



## Feasibility and utility of mobile health interventions for depression and anxiety in rural populations: A scoping review

Michael J. McCarthy<sup>a,\*</sup>, Alexandra Wicker<sup>b</sup>, Juliette Roddy<sup>c</sup>, Mark Remiker<sup>d</sup>, Indrakshi Roy<sup>d</sup>, Megan McCoy<sup>a</sup>, Eric S. Cerino<sup>b</sup>, Julie Baldwin<sup>d</sup>

<sup>a</sup> Department of Social Work, Northern Arizona University, 19 W McConnell Dr., Flagstaff, AZ 86011, United States of America

<sup>b</sup> Department of Psychological Sciences, Northern Arizona University, 1100 S Beaver St., Flagstaff, AZ 86011, United States of America

<sup>c</sup> Department of Criminology & Criminal Justice, Northern Arizona University, 5 E McConnell Dr., Flagstaff, AZ 86011, United States of America

<sup>d</sup> Center for Health Equity Research, Northern Arizona University, 1395 Knoles Drive, Flagstaff, AZ 86011, United States of America

### ARTICLE INFO

**Keywords:**  
Mobile health  
mHealth  
Depression  
Anxiety  
Rural  
Scoping review

### ABSTRACT

Despite the potential of mobile health (mHealth) to address high rates of depression and anxiety in underserved rural communities, most mHealth interventions do not explicitly consider the realities of rural life. The aim of this scoping review is to identify and examine the available literature on mHealth interventions that consider the needs of rural populations in order to gauge their feasibility and utility for addressing depression and anxiety. Additionally, we provide an overview of rural users' perceptions about and preferences for mHealth-delivered mental health screening and intervention systems. Out of 169 articles identified, 16 met inclusion criteria. Studies were conducted across a wide range of countries, age groups, and rural subpopulations including individuals with bipolar disorder, anxiety, perinatal depression, PTSD, and chronic pain, as well as refugees, veterans, and transgender and LGBTQ+ individuals. All interventions were in the feasibility/acceptability testing stage for rural users. Identified strengths included their simplicity, accessibility, convenience, availability of support between sessions with providers, and remote access to a care team. Weaknesses included problems with charging phone batteries and exceeding data limits, privacy concerns, and general lack of comfort with app-based support. Based upon this review, we provide recommendations for future mHealth intervention development including the value of developer-user coproduction methods, the need to consider user variation in access to and comfort with smartphones, and potential data or connectivity limitations, mental health stigma, and confidentiality concerns in rural communities.

### 1. Introduction

The World Health Organization (WHO) estimates that, globally, as many as 280 million people experience regular depressive episodes which may include feelings of sadness, hopelessness, guilt, or low self-worth, loss of interest or pleasure in activities, changes in appetite, sleep, or psychomotor behavior, lack of energy or fatigue, thinking or concentration problems, and thoughts of death or suicide (American Psychiatric Association, 2023a; World Health Organization, 2022). The global prevalence of anxiety is even higher, with an estimated 301 million people living with an anxiety disorder (World Health Organization, 2022). Common anxiety disorders include Generalized Anxiety Disorder, Panic Disorder, Phobias, Social Anxiety Disorder, and

Separation Anxiety Disorder, all of which are characterized by excessive fear and worry resulting in significantly impaired function (American Psychiatric Association, 2023b).

Depression and anxiety exact a high human cost. Population-based studies in the United States estimate that individuals with depression or anxiety die an average of 7.9 years earlier than those without depression or anxiety (Pratt et al., 2016). The WHO ranks depression as the single largest contributor to global disability, accounting for approximately 7.5 % of all “years lived with a disability”, or years of life lost due to living in a state of suboptimal health (Depression and Other Common Mental Disorders: Global Health Estimates, 2017; McPherson and Senra, 2022). The economic burden of these conditions is also substantial. A systematic review of cost-of-illness (COI) studies from

\* Corresponding author.

E-mail addresses: [michael.j.mccarthy@nau.edu](mailto:michael.j.mccarthy@nau.edu) (M.J. McCarthy), [alw594@nau.edu](mailto:alw594@nau.edu) (A. Wicker), [juliette.rodny@nau.edu](mailto:juliette.rodny@nau.edu) (J. Roddy), [mark.remiker@nau.edu](mailto:mark.remiker@nau.edu) (M. Remiker), [indrakshi.roy@nau.edu](mailto:indrakshi.roy@nau.edu) (I. Roy), [megan.mccoy@nau.edu](mailto:megan.mccoy@nau.edu) (M. McCoy), [eric.cerino@nau.edu](mailto:eric.cerino@nau.edu) (E.S. Cerino), [julie.baldwin@nau.edu](mailto:julie.baldwin@nau.edu) (J. Baldwin).

<https://doi.org/10.1016/j.invent.2024.100724>

Received 1 September 2023; Received in revised form 12 January 2024; Accepted 2 February 2024

Available online 3 February 2024

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around the world reported that, compared with non-depressed persons, mean excess costs associated with depression were 179 % higher for adolescents and 158 % higher for adults (König et al., 2020).

Data from the World Mental Health Survey suggest that persons suffering from mental health challenges are grossly underserved (Thornicroft et al., 2017). For example, only 40 % of individuals with depression across 21 countries receive mental health services and this number falls to approximately 18 % in lower-middle-income countries. Notably, these estimates overlook what the 2020 World Health Organization Mental Health Atlas describes as “potentially substantial variability within countries concerning... the availability of services or the existence of [mental health] promotion or prevention programs in rural versus urban areas” (p. 12) (World Health Organization, 2021). The need to address mental health in rural communities is based upon documented barriers to accessing supports including geographic isolation and lack of transportation, economic deprivation, lack of awareness and knowledge about mental health, and perceived stigma around seeking support (Ferris-Day et al., 2021).

Fortunately, this scarcity of services is occurring in the context of increasing smartphone ownership, including in underserved rural communities (Connolly et al., 2018; Pew Research Center, 2021), providing hope that accessible and effective treatments may become increasingly available. For the purpose of this review, underserved rural communities refers to communities of people living in sparsely populated geographic areas with limited access to health and social care (Rural Health Information Hub, 2023).

Mobile health (mHealth), defined as “any medical or public health practice which capitalizes on a mobile phone’s core utilit[ies] of voice and short messaging services (SMS), as well as more complex functionalities” (Tumuhimbise and Musiimenta, 2021, pg. 4), has the potential to address depression and anxiety in rural communities (Friesen, 2019; Hrynyschyn and Dockweiler, 2021; Kruse et al., 2022; Turan and Çetintaş, 2021). In addition to being accessible, a strength of mHealth is that it is customizable for specific mental health needs, language, and culture based upon theoretically-driven frameworks (Gonzalez et al., 2021; Li et al., 2020; Watson-Singleton et al., 2021; Castro et al., 2010; Cork et al., 2019). Compared with other health intervention delivery modes such as telehealth and face-to-face support, evidence suggests that mHealth may also be cost-effective (Gentili et al., 2022; Iribarren et al., 2017). These features may be particularly relevant for communities who cannot or do not access mental health care, including rural communities, due to systemic or personal financial constraints.

Although rurality may look different across countries and regions, individuals living in rural communities experience shared characteristics, lifestyles, and barriers to accessing support for mental health. These include a lack of available services, provider shortages, financial challenges and lack of insurance, cultural or attitudinal barriers, and social and geographic isolation (Ferris-Day et al., 2021; Connolly et al., 2018; Bhat et al., 2020; Cheesmond et al., 2019; Escobar-Viera et al., 2022). In recent years, numerous mHealth and similar digital interventions have been developed to promote positive mental health in specialized populations including children and youth (Ding et al., 2023; Williams and Pykett, 2022), college students (Oti and Pitt, 2021), perinatal populations (Dol et al., 2020; Tsai et al., 2022), and individuals with various chronic health conditions including diabetes, cancer, hypertension, heart disease, COPD, and stroke (Shah et al., 2022). However, few of these interventions have explicitly considered the realities of rural life.

There are a number of innovative mHealth interventions in the published literature from which we may learn. Although the countries of origin and target conditions vary, collectively, this emerging body of research provides a foundation upon which to further develop mHealth interventions designed to address depression and anxiety within the unique challenges of rural life. The first aim of this scoping review is to identify and examine the available literature on mHealth interventions that consider the needs of rural populations in order to gauge their feasibility and utility for addressing depression and anxiety. The second

aim is to provide an overview of rural users’ perceptions about and preferences for mHealth-delivered mental health screening and intervention systems.

## 2. Methods

This scoping review was guided by the Joanna Briggs Institute Scoping Review Methodology (Aromataris and Munn, 2020) and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) extension for scoping reviews (Tricco et al., 2018).

### 2.1. Study inclusion and exclusion criteria

Studies were included if they: 1) were peer-reviewed; 2) were available in English; 3) focused on mHealth-delivered screening or intervention systems, defined as a mobile smartphone application or short messaging service (SMS) (Tumuhimbise and Musiimenta, 2021); 4) specified rural users as the population of interest, and; 5) evaluated user depression or anxiety, either by self-report or diagnostic interview. Additionally, we included studies describing rural user perceptions about and preferences for mHealth interventions (i.e., that were systematically examined using primary data collected through surveys or qualitative interviews), as well as published study protocols describing development, deployment, or evaluation infrastructures for mHealth interventions currently being developed for people with depression or anxiety in rural settings. Dissertations, books, and conference proceedings were excluded from the review.

### 2.2. Search strategy

In January 2024, we searched Academic Search Complete, APA PsycArticles, APA PsycInfo, CINAHL, MEDLINE, and SocINDEX using MeSH-derived keywords developed in consultation with a university research librarian: ((mhealth OR ehealth OR “mobile health” OR technology-based intervention OR smartphone application OR mobile app OR “internet intervention” OR “digital health intervention” OR “self-help intervention”) NOT telehealth) AND rural AND (depression OR anxiety). There were no limiters applied to the search. In addition, we hand-searched the text and references, websites, and other peer-reviewed publications by the first, second, and last authors of articles we found through library databases to identify studies meeting the specified inclusion criteria.

One member of the review team conducted the initial search. Abstracts were organized using Zotero reference management software. Two reviewers independently screened abstracts for relevance, excluding those that did not focus on mHealth, rurality, and depression or anxiety, or that were otherwise off topic. Discrepancies were discussed and resolved abstract by abstract, as needed. Full-text articles were assessed for eligibility by the same two reviewers. Discrepancies were again discussed and resolved article by article, as needed, until agreement was reached. A third member of the review team reviewed the full texts to confirm that the studies met inclusion criteria. Consensus was therefore reached by three reviewers before a study was included in the review. We tracked the search process using a PRISMA flow diagram (Fig. 1).

### 2.3. Data extraction and synthesis

A draft data extraction table was created and circulated among the research team for feedback and revision. Final data extraction tables were populated by two members of the review team and confirmed by a third. Data extracted from the final studies included study authors and year, country, study objective, mHealth description and features, study methods, sample, and findings. The review team interpreted and narratively synthesized data contained in the data extraction tables to

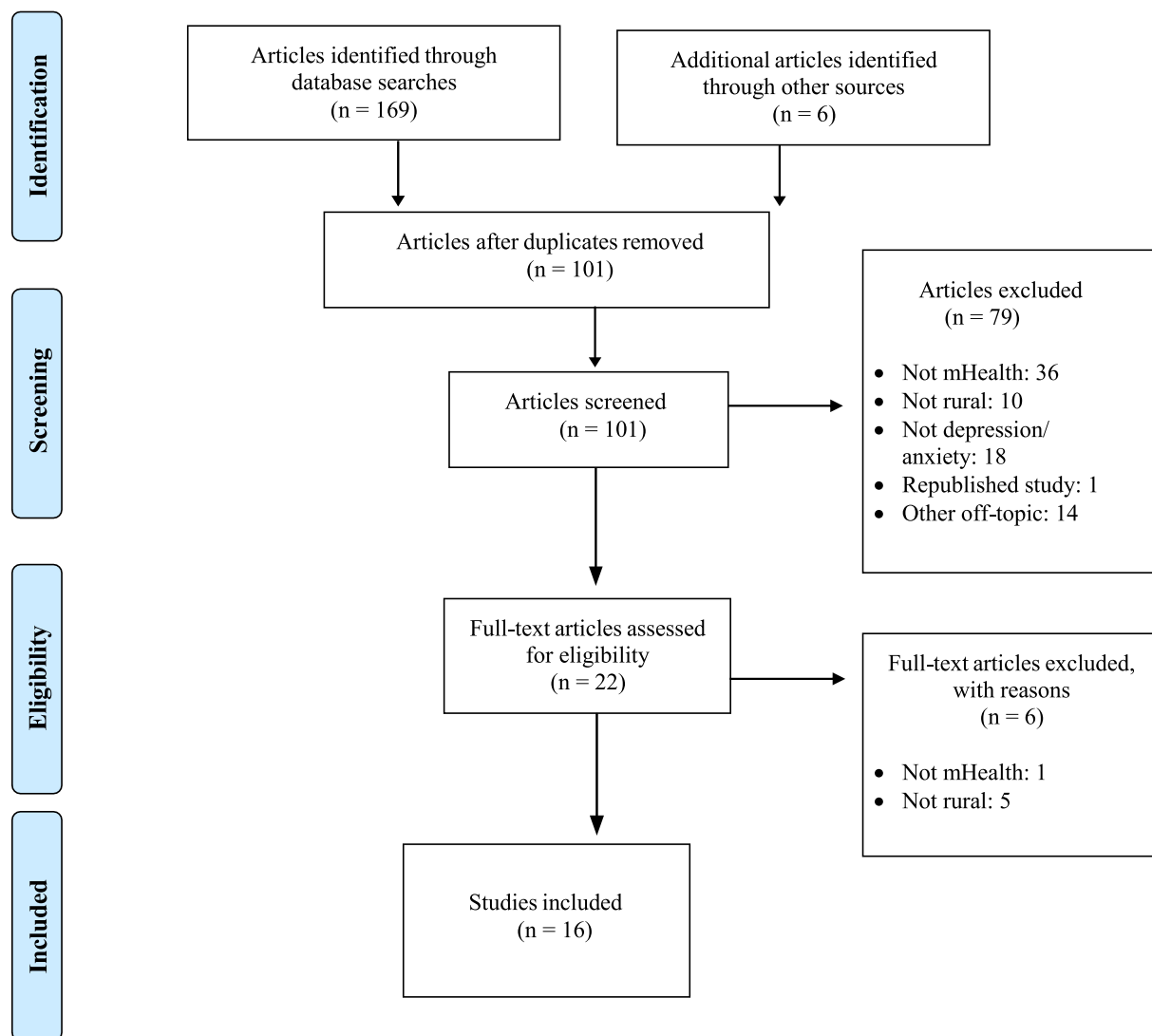


Fig. 1. PRISMA flow diagram of search process.

address the aims of the review. The lead author drafted the initial synthesis. Coauthors provided comments and edits to the draft, along with points for discussion and recommendations for future research and mHealth intervention development. This process continued iteratively until all authors agreed about the final synthesis, recommendations, and report.

### 3. Results

#### 3.1. Sources of evidence

Our search resulted in 175 abstracts which, after removing duplicates, was reduced to 101. Of these, 79 were excluded because they did not focus on mHealth-delivered screening or intervention systems ( $n = 36$ ), did not specify rural users as the population of interest ( $n = 10$ ), did not evaluate depression or anxiety ( $n = 18$ ), reproduced previously published findings ( $n = 1$ ), or were otherwise off-topic ( $n = 14$ ; e.g., described how technology can be generally useful for mental health providers). Twenty-two full-text articles were reviewed for inclusion. Of these, one was excluded for not focusing on mHealth and five were excluded for not specifying rural users. Sixteen studies are included in the scoping review.

#### 3.2. Characteristics of included studies

Characteristics of 11 studies assessing mHealth feasibility and utility are presented in Table 1. Nine present data for feasibility, acceptability, or outcomes from the evaluation of mHealth interventions (Bauer et al., 2017; Bhatia et al., 2021; Bhuiyan et al., 2021; Knutson et al., 2021; Maharjan et al., 2021; Seshu et al., 2021; Silfee et al., 2021; Vigil-Hayes et al., 2021; Forman-Hoffman et al., 2023) and two are study protocols describing development, deployment, or evaluation of future mHealth interventions (Arenas-Castañeda et al., 2020; Moffett et al., 2022). Of these eleven studies, six were conducted in the U.S. (Bauer et al., 2017; Bhuiyan et al., 2021; Knutson et al., 2021; Silfee et al., 2021; Vigil-Hayes et al., 2021; Forman-Hoffman et al., 2023) while the others were conducted in Mexico (Arenas-Castañeda et al., 2020), Canada (Bhatia et al., 2021), Nepal (Maharjan et al., 2021), South Africa (Moffett et al., 2022), and India (Seshu et al., 2021). All included user depression and anxiety symptoms among the problems they were designed to address. Sample sizes ranged from  $N = 14$  (Knutson et al., 2021) to  $N = 7044$  (Bhuiyan et al., 2021) and included youth and adults with bipolar disorder or PTSD (Bauer et al., 2017), chronic pain (Bhatia et al., 2021), Native Americans (Vigil-Hayes et al., 2021), perinatal women (Maharjan et al., 2021; Seshu et al., 2021), transgender and nonbinary individuals (Knutson et al., 2021), and otherwise healthy adults (Bhuiyan et al.,

**Table 1**  
Studies assessing mHealth feasibility and utility.

Author, year	Country	Study Objective	mHealth Description and Features	Methods	Sample	Findings
Arenas-Castañeda et al., 2020	Mexico	Protocol to evaluate feasibility of MeMind/ SMART-SCREEN mobile app for suicide detection in rural Mexico.	<ul style="list-style-type: none"> <li>- MeMind/SMART-SCREEN is a population-level screening tool for detection of suicide risk and mental health disorders in youth and adults.</li> <li>- Requires no active intervention by professionals.</li> <li>- Designed for Android and iOS.</li> </ul>	<ul style="list-style-type: none"> <li>- Population-based cross-sectional digital survey administered over 9 months.</li> </ul>	<ul style="list-style-type: none"> <li>- <math>N = 137,927</math> individuals recruited through posters in public places, educational institutions, and local suicide prevention programs (expected 70 % response rate).</li> <li>- Age 15–70 years.</li> </ul>	<ul style="list-style-type: none"> <li>- Outcome measures include recruitment and participation rate, sample representativeness, feasibility, rate of referral to healthcare providers, and cost, as well as prevalence of suicidal ideation and self-injury behaviors, intensity of suicidality, general well-being, substance use, depression, and anxiety.</li> </ul>
Bauer et al., 2017	United States	Identify strategies for incorporating the SPIRIT mobile app into the delivery of integrated primary care–based mental health services to patients with posttraumatic stress disorder and/or bipolar disorder in rural U.S.	<ul style="list-style-type: none"> <li>- SPIRIT (Study to Promote Innovation in Rural Integrated Telepsychiatry) is a free mobile app containing 7 modules: Check In, View Progress, Learn More, Reach Out for Help, Safety Plan, Settings, and About the SPIRIT App.</li> <li>- Supports patient mental health, as well as communication of patient information to providers.</li> <li>- Coproduced with rural patients and providers according to the 9 Principles for Digital Development including simplified registration, mapping to provider work flow, etc.</li> <li>- Available in multiple languages.</li> <li>- Designed for Android.</li> </ul>	<ul style="list-style-type: none"> <li>- Mixed methods data from patients and providers collected through immersion visits to rural health centers; requirements gathering and ideation sessions with patients, care managers, supervisors, and consumer advisory groups; and individual and group prototype testing/refinement periods and interviews.</li> </ul>	<ul style="list-style-type: none"> <li>- Pilot group of <math>N = 10</math> patients who received SPIRIT support for up to 52 weeks.</li> <li>- Ages not specified.</li> <li>- <math>N = 5</math> care managers who initially adopted SPIRIT.</li> <li>- All patients with symptoms of bipolar disorder or PTSD and reside in rural locations.</li> </ul>	<ul style="list-style-type: none"> <li>- Patients liked SPIRIT's simplicity, ease of use, convenience, reminders, access to care team, and mindfulness prompts.</li> <li>- Patients self-monitored symptoms on average every 2 weeks, which is more frequently than clinic-based assessment; 70 % sustained monitoring for 4+ months.</li> <li>- Patients disliked that symptom monitoring was infrequent (i.e., weekly rather than daily) and expressed interest in a diary-like function.</li> <li>- Increased accessibility of care for rural users overall; some issues with cell service in rural areas.</li> </ul>
Bhatia et al., 2021	Canada	Evaluate feasibility and user engagement with the MMP mobile app for patients with chronic pain receiving care in rural and urban clinics in Canada.	<ul style="list-style-type: none"> <li>- MMP (Manage My Pain) contains three components: (1) Customizable app for patients to track pain/medication, respond to questionnaires, and gain insights into their conditions; (2) Reports that summarize collected information to facilitate communication between patients and providers; and (3) A monitoring portal used by clinics to monitor patient progress remotely.</li> <li>- Available in multiple languages.</li> <li>- Designed for Android and iOS.</li> </ul>	<ul style="list-style-type: none"> <li>- Prospective, exploratory study of 30+ day users of MMP app.</li> <li>- Participant enrollment, retention, duration of app use.</li> <li>- Clinical measures of anxiety, depression, pain catastrophizing, satisfaction, and daily opioid consumption. 4.5 months or longer after initial visit collected through digital survey.</li> </ul>	<ul style="list-style-type: none"> <li>- <math>N = 246</math> adult patients with chronic pain at one rural (<math>n = 92</math>) and two urban (<math>n = 154</math>) pain clinics.</li> <li>- Mean age = 56.67 years (<math>SD = 13.12</math>).</li> <li>- All patients with moderate-to-severe pain intensity that lasted for at least 3 months.</li> </ul>	<ul style="list-style-type: none"> <li>- 73.6 % agreed to use the app, 63.4 % used it for at least one month, and 28 % continued to use it long-term; engagement was thus increased in comparison to clinic-based treatments.</li> <li>- MMP users rated lower anxiety symptoms (reduction in GAD-7 scores by 2.10 points) and lower pain catastrophizing (reduction in PCS score by 5.23 points).</li> <li>- No age/sex/location-based differences observed.</li> </ul>
Bhuiyan et al., 2021	United States	Understand associations between rural or urban status, psychological outcomes, and physical activity among users of the Calm mobile app.	<ul style="list-style-type: none"> <li>- Calm is a subscription-based mindfulness meditation app with three goals: (1) better sleep, (2) lower stress, and (3) less anxiety and depression.</li> <li>- Contains unique audio content, brief medication exercises, sleep stories, and Calm master classes.</li> <li>- Most content can be downloaded for offline use when internet is unreliable.</li> <li>- Available in multiple languages.</li> <li>- Designed for Android and iOS.</li> </ul>	<ul style="list-style-type: none"> <li>- Secondary analysis of national survey data from Calm subscribers.</li> <li>- Explored demographics, Calm app usage, and associations between rural/urban status and psychological outcomes, physical activity of users, as well as effects of COVID-19 on user outcomes.</li> </ul>	<ul style="list-style-type: none"> <li>- 14.3 % (<math>n = 1006</math> of 7044) of participants resided in Rural-urban Commuting (RUCA) codes 2–10, coded as rural.</li> <li>- Mean age = 47.53 years (<math>SD = 13.83</math>).</li> <li>- Participants had used the app at least once in the past 90 days.</li> </ul>	<ul style="list-style-type: none"> <li>- Significant decreases in depressive symptoms, anxiety symptoms, and perceived effects of COVID-19 on physical activity over time.</li> <li>- No associations between rural/urban status and psychological outcomes, physical activities, or perceived effects of COVID-19 on stress or mental health at baseline and thereafter.</li> <li>- Rural/urban status does not appear to drive differences in outcomes among Calm users.</li> </ul>
Forman-Hoffman et al., 2023	United States	Explore differences in mental health outcomes, user satisfaction, app usage, and therapeutic alliances across residential subgroups among users of WB-	<ul style="list-style-type: none"> <li>- Woebot LIFE (WB-LIFE) is a smartphone-based mobile health intervention that aims to help users better understand their moods.</li> <li>- Features a relational agent, Woebot, that</li> </ul>	<ul style="list-style-type: none"> <li>- 8 week, single-arm trial.</li> <li>- Analyses compared app usage and therapeutic alliance total scores as well as sub-scales (goal, task, and bond), program satisfaction, and mental health outcomes (symptoms of anxiety</li> </ul>	<ul style="list-style-type: none"> <li>- <math>N = 255</math> adults residing in metropolitan, nonmetropolitan, or rural area codes.</li> <li>- Few participants resided in nonmetropolitan (<math>n = 25</math>, 10 %) or rural (<math>n = 3</math>, 1 %) areas, but 39 %</li> </ul>	<ul style="list-style-type: none"> <li>- No significant differences in app use or satisfaction by MUA or MHPSA status.</li> <li>- No significant differences in mental health outcomes, except MUA participants had higher baseline depressive symptoms.</li> <li>- Therapeutic alliance scores did not differ</li> </ul>

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Table 1 (continued)

Author, year	Country	Study Objective	mHealth Description and Features	Methods	Sample	Findings
		LIFE, a digital mental health intervention.	converses with users via text-based messages.	and depression, stress, resilience, and burnout) across residential subgroups.	lived in a medically underserved area (MUA) and 55 % in a mental health provider shortage area (MHPSA).	by MHPSA status, but those in an MUA had higher goal and bond scores at day 3, and higher goal scores at week 8 compared to those not in an MUA. - Findings suggest that digital agent-guided therapy may be a beneficial intervention for vulnerable residential populations.
Knutson et al., 2021	United States	Evaluate feasibility of the TExT transgender affirming Short Messaging Service for transgender and non-binary individuals in rural U.S.	- Transgender Empowerment by Texting (TExT) is a 6-week, manualized CBT, SMS-based intervention. - Combination of psychoeducational information and coaching sessions to promote social support and community building among rural users.	- Pilot study with data for anxiety, depression, and social support collected by survey at pre-, post-treatment, and 3-month follow up.	- N = 14 adult users of TExT, identifying as transgender and/or nonbinary. - Mean age = 31.64 years (SD = 11.45).	- Anxiety and depressive symptoms both decreased significantly from pre- to post-intervention; anxiety continued to decrease up to the follow-up interviews. - Social support increased from pre-intervention to follow-up. - Intervention demonstrates good feasibility.
Maharjan et al., 2021	Nepal	Evaluate feasibility and acceptability of the StandStrong mobile screening app for low-resource, young mothers in rural Nepal.	- StandStrong (Sensing Technologies for Maternal Depression Treatment in Low Resource Settings) is a passive data collection platform designed for young mothers, including those with postpartum depression. - Data is collected in 4 domains: (1) mother's location via GPS, (2) physical activity via phone's accelerometer, (3) auditory environment using episodic audio recordings, and (4) mother-infant proximity. - Helpful in rural and similar environments when direct observation may be difficult. - Designed for Android.	- Feasibility evaluated based on the amount of passive sensing data collected compared to the amount that could be collected in a 2-week period. - Qualitative interviews conducted to understand participant experiences with passive data collection.	- N = 38 mothers enrolled (11 depressed, 27 non-depressed). - Mothers with infants <12 months old. - Aged 15–18 years (28.9 %), 19–22 years (57.9 %), 23–25 years (13.2).	- 782 women approached, 320 eligible, 38 enrolled. - On average, 57.4 % of the hour intervals of data recording had at least 1 audio recording, 50.6 % for activity, 41.1 % for proximity, and 35.4 % for GPS; this may be sufficient enough to inform health services. - Main challenges were phone battery charging, data usage exceeding prepaid limits, burden of carrying a phone, privacy concerns, and lack of family involvement. - For future studies, a culturally tailored machine learning model that can distinguish more detailed social sounds (i. e., child laughing, child crying, yelling) is recommended, as these are important predictors of positive/negative social environments. - In the future, StandStrong should be integrated with a self-report intervention, such as the Health Activity Program (HAP).
Moffett et al., 2022	South Africa	Protocol to evaluate feasibility, acceptability, and initial efficacy of the Kuamsha mobile app for adolescents in rural South Africa.	- Kuamsha is an interactive narrative game with six tailored modules based on Behavioral Activation principles, coproduced with users. - Each module has a corresponding homework assignment that encourages reflection and a mood tracker. - App supplemented by weekly 15-min calls from trained peer mentors to encourage app adherence. - Designed for Android.	- Two-arm, single-blind, individual-level randomized controlled pilot trial. - Mixed methods data to evaluate feasibility and acceptability.	- N = 200 adolescents in grades 9–11, from rural areas with symptoms of mild to moderately severe depression (PHQ Adolescent Version). - Age 15–19 years.	- Feasibility evaluated based on study recruitment, enrollment, and retention; feasibility of testing procedures and data collection; treatment adherence; fidelity - Surveys and in-depth interviews to evaluate acceptability of Kuamsha app and study procedures. - Outcome measures include social-affective and cognitive processing, risky behaviors, resilience, rumination, mental well-being, anxiety, and depression.
Seshu et al., 2021	India	Evaluate, feasibility, acceptability, and usefulness of the IVRS mobile app among women with perinatal depression in rural India.	- IVRS (Interactive Voice Response System) is an audio-based (instead of text, due to user literacy) intervention with seven episodes released every two weeks: (1) nutritional intake, (2) ante-natal care,	- Nine in-depth qualitative interviews and 1 focus group discussion with N = 8 perinatal mothers - Thematic analysis used to identify	- N = 17 women with perinatal depression using the IVRS app and belonging to a larger IVRS evaluation study. - Mean age = 23 years (range =	- 5 major themes emerged: (1) accessibility, (2) usability, (3) community participation, (4) cost, and (5) intervention preference. - Women thought the mobile intervention

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Table 1 (continued)

Author, year	Country	Study Objective	mHealth Description and Features	Methods	Sample	Findings
			(3) well-being through exercises and (4) meditation, (5) family planning, (6) domestic violence, and (7) stress management. - Lay counselor may be contacted through a hotline if needed.	major themes related to feasibility, acceptability, and usefulness.	18–30).	was useful as it made them feel lighter. - They were able to become familiar with terms like anxiety, depression, and burden and began using them in their conversations. - They learned about therapeutic strategies such as breathing, coping, and relaxation, and were able to incorporate them into their daily routines. - Overall, the mHealth intervention helped make mental health issues more visible/ acceptable to users.
Silfee et al., 2021	United States	Evaluate provider views about feasibility and acceptability of the RxWell mobile app for women receiving primary care in rural and urban settings in rural U.S.	- RxWell based on cognitive-behavioral mindfulness approaches. - 4 depression programs and 4 anxiety programs; can be text- or audio-based. - Digital health coach is also available if needed. - Anxiety/depression symptoms are periodically assessed via the app. - Not available offline.	- Serial qualitative interviews conducted over 12 weeks.	- N = 19 providers from a women's health center, an outpatient behavioral health clinic, and both rural and urban primary care settings who had referred adults with anxiety or depression. - Age range = 30–49 years.	- Providers are generally supportive of mHealth. - Enthusiastic about continuing to refer the app even after the study's conclusion. - Suggested that patient engagement may be impacted by lack of comfort with using a smartphone, preference for in-person therapy, or lack of motivation. - Liked that patients could get support between sessions, have an extra treatment option that taught BH exercises, and to have a CBT option that was not impacted by wait times, copays, or travel. - Hesitant to refer to individuals with severe symptoms.
Vigil-Hayes et al., 2021	United States	Evaluate acceptability of the ARORA mobile app among Native American youth in rural U.S.	- ARORA (Amplifying Resilience Over Restricted Internet Access) is a prototype behavioral health app coproduced with Native American youth, a community advisory board, and a clinical psychologist. - Uses mindfulness combined with rural Hopi and Navajo symbology, themes, and activities. - Four intervention activities: (1) mindfulness, (2) emotional and cognitive coping skills, (3) cultivation of resiliency factors, and (4) prosocial skills development. - Designed for Android.	- Qualitative analysis of the co-design and focus group sessions.	- N = 10 youth focus group participants; N = 6 community advisory board members. - Youth age range = 12–18 years. - Advisory board age range = 27–62 years.	- Youth expressed a desire in having more didactic interaction with cultural and behavioral health elements. - Suggested that the intervention should include why it was culturally relevant and why mindfulness contributed to well-being. - Youth enjoyed the physical mindfulness applications (i.e., breathing exercises and mindful walking) more than the cognitive applications (i.e., meditation).



2021; Forman-Hoffman et al., 2023). Most studies included rural users of specific mHealth applications, two studies included providers only (Silfee et al., 2021), and one included both users and providers (Bauer et al., 2017; Forman-Hoffman et al., 2023).

### 3.3. mHealth features, feasibility, and utility for addressing depression and anxiety

Of the 11 mHealth interventions reviewed, one was designed to screen for mental health disorders and/or suicide risk at the population-level (MeMind/SMART-SCREEN) (Arenas-Castañeda et al., 2020). The MeMind smartphone app is automated and requires no active intervention by providers. Deployment and evaluation of MeMind in a Mexican rural community is underway. Measures include user well-being (WHO Well-being Index-5) (Topp et al., 2015), depressive symptoms (Patient Health Questionnaire-9) (Kroenke et al., 2001), anxiety symptoms (Generalized Anxiety Disorder Scale-2) (Plummer et al., 2016), substance use (Alcohol Use Disorders Identification Test, Drug Abuse Screening Test) (Bohn et al., 1995; Yudko et al., 2007), and suicide risk (Columbia-Suicide Severity Rating Scales) (Chappell et al., 2012). Users who screen positive for mental health needs receive resources including healthcare recommendations and referral vouchers for local mental healthcare facilities.

Nine mHealth interventions are designed to provide psychoeducation and support: (SPIRIT) (Bauer et al., 2017), Manage My Pain (Bhatia et al., 2021), Calm (Bhuiyan et al., 2021), WB-LIFE (Forman-Hoffman et al., 2023), TeXT (Knutson et al., 2021), Kuamsha (Moffett et al., 2022), IVRS (Seshu et al., 2021), RxWell (Silfee et al., 2021), and ARORA (Vigil-Hayes et al., 2021). Kuamsha (Moffett et al., 2022) is under development and will employ an interactive narrative game to engage and support adolescents with depressive symptoms living in rural South Africa. One app (StandStrong (Maharjan et al., 2021)) is designed for passive data collection with young mothers experiencing postpartum depression. StandStrong collects data about the mother's location, physical activity, auditory environment, and mother-infant proximity in order to better understand daily activities, social behavior, and mother-child interactions.

All interventions are in the feasibility/acceptability testing stage for rural users. User- and provider-identified strengths of the apps include their simplicity, accessibility, convenience, and availability of support between sessions with providers, as well as specific features including reminders, psychoeducation and normalization of mental health challenges, content to improve coping strategies (e.g., mindfulness, deep breathing, and other relaxation techniques), and remote access to a care team for rural users. Weaknesses include infrequent monitoring of mental health symptoms (i.e., weekly rather than daily), problems with charging phone batteries and exceeding data limits, privacy concerns, and general lack of comfort with app-based support, as opposed to in-person provider support. One of these apps assessed outcomes in a convenience sample of  $N = 14$  transgender or nonbinary U.S. rural adults (TeXT) (Knutson et al., 2021) and found significant reductions in anxiety ( $t(13) = 2.95, p = 0.01, d = 0.40$ ) and depressive symptoms ( $t(13) = 2.76, p < 0.05, \eta^2 = 0.73$ ) from pre- to post-intervention.

Three additional studies assessed user outcomes (Manage My Pain, Calm, WB-LIFE). Bhatia et al. (Bhatia et al., 2021) conducted a prospective evaluation of the Manage My Pain app with  $N = 246$  Canadian adults with moderate- to severe chronic pain in urban ( $n = 154$ ) and rural ( $n = 92$ ) areas. Manage My Pain provides a platform for users to track medications and pain symptoms and to engage in productive conversations with providers. Manage My Pain users ( $n = 111$ ) experienced decreased anxiety symptoms at the 4.5 month follow-up (reduction of 2.10 points, 95 % CI -3.96 to -0.24), although there were no significant differences between app users vs. non-users ( $n = 135$ ) on anxiety or depressive symptoms. Subgroup analyses revealed no differences in outcomes by urban vs. rural location. Bhuiyan et al. (Bhuiyan et al., 2021) conducted a secondary analysis of  $N = 7044$  Calm app users

in U.S. urban ( $n = 6038$ ) and rural ( $n = 1006$ ) locations and found significant decreases in depressive symptoms (decrease of 0.44 points,  $p = 0.049$ ) and anxiety symptoms (decrease of 0.21 points,  $p = 0.03$ ), although the magnitude of effect was modest. There were no significant main effects from urban versus rural status on either outcome. Forman et al. (Forman-Hoffman et al., 2023) aimed to explore differences in usage, therapeutic alliance, satisfaction, and mental health outcomes between metropolitan, non-metropolitan, and rural users of the WB-LIFE app but lacked sufficient power for the proposed analyses.

### 3.4. Rural user perceptions and preferences for mHealth

Characteristics of the five studies exploring rural user perceptions about and preferences for mHealth interventions are presented in Table 2 (Connolly et al., 2018; Bhat et al., 2020; Escobar-Viera et al., 2022; Antle et al., 2021; Ben-Zeev et al., 2017). Antle et al. (Antle et al., 2021) used focus groups with rural primary care providers to explore barriers and facilitators of using an mHealth for treatment of depression in primary care settings. Barriers included technical challenges, staff resistance and frustration, and patient factors such as perceived stigma and distrust. However, mHealth was viewed as a viable option when adequate program and clinician supports were in place, when patients were incentivized to use mHealth, and when patients possessed a high readiness for change. Ben-Zeev et al. (Ben-Zeev et al., 2017) surveyed  $N = 272$  Palestinians living in refugee camps ( $n = 156$ ), urban ( $n = 82$ ), and rural ( $n = 34$ ) settings to explore the viability of mHealth for mental health treatment and found that the large majority of participants across all settings owned mobile phones (91.2 % in rural) and that social media (i.e., Facebook, WhatsApp, Twitter) use was nearly universal (99.6 %). Bhat et al. (Bhat et al., 2020) employed focus groups to explore attitudes toward mHealth-delivered mental health treatment among  $N = 69$  rural Indian women with Major Depression. Participants expressed concerns with mHealth including limited access to mobile phones, inability to read text messages and other content, and preference for in-person treatment. Connolly et al. (Connolly et al., 2018) employed semi-structured interviews to explore perceptions of mHealth among  $N = 66$  urban ( $n = 38$ ) and rural ( $n = 28$ ) U.S. veterans with PTSD and found strong opinions on both sides of the issue. In general, rural veterans tended to view mHealth as incongruous with their values, view smartphones as difficult to use, and perceive financial and connectivity barriers to adoption. Participants described the app "PTSD Coach" (Kuhn et al., 2018) as particularly helpful. Escobar-Viera et al. (Escobar-Viera et al., 2022) conducted online qualitative interviews with  $N = 20$  rural U.S. youth who identified as LGBTQ and socially isolated. The researchers assessed attitudes toward mHealth-delivered support and found that youth perceived both advantages (e.g., ease of access promotes usage, potential for proactive positive outreach and/or peer support, tailoring of resources) and disadvantages (e.g., lack of privacy, fear of being outed for being noticed using the app, redundancy with other social media apps) to this technology.

## 4. Discussion

The first aim of this scoping review was to identify and examine the available literature on mHealth interventions that consider the needs of rural populations, in order to gauge their feasibility and utility for addressing depression and anxiety. The second aim was to provide an overview of rural users' perceptions about and preferences for mHealth-delivered mental health screening and intervention systems. Taken together, the results provide information that may help to overcome inequities in access to mental health support, as well as mental health outcomes, in underserved rural communities (Thornicroft et al., 2017; World Health Organization, 2021).

Although the need for mental health support in underserved rural communities is clear (World Health Organization, 2022; Thornicroft et al., 2017; World Health Organization, 2021; Ferris-Day et al., 2021),

**Table 2**  
Studies assessing user perceptions and preferences.

Author, year	Country	Study Objective	Methods	Sample	Findings
Antle et al., 2021	United States	Explore barriers and facilitators of using an mHealth intervention for depression in rural primary care settings.	Semi-structured focus group interviews with providers at the conclusion of a 5-year RCT testing feasibility and effectiveness of computerized cognitive behavioral therapy (CCBT) for depression.	N = 18 physicians, nurses, and other medical staff from rural primary care clinics.	<ul style="list-style-type: none"> <li>- The barriers most often mentioned were: 1) technical barriers, 2) stigma, 3) distrust of outsiders, 4) motivational barriers, and 5) staff resistance/frustration.</li> <li>- CCBT was viewed as a viable option when there is 1) high readiness to change due to symptom severity, 2) program supports and incentives, such as laptops or gift cards, 3) clinician support, 4) the use of small goals and visual aids within the intervention itself, and 5) compatible patient characteristics, such as high education levels or socioeconomic status.</li> </ul>
Ben-Zeev et al., 2017	Palestine	Examine whether mHealth may be a viable alternative to traditional clinic-based care in urban, rural, and refugee camp settings.	Cross sectional survey with questions for demographic characteristics, access and use of mobile phones and social media, available infrastructure (e.g., electricity, Wi-Fi), perceptions about mental health needs in the community, and willingness to engage in various mHealth for mental health programs.	N = 272 adults with a mean age of 31.6 (SD = 12.6) in urban (n = 82), rural (n = 34), and refugee camp (n = 156) settings.	<ul style="list-style-type: none"> <li>- 93.4 % reported owning a mobile phone, 79.9 % owning a smartphone.</li> <li>- Most had reliable access to electricity (99.6 %) and Wi-Fi (80.9 %).</li> <li>- 61.4 % believed that between 51 % and 100 % of the population had a mental health condition such as depression, PTSD, or psychosis.</li> <li>- 88.2 % thought that mHealth would be a helpful support system for those with such mental health conditions.</li> <li>- 66.5 % were interested in smartphone applications in particular.</li> </ul>
Bhat et al., 2020	India	Examine barriers to accessing mental health treatment, reasons for non-adherence, and attitudes toward mHealth solutions among women in rural India.	Semi-structured focus group interviews.	Six groups of women aged 18–85 years with Major Depressive Disorder (N = 69) who had been treated at a rural community health center.	<ul style="list-style-type: none"> <li>- Women thought that their limited autonomy, financial/systematic barriers, and lack of immediate treatment response contributed to poor treatment access and non-adherence.</li> <li>- Illiteracy, limited access to phones, and preference for in-person treatment were identified as barriers to mHealth; women were still open to mHealth despite said barriers.</li> <li>- Potential solutions may be to tailor interventions so that they empower women, include family members in the intervention, incorporate cultural/local practices, and stray away from text-heavy methods, such as SMS messaging.</li> </ul>
Connolly et al., 2018	United States	Examine veterans' attitudes toward mHealth smartphone apps and to assess whether openness toward this technology varies by age or rurality.	Semi-structured individual interviews.	N = 66 veterans aged 18–70 with PTSD, Alcohol Use Disorder, or Major Depressive Disorder.	<ul style="list-style-type: none"> <li>- Rural veterans tended to oppose mHealth apps, describe smartphones as hard to navigate, and cite barriers such as connectivity issues or financial limitations more than urban veterans; some described smartphones as opposed to their values.</li> <li>- Some veterans liked how apps could allow them to track symptoms, serve as a distraction in the moment, or quickly connect them to resources.</li> <li>- Older veterans were more open to technology-based interventions than was expected; however, they may have trouble navigating such apps and may require simplified versions or training.</li> <li>- "PTSD Coach" was often cited by participants, more so than any other individual app.</li> </ul>
Escobar-Viera et al., 2022	United States	Examine supportive social media experiences; strategies to improve social media experiences, and; perspectives on modes of digital	Semi-structured individual interviews.	N = 20 LGBTQ youth aged 14–19 living in rural areas who screened positive for social isolation.	<ul style="list-style-type: none"> <li>- Youth valued content from people with shared experiences and platform features that allow them to connect with more people.</li> </ul>

(continued on next page)



Table 2 (continued)

Author, year	Country	Study Objective	Methods	Sample	Findings
		intervention delivery for rural LGBTQ youth.			-Youth suggested combining delivery modalities (e.g., mobile apps, social media pages, chatbots, dedicated website).

as well as the promise of mHealth to meet this need because of attributes including potential cost-effectiveness and ability to be customized according to local needs, resources, language, and culture (Friesen, 2019; Hrynyschyn and Dockweiler, 2021; Kruse et al., 2022; Turan and Çetintaş, 2021; Gonzalez et al., 2021; Li et al., 2020; Watson-Singleton et al., 2021; Gentili et al., 2022; Iribarren et al., 2017), there are at present few mHealth interventions specifically designed for rural communities.

Five of the studies included in this review are based on mHealth interventions developed in non-rural contexts and then deployed and evaluated with rural samples (Bhatia et al., 2021; Bhuiyan et al., 2021; Silfee et al., 2021; Forman-Hoffman et al., 2023; Arenas-Castaneda et al., 2020). However, even though these programs were not designed specifically for rural communities, some do confer benefits to rural users, including alleviating depressive and anxiety symptoms (Bhatia et al., 2021; Bhuiyan et al., 2021). These studies, combined with growing access to smartphone technology in rural communities (Connolly et al., 2018; Pew Research Center, 2021), as well as generally increasing comfort among the public with remotely-delivered health interventions since the COVID-19 pandemic (Mansouri and Darvishpour, 2023), suggest that mHealth developed in non-rural contexts holds promise for all users. Increasing access and use of mHealth technologies in resource-limited rural communities facing barriers to mental health care may be achieved through culturally-informed adaptation, rather than development from scratch.

However, it is notable that three of the studies included in this review are based on interventions that were co-produced with rural users and/or providers (Bauer et al., 2017; Vigil-Hayes et al., 2021; Moffett et al., 2022). Coproduction involves an iterative process of evidence review, systematic community input, intentional stakeholder and research team discussions, and intervention testing and refinement (Hawkins et al., 2017). Coproduction is a valuable approach, particularly with marginalized populations who may lack agency (Dunston et al., 2009; Slay and Stephens, 2013) and it is recommended to enhance user engagement and reduce dropout (Park and Ethan., 2020; Soto and Strain, 2018). In a rural context, this may involve a thoughtful and culturally-attuned process of partnering with community-based providers and patients to systematically identify needs and preferences for intervention content and delivery, rather than making assumptions, and then creating structured feedback loops to confirm or revise understanding.

The studies included in this review provide illustrative examples of how coproduction methods may be used to develop mHealth interventions that are feasible and acceptable in rural communities. Based upon insights gained through a coproduction development process, Bauer et al.'s (Bauer et al., 2017) SPIRIT app includes a simplified installation and SMS-driven self-registration process, intentional complementarity to existing patient management systems within resource-limited rural settings (i.e., as opposed to stand-alone apps), and mechanisms for ongoing in-app feedback. Similarly, Moffett et al. (Moffett et al., 2022) gamified their Kuamsha app to be appealing to adolescent users with depression and included features such as character personification and the ability to earn in-app points. Vigil-Hayes et al. (Vigil-Hayes et al., 2021) went to great lengths to use coproduction methods to ensure that their ARORA app honored the rural Hopi and Navajo cultures for which it was designed.

In addition to these elements, based upon the studies included in this review, it is recommended that mHealth interventions for rural

populations be developed for multiple platforms (i.e., Android and iOS), be easy to use and take into account individual variation in access/comfort with smartphones, as well as potential data and/or connectivity limitations. Developers may wish to consider including a human component which may better resonate with the values of certain rural users (Connolly et al., 2018), as well as strategies for addressing mental health stigma and confidentiality concerns in rural communities (e.g., multiple layers of assurance that privacy will be protected, designing apps so that they are not obviously focused on mental health) (Ferris-Day et al., 2021; McCarthy et al., 2023a). Further, passive data for monitoring and potentially improving user health and well-being should be leveraged. These may include heart-rate data (e.g., to monitor physical stress response), bed-based sleep data (e.g., to monitor amount and quality of sleep), and geolocation data to better understand the role of neighborhood factors in mHealth use and utility, as well as distance to healthcare access points. Lastly, transdiagnostic approaches that focus on individuals' experiences with mental health challenges, as opposed to specific diagnoses, may also be particularly useful in terms of scalability and cost-effectiveness in underserved communities (Dagleish et al., 2020; Schäfer et al., 2023).

It is further recommended that mHealth interventions for geographically isolated and economically challenged rural communities be developed with connectivity and sustainability in mind. Strategies to achieve this include engaging with policy-makers to advocate for internet connectivity, as well as access to smart devices being viewed as an essential basic need (i.e., similar to electricity, heat, and running water), partnering with local government and community organizations to install Wi-Fi hotspots in community settings, and providing rural individuals with vouchers for Wi-Fi service and/or free or low-cost smart devices. A parallel and potentially more immediate strategy may be to continue to develop low bandwidth interventions such as those that rely upon Short Messaging Services (Knutson et al., 2021) or Interactive Voice Response Systems (Seshu et al., 2021).

The diversity of rural populations represented in this scoping review is encouraging (i.e., countries, age groups, subpopulations). In particular, the receptivity to mHealth among LGBTQ+ individuals suggests that mHealth could be an important tool to advance health equity for this population, as LGBTQ+ individuals are at greater risk of social isolation, depression, anxiety, and suicide compared to heterosexual peers (King et al., 2008). However, it is recommended that more research and development of mHealth strategies to support rural subpopulations be conducted. For example, although two of the five interventions developed and evaluated in the U.S. are reported to be available in Spanish (Bauer et al., 2017; Bhuiyan et al., 2021), more could be done considering research showing that rural Hispanics may experience greater mental health challenges due to immigration-related trauma, weakened family support systems, acculturation stress, discrimination, and cultural barriers to care (Moyce et al., 2022). This represents a much-needed and potentially fruitful area for future research and development. Recent examples of cultural adaption efforts in the field of mHealth for psychological distress include the work of Quiñonez-Freire et al. (Quiñonez-Freire et al., 2020), Shala et al. (Shala et al., 2020), and Salamanca-Sanabria et al. (Salamanca-Sanabria et al., 2019) Other rural subpopulations in need of mental health support include older adults and families coping with chronic health conditions such as dementia (McCarthy et al., 2023b; Williamson et al., 2020; Williamson et al., 2022).

This review also found a lack of studies formally evaluating rural providers' perspectives on mHealth feasibility and utility which is critical for understanding the healthcare systems within which interventions will be deployed so that they can be built to be secure, scalable, and sustainable (Bauer et al., 2017; Forman-Hoffman et al., 2023).

#### 4.1. Limitations and conclusion

At least two limitations of this scoping review must be mentioned. First, our focus on mHealth interventions designed specifically to address depression and anxiety may have resulted in some mHealth interventions being overlooked (e.g., those designed to provide health-related information and support to rural communities in general or to individuals with specific health conditions). Future scoping reviews may benefit from a broader, transdiagnostic approach to mental health (Dalglish et al., 2020). This approach may also address the notable absence in this review of studies conducted in European countries. Second, by including only peer-reviewed studies, it is possible that this review may not have captured mHealth interventions currently in development. This field evolves at a rapid pace and future, updated scoping reviews on this topic will be valuable.

Findings from this scoping review provide insights into existing mHealth interventions for depression and anxiety that consider the needs of rural populations. This information contributes to a foundation upon which to build innovative mHealth interventions for underserved rural communities in the future. The mental health needs of these communities are well-documented. Additional resources, research, and development may help us to realize the potential of mHealth to address these needs and work toward reducing the rates and severity of depression and anxiety in rural populations.

#### Funding

This work was supported by the Northern Arizona Regional Behavioral Health Authority (NARBHA) Institute, Northern Arizona University's Interns-to-Scholars Program, Northern Arizona University's Wurgler Chair of Criminal Justice and Behavioral Health Endowment, and the National Institute on Minority Health and Health Disparities under Award Number U54 MD012388.

#### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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