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Review article

Common themes and emerging trends for the use of technology to support mental health and psychosocial well-being in limited resource settings: A review of the literature

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ABSTRACT

There are significant disparities in access to mental health care. With the burgeoning of technologies for health, digital tools have been leveraged within mental health and psychosocial support programming (eMental health). A review of the literature was conducted to understand and identify how eMental health has been used in resource-limited settings in general. PubMed, Ovid Medline and Web of Science were searched. Six-hundred and thirty full-text articles were identified and assessed for eligibility; of those, 67 articles met the inclusion criteria and were analyzed. The most common mental health use cases were for depression (n = 25) and general mental health and well-being (n = 21). Roughly one-third used a website or Internet-enabled intervention (n = 23) and nearly one-third used an SMS intervention (n = 22). Technology was applied to enhance service delivery (n = 32), behavior change communication (n = 26) and data collection (n = 8), and specifically dealt with adherence (n = 7), ecological momentary assessments (n = 7), well-being promotion (n = 5), education (n = 8), telemedicine (n = 28), machine learning (n = 5) and games (n = 2). Emerging trends identified wearables, predictive analytics, robots and virtual reality as promising areas. eMental health interventions that leverage low-tech tools can introduce, strengthen and expand mental health and psychosocial support services and can be a starting point for future, advanced tools.

List of Acronyms and Abbreviations

ADHD	Attention deficit and hyperactivity disorder
EEG	Electroencephalogram
M&E	Monitoring and evaluation
MMS	Multi-media messaging service
mTERG	mHealth Technical Evidence Review Group
PTSD	Post-traumatic stress disorder
SMS	Short messaging service
Tele-ECHO	tele-Extension for Community Healthcare Outcomes
TMH	Telemental health
USA	United States of America
VoIP	Voice-over-Internet Protocol
WHO	World Health Organization

1. Introduction

Mental health has increasingly become a global priority. According to the World Health Organization (WHO), mental and substance use disorders are the leading global cause of disability. Furthermore, 20% of children and adolescents suffer from neuropsychiatric disorders (WHO, n.d.). Unfortunately, the distribution of health and human resources for mental health are limited and unequal. Only 1% of the world's health workforce works in mental health, and nearly half of the world's population live in countries with fewer than 1 psychiatrist per 100,000 people (WHO, 2015). It is estimated that 75% of those affected by mental health issues reside in low-income countries (WHO, 2015). Low resource settings in higher-income countries face similar challenges as it relates to human resources for mental health and infrastructure (Andrilla et al., 2018; RHI, 2018).

Over the past several years, advances in digital technology have led to increased ownership and use, as well as a proliferation of

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implementations within the health sector (Lal and Adair, 2014). They have presented opportunities to enhance programming and accelerate the achievement of health outcomes. eMental health, which is defined as "mental health services and information delivered or enhanced through the Internet and related technologies" (Lal and Adair, 2014), has continued to garner attention. eMental health sits within the broader context of digital health, or "the convergence of digital technologies with health, health care, living and society" (Sonnier, 2016). Given the increased attention on eMental health, this review was conducted to understand and identify how digital technology has been and can be used specifically for mental health and psychosocial well-being in resource-limited settings.

2. Methods

The systematic review was conducted from February to March 2019. Search terms were identified *a priori* and refined prior to initiation of the formal review (*see supplementary material*). For the purposes of this review, psychosocial well-being, which overlaps with mental health, has been incorporated into the definition of eMental health, thus including social problems, emotional distress and mental disorders in the search (UNHCR, n.d.). The following peer-reviewed databases were searched: PubMed, Ovid Medline and Web of Science. Resource-limited setting rather than focusing on low-income countries alone was intentionally used for the criteria for two reasons: (1) it was anticipated that there would be fewer publications from low-income countries and (2) it would provide relevant information from potentially related yet diverse contexts for greater learning. Eligibility criteria were developed and applied to the search results. Title and abstract reviews were conducted first, then full text reviews. Articles that met the inclusion criteria then had their data abstracted for analysis. Reporting of the findings has adhered to the Preferred Reporting Items for Systematic and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009).

2.1. Inclusion criteria

The eligibility criteria were as follows:

- Original research articles
- Dealt with mental health, mental illness, substance abuse and [mental] well-being
- Discussed the use of digital technology in mental health and psychosocial support
- Reported on outcomes (with feasibility, acceptability, safety, usability, efficacy and effectiveness all eligible)
- Based in a resource-limited setting
- Published from 2005 to present to reflect findings from within the past 15 years
- Full-text available in English or French

Resource-limited setting was defined using the current World Bank's low- and middle-income country classifications and/or the articles clearly describing the population as living in "rural", "low-income" or "marginalized" settings, even in a high-income country.

2.2. Exclusion criteria

The following types of articles were excluded:

- Articles that were not original research or investigation: Protocols, single case studies, review articles, letters to the editor, commentaries
- Did not deal with digital technology or mental health
- Did not report on outcomes or solely described design or development process with no testing or pilot outcomes data
- Based in resource replete settings

While review articles were not included for analysis, their references were assessed for eligible studies.

2.3. Data extraction and analysis

One author (NNK) conducted the search and abstraction. First, titles and abstracts were screened. Then, relevant abstracts were reviewed to identify studies for full text review. Full texts were reviewed and articles that met the inclusion criteria then had their data abstracted for analysis. If there was uncertainty about the eligibility of a study, both authors (NNK and JM) would be involved in the review of that study. The following characteristics were extracted from the documents that met the eligibility criteria: aim, study design, study duration, population, mental health condition(s) addressed, sample size, intervention, technology type and features, technical application, users, deployment location and outcomes. The level of evidence per the National Health and Medical Research Council were assigned for each study (Shekelle, 2013). The technical application designations borrow from the WHO mHealth Technical Evidence Review Group (mTERG) framework (WHO, 2016).

3. Results

Over 60,000 records were identified in the peer-reviewed literature. Six-hundred and thirty full-text articles peer-reviewed articles were assessed for eligibility, of those 67 were included for full-text review and qualitative analyses (*see Fig. 1*). The levels of evidence ranged from II to IV, with most studies (n = 48, 71.6%) at level of evidence IV (of lower level evidence).

3.1. Mental health focus area

The mental health use cases covered in the 67 peer-reviewed articles were depression (n = 25, 37.3%), of which 7 focused specifically on postpartum depression (10.4%); general mental health (n = 21, 31.3%), of which 4 focused specifically on youth mental health and well-being (6%); substance use (n = 9, 13.4%); post-traumatic stress disorder (PTSD) (n = 7, 10.4%); anxiety (n = 4, 6%); attention deficit and hyperactivity disorder (ADHD) (n = 2, 3%); autism (n = 2, 3%); psychosis (n = 2, 3%); adjustment disorder (n = 1, 1.5%); bipolar disorder (n = 1, 1.5%); personality disorder (n = 1, 1.5%) and somatoform disorder (n = 1, 1.5%). There were several studies (n = 6, 9%) that focused on more than one mental health use case in their investigation.

3.2. Study characteristics

Almost 33% of studies evaluated the feasibility and acceptability of the technology intervention (n = 22). Nearly 30% of studies used a randomized controlled trial study design (n = 20). The focus on resource-limited settings intentionally allowed for the inclusion of diverse settings. The countries represented included the United States of America (USA) (n = 24, 35.8%), India (n = 9, 13.4%), China (n = 5, 7.5%), Canada (n = 4, 6%), Iran (n = 4, 6%), South Africa (n = 4, 6%), Peru (n = 3, 4.5%) and Australia (n = 2, 3%). There was one study from each of the following countries: Afghanistan, Brazil, Bulgaria, the Canary Islands, Georgia, Germany, Mexico, Nigeria, Spain, Thailand and the United Kingdom. The implementation settings were in the community alone (n = 32, 47.8%), health facility only (n = 11, 16.4%), school (n = 2, 3%), or both the community and health facility (n = 2, 3%) or a blend of all 3 locations (n = 2, 3%).

The smallest sample size was 3 participants (Barrera et al., 2017). The largest sample size had over 17,000 participants (Lara et al., 2014). Roughly 33% of studies used a short messaging service (SMS) intervention (n = 22), and 34% of studies used a website or Internet-enabled intervention (n = 23). Most of the Internet-enabled interventions were

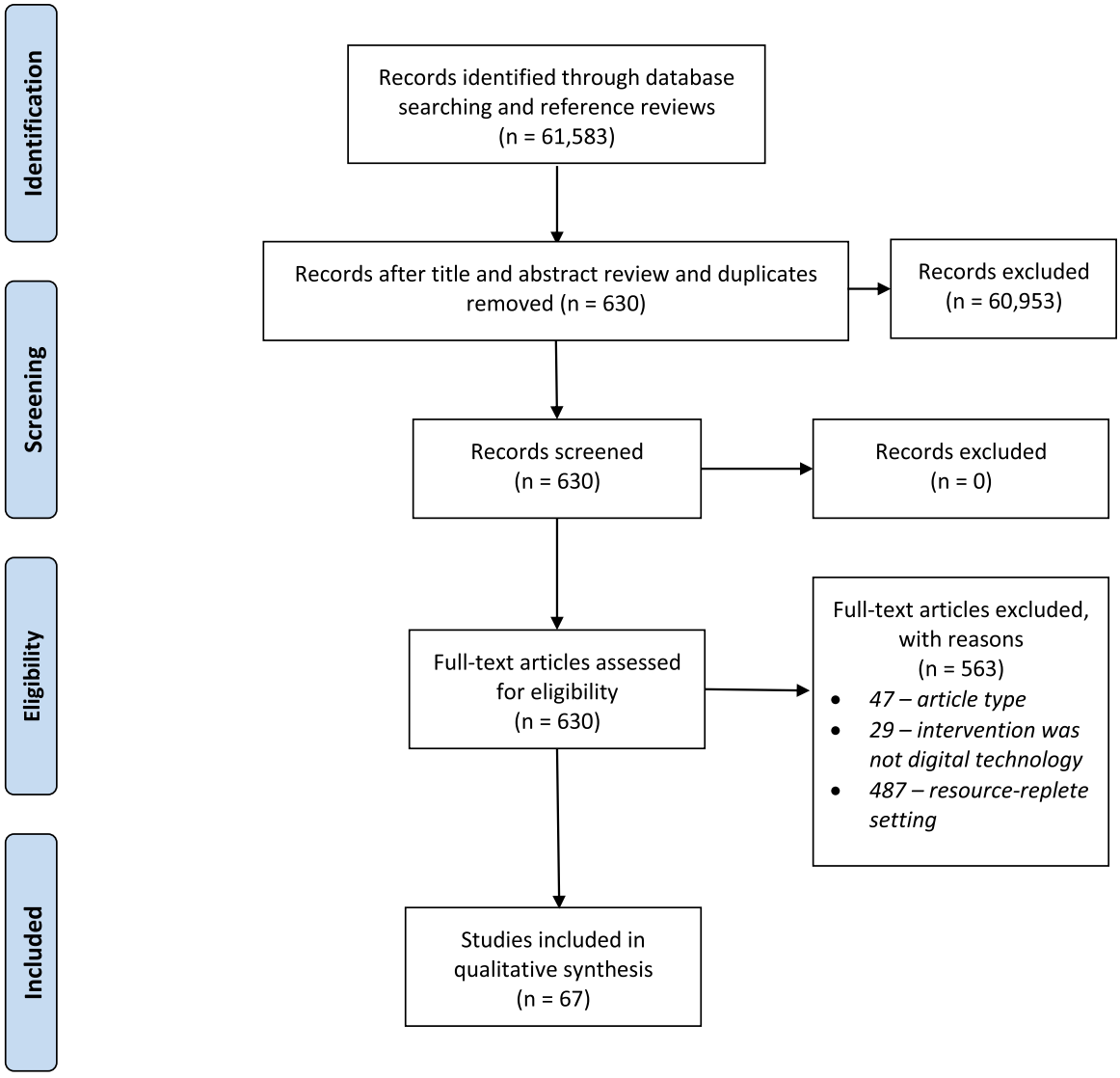

Fig. 1. PRISMA flow diagram.

for videoconferencing (n = 17, 74%). There were 7 smartphone apps described and evaluated by the studies (10.4%). Eleven articles included a telephone component to the intervention package (16.4%), of which four studies were standalone telephone-based interventions. Two studies delivered pre-recorded audio as an intervention.

There were several ways that digital technology was applied. The

Table 1
Data abstraction variables and definitions.

Variable	Description
Name	Name of the technology
Program or Article Name	Program name if different than the technology
First Author	Name of first author
Publication	Source publication
Year	Year of publication
Description	High-level description of the technology and its application
Mental Health Use Case	Mental health area that program seeks to address
Monitoring and Evaluation (M&E) / Outcomes	M&E and/or outcomes data; if none, write "none"
Deployment Location	Listing of clinics or types of geographies currently or recently using the technology
Country(-ies)	Current and previous geographic locations where technology is deployed
Technology	Type of technology (i.e., hardware, software)
Technical Application	Select from behavior change communication, data collection, point-of-care decision support, diagnostics, logistics or service delivery
Features	Prominent features of the technology
Users	Select from patients, caregivers, or health workers
Levels of Evidence	The National Health and Medical Research Council designations on levels of evidence (range from I to IV).
Additional Notes	Any additional information or notes

most common application was for service delivery (n = 32, 47.8%), followed by behavior change communication (n = 26, 38.8%). The next most common use was for data collection (n = 8, 11.9%). Technology was also used for training purposes (n = 4, 6%) and as a diagnostic tool (n = 3, 4.5%) coupled with neuroimaging techniques.

There was significant overlap between the intended end-users: 31 interventions had both patients and health workers as end-users (46.3%). A total of 57 studies included patients as end-users (85%), 41 had health workers as end-users (61.2%), 2 had caregivers (3%) and 1 included teachers (1.5%). Nine of the studies (13.4%) focused on adolescent mental health, and all but two assessed a telemedicine intervention.

3.3. Digital technology application

The most common ways that digital technology was applied within eMental health initiatives included adherence, ecological momentary assessments, promotion of well-being, telemedicine, machine learning and games. A few studies (n = 5) also covered lessons and key considerations based on learnings from eMental health implementations.

3.3.1. Adherence

Both phone calls and SMS were used to promote adherence to treatment (Aguilera, 2011; Diez-Canseco et al., 2018; Mall et al., 2013; Sibeko et al., 2017; Singh et al., 2017; Thomas et al., 2017; Toyama et al., 2017). In Nigeria, SMS-based appointment reminders directly to clients led to individuals with a first-time diagnosis of psychosis being twice as likely to attend appointments (Thomas et al., 2017). Positive results were also identified for an SMS reminder intervention, also directly to clients, in India. The two-arm RCT found that 63% of individuals in the intervention group attended their first appointment on time versus 45% in the control group (Singh et al., 2017). In Cape Town, a combination of direct-to-client SMS reminders and a treatment partner were packaged as part of an intervention (Mall et al., 2013; Sibeko et al., 2017). There was significant attrition at 3-months and 41% of participants did not receive an SMS. Furthermore, nurses, who were responsible for registering clients to receive the SMS reminders, found that the handsets used to manage the SMS system were burdensome despite re-training and three handsets were lost to theft (Sibeko et al., 2017).

In one case, direct-to-client SMS messages were piloted as an adjunct to in-person cognitive behavioral therapy for depression. Overall, 65% of the 12 participants responded to the messages, and most had a positive experience (Aguilera, 2011). Direct-to-client SMS reminders were also integrated into the Allillanchu Project in Peru. Of the 762 participants, 21.7% screened positive for a mental health disorder, and of those, 72.4% sought care (Diez-Canseco et al., 2018; Toyama et al., 2017).

3.3.2. Ecological momentary assessment

SMS and multi-media messaging service (MMS) provided means to obtain daily, 'real-time' information on individual's symptoms and behaviors (n = 5). Two studies in China evaluated the use of direct-to-client SMS and daily surveys on substance use (Han et al., 2018; Liang et al., 2018). In one study, individuals receiving the intervention were less likely to have a positive urine test (26.2% intervention vs 50% controls) (Liang et al., 2018). In another study, there was poor agreement between the daily assessment and urine test, but concordance increased as the study progressed (Han et al., 2018). A study among refugees in Durban, South Africa, found that depression screening via SMS exchange with clients was viable and as reliable as in-person screening (Tomita et al., 2016). Researchers in the USA found that daily mood, as measured by client responses to automated SMS, could predict attendance in group cognitive behavioral therapy (Bruehlman-Senecal et al., 2017). An alcohol therapeutic initiative used interactive voice response for post-treatment self-monitoring, skills practice and feedback in a rural state in the USA (Rose et al., 2010). Abstinence and coping were significantly increased during the time of the intervention. Health workers were also used to log 'real-time' information and screen for concerning mental health problems via phone or SMS (Tsai et al., 2014; Tewari et al., 2017).

3.3.3. Promote well-being

Phone and SMS communications were leveraged in attempts to promote positive moods (Agyapong et al., 2016; Broom et al., 2015; Chandra et al., 2014; Taleban et al., 2016; Tewari et al., 2017). For example, a feasibility and acceptability assessment of a helpline and SMS intervention for young women living in urban slums in Bangalore found that 62% of women receiving the intervention felt supported and felt good about the messages (Chandra et al., 2014). Also, in India, an interactive voice response system made calls to individuals who had been screened as positive for mental health issues by community-based workers. Individuals felt the messages encouraged them to seek care (Tewari et al., 2017).

Text4Mood, an SMS initiative in a rural Canadian province, delivered daily supportive messages to subscribers (Agyapong et al., 2016). The service was developed to complement counselling services. Most (81.7%) of the 894 survey respondents felt that the messages made them more hopeful about managing issues in life, 76.6% felt in charge of managing their depression and 75.2% felt connected to a support system (Agyapong et al., 2016). An initiative in the USA also used daily supportive SMS as an adjunct to standard care for postpartum depression (Broom et al., 2015). Low-income, minority women received four weekly messages for six months. Most of the women (89%) felt that they were easy to read and relevant, and 75% shared the messages with others (Broom et al., 2015).

An initiative in Iran examined the use of bibliotherapy and SMS. Bibliotherapy is the use of books, writing, stories or other written text as therapy. The researchers found that daily encouraging SMS and bibliotherapy had an initial significant impact on depressive symptoms, but it was not sustained at 3 months after the intervention period ended (Taleban et al., 2016). However, the group that used bibliotherapy only had a sustained decrease in depressive symptoms (Taleban et al., 2016).

3.3.4. Education

There were two ways technology was used for education: 1) to provide evidence-based information to patients and/or their caregivers and 2) for training and coaching purposes to strengthen provider mental health service delivery. There were two studies that examined education as part of the treatment package for patients (Baker-Ericzen et al., 2012; Sibeko et al., 2017), and one study that used a Web-based intervention featuring pictures and stories from affected individuals in conjunction with resources and facts for patient education (Logsdon et al., 2013). There were six studies that focused on eLearning for health workers (Alicata et al., 2016; Barkaia et al., 2017; Dingwall et al., 2015; Hegde et al., 2018; Pereira et al., 2015; Sagi et al., 2018; Tirmizi et al., 2017).

Patients and their treatment partners, in Cape Town, attended at least one education session on their mental health issue prior to discharge. It was unclear if the education happened remotely or in-person (Sibeko et al., 2017). In the USA, trained mental health advisors called low-income women with postpartum depression; prior to client contact, the advisors completed a remote course on the provision of education and emotional support (Baker-Ericzen et al., 2012). The effectiveness of the intervention was not assessed.

A distance coaching program was set-up for providers in Georgia with providers in the USA. Using Voice-over-Internet Protocol (VoIP, i.e., Skype), Georgian mental health providers received 'real-time' coaching during active sessions with their clients, who were children with autism. Coaches watched the therapy session. The Georgian providers wore an audio piece that allowed them to listen to their coaches and immediately act on the feedback. Qualitative review indicated that

children demonstrated improvements (Barkaia et al., 2017). In Australia, an indigenous eMental health training course was established. Aboriginal co-trainers were involved in the design and implementation of the training. Learners used an iPad app to engage with content. Of the 138 participants who underwent the training, 130 completed the pre- and post-training questionnaires; they showed significant improvements across all skills and knowledge except in confidence in using computers (Dingwall et al., 2015).

The University of Hawai'i established a child and adolescent psychiatry telemental health (TMH) unit that provides care to rural communities. TMH developed a remote training curriculum for mental health providers and medical students on telemental health in collaboration with the Mayo Clinic. The curriculum integrates minimum requirements from the Accreditation Council for Graduate Medical Education's clinical competencies for psychiatry, as well as understanding mental health disparities in rural communities (Alicata et al., 2016). An evaluation of the platform identified the importance of involving teachers as part of the care team for youth with mental health issues. The authors also conclude that the model demonstrates the success of virtual and in-person resources to provide quality mental health care. The effectiveness of the intervention was not assessed.

In India, a telementoring 'hub and spoke' model for drug addiction management involved the National Institute of Mental Health and Neurosciences' academic center as the hub and tele-Extension for Community Healthcare Outcomes (tele-ECHO) clinics as the spokes. The tele-ECHO units made it possible for clinicians to receive and engage with eLearning content. Clinicians were able to connect to the training content using their smartphone, tablet or computer. The model used videoconferencing, interactive materials and quizzes accessed through an app as well as what's app as a chat forum. Roughly half of the clinicians attended more than 6 out of the 11 sessions and the majority (89.5%) completed all three learning assignments. While 32.3% of the clinicians had increased confidence in managing drug addiction after the mentoring course, more than half (54.8%) had no change in their confidence levels (Sagi et al., 2018).

Also in India, a toll-free helpline offered specialist medical advice to community-based health workers in Maharashtra (Hegde et al., 2018). Out of the more than 450,000 calls received during the study period, 6285 (0.94%) were for mental health.

In Afghanistan, providers could participate in an eLearning course to aid with the management of depression, psychosis, PTSD and drug abuse. Providers could access the content using the mobile phone version of *moodle* and Skype. When compared to providers participating in-person workshops and courses, there were significant improvements in the overall knowledge in the eLearning course as compared to the controls – the average gain in score was 16 points for the intervention group versus 7 points in the control group (Tirmizi et al., 2017).

Health providers in Brazil could subscribe to a website that provided 9 sessions on alcohol abuse management in the primary care setting. Providers could access the course content synchronously or asynchronously and had a variety of media presented to them (e.g., video, chat forums and audio). Of the 100 free subscriptions provided, 67 individuals initiated the course and 33 completed it. Course satisfaction was inversely related to the frequency of Internet access (Pereira et al., 2015).

3.3.5. Telemedicine

Mental health services were successfully provided using videoconferencing, phone calls or SMS (n = 28; Azevedo et al., 2016; Baker-Ericzen et al., 2012; Barrera et al., 2017; Blitchtein-Winicki et al., 2017; Chavira et al., 2017; Choi et al., 2014; Chong and Moreno, 2012; Cluxton-Keller et al., 2018; Darvish et al., 2018; de las Cuevas et al., 2006; Fortney et al., 2015; Garcia et al., 2018; Hepburn et al., 2016; Irvine et al., 2012; Jacob et al., 2012; Knaevelsrud et al., 2015; Lara et al., 2014; Lipman et al., 2011; Myers et al., 2015; Painter et al., 2017; Parmanto et al., 2013; Pradhan et al., 2019; Pyne et al., 2010; Roberts et al., 2017; Thara et al., 2008; Thitipitchayanant et al., 2018; van den Berg et al., 2015; Wood et al., 2012).

In rural West Virginia, a telemedicine model integrated mental health services into a school-based health clinic to leverage existing resources and reach clients (Pradhan et al., 2019). Another intervention (videoconferencing) that focused on child and adolescent health had a high no show rate (58%) despite prior contact and confirmation with patients and their families (Jacob et al., 2012). A multi-family telemedicine treatment model for youth with autism in rural areas found that the model was acceptable, but some families struggled with using the technology (Hepburn et al., 2016). While attendance was 94% for all 10 sessions, 41% of families were disconnected at least one time. Another family-based telemedicine health intervention dealt with postpartum depression (Cluxton-Keller et al., 2018). All families completed the pilot and found the technology to be convenient and easy to use. The families had improvements in family functioning and the women experienced a significant reduction in their depressive symptoms.

In Mexico, a free web-based psycho-education cognitive-behavioral therapy intervention that contained seven self-help modules for depression found that user retention dropped significantly. However, the predictors for entering at least one module were: being female, older than 30 years old, have a disability and have attempted suicide in the past (Lara et al., 2014).

In Germany, a post-discharge support system that used telephone for follow-up support was set-up. Just over half (55%) of participants had at least one contact with a psychotherapist within 6 months of discharge. There were improvements in outcomes as compared to usual care (van den Berg et al., 2015).

The Skills Training in Affective and Interpersonal Regulation (STAIR) program was piloted with female veterans living in rural areas of the USA. The program was designed as 10-week skills building and mood management training program that included individual or group videoconferencing sessions. Participating in the intervention led to increased attendance and increased perceptions of safety (Azevedo et al., 2016).

Unemployed women in Spain who were victims of gender-based violence received 4 SMS messages per day for 28 days (Garcia et al., 2018). The messages were based on cognitive behavioral therapy for gender-based violence. Women were able to engage with the messages through sending responses. Phone calls were initiated if women's responses were concerning. The system automatically flagged concerning responses (i.e., self-harm) (Garcia et al., 2018). Similarly, in Iran, veterans received psychiatric support for PTSD via SMS for 6 months, in addition to standard care. There were significant improvements in PTSD symptoms and quality of life as compared to controls (Darvish et al., 2018). In Iran, women at risk of postpartum depression received twice daily SMS for 35 days and a phone call at 14 days after childbirth (Niksalehi et al., 2018). There was a significant decrease in postpartum depression by 35 days after delivery.

Cost-effectiveness analyses of a rural telemedicine mental health initiatives (videoconferencing) in the USA identified that the upfront costs were expensive, and those costs were not offset by reductions in health care utilization costs (Painter et al., 2017; Pyne et al., 2010).

3.3.6. Machine learning

Five articles dealing with machine learning were published within the last three years (2016 or more recently) (n = 5, 7.5%), and most of the studies had been conducted in China (n = 3, 4.5%) (Cao et al., 2018; Jiang et al., 2018; Zhang et al., 2018). The remaining studies were in Bulgaria and India (Ahn and Vassileva, 2016; Sarda et al., 2019).

In 4 of the use cases, machine learning was applied to neuroimaging for diagnostic purposes. In one study, a machine learning algorithm was trained on structural MRI imaging to predict the likelihood of response to therapy – in this case, electroconvulsive therapy for severe major

depressive disorder (Cao et al., 2018). Another study used machine learning coupled with neuroimaging to differentiate between conduct disorder and healthy individuals (Zhang et al., 2018). Machine learning was applied to identify common predictors and markers across different types of substance use. However, the researchers found only one common predictor, which was psychopathy (Ahn and Vassileva, 2016). A smartphone application used machine learning to passively detect changes in activity rates, communication levels, sleep patterns and mobility in efforts to help diagnose depression (Sarda et al., 2019).

Another study used audio files to train algorithms to detect depressed speech as a sign of depression. The model had 75% accuracy for females and 82% accuracy for males (Jiang et al., 2018).

3.3.7. Games

Only one study examined game-based interventions in a resource-limited setting (Rajabi et al., 2019); a separate study repurposed a gaming platform for use as a diagnostic tool (Dutta et al., 2013). A randomized controlled trial examined neurofeedback and game-based cognitive training by children with ADHD. Those in the intervention group attended 30 sessions and had pre- and post-intervention electroencephalograms (EEGs), integrated visual and auditory continuous performance and rating scales. The cognitive games were computer-based and focused on working memory and inhibitory control. The researchers found that there was normalization of atypical EEG features and increased sensory motor activity in the intervention group (Rajabi et al., 2019).

A Wii Balance Board – a Wii gaming system accessory that players stand on – was repurposed for use as a diagnostic tool for depression in the elderly. A Wii Balance Board was connected to a computer via Bluetooth and an emotive EEG neuroheadset was wirelessly relayed to the computer as well. The researchers identified an inverse relationship between balance score and depression – namely, as the balance score decreased, the depression score increased (and vice versa) (Dutta et al., 2013).

3.3.8. Lessons and considerations

Five articles discussed lessons from and considerations for eMental health implementations (Alicata et al., 2016; Aljaberi, 2018; Bauer et al., 2017; Chandra et al., 2014; Deb et al., 2018; Hadjistavropoulos et al., 2017; Liang et al., 2018; Pradhan et al., 2019; Swinton et al., 2009). There were common themes that spanned ethics, privacy and communications; they were as follows:

- Ensuring that informed consent was truly obtained and that confidentiality was maintained
- Using standards for privacy and security standards to protect personal health information
- Applying the Principles for Digital Development
- Sensitizing and training all key stakeholders and others who may interact with the technology to help manage expectations and integrate into routine care
- Identifying champions to help build critical mass of users
- Promoting and ensuring the authenticity of the relationship given the digital, rather than in-person, medium
- Having adequate incentives in-place to promote meaningful use of the technology

4. Discussion

This review of 67 peer-reviewed articles and four sources from the grey literature provide examples of how digital technologies are successfully being used to support mental health and psychosocial well-being initiatives in limited resource settings. Important themes from the literature were identified and included adherence to treatment (primarily appointments), 'real-time' assessments, promotion of well-being/mood elevation, education and training, remote therapy, machine learning and gaming. These themes were also identified in the broader literature that included studies in resource replete settings. There are additional themes and areas of opportunity that were not captured in this review due to the intentional focus of the review. Nevertheless, several limitations exist.

4.1. Areas of opportunity

There are several promising areas of opportunity for eMental health in resource-limited settings. This includes mental health first aid, ecological momentary assessments, hotlines, peer networks and mass advocacy/social media marketing. They often also use low-tech solutions (i.e., phone calls), and they provide means for education and awareness raising and building trust and support with reliable community-based resources. While this review focused on mental health and psychosocial well-being, digital technologies have been applied with success in other health areas and in human resources for health (Guse et al., 2012; Long et al., 2018; Steinberg, 2018; Tamrat and Kachnowski, 2012). Importantly, this means that digital tools and implementations can and should be repurposed and/or expanded to incorporate more than one health area. This is in line with the pathway towards integration and interoperability that digital health, overall, is headed in. Integration in therapy can also make a difference. Involving family and partners can help increase treatment retention and adherence (Fletcher, 2018; Honary et al., 2018; Singh et al., 2017; Vismara et al., 2013).

This may be especially useful in settings where the beneficiaries may have limited access to technology, let alone care. Those who do have access to digital devices, such as family members or health providers, could be the primary point of intervention in an effort to extend the reach of services and raise awareness – which could ultimately lead to improvements in quality and reductions in stigma. Additionally, leveraging existing technology, providing training and starting with 'low-tech' yet designing for 'high-tech' (to accommodate advancements of the technology) may increase access to and participation in eMental health initiatives.

4.2. Emerging trends

As technology continues to advance, there is opportunity for higher tech solutions to replace existing, more simple technology, and more greatly expand how technology can be used within the eMental health context. Emerging technologies include wearables, predictive analytics, robots and virtual reality. Devices like fitbits and smartglasses can be incorporated into therapy, collecting passive data that can better help optimize treatment (Cella et al., 2018). Predictive analytics are also gaining more attention to be proactive and provide targeted treatment approaches (Barros et al., 2017; Kalmady et al., 2019; Karstoft et al., 2015; Roetker et al., 2013). Robots are also being explored as a communication therapy tool for children with autism (Golestan et al., 2017; Saadatzi et al., 2018). Virtual reality is also in an experimental stage as part of therapy, primarily cognitive behavioral therapy (Banos et al., 2016; Cesa et al., 2013; Manzoni et al., 2016; Pallavicini et al., 2016). While more limited resource settings may not yet have the infrastructure to support these emerging trends, current implementations can be designed for future transition and adoption of these technologies and approaches when appropriate. For example, predictive analytics could be used to optimize the distribution of the limited resources for mental health, especially in settings where resources are scarce.

4.3. Limitations

The review has several limitations. First, there were a variety of study designs included for analysis. Meta-analyses of the outcomes data, while helpful, would not be appropriate. Secondly, only one of the authors conducted the search and reviewed the full texts. However, any clarity required for eligibility of studies were discussed by both authors.

Thirdly, many of these studies described pilots or were discrete research projects. Sustainability and longer-term implementations, while featured, were few. Relatedly, long-term outcomes were often not assessed. It is important to also note that loss-to-follow-up, which is a key concern for mental health treatment adherence even without a technology intervention, was not examined in these studies, as well. Fourth, overall, the studies had a high risk of bias, as evidenced by most studies having a level of evidence of IV. This review had used current World Bank income classification criteria which does not reflect the transient nature of countries within those categories, thus potentially introducing misclassification bias. Of note, it is not entirely clear what has truly failed; yet there are important lessons to learn from both failure and success. Interestingly, this review had minimal overlap with two other literature reviews on mental health, including one that focuses in low- and middle-income countries (Naslund et al., 2015, 2017). This was most likely due to the nature of the search and the texts available to the authors.

4.4. Strengths

Despite these limitations, there were notable strengths. This review provides comprehensive insights into how digital technology can be applied to enhance outcomes related to mental health and psychosocial well-being. While all study locations were in resource-limited settings, they spanned a diverse set of cultures, geographies and populations. In addition, the same types of technology features or platforms were used for different purposes, with reasonable impacts on health outcomes. Furthermore, while different studies were identified in this review, the findings did correspond with the findings from previous reviews (Naslund et al., 2015, 2017).

5. Conclusion

Across a diverse geography of limited resource settings, eMental health interventions are often feasible and acceptable. Organizations seeking to support mental health initiatives can leverage technology in a few ways to support their programming. This includes, but is not limited to, supporting treatment adherence, providing interventions directly to patients where they are and education to both health workers and clients. Furthermore, interventions can be designed with the future in mind but use low-tech and existing solutions to support their clients' mental health and psychosocial well-being.

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CRediT authorship contribution statement

Nadi Nina Kaonga: Conceptualization, Methodology, Investigation, Writing - original draft. **Jonathan Morgan:** Conceptualization, Methodology, Writing - review & editing.

Declaration of Competing Interest

The authors have no competing interests to declare.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2019.112594.

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