated time and space for employees to participate has been identified as a crucial facilitator of successful implementation [31].

In terms of the innovation itself, surprisingly, in some cases, healthcare workers in this organization preferred accessing in-person peer support over accessing them through the Beyond Silence app. This contrasts with earlier meta-analytic findings suggesting that digital tools integrated with human support, such as peer support, are typically seen as desirable features that can enhance engagement [32]. It is also worth noting that while previous studies have identified co-interventions within organizations as barriers to mental health research focused on primary interventions [33], in this study, we view the availability of in-person peer support as complementary rather than competing with the app-based intervention. Furthermore, app-based peer support is a relatively novel approach that has not been extensively studied, highlighting the need for additional systematic research to evaluate the respective "use cases" for app-based versus in-person support. Given the growing interest in peer support as a valuable resource for healthcare workers and the

potential of technology to facilitate such connections, this study provides an important opportunity to critically examine patterns of uptake and user preferences.

Additionally, we found that the in-person launch event at the organization contributed strongly to the initial uptake of the app. This underscores the importance of visual and/or in-person demonstrations, particularly for addressing concerns related to limited digital literacy and an opportunity for providing real-time technical support [31]. Despite this initial engagement, however, there was a notable decline in app usage over time- a trend frequently observed in studies examining the adoption and sustained use of digital mental health interventions [34]. While sustained engagement with digital mental health tools is often considered ideal, innovations like the Beyond Silence app, which are designed for on-demand use without a fixed endpoint, should instead aim for achieving optimal engagement through tailored, context-specific engagement and communication strategies [12,34,35].

Future research is also needed to systematically evaluate implementation along with impact of mobile health approaches to workplace mental health though effectiveness-implementation hybrid study designs [36]. Findings from this case study suggest that, despite potential barriers in implementing and using the app, digital mental health solutions can play an important role in supporting the mental health at work. For some employees, mental health apps can be an anonymous and on demand medium to access anonymous support. To optimize uptake and implementation, key strategies include developing a clear implementation plan with consistent and ongoing communication about the app, assessing the readiness of the implementation context, and improving the alignment between the app

and the organizational setting. This could include allocating sufficient resources to inform users about the app, and how to use it, as well as ensuring the time to engage with the app.

Strengths and Limitations

This study provided a unique opportunity to explore how an innovative app platform could be used to facilitate access to mental information and peer support for healthcare workers. The use of multiple data sources collected over a 16-month period contributed to a robust and rich longitudinal dataset, allowing for a comprehensive understanding of the app's implementation over time. This longitudinal nature of the study enabled a more nuanced understanding of the implementation process, the organizational context, as well as factors influencing the app usage over time. Additionally, the use of the CFIR to develop interview and focus group questions, and subsequently synthesize findings, ensured theoretical consistency. This framework supported the identification of key constructs, allowing for a theory-driven exploration of the mechanisms behind app downloads and usage, and enhancing the study's ability to offer informed explanations of facilitators and barriers grounded in implementation science [37].

However, several limitations need to be acknowledged. First, data was gathered from a single organization as a case study involving two interview champions and six peer support providers, limiting the generalizability of findings. While the data provided valuable insights into the organizational culture and context, the findings may be context-specific with the transferability of findings limited across other organizations. As such, details of the organizational context have been reported to assess whether these findings

are applicable to other similar settings. Additionally, our study primarily explored facilitators and barriers from the perspectives of implementation deliverers (i.e., champions and peer support providers). However, we acknowledge a significant limitation in the absence of direct data from app users, which limits our ability to fully assess how frontline healthcare workers engaged with and experienced the app in real-world settings. This limitation highlights the challenges of evaluating innovations that prioritize user anonymity, as it restricts our capacity to thoroughly understand the mechanisms driving user interaction with the app. Despite these constraints, the study offers valuable insights into the organizational factors influencing the implementation and use of mental health innovations in healthcare settings. Future research should aim to include broader and more diverse perspectives by employing alternative methodologies to capture users' experiences, potentially through implementation-effectiveness hybrid trials [36] that simultaneously test implementation strategies and evaluate innovation outcomes**.**

Conclusion

Mental health apps such as Beyond Silence can be a promising solution for proactive promotion of early intervention for mental health issues among healthcare workers. This study provides valuable insights into the factors that shaped the implementation and use of the Beyond Silence app within a mid-size, multisite Hospital that can be used to improve uptake of the app and optimize its potential impact. Common facilitators to implementation and use included: critical incidents related to growing mental health crisis in healthcare, perceived alignment with organization's need and mission, and initial success in engagement. Key barriers to implementation and use included: insufficient time to

download and use the app, preferences for in person support, and limited tailored, limited resources for sustaining engagement over time. Future studies should adopt an implementation science perspective to assess both the process and outcomes of integrating mental health apps in the workplace. Data from these studies could inform the development of guidelines and tools to assist occupational health practitioners, human resource managers, and leaders in identifying, implementing, and evaluating relevant mental health apps.

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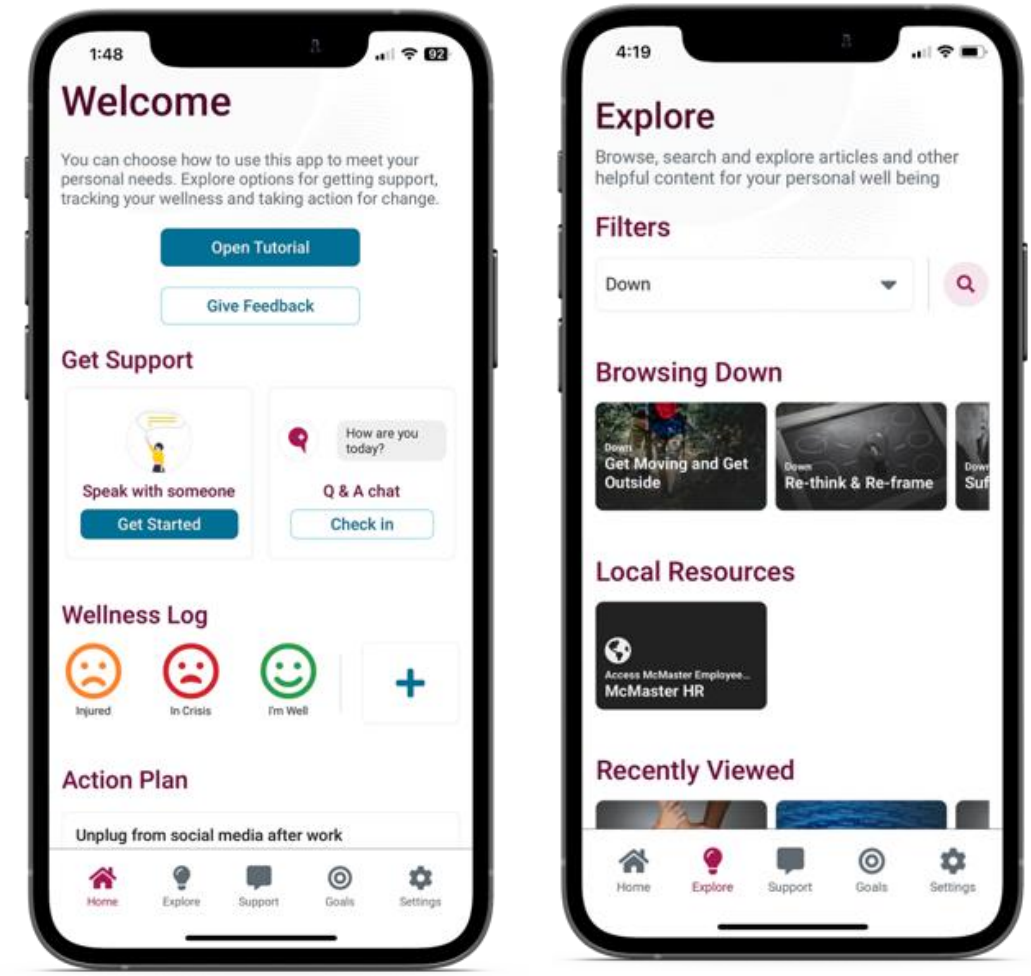
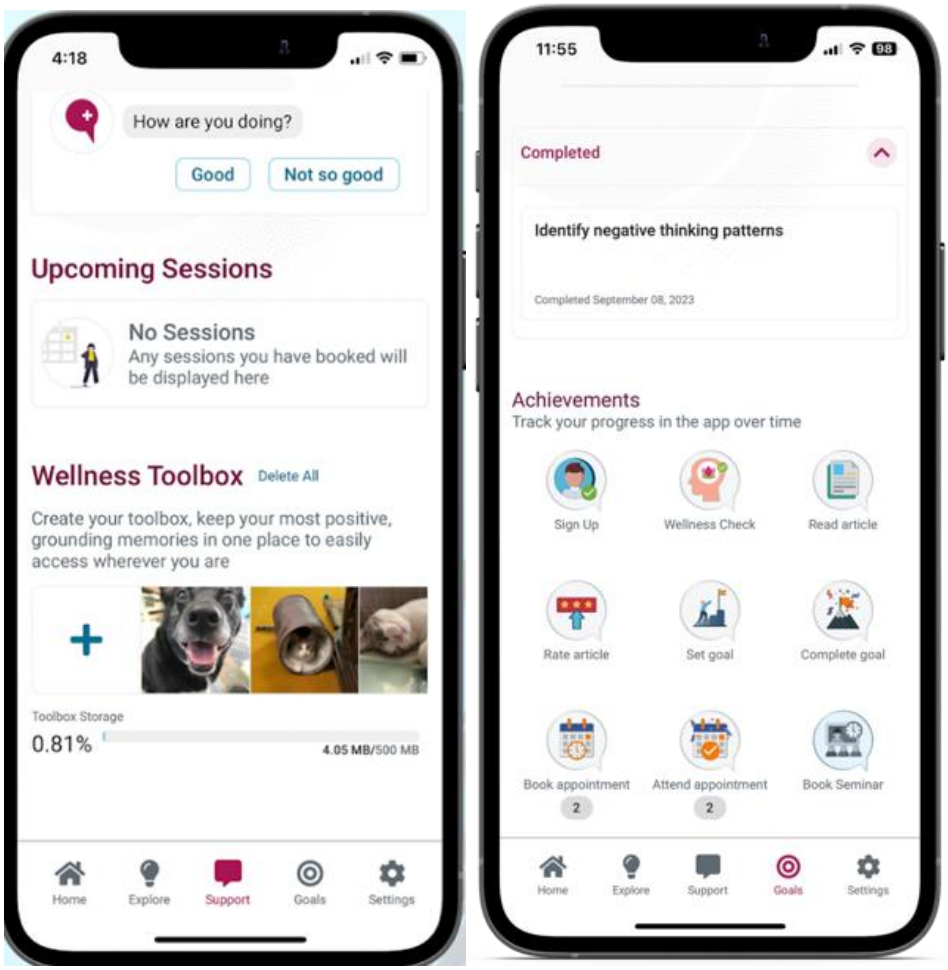
Appendix 3

A. Beyond Silence App Screenshots





B. Baseline Interview Guide (For Organizational Champions)

The purpose of this interview is to get your input on implementation of the Beyond Silence App, as a peer support tool, in your organization. There are no right or wrong answers. We seek to learn about the different factors that could influence the implementation of the pilot program from your perspective. Questions are based upon the CFIR Framework and its various domains (www.cfirguide.org). So thinking about your organization and the processes, we are interested to know some of your reflections on how this might fit

within your goals, day-to-day operations etc.

1. Tell me about your current role in the organization (Job title, duties, tenure)
    - How did you get chosen to be an organizational champion? (Appointed? Volunteered? Voluntold?)
    - Who else is (or should be) involved with leading the implementation?
2. What do you know already about the Beyond Silence app?
    - How did your organization become involved in implementing the intervention?
3. One of the core functions of the app is to link to peer support. Is there a culture of peer support in your organization? If so, describe. If not, what gets in the way?
    - Are there people in your organization who might be willing to be trained to provide peer support via the app? How might they be supported by the organization in this role?
4. How receptive do you think people will be to the app?
    - Do you think that some people will be more receptive to it than others? (explain)
    - What factors might influence whether people download and use the app?
5. How would you describe the culture of your organization?

- What is the culture related to mental health and reaching out for support?
- Has the culture of your organization changed in the past year?
- To what extent are new ideas embraced and used to make improvements in your organization
- Can you describe a recent example?
- How do you think your organization's culture (general beliefs, values, assumptions that people embrace) will affect the implementation of the Beyond Silence app?

6. What kinds of pressures are staff in your organization experiencing that impact their mental health?
    - What workplace mental health initiatives currently exist?
    - Are there gaps in existing services?
    - How might the app fit within existing programs in your setting?
    - Is there a strong need for this app? Why or why not?
7. When considering how to communicate with employees about the app, are there particular strategies that work well when communicating about other workplace initiatives?
    - Who should be involved in sharing info with employees?
    - What communication channels currently exist that might be effective?

8. What is happening right now in healthcare that may influence the need for something like a mental health app?

    - To what extent has COVID-19 influenced the need for a mental health app?

9. Can you describe the plan for implementing the app in your organization?

    - Who are the key influential members who need to be involved in the planning process? What are their roles? And how will they be engaged?
    - How will your plan address any potential barriers to implementation?
    - What is your perception of the quality of the supporting materials, packaging, and bundling of the intervention for implementation?
    - What supports, such promotional material, resources, are currently available and would be required to help you implement and promote the use of the app?

10. How will you communicate to the employees within your organization about the app?
11. How confident are you that you will be able to successfully implement the intervention?

    - What gives you that level of confidence (or lack of confidence)?

12. To what extent has your organization set goals for implementing the intervention?

Thank you!

C. Follow-up Interview Guide (For Organizational Champions)

The purpose of this interview is to get your input on the implementation of the Beyond Silence App, as a peer support tool, in your organization. There are no right or wrong

answers. We seek to learn about the different factors that could influence the implementation of the pilot program from your perspective. Questions are based upon the CFIR Framework and its various domains (www.cfirguide.org). So, thinking back through the last three-six months, we are interested to know some of your reflections.

1. Check-in: Talk through the report: the usage patterns, implementation strategies.
2. What are your impressions of how the app is being used in your setting?
    - How receptive are employees to the app?
    - Do you have a sense of who is /is not using the app?
    - Any positives that you have heard?
    - What are some of the barriers to app use?
3. As an organizational champion, can you share your experiences in leading the efforts to implement the app? Describe any supports and barriers from org & research team.
    - What was the level of leadership involvement in the implementation of the app? Any positives/ feedback about the app and its implementation from a leadership perspective?
4. Implementing this app requires an investment of time, effort and other resources as a champion and for provision of peer support services (approx. 3-hours/week). Considering these costs, what were the investments of time and efforts for you?
    - How were the internal peer supporters nominated and supported in their role during this 3-month trial.

- If we were to charge for this service, what would the value look like for your organization?

5. What might be needed to optimize the use and impact of the app in your setting?
    - What are some broad forces that are shaping your work in supporting mental health of your employees?
6. How does the Beyond Silence app fit within the organizational initiatives/ strategic plan to support employee mental health?
    - What advantages/disadvantages does the app have compared to existing programs?
    - What is the priority of getting the app implemented relative to other initiatives that are happening now? Will implementation conflict/ help achieve or relieve pressure related to these priorities?
    - What was the general level of receptivity in your organization to implementing the app?
    - Describe the communication channel that were employed to share information regarding the app. When were they implemented and who did they reach?
7. How did you choose your plan for implementing the app?
8. Any other suggestions/ recommendation for how to optimize the value of this app for workers in healthcare?

Thank you!

D. Peer Support Interview Guide

The purpose of this interview is to get your input on implementation of the Beyond Silence peer support app in your organization. We want to know more about your experience over the past 6 months and your impressions of factors that influence uptake of the app and peer support.

Introductions

1. Tell me about your current role in the organization (Job title, duties, tenure)
2. Tell me about why you volunteered to take on this peer support role.
3. What are your impressions of the Beyond silence app and how it links to peer support?
4. What are your impressions of how the app, including peer support, is being used in your setting?
    - How receptive were the employees to the app?
    - How receptive were employees to using peer support?
    - Do you have a sense of who is/is not using the app and/or peer support?
    - What do you see as the opportunities and challenges with this technology?
5. What was your experience as a peer support provider related to the app?
    - Explore positive experiences & challenges
6. What was your experience with the peer support training?
    - Would you change anything to the training?

7. What was your experience with the support for peer providers?

    - Would you change anything to how support is provided?
    - Was there enough support?

8. How does the Beyond Silence app fit within organizational initiatives to support employee mental health?
    - What advantages does the app have compared to existing programs?
    - What disadvantages does the app have compared to existing programs?
9. How does the app compare to other alternatives that may have been considered or that you know about?
10. How complicated was the app to implement and use?
11. Was peer support implemented as per the original plan?
12. To what extent was it important to have options to access peer support within the organization?
13. To what extent was it important to have options to access peer support outside the organization?
14. What kinds of changes do you think you are needed to optimize the use and impact of the app in your setting?
15. What policies or strategies could support implementation?
16. How do you think your organization's culture (general beliefs, values, assumptions that people embrace) affected implementation of the app?

17. What was the general level of receptivity in your organization to implementing the app?
18. Is there a strong need for peer support in your organization? Or a need for technology to access information and support?
    - Why or why not?
19. How well does the app fit with your values and norms and the values and norms within the organization?
20. How well does the app fit with existing work processes and practices in your setting?
21. Any final suggestions for how to optimize the value of this app for workers in healthcare?

Thank you for your time!

E. Ethics Approval

Hamilton Integrated Research Ethics Board

Annual Review Approval

Date: May-17-2023
Local Principal Investigator: Dr.SandraMoll
Project ID: 14740
Project Title: BeyondSilence:AdvancingE-mentalhealthsolutionstosupportCanadianhealthcareworkers
Review Type: Delegated
Approval Date: May-16-2023
Approval Period: May-17-2023 - May-17-2024

The Hamilton Integrated Research Ethics Board (HiREB) Panel B has reviewed the renewal application. This study, including all currently approved documents, has been rea pproved for the period noted above.

While HiREB has reviewed and approved this application, the research must be conducted in accordance with applicable regulations and institutional and/or public health requirements.

REB members involved in the research project do not participate in the review, discussion or decision.

The Hamilton Integrated Research Ethics Board (HiREB) provides ethical review and ongoing ethical oversight on behalf of Hamilton Health Sciences, St. Joseph's Healthcare Hamilton, Research St. Joseph's-Hamilton, the Faculty of Health Sciences at McMaster University and Niagara Health. HiREB operates in compliance with and is constituted in accordance with the requirements of: The Tri-Council Policy Statement on Ethical Conduct of Research Involving Humans (TCPS 2); The International Conference on Harmonisation of Good Clinical Practices Guideline (ICH GCP); Part C Division 5 of the Food and Drug Regulations, Part 4 of the Natural Health Products Regulations; Part 3 of the Medical Devices Regulations and the provisions of the Ontario Personal Health Information Protection Act 2004 and its applicable Regulations. For studies conducted at St. Joseph's Healthcare Hamilton, HiREB complies with the Health Ethics Guide of the Catholic Alliance of Canada. HiREB is qualified through the Clinical Trials Ontario (CTO) REB Qualification Program and is registered with the U.S. Department of Health and Human Services (DHHS) Office for Human Research Protection (OHRP).

Sincerely,

Chapter 5 Discussion

5.1 Overview of chapter

This final chapter is a discussion of the overall findings from the three individual papers included in this thesis. The purpose of this thesis was to summarize the current evidence for implementing and evaluating mental health apps in the workplace. The chapter begins by providing a summary of each study's contribution toward the primary objective of the thesis, followed by a discussion of the overall findings by synthesizing and integrating findings from all three studies. Following this, the chapter then presents the implications of these findings for research and practice while considering them in light of the scope and limitations of this thesis. Finally, the chapter outlines the key contributions and provides a conclusion for this thesis.

5.2. Assessing the approaches to the evaluation of mental health apps in the workplace

The first paper of this thesis (Chapter 2) adopted a broad exploratory lens to systematically map the current literature related to mental health apps for workers to provide an overview of existing empirical evidence and identify key themes among studies in their approaches

to evaluating these innovations in the workplace. As this is an emerging field, there was considerable uncertainty about the extent of research in the literature prior to undertaking this review since there were no previous reviews focused exclusively on studies examining smartphone-based mental health apps in the workplace setting. Surprisingly, 54 studies were identified in the scoping review, clearly showcasing the increasing trend in using technology to deliver mental health interventions in the workplace. The extent and range of evaluation approaches used by existing studies in this field encompass three different types of evaluation approaches: 1. the assessment of usage and engagement with the mental health app (App Evaluation), 2. the impact of using mental health apps for workers (Impact Evaluation) and, 3. the process in which these interventions were implemented in workplace settings (Process Evaluation). This review showed that the majority of research in this field has focused on Impact Evaluation to establish evidence for the effects of using mental health apps on several mental health outcomes and, in some cases, even on workplace-related outcomes such as assessing improvements on work engagement, and productivity levels. The review also highlighted that only a small proportion of studies evaluated usage and engagement (App Evaluation) and how these digital innovations are implemented in the workplace context (Process Evaluation). Additionally, the identification of an adequate number of relevant studies in this scoping review provided a strong rationale for undertaking a subsequent systematic review to comprehensively evaluate the effectiveness of mental health apps in workplace settings.

The continuous growth of research in this emerging field of workplace digital mental health interventions indicated a need to systematically summarize the available

empirical evidence related to the effectiveness of workplace mental health apps (Chapter 3). The systematic review and meta-analysis demonstrated very low certainty evidence supporting the effectiveness of mental health apps in improving the mental health of workers by demonstrating significant small to moderate effects in improving perceived stress, symptoms of depression and anxiety, burnout and well-being when compared to a control group. This study makes an important contribution to the field, where for the first time, evidence regarding the use of mental health apps for workers is synthesized and critically appraised to determine the effectiveness of these interventions for workers and help identify gaps in our knowledge to strengthen future evidence generation in the field.

The majority of the current evidence is focused on summative evaluations of the impacts of mental health apps for workers that established foundational evidence regarding their benefits; however, current evidence lacks an explanation of how and why an expected outcome occurs or does not occur. Thus, the third paper in this thesis adopted an implementation science approach in an attempt to explore the various action mechanisms that influence the uptake and implementation of the Beyond Silence app at a medium-sized multisite hospital. This case study of implementing the Beyond Silence app has showcased the influence of the key action mechanisms that shaped the uptake and implementation of the app. Factors that facilitated the implementation and use of the Beyond Silence app included critical incidents related to the growing mental health crisis in healthcare, perceived alignment with the organization's need and mission, and initial success in engagement during the launch of the app. Key barriers to implementation and use included

insufficient time to download and use the app, preferences for in-person support, and limited, tailored, limited resources for sustaining engagement over time.

5.3 Trends and gaps in the current evaluation approaches

Given the high number of studies identified in the scoping review and systematic review in this emerging field, mental health apps are increasingly being considered a desirable medium for addressing the mental health of workers. Studies evaluating mental health apps were conducted with workers from across various industries, but healthcare has been a popular industry for deploying mental health apps. Nearly half of the studies found in both the scoping review (42% of studies) and the systematic review (57% of studies) were conducted in the healthcare field. This focus on the healthcare industry could be likely due to the unique and urgent needs of workers in this industry, who are often at a higher risk for mental health issues due to the nature of their jobs [1–3]. Mental health apps could present a unique opportunity to address barriers for healthcare workers who often manage busy work schedules and are in shift work, making it difficult to engage in traditional in person interventions that are usually intensive and time-consuming [2,4–6]. The case study of implementing the Beyond Silence app (Chapter 4) demonstrated that implementing mental health apps in a healthcare organization is a complex process and involves attention to various factors at different levels related to the organizational implementation context, the individuals within and across the hospital sites, the innovation itself, and the implementation strategies used to promote the app.

The case study of implementing the Beyond Silence app (Chapter 4) demonstrated that implementing mental health apps in a healthcare organization is a complex process that

requires a great deal of deliberation in terms of implementation planning. Conceptualizing the implementation of the Beyond Silence app by using the CFIR allowed the consideration of the innovation itself (e.g., the complexity of downloading and using the app, the relative advantage of accessing in-person peer support vs virtual) and the ecosystem around the app, such as characteristics of the Individual and the Inner Context of the organizations where the app was being implemented (e.g., organizational culture, and readiness), the Outer Context (broader climate in healthcare), as well as the fit between the innovation and implementation settings [7]. Because of the existence of many factors in real-world implementation research, adopting the CFIR as a guiding tool provided a rationale for construct and subconstruct selection, along with identifying and articulating barriers and facilitators associated with successful implementation and uptake of the Beyond Silence app [7]. Moreover, the adoption of the CFIR framework embedded in a case study approach also demonstrated how to use this theoretical framework to inform data collection and analysis and how to use the case study approach to guide the interpretation of findings to help advance the understanding of the implementation of digital mental health innovations in the workplace [7–9].

The implementation of the Beyond Silence app has provided preliminary evidence into the implementation barriers and facilitators in healthcare organizations; however, due to the dynamic nature of organizations and work industries, these factors could likely be different across different sectors such as construction, Information Technology, and Education [10]. So far, research into specific mechanisms and process factors associated with the successful delivery of mental health apps in the workplace is limited. Out of the

54 studies included in the scoping review, only seven explored the role of workplace factors and how they are implemented within the workplace. Additionally, nine studies from the systematic review evaluated the impact of mental health apps on workplace outcomes. Yet, none of the studies examined pathways for how and why apps were effective.

Furthermore, evidence from studies that evaluated app usage suggests a wide variability in usage rates, typically characterized by lower rates, a problematic trend seen across the literature on digital mental health innovations [11–13]. For instance, in the case study of implementing the Beyond Silence app (Chapter 4), 14% of the total employees from the organization downloaded the app. A previous systematic review of digital mental health interventions in the workplace found the usage rates for individual studies ranged from 3% to 95%, with the average level across all studies being less than half at 45% [14]. Moreover, constructs related to usage are not uniformly defined, with terms such as adherence, engagement, and utilization used synonymously to refer to the extent to which users accessed the intervention [11]. Individual studies varied in their operational definitions of these constructs along with how they were measured, ranging from objective measures of usages (frequency and duration of use) that are passively collected from within the app to subjective measures of user ratings of usefulness and satisfaction [11]. Arguably, each of these measures could be valuable in determining whether users who reported higher levels of usage, found apps useful, and were satisfied were more likely to engage with the intervention optimally, subsequently leading to significant improvements in outcomes. However, most studies did not make this link between the dose (the extent to which an app

needs to be used) and the response (a significant improvement in outcomes), bearing little resemblance to high-quality trials [11,15].

As the field of digital mental health innovations continues to expand, this thesis's findings present an evidence synthesis of empirical studies emerging in this field and have highlighted critical knowledge gaps in implementing mental health apps in the workplace.

5.4 Implications and Recommendations for Future Research and Practice

The findings from this thesis have implications for both research and practice- specifically for organizations interested in exploring technology-based solutions as part of their strategies to address the mental health of their workforce.

5.4.1 Implications for research

Over the last decade, a great deal of research has emerged into the efficacy and effectiveness of mental health apps. This thesis adds to the existing evidence on workplace mental health apps in several ways.

The thesis demonstrated evidence that mental health apps, spanning across the spectrum of mental health, are somewhat effective in reducing symptoms of distress (including symptoms of anxiety, depression and stress) and burnout as well as improving wellbeing among workers. The subgroup analysis within the meta-analysis (Chapter 3) exploring the effects of the type of mental health apps on mental health outcomes showed no significant difference in their effects, however, psychoeducation, and mindfulness-based apps seemed to have slightly higher effects than behaviour-techniques based apps. The meta-analysis of mental health apps (chapter 3) indicated a significant positive effect in

reducing burnout improvement, but no significant effects were found for the improvement of workplace engagement and performance. This result has implications for further research to explore the scope of individual-level mental health apps on broader workplace-related outcomes by systematically mapping the congruence between the intervention components to target, identify and measure appropriate outcomes.

Findings from the synthesis of evidence in this thesis indicated a wide variability among the studies, as noted in the scoping review (Chapter 2), and substantial heterogeneity found in the systematic review (Chapter 3). This finding suggests that by grouping all studies evaluating mental health apps in the workplace together, findings may not be generalizable or actionable, particularly given the high variability in the inclusion and exclusion criteria of studies, type of mental health app and extent of usage, characteristics of study participants, and outcomes and measures used to assess them. The presence of such variability between studies suggests a need to further examine the role of different moderators within the study context (e.g., recruitment method, guidance for usage of app), participant characteristics (e.g., gender, clinical or non-clinical sample), type and extent in usage of mental health app. For instance, a previous review of digital mental health interventions in the workplace indicated that higher levels of stress among participants, community recruitment and guidance to use the digital innovation moderated treatment effects [14]. While it was not feasible to conduct a moderator analysis and meta-regression to further explore the role of heterogeneity in the meta-analysis findings due to the limited scope of this thesis, a future study assessing moderators within the systematic review is necessary.

Findings from this thesis suggest that understanding the workplace context and implementation processes is crucial for optimizing the implementation and uptake of a mental health app. Adopting a theoretical framework and an implementation science lens in understanding the implementation of the Beyond Silence app (Chapter 4) highlighted that many forces together can shape the uptake and implementation of a mental health app in the workplace [7]. Exploring the potential fit between the app, its users and the workplace context can help identify context-specific implementation strategies for future implementation of the Beyond Silence app across similar healthcare organizations. Future research can evaluate these implementation strategies and the effectiveness of the Beyond Silence app by designing an implementation-effectiveness hybrid trial [16]. The blending research aims of both evaluating implementation and effectiveness could accelerate the process of knowledge generation and increase the usefulness of these findings in understanding the implementation conditions under the outcome effects observed [16]. An effectiveness-implementation hybrid design is one such emerging study design that adopts a dual focus in assessing clinical effectiveness and implementation. Such integration of aims can be achieved by using the hybrid implementation-effectiveness study designs. Future mental health apps evaluation studies adopting this design that can more rapid insights into effective implementation strategies thereby providing more useful information for researchers, app developers and organizations interested in implementing mental health apps.

Moreover, the use of CFIR as a theoretical framework informed the appraisal of findings from Chapters 2 and 3 and more profoundly in Chapter 4, where the framework

provided guidance for conceptualizing the study, designing data collection tools (interview and focus group guide), and capturing key factors that influenced the uptake and implementation of the Beyond Silence app. Integrating CFIR as a theoretical framework guiding this thesis adds to the growing body of empirical studies employing CFIR by demonstrating the utility and feasibility of this framework for guiding the evaluation of mental health apps in the workplace. Future studies can consider adopting this framework along with other emerging technology-centric frameworks (e.g., NASSS Framework and integrated technology implementation model) to fully capture the complexities of mental health app implementation in the workplace.

The findings from this thesis produced several end-of-grant products for dissemination through different knowledge translation activities. For instance, the scoping review study (Chapter 2) was presented at the Canadian Association for Research on Work and Health conference. Findings from the case study of implementing the Beyond Silence app (Chapter 4) were shared with participating site leaders and organizational champions. Additionally, all papers in this thesis are written as per the guidelines for journals and have been submitted to the journals for peer-review publication.

5.4.2 Implications for practice

The synthesis of empirical studies in Chapters 2 and 3 provides an up-to-date summary of the existing evidence on the benefits of mental health apps. Organizational stakeholders, including occupational health and safety practitioners, Human Resources professionals, and other potential knowledge users, may face challenges in accessing, identifying, and appraising empirical findings from individual studies. Specialized skills

are often required to locate, interpret, and effectively use evidence-based information, posing a barrier to the practical application of research knowledge.

The synthesis presented, including findings from the scoping review and systematic review, submitted for publication in open-access journals to ensure broader accessibility is highly relevant for workplace stakeholders, as it supports informed decision-making about the implementation and evaluation of mental health apps. It highlights the potential value of these apps and outlines the key considerations organizations must address when deciding to integrate them into their workplace.

Several types of mental health apps demonstrate varying levels of evidence, as highlighted in Chapters 2 and 3. Organizations selecting a mental health app for implementation must carefully examine which apps align with the organization's psychological health and safety mission, mandate, and workers' unique needs, ensuring they are consistent with the app's components and goals. While mental health apps were broadly found to be beneficial, findings from the Chapter 3 revealed that mindfulness and psychoeducation apps may have superior effects compared to behavioral apps.

The implementation of the Beyond Silence app (Chapter 4) revealed four interconnected recommendations that shape uptake and implementation: organizational readiness, clear implementation planning, sufficient time and resources, and ensuring ongoing communication. Mid-sized tertiary healthcare organizations could use these elements to design comprehensive implementation of digital mental health apps to ensure optimal uptake. Further research is needed to validate facilitators and how they should be used in the process of implementation of mental health apps while considering contextual

factors such as industry, organizational readiness, factors related to individual workers, and external policies. Nevertheless, these recommendations could still be particularly relevant for mental health apps implemented in similar contexts.

5.4. Limitations

This thesis presents an evidence synthesis from a rapidly emerging field that is a representation of the current knowledge base at the time of writing the thesis. With an increasing number of studies being published, these findings may soon require updates to reflect new findings. As the findings in this thesis are based on preliminary studies evaluating mental health apps in the workplace, there was a high variability among the studies, making it challenging to combine findings and draw conclusions that could be generalized across the different workplace contexts. While the thesis was limited in its scope to generate broad recommendations of what apps can be used when and for whom, the findings related to using implementation science approaches in mental health app evaluation studies provide a basis for future studies to expand the knowledge of when and why mental health apps can be effective for workers. Although the scoping review (Chapter 2) identified 54 studies, only findings from RCTs were further explored in detail in the subsequent systematic review (Chapter 3). Due to practical concerns and the limited scope of this thesis, findings from observational, mixed-methods and qualitative studies were not explored. As more qualitative and mixed-methods studies continue to emerge, there is a need for a subsequent study to expand and supplement the findings of this thesis by undertaking a synthesis of evidence to identify implementation strategies, barriers and facilitators across studies.

5.5 Conclusion

There is a growing recognition of the need to support mental health in the workplace. This thesis explored the value of mental health apps in addressing the mental health needs of the workforce. Findings from the first paper of the thesis showcased that a growing number of studies are evaluating mental health apps, examining their effects in improving mental health and workplace-related outcomes, while also assessing how workers use these apps with limited studies exploring the process in which these innovations are implemented in the workplace. The second paper in this thesis demonstrated evidence for the effectiveness of mental health apps in improving the mental health of workers. Lastly, the third paper of this thesis presented a case study of implementing an evidence-based mental health app, Beyond Silence, highlighting that there are several facilitators and barriers when implementing a mental health app in the workplace context, emphasizing the need to adopt an implementation science approach to optimize effects and evidence generation.

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