



Digital technology for treating and preventing mental disorders in low-income and middle-income countries: a narrative review of the literature

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Few individuals living with mental disorders around the globe have access to mental health care, yet most have access to a mobile phone. Digital technology holds promise for improving access to, and quality of, mental health care. We reviewed evidence on the use of mobile, online, and other remote technologies for treatment and prevention of mental disorders in low-income and middle-income countries. Of the 49 studies identified, most were preliminary evaluations of feasibility and acceptability. The findings were promising, showing the potential effectiveness of online, text-messaging, and telephone support interventions. We summarised the evaluations as: technology for supporting clinical care and educating health workers, mobile tools for facilitating diagnosis and detection of mental disorders, technologies for promoting treatment adherence and supporting recovery, online self-help programmes for individuals with mental disorders, and programmes for substance misuse prevention and treatment. Continued research is needed to rigorously evaluate effectiveness, assess costs, and carefully consider potential risks of digital technology interventions for mental disorders, while determining how emerging technologies might support the scale-up of mental health treatment and prevention efforts across low-resource settings.

Introduction

Mental health disorders are the leading cause of disability worldwide, accounting for nearly a third of all years lived with disability¹ and 8 million deaths annually.² Low-income and middle-income countries are disproportionately affected by the burden of mental disorders, largely because of fragmented and underdeveloped health-care systems, few available mental health specialists or treatment opportunities, and the devastating consequences of poverty, stigma, and social disenfranchisement on individuals' mental wellbeing.³ The gap between individuals with mental disorders in need of treatment and those who receive it is substantial and up to 90% of individuals living with mental disorders in low-resource countries receive no mental health care.⁴ Over the past decade, treatments for mental disorders such as depression or schizophrenia have been evaluated and shown to be clinically and cost-effective across a number of low-income and middle-income countries.⁵ However, considerable barriers to implementation of such treatments remain, including few workers trained in mental health care, resistance to decentralisation of mental health services, and little political motivation to make mental disorders a public health priority.⁶

The scarcity of mental health providers in low-income and middle-income countries is well documented and often cited as one of the limiting factors to provision of even basic mental health care.⁷ The ratio of mental health workers to population is estimated to be nearly 200 times greater in high-income countries than in countries with few resources.⁷ In some cases, only one or two psychiatrists are available for the entire country, as reported in countries such as Chad, Liberia, and Rwanda.⁷ With such substantial workforce shortages, calls for greater investment in psychiatric training programmes, equipping primary

care providers with skills to deliver basic mental health care, developing community-based programmes, and task shifting services to lay providers, non-professionals, and caregivers⁸ will probably not be enough to close this gap. Therefore, innovative approaches to preventing and treating mental disorders need to be considered.

The unprecedented growth in mobile telecommunications and internet access across many low-income and middle-income countries might present new opportunities to reach, support, and treat individuals living with mental disorders.⁹ Reports have highlighted that mobile cellular phone subscriptions exceed 80% of the population in many low-income countries in Africa, Central America, and south Asia.¹⁰ The proportion of individuals with internet access is lower than the proportion with mobile phone subscriptions, ranging from 27% of the population in south Asia to 60% in South America.¹⁰ However, nearly 40% of the world's internet traffic comes from mobile devices, highlighting that more and more individuals from low-income regions are finding ways to access the internet.¹⁰ For example, mobile devices account for 66% of web traffic in India, 70% in Indonesia, 82% in Nigeria, and 75% in South Africa.¹⁰ Although many gaps in mobile and online connectivity remain, especially in rural areas and for people who live in the most impoverished regions in Africa and south Asia, internet access has spread rapidly to a substantial proportion of the global population. Through increased connectivity afforded by these technologies, potential exists to begin to bridge the treatment gap and to reach an increased number of individuals living with mental disorders.

In this narrative Review, we aimed to summarise the evidence on use of digital technology, including mobile, online, and other remote technologies, for treatment

and prevention of mental disorders in low-income and middle-income countries. We included all study designs to assess feasibility, acceptability, and potential effectiveness of different digital technology interventions. Specifically, we were interested in interventions using technology to connect remotely with people with mental disorders without requiring face-to-face contact, or mobile technology to facilitate in-person encounters with lay providers or community health workers. This technology included mobile devices such as cellphones or smartphones, telepsychiatry applications, and online interventions for diagnosis, screening, treatment, prevention, education, or facilitating self-management of mental disorders across diverse low-resource settings. We included interventions targeting depression; serious mental illnesses, including schizophrenia spectrum disorders and bipolar disorder; anxiety disorders; and post-traumatic stress disorder. We also included interventions targeting alcohol and other substance-misuse disorders. We consider how these emerging technologies could overcome barriers to improving access to mental health care in low-income and middle-income countries, and conclude by discussing implications for policy and practice.

Methods

Inclusion and exclusion criteria

Included studies evaluated digital technology interventions targeting serious mental illness, defined as schizophrenia, schizoaffective disorder, or bipolar disorder; depression, including depressive symptoms and major depressive disorder; substance misuse, including alcohol use, illicit drug use, and other substance use disorders; and other common mental health concerns, including anxiety disorders and post-traumatic stress disorder. Interventions involved the use of mobile, online, or other technology, which included mobile phones, smartphones, internet-delivered programmes, telepsychiatry, text-messaging, remote sensing, wearable devices, and mobile applications. Included interventions could target patients, families, or providers, but had to have reported outcomes. Outcomes were broadly defined, and included feasibility, usability, safety, acceptability, costs, efficacy, clinical effectiveness, or implementation measures. We also included preliminary feasibility or acceptability studies, and programme implementation or naturalistic studies. All study designs were included. We excluded discussion articles, programme descriptions, and study protocols. The appendix shows the complete search strategy used in MEDLINE. The same search strategy was used in all databases.

Low-income and middle-income countries were defined according to the 2015 World Bank classification;¹¹ however, we also included countries that had recently transitioned from middle-income to high-income classification (ie, Argentina, Chile, Russia, Uruguay, and Venezuela). Our rationale for including countries that had recently transitioned was to allow more

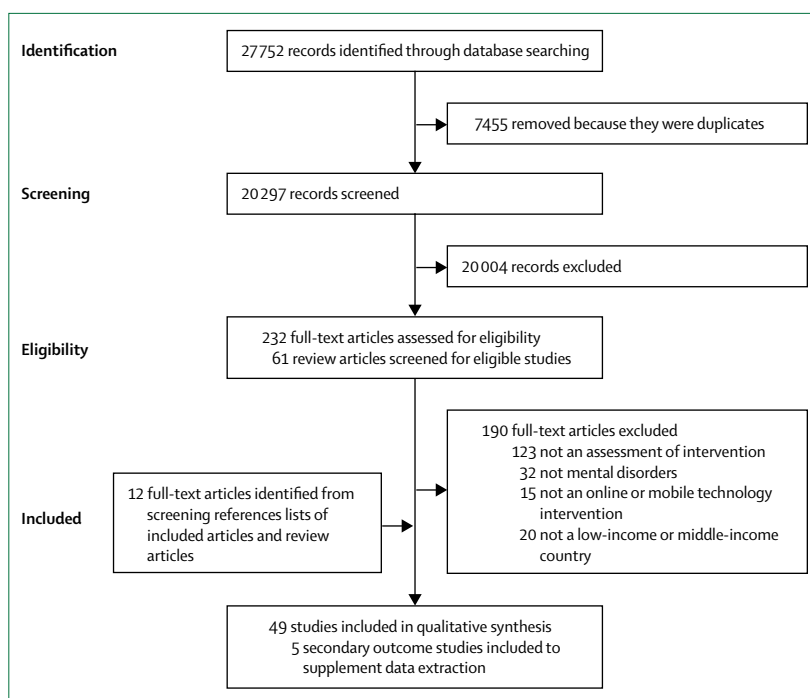


Figure: Study selection

inclusive study eligibility criteria and because published research from these countries might have been started or completed before the income classification change. We also deemed it important to allow more inclusive study eligibility because World Bank income classifications can fluctuate annually, whereby countries can transition from middle-income to high-income classification or vice versa depending on economic factors at the time.

Study selection and data extraction

The lead author (JAN) screened titles to identify relevant studies and reviewed relevant abstracts to identify studies to undergo full-text review. JAN discussed potentially eligible studies with coauthors (LAM and SJB) and extracted data from the included studies to summarise in tables. A second author (KAA) reviewed the list of included studies and the data included in the summary tables to confirm accuracy in data extraction. An additional author (VP) reviewed the final list of included studies. All authors reviewed the final tables. Data were extracted for country of origin, study design and duration, sample description, intervention description, and primary outcome. We obtained English language abstracts for all non-English language articles included in this Review. For several non-English language articles we also obtained English language translations. JAN extracted data directly for all articles published in French and Spanish. For remaining non-English language articles, we used Google Translate online software to facilitate data extraction.

See Online for appendix

Results

We identified 49 studies of digital technology for the treatment, prevention, diagnosis, and management of mental disorders or for the provision of mental health training and education to health workers in over 20 low-income and middle-income countries (figure). Included studies mainly targeted depression (16; 33%), serious mental illness (9; 18%), or substance misuse (7; 14%), and were from Latin America (19; 39%), south Asia (8; 16%), east Asia (7; 14%), Africa (7; 14%), eastern Europe and central Asia (5; 10%), and the Middle East (3; 6%). We also identified five articles reporting secondary outcomes for the included studies that we used to supplement our data extraction and summary. Because many of the studies were preliminary in nature, and involved pilot evaluations of emerging technologies and varying study designs, a formal quality or risk of bias assessment was not done, and a formal meta-analysis was not possible. We categorised included studies on the basis of how the intervention was delivered rather than by specific type of mental disorder, and grouped substance misuse prevention and treatment interventions separately. We considered the different objectives for the use of technology to address mental disorders, and whether technology was used in clinical settings, to support clinicians, or to directly reach individuals living with

mental disorders. We grouped the evaluations according to five objectives: technology for supporting clinical care and educating health workers, mobile tools for facilitating diagnosis and detection of mental disorders, technologies for promoting treatment adherence and supporting recovery, online self-help programmes for individuals with mental disorders, and programmes for substance misuse prevention and treatment.

We identified 14 studies^{12–25} using digital technology to support mental health care delivery in clinical settings and to provide basic mental health education to health workers (table 1). Telepsychiatry using online videoconferencing seemed to be feasible and acceptable for allowing psychiatrists to provide direct clinical consultations for diagnosis or follow-up care to patients with depression, serious mental illness, and other mental disorders in Somaliland,¹² South Africa,¹³ and India.¹⁴ In Brazil, monthly videoconferencing follow-up visits for care of people with depression achieved similar clinical outcomes as standard face-to-face treatment.¹⁵ In Chile, an online platform facilitated collaborative care by giving primary care providers remote access to a psychiatrist, which contributed to improved outcomes for care of people with depression.¹⁶ In one study,¹⁷ primary care providers from district hospitals in India sent patient reports to consulting psychiatrists at a tertiary medical

	Country	Study design and duration	Participants	Intervention	Outcome
Abdi and Elmi (2011) ¹²	Somaliland	Descriptive, naturalistic, pilot feasibility study; 18 months	132 participants (32% female) with a range of diagnoses including schizophrenia and mood disorders	Skype-based online telepsychiatry consultations from psychiatrists located in Scandinavia (Denmark, Norway, and Sweden) delivered on a computer within the central mental health clinic to outpatients in need of mental health care	Feasibility of programme shown by increasing use among patients, patients choosing to travel long distances for consultations, and satisfaction reported among clinic staff, local authorities, and communities
Balasinorwala et al (2014) ¹⁷	India	Retrospective analysis of feasibility; 6 years	94 participants (36% female) mostly with schizophrenia, other psychotic disorders, or mood disorders	Asynchronous (store-and-forward) telepsychiatry programme, whereby primary care physicians send notes and investigation reports by email to a psychiatrist to review at a central hospital	Feasibility shown as a definite psychiatric diagnosis was possible for 89 (95%) patients
Barrera-Valencia et al (2016) ¹⁹	Colombia	RCT and cost-effectiveness analysis; 6 month follow-up	106 male prisoners with symptoms of depression	Asynchronous (store-and-forward) telepsychiatry model, whereby primary care physicians see prisoners and send notes electronically to a consulting psychiatrist for diagnosis, treatment, and medication recommendations; compared with a synchronous telepsychiatry model involving videoconferencing consultation between prisoners and a psychiatrist	99 (93%) participants completed follow-up; both telepsychiatry models contributed to reduction in depressive symptoms among prisoners ($p<0.001$); the asynchronous model showed a greater decrease in depressive symptoms than did the synchronous model ($p=0.01$); the cost of the asynchronous model was significantly lower than that of the synchronous model ($p<0.001$)
Chipps et al (2012) ¹³	South Africa	Development and implementation project; 3 years	31 patients with a range of mental disorders including schizophrenia and mood disorders	Development, pilot testing, and implementation of a telepsychiatry service at the University of KwaZulu-Natal to provide telepsychiatry education to clinicians and clinical outreach services to patients using videoconferencing technology; patients participated in individual or group telepsychiatry sessions	The programme is feasible and appears beneficial for overcoming long distances, improving clinical efficiency, and delivering group sessions; there were many technical difficulties, challenges with scheduling, and high staff turnover
Hungerbuehler et al (2016) ¹⁵	Brazil	Pilot RCT; 6 month and 12 month follow-up	107 outpatients (71% female) with stable unipolar depressive disorder	Telepsychiatry involving monthly online Skype videoconferencing consultations with psychoeducation, medication monitoring, and counselling with a psychiatrist and medication delivery to patients' homes; comparison group had monthly face-to-face consultations at the psychiatric hospital, and medications available at the clinic following the consultation	85 (79%) participants completed 12 month follow-up; during the study there were 489 video consultations and 461 face-to-face consultations; both groups had a reduction in depressive symptoms ($p<0.001$) and an improvement in mental health status ($p=0.001$); clinical outcomes did not differ significantly between groups; patients in both groups reported satisfaction with their treatment

(Table 1 continues on next page)

	Country	Study design and duration	Participants	Intervention	Outcome
(Continued from previous page)					
Kale et al (2016) ¹⁴	India	Descriptive, naturalistic study; 3 years	316 outpatients with mental disorders including depression, anxiety disorders, and schizophrenia	Telepsychiatry consultations using web videoconferencing to provide diagnosis, treatment, and specialist follow-up care to outpatients at a rural hospital; remote consulting psychiatrists had access to patients' electronic medical records	Feasibility of the programme was demonstrated by providing 1200 consultations to 316 patients; reduction in referral rates to medical colleges for psychiatric illnesses; satisfaction reported by consulting psychiatrists and patients
Keynejad et al (2016) ²⁰	Somaliland	Mixed methods study; 1 year	48 medical students (half from Somaliland and half from the UK) divided into 24 pairs	Aqoon is an online psychiatry education programme involving peer-to-peer partnerships between medical students in Somaliland and the UK; ten instant messaging meetings between student pairs on the MedicineAfrica web platform cover core psychiatry curriculum including common disorders and cultural perspectives	Students from Somaliland rated online peer-to-peer education partnerships positively for enjoyment, interest, and academic helpfulness; attitudes towards psychiatry improved among Somaliland students, but not among UK students; Somaliland students reported more gains in factual knowledge and UK students reported greater cross-cultural learning
Lowenthal et al (2012) ^{22,25}	Brazil	Pilot feasibility study; 4 months	25 primary care workers (75% female) including doctors and nurses	Online tele-education programme to provide primary care professionals with training in child and adolescent mental health; distance education includes videos about depression, anxiety, attention deficit hyperactivity disorder, conduct disorder, and pervasive developmental disorder with animated tutorials about screening for mental health problems; tele-education programme is followed by a 1 day classroom training session	Primary health-care workers showed acquisition of knowledge about the content and learning objectives covered in the tele-education programme ($p<0.01$), and improvement in their knowledge ($p<0.01$), attitudes ($p<0.01$), and practice associated with diagnosing and treating mental disorders in childhood and adolescence
Novaes et al (2012) ²³	Brazil	Descriptive, naturalistic study; 12 months	1422 health-care professionals	Tele-education programme consisting of weekly web conference seminars and moderated discussion forums to provide education to family health-care teams about mental health	39 tele-education sessions were done during the 1 year period and 384 (27%) health professionals responded to follow-up evaluations; nearly all respondents were satisfied with the programme and thought that the seminars contributed to their professional development; two-thirds reported difficulties with video and audio connectivity
Pereira et al (2015) ²¹	Brazil	Pre-post study; 2 month follow-up	33 health-care professionals (82% female) working in primary care settings	Online course to enhance health professionals' knowledge about clinical management of alcohol misuse; course consisted of nine instructor-led classes and web conferences, video exhibitions, text materials, and online chats and forums	33 of 100 enrolled participants completed the course; participants who completed the course showed significant improvement in knowledge about clinical management of alcohol related problems ($p<0.001$), but no improvement in understanding about misconceptions and biases related to alcohol problems; participants expressed satisfaction with the course
Pereira et al (2015) ²⁴	Brazil	Three arm cluster RCT; 3 weeks	213 primary school teachers recruited from nine different schools	Web-based programme to educate primary school teachers about childhood mental disorders; interactive programme consisting of tutorials, educational videos, online discussion forum, expert feedback and consultation from a psychiatrist, and written materials; compared with a text and video materials only control group, and a waitlist control group	115 (54%) teachers completed follow-up; teachers in the web-based programme had greater gains in knowledge about mental disorders such as depression and conduct disorder ($p<0.05$), and better understanding about mental disorders, such as less stigmatised views ($p<0.05$), than did those in the text and video only and waitlist control groups; no differences between groups in attitudes about mental disorders
Rahman et al (2006) ¹⁸	Pakistan	Pilot feasibility study; 6 months	20 child or adolescent (aged ≤ 16 years) outpatients (50% female) with various mental disorders	A child telepsychiatry programme using a store-and-forward approach, whereby information recorded on complex cases was transferred by email to a consulting psychiatrist in the UK	Programme is feasible for supporting diagnosis of complex child psychiatry cases, and providing training and supervision to local clinicians; positive feedback obtained from patients and clinicians
Rojas et al (2014) ¹⁶	Chile	Controlled pilot study; 3 month follow-up	81 patients (84% female) with depression	Online telepsychiatry programme that links primary care staff with a consulting psychiatrist to facilitate collaborative care; combined with telephone monitoring to provide patients with advice about medication side-effects and to promote medication adherence; compared with usual care	70 (86%) patients completed 3 month follow-up; significantly greater decrease in depressive symptoms in patient group than the control group ($p=0.037$); programme offers primary care teams remote access to a psychiatrist

RCT=randomised controlled trial.

Table 1: Studies using digital technology for supporting clinical care and educating health workers

centre to obtain treatment recommendations, whereas in another study from Pakistan,¹⁸ reports on children or adolescents with complex presentations of mental illness were sent to psychiatrists in the UK for clinical guidance and feedback. Use of email to seek remote consultation from specialists is referred to as asynchronous or so-called

store-and-forward telepsychiatry,^{17,18} however, this approach seems to be an extension of existing practices of sending paper copies to consultants rather than an application of technology with potential for population-level impact. Nonetheless, this method can afford benefit, as shown in a study from Colombia¹⁹ in which asynchronous

	Country	Study design and duration	Participants	Intervention	Outcome
Chattopadhyay (2012) ²⁷	India	Pilot reliability and validity evaluation; 1 year	123 participants (51% female) with varying levels of depression	e-DAT is web based and can be accessed from a computer or mobile device; includes 26 questions to assess symptoms and depression load	e-DAT is considered reliable and valid for diagnosing depression; the mean accuracy of the tool for detecting mild, moderate, or severe depression is 93%
Malhotra et al (2015) ^{28,29}	India	Pilot validity and reliability study; 6 months	100 outpatients (47% female) with a range of mental disorders	Internet-based psychiatric screening and diagnostic application intended for use among non-specialists in remote care settings; to assess validity and reliability of the application, outpatients were assessed by non-specialists using the application at remote sites, and were also assessed using online videoconferencing and using a standard screening and diagnostic tool	Moderate to high agreement between different diagnostic methods; the application had high sensitivity, low positive predictive values, but high negative predictive values for most disorders; the internet-based diagnostic tool has acceptable validity and reliability when used by non-specialists at remote sites
Malhotra et al (2015) ³⁰	India	Pilot accuracy and feasibility study; 6 months	274 outpatients (42% female) with a range of mental disorders	Internet-based decision support system for diagnosis and management of common psychiatric disorders that consists of modules for diagnosis, pharmacological and psychosocial treatment, and follow-up care; compared with a standard screening and diagnostic tool	Internet-based application had high sensitivity, specificity, and negative predictive values for most disorders, but low positive predictive values; good inter-rater reliability and effective for assessing symptom severity and functional status; application seems feasible on the basis of satisfaction reported by patients and interviewers
Tomita et al (2016) ³¹	South Africa	Pilot feasibility, reliability, and acceptability study; 10 months	153 refugees (50% female) mainly from Zimbabwe and the Democratic Republic of the Congo	Mobile SMS-based depression screening intervention for refugees; involves a 16 item depressive symptoms inventory; compared with face-to-face consultation	135 participants completed follow-up and both the SMS and face-to-face depression screens; nearly all participants had mobile phones and used SMS; fair agreement between SMS and face-to-face methods; participants were satisfied with SMS approach

e-DAT=electronic depression assessment tool. SMS=short message service.

Table 2: Studies evaluating mobile tools for facilitating diagnosis and detection of mental disorders

telepsychiatry was used to supplement primary care visits for depression treatment among prisoners. The asynchronous approach contributed to greater reduction in depressive symptoms at a lower cost than direct videoconferencing consultations with a psychiatrist.¹⁹ Overall, telepsychiatry seems to be restricted because intensive clinician involvement is required from both primary care providers at local clinics and remotely located psychiatrists. In view of the low availability of specialists in low-income and middle-income countries, it is unlikely that telepsychiatry will substantially reduce workforce shortages and facilitate the provision of mental health care to the millions who are without access.

Online education is another approach that could afford opportunities to address workforce shortages in low-income and middle-income countries by providing medical training to health-care workers.²⁶ An online peer-to-peer learning programme whereby medical students from Somaliland were partnered with medical students in the UK, was acceptable for covering core psychiatry curriculum content.²⁰

We also identified four studies from Brazil of self-directed online education programmes. These studies included programmes for educating primary health-care workers and doctors about alcohol misuse,²¹ child and adolescent mental health,²² and general mental health care,²³ and an online programme to educate primary school teachers about childhood mental disorders.²⁴ A potential barrier to the use of online education programmes is the requirement for a strong internet connection, typically through a computer. Such access remains low in remote regions or impoverished settings and the success of online mental health education

programmes is likely to depend on whether these programmes can be accessed via mobile devices.

Provision of primary health-care providers, community health-care workers, and other lay providers with tools to diagnose and detect mental disorders is necessary to meet the needs of individuals with mental disorders who might have access to basic health care. Technology could play an important role by shifting tasks performed by specialist medical providers into the hands of non-medical health workers. We found four studies that evaluated mobile and online tools for the diagnosis and detection of mental disorders (table 2). Web-based screening tools designed to be delivered on mobile phones by non-medical health workers were effective for diagnosing depression²⁷ or common psychiatric disorders^{28,30} in clinical settings in India. In South Africa, a mobile short message service (SMS) text-messaging screening tool for depression was used to reach refugees, mostly from Zimbabwe or the Democratic Republic of the Congo, residing within social services settings.³¹ This screening tool effectively assessed depressive symptoms among refugees, and showed agreement with standard face-to-face assessment methods.³¹ These studies highlight the potential for simple mobile technologies to reach susceptible population groups and enable non-medical health workers to reliably detect and diagnose mental disorders in rural and under-resourced settings.

We found 13 studies³²⁻⁴⁵ that used SMS text-messaging, online programmes, and telephone coaching to reach individuals with mental disorders outside clinical encounters, promote treatment or medication adherence, and provide ongoing encouragement and targeted psychosocial support (table 3). SMS text-message

	Countries	Study design and duration	Participants	Intervention	Outcome
Burton et al (2016) ⁴⁵	Romania, Spain, and Scotland	Pilot RCT; 6 week intervention	27 participants (67% female) with major depressive disorder or depressive symptoms	Help4Mood is a computer application to support depression treatment between clinical appointments; the cognitive behavioural therapy-based programme involves daily and weekly mood checks, relaxation exercises, and activities to track progress; compared with usual treatment	Participants used Help4Mood a median of 10.5 times during the study; improvement in depressive symptoms observed, but no significant difference compared with the control group; participant feedback was mixed, many indicated they would continue to use the programme, whereas others raised concerns about repetitive content and need for more customisable content
Carrasco (2016) ³⁸	Chile	Pilot feasibility and acceptability study; 1 year	15 female adolescent patients with symptoms of depression	Maya is an online adventure video game used for depression treatment in adolescents; narrative structure follows a hero's journey to promote skill building, problem solving, decision making, and behavioural activation. Information and resources also available through the private online system	Participants played the game for a mean 11.57 min (SD 3.42); four participants played the game more than once; 13 participants completed acceptability ratings; nine participants reported positive acceptability and considered the game beneficial; four participants did not find the game beneficial
Chandra et al (2014) ⁴⁰	India	Qualitative pilot study of feasibility and acceptability; 1 month intervention	40 female participants aged between 16 and 18 years from urban slums in Bangalore with access to a mobile phone	Participants received one daily SMS text-message for 1 month with mental health tips, positive messages, or helpline information; participants could respond if they felt sad, angry or depressed, or to talk to a counsellor	Feasible and acceptable approach for mental health promotion and prevention among young women; most participants responded to the messages by phone (63%) or text-message (58%); most (62%) participants were satisfied with receiving the message; participants preferred the helpline messages
Chen et al (2007) ³⁴	China	RCT; 1 year follow-up	71 patients (46% female) with schizophrenia	Online psychoeducation for relapse prevention combined with drug treatment for non-acute schizophrenia; compared with general rehabilitation control group	Intervention group showed a significant decrease in positive and negative symptoms and relapse incidence compared with control group ($p<0.01$); intervention group had better medication adherence and social function than the control group ($p<0.01$)
Espinosa et al (2016) ³⁹	Chile	Pilot feasibility and acceptability study; 8 months	35 patients (60% female) who received treatment for major depression	ASCENSO is an online programme to support depression treatment and prevent relapse; the programme includes reminder emails and web-based modules for symptom monitoring, self-care recommendations, online counselling appointments with a psychologist, and information and resources	23 (66%) participants actively used the programme and were sent 330 reminders to monitor their depressive symptoms; most participants reported that the programme was beneficial and that the monitoring component was useful; technical issues and limited time were cited as primary reasons for not using the programme
Fang et al (2011) ³⁵	China	RCT; 2 year follow-up	91 patients (47% female) with clinically stable schizophrenia	Mobile SMS text-messages sent daily as reminders for medication adherence combined with antipsychotic treatment and telephone follow-up; compared with control group with antipsychotic treatment and telephone follow-up only	At 2 year follow-up, relapse rates were 36% in the intervention group compared with 61% in the control group ($p=0.03$); daily SMS text-message reminders appear effective for reducing relapse in schizophrenia
Fritsch et al (2007) ⁴¹	Chile	RCT; 3 month and 6 month follow-up	345 female participants with depression	Pharmacotherapy with phone monitoring for depression treatment in primary care settings; telephone contact from non-professionals to provide education and medication monitoring to reinforce adherence and provide support; compared with usual care	307 (89%) participants completed 3 month follow-up and 274 (79%) participants completed 6 month follow-up; significant improvement in depressive symptoms at 3 months ($p<0.001$) and 6 months ($p=0.015$) compared with the control; improved mental health at 3 months ($p<0.001$) and 6 months ($p=0.009$) compared with the control
Maiga (2011) ³²	Niger	RCT; 4 month follow-up	100 participants (33% female) with psychosis	Reminder SMS text-messages and phone calls 2 days before monthly follow-up appointments; compared with control without appointment reminders	The intervention group attended significantly more monthly follow-up visits than the control group ($p<0.05$)
Marasinghe et al (2012) ³⁷	Sri Lanka	RCT; 6 month and 12 month follow-up	68 outpatients (50% female) undergoing treatment following a suicide attempt	Brief mobile treatment includes face-to-face training in problem solving, meditation, mental health assessment, and advice on alcohol and drug use, and ten telephone follow-up calls to assess suicidality and provide guidance, access to audio messages to support meditation and problem solving, and weekly supportive and encouraging SMS reminders; compared with waitlist control group receiving usual care	Participants who received the intervention showed significant reductions in suicidal ideation and depression, and improvement in social support compared with the control group; no reduction in self-harm or substance misuse, and reduction in alcohol use among men only
Özkan et al (2013) ⁴² and Ozkan et al (2013) ⁴³	Turkey	Pilot RCT; 6 month intervention	62 participants (50% female) with schizophrenia and their caregivers (53% female)	Psychoeducation with weekly telephone follow-up for both participants with schizophrenia and their caregivers; compared with control without psychoeducation and telephone follow-up	Improvement in treatment adherence and social functioning among participants with schizophrenia; caregivers also showed decreased family burden, emotional expression, and depressive symptoms
Talebani et al (2016) ³⁶	Iran	RCT; 3 month follow-up	203 participants (94% female) from rural areas affected by depressive symptoms	Participants were given a booklet with evidence-based strategies for managing and preventing depressive symptoms; daily text-messages were sent to provide encouragement to participants and to recommend reviewing sections of the booklet for a 30 day period; the booklet with text-messaging was compared with a booklet only group and a control group	198 participants (98%) completed the study; all groups showed a decrease in depressive symptoms over time ($p<0.01$); the booklet with text-messaging group and the booklet-only group had a significant reduction in depressive symptoms compared with the control group ($p<0.001$); change in depressive symptoms did not differ between the booklet with text-messaging group and the booklet only group

(Table 3 continues on next page)

	Countries	Study design and duration	Participants	Intervention	Outcome
(Continued from previous page)					
Temmingh et al (2013) ⁴⁴	South Africa	Prospective naturalistic study; 12 month intervention	761 participants (72% female) with serious mental illness, including schizophrenia spectrum disorder and mood disorders	Telephone-delivered lifestyle coaching intervention aimed at weight reduction and wellness improvement in psychiatric outpatients; weekly calls for 3 months followed by monthly calls for 9 months; consists of exercise and meal planning, goal setting, self-monitoring, encouragement, and health management education	467 participants (61%) completed the intervention; among participants who completed the intervention, mean weight loss was 4.8 kg (95% CI -5.67 to -3.82), and 46% of participants lost 5% or more of their baseline weight; weight loss ($p < 0.001$) and improvement in general health ratings ($p < 0.001$) were significant; participants who dropped out were younger and were more likely to have a mood disorder
Thomas et al (2016) ³³	Nigeria	RCT; 6 month study period	200 patients (54% female) with first episode psychosis (45% schizophrenia)	The intervention consisted of SMS appointment reminders sent 5 and 3 days before follow-up appointments at the outpatient psychiatry clinic; compared with standard paper appointment reminder cards in the control group	Participants who received the SMS reminders were nearly twice as likely to attend the appointments compared with the control group (OR 1.80; 95% CI 1.02-3.19); the SMS reminders significantly improved clinic attendance ($p < 0.03$)

RCT=randomised controlled trial. SMS=short message service.

Table 3: Studies evaluating technologies for promoting treatment adherence and supporting recovery

reminders were effective for promoting attendance at clinical appointments in people with serious mental illness, as shown in randomised controlled trials from Niger³² and Nigeria.³³ In two randomised controlled trials^{34,35} from China, SMS text-messaging support and online psychoeducation were effective for improving medication adherence and preventing relapse among patients with schizophrenia. In a randomised trial³⁶ from Iran, daily SMS text-messages encouraged the use of a paper booklet for depression treatment among individuals from rural areas, although reduction in depressive symptoms did not differ compared with use of the paper booklet alone. In Sri Lanka, the combination of encouragement of SMS text-message reminders and supportive telephone calls reduced suicidal ideation and depression for individuals after a suicide attempt.³⁷ Two pilot studies from Chile showed the acceptability of online depression treatment, including an online video game for supporting depression treatment among adolescents³⁸ and an online programme for symptom monitoring in patients receiving treatment for major depression.³⁹ An exploratory study⁴⁰ also showed that SMS text-messaging was feasible and acceptable for promotion of positive mental health in young women living in urban slums in Bangalore, India.

Telephone support seemed to be effective for promoting treatment adherence and positive clinical outcomes. In Chile, a telephone monitoring intervention in which non-professionals provided education and reinforced adherence and treatment goals was effective at reducing symptoms in people receiving treatment for depression.⁴¹ In a pilot study from Turkey, standard psychoeducation was supported by weekly telephone follow-up for patients with schizophrenia and their caregivers, and contributed to improved treatment adherence and social functioning among patients⁴² and reduced burden and depression among family members.⁴³ In a study from South Africa,⁴⁴ weekly telephone lifestyle coaching sessions were effective for reducing antipsychotic-induced weight

gain in individuals with serious mental illness. A pilot study⁴⁵ that recruited participants mainly from Romania, and from high-income countries including Spain and Scotland, showed that a computer application could support depression treatment between clinical appointments through mood self-monitoring and cognitive behavioural therapy exercises. This study also highlights the benefits of collaboration between high-income and low-income settings. Together, these studies support the feasibility and acceptability of use of technology to support care for individuals receiving treatment for mental health disorders. These studies also show the potential effectiveness of such approaches for improving adherence and retention in care, reducing symptoms, and promoting mental wellbeing.

Digital technology might afford opportunities to reach individuals without access to care, or who might be reluctant to seek services because of stigma, long travel distances, or out-of-pocket expenses. Online self-help programmes can provide on-demand access to resources and supportive online communities, while offering a discrete and anonymous method for seeking support. We found 13 studies⁴⁶⁻⁵⁸ of online self-help programmes for mental disorders (table 4), which included pilot studies, randomised controlled trials, and naturalistic studies of evidence-based psychoeducation or cognitive behavioural therapy programmes adapted for delivery through online platforms for depression or anxiety disorders among individuals in Mexico,⁴⁶⁻⁴⁸ Romania,^{49,50} China,^{51,52} and Malaysia,⁵² as well as Russian-speaking populations.⁵³ Attrition rates in these studies were high, ranging from 13% to nearly 95%. Individuals who successfully completed the online programmes frequently experienced benefits including reduction in symptoms of depression and anxiety and improved quality of life. One study⁵⁴ aimed at prevention of post-partum depression recruited Spanish-speaking participants from 23 countries, mostly in Latin America. This study showed that online self-help programmes can

	Countries	Study design and duration	Participants	Intervention	Outcome
Barrera et al (2015) ⁵⁴	Argentina, Chile, Columbia, Mexico, Spain, and USA	Pilot RCT; 3 month and 6 month follow-up post partum	852 pregnant women who were mostly Spanish-speaking (83%) and from 23 different countries	Online intervention to prevent post-partum depression by teaching women how to create a healthy lifestyle for themselves and their newborn; eight weekly sessions in English or Spanish that include text, audio, and video materials and worksheets. Compared with information only control group	111 (13%) completed follow-up, had complete data and were included in the analysis; prevention of post-partum depression did not differ significantly between groups; benefits of the intervention were higher for pregnant women reporting higher levels of depressive symptoms (p=0.023)
Kishimoto et al (2016) ⁵¹	China	Controlled trial with use of propensity scores to account for non-randomisation; 8 week intervention	197 participants (73% female) with social anxiety disorder or elevated social anxiety symptoms	Internet-based cognitive behavioural therapy self-help programme for social anxiety disorder adapted for Chinese population; the 8 week programme consists of eight text-based information modules and homework assignments; therapist provides minimal guidance using weekly motivational emails and email support; therapist-guided programme was compared with self-guided programme alone and a waitlist control group	94 (48%) participants completed follow-up assessments; therapist-guided programme and self-guided programme contributed to improvement in social anxiety (p<0.001) and social phobia (p<0.001) compared with waitlist control group; no differences between therapist-guided and self-guided programmes; change in depressive symptoms did not differ between groups; therapist-guided and self-guided programme participants completed comparable numbers of programme modules
Knaevelsrud et al (2015) ⁵⁵	Iraq	RCT; 5 week study intervention and 3 month follow-up	159 participants (91% female) experiencing post-traumatic stress	Internet-based cognitive behavioural therapy intervention for post-traumatic stress disorder translated into Arabic; consists of two weekly online sessions delivered over 5 weeks, and structured writing assignments and text-based asynchronous communication with a therapist; compared with a waitlist control group	59% of participants completed follow-up assessments; significant reduction in post-traumatic stress symptoms compared with control group (p<0.001); treatment effects were sustained at 3-month post-intervention follow-up
Lara et al (2014) ⁴⁶	Mexico	Descriptive naturalistic study; 4 years	17 318 participants (84% female) who registered and accessed the programme two or more times (28 078 visitors to the website); 80% were aged between 18 and 40 years; 95% lived in Mexico City; and 65% had higher than high school education	Help for Depression is a free web-based psychoeducation, cognitive behavioural intervention based on face-to-face interventions for depression developed in Mexico; the programme includes seven self-help modules with symptom assessment, feedback for users, vignettes, recorded messages, relaxation exercises, workbooks, blogs, and a discussion forum	High attrition rate, 5% of users completed all seven modules; 65% used the workbook, 61% used the discussion forum of which 16% added a post, and 67% contributed to the blogs; the helpfulness and usefulness of the modules were rated as high; extensive positive exchanges within the forum including sharing personal experiences and feelings, providing advice or information, or emotional support; no harmful exchanges observed; participants appeared to benefit, and recommended improvements to user interface
Liu et al (2015) ⁵²	China and Malaysia	Descriptive, naturalistic study; 7 months	4709 Chinese-speaking individuals (62% female) at risk of depression or suicide	Internet-based Chinese-language depression and suicide screener that targeted people who search for depression or suicide information online. Individuals who reported high levels of depressive symptoms or any degree of suicidality received personalised feedback, referral to online suicide-prevention resources, and recommendations to consult with a mental health professional or go to a hospital	11 631 individuals visited the website and 4709 completed the screener; 89% reported not knowing of available mental health services where they lived; 49% screened positive for a current major depressive episode, of whom 78% reported never seeking help; 18% reported attempting suicide in the past 2 weeks, and were mostly women; feasible for identification and reaching of at-risk Chinese-speaking people
López et al (2014) ⁴⁷	Mexico	Pilot RCT; 3 month follow-up	66 participants with social anxiety	Internet-based psychoeducation programme for social anxiety based on cognitive behavioural therapy; the programme consists of three modules for evaluation, treatment and prevention; compared with face-to-face therapy and a waitlist control group	43 participants (61% female) completed the intervention and follow-up (65% retention); improvement in measures of anxiety in both active groups, and compared with the waitlist control (p<0.05); supports feasibility of this programme for use in Mexico
Mogoase et al (2013) ⁴⁹	Romania	Pilot RCT; 7 day intervention	42 undergraduate students (95% female) with depressive symptoms	Online concreteness training, involving cognitive skill exercises and relaxation techniques to overcome self-defeating thought patterns, for treatment of depression, consisting of daily writing exercises and questions related to positive or negative scenarios over a 7 day period; compared with waitlist control	Improvement in concreteness of thinking (more specific and positive thought patterns) compared with the control (p<0.001); no effect on depressive symptoms or rumination; does not seem to be effective as stand-alone treatment for depression
Moritz & Russu (2013) ⁵³	Russia	Pilot RCT; 4 week intervention	72 participants (54% female) with obsessive-compulsive disorder	Online Russian-language cognitive behavioural therapy self-help intervention for obsessive-compulsive disorder; consists of online materials to learn association splitting techniques; compared with waitlist control	48 participants (67%) completed follow-up assessments; significant improvement in obsessions (p<0.05) and depression (p<0.05) compared with the control group; highlights feasibility and effectiveness of online intervention for Russian-speaking participants
Plata et al (2014) ⁴⁸	Mexico	Pilot feasibility study; 6 month follow-up	Eight participants (75% female) with depression	Online cognitive behavioural intervention for treatment of depression, consisting of 16 weekly sessions focused on problem solving, cognitive reframing, emotional expression, and self-esteem	Improvement in anxiety and depressive symptoms after treatment; improvements maintained at 6-month follow-up; participants were satisfied with the online intervention

(Table 4 continues on next page)

	Countries	Study design and duration	Participants	Intervention	Outcome	
(Continued from previous page)						
	Tulbure et al (2015) ⁵⁰	Romania	RCT; 6 month follow-up	76 participants (41% female) with social anxiety disorder	Internet-based cognitive-behavioural therapy for social anxiety disorder consisting of nine weekly modules on behavioural strategies training; modules include writing exercises and questionnaires, a weekly social anxiety measure, and access to an online psychologist; compared with waitlist control	Significant reduction in social anxiety symptoms ($p<0.01$), social phobia ($p<0.01$), depressive symptoms ($p<0.01$), and negative emotions ($p<0.01$) compared with the control group post-intervention; most symptom reductions were maintained at 6 months except for social anxiety and depressive symptoms; participants reported satisfaction with the online treatment
	Wagner et al (2012) ⁵⁶	Iraq	Pilot study; 5 week intervention	40 participants experiencing post-traumatic stress	Internet-based cognitive behavioural therapy adapted for Iraqi population and translated into Arabic; consists of two weekly 45 min writing assignments over a 5 week period; therapists participate in weekly supervision sessions and contribute to online supervision forum	15 participants (87% female) completed the intervention and follow-up period (38% retention); among completers, a significant reduction in post-traumatic stress symptoms was observed over time ($p<0.001$) and a significant reduction in symptoms of depression and anxiety ($p<0.001$); quality of life also improved over time ($p<0.001$)
	Wang et al (2013) ⁵⁷	China	RCT; 3 month follow-up	197 trauma survivors (103 from urban areas and 94 from rural areas; 78% female)	MyTrauma Recovery is an online self-help programme for trauma based on social cognitive theory; the 1 month programme consists of six modules with videos and educational materials on trauma, coping skills, social support, and relaxation techniques; compared with a waitlist control	Of participants from urban areas, 61 (59%) completed post-intervention and 34 (33%) completed 3 month follow-up assessments; of participants from rural areas, 90 (97%) completed post-intervention and 87 (93%) completed 3 month follow-up assessments; significant reduction in post-traumatic symptom severity was observed in the urban ($p=0.007$) and rural ($p=0.02$) groups; these positive findings were sustained at the 3 month follow-up assessments
	Xu et al (2015) ⁵⁸	China	Pilot RCT; 1 month follow-up	82 participants (75% female) who have experienced a traumatic event and had post-traumatic stress symptoms	MyTrauma Recovery is an online self-help programme to help people cope with post-traumatic stress disorder; the 1-month programme consists of six modules with videos and educational materials on trauma, coping skills, social support, and relaxation techniques; compared with a waitlist control	50 (61%) participants completed 1 month assessments; post-traumatic stress disorder symptoms decreased in the intervention compared with the control ($p<0.001$); significant improvement in social acknowledgement ($p=0.007$) and disclosure of trauma ($p=0.02$) compared with the control group

RCT=randomised controlled trial.

Table 4: Studies evaluating online self-help programmes for individuals with mental disorders

promote mental wellbeing among individuals residing in both high-income and lower income countries.⁵⁴

We also found four studies of online programmes targeting victims of trauma in Iraq^{55,56} and China.^{57,58} The online programme delivered in Iraq was adapted from an evidence-based programme and translated into Arabic. Two studies showed the effectiveness of this programme in reducing symptoms of post-traumatic stress disorder and highlighted the potential of use of technology to support individuals in conflict zones.^{55,56} In China, online programmes were effective at reducing symptoms of post-traumatic stress disorder⁵⁷ and facilitating coping skills⁵⁸ among victims of trauma. An online programme for Chinese-speaking populations was also used to identify individuals at risk of suicide or depression, deliver suicide prevention content, and support coping among these individuals.⁵² These studies offer promise for use of online platforms to provide on-demand support for individuals with mental disorders, but efforts are needed to identify effective strategies to promote programme engagement and prevent attrition.

Six studies⁵⁹⁻⁶⁴ used telephone support or online self-help programmes targeting alcohol use and other substance misuse (table 5). Telephone-based brief motivational interventions were effective for reducing

alcohol consumption compared with standard print materials in Brazil⁵⁹ and Thailand.⁶⁰ In Brazil, an online self-help programme was effective for reducing alcohol consumption among harmful or hazardous users and users with suggested dependence, although programme adherence was low.⁶¹ In another study from Brazil,⁶² an online motivational intervention for preventing general substance misuse was as effective at reducing use of alcohol, cannabis, and other drugs as a face-to-face version of the same intervention. A 6 month telephone-based brief motivational intervention from Brazil was effective at promoting cannabis cessation among individuals who completed the programme; however, attrition rates were high.⁶³ Low participation and high attrition were likewise observed in an online substance misuse prevention programme from Uruguay, although email and SMS text-message reminders were able to improve engagement with the intervention.⁶⁴ Future studies are needed to determine the effectiveness of digital substance-misuse prevention programmes and to address challenges associated with high attrition in these programmes.

Discussion

The studies identified in this narrative Review supported the feasibility and acceptability of digital technology for

	Country	Study design and duration	Participants	Intervention	Outcome
Andrade et al (2016) ⁶¹	Brazil	Prospective naturalistic study; 6 week intervention	929 participants (46% female) classified as low-risk users (34%), harmful or hazardous users (32%), or suggestive substance users (34%)	Bebermenos is a web-based self-help programme for alcohol use supported by WHO. Includes alcohol use self-monitoring, goal setting with automated feedback, exercises to handle relapse and risky situations, weekly email reminders and progress reports, and support available in discussion forums	214 (29%) participants completed 6 week follow-up; reduction in alcohol consumption among harmful or hazardous users (63%) and suggestive substance misusers (65%) compared with baseline (p=0.02); overall programme adherence was low, but was higher among harmful or hazardous users than among low-risk users
Balsa et al (2014) ⁶⁴	Uruguay	Descriptive naturalistic study; 3 month intervention	359 adolescents (50% female) in ninth and tenth grade	COLOKT is a web-based substance misuse prevention intervention implemented in ten private schools in Montevideo; the programme consists of educational materials, discussion forums mediated by a psychologist, and reminder SMS and emails	Participation was low, 74 (21%) participants used the website at least once, mainly because of disinterest in the subject; predictors of website use included greater weekly internet use, prior use of the internet to search for health-associated topics, fewer extracurricular activities, and excessive alcohol consumption in the past month; email and SMS reminders increased interaction with the website
Christoff and Boerngen-Lacerda (2015) ⁶²	Brazil	Three arm RCT; 3 month intervention	333 college students (58% female)	Computer-based and online screening and motivational intervention to raise awareness of the risks of substance misuse, give advice, teach coping skills, encourage behavioural change, and obtain participant self-reports; compared with face-to-face version of the intervention, and screening only control condition	Reduction in substance misuse scores for tobacco, alcohol, marijuana, and other drugs observed across all three groups (p<0.001); students in the online computer intervention group had a greater reduction in alcohol use than did those in the screening only control group (p<0.007); online computer intervention does not seem to be more effective than a face-to-face intervention or screening alone
Fernandes et al (2010) ⁶³	Brazil	RCT; 6 month follow-up	1744 participants (26% female) who self-reported marijuana use and who called a toll-free number	Brief motivational intervention delivered by telephone for marijuana cessation and relapse prevention; aims to promote motivation and self-efficacy to stop using marijuana, create strategies to prevent relapse, and set a quit date; control condition received printed self-help materials	524 (30%) participants completed the 6 month intervention and follow-up assessments; per-protocol analysis of completers showed that telephone-based brief motivational intervention contributed to greater self-reported marijuana cessation (73%) compared with the control condition (59%; p<0.05)
Wongpakaran et al (2011) ⁶⁰	Thailand	Pilot RCT; 6 week study and 18 week follow-up	60 individuals (15% female) with alcohol misuse	Telephone-based intervention involving motivational interviewing and supportive techniques; consists of weekly telephone therapy sessions for 6 weeks; compared with control group that received weekly print materials by mail	56 (93%) completed 18 week follow-up; significant reduction at 6 weeks in mean amount and frequency of alcohol consumption compared with control (p<0.01); fewer days drinking compared with control (p<0.001); and 37% reduced alcohol consumption compared with 12% in the control group (p<0.001); outcomes sustained at 18 week follow-up; no change in depression, anxiety, or self-esteem between groups
Signor et al (2013) ⁵⁹	Brazil	RCT; 6 month follow-up	637 self-reported alcohol users (29% female) who called a national helpline to stop drinking	Telephone-based brief motivational intervention for treatment of alcohol misuse, that includes a 20 min motivational call and follow-up questionnaires; both groups received printed materials and follow-up calls at days 1, 3, and 7, and months 1, 2, 3, and 6 after alcohol cessation date	147 (23%) participants completed 6 month follow-up; intention-to-treat analysis at 6 months found that 46 (58%) brief motivational intervention participants compared with 34 (42%) control participants had stopped consuming alcohol (p<0.05)

SMS=short message service. RCT=randomised controlled trial.

Table 5: Studies evaluating programmes for substance use prevention and treatment

treatment and prevention of mental health and substance-misuse disorders in low-income and middle-income countries. Numerous studies also showed the potential effectiveness of online, text-messaging, and telephone support interventions, and pilot studies described preliminary results of technology interventions delivered in both clinical and community settings. However, many studies were not rigorously designed trials and did not have adequate comparison conditions. Few studies reported costs, which is a notable limitation in view of the promise that emerging technologies could make mental health care more affordable. Large-scale effectiveness studies of digital technology interventions are necessary, with emphasis on the cost-effectiveness and costs of implementation of these interventions. Careful consideration of programme fidelity is also important to ensure that target users receive, engage with, and benefit

from technology interventions as intended. For example, to facilitate acceptance and sustainability of technology interventions for mental disorders, specific design elements, such as programme interface or content, could accommodate local cultural perceptions and customs from different regions. These combined efforts might advance the scale-up of mental health treatment and prevention across low-resource settings. Additionally, continued feasibility and acceptability studies are necessary to develop new ways of using technology to treat the most at-risk individuals with mental disorders.

Our Review has some limitations. This was a narrative review with the primary aim of providing a broad overview of the feasibility, acceptability, and potential effectiveness of technological interventions. Therefore, we did not assess intervention effects for specific mental disorders or by different types of delivery systems or across different

settings. Formal meta-analyses by type of mental disorder will be necessary to draw conclusions regarding the effectiveness of technological interventions in low-income and middle-income countries. Additionally, we included a wide range of study designs that reported varying types of outcomes, and as a result we did not do a formal assessment of study quality or risk of bias. However, we can still draw important insights regarding unique advantages that technology might offer for addressing gaps in global mental health care.

Digital technologies can potentially extend mental health workforce capacity and reach. We found that technology can support treatment and clinical care,^{32–35,41–43} connect patients or community providers with mental health specialists,^{12–18} and can be used by non-medical health providers in local clinics for the diagnosis and detection of mental disorders.^{27–30} Online education programmes are promising tools for developing skills in mental health care among community health workers or other non-specialist providers working in community or primary care settings.^{21–25} Digital technologies could also extend the role of the small number of mental health specialists by facilitating the supervision and mentoring of non-medical care workers and coordinating delivery of mental health care. By connecting community health workers, lay providers, or volunteers with mental health specialists through online or mobile platforms, support, treatment recommendations, and professional development opportunities could be offered, while promoting workforce retention and satisfaction.

Digital technology might support efforts to reach traumatised individuals in conflict zones and other hard to reach areas. We noted that an online intervention could support traumatised individuals in Iraq.^{55,56} Effective treatment of individuals with mental disorders in conflict or disaster zones is extremely difficult; however, if individuals in conflict or disaster zones, or displaced populations such as refugees or asylum seekers, are able to maintain access to a mobile phone, delivery of evidence-based mental health services might be possible. This approach has potential for considerable impact: in 2014 the UN Refugee Agency estimated that nearly 60 million people were forcibly displaced worldwide—more than at any other time in history.⁶⁵ This estimate includes roughly 19·5 million refugees, of whom over 86% reside in low-income and middle-income countries, and an additional 38·2 million internally displaced individuals who have been uprooted from their homes and forced to live elsewhere in their home country because of conflict or other crises.⁶⁵ In Syria, for example, nearly half of the population has been displaced since 2011, and individuals affected by the conflict are at elevated risk of trauma, emotional distress, and other anxiety disorders.⁶⁶ The conflict has made delivery of adequate mental health care to these individuals almost impossible, in view of the destruction of infrastructure and violence. A survey of Syrian refugees in Turkey found that nearly half were

interested in receiving mental health services through telepsychiatry⁶⁷ and, lately, efforts have focused on the use of technology to reach Syrian refugees in Jordan.⁶⁸ In view of the elevated burden of untreated mental disorders among refugees, and the long-term consequences on functioning and community participation, efforts are urgently needed to evaluate online cognitive behavioural therapy programmes, SMS text-messaging support, and mobile screening tools for identification of individuals at greatest risk and delivery of effective treatments to refugee populations in diverse settings.

Digital technology might play a crucial role in mobilising efforts to address the mental health needs of youth and young adults aged 10–24 years. For young people, mental disorders that are untreated early on can have devastating consequences across the lifespan, such as greater social isolation and victimisation, increased risk of suicide or substance misuse, higher rates of criminality, and inability to pursue work, education, or family commitments.^{69,70} Nearly 90% of young people worldwide live in low-income and middle-income countries.⁷¹ The extent of unmet mental health needs among young people in these settings is staggering, and some low-income countries have no available services for youth mental health.⁶⁹ Numerous social challenges also exist, including intimate partner violence, sexual abuse, stigma and discrimination, and poverty.⁷⁰ However, young people are quick to adopt new technologies, and they use mobile devices and social media more frequently than individuals from older age groups, even in many low-resource settings.^{72–74} A 2015 study⁷⁵ surveyed over 4500 young people from Ghana, Malawi, and South Africa, and found that these individuals frequently used their mobile devices in the event of sickness, personal health crises, or in response to the health concerns of a friend or relative. Many respondents used their mobile devices to contact other household members, friends, or neighbours to seek advice, recommendations, or support.⁷⁵ In South Africa, where stronger network coverage is more widely available than in Ghana and Malawi, many respondents also used their mobile devices to access the internet to research health conditions and for other health purposes.⁷⁵ These findings suggest that young people in low-resource settings not only have access to mobile devices, but also might rely on these devices to seek informal support for their health-care needs in the absence of readily available services. Therefore, opportunities might exist to reach young people through familiar online platforms and mobile devices to deliver targeted programmes aimed at addressing their mental health needs.

Digital technologies could help empower individuals with mental disorders and their families to take charge of their own care and to support each other. We have observed this process, described as online peer-to-peer support, unfold on social media websites such as Facebook, whereby individuals with highly stigmatised mental illnesses connect with each other, provide support,

challenge stigma, and share personal strategies for coping with symptoms.⁷⁶ The risks of social media for individuals with mental disorders must also be carefully considered, such as obtaining advice from peers with unknown credentials, exposure to online harassment, or encountering online forums that are supportive of self-harm or other destructive behaviours. Online support networks might enable individuals with stigmatised mental health conditions to feel less alone and to find support from others with the shared experience of living with mental illness, regardless of international borders, time zones, or access to care. As families assume much of the social and economic burden of providing care to relatives with mental disorders,⁵ the potential for family members to access important resources such as social support, recommended coping strategies, and self-help programmes through online communities should also be considered. With over 2 billion social media users worldwide and the most rapid growth in access and use occurring in low-income and middle-income countries,¹⁰ efforts are needed to explore how these online platforms could be leveraged to improve the treatment, care, and support available to people with mental disorders. Research from high-income countries suggests that the benefits of interaction within online networks outweigh potential risks for people with mental disorders, although future research is needed to assess the effect of online patient communities on objective and meaningful outcomes associated with functioning and mental wellbeing in everyday life.⁷⁶

As digital technologies become embedded within societies and cultures worldwide,⁷⁵ opportunities will arise to leverage these technologies for advancing global mental health care.⁹ Technology could be the driver rather than the facilitator of change to mental health care delivery in low-income and middle-income countries. In resource limited settings, where health-care systems are fragmented and available care is unequally distributed, the need to develop costly psychiatric care practices and inpatient services could be reduced by offering direct-to-consumer programmes for mental health care delivered through mobile devices. Technology could represent a way for millions of people to gain access to urgently needed mental health care, improving the reach of highly trained providers of specialty mental health care.

Substantial work needs to be done to determine the effectiveness of mobile or online approaches for treatment of mental disorders across diverse settings and among different cultural and ethnic groups. Digital technology for mental disorders in low-income and middle-income countries is a nascent field of research, and more rigorous controlled effectiveness studies are needed to evaluate potential clinical, social, and economic benefits of these interventions. The studies included in this Review show that diverse technologies could contribute to promising clinical benefits, including symptom remission and improved functioning, although

more research is needed to assess potential social benefits, such as employment, increased productivity, and ability to care for and attend to family or community responsibilities. Assessment of the economic benefits potentially afforded by these technologies is also necessary, such as helping individuals with mental disorders avoid lengthy and costly travel to centrally located mental health clinics, or alleviating out-of-pocket expenses for mental health care encountered by patients and families. Limitations and risks of digital technologies should also be explored further. Important risks and concerns might exist among some population groups with regard to sharing mental health information or substance misuse problems online. Furthermore, technology interventions might have the unintended consequence of widening inequalities in mental health care between individuals who have access to mobile devices or the internet and those who do not.

Despite the potential benefits afforded by emerging technologies, many individuals will remain without access. Those without access might include individuals in the most impoverished settings, women who have less access to mobile devices than men, individuals in rural areas without electricity or reliable network coverage, and those living in regions without access to mobile phones or the internet because of governmental policies and strict regulation of telecommunications sectors.⁷⁷ Innovative ways to overcome structural and social barriers to reach the most isolated and susceptible individuals with mental disorders should be considered, because such individuals are likely to be in the greatest need of services, but face the greatest challenges accessing mobile or online interventions. Although digital technology represents a highly promising

Search strategy and selection criteria

We submitted our protocol for this narrative Review to the Prospero International prospective register of systematic reviews (registration number CRD42015027179). Our initial intention was to do a systematic review; however, we elected to do a narrative review because potentially eligible studies used varying study designs, enrolled highly diverse target populations with a wide range of mental disorders, and reported heterogeneous outcomes. A systematic review would have required greater consideration of intervention effectiveness and synthesis of outcomes. Therefore, we considered a narrative review an ideal approach for addressing our primary study objective. Additionally, a narrative review allowed for greater discussion of important areas in which we believe that digital technology could yield considerable gains towards addressing the global burden of mental disorders.

We searched MEDLINE, Embase, Cochrane Central, PsychINFO, CINAHL, ScIELO, and Web of Science for studies published from the inception of each database to Aug 31, 2016.

We also searched Google Scholar and reference lists of included studies. We applied no language restrictions. Search terms for “mental disorders” and “technology” and “low-income and middle-income countries” were combined. Many studies were preliminary and involved pilot evaluations, recruited diverse population groups, used varying study designs, and reported wide-ranging outcomes. Therefore, a meta-analysis of quantitative findings was not possible.

collection of approaches that could be used in combination with existing face-to-face programmes to support community health providers, or to directly reach individuals with mental disorders, technology should not be considered the only solution for addressing the global burden of mental disorders. Technology might help to bridge the gap between individuals with mental disorders in need of treatment and those who receive treatment, but will not replace the need for progressive leadership, human resources, and the political will to make mental health a public health priority. Continued efforts will be needed to ensure the availability of affordable and effective medications, well trained community providers to coordinate care, and mental health specialists to provide supervision and to meet the needs of patients with the most complex disorders. Importantly, public policies should be aimed at protecting the human rights and dignity of individuals living with mental disorders. Digital technologies represent tools that clinicians, researchers, and policy makers must embrace to advance efforts to support and treat individuals with mental health and substance-misuse disorders in low-income and middle-income countries.

Contributors

JAN completed the literature search, compiled the tables and figures, and wrote the first draft. JAN, RA, and VP outlined the aims and purpose of this narrative review. JAN, LAM, and SJB reviewed the search criteria, studies for inclusion, and preliminary data tables. VP reviewed the study protocol and final list of included studies. JAN completed data extraction and constructed the tables. KAA reviewed the study protocol, list of included studies, and the data included in the summary tables. KAA, RA, LAM, JU, VP, and SJB contributed to the revision of multiple drafts. All authors reviewed the final list of included studies, contributed to the structure and ideas presented in this manuscript, and reviewed and approved the final version. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Declaration of interests

LAM received grants from the US National Institutes of Health, National Institute on Drug Abuse, during the completion of this Review, and grants from HealthSim and Square2 outside of the submitted work. JAN, RA, VP, SJB, KAA, and JU declare no competing interests.

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