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Systematic review regarding the use of mindfulness-based mobile applications to reduce psychological symptoms and enhance well-being among general and clinical population adults: benefits, limitations and future directions

Brian Clawson

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Pepperdine University

Graduate School of Education and Psychology

SYSTEMATIC REVIEW REGARDING THE USE OF MINDFULNESS-BASED MOBILE
APPLICATIONS TO REDUCE PSYCHOLOGICAL SYMPTOMS AND ENHANCE
WELL-BEING AMONG GENERAL AND CLINICAL POPULATION ADULTS:
BENEFITS, LIMITATIONS AND FUTURE DIRECTIONS

A clinical dissertation submitted in partial satisfaction

of the requirements for the degree of

Doctor of Psychology

by

Brian Clawson

July, 2022

Adel Najdowski, Ph.D.- Dissertation Chairperson

This clinical dissertation, written by

Brian Clawson

under the guidance of a Faculty Committee and approved by its members, has been submitted to and accepted by the Graduate Faculty in partial fulfillment of the requirements for the degree of

DOCTOR OF PSYCHOLOGY

Doctoral Committee:

Adel Najdowski, Ph.D., Chairperson

Francesca Parker, Psy.D.

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DEDICATION

My journey in mindfulness began when it was introduced to me by my high school English teacher, Mr. Lucas. The impact of this was profound as it helped me better appreciate life and was the beginning of a long journey in which I incorporated mindfulness both into my personal life and clinical work. Sadly, he passed away from cancer during my senior year before I was able to tell him about the impact it had on me; however, the lessons he taught me have continued to guide me since. This review is in honor of him.

ACKNOWLEDGEMENTS

I would like to extend my thanks to my previous chairperson Dr. Drew Erhardt who helped guide me through my preliminary exam before he had to take medical leave. Dr. Erhardt interviewed me when I applied to Pepperdine University and has been a role model for me ever since. Moreover, I have been incredibly lucky to have found my chairperson Dr. Adel Najdowski who was incredibly helpful and supportive as I adapted to the many changes that have occurred since 2020. Special thanks to my committee member Dr. Francesca Parker for the many zoom meetings we had despite the different time zones and for your support from the beginning in conducting this review. I also would like to thank my research assistant Francis Miguez (“Blake” as he prefers to be called) for the outstanding work he has done and for his dedication throughout the data collection process. Furthermore, I would like to thank the many classmates and professors whom I consulted with during this process as their source of overwhelming kindness and collaboration continues to inspire me. I consider myself very lucky for having parents who have been supportive since the beginning regarding my career path in psychology and who have above all inspired me to work hard to achieve my dreams. Most of all, I could not have done this without the love and support of my fiancée Jaimie Porras, as I cannot express enough my gratitude for having her come into my life.

VITA

Brian Clawson

EDUCATION

Pepperdine University (2018-2022)

West Los Angeles, California

Doctor of Psychology in Clinical Psychology

Dissertation Title: Using mindfulness-based mobile apps to reduce psychological symptoms and enhance well-being among general and clinical population adults: Benefits, limitations, and future directions (proposed and passed on Feb 2020; defense planned for April 2022)

Dissertation Chair: Adel Najdowski, PhD

Pepperdine University (2016-2018)

Irvine, California

Master of Arts in Clinical Psychology with an Emphasis in Marriage & Family Therapy with Latinos/as

Seattle University (2010-2014)

Seattle, Washington

Bachelor of Science in Psychology with an additional major in Spanish

CLINICAL EXPERIENCE

Tuscaloosa VA Medical Center (TVAMC)

Tuscaloosa, Alabama

Psychology Intern,

July 2021-June 2022

Psychological Assessment and Testing Center (PATC): Supervisor Adriana Yon, PhD, ABPP

- Conduct neuropsychological evaluations at the Psychological Assessment and Testing Center (PATC) which provides services to adult and geriatric inpatients and outpatients with a variety of psychiatric, medical, and neurological conditions.
- Common reasons for referral include diagnostic issues related to traumatic brain injury, neurodegenerative disorders, stroke, infections, and neoplastic disease. Furthermore, many Veterans also have comorbid conditions such as substance abuse, depression, anxiety, severe mental illness, PTSD, and attentional/learning disorders.
- Have the opportunity to be involved in all aspects of the assessment process including the medical record review, test selection, clinical interview, test administration, test interpretation, report writing, and provision of feedback to Veterans and treatment providers.

Geropsychology Rotation: Supervisor Martin Morthland, PhD

- Conduct brief and comprehensive assessments with inpatient Veterans at the dementia ward and geriatrics and extended care home (GEC) for neurocognitive disorders, informing differential diagnoses, degrees of capacity, and the application of therapy.
- Conduct individual and group therapy in a variety of psychotherapy modalities such as Acceptance and Commitment Therapy, Cognitive Behavioral Therapy, Reminiscence Therapy and supportive therapy with geriatric Veterans.
- Additionally, have the experience of following older adult Veterans from assessment to practice in order to experience how the assessment results are best applied clinically to the individual.
- Have the opportunity to conduct medical decision-making capacity evaluations.

Neurology Rotation: Supervisor Daniel C. Potts, MD

- Have the opportunity to shadow neurology to gain a better understanding and appreciation of the neurological exams performed during initial consults and follow-up appointments.
- Learn more about the evaluation and treatment of primary neurological disorders.
- Strengthen ability to understand neuroimaging findings by reviewing imaging with neurologist before patient appointments (CT scans, MRI, etc.).

Research Rotation: Supervisor Michelle M Hilgeman, PhD

Developed a conference abstract and poster using existing data from an ongoing VA Rehabilitation Research & Development funded pilot study (Hilgeman, RR&D CDA2). The poster was presented at the Gerontological Society of America and focused on the utility of the FFMQ-15 in older Veterans with dementia and their caregivers. Results indicated that the mindfulness measure demonstrated limited utility with Veterans with dementia, suggesting that this measure is not appropriate for this population as delivered.

OEI/OIF/OND Transition Center: Supervisor Vincent Intoccia, PsyD

- Conduct individual therapy using evidenced-based practices such as prolonged exposure, acceptance and commitment therapy, cognitive behavioral therapy at the post-deployment integrated care clinic serving recently returned veterans from Operation Enduring Freedom, Operation Iraqi Freedom, and Operation New Dawn.
- Work collaboratively and efficiently within a multidisciplinary primary care setting to provide effective consultation with medical team members, brief targeted assessment, and the provision of brief, evidenced-based psychotherapy for the treatment of anxiety and mood disorders.
- Receive specific training that mirrors the National Center for PTSD PE training for VA providers on Prolonged Exposure for the treatment of combat and non-combat PTSD which includes session- by-session review of the *Prolonged Exposure Therapy for PTSD* manual (Foa, Hembree, & Rothbaum, 2007), audio review of PE sessions, fidelity checklists for each session, and modeling as needed.

Outpatient Mental Health Clinic: Supervisor Samuel J. Popkin, PhD

- Conduct individual therapy with Veterans using a variety of therapeutic modalities such as Cognitive Behavioral Therapy, Cognitive Processing Therapy and Cognitive Behavioral Therapy for substance abuse.

Olive View-UCLA Medical Center
California

Sylmar,

Bilingual Neuropsychology Extern, Supervisor Yurivia Cervantes-Manzo, PhD
2021

June 2020-June

- Conduct inpatient neuropsychological assessments with monolingual and bilingual (Spanish/English) patients referred from the locked psychiatric inpatient units, which include referrals from the Office of Diversion and Re-entry (ODR) program and the Psychiatry Consultation and Liaison (C&L) service.
- Conduct bilingual (Spanish/English) outpatient neuropsychological assessments of individuals suffering from a variety of medical and mental health illnesses. Patients consist of adults who are racially/ethnically diverse and often have multiple neurological and neuropsychiatric diagnoses, including dementias (e.g., Alzheimer's, frontotemporal, vascular), multiple sclerosis, epilepsy, brain injuries, cerebrovascular accidents, lupus, Parkinson's Disease, HIV, unspecified cognitive decline, schizophrenia and co-morbid psychiatric conditions including anxiety disorders, mood disorders, substance use disorders and post-traumatic stress disorder. Factors that influence differential diagnosis include language status (i.e., English as a second language), acculturation, ethnicity, homelessness, poor nutrition, lack of education, poverty, and chronic mental illness.
- In addition to conducting comprehensive bilingual inpatient and outpatient neuropsychological assessments, responsibilities include the scoring, interpretation of data, and the writing of both brief summaries and neuropsychological reports, which include results in cognitive domains, performance validity testing, psychological functioning, diagnostic impressions, and recommendations.
- Learn how to communicate with medical treatment teams both prior to and after assessments as well as gather a broad range of information from collaterals to make treatment and placement recommendations.
- Participate in didactic seminars on neuropsychology topics (e.g., functional neuroanatomy, psychopharmacology, neurological and neuropsychiatric conditions, psychometrics, performance validity testing, multicultural considerations of testing, etc.) as well as topics in the fields of psychology and psychiatry.
- Attend grand rounds with psychiatry, neurology, and radiology.
- Attend Neuropsychiatry Lecture series with PSY2 Psychiatry Residents.
- Attend monthly Neuroradiology Case Conference with Psychiatry, Neurology, Radiology department staff and residents.
- Receive weekly individual bilingual supervision.

**University of California Los Angeles (UCLA)
Cultural Neuropsychology Practicum (CNP)**

Los Angeles, California
June 2019-June 2021

Bilingual Neuropsychology Extern, Primary Supervisors: Xavier Cagigas, PhD, and Paola Suarez, PhD

- Conduct neuropsychological assessments to both inpatient and outpatient populations in English and Spanish to patients across the lifespan with typical referrals including the following: pre-surgical evaluations for organ transplant, epilepsy, tumor, vascular, and deep brain stimulation cases; dementia evaluations; evaluations for intellectual or developmental disorders; acquired neurological disorders; comorbid psychiatric conditions and many other diverse etiologies.
- Conduct comprehensive chart reviews, write pre-evals, conduct clinical interviews, write integrated assessment reports, and attend patient feedback sessions in order to fully participate in the assessment process.
- Focus and specialized training in the administration and interpretation of linguistically and culturally appropriate neuropsychological measures with patients who are Spanish dominant and bilingual (English/Spanish).
- Present cases at case conference, which includes members from multiple tracks at UCLA, to discuss and receive feedback about neuropsychological and psychodiagnostics test selection, administration, scoring, interpretation, and diagnostic issues.
- Participate in weekly didactics which include Functional Neuroanatomy, Neuropsychology Seminar, Clinical Syndromes, Advanced Topics in Neuropsychology Seminar and Neuropsychological Syndromes Seminar.
- Have had the opportunity to participate in Wada exam as part of neurosurgical evaluation, IMPACT testing for the Galaxy and LAFC (Los Angeles Futbol Club) and observe weekly brain cuttings.
- Extensive experience conducting neuropsychological batteries on telehealth due to the Covid-19 pandemic.
- Held crucial role in the adaptation and training for telehealth evaluations to incoming externs in response to the Covid-19 pandemic.

Pepperdine University Community Counseling Clinic

West Los Angeles, California

PsyD Trainee, Supervisor Joan Rosenberg, PhD

September 2018-Present

- Provide individual and family therapy across the lifespan for diverse populations that present with personality disorders, mood disorders, anxiety disorders, trauma disorders, adjustment difficulties, relational difficulties, and general life distress.
- Utilize and conceptualize from evidence-based treatments such as Psychodynamic therapy as well as a specific integrative model that is grounded in neuroscience with an emphasis on increasing affective awareness and tolerance.
- Conduct structured clinical intake evaluations and write comprehensive intake reports.
- Administer self-report outcome measures such as the BDI-II, BAI, PHQ-9, OQ45.2, BMMRS, and MSPSS to measure symptomology, religiosity, and perceived social support to both enhance treatment and better assess progress in therapy.
- Participate in weekly group supervision and case conferences, in which there are video presentations of sessions with clients, to assist with the utilization of clinical skills and enhance treatment.

Western Youth Services

Anaheim, California

MFT Trainee, Supervisor Adriana Lopez, LPCC

August 2017-June 2018

- Provided bilingual psychotherapy to monolingual/bilingual children, adolescents and families who were experiencing family difficulties, post-traumatic stress disorder, autism, attention deficit hyperactivity disorder, psychosis, oppositional defiant disorder, conduct disorder, using a Rogerian and Family Systems theoretical orientation.
- Utilized Family Systems theoretical orientation as well as cultural competency and cultural humility skills when working with both the client, parents/caregivers and school staff as an integrated team.
- Extensive experience with case management which included child protective services (CPS) reports, consulting with social workers and crisis management.
- Attended workshops for Acceptance and Commitment Therapy, Dialectic Behavioral Therapy, Family Systems Therapy, Sand Play, and Clay Therapy.

- Attended trainings in trauma, IEP's, medically-induced psychological symptoms, and substance abuse.

PRESENTATIONS AT SCIENTIFIC MEETINGS

Clawson, B. R., Block, P. R., Durkin, D., Collins, A., Jacobs, L., & Hilgeman, M. M. (2021, November 10- 13). *Measuring Mindfulness: Assessing the Utility of the FFMQ in the Older Veterans With Dementia and Their Caregivers* [Poster Presentation]. The Gerontological Society of America (GSA) 2021 Annual Scientific Meeting. Phoenix, AR, USA. (Virtual) [GSA 2021 Annual Scientific Meeting > Home](#)

Clawson, B. R., Dupont, A., Cervantes-Manzo, Y., (2021, February 2-5). *Long Term Effects of Anti-NMDA Receptor Encephalitis on Cognitive and Emotional Functioning: A Case Study of a Hispanic Female* [Poster Presentation]. The International Neuropsychological Society 49th Annual Virtual Meeting, San Diego, CA, USA. <https://www.the-ins.org/meetings/sandiego2021/>

PROFESSIONAL PRESENTATIONS

Clawson, B. R., & Cervantes-Manzo, Y. (2021, March 11th). *Case Presentation: HIV Dementia*. Case Presentation at Olive View-UCLA Medical Center Neuroradiology Case Conference. Sylmar, CA.

Clawson, B. R., & Birath, J. (2021, February 11th). *Case Presentation: Multiple Sclerosis*. Case Presentation at Olive View-UCLA Medical Center Neuroradiology Case Conference. Sylmar, CA.

BLOG POSTS / PUBLIC HEALTH PUBLICATIONS

Clawson, B. R., Yon, A., (2021, September 22nd). Ask the experts- Sleep and Alzheimer's Disease, *American Academy of Clinical Neuropsychology, Facebook Page*. [American Academy of Clinical Neuropsychology | Facebook](#)

RESEARCH EXPERIENCE

Case study of Anti-NMDA Receptor Encephalitis

Bilingual trainee at Olive View UCLA Medical Center

Sylmar, California

Presented at INS February, 2021

- Presented a case study at the International Neuropsychological Society (INS) of a monolingual Spanish-speaking female with 9 years of education and a history of anti-NMDA receptor encephalitis. Goal is to contribute to the literature about the long-term effects of the condition on cognitive and emotional functioning, particularly on a diverse individual.

Pepperdine University Dissertation Research

Primary Investigator

Los Angeles, California

December 2018-Present

- Dissertation title: Using mindfulness-based mobile apps to reduce psychological symptoms and enhance well-being among general and clinical population adults: Benefits, limitations, and future directions.
- Examines the efficacy of mindfulness-based mobile apps to answer the following questions: What benefits are associated with the use of mindfulness-based apps for clinical and general population adults with respect to stress, symptoms of anxiety and symptoms of depression? Have mindfulness-based apps been found to enhance well-being for clinical and general population adults? What limitations have been identified with respect to the use of meditation-based apps for clinical and general population adults?

LaTeena Power Research Project

Researcher at Pepperdine University

Irvine, California

February 2017-June 2017

- Explained consent forms and other documents in both English and Spanish to parents and participated in data collection of outcome measures filled out by students that assessed for self-esteem, self-hope, and self-efficacy.
- Coordinated and interacted with school staff to help recruit volunteers.

Centerstone of Seattle

Researcher

Seattle, Washington

March 2013- June 2013

- Conducted community service project with Centerstone, a non-profit that supports a diverse group of low-income families by offering a service to assist people who need help paying their

winter heating and other utility bills, by collecting satisfaction surveys in multiple languages (Cantonese, Mandarin, English and Spanish) from their clientele to better improve their services.

- Collected, analyzed, gave feedback to Centerstone to explain the results of outcome measures.

Social Perceptions of Promiscuity on Likability

Seattle University

Seattle, Washington

January- June 2013

- Presented research findings at Stanford, University of Washington, Seattle University and for Psi Chi the International Honor Society of Psychology.
- Results of the study found that women who are promiscuous are perceived more negatively by others than men who are promiscuous and those who are not.

TEACHING AND CONSULTATION EXPERIENCE

Pepperdine University

Peer Consultant to Joan Rosenberg, PhD

Irvine, California

September 2020- May 2021

- Provide weekly peer consultation to three first year doctoral students at the Irvine Pepperdine Community Counseling Clinic in addition to supporting and giving trainees consultation during case/crisis management situations.
- Receive weekly supervision from supervisor to receive feedback and assist with peer consultation skills and professional growth.
- Attend weekly case conference to give feedback to consultees' presenting video recording of client sessions to better enhance treatment and utilization of clinical skills.
- Apply concepts from supervision class, in order to enhance overall skill development in clinical case presentation and consultation as well as better facilitate peer consultation. This includes learning about approaches utilized in supervision to help assist the consultee adapt clinical interventions to the individual client, taking into consideration motivation, cultural and contextual factors.
- Evaluate and give feedback regarding consultees' progress notes and intake reports to better enhance diagnostic skills, treatment planning, case conceptualization, and legal/ethical issues.

Pepperdine University

Assessment Graduate Assistant to Carolyn Keatinge, Ph.D.

West Los Angeles, California

July 2020- April 2021

- Worked with psychological assessment professors to change on ground doctoral level assessment classes (i.e., Intake and interviewing, Cognitive Assessment, Emotional Assessment and Advanced Integrated Assessment) to an online format.
- Duties included developing new course materials to optimize student learning and material retention.
- Role specifically involved developing WAIS-IV administration videos, neuropsychological administration videos for a range of neuropsychological assessment measures. Additionally, role included scoring multiple Rorschach and WAIS-IV protocols to determine inter-rater reliability.
- Final integrated psychological assessment report was selected as the training sample for the Advanced Integrated Psychological Assessment class.
- Active participant in the piloting of small group exercises on interviewing, the scoring and interpretation of test data.

Pepperdine University

Assessment Teaching Assistant to Susan Himelstein, PhD

West Los Angeles, California

September 2019- March 2020

- Graded cognitive and personality assessments for multiple classes which include the following: MMPI-II, COWAT, WRAT-5, Trailmaking Test, Bender Gestalt, Beery VMI, WAIS-IV, NEO-PI R, RISB, MCMI-IV, WISC-V, MMSE, and RAVLT.
- Administered assessment workshops for students learning the WAIS-IV and Rorschach to provide feedback and help enhance their administration skills.

Pepperdine University

Graduate Assistant for Miguel Gallardo, PsyD

Irvine, California

October 2016- August 2017

- Helped edit the Aliento website to better enhance the experience of prospective students who were seeking to learn more about the Aliento program, which is dedicated to addressing the

individual and communal mental health needs of Latinx communities by training culturally competent and bilingual MFT's.

- Conducted several online surveys to help faculty receive feedback from students about the program as well as worked extensively with academic counsellor creating new year plans and flowcharts to help students graduate on time.
- Participated in research for LaTeena Power which utilized a course designed by Dr. Ana Nogales to help empower Latina youth and encourage them to go to college by using a cultural approach highlighting the strengths of women in Latina culture.

Presentation on GRIT and Growth/Fixed Mindset

Fullerton, California

Presenter at Cal State University Fullerton- GAP 4+1 Cohort

November 2018

- Explained the concept of GRIT, which is a combination of passion and perseverance for a singularly important goal and the concept of a Growth/Fixed Mindset.
- Explained how utilization of GRIT and Growth Mindset relate to success in the business world and can positively affect mental health.
- Gave GRIT assessment to cohort and explained results.

Presentation on GRIT

Fullerton, California

Presenter for the Cal State University Fullerton- GAP 4+1 Cohort

November 2017

- Gave presentation explaining importance of GRIT in the business world.
- Gave GRIT assessment to cohort and explained the results as well as reviewed ways to improve GRIT.

TRAINING AND OUTREACH EXPERIENCE

Enhancing Psychodynamic Emotional Regulation:

Los Angeles, CA

A Day of Clinical Video with Master ISTDP Therapists Workshop

February 2020

- Watched multiple videos of real sessions conducted by Master ISTDP therapists.
- Learned how ISTDP is used in both short-term and long-term therapy as well as various techniques and interventions that contribute to its effectiveness.

Concussion Champions Workshop: UCLA

Los Angeles, CA

Advancing the Understanding & Treatment of Sport-Related Concussions for Youth

August 2019

- Goal of workshop included educating participants to serve as "Concussion Champions" at each respective clinic and be current on sports-concussion management for athletes, ages 5-25.
- Learned how to relate the risks and benefits of sports participation to families, including the relative risks for concussion in different sports and different conditions.
- Learned about a multimodal clinical concussion assessment test battery that may include symptoms, cognition (including computerized testing), balance, reaction time and number reading.
- Discovered how to relate to families the potential risks of repetitive concussions based upon peer-reviewed publications and yet also be aware of current information circulated through the media.

VOLUNTEER COMMUNITY OUTREACH EXPERIENCE

Kaiser Permanente in Union City

Union City, California

Volunteer at Chemical Dependency Recovery Center

January 2016

- Sat in and observed group therapy sessions for client suffering from substance use disorders as well as comorbid mood disorders.
- Learned about the detox and treatment process of the Chemical Dependency Recovery Center as well as the requirements necessary to graduate from the program.

Kaiser Permanente in South San Francisco

San Francisco, California

Student Volunteer

October 2015

- Participated in shadowing experience of psychiatrist who treated patients suffering from trauma and mood disorder as well as learned more about the field of Psychiatry including the challenges of time management when seeing patients.

PROFESSIONAL AFFILIATIONS

American Psychological Association (APA)
 American Psychological Association Division 22: Rehabilitation Psychology
 American Psychological Association Division 40: Society for Clinical
 Neuropsychology Gerontological Society of America (GSA)
 Hispanic Neuropsychological Society (HNS)
 International Neuropsychology Society (INS)

REFERENCES**Adriana Yon, PhD, ABPP**

Board Certified Clinical Neuropsychologist
 Tuscaloosa VA Medical Center
 Relationship: Current Clinical
 Supervisor

Xavier Cagigas, PhD

Director of Cultural Neuropsychology Initiative Practicum
 Associate Director of the UCLA Hispanic Neuropsychiatric Center of Excellence
 Relationship: Past Clinical Supervisor

Yurivia Cervantes-Manzo, PhD

Externship Supervisor: Neuropsychology
 Track Olive View-UCLA Medical Center
 Health Sciences Clinical Instructor
 David Geffen School of Medicine at UCLA
 Relationship: Past Clinical Supervisor

Adel Najdowski, PhD, BCBA-D

Board Certified Behavior Analyst
 Associate Professor
 Program Director, MS Applied Behavior
 Analysis Relationship: Current dissertation
 chairperson

ABSTRACT

Mindfulness is now utilized throughout Western Society and is part of the growing behavioral health, self-help, and wellness movements. Mobile applications have become increasingly popular for a wide variety of uses related to physical health, mental health, and self-improvement. Therefore, mindfulness-based mobile applications have promise both as stand-alone tools for end-users seeking self-help resources and as clinician-recommended adjunctive tools to enhance the process and outcomes of professional therapy. This systematic review identified, reviewed, and synthesized the findings from studies ($n = 29$) concerning the impact of mindfulness-based mobile applications on specific aspects of psychological functioning in both the general population and clinical samples. The aim was to clarify the conclusions warranted based on the extant literature regarding the benefits, limitations, and future directions of mindfulness-based mobile applications with respect to enhancing well-being and reducing depressive symptoms, anxiety symptoms, and stress among clinical and general population adults. English-language studies published between 2009 and 2021 that examined iOS and/or Android compatible mindfulness-based mobile applications were included in the review. The results indicated that mindfulness-based mobile applications are effective in reducing symptoms of anxiety, depression, and stress (both perceived and physiological), in addition to improving well-being. Areas for future research are discussed.

Keywords: anxiety, depression, mindfulness, mobile apps, stress, well-being

Chapter 1: Background and Rationale

Statement of the Problem

Symptoms of anxiety and depression are common in the general population, with anxiety disorders being the most common mental health disorders worldwide, depression being the leading cause of disability globally (World Health Organization [WHO], 2021), and the comorbidity rate of Major Depressive Disorder and Anxiety Disorders being 60% in the United States (Calkins et al., 2015). Symptoms of anxiety and depression represent a significant public health concern, as they are associated with distress and can increase one's risk for developing diagnosable anxiety and mood disorders (Laeger et al., 2012). Anxious and depressive symptoms may also contribute to or exacerbate physiological conditions, such as cardiovascular disease (Bomhof-Roordink et al., 2015) and insomnia (Jansson-Fröjmark & Lindblom, 2008). Furthermore, anxiety disorders have been found to be more common in western cultures (Baxter et al., 2013) resulting in an economic burden of 63.1 billion dollars in the United States in 1998 due primarily to medical expenses such as primary care visits (Greenberg et al., 1999). A comorbid diagnosis of depression and anxiety has also been found to be more costly to treat in comparison to those only suffering from an anxiety disorder (Marciniak et al., 2005). Both anxious and depressive symptoms can affect cognitive functioning. For example, Ng et al. (2012) found that higher levels of depressive symptoms were associated with decreased efficiency when completing a cognitive task. Additionally, anxiety symptoms were associated with increased reaction times, resulting in slower completion of the cognitive task.

Unfortunately, various factors can exacerbate mental illness, with stress being a notable example. Hirsch et al. (2019) found that higher perceived stress among college students was associated with greater risk for depressive symptoms and, consequently, an increased risk for suicide. Although everyone experiences stress from time to time, high

levels of stress have been found to worsen mental illness. For instance, Toussaint et al. (2016) used an online stress assessment system to measure 96 types of acute and chronic stress that have been demonstrated to adversely affect health. They found that the greater the stress exposure severity was throughout one's life, the higher the likelihood of poorer mental and physical health. Chronic stress can also impact physical and cognitive health. Corrêa et al. (2018) found that familial caregivers of patients with Alzheimer's disease suffered cognitive impairments due to the stress of caregiving, which increased their own risk for cognitive decline.

However, there are indications that some factors can buffer these adverse impacts of stress. For example, perceived self-efficacy has been found to buffer the impact of daily stressors, resulting in fewer symptoms of depression, anxiety, and stress (Schönfeld et al., 2016). This demonstrates that individuals with higher levels of self-efficacy can cope better with the daily stress of life. Being better able to handle stress is also associated with increases in positive factors such as well-being (Rupert & Dorociak, 2019). Well-being is frequently used as a general population indicator to determine how individuals are coping with the daily stressors of life and how well one can maximize positive affect and minimize negative affect in the face of life stressors (Boggero & Segerstrom, 2019).

The high prevalence rates of anxious and depressive symptoms, the adverse effects of stress on mental and physical health, and the moderating impact of stress management and self-efficacy beliefs on these adverse effects, all support the extensive use of effective psychological therapies. Unfortunately, however, the majority of individuals in the United States experiencing anxiety and mood disorders do not receive any treatment; an unmet need that is even worse for members of minority groups (Alegría et al., 2002). It seems reasonable to assume that an even greater percentage of those with anxious and depressive symptoms go untreated. Numerous factors likely contribute to such underutilization of psychological

treatments, including financial and time constraints, as well as available treatments not meeting the needs of individual patients (Jones et al., 2014). Furthermore, stigma associated with help seeking for psychological concerns, cultural norms regarding identifying and seeking help for mental health concerns, and limited resources and availability of mental health professionals are also frequent concerns (Petros et al., 2016). Therefore, a need exists for interventions other than traditional psychotherapy, given that the latter can be difficult to attain due to financial limitations, stigma, time-constraints, and insufficient availability of therapists.

Mental health applications (“apps”) have the potential to help address the needs of those experiencing mental health symptoms by addressing many of the current barriers to help-seeking. Applications are available to all with a smartphone and an internet connection. This makes the potential reach of mental health applications immense, as the majority of people in the United States (77%) own a smartphone device (Poushter et al., 2019). The accessibility of these applications is also served by their typically low cost, particularly when compared to traditionally delivered mental health services. Stigma and other factors associated with reduced help seeking can also be addressed by the fact that mental health applications offer privacy, convenient 24/7 access, data security, and the ability to use the application when alone (Erhardt & Dorian, 2017; Mani et al., 2015). Well-designed applications can replicate key components of many types of mental health interventions, including psychoeducation, self-monitoring, skill acquisition and practice, social support, and ongoing assessment. Many of these advantages of mental health applications were particularly salient during the severe restrictions imposed on much of the population by the coronavirus pandemic. Not only did the pandemic induce stress, anxiety, and other dysphoric mood states but the disruptions to traditional service delivery likely induced many to sample and benefit from these accessible, inexpensive options for stress and symptom reduction

(Klussman et al., 2021; Sorkin et al., 2021). Thus, interventions delivered through mobile applications would appear to appeal to adults in both the general and clinical population given their potential to decrease stress, anxiety, and depression while enhancing well-being.

Mindfulness is among the interventions that have been translated for mobile application delivery. There is evidence of the efficacy of mindfulness for reducing stress along with depressive and anxious symptoms (Medvedev et al., 2018) and enhancing well-being (Lomas et al., 2019). Meditation and mindfulness interventions have also been associated with somatic relief for users. For example, Carissoli et al. (2015) found that participants who meditated using a 3-week mindfulness-inspired protocol delivered via an android application reported a significant decrease in average heartbeats per minute after each session. As the popularity of mindfulness grows, more users are turning to mobile applications to both learn about, acquire, and use these tools. Not only are mindfulness-based applications widely available (Tunney et al., 2017), but there may be a sizable number of people who prefer to receive meditation and mindfulness interventions via mobile applications rather than through traditional in-person methods. Supporting this possibility is the explosive growth in the availability and adoption of mindfulness-based applications (Mani et al., 2015). The fact that mindfulness applications are proliferating, widely adopted, and promising with respect to addressing anxious and depressive symptoms in clinical and general populations demonstrates the need for a review of the literature to clarify what is currently known about the benefits and limitations of these tools and where future research efforts should be directed.

Overview of Relevant Research

The Emergence of Mindfulness in Western Society

According to Martin (1997) who conceptualized mindfulness using both eastern and western psychological literature, mindfulness is “a state of psychological freedom that occurs

when attention remains quiet and limber, without attachment to any particular point of view” (p. 291-292). Another definition of mindfulness that is common is “a nonjudging way of attending to the body, breath, sensations, thoughts, feelings, and external stimuli in the present moment” (Koerbel & Zucker, 2007, p. 266). Many in western society are familiar with mindfulness because of Mindfulness-Based Stress Reduction (MBSR) which was developed by Jon Kabat-Zinn in 1979 (2014). Kabat-Zinn (1982) found that half of the patients who enrolled in the 10-week MBSR course experienced a pain reduction of nearly 50% in addition to improvements in mood and other psychiatric symptoms. These impressive results demonstrating that mindfulness could help users better regulate pain contributed to mindfulness and its benefits becoming more well-known.

Mindfulness is now being utilized throughout Western Society. For example, mindfulness interventions are used in institutions such as schools, workplaces (Creswell, 2017), colleges (Shearer et al., 2016), forensic facilities (Lyons & Cantrell, 2016), and even the military, spurred by research showing that mindfulness can help mitigate adverse effects of combat exposure including PTSD, depression, risky behaviors, functional impairment, and pain (Nassif et al., 2019). Mindfulness is also part of the growing behavioral health, self-help, and self-improvement movements. In 2012, 8% of adults reported using mindfulness, making it one of the top five complementary health approaches among adults in the United States (Clarke, 2015). The emergence and dissemination of specific mindfulness-based interventions have also made mindfulness more popular and well-known in the United States. As previously noted, one widely used example is MBSR, which is typically an 8-week, group-based intervention focused on the direct experience of mindfulness through formal exercises and group discussions (Giannandrea et al., 2018).

Limitations of Mindfulness Research

Although the scientific study of mindfulness-based interventions has increased markedly over recent decades with promising results, several factors create limitations for research on mindfulness. First, research on mindfulness is complicated by the diverse nature of the construct itself, as there are many types of mindfulness practices. Consequently, mindfulness eludes easy or definitive characterization leading to competing definitions. Creswell (2017) defines mindfulness as a process of openly attending, with awareness, to one's present moment experience but there are many alternative definitions. As discussed by Davidson and Dahl (2018), research has focused on only a few types of the many types of mindfulness practice, excluding other types of practice that may have great potential.

Second, it is unclear how well mindfulness interventions work across different populations. The availability and adoption of mindfulness interventions does not appear to be comparable across different groups. According to Olano et al. (2015), mindfulness interventions, although widely available, have been primarily sought out and used by high socioeconomic status (SES), healthy, Caucasian individuals, but are underutilized in minority and low SES populations. This presents challenges for research since samples using largely white, healthy, and relatively affluent individuals could make it difficult to determine how results generalize to other groups, including the general population, clinical populations, and persons of color.

Third, when looking at the research, it is clear that there is a need for higher quality studies (Farias et al., 2016). For instance, many studies use non-active control conditions (e.g., wait-list controls) and generic outcome measures (e.g., quality of life) that preclude determination of what specific variables mindfulness may or may not affect. In particular, methodological limitations of this body of research make it more difficult to determine the effect of mindfulness interventions on clinical populations (Hedman-Lagerlöf et al., 2018;

Medvedev et al., 2018). For example, it is difficult to determine how well mindfulness-based interventions work within clinical populations if the studies are lacking reliability in procedures for diagnostic assessment of participants and outcomes (i.e., blinded outcome assessors). This is in addition to not checking key treatment characteristics such as treatment adherence and therapist competence which could possibly be confounding factors. Additionally, despite promising results regarding general effects, studies have not yet attended to potential moderating factors such as duration, intensity, and regularity of practice as well as whether mindfulness is utilized during common activities of daily living (Davidson & Dahl, 2018).

Fourth, it is unclear how mindfulness compares to other treatments. For instance, one meta-analysis found mindfulness to be more effective than relaxation training and cognitive trainings (Sedlmeier et al., 2018). However, this meta-analysis only evaluated adults from a non-clinical sample, so it is unclear whether the results regarding differential treatment efficacy apply to clinical populations.

Fifth, there are significant challenges concerning mindfulness-based interventions that aim to promote mindfulness due to difficulties in measuring the state of mindfulness and the skills needed to achieve it. Measuring levels of mindfulness is problematic, in part, because mindfulness does not have a set definition. Bergomi et al. (2013) argue that all eight of the mindfulness scales they identified may not constitute an adequate measure of mindfulness because they do not provide a comprehensive assessment of all aspects of mindfulness in general population samples. Mindfulness scales focused on specific, often clinical populations, may not be applicable for use with the general population. Although the self-report measures typically used in these studies are subject to various forms of bias and likely affected by interpretations of mindfulness that differ across populations, the use of objective measures (e.g., electroencephalogram [EEG], magnetic resonance imaging [MRI]) is limited

by expense and lack of consensus regarding how they might validate a state of mindfulness (Bergomi et al., 2013). Adding to these limitations is the lack of research that explores factors such as duration, intensity and regularity of practice, as well as whether mindfulness can be utilized during common activities of daily living thereby increasing its mobility (Davidson & Dahl, 2018).

Sixth, even though Mindfulness has been around for thousands of years, the research is still lacking in regard to identifying *how* the intervention works. Creswell (2017) has described how little is known about the specific mechanisms of mindfulness interventions and the need to explore them to optimize clinical interventions involving mindfulness.

Finally, treatment adherence is a concern for any intervention research. Mindfulness research has struggled with getting participants to use the intervention consistently over the course of a trial. Nam and Toneatto's (2016) meta-analysis found that the majority of mindfulness randomized controlled trials (RCTs) had a 20% or higher attrition rate, which significantly affects the researcher's ability to control for bias. Also problematic is that information that might shed light on the reasons for attrition was not collected in most of the studies.

Adverse Effects of Mindfulness. Although mindfulness is associated with many different benefits (some of which are reviewed below), there has been limited examination of adverse effects. Creswell et al. (2017) report that there is little published empirical research on the prevalence, type, and severity of intense negative experiences and other adverse effects associated with mindfulness interventions (e.g., agitation, anxiety, discomfort, confusion). Mindfulness can cause physiological discomfort for some individuals, primarily at the beginning stage of practice. For example, Creswell et al. (2014) found that the effort used to become more mindful during a stress task increased cortisol reactivity in subjects, though they were nonetheless able to continue the intervention and improve their emotion regulation

skills. Meditation has been shown to exacerbate worries for some users. Chittaro and Vianello (2016) found that several of their participants experienced more negative feelings when using a mindfulness application due to thinking more about their worries, whereas others reported that they could not decenter from all of their worries. This suggests that not only might mindfulness be ineffective work for everyone, but it may exacerbate various forms of distress for some individuals. Although studies have yet to explore what variables might predict a negative response (e.g., level of experience with meditating), it is worth noting that discomfort from trying a new intervention is not unique to mindfulness and might be expected from any other interventions in which the individual is trying something new and challenging.

Uncertainty About Necessary Dosage for Mindfulness. A crucial question in regard to the benefits of meditating involves the “dosage” (viz., amount of guided instruction or practice) necessary to produce a favorable response. The dosage necessary for participants to receive the benefits of mindfulness varies significantly between studies. For example, Carissoli et al. (2015) hypothesized that a 3-week mindfulness program was not a sufficient duration to attain significant results in reducing stress and anxiety. Flett et al. (2018) found that participants who utilized their mindfulness applications more often showed significant benefits in regard to college adjustment, mindfulness, depressive symptoms, and anxiety symptoms after just 10 days of meditation sessions. The meaning of this finding with respect to sufficient “dosage” of training is rendered less clear, however, by the fact that the duration of the meditations available ranged considerably and that the exact duration of the sessions was not reported.

Kral et al. (2018) found that the amount of mindfulness practice was not significantly correlated with amygdala reactivity, which led the researchers to speculate that the amount of practice necessary to realize benefits could be influenced by other factors (e.g., prior

experience with meditation, motivation, level of distress, training environment). For example, the necessary “dosage” required to obtain benefits may be reduced if training occurs in the context of a meditation retreat, where motivated individuals immerse themselves in a controlled environment with fewer distractions from work or personal responsibilities, more social support, and a higher degree of accountability than is the case in other training environments. Factors related to dosage are an important area for future research so we can better understand the length of time necessary in different training conditions for one to experience the benefits of meditation after having started a routine.

Uncertainty About Effects of Mindfulness in Clinical Populations. Research on meditation with clinical populations has been pursued by researchers who are curious about its potential to reduce symptoms in patients suffering from various types of mental illness. Lee et al. (2016) found that a 6-week mindfulness training program produced modest benefits in adults with respect to attention and subjective well-being but no significant reductions in depression and anxiety. This suggests that some users will experience benefits from adding a meditation routine to their life but may not experience clinically relevant reduction in symptoms for mental health disorders such as anxiety and depression. However, Hedman-Lagerlöf et al. (2018) found that Mindfulness-Based Interventions (MBI's) were efficacious for reducing depression. Currently, the literature may be somewhat mixed with respect to the benefits of mindfulness when applied as an intervention for clinical population. However, Goldberg et al. (2018) reported promising results in a recently conducted systematic review and meta-analysis of 142 RCTs examining the efficacy of mindfulness-based interventions on clinical symptoms of mental health disorders. They found mindfulness interventions did not differ from evidence-based treatments and that their efficacy was most consistently supported for depression, pain conditions, smoking, and addictive disorders.

Benefits of Mindfulness

Despite the limitations discussed earlier, mindfulness has the potential to help people in a variety of ways. Even though research with mindfulness is still in its early stages, there are several promising avenues for its use. Most of all, it has been incorporated into certain efficacious psychotherapy models of treatment such MBSR and Mindfulness-Based Cognitive Therapy (MBCT; Giannandrea et al., 2018; Moir et al., 2019). MBSR has been associated with benefits in reducing stress, distress, and psychological symptoms among both clinical and nonclinical populations (Khoury et al., 2015). It is a popular intervention among the general population of the United States (Olano et al., 2015) and is appealing due to being an alternative to group sessions, convenient to use and offering objective measures of adherence (i.e., automatically collecting data to mark progress; Bostock et al. 2019).

Decrease in Symptoms of Depression and Anxiety. Although not yet sufficiently studied, results pertaining to the impact of mindfulness on depression and anxiety are mixed but promising overall. As stated above, Goldberg et al. (2018) found convincing evidence that MBI's were effective for decreasing depressive symptoms, but not anxiety. In a study examining different facets of mindfulness training, Medvedev et al. (2018) found that fostering a non-judgmental attitude towards oneself was the most important factor for the reduction of anxiety, stress, and depression in a nonclinical student population. Similarly, Petrocchi and Ottaviani (2016) found nonjudgment to be the only facet of mindfulness to predict reduced depressive symptoms in a sample of primarily Caucasian adult participants. The researchers speculated that nonjudgment along with self-compassion could help improve dispositional mindfulness, providing users with even more benefits in regard to lowering depressive symptoms. This demonstrates that a nonjudgmental, self-compassionate attitude learned from mindfulness can possibly help prevent or mitigate the symptoms of depression.

Khoury et al. (2015) found that MBSR had moderate effects on nonclinical individuals for depression, anxiety and distress.

Other research has also found mindfulness to have benefits with respect to anxiety symptoms. Penberthy et al. (2017) found that anxiety symptoms significantly decreased in participants who were assigned a Tibetan Buddhist meditation instruction and discussion class, which helped them both learn and explore mindfulness and well-being. Lee and Zelman (2019) found that average or greater dispositional mindfulness was associated with lower negative affect such as anxiety. Gautam et al. (2019) found that all facets of mindfulness (non-judging, non-reacting, acting with awareness, observing and describing), except for observing, helped college students reduce procrastination due to lowered anxiety. In addition, being able to describe one's internal state, which is a key facet of mindfulness, was especially found to lower anxiety. Hertz, et al. (2015) found that individuals higher in mindfulness experienced less attachment anxiety during a conflict discussion possibly due to feeling more secure in the attachment with another as well as experiencing less subjective distress.

Mindfulness Can Help Reduce Stress. Khoury et al. (2015) found in their meta-analysis of healthy individuals that MBSR interventions had a large effect in terms of reducing stress, especially among healthcare professionals. Additionally, MBSR's lower attrition rate in comparison to cognitive-behavioral interventions (17% to 22.5%) suggested that participants were significantly committed to this treatment approach. In a systematic review of mindfulness-based interventions (MBI) used in the workplace, Heckenberg et al. (2018) found participants who had used mindfulness-based interventions were more likely to have better regulated hypothalamic-pituitary-adrenal (HPA) axis, improved autonomic balance based on their heart rate variability (HRV) coherence ratio measure, better immune system functioning, and a decrease on some measures of inflammation. Gu et al. (2015)

found that teachers who underwent a meditation training, which included emotion and attention skills training had less of an anticipatory stress response to a social stressor (viz., the Trier Social Stress Tests [TSST]). Singh et al. (2016) found that mindfulness was negatively associated with perceived stress in a sample of college students and suggested that mindfulness can help reduce the perception of stress by accepting the reality of the situation and letting go of things outside of one's control. Medvedev et al. (2018) found that mindfulness can decrease stress related symptoms both in young and older adults. Ramasubramanian (2017) found that freshmen college students experiencing the stress of adjusting to college life were better able to cope with the stress and experienced less perceived stress after taking a 14-week semester-long one credit seminar on mindful communication. Hertz et al. (2015) found that mindfulness may buffer the response against stress and thereby help couples become more adept at handling conflict in the relationship. They speculated that individuals high in mindfulness could better handle conflict by being more present to the situation due to having a more robust coping mechanism as indicated by having lower cortisol levels. Mindfulness may more specifically be able to lower perceived stress due to emotion regulation as suggested by Prakash et al. (2015) whose findings revealed that enhanced emotion regulation was a possible mechanism that explained the stress-reducing capacity of dispositional mindfulness.

Mindfulness may be able to help those in situations prone to produce chronic stress. Cachia et al. (2016) found in their systematic review that mindfulness can reduce stress in parents of children with autism spectrum disorder (ASD). Yang et al. (2017) found in a sample of Singaporean mental health professionals that all mindfulness facets were negatively associated with both stress and burnout, even when controlling for participants' years of professional experience. This suggests that mindfulness can benefit individuals, at least in terms of stress reduction, regardless of their level of work experience. The positive

effects of mindfulness on stress reduction have also been established in the military with Meland et al. (2015) finding that mindfulness significantly reduced the physiological stress response based on cortisol levels during a prolonged high-demand workload for a Norwegian military helicopter unit.

Mindfulness Can Help Those Suffering from Addiction. A meta-analysis by Li et al. (2017) found mindfulness to have efficacy as a treatment for substance as evidenced by its small but significant effect on reducing substance misuse and medium effect on reducing craving. Additionally, mindfulness treatment had a large effect on reducing stress levels, which, in turn, contributed to its ability to help individuals better resist the symptoms of withdrawal. This potential for mindfulness to play a role in substance use treatment by reducing elevated stress levels that often prompt relapse is further supported by Carroll and Lustyk (2018) who found that participants in a substance abuse care facility who completed the Mindfulness Based Relapse Prevention (MBRP) program learned to deal with stress in a more adaptive, flexible manner, which could help prevent them from relapsing.

Mindfulness Can Increase Well-Being and Help Gain Awareness of Mood. As mentioned earlier, well-being is used to determine how individuals are coping with the daily stressors of life and how well one can maximize positive affect and minimize negative affect in the face of stressors. Mindfulness has been found to increase well-being (Beshai et al., 2016). Christie et al. (2017) found that mindfulness increased well-being in separate samples of undergraduate and postgraduate students. The authors suggest that the increased well-being was mediated by mindfulness' encouragement to both clarify and act in accordance with one's values. Mindfulness had also been found to increase well-being in parents caring for children with Autistic Spectrum Disorders (Cachia et al., 2016). There are also indications that participation in a long-term meditation group can lead to more accurate perceptions of one's internal state (Rosenkranz et al., 2016)

Decrease in Emotional Reactivity. Long-term mindfulness training has also been demonstrated to reduce emotional reactivity. For instance, Davidson et al. (2018) found that college participants who engaged in long-term mindfulness had less right amygdala activation when shown affective pictures in comparison to control groups. The researchers speculated that the results, along with functional magnetic resonance imaging (fMRI) data from the participants, strengthened their hypothesis that individuals who engage in long-term mindfulness meditation can experience improved emotion regulation due to reductions in emotional reactivity to both negative and positive stimuli. This seems to fit with ideas stemming from contemplative traditions that one's emotional reactivity can be reduced by no longer trying to avoid unpleasant feelings or gravitate towards pleasant experiences.

Additional Benefits: Low Cost, Convenience, Extensive Training Not Required, and Use as an Adjunctive Treatment. Mindfulness has many characteristics likely to increase its appeal to newcomers. It can be used in a variety of settings, making it helpful for those who are frequently on-the-go and have demanding schedules. Mindfulness is also not a costly intervention since it can technically be learned for free or at low-cost through the internet, applications, books, and group classes. Another appeal of mindfulness is that it does not require extensive training as studies have shown that benefits of mindfulness can be achieved by participants who engage in the practice as infrequently as 10 times during an 8-week intervention period (Bostock et al., 2019). Additionally, mindfulness appears able to enhance other treatments as is the case of MBSR (Evans et al., 2018) and MBCT (James & Rimes, 2018), due at least in part to the increase in self-compassion that can result from increased mindfulness.

Flexible Delivery Models. There are indications that mindfulness interventions delivered through various forms of technology as opposed to traditional methods are both efficacious and well received by participants. Tunney et al. (2017) compared a mindfulness

and relaxation intervention delivered through a traditional live face-to-face group with one delivered via a computer game avatar. They found that the computer-game delivery was well received by their sample of 10 to 12-year-old children who generally found the intervention more engaging and less confusing in comparison to the face-to-face version. Furthermore, their analyses suggested that the potential mechanism of change involved the content of the exercises rather than being dependent upon any human-to-human interaction. This is a notable finding since it indicates that mindfulness-based interventions delivered through technology can be just as beneficial as interventions given in a face-to-face context by a practitioner. The standardization of the mindfulness-based interventions given via technology could be a potential benefit in reducing confusion associated with live human leaders such as unclear communication, omission of key details, and variation across leaders.

Receptivity toward alternative delivery methods does not appear to be limited to youth. A systematic review by Fish et al. (2016) demonstrated that adult participants, ages 25-56, enjoyed the content of the mindfulness interventions being delivered by a variety of different technologies, including text, and audio/video (though animation was less popular). The authors concluded that there was evidence to support the claim that mindfulness-based interventions can be effectively delivered through technology in accordance with accepted mindfulness models.

Efficacy of Interventions Delivered Via Mobile Applications

Mobile applications have become increasingly popular for a wide variety of health and self-improvement related uses. These include exercising (Muntaner-Mas et al., 2019), reducing nicotine usage and other addictions (Spears et al., 2019), gaining emotional awareness (Bakker & Rickard, 2018), reducing stress and teaching stress management (Coulon et al., 2016; Dillon et al., 2016), relieving depression and promoting well-being (Bakker et al., 2018), and teaching health-related skills (Flett et al., 2018). Mobile

applications have even made their way into therapy, now being used as an adjunctive component of treatment (Bakker & Rickard, 2019). Wen et al. (2017) found that medical students using a mindfulness-based smartphone application experienced increases in both positive affect and in mindfulness scores while negative affect scores demonstrated no change. This indicates that mindfulness interventions via mobile application can help professionals in demanding careers to reduce burnout since the study also found that the results applied regardless of the degree of distress that participants reported at baseline. Flett et al. (2018) found that participants who utilized mindfulness applications more often were more likely to show greater benefits in regard to college adjustment, mindfulness, depressive, and anxiety symptoms. Even more interesting is that their results indicated that significant improvements were found after just 10 days of using either the Headspace or Smiling Mind mindfulness-based application when compared to the control condition. Length of time necessary to demonstrate improvement is an important area for future research since it is difficult to assess how long it will take for one to experience benefits of meditation after having started a routine. Nonetheless, the current data suggest that mindfulness as an intervention does not require a large time commitment.

Limitations of Mobile Applications

There are some limitations to using mobile applications. First, individuals must have sufficient financial resources to both obtain an internet-connected smartphone and to pay for applications, which increasingly rely on subscription models. Second, some users may be hampered by a lack of familiarity with applications and/or smartphone technology. Third, some users may not have reliable access to the internet, which could also impact their ability to download or use such applications (Tunney et al., 2017). Fourth, despite the abundance of available health related applications, very few have been subjected to research to test their efficacy. This can make it difficult for health professionals and consumers to determine

which applications are the best suited to help their clients or themselves. For example, in 2013, there were 1,536 depression-related applications available for download, but only 32 published articles regarding depression applications (Martínez-Pérez et al., 2013). Similarly, over 85% of applications in England's National Health Service's application library do not have scientific evidence to support them, making it impossible to determine how effective they are (Leigh & Flatt, 2015).

Another important consideration is how mobile applications can be used most effectively. Although far from definitive, some current evidence suggests that mobile applications are more effective when used as adjunctive resources in the context of professionally delivered treatment than as stand-alone self-help resources (whether used by members of the general or clinical population). For example, Firth et al. (2017) found that utilizing smartphones to treat anxiety disorders was most effective when these devices were used to enhance and support the delivery of existing face-to-face or internet-based therapy programs. Another notable limitation is that few mental health applications have any empirical support and that many of those that do were developed specifically for research purposes and are not available to the public.

There are several additional potential drawbacks associated with the use of applications to deliver mindfulness training. Due to the online nature of the applications, there are concerns about both consumer privacy and security as well as a lack of scientific evaluation regarding their effectiveness since only a minority (7%) of the mindfulness applications reviewed in European application stores by Schultchen et al. (2021) provided any evidence regarding their effectiveness. Furthermore, Schultchen et al. (2021) also found that 2% of the applications they reviewed offered user support such as hotline numbers in the case of a crisis or emergency, which could make applications less appealing for users who seek more immediate support should unexpected symptoms occur while engaging in

mindfulness. Lastly, some applications may be less appealing or less effective because they lack an explicit teaching component or have poorly designed user-interfaces that render them difficult to use (Plaza et al., 2013).

Benefits of Mobile Applications in Mental Health Care

Despite these limitations, mobile applications have many advantages as well. Mobile applications are widely available via the app store platforms for both iPhone and Android. Some individuals may prefer mobile technology of applications due to relatively low cost, convenience, 24/7 availability and privacy protections (Erhardt & Dorian, 2017). Some individuals may prefer apps over face-to-face meetings due to typical barriers of treatment such as geographic distance, scheduling conflicts, and transportation (Leigh & Flatt, 2015). Mobile apps can also be appealing due to many features they offer that allow users to hold themselves more accountable. These include reminders, notifications, encouraging messages, and support services. Some encouraging findings regarding the benefits of mental health applications when used as self-help tools with respect to depressive symptoms, anxious symptoms, and well-being suggest that they might also be useful as adjunctive tools to improve the efficacy and efficiency of professional therapy (Leigh & Flatt, 2015).

Mobile applications have demonstrated that they can be valuable self-help tools. Their potential benefits include greater volume and accuracy of clinical data collected via self-monitoring, progress tracking (e.g., via prompted measure completion and automatic charting), improved skill acquisition through increased density of practice in real-life situations, consolidation of therapeutic learning via psychoeducational components, and providing a means for support and guidance independent of the therapist that may encourage autonomy and facilitate termination of formal treatment. It was also found that users who used three different applications (*MoodKit*, *MoodPrism*, and *MoodMission*) as a self-help tool for either learning CBT strategies or self-monitoring their emotional well-being, experienced

significant improvements in well-being (Bakker & Rickard, 2018). However, only *Moodkit* and *MoodMission* were found to decrease depressive symptoms suggesting that emotional awareness was not sufficient to decrease such symptoms, but rather increasing coping self-efficacy led to improvements in mood. Additionally, none of the applications demonstrated any significant effects in decreasing anxiety.

In addition to their use as stand-alone, self-help resources, research has shown that this type of self-help tool can benefit those who are clinically depressed or anxious. In another study by the same authors, Bakker and Richard (2018) conducted a study in which participants who were not receiving therapy received CBT strategies after they reported their mood to the *MoodMission* application when they were feeling sad or anxious. The results indicated significant improvements in coping self-efficacy and well-being in those who used the application regularly, especially by those who were subclinically or moderately depressed. However, such effects were not found with participants who had severe anxiety or depression, suggesting that such individuals likely require additional resources (i.e., professional therapy) in combination with the *MoodMission* application.

Taken together, this raises the possibility that clients could use such mobile applications outside of therapy sessions as an adjunctive resource to enhance treatment, by continuing to practice skills that they are learning in therapy. This in turn could make therapy more effective due to the greater mastery of targeted skills. This also benefits the provider because it allows them to give more resources to their patients in the moments they are not there, in addition to empowering the client to take charge of their mental health when not in a session with their therapist. Having resources available via the mobile application in the moment they are needed could also help clients develop more self-efficacy (Dillon et al., 2016). Based on these encouraging findings which include the benefits of mental health applications when used as adjunctive tools with respect to depressive symptoms, anxious

symptoms, and well-being suggest that they might also be useful as adjunctive tools to improve the efficacy and efficiency of professional therapy.

COVID-19 and the Increased Use of Mindfulness

The COVID-19 pandemic officially began on March 11th, 2020, when the World Health Organization (WHO) declared it a global pandemic (Johnson et al., 2021). This resulted in lockdowns and quarantines throughout the world. This was done to inhibit the spread of the virus and to lessen the burden of hospitals which were at risk of becoming overwhelmed. However, there were many unintended consequences of these precautions. First responders such as police officers, who were expected to help carry out these precautions, experienced increases in stress due to having to adapt their policing to avoid contracting the virus amid a shortage of personal protective equipment (PPE) in addition to being disliked because of enforcing unpopular measures to help reduce the spread of the virus (Stogner et al., 2020). Within the medical community, there were significant challenges encountered with enforcing social distancing measures at hospitals and concerns about giving care to patients via telehealth due to some patients being unable to utilize the technology necessary for such appointments. Due to the stay-at-home orders, individuals also experienced increased loneliness, family conflicts, and domestic violence (Johnson et al. 2021). According to an analysis of twitter posts in the United States from March 13th to May 6th by Guntuku et al. (2020), there were significant increases in tweets mentioning anxiety, stress, and loneliness when compared to 2019. Otu et al. (2020) speculated that the significant increase in time spent watching various media sources to obtain information concerning COVID-19 would likely increase individuals' anxiety.

To help address this, headspace began to offer their services for free to healthcare workers for the remainder of 2020 and gave the general public access to some of their content such as articles and guided meditations (Headspace, n.d.; Young, 2020). Several other

applications followed suit, and this ultimately resulted in a substantial increase in the awareness of mindfulness for coping. This no doubt has brought about an increase in mindfulness to multiple sectors of the population who had been previously unaware of its use and benefits. Furthermore, research has shown that some of these applications have been effective in mitigating the deleterious effects of COVID-19 on mental health. A study by Sun et al. (2021) found that a mindfulness-based mobile application had a high retention rate among its users (young adult Chinese students who were in quarantine) as well as demonstrated a superior effect against anxiety and improved depressive symptoms. Although there has been significant progress made in combating COVID-19, many researchers caution that these psychological effects will be felt for years to come (Galea et al., 2020).

Rationale, Primary Aim(s), and Key Research Questions

The aim of the proposed systematic review is to examine the evidence for using mindfulness-based mobile applications to reduce symptoms of depression and anxiety, lessen stress, and enhance well-being in both general population and clinical adult samples. Conducting the review should help the general population make more informed decisions about which applications to use and clinicians to make more informed decisions about which applications to suggest to clients, whether for use in sessions, out of sessions, or following the discontinuation of therapy. Mindfulness has now become popular within western culture and is being utilized as an alternative treatment for a variety of symptoms (Teresa & Sy, 2012). Although there are questions about the scope and magnitude of its efficacy, it remains a popular intervention among the general public and is now commonly being used in therapy through such modalities like MBSR and MBCT (Teresa & Sy, 2012). Additionally, subsequent to the immense growth of smartphone use by the general population (Poushter et al., 2019), mobile applications have become both a popular and appealing way to receive health-related interventions due to their low cost and accessibility for consumers (). As a

result, mindfulness interventions are increasingly being used by the public and by clinicians through mindfulness-based mobile applications (Krebs & Duncan, 2015).

However, resources are lacking to educate those considering the use of mindfulness-based mobile applications with respect to their established benefits and limitations.

Therefore, the aim of the proposed project is to conduct a systematic review of the current literature to better clarify the benefits, limitations, and future directions of mindfulness based mobile applications in order to better inform members of the general public seeking mindfulness-based self-help resources and treatment providers who wish to integrate such applications into their clinical work with adult clients or to recommend them as adjunctive treatments.

The key research questions are the following:

- What benefits are associated with the use of mindfulness-based applications for clinical and general population adults with respect to stress, symptoms of anxiety, and symptoms of depression?
- Have mindfulness-based applications been found to enhance well-being for clinical and general population adults?
- What limitations have been identified with respect to the use of meditation-based applications for clinical and general population adults?

Chapter 2: Methodology

Systematic Review Approach

A systematic review utilizing a narrative synthesis was used to identify, review, and synthesize the findings from studies concerning the impact of mindfulness-based mobile apps on specific aspects of psychological functioning in both the general population and clinical groups. A systematic review was chosen due to it being considered the “gold standard” concerning literature reviews that assess specific research questions to provide evidence-based answers and better inform the public (Boland et al., 2017). The author was given approval by the IRB board at Pepperdine University on 7/14/2020 (see Appendix A). The aim of this systematic review was to clarify the conclusions warranted based on the extant literature regarding the benefits, limitations, and future directions of mindfulness-based mobile apps with respect to enhancing well-being and reducing depressive symptoms, anxiety symptoms, and stress among clinical and general population adults. Furthermore, a narrative synthesis has been found to be a useful tool in the assessment of complex interventions concerning data from different study designs that are not easily combined for analysis (Ryan, 2013). Given that the research of mindfulness-based mobile apps is still in its infancy, a narrative synthesis approach was deemed appropriate.

Eligibility Criteria

Inclusion Criteria

Source Eligibility Criteria. Studies eligible for inclusion were published as English language articles in peer-reviewed academic journals between the years 2009 and 2021. Additionally, the studies must have examined publicly available and accessible mindfulness-based mobile apps downloadable to iOS or Android smartphones.

Study Eligibility Criteria. Studies eligible for inclusion must have involved general population or clinical participants over the age of 18 years and included quantitative self-

report measures related to depressive symptoms, anxious symptoms, stress (including self-report and physiological assessments), and/or well-being. For studies addressing well-being, there had to be a self-report measure that specifically measures well-being. Studies had to examine the use of mobile apps in delivering mindfulness interventions.

Exclusion Criteria

Although the review includes the clinical population, it is considered beyond the scope of this study to include clinical disorders that are considered “serious mental illness.” Therefore, studies relying on inpatient populations or participants with psychotic disorders (schizophrenia, etc.) or psychotic symptoms (i.e., bipolar disorder with psychotic symptoms, etc.) were excluded. Furthermore, studies assessing populations with personality disorders, manic symptoms, substance use and symptoms of trauma and stressor related disorders such as Post-Traumatic Stress Disorder (PTSD) were also excluded. In order to reduce potential confounding variables, such as amelioration of psychological symptoms from other interventions, studies that utilized mindfulness-based interventions with significant components of therapeutic modalities (i.e., acceptance and commitment therapy (ACT), cognitive behavioral therapy (CBT), dialectical behavioral therapy (DBT) etc.) were also excluded. Lastly, studies utilizing other technologies in conjunction with mobile apps such as virtual reality (VR), neurofeedback, electroencephalogram (EEG), etc. were excluded.

Search, Screening, and Selection Processes

Information Sources. Relevant studies were identified through the electronic search of Elton B. Stephens CO (company) (EBSCO), which has a robust selection of databases. Additionally, the home pages of Headspace and Calm were reviewed to identify any published studies related to those apps.

Search Terms. Search terms for EBSCO were identified via a preliminary search of the literature and in consultation with the head librarian of Pepperdine University. The search

terms thereby consisted of the following: (a) Mobile apps included: “app or mobile app or apps or mobile device applications or mobile apps or smartphone; (b) Mindfulness included: “meditat* or mindful*;;” (c) Effectiveness included: “efficacy or effectiveness or impact or benefits or outcomes;” (d) Psychological symptoms included: “well-being” or “stress or anxiety or depression;” The operator AND was used to combine these search terms.

Furthermore, search terms were made to *not* include the following in order to enhance the exclusionary criteria: (e) Adolescents: “teenagers or adolescents or teens or youth;” (f) ACT: “acceptance and commitment therapy;” (g) CBT: “cognitive behavioral therapy;” (h) Virtual Reality: “virtual reality or VR or augmented reality;” and (i) Computers: “computers or laptops.” These search terms were likewise included by including the operator NOT (See Table 1 for the search documentation record). Lastly, specifiers were made to include peer-reviewed articles between the years 2009-2021.

The finalized search syntax utilized on EBSCO on 01/09/2022 consisted of 187 articles; however, after duplicate articles had been removed (71 duplicate articles) there were a total of 116 articles remaining.

For the published studies available on the official website of Calm and Headspace, the articles were checked on 12/08/2021 to ensure that they were peer reviewed and had been published between the years 2009-2021. Given the Calm and Headspace app’s relevance to this research, and that both are popular mindfulness-based mobile apps, there was no additional search procedure deemed necessary. This resulted in 10 articles from the Calm website and 25 articles from the Headspace website, leaving a total of 35 articles. Notably, the Calm website listed 5 ongoing studies which were unable to be retrieved. No duplicate articles were identified during this search. The first round of screening resulted in 15 articles from the Calm and Headspace website being removed due to not meeting the inclusionary and exclusionary criteria. The 20 remaining articles were likewise given a full text review to

further determine if they met the inclusionary and exclusionary criteria of this review. After the first phase of screening titles and abstracts for EBSCO (see below for full description of two-round screening process), there were 90 articles left and 9 additional duplicate articles were identified in the EBSCO search due to the hand search of two popular mindfulness app websites (see below; 2 articles from the Calm website and 6 articles from the Headspace website). This resulted in the remaining 81 articles being reviewed via full text to further determine if they met the inclusionary and exclusionary criteria of this review.

Selection of Studies. The process for identifying studies for the proposed review consisted of two rounds of screening. The first round of screening consisted of the titles and abstracts of articles identified via the search described above to be reviewed to determine if they meet the review's inclusionary and exclusionary criteria. Duplicate articles were identified and deleted. To reduce bias and errors, the first round of screening was done separately by a second reviewer (research assistant) utilizing the same method. If there were any differences noted, the author and research assistant would discuss (until consensus was met) whether the reference was appropriate to continue to the second phase of screening (see Appendix B).

The second round of screening consisted of a data extraction process of the articles identified via the prior screening and consisted of the following steps: (a) The data collection and extraction were performed by the author and research assistant to ensure that they met the review's inclusionary and exclusionary criteria. Furthermore, if there was insufficient information in the abstract and title, then the full text was retrieved to further evaluate if the article met the inclusion or exclusion criteria. Any articles that had conflicting eligibility criteria or where the decision regarding inclusion/exclusion was unclear, were included temporarily until both the author and research assistant discussed whether the reference was appropriate for final inclusion; (b) a random subset of the initial forms (30% of the total

selected studies) completed by the author was checked by the research assistant and vice versa for accuracy and to reduce bias. The random subset of forms assigned to both the author and the second reviewer was done through the random number generator app. If there were any inconsistencies in the author and research assistant's extraction data, the finalized entries were determined collaboratively by the author and research assistant, and lastly; (c) the data extraction forms were stored electronically on google forms which then converted the data onto a Microsoft Excel sheet. All studies reviewed, after having passed the two rounds of screening, had their data extracted onto a data collection form using Microsoft Excel (see Appendix C). Figure 1 shows a PRISMA Flow Diagram which was designed to visually summarize the process of selecting the final set of studies for the systematic review. It included the key steps and methods used to obtain the final set of studies which included the sources of the articles (database and other), the elimination of duplicate articles, and the two-step screening process (title/abstract search, and context/full text search).

Data Collection and Extraction

Data collected from eligible studies served as the basis for answering the research questions involving the benefits, limitations, and future directions pertaining to the effects of mindfulness-based mobile apps on depressive symptoms, anxious symptoms, stress, and well-being among clinical and general population adults. Specifically, a data extraction form adapted from the Cochrane Collaboration was used to record the relevant variables for each of the studies included in the review. The form was converted to google forms which then converted the data onto a Microsoft Excel spreadsheet (Appendix C). It included the following information: Document ID, authors' names, full document title, research variables of the study, research variables of the review; General Information included: name of person extracting data, if reviewer was completing form as a secondary reviewer, date form was completed, source name, if the source was peer reviewed/published, year it was published,

document language; Design characteristics and methodological features: type of mindfulness app utilized, if app was available and accessible to general public, duration and frequency of meditation, if mindfulness app utilized a significant component of a therapeutic modality/other technology to deliver mindfulness intervention, aim of the study, method of study (quantitative, qualitative, mixed), specific design or research approach, differences in dosage and frequency of mindfulness intervention; Assessment of Research Variables: type of measure used for anxiety, depression, stress, well-being, as well as measures of reliability and validity; Study Participant Characteristics and Recruitment: population of interest, recruitment methods, sample size, age range, gender, diagnosis, education level, nationality, ethnicity, marital status, religion, socioeconomic status, occupation, languages spoken; Setting Characteristics: Study location, data collection setting; Results: results for anxiety, depression, stress, well-being, meditation duration/frequency, attrition rate, adherence rate; Conclusions and Follow-up: conclusion and recommendations of study authors, interpretations based on the results ability to answer the research questions of the review, implications for practice, study limitations, potential conflict of interest, and follow-up (if necessary).

Quality Appraisal

A quality appraisal form was utilized to determine the quality and strength of the studies retrieved. Specifically, the form assessed the strength of literature foundation and rationale for study, clarity and specificity of research aims/objectives/questions, quality of research design methodological approach, sample selection and characteristics, measures/data collection tools, data collection, analysis of data, diversity/cultural issues, discussion of study limitations, and an overall rating. The purpose was to better inform the review's questions regarding the strength of the literature to support potential benefits of mindfulness apps in ameliorating the psychological symptoms specific to the review. The quality appraisal of

included studies occurred during the data extraction phase of the project, after the selection of studies for the review had been finalized. The appraisal was made based on an *Individual Study Quality Assessment* form (see Appendix D). As guided by the *Individual Study Quality Assessment* form, each study was assessed in a range of domains using the following scale: Strong (3 points), Good/Adequate (2 points), Weak (1 point), Missing (0 points), or Not Applicable.

Data Management, Synthesis, and Analysis Plan

Due to the research of mindfulness-based mobile apps being in its infancy, a narrative synthesis was chosen to analyze the data obtained throughout the review. A narrative synthesis is when the results of a study are presented primarily via written explanation but can include graphs and other visual tools to illustrate the findings of the study (Boland et al., 2017). A Microsoft Excel sheet was used for recording and storing data collected for the review. A narrative synthesis of study characteristics and data pertinent to the research questions was made based on careful review of the data extraction and quality appraisal forms. As shown in Table 2, an Evidence Base for Research Questions Table presented information on the volume of studies, quality of studies, and results/conclusions of studies pertinent to the research questions of this review based on the data extraction and Individual Study Quality Assessment forms. The basis for excluding all rejected studies was recorded (see Appendix E).

Chapter 3: Results

The purpose of this research was to review the current literature to clarify the benefits, limitations, and future directions of mindfulness-based mobile apps to better inform members of the general public seeking mindfulness-based self-help resources and treatment providers who wish to integrate such apps into their clinical work with adult clients or to recommend them as adjunctive treatments. The review sought to answer the following questions: (a) What benefits are associated with the use of mindfulness-based apps for clinical and general population adults with respect to stress, symptoms of anxiety and symptoms of depression? (b) Have mindfulness-based apps been found to enhance well-being for clinical and general population adults? (c) What limitations have been identified with respect to the use of meditation-based apps for clinical and general population adults?

Selection Results of the Review

Screening Process Results

As shown in Figure 1, a total of 187 articles were identified through the electronic database search utilizing EBSCO. After 71 duplicates were removed, 116 articles remained for screening. Additionally, a separate search done on the official website for both Calm and Headspace applications was conducted. This search yielded 35 articles, none of which were duplicates. When the articles were combined, 10 additional duplicate articles were identified, leaving a total of 141 articles. These articles were run through title and abstract screening for basic eligibility pertaining to the inclusionary and exclusionary criteria. Following the first round of screening, there were 81 articles remaining for the second round of screening, which included a full text review as well as the completion of the data extraction and critical quality appraisal form if the article met full criteria for the purposes of this review. A total of 52 articles were eliminated during the second round of screening. Ultimately, 29 articles were eligible for inclusion in the study.

Excluded Studies

The primary reason for articles being excluded during phase I was that the study did not utilize a mindfulness app ($n = 19$). This was closely followed by the article not measuring relevant psychological factors (i.e., anxiety, depression, stress and well-being) pertaining to the review ($n = 17$). Although a limiter was made to exclude dissertations and other gray literature, there were nine articles that were excluded due to being either a research proposal or application review with no self-report measures/data. Despite having limiters for therapeutic modalities such as CBT and ACT, there were five articles that did use significant components, the most common being behavioral activation. There were four articles that exclusively used qualitative data. Limiters were also made for other technologies that deliver mindfulness interventions such as VR or augmented reality, and two articles were found to have used such technologies. Furthermore, two articles were found to include participants with serious mental illness such as personality disorders, so they were excluded. Notably, only one article was excluded due to the mindfulness application not being publicly available to the public. Limiters were made to exclude non-adult populations; however, there was one article that had a sample of children and adolescents. Lastly, 10 additional articles were discovered to be duplicates when the articles from EBSCO and the Calm and Headspace websites were combined.

During the second phase of screening, the most common reasons for exclusion of studies were as follows. Many of the studies excluded either did not include a mindfulness application or instead used another type of health-related application (e.g., weight-loss application, smoking cessation application; $n = 14$). Several of the studies did not use a public available mindfulness application ($n = 11$) or did not measure the psychological variables pertaining to this review ($n = 7$). There were studies that lacked any self-report measures to demonstrate significant changes in psychological variables pertaining to this review ($n = 6$) or

used a significant component of a therapeutic modality ($n = 5$). Several studies included participants with serious mental illness ($n = 5$). A minority of studies were research proposals or responses to editor articles ($n = 3$) or included adolescents and children in their sample ($n = 1$).

Results of the Included Studies

Mindfulness Applications

Of the 29 included studies, Headspace was the most prominent application featured in the review ($n = 19$) followed by Calm ($n = 4$). There were other mindfulness applications that were analyzed such as Smiling Mind, Mindful You, Mindapps, Mindfulness Coach, Tension Tamer, and Stop Breathe & Think (see figure 2 for all mindfulness applications included in this review). Each of these mindfulness applications were featured in only one study except for Tension Tamer ($n = 2$). All of these mindfulness applications are available via the Apple store except for Tension Tamer, which is on the Android store. It should be noted that Mindapps is available in the Apple store, but because it is a German application, users must go to the German Apple store to utilize it. All of the mindfulness applications were developed by private companies with the exception of Mindfulness Coach, which was designed by the VA to help Veterans both learn and practice Mindfulness (U.S. Department of Veteran Affairs, n.d.).

Duration of Mindfulness Intervention via Mobile App

Several mindfulness applications asked participants to meditate for 10 minutes daily ($n = 15$, 51%). Six (20%) of the studies asked participants to meditate 10-20 minutes daily, and six (20%) of the studies did not ask for a set amount of meditation to be completed daily. Two (6%) studies, one which used The Mindapp, and the other Tension Tamer, asked participants to meditate twice a day (i.e., 10-15-minute meditations each time). The study featuring The Mindapp was the only study that encouraged participants to do more than the

prescribed amount of meditation. There was one study that was two weeks or shorter, twenty-two (75%) studies that were 2-10 weeks long and six (20%) studies that lasted three months or longer.

Psychological Variables Measured

The most common psychological variable pertaining to the review that was analyzed by the included studies was stress ($n = 20$; 68%). Both stress and distress were included under the term “stress.” Mindfulness Based Stress Reduction was originally designed to help individuals suffering from chronic pain and stress; therefore, this pattern follows existing research regarding the origins of mindfulness as an intervention in the West (Kabat-Zinn, 1982). Anxiety and depression were both measured in 33% ($n = 10$) studies, and this is likely due to them being measured together frequently on self-report measures such as the Hospital Anxiety and Depression Scale (HADS) rather than separately (see self-report measures below). Only one (5%) study measured anxiety separately and three (15%) measured depression separately. Well-being was the least frequent psychological variable present in the included studies ($n = 6$; 30%); however, this likely was due to the requirement of this review that self-report measures had to specifically measure well-being instead of other constructs such as life satisfaction, and so on.

Research Design

In sum, there were 15 randomized controlled trials (RCT), three pilot studies, one prospective self-controlled studies, one prospective cohort study, one secondary analysis, one single-group pilot intervention, one evidence-based practice (EBP), one quality improvement (QI) initiative, one single arm trial, and one within subjects pre-post design. Three studies did not report the type of research design employed, and one of these studies reported it was developed as part of a future randomized trial. Taken together, a little more than half of the

studies utilized a RCT design (51%) while the next most common research design was a pilot study (10%). Each other research design encompassed 3% of the total studies included.

Self-Report Measures

There were 10 (34%) studies that used self-report measures for anxiety. These included measures such as the National Institutes of Health Patient Reported Outcomes Measurement Information System (NIH PROMIS), Hospital Anxiety and Depression Scale (HADS), Depression Anxiety Stress Scale (DASS-21), and Patient-Health Questionnaire- 4 (PHQ-4). The most common self-report measure used for anxiety was the HADS ($n=6$; 60%), followed by the NIH PROMIS ($n = 2$; 20%), DASS-21 ($n = 1$; 10%) and PHQ-4 ($n = 1$; 10%).

Regarding self-report measures for depression, there were 18 (62%) studies. These included the National Institutes of Health Patient Reported Outcomes Measurement Information System (NIH PROMIS), Hospital Anxiety and Depression Scale (HADS), Depression Anxiety Stress Scale (DASS-21), Beck's Depression Inventory (BDI), Center for Epidemiologic Studies Depression Scale-10 (CESD-10), Patient-Health Questionnaire- 8 (PHQ-8), Patient-Health Questionnaire- 4 (PHQ-4), Positive and Negative Affect Schedule (PANAS) and the Center for Epidemiological Studies Depression Scale (CES-D). The most common measure used for depression was the HADS ($n = 6$; 33%), followed by the PANAS ($n = 4$; 22%), CES-D ($n = 2$; 11%), NIH PROMIS ($n = 2$; 11%), PHQ-4 ($n = 1$; 5%), PHQ-8 ($n = 1$; 5%), BDI ($n = 1$; 5%), and DASS-21 ($n = 1$; 5%).

There were 19 (65%) studies that used self-report measures for stress, and three studies used physiological measures for stress. The self-report measures were the following: Perceived Stress Scale (PSS-4; PSS-10), Depression Anxiety Stress Scale (DASS-21), The National Comprehensive Cancer Network Distress Thermometer, and the Stress Overload Scale (SOS). One self-report measure was in German but was translated into English ("Änderungssensitive Symptomliste zu Entspannungserleben, Wohlbefinden, Beschwerden-

und Problembelastungen”, list of change sensitive symptoms of relaxation, well-being, exposure to discomforts and difficulties, ASS-SYM; Krampen, 2006). Notably, instruments such as blood pressure monitors were used to capture changes in the physiological stress of their participants, however, these studies were a minority in this review ($n = 3$; 15%). The blood pressure monitors used were the GE Carescape V100 monitor, Omron R2 wrist BP monitor and Spacelabs Healthcare 90207 ambulatory monitor.

As stated previously, self-report measures concerning well-being were only considered if they explicitly reported measuring well-being rather than other variables such as quality of life. There were only six self-report measures for well-being and these included the Well-Being Index (WBI), Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS), General Well-Being Schedule (GWBS-38) and Short Warwick Edinburgh Mental Wellbeing Scale (SWEMWBS). The most common self-report measure used for well-being was the WEMWBS ($n = 3$; 50%), followed by the WBI ($n = 1$; 16%), GWBS-38 ($n = 1$; 16%) and SWEMWBS ($n = 1$; 16%).

Demographic Information of Participants

Population of interest

The populations of interest in this review encompassed primarily incoming or current college students ($n = 5$; 17%), including medical students ($n = 3$; 10%). A moderate amount of the studies included cancer patients ($n = 4$; 13%), of which, two also included their caregivers. One study conducted their research during the COVID-19 pandemic and specifically sought to address questions pertaining to mental health during this time for pregnant women ($n = 1$; 3%). Another study sought pregnant women who were experiencing perinatal depression ($n = 1$; 3%). Two studies included medical professionals, one which consisted of emergency department staff and the other included nurses and nurse practitioners. One study specifically sought to have all their participants be individuals who

identified as African American. Other studies' populations of interest included the geriatric population ($n = 1$; 3%), caregivers of adults with cognitive impairment ($n = 1$; 3%), and prehypertensive adults ($n = 1$; 3%). Another study's population of interest was patients who had experienced multisystem trauma ($n = 1$; 3%). One study aimed to look at a community sample of women living in southern Louisiana. Some studies specifically looked at general adult populations between 19-64 years old ($n = 2$; 6%) or 18-49 years old ($n = 1$; 3%). Two studies featured adult participants who were experiencing high levels of stress at work environments such as high-tech companies and pharmaceuticals. One study examined participants who were happiness seekers ($n = 1$; 3%). Lastly, one study sought participants who were police employees from five forces based in the United Kingdom (Avon and Somerset, Bedfordshire, Cambridgeshire, Hertfordshire and South Wales).

Age Range

It was common for the studies to report the age of their participants (86%; $n = 25$), yet 13% ($n = 4$) did not report the specific ages of their participants, and instead, stated they were adults (e.g., 18 years or older, 21 years or older). 20% of studies had a mean age ranging from 18-30 ($n = 6$) and 24% studies had a mean age ranging from 30-40 ($n = 7$). 17% ($n = 5$) of studies had a mean age range from 40-65, and 3% ($n = 1$) of studies' mean age was 70 years old. One (3%) study specifically investigated the geriatric population (i.e., 65 years or older), and 17% ($n = 5$) of studies did not report a mean age, but instead, reported the age range which consisted of 19-64, 20-39, 18-80, 18-49, 19-39.

Gender

Overall, across all studies, there were 4,871 participants. Notably, three studies did not include any demographic data concerning gender, one of which had a participant sample of 1,337. In total, concerning the studies that included the self-identified gender of its

participants, 60.13% ($n = 2,125$) of participants were female, 39.8% ($n = 1,408$) were male, and <1% ($n = 3$) indicated “other.”

Education level

Approximately 79% ($n = 23,1985$ participants) of the studies included the educational level of participants. 13% ($n = 270$) of participants had less than a college degree, 22% ($n = 440$) were attending college at the time of the study, <1% ($n = 8$) had an Associate's degree, 51% ($n = 1,014$) had a bachelor's degree, 8% ($n = 171$) were in a graduate school (e.g., medical students, medical residents, trainees), and 4% ($n = 82$) had a graduate degree.

Race

A little more than half the studies included in this review reported the race of their participants (65%, $n = 19,1817$ participants). The breakdown of the participants by race was the following: 6% ($n = 119$) were Black or African American, <1% ($n = 3$) were Native American/Alaskan, 2% ($n = 37$) were Hispanic or Latino/a, 6% ($n = 112$) were Asian, 2% ($n = 38$) were Biracial/Multiracial, 2% ($n = 40$) were Maori or Pasifika, <1% ($n = 9$) were Indian, 4% ($n = 77$) were Other, <1% ($n = 6$) preferred to not respond, and 70% ($n = 1,281$) were White. <1% ($n = 5$) were not identified in the studies, and 5% ($n = 93$) were specifically identified as “Non-Hispanic Black or Other/Multi/Hispanic”.

Marital Status

There were 11 studies that collected information about their participants' marital status (37%; 1,055 participants). The breakdown of the participants' marital status is the following: 70% ($n = 745$) were married or partnered, 21% ($n = 232$) of participants were single, 3% ($n = 42$) were divorced, 1% ($n = 19$) were widowed, <1% ($n = 8$) common law marriage, <1% ($n = 6$) of participants were separated, and <1% ($n = 3$) were not reported.

Religion

Only one (<1 %) of the studies accounted for the religion of its participants. Of the religions represented in this study, there were those who indicated Other (e.g., religious science, spiritual; $n = 15$; 41%), non-denominational Christian ($n = 8$; 20.5%), no religion at all ($n = 8$; 20.5%), Baptist ($n = 3$; 7.6%), Protestant ($n = 2$; 5.1%), and Catholic ($n = 2$; 5.1%).

Socio-Economic Status

Eight of the included studies gathered information concerning the socio-economic status of their participants ($n = 553$ participants). Regarding lower to middle socioeconomic status, the following was reported: 21% ($n = 119$) of participants earned <\$50,000, 18% ($n = 100$) earned >\$50,000, 11% ($n = 69$) earned \$21,000-\$74,999, 9% ($n = 52$) earned >\$61,000, 8% ($n = 49$) earned <\$29,999, 7% ($n = 39$) earned <\$75,000, and five participants did not report their income (<1%). Concerning high socioeconomic status, the following was reported: 9% ($n = 78$) earned \geq \$100,000, 6% ($n = 41$) earned <\$100,000, and <1% ($n = 1$) earned >\$75,000.

Occupation

A total of 16 studies (55%; 2,643 participants) collected information from their participants pertaining to their occupational status. These studies reported the following occupations: 25% ($n = 682$) of participants were students, 50% ($n = 1,337$) were police force workers, 13% ($n = 171$) were residents or trainees, 10% ($n = 142$) were nurses, 9% ($n = 120$) were pharmaceutical workers, 8% ($n = 113$) were high tech workers, 3% ($n = 51$) were retired, 2% ($n = 35$) were doctors, <1% ($n = 12$) were nurse practitioners, <1% ($n = 12$) were other health care staff, <1% ($n = 11$) were administrative staff at a hospital, and <1% ($n = 3$) were teachers. An additional 10% ($n = 3$) of the total studies mentioned that their participants worked but declined to specify the occupation.

Languages Spoken

Only two of the studies gathered information related to the language or languages that the participants spoke; however, this was due to the exclusion criteria. The two studies reported that their participants had to speak English to be included in the study because their mindfulness app was not available in any other language but English. No other article mentioned the language of their participants.

Previous Experience with Mindfulness

Nearly half ($n = 16$; 55%) of the studies did not report if their participants had any experience with mindfulness. Of the studies that did report these data ($n = 13$; 44%; see figure 3 for levels of mindfulness experience participants had entering the included studies), most allowed those who had prior experience meditating to be included ($n = 11$; 84%), eight of which the meditation experience was limited (61%; e.g., participants had used an application-based mindfulness program previously but were not currently) and two (15%) studies did not include participants who had meditated previously in their lifetime. Notably, for the studies that allowed previous meditation experience, the portion of their sample who endorsed previous mindfulness experience ranged from 20%-95%. Some of these studies had exclusion criteria, which limited the participants current meditative practice prior to entering the study if a participant meditated regularly ($n = 3$; 23%), or more specifically, if they had meditated for more than 20 minutes over the past six months ($n = 1$; 7%), had practiced meditation for more than 20 minutes ($n = 1$; 7%), or had practiced at all in the previous six months ($n = 1$; 7%).

Settings

The included studies encompassed a total of eight countries. The vast majority of the studies took place in the United States ($n = 15$; 51%), with some taking place in the United Kingdom ($n = 5$; 17%), New Zealand ($n = 2$; 6%), and Australia ($n = 2$; 6%). There was one

study from each of the following countries: Germany (3%), Canada (3%), Italy (3%), and Ireland (3%). Lastly, there was one study (3%) which recruited participants internationally with the sample representing 11 countries (including Australia, USA, Poland, Switzerland, Malta, Sweden, and Singapore; other countries not listed).

Attrition

Mindfulness research is known for its high dropout rate by participants according to Nam and Toneatto (2016), and the studies included in this review confirmed this trend. 48% ($n = 14$) of studies had an attrition rate of 26%-50%, 20% ($n = 6$) had an attrition rate of 16%-25%, 13% ($n = 4$) of studies had 3%-15%, 6% ($n = 2$) of studies demonstrated small attrition rates (0%-2%), and 3% ($n = 1$) had an attrition rate of 51% and higher. Lastly, two articles did not report their attrition rate.

Adherence

Concerning studies that asked participants to meditate a specific amount (e.g., 10 minutes daily), 27% ($n = 8$) of studies had a 0% adherence rate, 6% ($n = 2$) had 13% adherence rate, 6% ($n = 2$) had 22%-24% adherence rate, 3% ($n = 1$) of studies had a 39%-46% adherence rate, 3% ($n = 1$) of studies had a 61%-70% adherence rate, 3% ($n = 1$) of studies had a 87%-120% adherence rate, and 6% ($n = 2$) of studies had a 100% adherence rate. Six (20%) other studies adherence rates were based on if their participants used the application at all instead of doing a specific duration of meditation. One (3%) of which, found that the adherence was greater for its university sample depending on when in the semester the students took part in the study (i.e., earlier in the semester; 66.10% vs 44.40% adherence). Adherence rate for the remaining studies consisted of the following: 6% ($n = 2$) of studies had an adherence rate of 95%-100%, 3% ($n = 1$) of studies had an adherence rate of 72%, 6% ($n = 2$) of studies had an adherence rate of 55%-60%, and 20% ($n = 6$) of studies did not report the adherence rate.

Research Findings

Research Question 1: What benefits are associated with the use of mindfulness-based apps for clinical and general population adults with respect to stress, symptoms of anxiety, and symptoms of depression?

Anxiety. There were 10 (34%) articles that assessed for changes in the anxiety levels of their participants. Regarding studies that used Headspace ($n = 5$; 50%), all of these studies ($n = 5$; 100%) found a significant effect in reducing anxiety. Concerning studies that used the Calm application ($n = 3$; 30%), 60% ($n = 2$) found that users of the application self-reported significantly less anxiety than those in the control group while 30% did not ($n = 1$). 30% ($n = 1$) of these studies found a small effect size. Regarding other applications used ($n = 2$; 20%), one study used the Mindfulness Coach application and found that (a) anxiety symptoms significantly decreased as the study weeks increased and (b) the more time spent using the application, the greater the association between decreases in symptoms of anxiety. The other study used the Stop Breathe & Think application, which did not find a significant difference in anxiety between the control and experimental group.

Depression. Overall, eighteen studies were assessed for changes in depressive symptoms (e.g., depression and negative affect) in their participants. 55% ($n = 10$) of studies found significant reductions in the depressive symptoms of its participants, 33% ($n = 6$) did not find statistically significant reductions in depressive symptoms, and 11% of studies found mixed results ($n = 2$; i.e., two groups used a mindfulness application but only one was found to have statistically significant decreases in depressive symptoms).

Concerning Headspace, 76% ($n = 13$) of the studies used the application. 69% ($n = 9$) of such studies found that using Headspace resulted in statistically significant reductions in depressive symptoms. 7% of studies ($n = 1$) found that the Headspace and gradual-muscle-relaxation interventions were equally effective in reducing depression. 7% of studies ($n = 1$)

found significant reductions in depressive symptoms when participants were using either Headspace or Smiling Mind, but the changes were only maintained in Smiling Mind at the final time point (i.e., 40 days). A significant reduction in depression, along with a medium effect size, was found in 14% ($n = 2$) of studies. Furthermore, one of these studies found that the medium effect size persisted into the four month follow up. 7% ($n = 1$) of studies found that depression was significantly reduced, with a small effect size. 14% ($n = 2$) of studies had mixed findings, in which one group experienced benefits in depression while the other did not (both groups used the Headspace application). There were 21% ($n = 3$) of studies that found no change in depressive symptoms. One of these studies noted a reduction in negative affect as well as a small-medium effect size but it was not statistically significant.

Regarding studies that used Calm ($n = 3$; 16%), 66% ($n = 2$) of such studies found significant reductions in depressive symptoms and one of these studies reported a small effect size. 33% ($n = 1$) of studies did not find a statistically significant decrease in depressive symptoms but found a small-to-medium effect size.

Of the 14% ($n = 3$) of studies that used other applications, 33% ($n = 1$) used Stop Breathe & Think and did not find a significant difference between the control group and experimental group both during the intervention phase nor at follow-up. 33% ($n = 1$) of these studies utilized Mindfulness Coach and found that depressive symptoms within the intervention group significantly improved as the study's weeks and time spent using the application continued. As mentioned previously, the other 33% ($n = 1$) of studies had participants who were using either Headspace or Smiling Mind, and significant reductions in depression were found but the changes were only maintained in Smiling Mind at the final time point (i.e., 40 days).

Stress. Twenty-one studies (72%) assessed changes in the stress levels of their participants, and 14% ($n = 3$) of these studies used devices to measure physiological changes in stress levels. 80% ($n = 17$) of the studies found significant reductions in the perceived stress or physiological measurements of stress of their participants, while 14% ($n = 3$) did not find a significant decrease in perceived stress. 4% ($n = 1$) of studies found mixed results, due to having two groups that used the application but only one group experiencing a reduction in perceived stress.

Concerning Calm, two (9%) studies used the application, and both of them found a significant reduction in perceived stress. Additionally, one of them demonstrated a large effect size and the other showed a moderate effect size.

The majority of the studies used Headspace (61% of studies; $n = 13$) and 76% ($n = 10$) of these studies found a significant reduction in perceived stress or physiological measurements of stress. Only 7% ($n = 1$) of these studies measured physiological changes in stress. Moreover, 16% ($n = 2$) of studies found no beneficial effect, and 8% ($n = 1$) found mixed results. Only 53% ($n = 7$) of studies using Headspace reported effect sizes, wherein 71% ($n = 5$) found a small-to-medium effect size, and 28% ($n = 2$) found a large effect size.

Concerning other applications, 23% ($n = 6$) of the studies used applications besides Calm and Headspace. 83% ($n = 5$) of these studies found significant reductions in their participants' self-reported or physiological stress. 60% ($n = 3$) of the studies measured changes in stress through physiological devices (e.g., blood pressure monitors). 16% of these studies found no significant reduction in perceived stress ($n = 1$). Only two studies reported their effect sizes. One of the studies found large effect size for systolic blood pressure, medium-to-large effect size for diastolic blood pressure and low effect size on heart rate. One study found a small-to-medium effect size.

Research Question 2: Have mindfulness-based apps been found to enhance well-being for clinical and general population adults?

Only 20% ($n = 6$) of the included studies assessed for changes in well-being in their research participants, and all of them used the Headspace application. 83% ($n = 5$) of such studies found increases in well-being in their participants, while 16% ($n = 1$) did not. Of the studies that reported their effect sizes ($n = 4$), 50% ($n = 2$) reported a small effect size, and 50% ($n = 2$) reported a medium effect size.

Research Question 3: What limitations have been identified with respect to the use of meditation-based apps for clinical and general population adults?

Nearly half of the studies indicated that they needed to have more diverse samples that were inclusive of the general population ($n = 12$; 41%). This was further elaborated in that researchers were worried that the results would not generalize to men since their samples consisted of either entirely or primarily women ($n = 5$), being from the same culture or race ($n = 4$), to certain age groups ($n = 1$) or non-English speakers ($n = 2$). Another study speculated that its participants, who were primarily older, highly educated female participants (i.e., over 60 years old), were not representative of the general older adult population due to multiple demographic factors as well as these participants familiarity or fluency in digital devices such as smartphones. One also reported that more research was needed to understand the dosage necessary for beneficial effects as well as the long-term sustainability of improvements in mindfulness application-based interventions. A couple studies also noted the need to include more objective measures to capture how much their participants were actually meditating due to it often being self-reported by the participants ($n = 2$). One study used PMR as an active control group; however, there were concerns that the similarities between the two interventions could have impacted the results. Some studies noted concerns regarding the outcome measures they had chosen. For instance, one study found that the

results of their study would be hard to compare to the existing literature due to not being a global measure of stress. Another study stated that they were limited by not including objective measurements. A few studies expressed concern that their study was not long enough to see a significant reduction in psychological symptoms ($n = 3$). Other studies noted trends in which there was a significant effect early, but it was not maintained or may have plateaued ($n = 3$). One study reported not having an active control group, which could have made it more difficult to assess the changes in psychological variables during the mindfulness intervention via application period. A couple studies also noted that their participants began either not using the application as instructed or meditating without the app (e.g., learning how to meditate with the application and then meditating on their own; $n = 2$).

Results of Individual Study Quality Appraisal

Of the 29 included studies, the most common classification rating given to the studies was strong ($n = 12$; 41%) based on the Individual Study Quality Appraisal form (see Appendix C). This was followed by the exemplary rating ($n = 7$; 24%). There were additional studies ($n = 9$, 31%) that met criteria for the good/adequate classification and 3% ($n = 1$) of studies were classified as weak.

Chapter 4: Discussion

Overview of the Review

The systematic review was aimed at summarizing and synthesizing the research literature from 2009-2021 on mindfulness-based mobile applications, as well as their benefits with respect to stress, symptoms of anxiety, depression, and well-being. Furthermore, the review sought to address the limitations of these applications. The discussion section will review the implications of these findings and their relevance to general and clinical population adults as well as directions for future research.

Significant Findings Concerning the Research Questions

Research Question 1: What benefits are associated with the use of mindfulness-based apps for clinical and general population adults with respect to stress, symptoms of anxiety, and symptoms of depression?

Anxiety. Of the 10 studies that measured anxiety, only two studies (20%) did not find a statistically significant reduction in anxiety symptoms. The rest of the studies found significant decreases in the anxiety levels of their participants and effect sizes of small-to-large were reported ($n = 8$; 80%). Another study found that the Headspace and gradual-muscle-relaxation interventions were equally effective in reducing anxiety. One study compared both Headspace and Smiling Mind and found that they both significantly reduced anxiety symptoms for college students, which was maintained at the final time point at 30 days post-intervention (i.e., 30-day open period for participants to use the application without a recommended dosage). Future studies comparing applications will help determine which applications are most effective.

These promising results were even found with unique populations such as cancer patients and those who had experienced a traumatic injury. Two studies found significant reductions in anxiety for patients suffering from cancer based on reductions in their HADS

scores, but this effect was not observed for their caregivers who used the Headspace application under the same conditions. Notably, one of the studies that did not find any significant change in anxiety levels was conducted with a sample of adults who had experienced multisystem trauma. This potentially demonstrates a limitation for the use of mindfulness applications with this population and suggests that participants must be cognitively engaged enough to use them, which could apply to other populations as well (e.g., dementia patients). Future research in the acceptability and usability of mindfulness-based mobile applications with populations with cognitive difficulties will better establish for whom these interventions are appropriate.

Two studies pointed towards a pattern in which greater reductions in anxiety were associated with longer use of the mindfulness application over time and more frequent meditations. Specifically, one study that used the Mindfulness Coach application found that the more time spent using the application, the greater the association between decreases in symptoms of anxiety. This study found that anxiety symptoms significantly decreased as the study weeks increased, which was unique since it was carried out before the pandemic began and then ended while the pandemic was still ongoing. In another study that found a large effect size, the average participant completed 17 meditation sessions and results further indicated that if participants meditated for 10 sessions or more that there was a significantly higher likelihood of their anxiety symptoms improving. Although this seems promising, future research aimed at differentiating between different amounts of dosage will help better understand the minimum dosage necessary to alleviate anxiety. The implications of these findings suggest that there is strong evidence that mindfulness applications can alleviate symptoms of anxiety due to the majority of the studies finding significant reductions in their participants. However, clinicians should be mindful that the majority of these articles used the Headspace application.

Depression. More than half of the studies measuring changes in the depression levels of its participants found significant reductions ($n = 10$; 55%). A third of the studies ($n = 6$; 33%) found no statistically significant reduction in depression. Notably, some studies found mixed results ($n = 2$; 11%).

Most of the studies involving Headspace found significant reductions in depressive symptoms in their participants ($n = 14$; 72%). Concerning the Headspace application, 6% of studies found that the Headspace and gradual-muscle-relaxation participants were equally effective in reducing depression. 6% of studies found significant reductions in depressive symptoms with both Headspace and Smiling Mind, but the changes were only maintained in Smiling Mind at the final time point (i.e., 40 days). 6% of studies found that depression was significantly reduced, with a small effect size. There were 21% of studies, however, that found no change in depressive symptoms.

There were only two studies using Calm (11%) and 50% found a significant reduction in depressive symptoms while the other 50% did not. The other applications featured were mixed in their results. A study using Stop Breathe & Think did not find a significant difference between the control group and experimental group (i.e., Stop Breathe & Think group) both during the intervention phase nor at follow-up. But the study utilizing Mindfulness Coach found that depressive symptoms within the intervention group improved as the study weeks and time spent using the application continued.

Regarding unique populations, studies among cancer patients and caregivers were mixed. One study found that cancer patients who used the Headspace application did not experience a statistically significant reduction in their depressive symptoms but that their caregivers did. Yet, a different study found the opposite, that their participants who were cancer patients experienced statistically greater improvements on their depression score in comparison to their caregivers. One study looked specifically at pregnant women suffering

from depressive symptoms using Headspace and found that using the application was significantly associated with reduced depressive symptoms. A study involving anesthesia trainees found that the trainees' depression scores significantly decreased after one month of using Headspace and that the moderate effect size persisted into the four month follow up. Lastly, in a study with female participants from Southern Louisiana, there was a statistically significant reduction in depressive symptoms but only 43 of the 318 participants used the Headspace application (13.5%). This study had one of the most diverse sample populations in the review so future research should continue to build upon including more diverse populations to discover the barriers they can experience when trying to use this intervention. In sum, there is strong evidence that mindfulness applications are effective in reducing symptoms of depression but there may be more variables to consider regarding increasing their effectiveness such as total duration of the mindfulness application, different types of meditations that are more targeted towards improving mood (e.g., meditations involving compassion, etc.) and making these applications more desirable and convenient for diverse populations who experience significant treatment barriers.

Stress. Twenty-one studies assessed for changes in the stress levels of their participants (72%). One study of German female university students found that both PMR and Headspace were comparable to each other in reducing stress. This could indicate future research to continue directing comparing such interventions to identify advantages and disadvantages each has. The studies also demonstrated improvements in stress for caregivers of both loved ones with cancer and dementia ($n = 3$; 14%). Future research concerning the dementia population will help continue to determine if these applications are appropriate and beneficial for this population.

Three studies used physiological changes to determine changes in stress levels. Of the studies that measured changes in stress based on physiological changes, results were

encouraging ($n = 3$; 14%). Overall, the studies found significant reductions in blood pressure, both systolic and diastolic, and that the participants with higher blood pressure entering the study tended to see the biggest effects. All these studies reported moderate to large effect sizes. Future studies assessing the effects of mindfulness applications with different physiological instruments will continue to aid in our understanding of the effects of mindfulness applications to lower stress.

Many of these studies featured unique populations and results overall were encouraging. Three studies were done with medical residents and found to significantly reduce stress which is important given the time constraints and level of responsibility these individuals have in their profession. In a study of patients who had suffered multisystem trauma, results indicated no significant reductions in stress scores, potentially identifying a limitation in who can use these applications. In a study with all women from Southern Louisiana, there was no significant change in stress levels in the group of women who chose to use the Headspace app. The authors contributed this to the fact that the women who used the app reported less stress upon entering the study which they speculated may suggest that those who need the app the most (i.e., very stressed individuals) require more outreach to encourage them to use the application. Another study found that its participants, who were pregnant women who scored in the moderate to moderately severe level of depression per self-report on the PHQ-9, experienced a significant decrease in depressive symptoms when compared to baseline, at the 6-week post-intervention follow up. The study that used the Mindfulness You application found in their all African American sample that these participants experienced reductions in self-reported stress. This is especially important concerning diverse populations as this application was made specifically for African Americans who wanted to learn how to meditate.

Overall, these results suggest that mindfulness applications demonstrate excellent effectiveness in reducing both physiological and psychological symptoms of stress which indicates that these applications may not be beneficial for just mental health disorders but can also improve symptoms of medical conditions that are exacerbated or triggered by stress. Of notable significance, mindfulness applications often demonstrated moderate to large effect sizes which further support this conclusion.

Research Question 2: Have mindfulness-based apps been found to enhance well-being for clinical and general population adults?

Well-Being. Only 20% ($n = 6$) of the included studies assessed for changes in well-being in their research participants and all of them used the Headspace application. Most of these studies (83%; $n = 5$) of these studies found increases in well-being in their participants, while 16% ($n = 1$) did not. This indicates that mindfulness applications utilizing Headspace are effective in increasing well-being. However, despite the encouraging results there exists a clear need for more studies to be conducted assessing changes in well-being among individuals using mindfulness apps and for these studies to also assess these changes in other applications besides Headspace. Furthermore, future studies should specifically focus on measuring well-being as many of the included studies for this review claimed to study well-being but would use distress or depression as a proxy for it. Should providers wish to suggest the use of these applications to improve the well-being of their clients, it is again recommended that they keep in mind that all the studies utilized the Headspace application so it is unclear if other mindfulness applications would produce similar outcomes.

Research Question 3: What limitations have been identified with respect to the use of meditation-based apps for clinical and general population adults?

Clinical Population Adults. Certain populations did not appear to respond well to the mindfulness-based mobile applications for specific psychological symptoms. Studies

involving adult multisystem trauma patients and myeloproliferative neoplasm patients were less likely to find reductions in symptoms of anxiety. It is therefore possible that certain populations, especially those suffering from serious or life-threatening medical conditions may not experience reductions in anxiety that would typically be found in the general population. One study involving pregnant women suffering from moderate-to-moderately-severe antenatal depressive symptoms, however, did find significant reductions in self-report measures for depression and stress. Due to the review not including participants with serious mental illness, studies with individuals with a mental health disorder were limited. Therefore, this limits the generalizability of these findings concerning clinical and inpatient populations. Future research that includes serious mental illness as well as inpatient populations will help to determine if these applications are beneficial for those suffering from more debilitating and harder to treat mental health disorders.

General Population Adults. It was a recurrent theme that the majority of participants in a given study would experience difficulty either using the mindfulness application at all or not typically use it for more than 50% of the recommended time. Even though the users who did consistently utilize the mindfulness application generally experienced improvements in psychological symptoms such as anxiety, stress, depression and well-being, this is still a notable limitation. This ultimately suggests that it remains unclear how users of mindfulness applications can be further engaged to use the application consistently to maximize benefits. Furthermore, there appeared to be difficulties in using it consistently (e.g., daily), and it was not uncommon for the participants to use it for “short bursts” before not using it again for a period of time. The results of the review also suggested significant limitations regarding the generalizability of the studies to diverse populations due to the majority of participants being White, highly educated females. This was even further exacerbated by the fact that none of the applications had versions in other languages, which thereby excluded any non-English

speakers. Moreover, there have been concerns that mindfulness-based mobile applications are geared primarily towards White individuals due to lacking culturally diverse content. Additionally, only one of the studies considered the gender identity of its participants. There was also concern by the researchers that participants were not using the application correctly (i.e., not meditating in a quiet space or alone). There was one study which found that a participant was meditating but not using the application when meditating, which led his data to not be counted for the purposes of that study. There were also observations of a potential plateau regarding the psychological benefits of these applications. This indicates that it is difficult for providers to suggest a set dosage when recommending these applications to clients and that there is an urgent need for more structure in clarity to maximize the potential effects of mindfulness applications. Lastly, there were concerns about the sample sizes of the studies due to the high attrition rate observed in this review. Future research that focuses on recruiting larger sample sizes will significantly aid research in better determining effect sizes of mindfulness interventions.

Diversity

It was a recurrent theme that many of the studies did not have a significant representation of minorities. Surprisingly, the majority of studies had predominantly female participants ($n = 20$; 68%), which many of the studies listed as an area of limitation due to concerns of the generalizability of their results. Furthermore, these female participants also tended to be younger and Caucasian. Only four (13%) studies had a predominantly male population. In fact, there were some ($n = 4$; 13%) studies that had samples that were entirely female versus only one (3%) that was composed entirely of male participants. Of note, only one study accounted for individuals who identified as transgender or other gender identity which represents a crucial area of future research.

Regarding race, there was one study in which the sample was not majority White (i.e., consisted entirely of African Americans). The other studies that had African American participants, had a participant percentage ranging from 1%-31% of the total sample. Notably, there were three studies from New Zealand that included native populations such as the Māori or Pasifika and two studies that had Native Americans from the United States in their sample, but they only totaled <9 % of the total sample. Thirteen studies had participants who identified as Asian, and the sample range was between 2%-25% of the total sample for those studies. Six of the studies had participants who identified as Latino/a or Hispanic and the sample range was between 1.7%-15% for those studies. There were several studies that had participants who identified as biracial or multiracial, yet the majority of studies did not offer that as an option for participants to endorse and did not even have an “other” option. This is worrisome given the changing demographic of the United States. For instance, in studies conducted in New Zealand, 8%-13% of participants chose “other” when asked to identify their race. The authors of those studies speculated that this was because there was no biracial or multiracial category. Future research that includes such demographic options will be critical in order to best capture individual’s self-identified race.

This was also notable regarding language, as it was only used as an exclusion criteria for the studies rather than to learn more about the languages its participants spoke in order to potentially offer mindfulness based mobile applications in their native tongue. This was frequently mentioned as an area of future research, since most of the studies utilized applications that were only available in English. This is further supported by several studies describing concerns in their ability to recruit diverse populations if unable to provide the application in a non-English language.

Related to this was the near complete lack of religious diversity within the included studies. There was only one study which collected information concerning the religious

identification of its participants. This was particularly surprising given that mindfulness has strong roots in eastern cultures (Brazier, 2013) and could highly influence one's receptibility to the practice. Half of the studies also did not report if their participants had any experience with mindfulness prior to the study. By not having information related to the participants' religion, it also makes it harder to determine how they possibly learned mindfulness. Future research that collects information on participants' religion and religious practice will help better clarify the effects of previous experience with mindfulness as well as receptivity of mindfulness to those of other religions (e.g., Christians, Muslims).

Only a little more than a third of the total included studies had information pertaining to the marital status of its participants. This was surprising given the importance that marriage can have on one's physical and mental health (Kiecolt-Glaser & Newton, 2001). The majority of studies had samples in which the overwhelming majority of the participants were married or partnered. Interestingly, the studies often did not separately define being married versus being in a relationship. There was only one study in which the majority of participants were single or never married. Given the high number of studies with students and residents, there was still a sizable minority of individuals who were single.

As stated previously, the majority of the sample of the included studies consisted of younger adults. Studies with geriatric adults were significantly limited with only three studies having participants who were 65 years or older. Given that the majority of the sample population was either students or residents/trainees, it is not surprising that the geriatric population is not as represented in this research.

Concerning education, most of the studies included the education level of their participants and the majority of the studies had samples who had at least some years of college. Moreover, four of the studies' participants were in college at the time of the study. Only one study had a sample in which the majority had less than a college degree which

again signals a population that is lacking representation in this research. The participants represented a broad range of socioeconomic status, but the majority consisted of wealthier individuals (31% earned \$50,000 or more).

Many researchers voiced concern over their reported sample and it is clear that there needs to be future research that includes more diverse individuals to better determine if mindfulness interventions via smartphone apps can be applied cross-culturally. This is especially warranted given transgender and other gender identifying individuals as there was only one study that even took this population into account when collecting demographic data. Furthermore, the research is lacking participants from different avenues of life (e.g., trade school, older adults, non-college educated individuals). Ultimately, this suggests that it still remains unclear how well mindfulness applications work with diverse and underrepresented populations.

Attrition and Adherence

Most of the studies had an attrition rate of 26% or more with nearly a third of the studies having attrition rates ranging from 0%-15%. Notably, one study that had an attrition rate of 2% was because a participant decided to meditate without the app; however, this was an isolated phenomenon that was not found in the other studies. This indicates potential problems in the dispersal of mindfulness-based mobile applications as an intervention. If a quarter to half of participants will typically stop using the application, this begs the question of how well this kind of intervention would be received in the general community. One of the most common reasons for dropping out included not having time or being too busy. This is ironic given that much of mindfulness research has been aimed at targeting such individuals to help teach them better ways to cope with stressors associated with this kind of lifestyle (Berthon & Pitt, 2019).

Adherence, likewise, also suffered due to only two studies having 100% adherence. In fact, it was common for participants to adhere either 24% of the time or less regarding the dosage of mindfulness that they were advised to engage in by the researchers. This also highlights the need for future research to be directed towards increasing application usage to better encourage and engage the participants. There were four studies in which at least 27% of the participants in the intervention group never used the mindfulness app. Mindfulness research has long been plagued with low adherence rates by its participants (Baydoun, et al., 2021), and this is a crucial area in need of improvement. If practitioners are to give mindfulness apps to their patients as adjunct treatments, it is critical that this is done in a way that is likely for the patient to engage in the recommended dosage to receive the maximum clinical benefit possible.

Meditation Duration and Frequency

Of the studies who requested participants to meditate for a certain duration, the most popular duration requested was 10 minutes. Not surprisingly, the studies that gave participants a meditation regimen generally had participants who meditated more, and therefore received more psychological benefits such as reductions in anxiety, depression, or stress. Of note, several studies that did not find a significant effect for the psychological symptoms they were measuring, speculated that this was potentially due to the overall short length of the study (e.g., 2-4 weeks). Some of the more robust decreases in stress (both self-report and physiological) were found in studies that asked its participants to meditate several times a day (e.g., twice daily) and for longer durations (e.g., 15 minutes). Although the participants in the more demanding groups did experience a lower adherence rate over time, their results were often the most pronounced during the beginning of the study (i.e., first month). Furthermore, many participants of the studies typically practiced half the recommended dosage of mindfulness by the researchers ($n = 12$). There did appear to be a

“sweet spot” regarding what participants gravitated towards in terms of a mindfulness practice, as the majority of studies had participants who practiced mindfulness at least 1-2 times per week ($n = 17$).

Of the studies that did not instruct their participants to meditate a certain amount on a daily or weekly basis, they typically showed less progress in reducing psychological symptoms pertaining to this review. Some studies did ask participants to do a course (e.g., “Take Ten” program in which one meditates 10 minutes daily for 10 days on Headspace) and these results demonstrated good adherence rates. This likely signals that meditation courses may be easier for some individuals to follow due to the inherent structure and convenience of doing a meditation course (e.g., following a guided meditation rather than choosing a specific meditation). Calm tended to have shorter study durations (4-8 weeks); whereas, Headspace had studies that typically continued for 10- 24 weeks. This could be an important reason for why studies using Headspace consistently found improvements in the psychological variables pertaining to this review (i.e., anxiety, depression, stress, and well-being). Future research should examine the effects of varying weeks of duration to better understand the minimum duration of meditation needed for reduction in mental health symptoms.

Notably, several of the articles found that meditation duration and frequency did impact decreases with anxiety, depression, and stress. Although this review found that meditating for 10 minutes several times a week is associated with benefits in stress, anxiety, depression and well-being, there is still not enough research to determine a minimum dosage. This demonstrates that clinicians who advise their patients to use these applications should be familiar with the research regarding the minimum dosage to receive clinical benefits.

Applications Utilized

A surprising finding of the review was that the popular app “10% Happier” utilized significant components of CBT which led it to be excluded from this study (Ten Percent

Happier, n.d.). The majority of the applications in the included studies were from Headspace, and given the economics involved, this is not surprising. Currently, Headspace is valued at \$3 billion dollars (Anand, 2021), and this has likely allowed it to conduct more research and better quality research than its competitors. Calm has been financially successful and is valued at \$2 billion dollars (Wilhelm & Mascarenhas, 2020), which further explains its significant presence in this research. Moreover, given the fact that the other applications had only one study each on average, this suggests that they were unable to partition enough money to engage in research to demonstrate the efficacy of their application. Given that many of the applications were only featured in one study for this review, it is still too early for any conclusions to be made about their effectiveness. This indicates that the current pool of studies is comprised primarily of certain mindfulness applications that have the necessary funds to complete research, and this could lead them to be favored over other applications that do not have the ability to conduct their own research. Therefore, future research should focus on including a more diverse array of mindfulness applications, especially those that do not have large budgets, to enhance our existing knowledge of the benefits and limitations of these applications.

Research Designs Utilized

The majority of studies utilized a randomized control trial (RCT; $n = 15$; 51%), which split participants into the intervention group and either the control or active control group. Concerns were frequently noted by the researchers concerning an appropriate active control group, as most of the RCTs that compared a mindfulness-based mobile application with PMR did not find a significant difference between the two groups. The second most common research designs were pilot studies ($n = 3$; 10%). In sum, this indicates that the research designs for the included studies are strong due to the randomization component of RCTs and the many other benefits they confer. Implications of this are that the included studies have

strong research designs but that very few of them compared one mindfulness application to the other and instead to a control group. Future research could continue to focus on developing more effective active-control groups as well as comparing mindfulness applications to each other.

Self-Report Measures Utilized

Most of the studies utilized self-report measures that captured multiple symptoms. For this reason, the HADS, NIH PROMIS and PANAS measures were the most popular among the included studies. This is notable because these studies may not be used often at outpatient clinics, but rather, in inpatient settings. Self-report measures such as the PHQ-4, PHQ-8 and BDI were used rather infrequently across the studies, and this is a potential limitation as more sensitive self-report measures could possibly capture symptom changes better. The measurement of stress was also notable in that some of the studies used physiological measurements to determine if there were changes in stress levels. This highlights an important area of future research as receiving objective and immediate feedback about one's physiological state could help improve the delivery of mindfulness-based mobile interventions. Moreover, using more sensitive self-report measures (e.g., BDI-2, PHQ-9) would be an important avenue for future research, as this would allow greater specificity in documenting changes in psychological symptoms.

Potential Conflicts of Interest

Regarding studies that reported potential conflicts of interest, Calm studies were most likely to report potential conflicts of interest. This was notable as there were often authors present on these studies who were employed by Calm. One such author is actually the current Director of Science at Calm. Furthermore, some of these studies mentioned that the research was being done “in collaboration with Calm,” but the details of this collaboration were not entirely clear. Kaiser Permanente now offers its members Calm for free as part of being a

member, which likewise raises suspicions about studies done at Kaiser Permanente using the Calm application. Despite such disclaimers assuring that there was no financial support for the research, authorship, and publication of the study, this does suggest that the results of these studies may need to be taken cautiously. Likewise, there are concerns about research conducted using Headspace, since Headspace often provided study authors and participants free subscriptions or trials of the Headspace application. Some studies using Headspace mentioned that the Headspace research team provided assistance, but they denied letting those researchers have any control over the data or input into the design, analysis, or reporting of the study. Similar to studies utilizing Calm, some studies involving Headspace had authors who worked at Headspace, but this was reported as a conflict of interest. Notably, there were some studies in which there was no disclaimer declaring or denying a conflict of interest which was notably worrisome. The implications for this are considerable in that there is a need for more independent research to confirm these findings and that providers should be aware of the economic incentives of these companies when assessing the research of these mindfulness applications. Future research should include more studies in which the ties between the researchers and the mindfulness application companies are limited or nonexistent in order to reduce potential bias.

COVID-19

Some of the studies were conducted during the COVID-19 pandemic and demonstrated significant effects in reducing psychological distress, anxiety, and depressive symptoms (none of these studies measured changes in well-being). Importantly, they were deemed to be convenient, feasible, and effective interventions given that many of the participants were vulnerable to infection from COVID-19 and even more vulnerable to suffering from complications (e.g., cancer patients with diminished immune systems). This implies that mindfulness applications could be an important intervention for at risk

populations or those who experience treatment barriers including transportation issues or lack of time to commute. Future research should aim at measuring the effectiveness of these applications during future lockdowns and quarantines due to the probable likelihood that such events will reoccur.

Limitations

Although this review provided some much-needed direction concerning the efficacy of mindfulness-based mobile apps, there remain important questions regarding their use. Given that only a subset of available academic databases was searched, it is possible that some relevant publications on mindfulness-based mobile applications were missed. The inclusionary criteria employed also resulted in the omission of studies of mindfulness applications developed exclusively for desktop, laptop, or tablet computers, those designed only for non-English speakers, and those available outside of platforms such as iOS and Android. Future research involving the inclusion of this technology could aid in better understanding the benefits and limitations of mindfulness interventions being delivered via newer technological equipment. Most notably, perhaps, the fact that only a small fraction of available mindfulness-based apps have been subjected to empirical study inevitably means that the results of this review were based only on a small subset of extant mindfulness-based apps, making the generalizability of the results to all such apps uncertain.

Additionally, this study did not assess where people were using the applications, which is important given the potential impact of the environment (i.e., in a silent or noisy environment) on the efficacy of the mindfulness intervention being delivered through a mobile device. It was also beyond the scope of this research to assess for application variables concerning the efficacy of the mobile mindfulness-based application. Therefore, there is little in the way of determining application preference based on efficacy. Future

research aimed at comparing the efficacy of these applications will be crucial in helping inform consumers on which application is most appropriate for their needs.

Concerning psychological variables, the role of anxiety, depression, stress (self-report and physiological), and well-being were explored in this review. However, there was no examination of the role of trauma symptoms such as those found in PTSD. Given that mindfulness interventions have become popular within populations that are at a higher risk of developing PTSD such as first responders and those in the military (Chopko et al., 2018; Gallegos, et al., 2015; Kline et al., 2016), this is a notable limitation of the review. The review also did not assess how these applications were used in inpatient settings and in those with psychotic symptoms/disorders. Therefore, it is unclear how effective these applications are in populations suffering from serious mental illness. Lastly, the review did not assess psychological variables pertaining to substance use, making it unclear how effective these applications are for the treatment of addiction. Future research concerning these psychological variables will significantly improve our understanding concerning the efficacy of these applications with patients suffering from serious mental illness and those residing in inpatient settings.

Future Directions

As previously stated, there are multiple avenues to explore concerning the improvement and future role of mindfulness-based mobile applications in reducing psychological symptoms and suffering. Comprehensive studies that consider the variables of existing applications (e.g., gamification and feasibility of applications) and evaluate them based on personal efficacy remain a promising area of research, as this will allow consumers and treatment professionals to determine which applications hold the most promise for mental health treatment and to be informed as to why they are more effective than other mindfulness applications.

Most of all, there continue to be many questions regarding the dosage of meditation to receive its multiple benefits and there continues to be a need for research to be conducted that better assesses the minimum dose necessary for alleviating psychological symptoms. Additionally, future studies that measure the duration of these reductions to determine how long they are maintained post-intervention would contribute greatly to the literature. Moreover, there exist various types of meditation which could potentially have more specific uses concerning alleviating psychological distress. Given that many treatment providers desire to include mindfulness-based mobile applications into treatment or refer such applications to their patients as adjunctive treatment, future research could look at how well these applications do in either aiding treatment or being used as a separate intervention outside of session. Furthermore, future research pertaining to the application variables concerning efficacy of these applications will greatly strengthen our understanding of what makes a suitable application for the delivery of mindfulness interventions.

Notably, this review focused on how well mindfulness can be delivered through a specific technological manner (i.e., mobile devices); however, it is unclear if there are any benefits or limitations regarding the delivery of mindfulness through other technologies such as tablets, virtual reality, laptops, and so on. This will likely become more relevant as additional technology is introduced to deliver mindfulness interventions. Therefore, future research assessing application variables and the ideal environment for them to be used will significantly aid in our understanding regarding how to best enhance their effectiveness. The mindfulness-based mobile applications that were selected in this study purposely excluded apps that incorporated significant components of therapeutic modalities in order to better assess the efficacy of the mindfulness applications. Therefore, due to not having specific protocols as is common in evidenced-based treatments, a promising future avenue of research could be to study the effectiveness of mindfulness-based mobile applications that utilize

evidenced-based treatments that include mindfulness as a core component of their modality such as MBCT, dialectical behavioral therapy (DBT), and ACT, to name a few. This is potentially on the horizon, as Headspace in January 2022 acquired Sayana, a self-care application that utilizes mood trackers, sleep sessions, check-ins, breathing exercises and exercises with components of treatment modalities such as CBT, ACT and DBT (Landi, 2022). Furthermore, Headspace acquired Ginger, an online mental health service that utilizes smartphone-based technology and services such as therapy, behavioral health coaching, medication evaluations with psychiatry and self-care resources (Landi, 2021). In fact, other applications such as Anxiety Solution & Relief based on Chloe Brotheridge's book *The Anxiety Solution* already contain CBT techniques, mood tracking and journaling (Psyt, 2019). Moreover, given the potential change in preference concerning the technological delivery of mindfulness interventions, it will likewise be helpful to conduct research assessing the delivery of these applications through other forms of technology such as VR.

Lastly, given the significant economics involved in this research, a compelling case can be made that there needs to be a way for other application companies that lack appropriate funding to conduct research. This is a highly important avenue concerning future research due to certain companies being able to dominate the market, particularly high-earning companies, simply by being one of the few that can devote money to research. If the majority of mindfulness application companies are unable to afford conducting research this could significantly delay the future of this kind of research.

Conclusion

This systematic review sought to address the effectiveness of mindfulness-based mobile applications to improve common psychological symptoms (i.e., anxiety, depression, stress and well-being). Mindfulness-based mobile applications have demonstrated effectiveness in reducing common psychological symptoms such as anxiety, depression, perceived stress (as

well as physiological markers of stress) and improving well-being. Research is still needed to further improve their usability and feasibility as well as compare differences between mindfulness applications. Moreover, future research determining the proper duration and frequency of utilizing mindfulness-based mobile applications to improve psychological symptoms would greatly benefit the field. Likewise, it is highly warranted that future studies include more diverse populations regarding gender, race, ethnicity, socioeconomic status and religion. Given that mindfulness-based mobile applications are widely available to the general public and have been shown to be effective for a variety of adult populations as is indicated by this review, they represent a promising intervention that could be used by many in both the general and clinical adult population.

REFERENCES

- Alegria M., Canino G., Ríos R., Vera M., Calderón J., Rusch D., Ortega A. N. (2002). Inequalities in use of specialty mental health services among Latinos, African Americans, and non-Latino whites. *Psychiatric Services*, 53(12), 1547-55. Doi:10.1176/appi.ps.53.12.1547.
- Alsubaie, M., Abbott, R., Dunn, B., Dickens, C., Keil, T. F., Henley, W., & Kuyken, W. (2017). Mechanisms of action in mindfulness-based cognitive therapy (MBCT) and mindfulness-based stress reduction (MBSR) in people with physical and/or psychological conditions: A systematic review. *Clinical Psychology Review*, 55, 74-91. <https://doi.org/10.1016/j.cpr.2017.04.008>
- Anand, P. (2021, August 25). *Meditation app Headspace to merge with Blackstone-backed Ginger*. Bloomberg. <https://www.bloomberg.com/news/articles/2021-08-25/meditation-app-headspace-acquires-blackstone-backed-ginger>
- Bakker, D., Kazantzis, N., Rickwood, D., & Rickard, N. (2018). A randomized controlled trial of three smartphone apps for enhancing public mental health. *Behaviour Research and Therapy*, 109, 75–83. doi: 10.1016/j.brat.2018.08.003.
- Bakker, D., & Rickard, N. (2018). Engagement in mobile phone app for self-monitoring of emotional wellbeing predicts changes in mental health: MoodPrism. *Journal of Affective Disorders*, 227, 432–442. doi: 10.1016/j.jad.2017.11.016.
- Bakker, D., & Rickard, N. (2019). Engagement with a cognitive behavioural therapy mobile phone app predicts changes in mental health and wellbeing: Moodmission. *Australian Psychologist*, 54(4), 245-260. <https://doi.org/10.1111/ap.12383>
- Baxter, A. J., Scott, K. M., Vos, T., & Whiteford, H. A. (2013). Global prevalence of anxiety disorders: A systematic review and meta-regression. *Psychological Medicine*, 43(5), 897–910. <https://doi.org/10.1017/S003329171200147X>

- Baydoun, M., Moran, C., McLennan, A., Piedalue, K.-A. L., Oberoi, D., & Carlson, L. E. (2021). Mindfulness-based interventions in cancer survivors: a systematic review of participants' adherence to home practice. *Patient Preference and Adherence*, 15, 1225–1242. <https://doi.org/10.2147/PPA.S267064>
- Bergomi, C., Tschacher, W., & Kupper, Z. (2013). The assessment of mindfulness with self-report measures: Existing scales and open issues. *Mindfulness*, 4(3), 191–202. <https://doi.org/10.1007/s12671-012-0110-9>
- Berthon, P. R., & Pitt, L. F. (2019). Types of mindfulness in an age of digital distraction. *Business Horizons*, 62(2), 131–137. <https://doi.org/10.1016/j.bushor.2018.10.003>
- Beshai, S., McAlpine, L., Weare, K., & Kuyken, W. (2016). A non-randomised feasibility trial assessing the efficacy of a mindfulness-based intervention for teachers to reduce stress and improve well-being. *Mindfulness*, 7(1), 198–208. <https://doi.org/10.1007/s12671-015-0436-1>
- Boggero, I. A., & Segerstrom, S. C. (2019). Maintenance of affective wellbeing following acute pain in healthy older and younger adults. *Journal of Behavioral Medicine*, 42(5), 934–946. <https://doi.org/10.1007/s10865-019-00019-2>
- Boland, A., Cherry, M. G., & Dickson, R. (Eds.). (2017). *Doing a systematic review: A student's guide* (2nd ed.). SAGE.
- Bomhof-Roordink, H., Seldenrijk, A., Penninx, B. W. J. H., van, H. H. P. J., van, M. H. W. J., & Diamant, M. (2015). Associations between life stress and subclinical cardiovascular disease are partly mediated by depressive and anxiety symptoms. *Journal of Psychosomatic Research*, 78(4), 332–339. doi: 10.1016/j.jpsychores.2015.02.009.

- Bostock, S., Crosswell, A. D., Prather, A. A., & Steptoe, A. (2019). Mindfulness on-the-go: Effects of a mindfulness meditation app on work stress and well-being. *Journal of Occupational Health Psychology, 24*(1), 127–138. doi: 10.1037/ocp0000118.
- Brazier, C. (2013). Roots of mindfulness. *European Journal of Psychotherapy & Counselling, 15*(2), 127–138. <https://doi.org/10.1080/13642537.2013.795336>
- Cachia, R. L., Anderson, A., & Moore, D. W. (2016). Mindfulness, stress and well-being in parents of children with Autism Spectrum Disorder: A systematic review. *Journal of Child and Family Studies, 25*(1), 1–14. <https://doi.org/10.1007/s10826-015-0193-8>
- Calkins, A. W., Rogers, A. H., Campbell, A. A., & Simon, N. M. (2015). Comorbidity of anxiety and depression. In K. J. Ressler, D. S. Pine, & B. O. Rothbaum (Eds.), *Anxiety disorders: Translational perspectives on diagnosis and treatment*. (pp. 299–314). Oxford University Press. <https://doi.org/10.1093/med/9780199395125.003.0021>
- Carissoli, Villani, D., & C., Riva, G. (2015). Does a meditation protocol supported by a mobile application help people reduce stress? Suggestions from a controlled pragmatic trial. *Cyberpsychology, Behavior, and Social Networking, 18*(1), 46-53. <https://doi.org/10.1089/cyber.2014.0062>
- Carroll, H., & Lustyk, M. K. B. (2018). Mindfulness-based relapse prevention for substance use disorders: Effects on cardiac vagal control and craving under stress. *Mindfulness, 9*(2), 488–499. doi: 10.1007/s12671-017-0791-1.
- Chittaro, L., & Vianello, A. (2016). Mobile mindfulness and user's worry: A qualitative study of using a smartphone app for distancing from negative thoughts. *Interacting with Computers, 28*(6), 695-717. <https://doi.org/10.1093/iwc/iwv044>
- Chopko, B. A., Papazoglou, K., & Schwartz, R. C. (2018). Mindfulness-based psychotherapy approaches for first responders: From research to clinical practice. *American Journal*

of *Psychotherapy*, 71(2), 55–64.

<https://doi.org/10.1176/appi.psychotherapy.20180015>

Christie, A. M., Atkins, P. W. B., & Donald, J. N. (2017). The meaning and doing of mindfulness: The role of values in the link between mindfulness and well-being.

Mindfulness, 8(2), 368–378. <https://doi.org/10.1007/s12671-016-0606-9>

Clarke T. C., Black L. I., Stussman B. J., Barnes P. M., Nahin R. L. (2015) Trends in the use of complementary health approaches among adults: United States, 2002-2012.

National Health Statistics Report, 10(79), 1-16.

<https://www.cdc.gov/nchs/data/nhsr/nhsr079.pdf>

Corrêa M.S., de, L. D. B., Giacobbo, B. L., Vedovelli, K., Argimon, I. I. L., & Bromberg, E. (2018). Mental health in familial caregivers of alzheimer's disease patients: Are the effects of chronic stress on cognition inevitable? *Stress: The International Journal on the Biology of Stress* 22(1), 83-92 . doi: 10.1080/10253890.2018.1510485.

Coulon, S. M., Monroe, C. M., & West, D. S. (2016). A systematic, multi-domain review of mobile smartphone apps for evidence-based stress management. *American Journal of Preventive Medicine* 51(1), 95-105. doi: 10.1016/j.amepre.2016.01.026.

Creswell, J. D., Pacilio, L. E., Lindsay, E. K., & Brown, K. W. (2014). Brief mindfulness meditation training alters psychological and neuroendocrine responses to social evaluative stress. *Psychoneuroendocrinology* 44, 1–12 DOI: 10.1016/j.psyneuen.2014.02.007

Creswell, J. D. (2017). Mindfulness Interventions. *Annual Review of Psychology*, 68(1), 491–516. <https://doi.org/10.1146/annurev-psych-042716-051139>

Davidson, R. J., & Dahl, C. J. (2018). Outstanding challenges in scientific research on mindfulness and meditation. *Perspectives on Psychological Science*, 13(1), 62–65. doi: 10.1177/1745691617718358.

- Dillon, A., Kelly, M., Robertson, I. H., & Robertson, D. A. (2016). Smartphone applications utilizing biofeedback can aid stress reduction. *Frontiers in Psychology*, 7(JUN).
<https://doi.org/10.3389/fpsyg.2016.00832>
- Erhardt, D. & Dorian, E. (2017). Mobile applications for psychological treatment. In A. Wenzel (Ed.), *The sage encyclopedia of abnormal and clinical psychology* (Vol. 1, pp. 2130-2132). SAGE Publications, Inc. doi: 10.4135/9781483365817.n858
- Evans, S., Allen, E. S., Wyka, K., & Blaha, K. T. (2018). Self-compassion mediates improvement in well-being in a mindfulness-based stress reduction program in a community-based sample. *Mindfulness*, 9(4), 1280–1287.
<https://doi.org/10.1007/s12671-017-0872-1>
- Farias M., Wikholm C., & Delmonte R. (2016). What is Mindfulness-Based Therapy good for? *The Lancet Psychiatry*, 3(11), 1012-1013 DOI: 10.1016/S2215-0366(16)30211-5
- Firth, J., Torous, J., Nicholas, J., Carney, R., Rosenbaum, S., & Sarris, J. (2017). Can smartphone mental health interventions reduce symptoms of anxiety? A meta-analysis of randomized controlled trials. *Journal of Affective Disorders*, 218, 15–22. doi: 10.1016/j.jad.2017.04.046.
- Fish, J., Brimson, J., & Lynch, S. (2016). Mindfulness interventions delivered by technology without facilitator involvement: What research exists and what are the clinical outcomes? *Mindfulness* 7(5), 1011-1023. <https://doi.org/10.1007/s12671-016-0548-2>
- Flett, J. A. M., Hayne, H., Riordan, B. C., Thompson, L. M., & Conner, T. S. (2018). Mobile mindfulness meditation: A randomised controlled trial of the effect of two popular apps on mental health. *Mindfulness*, 10(5), 863–876. <https://doi.org/10.1007/s12671-018-1050-9>

- Galea S., Merchant R.M., Lurie N. (2020) The Mental Health Consequences of COVID-19 and Physical Distancing: The Need for Prevention and Early Intervention. *JAMA Internal Medicine*. 180(6), 817–818. Doi:10.1001/jamainternmed.2020.1562
- Gallegos, A. M., Cross, W., & Pigeon, W. R. (2015). Mindfulness-based stress reduction for veterans exposed to military sexual trauma: Rationale and implementation considerations. *Military Medicine*, 180(6), 684–9. <https://doi.org/10.7205/MILMED-D-14-00448>
- Gautam, A., Polizzi, C. P., & Mattson, R. E. (2019). Mindfulness, procrastination, and anxiety: Assessing their interrelationships. *Psychology of Consciousness: Theory, Research, and Practice*. DOI:10.1037/cns0000209
- Giannandrea, A., Simione, L., Pescatori, B., Ferrell, K., Olivetti Belardinelli, M., Hickman, S. D., & Raffone, A. (2018). Effects of the mindfulness-based stress reduction program on mind wandering and dispositional mindfulness facets. *Mindfulness*, 10, 185–195. <https://doi.org/10.1007/s12671-018-1070-5>
- Goldberg, S. B., Tucker, R. P., Greene, P. A., Davidson, R. J., Wampold, B. E., Kearney, D. J., & Simpson, T. L. (2018). Mindfulness-based interventions for psychiatric disorders: A systematic review and meta-analysis. *Clinical Psychology Review*, 59, 52–60. doi: 10.1016/j.cpr.2017.10.011.
- Greenberg P.E., Sisitsky T, Kessler R.C., Finkelstein S.N., Berndt E.R., Davidson J.R., Ballenger J.C., & Fyer A.J. (1999). The economic burden of anxiety disorders in the 1990s. *The Journal of Clinical Psychiatry*, 60(7):427-35. doi: 10.4088/jcp.v60n0702. PMID: 10453795.
- Gu, J., Bond, R., Cavanagh, K., & Strauss, C. (2015). How do mindfulness-based cognitive therapy and mindfulness-based stress reduction improve mental health and wellbeing?

- A systematic review and meta-analysis of mediation studies. *Clinical Psychology Review* 37, 1-12. <https://doi.org/10.1016/j.cpr.2015.01.006>
- Guntuku, S. C., Sherman, G., Stokes, D. C., Agarwal, A. K., Seltzer, E., Merchant, R. M., & Ungar, L. H. (2020). Tracking mental health and symptom mentions on twitter during covid-19. *Journal of General Internal Medicine*, 35(9), 2798–2800.
<https://doi.org/10.1007/s11606-020-05988-8>
- Headspace. (n.d.) *We're here for you*. <https://www.headspace.com/covid-19>
- Heckenberg, R. A., Eddy, P., Kent, S., & Wright, B. J. (2018). Do workplace-based mindfulness meditation programs improve physiological indices of stress? A systematic review and meta-analysis. *Journal of Psychosomatic Research*, 114, 62-71.
Doi:10.1016/j.jpsychores.2018.09.010
- Hedman-Lagerlöf, M., Hedman-Lagerlöf, E., & Öst, L.-G. (2018). The empirical support for mindfulness-based interventions for common psychiatric disorders: A systematic review and meta-analysis. *Psychological Medicine*, 48(13), 2116–2129.
doi: 10.1017/S0033291718000259.
- Hertz, R. M., Laurent, H. K., & Laurent, S. M. (2015). Attachment mediates effects of trait mindfulness on stress responses to conflict. *Mindfulness*, 6(3), 483–489.
<https://doi.org/10.1007/s12671-014-0281-7>
- Hirsch, J. K., Rabon, J. K., Reynolds, E. E., Barton, A. L., & Chang, E. C. (2019). Perceived stress and suicidal behaviors in college students: Conditional indirect effects of depressive symptoms and mental health stigma. *Stigma and Health*, 4(1), 98–106. <https://doi.org/10.1037/sah0000125>
- James, K., & Rimes, K. A. (2018). Mindfulness-based cognitive therapy versus pure cognitive behavioural self-help for perfectionism: A pilot randomized study. *Mindfulness*, 9(3), 801–814. <https://doi.org/10.1007/s12671-017-0817-8>

- Jansson-Fröjmark M., & Lindblom, K. (2008). A bidirectional relationship between anxiety and depression, and insomnia? A prospective study in the general population. *Journal of Psychosomatic Research*, 64(4), 443–9.
<https://doi.org/10.1016/j.jpsychores.2007.10.016>
- Jones, E., Lebrun-Harris, L. A., Sripipatana, A., & Ngo-Metzger, Q. (2014). Access to mental health services among patients at health centers and factors associated with unmet needs. *Journal of Health Care for the Poor and Underserved*, 25(1), 425–436. doi: 10.1353/hpu.2014.0056.
- Johnson, S., Dalton-Locke, C., Vera San Juan, N., Foye, U., Oram, S., Papamichail, A., Landau, S., Rowan Olive, R., Jeynes, T., Shah, P., Sheridan Rains, L., Lloyd-Evans, B., Carr, S., Killaspy, H., Gillard, S., & Simpson, A. (2021). Impact on mental health care and on mental health service users of the covid-19 pandemic: a mixed methods survey of uk mental health care staff. *Social Psychiatry and Psychiatric Epidemiology: The International Journal for Research in Social and Genetic Epidemiology and Mental Health Services*, 56(1), 25–37.
<https://doi.org/10.1007/s00127-020-01927-4>
- Kabat-Zinn, J. (1982). An out-patient program in behavioral medicine for chronic pain patients based on the practice of mindfulness meditation: theoretical considerations and preliminary results. *General Hospital Psychiatry* 4, 33–47 DOI: 10.1016/0163-8343(82)90026-3
- Kabat-Zinn, J. (2014). Meditation is not for the faint-hearted. *Mindfulness*, 5(3), 341-344.
<http://doi:10.1007/s12671-014-0307-1>
- Khoury, B., Sharma, M., Rush, S. E., & Fournier, C. (2015). Mindfulness-based stress reduction for healthy individuals: A meta-analysis. *Journal of Psychosomatic Research*, 78(6), 519–528. doi: 10.1016/j.jpsychores.2015.03.009.

- Kline, A., Chesin, M., Latorre, M., Miller, R., St. Hill, L., Shcherbakov, A., King, A., Stanley, B., Weiner, M. D., & Interian, A. (2016). Rationale and study design of a trial of mindfulness-based cognitive therapy for preventing suicidal behavior (mbct-s) in military veterans. *Contemporary Clinical Trials*, 50, 245–252.
<https://doi.org/10.1016/j.cct.2016.08.015>
- Kiecolt-Glaser, J. K., & Newton, T. L. (2001). Marriage and health: His and hers. *Psychological Bulletin*, 127(4), 472–503.
- Klussman, K., Nichols, A. L., & Langer, J. (2021). Mental health in the United States during the covid-19 pandemic: a longitudinal examination of the ameliorating effect of meaning salience. *Current Psychology* 1–8. <https://doi.org/10.1007/s12144-021-01538-5>
- Koerbel, L., & Zucker, D. (2007). The suitability of mindfulness-based stress reduction for chronic hepatitis c. *Journal of Holistic Nursing*, 25(4), 265-274. doi: 10.1177/0898010107304742.
- Kral, T. R. A., Schuyler, B. S., Mumford, J. A., Rosenkranz, M. A., Lutz, A., & Davidson, R. J. (2018). Impact of short- and long-term mindfulness meditation training on amygdala reactivity to emotional stimuli. *NeuroImage*, 181, 301–313. doi: 10.1016/j.neuroimage.2018.07.013.
- Krampen, G. (2006). List of change sensitive symptoms of relaxation, well-being, exposure to discomforts and difficulties (ASS-SYM). Hogrefe, Göttingen
- Krebs P., & Duncan D. (2015). Health App Use Among US Mobile Phone Owners: A National Survey *JMIR Mhealth Uhealth* 3(4), 101 DOI: 10.2196/mhealth.4924
- Laeger, I., Dobel, C., Dannlowski, U., Kugel, H., Grotegerd, D., Kissler, J., Keuper, K., Eden, A., Zwieterlood, P., & Zwanzger, P. (2012). Amygdala responsiveness to

- emotional words is modulated by subclinical anxiety and depression. *Behavioural Brain Research*, 233(2), 508–516. doi: 10.1016/j.bbr.2012.05.036.
- Landi, H. (2021, October 21) *Headspace, Ginger finalize merger to form \$3B mental health company*. Fierce Healthcare. <https://www.fiercehealthcare.com/tech/headspace-ginger-finalize-3b-merger-to-offer-meditation-mindfulness-and-tele-therapy>
- Landi, H. (2022, January 12) *JPM 2022: Headspace Health grabs startup Sayana to build out AI-based mental health tools*. Fierce Healthcare. <https://www.fiercehealthcare.com/digital-health/headspace-health-picks-up-mental-health-app-sayana-to-expand-ai-capabilities>
- Lee, D., Moreno, S., Farb, N., Pino, L., Bhayee, S., Moffat, G., & Tomaszewski, P. (2016). Attentional and affective consequences of technology supported mindfulness training: A randomized, active control, efficacy trial. *BMC Psychology* 4(1), 60 . <https://doi.org/10.1186/s40359-016-0168-6>
- Lee, F. K. S., & Zelman, D. C. (2019). Boredom proneness as a predictor of depression, anxiety and stress: The moderating effects of dispositional mindfulness. *Personality and Individual Differences*, 146, 68–75. DOI:10.1016/j.paid.2019.04.001
- Leigh, S., & Flatt, S. (2015). App-based psychological interventions: Friend or foe? *Evidence-Based Mental Health*, 18(4), 97–99. <https://doi.org/10.1136/eb-2015-102203>
- Li, W., Howard, M. O., Garland, E. L., McGovern, P., & Lazar, M. (2017). Mindfulness treatment for substance misuse: A systematic review and meta-analysis. *Journal of Substance Abuse Treatment*, 75, 62–96. doi: 10.1016/j.jsat.2017.01.008.
- Lomas, T., Medina, J. C., Ivztan, I., Rupprecht, S., & Eiroa-Orosa, F. J. (2019). Mindfulness-based interventions in the workplace: An inclusive systematic review and meta-

- analysis of their impact upon wellbeing. *The Journal of Positive Psychology*, 14(5), 625–640. DOI:10.1080/17439760.2018.1519588.
- Lyons, T., & Cantrell, W. D. (2016). Prison meditation movements and mass incarceration. *International Journal of Offender Therapy and Comparative Criminology*, 60(12), 1363–1375. doi: 10.1177/0306624X15583807.
- Mani, M., Kavanagh, D. J., Hides, L., & Stoyanov, S. R. (2015). Review and evaluation of mindfulness-based iphone apps. *Jmir Mhealth and Uhealth*, 3(3), 82.
<https://doi:10.2196/mhealth.4328>
- Martínez-Pérez B., Torre-Díez I.D.L., & López-Coronado M. (2013). Mobile health applications for the most prevalent conditions by the World Health Organization: review and analysis. *J Med Internet Res*. 15(6):e120. doi: 10.2196/jmir.2600.
- Marciniak, M. D., Lage, M. J., Dunayevich, E., Russell, J. M., Bowman, L., Landbloom, R. P., & Levine, L. R. (2005). The cost of treating anxiety: the medical and demographic correlates that impact total medical costs. *Depression and Anxiety*, 21(4), 178–84.
DOI: 10.1002/da.20074
- Martin, J. R. (1997). Mindfulness: A proposed common factor. *Journal of Psychotherapy Integration*, 7(4), 291–312. <https://doi.org/10.1023/B:JOPI.0000010885.18025.bc>
- Medvedev, O. N., Norden, P. A., Krägeloh Christian U, & Siegert, R. J. (2018). Investigating unique contributions of dispositional mindfulness facets to depression, anxiety, and stress in general and student populations. *Mindfulness*, 9(6), 1757–1767.
<https://doi.org/10.1007/s12671-018-0917-0>
- Meland, A., Ishimatsu, K., Pensgaard, A. M., Wagstaff, A., Fonne, V., Garde, A. H., & Harris, A. (2015). Impact of mindfulness training on physiological measures of stress and objective measures of attention control in a military helicopter unit. *The*

- International Journal of Aviation Psychology*, 25(3–4), 191–208. doi: 10.1080/10508414.2015.1162639.
- Moir, S., Skues, J., & Theiler, S. (2019). Exploring the perspectives of psychologists who use mindfulness in therapeutic practice. *Australian Psychologist* 54(1), 26-36.
<https://doi.org/10.1111/ap.12356>
- Muntaner-Mas, A., Martinez-Nicolas, A., Lavie, C. J., Blair, S. N., Ross, R., Arena, R., & Ortega, F. B. (2019). A systematic review of fitness apps and their potential clinical and sports utility for objective and remote assessment of cardiorespiratory fitness. *Sports Medicine*, 49(4), 587-600. <https://doi:10.1007/s40279-019-01084-y>
- Nam, S., & Toneatto, T. (2016). The influence of attrition in evaluating the efficacy and effectiveness of mindfulness-based interventions. *International Journal of Mental Health and Addiction*, 14(6), 969–981. <https://doi.org/10.1007/s11469-016-9667-1>
- Nassif, T. H., Start, A. R., Toblin, R. L., & Adler, A. B. (2019). Self-reported mindfulness and soldier health following a combat deployment. *Psychological Trauma: Theory, Research, Practice, and Policy*, 11(4), 466–474. doi: 10.1037/tra0000413.
- Ng, J., Chan, H. Y., & Schlaghecken, F. (2012). Dissociating effects of subclinical anxiety and depression on cognitive control. *Advances in Cognitive Psychology*, 8(1), 38–49. doi: 10.2478/v10053-008-0100-6
- Olano, H. A., Kachan, D., Tannenbaum, S. L., Mehta, A., Annane, D., & Lee, D. J. (2015). Engagement in mindfulness practices by US adults: Sociodemographic barriers. *The Journal of Alternative and Complementary Medicine*, 21(2), 100–102. doi: 10.1089/acm.2014.0269.
- Otu, A., Ahinkorah, B.O., Ameyaw, E.K., Seidu A.A. & Yaya S. (2020). One country, two crises: what Covid-19 reveals about health inequalities among BAME communities in

- the United Kingdom and the sustainability of its health system? *Int J Equity Health* 19, 189. <https://doi.org/10.1186/s12939-020-01307-z>
- Penberthy, J. K., Williams, S., Le, N., Schorling, J., Hook, J. N., Bloch, J., Forsyth J, Penberthy J.M., Germano D., Schaeffer, K. (2017). Impact of a Tibetan Buddhist meditation course and application of related modern contemplative practices on college students' psychological well-being: A pilot study. *Mindfulness*, 8(4), 911–919. <https://doi.org/10.1007/s12671-016-0665-y>
- Petrocchi, N., & Ottaviani, C. (2016). Mindfulness facets distinctively predict depressive symptoms after two years: the mediating role of rumination. *Personality and Individual Differences*, 93, 92–96. <https://doi.org/10.1016/j.paid.2015.08.017>
- Petros, R., Solomon, P., Linz, S. J., DeCesaris, M., & Hanrahan, N. P. (2016). Capabilities approach: Contextualizing participants' perspectives on systems barriers to recovery. *International Journal of Mental Health*, 45(4), 262–278. <https://doi.org/10.1080/00207411.2016.1238742>
- Plaza, I., Demarzo, M. M., Herrera-Mercadal, P., & García-Campayo J. (2013). Mindfulness-based mobile applications: Literature review and analysis of current features. *Jmir Mhealth and Uhealth*, 1(2), 24. Doi:10.2196/mhealth.2733
- Poushter, J., Bishop, C., & Chwe, H. (2019). Social media use continues to rise in developing countries. <https://www.pewresearch.org/global/2018/06/19/social-media-use-continues-to-rise-in-developing-countries-but-plateaus-across-developed-ones/#table>
- Prakash, R. S., Hussain, M. A., & Schirda, B. (2015). The role of emotion regulation and cognitive control in the association between mindfulness disposition and stress. *Psychology and Aging*, 30(1), 160–171. doi: 10.1037/a0038544.
- Psyt. (2019). *Anxiety Solution & Relief* (Version 1.72) [Mobile app]. App Store. <https://apps.apple.com/us/app/anxiety-solution-stress-relief/id1477189222>

- Ramasubramanian, S. (2017). Mindfulness, stress coping and everyday resilience among emerging youth in a university setting: A mixed methods approach. *International Journal of Adolescence and Youth*, 22(3), 308–321.
<https://doi.org/10.1080/02673843.2016.1175361>
- Rosenkranz, M. A., Lutz, A., Perlman, D. M., Bachhuber, D. R. W., Schuyler, B. S., MacCoon, D. G., & Davidson, R. J. (2016). Reduced stress and inflammatory responsiveness in experienced meditators compared to a matched healthy control group. *Psychoneuroendocrinology*, 68, 117-25.
<https://doi.org/10.1016/j.psyneuen.2016.02.013>
- Rupert, P. A., & Dorociak, K. E. (2019). Self-care, stress, and well-being among practicing psychologists. *Professional Psychology: Research and Practice*, 50(5), 343–350.
<https://doi.org/10.1037/pro0000251>
- Ryan R. (2013). *Cochrane consumer and communication review group: Data synthesis and analysis*. Cochrane Consumers and Communication Review Group.
<http://cccr.org.cochrane.org>
- Schönfeld, P., Julia, B., Angela, B., Xiao, C. Z., & Margraf, J. (2016). The effects of daily stress on positive and negative mental health: Mediation through self-efficacy. *International Journal of Clinical and Health Psychology*, 16(1), 1–10. doi: 10.1016/j.ijchp.2015.08.005.
- Schultchen, D., Terhorst, Y., Holderied, T., Stach M., Messner E.M., Baumeister H. & Sander L.B. (2021). Stay Present with Your Phone: A Systematic Review and Standardized Rating of Mindfulness Apps in European App Stores. *International Journal of Behavioral. Medicine*, 28, 552–560. <https://doi.org/10.1007/s12529-020-09944-y>

- Sedlmeier, P., Loße, C., & Quasten, L. C. (2018). Psychological effects of meditation for healthy practitioners: An update. *Mindfulness*, 9(2), 371–387.
<https://doi.org/10.1007/s12671-017-0780-4>
- Shearer, A., Hunt, M., Chowdhury, M., & Nicol, L. (2016). Effects of a brief mindfulness meditation intervention on student stress and heart rate variability. *International Journal of Stress Management*, 23(2), 232–254. <https://doi.org/10.1037/a0039814>
- Singh, A. K., Choubey, A. K., & Singh, S. (2016). Does mindfulness enhance psychological well-being of the students. *Journal of Psychosocial Research*, 11(2), 241–250.
- Sorkin, D. H., Janio, E. A., Eikey, E. V., Schneider, M., Davis, K., Schueller, S. M., Stadnick, N. A., Zheng, K., Neary, M., Safani, D., & Mukamel, D. B. (2021). Rise in use of digital mental health tools and technologies in the united states during the covid-19 pandemic: Survey study. *Journal of Medical Internet Research*, 23(4), 26994. <https://doi.org/10.2196/26994>
- Spears, C. A., Bell, S. A., Scarlett, C. A., Anderson, N. K., Cottrell-Daniels, C., Lotfalian, S., Lotfalian S., Bandlamudi, M., Grant A., Sigurdardottir A., Carter B. P., Abroms L. C., Wetter, D. W. (2019). Text messaging to enhance mindfulness-based smoking cessation treatment: program development through qualitative research. *Jmir Mhealth and Uhealth*, 7(1), 11246. <https://doi.org/10.2196/11246>
- Stogner, J., Miller, B. L., & McLean, K. (2020). Police stress, mental health, and resiliency during the covid-19 pandemic. *American Journal of Criminal Justice: The Journal of the Southern Criminal Justice Association*, 45(4), 718–730.
<https://doi.org/10.1007/s12103-020-09548-y>
- Sun S., Lin D., Goldberg S., Shen Z., Chen P., Qiao S., Brewer J., Loucks E., & Operario D. A. (2021). Mindfulness-based mobile health (mHealth) intervention among psychologically distressed university students in quarantine during the COVID-19

pandemic: A randomized controlled trial. *Journal of Counseling Psychology*, 69(2):157-171. doi: 10.1037/cou0000568.

Ten Percent Happier (n.d.). *Do you constantly worry about work?*

<https://www.tenpercent.com/work-anxiety>

Teresa, M. E., & Sy, A. S. (2012). An update on mindfulness meditation as a self-help treatment for anxiety and depression. *Psychology Research and Behavior Management*, 131–141. <https://doi.org/10.2147/PRBM.S34937>

Toussaint, L., Shields, G. S., Dorn, G., & Slavich, G. M. (2016). Effects of lifetime stress exposure on mental and physical health in young adulthood: How stress degrades and forgiveness protects health. *Journal of Health Psychology*, 21(6), 1004–1014. doi: 10.1177/1359105314544132.

Tunney, C., Cooney, P., Coyle, D., & O'Reilly, G. (2017). Comparing young people's experience of technology-delivered v. face-to-face mindfulness and relaxation: Two-armed qualitative focus group study. *British Journal of Psychiatry*, 210(4), 284-289. <https://doi.org/10.1192/bjp.bp.115.172783>

U.S. Department of Veteran Affairs (n.d.). Mindfulness Coach. VA Mobile. Retrieved April 1, 2022, from <https://mobile.va.gov/app/mindfulness-coach>

Wen, L., Sweeney, T. E., Welton, L., Trockel, M., & Katznelson, L. (2017). Encouraging mindfulness in medical house staff via smartphone app: A Pilot Study. *Academic Psychiatry*, 41(5), 646-650. <https://doi.org/10.1007/s40596-017-0768-3>

Wilhelm A., Mascarenhas, N. (2020, December 8) *Calm raises \$75M more at \$2B valuation*. TechCrunch. https://techcrunch.com/2020/12/08/calm-raises-75m-more-at-2b-valuation/?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig=AQAAAAdYO8Bmf5k7P8WN3PZZdH12wiJxDZGM6Mk7iCSltYfofGSCHY0J8HoLzprVjGHskgDLgpgFeOTzOGAxxPvI04WCUPTrXtJH69ph45Z

[hScCXI9jMgPLkogsZLCXu6I7oIbTFDaLy550M9qWSmgcHy__ist5ZT5c3bopNvnW](#)

[Oug](#)

World Health Organization (2021). Depression. <https://www.who.int/news-room/fact-sheets/detail/depression>

Yang, S., Meredith, P., & Khan, A. (2017). Is mindfulness associated with stress and burnout among mental health professionals in Singapore? *Psychology, Health & Medicine*, 22(6), 673–679. doi: 10.1080/13548506.2016.1220595.

Young, Alex (2020, April 13). *Headspace offering free access for health care workers to help manage stress of COVID-19*. Healio.
<https://www.healio.com/news/gastroenterology/20200413/headspace-offering-free-access-for-health-care-workers-to-help-manage-stress-of-covid19>

TABLES

Table 1*Search Documentation Record*

<u>Search Type</u>	<u>Databases or Sources</u>	<u>Search Syntax or Instructions</u>	<u>Specifiers</u>
Electronic Database	EBSCO (46 databases included in search)	(app or mobile app or apps or mobile device applications or mobile apps or smartphone) AND (meditat* or mindful*) AND (efficacy or effectiveness or impact or benefits or outcomes) AND ("well-being" or stress or anxiety or depression) NOT (teenagers or adolescents or teens) NOT (acceptance and commitment therapy or act) NOT (cognitive behavioral therapy or cbt) NOT (virtual reality or vr or augmented reality) NOT (computers or laptops)	*Years: 2009-2021 *Type: Peer-reviewed articles only
Website	Official Website for Headspace	Hand search through available articles	*Years: 2009-2021 *Type: Peer-reviewed articles only

Table 2*Evidence Based Table*

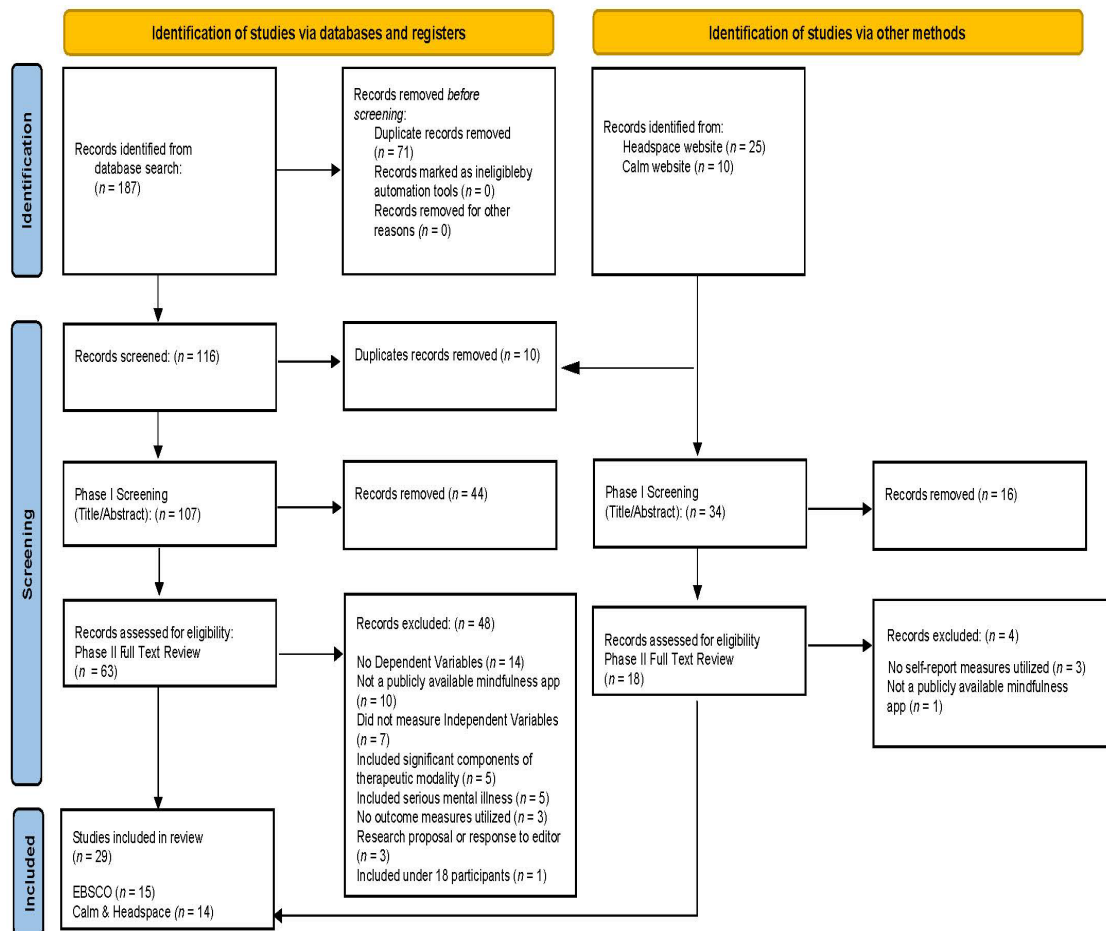
Citation	Sample Size	Study Design	Key Findings	Future Research and Recommendations
Puzia et al., 2020	80 Myeloproliferative Neoplasm Patients	Exploratory Secondary Analysis	Reduced depressive and anxiety symptoms	More research to understand required dosage and the long-term sustainability of improvements in app-based meditation interventions.
Huberty et al., 2019	88 Arizona State University students	RCT	Reduced stress	Explore efficacy in more diverse samples (e.g., race/ethnicity, education level, and chronic disease status) and in non-English speakers. Objective measures instead of self-report.
Huberty et al., 2019	128 Myeloproliferative Neoplasm Patients	RCT	Reduced anxiety and depression	Determine the effects of a mobile app to improve health-related outcomes in cancer patients, especially when cancer patients are already using mobile apps.
Knill et al., 2019	67 Nurse and Nurse Practitioners	Evidenced Based Practice Quality Improvement Initiative	Increased well-being	None Reported
Watson-Singleton et al., 2021	39 African Americans	within subjects pre-post design	Reduced stress	Recruit more male participants. Assess the impact of app usage on culturally relevant social determinants of health, like race-related stress.
Flett et al., 2020	250 Undergraduate Students	RCT	Decreased distress	Increasing app use and sustaining acceptability of the intervention should be a focus of future research. Persuasive design features could be leveraged promote app use and encourage habit formation.
Eichela et al., 2020	42 Female University Students	Experimental Design	Reduced stress	A clearer differentiation between the two training methods (PMR and meditation).
Smith et al., 2021	101 Female Obstetric and Gynecology Patients	RCT	Reduced perceived stress, depression and anxiety	Include different types of meditation applications.
Xu et al., 2021	148 Emergency Department staff	RCT	Improved well-being	Ways to include participants who did not use the application.
Mahlo et al., 2020	46 Older adults	single-group 30-day pilot intervention	Decreased negative affect	Active comparison groups with long-term follow-up to more reliably establish efficacy and sustainability.
Kozlov et al., 2021	60 Caregivers of Adults with Cognitive Impairment	pilot feasibility study	Decreased symptoms of anxiety, depression and stress	Consider participants' ratings of severity of other external life stressors to elucidate the potential differential impact of mHealth MT based on individual circumstances. Include more participants from diverse racial and ethnic backgrounds as well as from different age groups to ensure generalizability of findings. Prioritize recruitment strategies to maximize generalizability.
Clement et al., 2020	123 Multisystem trauma patients	prospective cohort study	No reductions in depression, anxiety or stress	Future studies of mindfulness in trauma patients.
Carullo et al., 2021	53 Anesthesiology Trainees	prospective, self-controlled study	Decreased depressive symptoms	Find the optimal use duration for studying the effects of a mindfulness intervention requires more investigation.
Gregoski et al., 2013	3 Adult Male Teachers	RTC	Decreased physiological measures of stress	Establish criteria to determine meditation session quality
Adams, et al., 2015	64 Prehypertensive Adults	RTC	Decreased physiological measures of stress	Trials to test the utility of other available apps, the integration of a broader array of sensing technologies to track progress, and studies in other at-risk populations.
Rung et al., 2018	236 Women	Not Reported	Decreased depressive symptoms	None Reported
Kubo et al., 2019	104 Advanced Cancer Patients and 39 Caregivers	RCT	Reductions in distress, anxiety and depressive symptoms	Future studies that focus on male patients and minority populations may help reduce the current gap in knowledge.

Citation	Sample Size	Study Design	Key Findings	Future Research and Recommendations
Kubo et al., 2020	20 Pregnant Women with Moderate-to-moderately-Severe Antenatal Depressive Symptoms	Single Arm Trial	Decreased depressive symptoms	Further develop more effective mHealth interventions for antenatal depression
Kubo et al., 2020	42 Cancer Patients and Their Informal Caregivers	single-arm pilot study	Reduced distress	Further engage clinical staff to maximize enrollment. A brief introductory conversation with participants about the benefits of stress reduction and/or an introduction to the program to increase patient engagement. Continue to involve caregivers, and investigate how to increase the enrollment, adherence, and completion rates among understudied populations. Offer the intervention in languages other than English to improve minority population participation.
Noone & Hogan, 2018	91 University Students	RCT	No reductions found in stress or well-being	Development of better measures. Have a longer or more intensive mindfulness intervention, and/or the involvement of a mindfulness instructor. Recruit adequate sample sizes.
Wen et al., 2017	30 Medical Residents	Prospective Pilot Study	No reduction in negative affect	Collect qualitative data on barriers to use. Recruit more diverse participants. Include a control population.
Economides et al., 2018	59 General Population Adults	RCT	Reductions in stress and negative affect	Use global measures of stress to compare this result to the existing literature. Longer intervention period.
Champion et al., 2018	74 General Population Adults	RCT	Reduction in stress	Recruit larger samples. Use active control groups. Investigate the impact of app-based MM training in more diverse, less biased study populations.
Bostock et al., 2019	238 Employees of a High-Tech Company or Pharmaceutical Firm	RCT	Improved well-being and decreased distress	Explore potential mechanisms of workplace mindfulness trainings and tailor interventions to target those mechanisms. Examine whether these improvements can be sustained over time and, if so, whether mindfulness meditation practiced via mobile app improves long-term psychological and physical health. Recruit participants based on high levels of work stress or BP, as that would leave more room for the intervention to change those outcomes. Compare app-based delivery of mindfulness training with traditional group-based delivery, as well as compare mindfulness with other scalable stress-reduction techniques (e.g., lunchtime park walks).
Howells et al., 2016	121 "Happiness Seekers"	Not Reported	Increased wellbeing	Explore the comparison or the addition of smartphone-based application delivery to alternative formats.
Quinones & Griffiths, 2019	994 General Population Adults who Worked Long Hours	RCT	Reductions in anxiety and depressive symptoms	Clarify if mindfulness intervention requires a higher level of effort for individuals than the gradual muscle relaxation intervention.
Flett et al., 2019	210 University Students	RCT	Reductions in anxiety and depressive symptoms.	Use more conservative effect size estimates when conducting their power analyses. Design protocol to collect objective measures of app usage. Collect more objective behavioral measures to support their self-reported measures. Investigate mindfulness-based apps as standalone vs. adjunct-to-treatment as usual. Compare mindfulness-based apps to not only established mindfulness meditation programs but also to active app-based controls.
Yang et al., 2018	88 Medical Students	RCT	Decreased stress	Examine if there are differences between participants who actually use the mobile app and those who never did.
Fitzhugh et al., 2019	1,337 Police Officers in the United Kingdom	RCT	Improved wellbeing	Include more male participants

FIGURES

Figure 1*PRISMA Flow Diagram*

PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources



From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: <http://www.prisma-statement.org/>

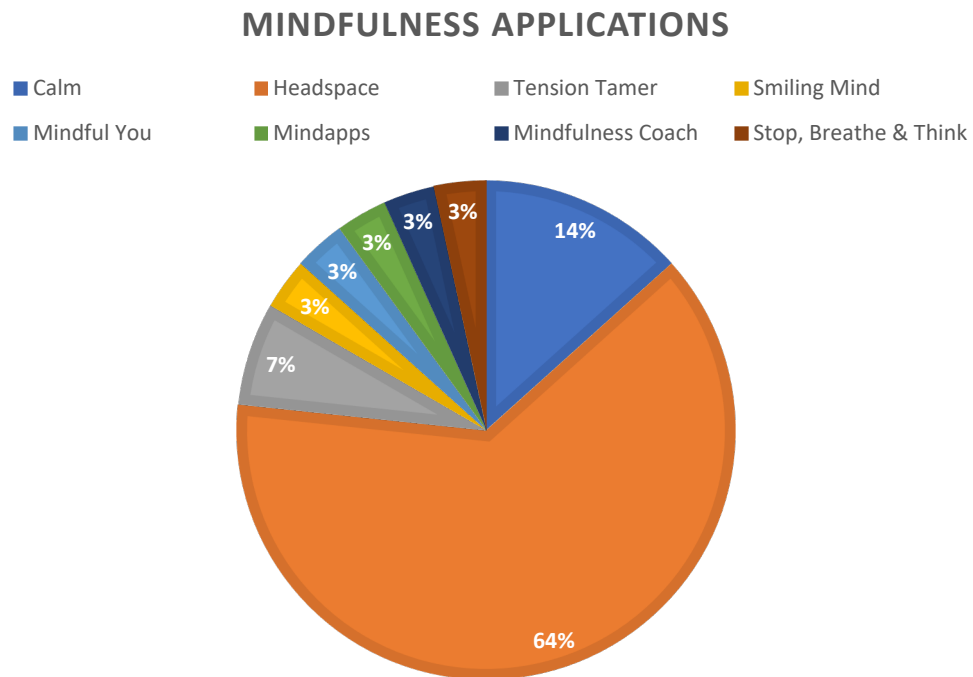
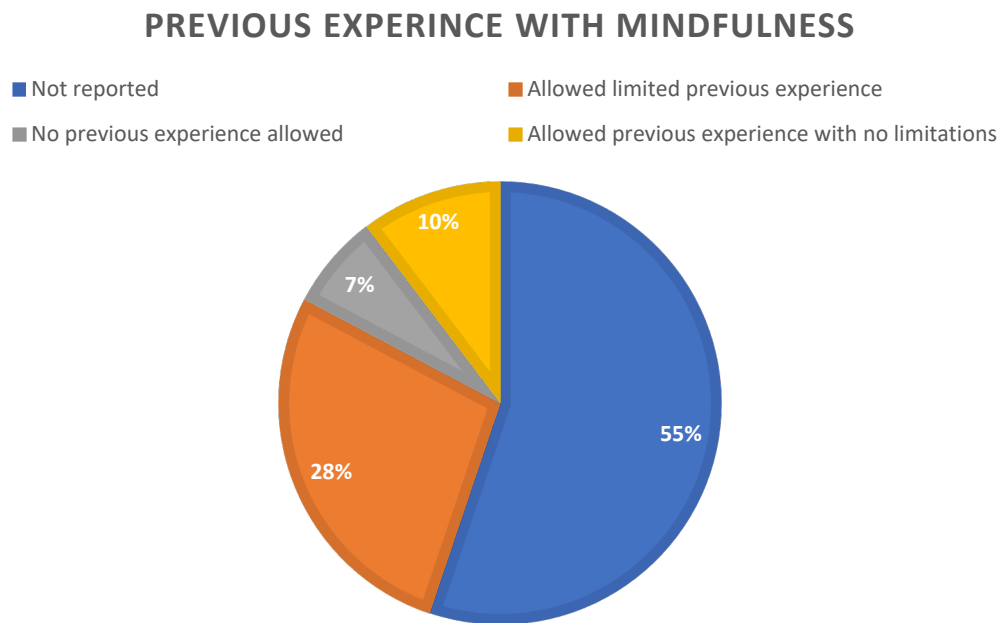
Figure 2*Mindfulness Applications*

Figure 3

Previous Experience with Mindfulness



APPENDIX A

IRB Approval

PEPPERDINE UNIVERSITY

Graduate & Professional Schools Institutional Review Board

July 14, 2020

Protocol #: **71420**

Project Title: Using Mindfulness-Based Mobile Apps to Reduce Psychological Symptoms and Enhance Well-Being Among General and Clinical Population Adults: Benefits, Limitations, and Future Directions.

Dear Brian:

Thank you for submitting a “GPS IRB Non-Human Subjects Notification Form” for *Using Mindfulness-Based Mobile Apps to Reduce Psychological Symptoms and Enhance Well-Being Among General and Clinical Population Adults: Benefits, Limitations, and Future Directions* project to Pepperdine University’s Institutional Review Board (IRB) for review. The IRB has reviewed your submitted form and all ancillary materials. Upon review, the IRB has determined that the above titled project meets the requirements for *non-human subject research* under the federal regulations 45 CFR 46.101 that govern the protection of human subjects.

Your research must be conducted according to the form that was submitted to the IRB. If changes to the approved project occur, you will be required to submit *either* a new “GPS IRB Non-Human Subjects Notification Form” or an IRB application via the eProtocol system (<http://irb.pepperdine.edu>) to the Institutional Review Board.

A goal of the IRB is to prevent negative occurrences during any research study. However, despite our best intent, unforeseen circumstances or events may arise during the research. If an unexpected situation or adverse event happens during your investigation, please notify the IRB as soon as possible. We will ask for a complete explanation of the event and your response. Other actions also may be required depending on the nature of the event. Details regarding the timeframe in which adverse events must be reported to the IRB and documenting the adverse event can be found in the *Pepperdine University Protection of Human Participants in Research: Policies and Procedures Manual* at <https://community.pepperdine.edu/irb/policies/>.

Please refer to the protocol number denoted above in all further communication or correspondence related to this approval.

On behalf of the IRB, we wish you success in this scholarly pursuit.

Sincerely,
Institutional Review Board (IRB)
Pepperdine University

cc: Mrs. Katy Carr, Assistant Provost for Research

Dr. Judy Ho, Graduate School of Education and Psychology IRB Chair

APPENDIX B

Screening and Selection Record

APPENDIX C

Data Collection and Extraction Form

Document ID#
Authors and Year (<i>last names of authors and year of publication, e.g., Johnson, Jones, and Jackson 2011</i>)
Full Document Title
Research Variables (Psychological Symptoms and/or well-being)
Notes:

General Information

Date form completed (<i>dd/mm/yyyy</i>)	
Initials/ID of person extracting data	
Source/Publication Type (<i>journal, book, conference, report, dissertation, abstract, etc.</i>)	
Source Name (<i>Title of Journal, Book, Organization, etc.</i>)	
Publication Status (<i>Published, Unpublished</i>)	
Author(s) Name(s)	
Document Language	
Purpose/Research question of the study	
Independent Variable: Was a mindfulness app used? If yes, name the app(s) ***IF IT IS NOT A MINDFULNESS APP THEN EXCLUDE***	
Was the App (or apps) used in the Article available AND accessible to the public? (i.e., downloadable to iOS or Android smartphones) -if no, explain (it's not enough to be on the app store, it needs to be able to be accessed once it's downloaded) ***exclude if the app is not available***	
Independent Research Variables (Select All That Apply) ***IF THE ARTICLE DOES NOT MEASURE ANY, THEN EXCLUDE***	
OTHER:	
Notes:	

Design Characteristics and Methodological Features

	Descriptions as stated in report/paper	Location in text (pg & ¶/fig/table)
What was the duration of meditation that the participants were instructed to engage in?		
Did any of the mindfulness apps utilize a significant component of a therapeutic modality (i.e., CBT) ***IF YES THEN EXCLUDE***		
Did the app utilize other technology to deliver the mindfulness intervention (i.e., VR, EEG, neurofeedback, etc.) ***IF YES THEN EXCLUDE***		
General Method (Quant, Qual, Mixed)		
Design or Specific Research Approach (RCT, etc.)		
Did the study account for differences in dosage and frequency of mindfulness intervention delivered via app? (i.e., did they make different intervention groups for mindfulness dosage and frequency)		
If yes, then describe the different groups for dosage and frequency between the research participants (i.e., one group meditated for 5 min daily while another did 15 min daily)		
Which apps did not meet any exclusion criteria and are therefore appropriate for this review?		
App Name and available to general population		
Notes:		

Assessment of Research Variables

RESEARCH VARIABLES	How Assessed (<i>Measure, Observation, Interview Question, Archival, etc.</i>)	Reliability/Validity/Utility	Location in text (pg & ¶/fig/table)
Anxiety			
Depression			
Negative Affect			
Perceived Stress			
Physiological measurements of stress			
Well-being			
Notes:			

Study Participant Characteristics and Recruitment

	Description as stated in report/paper	Location in text (pg & ¶/fig/table)
Population of Interest		
Recruitment Methods		
Sample Size		
Age		
Gender		
Diagnosis/diagnoses of participants		
Education Level		
Race/Ethnicity		
Marital Status		
Religion		
Socioeconomic Status		
Occupation		
Primary Language Spoken		

	Description as stated in report/paper	Location in text (pg & ¶/fig/table)
Did the participants have any prior experience with mindfulness or meditating?		
Notes:		

Setting Characteristics

	Descriptions as stated in report/paper	Location in text (pg & ¶/fig/table)
Study Location		
Data Collection Setting(s)		
Other		
Other		
Notes:		

Results

	Description as stated in report/paper	Location in text (pg & ¶/fig/table)
Anxiety		
Depression		
Negative Affect		

	Description as stated in report/paper	Location in text (pg & ¶/fig/table)
Perceived Stress		
Physiological Measurements of Stress		
Well-being		
Meditation Duration/Frequency		
Adherence to Mindfulness Intervention		
Notes:		

Conclusions and Follow-up

	Description as stated in report/paper	Location in text (pg & ¶/fig/table)
Did the Authors find significant benefits for any of the psychological variables related to the dissertation (i.e. anxiety, depression, etc.)?		
Key conclusions of study authors		
Study Author's Recommendations for Future Research		
Does the study directly address research question #1: What benefits are associated with the use of mindfulness-based apps for clinical and general population adults with respect to stress,		

symptoms of anxiety and symptoms of depression?		
Does the study directly address research question #2: Have mindfulness-based apps been found to enhance well-being for clinical and general population adults?		
Does the study directly address research question #3: What limitations have been identified with respect to the use of meditation-based apps for clinical and general population adults?		
Your Take-Aways (General) - Few Sentences about how does it relate to psychological variables and does it tell us anything noteworthy about the app(s) used		
Your Take-Aways: Implications for Practice (Would we suggest this/these app(s) to be used in, outside, or as an adjunct to treatment?)		
Salient Study Limitations (to inform Quality Appraisal)		
Is there a potential conflict of interest in this article? (Copy and paste authors' explanation regarding conflict)		
Potential Conflict of Interest - Do you believe there to be bias? If so, what type? Explain.		
Further study information needed? <i>(from whom, what and when, contact info)</i>		
Correspondence received <i>(from whom, what and when)</i>		

Notes:

APPENDIX D

Individual Study Quality Assessment (Template)

Individual Study Quality Assessment (Template)

Author(s) and Year: _____ **Study**
ID# _____

1. Methodology:	Quantitative	Qualitative	Mixed Methods
2. Specific		Design/Inquiry	Approach:

RATING SCALE: Strong=3 Good/Adequate=2 Weak=1 Missing=0
N/A

3. Strength of Literature Foundation and Rationale for Study: _____

(POSSIBLE CONSIDERATIONS: current and relevant references, background literature sufficiently comprehensive regarding mindfulness, mindfulness-based mobile apps and psychological symptoms as specified earlier. Need/Rationale for study clearly stated.)

4. Clarity and specificity of Research Aims/Objectives/Questions: _____

(POSSIBLE CONSIDERATIONS: research aims/objectives/questions are clearly stated in the protocol, hypotheses are formed, researchers explain how they plan to test questions and measure objectives, researchers define symptoms well (i.e. depressive symptoms instead of perceived stress))

5. Quality of research design or methodological approach: _____

(POSSIBLE CONSIDERATIONS: provides rationale for design chosen, appropriateness for research questions, clear description of design and methodological approach, strength of design characteristics utilized (e.g., randomization, blinding, triangulation, etc.), potential confounds identified and addressed in some way, consideration of internal and external validity in design, specific design-based “risk of bias” criteria)

6. Sample Selection and Characteristics: _____

(POSSIBLE CONSIDERATIONS: adequacy of sample size in context of design, detailed description of sample characteristics, representativeness of sample, adequacy of sample characteristics in the context of research aims, detailed description of recruitment and selection of participants, control group/active control group/no control group, randomization and stratification for sample, extent of selection or sample bias, past meditation experience of participants, age, nationality)

7. Measures / Data Collection Tools: _____

(POSSIBLE CONSIDERATIONS: rationale for selection, appropriateness for assessing variables, development of new tool clearly described, psychometric properties (reliability, validity, utility) described, adequacy of psychometric properties, sufficiently comprehensive, etc.)

8. Data Collection:_____

(POSSIBLE CONSIDERATIONS: data collection procedures clearly described, intervention strategies and implementation described in detail, quality of data collected, attrition, etc.)

9. Analysis of Data: _____

(POSSIBLE CONSIDERATIONS: appropriateness of analysis for research questions and type of data, power and effect size presented, results presented clearly and comprehensively, etc.)

10. Discussion of Study Limitations: _____

(POSSIBLE CONSIDERATIONS: identifies and discusses limitations in the context of design/strategy utilized (e.g., various forms of bias, internal validity, external validity (generalizability), ecological validity, transferability, credibility, transparency, etc.), comprehensiveness of limitations identified)

11. Consideration of culture and diversity: _____

(POSSIBLE CONSIDERATIONS: attention to diversity within sample, includes culturally appropriate methods and tools, avoids biased language, uses appropriate terminology, etc.)

12. OVERALL RATING:	EXEMPLARY	STRONG	GOOD/ADEQUATE	
WEAK	(all "3"s)	(mostly "3"s)	(mostly "2"s)	(mostly "1"s)

APPENDIX E

Excluded Studies and Reason for Exclusion

Excluded studies	Reason for exclusion
A mindfulness meditation mobile app improves depression and anxiety in adults with sleep disturbance: Analysis from a randomized controlled trial	Sample included those with serious mental illness
Usage Patterns of the Calm Meditation App Among People with Cardiovascular Disease	No self-report measures utilized
A New Mental Health Mobile App for Well-Being and Stress Reduction in Working Women: Randomized Controlled Trial	Not a publicly available mindfulness app
Characteristics and Usage Patterns Among 12,151 Paid Subscribers of the Calm Meditation App: Cross-Sectional Survey	No self-report measure utilized
Use of the Consumer-Based Meditation App Calm for Sleep Disturbances: Cross-Sectional Survey Study	No self-report measure utilized
Use of Mobile Mindfulness Apps in Young Adults With Depression: Results From a Cross-Sectional Survey	Did not measure independent variables
The efficacy of mindfulness meditation apps in enhancing users' well-being and mental health related outcomes: A meta-analysis of randomized controlled trials.	Not a publicly available mindfulness app
Comparing effects of detached mindfulness and cognitive restructuring in obsessive-compulsive disorder using ecological momentary assessment	Did not measure independent variables
Adding Mindfulness to an Evidence-Based Reading Intervention for a Student with SLD: a Pilot Study	Included adolescent or child population
Brief, one-on-one, telephone-adapted mindfulness-based stress reduction for patients undergoing percutaneous coronary intervention: A randomized controlled trial.	No dependent variables
Acceptance lowers stress reactivity: Dismantling mindfulness training in a randomized controlled trial.	Not a publicly available mindfulness app
570-P: Impact of Psychosocial Factors, Self-Efficacy, Knowledge, and Nutrition Using 12-Week Courses on Diabetes Management for Veterans.	No dependent variables
Can a meditation app help my sleep? A cross sectional survey of Calm users	Did not measure independent variables

Effectiveness of app-based relaxation for patients with chronic low back pain (Relaxback) and chronic neck pain (Relaxneck): study protocol for two randomized pragmatic trials	Did not measure independent variables
Post-9/11 Veterans and Their Partners Improve Mental Health Outcomes with a Self-directed Mobile and Web-based Wellness Training Program: A Randomized Controlled Trial	Sample included those with serious mental illness
Evaluating mobile phone applications for health behaviour change: A systematic review	No self-report measures utilized
Resilience Training for Work-Related Stress Among Health Care Workers: Results of a Randomized Clinical Trial Comparing In-Person and Smartphone-Delivered Interventions.	No dependent variables
Effectiveness of a smartphone-based worry-reduction training for stress reduction: A randomized-controlled trial	Included significant components of therapeutic modality
Mindfulness training and systemic low-grade inflammation in stressed community adults: Evidence from two randomized controlled trials.	Included significant components of therapeutic modality
Effects of a 12-Minute Smartphone-Based Mindful Breathing Task on Heart Rate Variability for Students With Clinically Relevant Chronic Pain, Depression, and Anxiety: Protocol for a Randomized Controlled Trial.	Not a publicly available mindfulness app
Pilot evaluation of the stop, breathe & think mindfulness app for student clients on a college counseling center waitlist.	Not a publicly available mindfulness app
Optimizing a self-directed mobile mindfulness intervention for improving cardiorespiratory failure survivors' psychological distress (LIFT2): Design and rationale of a randomized factorial experimental clinical trial.	Does not measure independent variables
Effectiveness of using a meditation app in reducing anxiety and improving well-being during the COVID-19 pandemic: A structured summary of a study protocol for a randomized controlled trial	Research proposal
Effectiveness of Smartphone-Based Mindfulness Training on Maternal Perinatal Depression: Randomized Controlled Trial.	Not a publicly available mindfulness app

Mobile well-being in pregnancy: suggestions from a quasi-experimental controlled study	Included significant components of therapeutic modality
The effectiveness of smartphone compassion training on stress among Swedish university students: A pilot randomized trial.	Does not measure independent variables
Feasibility and Effectiveness of the Web-Based WeActive and WeMindful Interventions on Physical Activity and Psychological Well-Being	No dependent variables
Response to: 'Mindfulness-based mobile app reduces anxiety and increases self-compassion in healthcare students: A randomised controlled trial'	Response to editor
Does a meditation protocol supported by a mobile application help people reduce stress? Suggestions from a controlled pragmatic trial.	Not a publicly available mindfulness app
Ecological momentary assessment and beyond: The rising interest in e-mental health research	Response to editor
Pathways to happiness are multidirectional: Associations between state mindfulness and everyday affective experience.	No dependent variables
The future of mindfulness training is digital, and the future is now	No self-report measures utilized
Feasibility and effectiveness of a worry-reduction training using the smartphone: A pilot randomised controlled trial.	Not a publicly available mindfulness app
Can mindfulness mechanistically target worry to improve sleep disturbances? Theory and study protocol for app-based anxiety program.	Included significant components of therapeutic modality
The efficacy of mindfulness meditation apps in enhancing users' well-being and mental health related outcomes: a meta-analysis of randomized controlled trials	Not a publicly available mindfulness app
Identifying Mechanisms That Link Pain to Smoking Relapse During a Quit Attempt	Did not measure independent variables
The effects of app-based mindfulness practice on the well-being of university students and staff	Sample included those with serious mental illness

Use of Mobile Mindfulness Apps in Young Adults With Depression: Results From a Cross-Sectional Survey	Did not measure independent variables
Pilot testing in app-based meditation intervention among firefighters during the COVID-19 pandemic	No self-report measures utilized
Feasibility and Acceptability of Smartphone Assessment in Older Adults with Cognitive and Emotional Difficulties.	No dependent variables
Promoting Well-Being Through Relationship Building: The Role of Smartphone Technology in Foster Care.	No dependent variables
A mindfulness mobile app for people dealing with infertility	Did not measure independent variables
Effectiveness of Mindfulness-Based Stress Management in The Mental Health of Iranian University Students: A Comparison of Blended Therapy, Face-to-Face Sessions, and mHealth App (Aramgar)	Not a publicly available mindfulness app
How Mindfulness Training Promotes Positive Emotions: Dismantling Acceptance Skills Training in Two Randomized Controlled Trials	No dependent variables
Mobile Mental Health Apps in China: Systematic App Store Search	No dependent variables
Effects of a Brief Electronic Mindfulness-Based Intervention on Relieving Prenatal Depression and Anxiety in Hospitalized High-Risk Pregnant Women: Exploratory Pilot Study.	Not a publicly available mindfulness app
Not all types of meditation are the same: Mediators of change in mindfulness and compassion meditation interventions	No dependent variables
How FOMO (Fear of Missing Out), the Smartphone, and Social Media May Be Affecting University Students in the Middle East	No dependent variables
Meta-analysis of Technology-Enabled Mindfulness-Based Programs for Negative Affect and Mindful Awareness	No dependent variables
A Systematic Review of Electronic Mindfulness-Based Therapeutic Interventions for Weight, Weight-Related Behaviors, and Psychological Stress	No dependent variables

A randomised active-controlled trial to examine the effects of an online mindfulness intervention on executive control, critical thinking and key thinking dispositions in a university student sample	Did not measure independent variables
MindfulSpot: A mindfulness mobile app for people dealing with infertility.	No dependent variables
Testing a mindfulness meditation mobile app for the treatment of sleep-related symptoms in adults with sleep disturbance: A randomized controlled trial	No dependent variables
Experiences of Using a Consumer-Based Mobile Meditation App to Improve Fatigue in Myeloproliferative Patients: Qualitative Study	Did not measure independent variables
Cancer Patients' and Survivors' Perceptions of the Calm App: Cross-Sectional Descriptive study	Did not measure independent variables
Adult colouring: the effect of app-based vs. pen-and-paper colouring on mindfulness and anxiety.	No dependent variables
An App a Day Keeps the Doctor Away: Guided Education and Training via Smartphones in Subthreshold Post Traumatic Stress Disorder.	Included serious mental illness
A smartphone application for treating depressive symptoms: study protocol for a randomised controlled trial.	Included significant components of therapeutic modality
A Qualitative Cultural Sensitivity Assessment of the Breathe Easier Mobile Application for Lung Cancer Survivors and Their Families.	Utilized only qualitative data
A Focus Group Evaluation of Breathe Easier: A Mindfulness-Based mHealth App for Survivors of Lung Cancer and Their Family Members.	Did not measure independent variables
A review of popular smartphone apps for depression and anxiety: Assessing the inclusion of evidence-based content.	No self-report measures utilized
A mindfulness mobile app for traumatized COVID-19 healthcare workers and recovered patients: A response to 'The use of digital applications and COVID-19'.	Research proposal or response to editor
App-based delivery of clinical emotional freedom techniques: Cross-sectional study of app user self-ratings.	No dependent variables

A pilot randomized controlled trial of smartphone-assisted mindfulness-based intervention with contingency management for smokers with mood disorders.	Included significant components of therapeutic modality
Advanced Practice Provider Burnout in a Large Urban Medical Center.	No dependent variables
Comparing focused attention meditation to meditation with mobile neurofeedback for persistent symptoms after mild-moderate traumatic brain injury: a pilot study.	Utilized other technology to deliver mindfulness
The experience sampling method as an mHealth tool to support self-monitoring, self-insight, and personalized health care in clinical practice.	No dependent variables
Testing a mobile mindful eating intervention targeting craving-related eating: feasibility and proof of concept.	Did not measure independent variables
Hospice and Palliative Care Provider Experiences With Meditation Using Mobile Applications.	Utilized only qualitative data
Reducing Stress and Anxiety During Pregnancy.	No dependent variables
Remote assessment of disease and relapse in major depressive disorder (RADAR-MDD): a multi-centre prospective cohort study protocol.	Research proposal or response to editor
Mindful Age and Technology: a Qualitative Analysis of a Tablet/Smartphone App Intervention Designed for Older Adults.	Utilized only qualitative data
Exploring the relationships between resilience, mindfulness, and experiential avoidance after the use of a mindfulness- and acceptance-based mobile app for posttraumatic stress disorder.	Did not measure independent variables
Opportunities to Integrate Mobile App-Based Interventions Into Mental Health and Substance Use Disorder Treatment Services in the Wake of COVID-19.	Research proposal or response to editor
Transitions in medicine: Trainee doctor stress and support mechanisms.	No dependent variables
Mindful instant messaging: Mindfulness and autonomous motivation as predictors of well-being in smartphone communication.	No dependent variables

The experience sampling method as an mHealth tool to support self-monitoring, self-insight, and personalized health care in clinical practice.	No dependent variables
PHIT for duty, a mobile application for stress reduction, sleep improvement, and alcohol moderation.	Included significant components of therapeutic modality
Momentary negative affect is lower during mindful movement than while sitting: An experience sampling study.	No dependent variables
Quality of life among women diagnosed with breast Cancer: A randomized waitlist controlled trial of commercially available mobile app-delivered mindfulness training.	Did not measure independent variables
Stress and neurocognitive efficiency in managerial contexts: A study on technology-mediated mindfulness practice.	Utilized other technology to deliver mindfulness
The role of state and trait positive affect and mindfulness in affective reactivity to pain in chronic migraine.	No dependent variables
Is online treatment as effective as in-person treatment?: Psychological change in two relationship skills groups.	No dependent variables
The therapy process questionnaire - factor analysis and psychometric properties of a multidimensional self-rating scale for high-frequency monitoring of psychotherapeutic processes.	No dependent variables
Integrating wearables in stress management interventions: Promising evidence from a randomized trial.	No dependent variables
Feasibility and efficacy of the addition of heart rate variability biofeedback to a remote digital health intervention for depression.	No dependent variables
Preventing depression using a smartphone app: A randomized controlled trial.	Included significant components of therapeutic modality
Does mindfulness reduce the effects of risk factors for problematic smartphone use? Comparing frequency of use versus self-reported addiction.	No dependent variables
Exploring the effects of a brief biofeedback breathing session delivered through the BioBase app in	No dependent variables

facilitating employee stress recovery: Randomized experimental study.	
Reassessing evidence-based content in popular smartphone apps for depression and anxiety: Developing and applying user-adjusted analyses.	Did not measure independent variables
Trivago flowlab—A case study on how to improve employees' well-being in a corporate environment.	No dependent variables
Measuring meditation progress with a consumer-grade EEG device: Caution from a randomized controlled trial.	Utilized other technology to deliver mindfulness
Smarthealth technology study protocol to improve relationships between older adults with dementia and family caregivers.	Research proposal or response to editor
Conceptualizing digital well-being and technology addiction in I-O psychology.	No self-report measures utilized
Describing the use of a mindfulness-based app for sleep and mental well-being, across age, in children.	Included adolescent or child population
Improvements in Health Might Contradict Adherence to Mobile Health Interventions: Findings from a Self-Care Cancer App Study.	Not a publicly available mindfulness app
A clinical trial of group-based body psychotherapy to improve bodily disturbances in post-treatment cancer patients in combination with randomized controlled smartphone-triggered bodily interventions (KPTK): Study protocol.	Included significant components of therapeutic modality
EMOTEO: A Smartphone Application for Monitoring and Reducing Aversive Tension in Borderline Personality Disorder Patients, a Pilot Study.	Included serious mental illness
Mobile applications may be the future of veteran mental health support but do veterans know yet? A survey of app knowledge and use.	No self-report measures utilized
Development and initial evaluation of a mobile application to help with mindfulness training and practice.	Did not measure independent variables
Mindfulness and compassion: An examination of mechanism and scalability	Did not measure independent variables
A mindfulness intervention for residents: Relevance for pediatricians	Did not measure independent variables

Making time for mindfulness. International Journal of Medical Informatics	Utilized only qualitative data
Online-based mindfulness training reduces behavioral markers of mind wandering. Journal of Cognitive Enhancement	Did not measure independent variables
A randomized controlled trial of mHealth mindfulness intervention for cancer patients and informal cancer caregivers: A feasibility study within an integrated health care delivery system	Did not measure independent variables
Be(coming) real: a multi-source and an intervention study on mindfulness and authentic leadership	Did not measure independent variables
Meditation inhibits aggressive responses to provocations	Did not measure independent variables
Mindfulness for novice pediatric nurses: smartphone application versus traditional intervention	Did not measure independent variables
The effect of mindfulness-training on extinction retention	No self-report measures utilized
The peril of self-reported adherence in digital interventions: A brief example	Did not measure independent variables
On-the-spot binaural beats and mindfulness reduces behavioral markers of mind wandering	No dependent variables
Mobile mindfulness intervention on an acute psychiatric unit: feasibility and acceptability study	Included serious mental illness
Review and evaluation of mindfulness-based iPhone apps	Did not measure independent variables
Feasibility of an app-based mindfulness intervention among women with an FMR1 premutation experiencing maternal stress.	Did not measure independent variables
Mental Health and Meditation Practices of Pregnant Women during COVID-19	Included serious mental illness
Comparing effects of detached mindfulness and cognitive restructuring in obsessive-compulsive disorder using ecological momentary assessment.	Did not measure independent variables
Adding mindfulness to an evidence-based reading intervention for a student with sld: A pilot study.	Included adolescent or child population

A New Mental Health Mobile App for Well-Being and Stress Reduction in Working Women: Randomized Controlled Trial.	Included Significant components of therapeutic modality
Can a meditation app help my sleep? A cross-sectional survey of Calm users.	Did not measure independent variables
Effectiveness of app-based relaxation for patients with chronic low back pain (Relaxback) and chronic neck pain (Relaxneck): study protocol for two randomized pragmatic trials.	Did not measure independent variables
Post-9/11 Veterans and Their Partners Improve Mental Health Outcomes with a Self-directed Mobile and Web-based Wellness Training Program: A Randomized Controlled Trial.	Included serious mental illness
Effectiveness of Mindfulness- and Relaxation-Based eHealth Interventions for Patients with Medical Conditions: a Systematic Review and Synthesis.	No dependent variables

Total Number of Excluded Articles	112
No dependent variables	31
Did not measure independent variables	28
Not a publicly available mindfulness app	12
No self-report measures utilized	10
Included significant components of therapeutic modality	10
Included serious mental illness	6
Research proposal or response to editor	5
Utilized only qualitative data	4
Utilized other technology to deliver mindfulness	3
Included adolescent or child population	3

*Independent variables include anxiety, depression, stress and well-being

*Dependent variables include types of mobile-based mindfulness apps