

Review

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Digital mental health interventions for treating mental disorders in young people based in low- and middle-income countries: A systematic review of the literature

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Abstract

Young people (YP) (between 10 and 24 years) are disproportionately vulnerable to developing and being affected by mental health conditions due to physical, social and emotional risk factors. YP in low- and middle-income countries (LMICs) have poorer access to, and quality of, mental health services compared to those in high-income countries. Digital mental health interventions (DMHIs) have been proposed as tools to address this burden of disease and reduce the global treatment gap in youth mental health outcomes. This study aimed to examine the evidence for DMHIs for treating mental disorders in YP based in LMICs. To do this, the author searched academic databases (MEDLINE, PsycINFO, Embase and Web of Science) for primary studies on DMHIs targeting YP in LMICs. Preferred Reporting Items for Systematic Reviews and Meta-Analyses criteria were followed. The quality of the studies was assessed using the Critical Appraisal Skills Programme) framework. A narrative synthesis methodology was used to summarise and explain the findings. The authors identified 287 studies of which 7 were eligible in the final review. The authors found evidence of the effectiveness of multiple forms of DMHI (especially internet-based cognitive behavioural therapy) on anxiety and depression outcomes. Studies reported a lack of long-term benefits of treatment, high dropout rates, and did not include key geographical settings or data on cost-effectiveness. No studies were judged to be of high quality. This review highlights the available evidence showing that DMHIs can improve mental health outcomes for YP in LMICs, but due to the limited number of studies and lack of high-quality data, increased adoption and scaling up of digital interventions require more rigorous studies showing clinical effectiveness and ability to provide return on investment.

Impact statement

Young people have an increased vulnerability to mental health conditions, and those living in low- and middle-income countries face disproportionate barriers in accessing high quality mental health care. Given increasing digital connectivity in the global south, digital mental health interventions (DMHIs) show promise in improving mental health outcomes for these populations by circumventing key barriers to care. In this systematic review, we evaluate the quality and availability of evidence on the effectiveness of DMHIs for young people and use this to provide evidence-based policy recommendations to improve youth mental health outcomes. Our findings show evidence of the effectiveness of multiple forms of DMHI (especially internet-based cognitive behavioural therapy) on anxiety and depression outcomes. At the same time, our results show a lack of high-quality studies on the topic, characterised by high dropout rates, small sample sizes and insufficient data on the statistical significance of treatment effects and long-term benefits of treatment. Our findings highlight that DMHIs have the potential to improve youth mental health outcomes in these settings but given the lack of robust data, increased adoption of these technologies would require further research on the topic.

Introduction

Young people (YP) make up around a quarter (1.8 billion) of the world's population, with almost 90% living in low- and middle-income countries (LMICs), where they constitute up to 50% of the population (UNFPA, 2014). YP, defined as those aged 10–24 by the World Health Organisation (WHO), are disproportionately affected by mental health issues (WHO, 2024). Around 50% of mental health conditions start by age 14, and 75% by age 24, and around 1 in 5 adolescents experience a mental health condition each year (Kessler et al., 2005), resulting in over 250 million



YP globally having a mental health disorder (IHME, 2023). The Covid-19 pandemic and associated lockdowns have further exacerbated this burden (Racine *et al.*, 2021).

YP are especially vulnerable to mental health problems due to exposure to physical, emotional and social risk factors, such as pressure from peers to conform, exploration of identity, stigma, discrimination, lack of access to quality mental health services, poverty, abuse and violence (Patel *et al.*, 2007; WHO, 2020). Unfortunately, most mental illnesses among YP remain undiagnosed and untreated due to barriers to accessing and seeking care (Lehtimaki *et al.*, 2021; UNICEF, 2021). YP in LMICs are disproportionately affected by this burden, due to fragmented and lower-resourced healthcare systems, poverty, stigma, lack of government policy, inadequate funding and a paucity of trained clinicians (Kieling *et al.*, 2011; Rathod *et al.*, 2017; Wainberg *et al.*, 2017). The mental health treatment gap, defined as the difference between the number of people who need care and those who receive it (Jansen *et al.*, 2015), is particularly significant for YP in LMICs, reaching rates of up to 90% (The WHO World Mental Health Survey Consortium, 2004; Duarte *et al.*, 2022).

Digital mental health interventions (DMHIs), defined as ‘information, support and therapy for mental health conditions delivered through an electronic medium with the aim of treating, alleviating or managing (mental health) symptoms’ (Torous *et al.*, 2021), are a viable alternative to face-to-face mental healthcare. These interventions can be delivered via multiple platforms, such as smartphone apps, online programmes, text messaging, telepsychiatry and wearable devices such as smart watches (Carter *et al.*, 2021). Although YP living in LMICs have limited access to mental healthcare, many have access to digital technologies (WHO, 2020), at increasingly younger ages (Kardefelt Winther *et al.*, 2019). Given that wireless connectivity in LMICs is becoming more widely available (The World Bank, 2024), and that smartphones are becoming cheaper, people in LMICs are increasingly able to access the internet (Kemp, 2020), making DMHIs a feasible solution to this treatment gap.

Effective DMHIs have the potential to help address the global inequality in the provision of mental health services, providing greater accessibility, acceptability, affordability, confidentiality and flexibility, leading to improved access to care (Wallin *et al.*, 2016). By meeting the WHO criteria for YP-friendly interventions, namely availability, accessibility, equitability (e.g., non-judgmental care), acceptability (e.g., provision of confidential and youth-centred care) and appropriateness (Mazur *et al.*, 2018), DMHIs can improve YP’s empowerment, participation and help-seeking behaviours (Shortliffe, 2016). Additionally, they could counter mental health stigma and provide safe and confidential care in cases where YP may fear social isolation or other inhumane responses to their mental illness (Semrau *et al.*, 2015).

Despite their potential, there is limited research on DMHIs in LMICs, potentially due to researchers and clinicians prioritising clinical care over research output in resource-scarce healthcare systems (Kar *et al.*, 2020; Lehtimaki *et al.*, 2021). Additionally, there is a lack of governance and regulation over the use of DMHIs to improve YP’s mental health in LMICs (Petersen *et al.*, 2017). These barriers may prevent the development, implementation and evaluation of such interventions in LMICs.

Until recently, DMHIs have mainly been developed for and used in high-income countries (HICs), where they have been found to be effective at reducing symptoms of mental health conditions such as depression (Firth *et al.*, 2017), psychosis (Gire *et al.*, 2017) and other severe mental illnesses (Naslund *et al.*, 2015), while also improving medication adherence (Rootes-Murphy *et al.*, 2018). Evidence of

their effectiveness in LMICs is scarce (Larsen *et al.*, 2019), limiting their applicability in these settings (Henrich *et al.*, 2010). To understand opportunities for DMHIs for YP in LMICs, it is therefore essential to examine studies from these settings (Carter *et al.*, 2021), given the under-prioritisation of mental health research (Becker and Kleinman, 2013) and the lack of governance and regulation around DMHIs (Petersen *et al.*, 2017).

Aims and objectives

To respond to the opportunities offered by DMHIs for YP in LMICs, comprehensive identification and assessment of the available evidence base is required. However, no literature reviews were found investigating this topic. Therefore, the overall aim of this review is to examine the evidence for DMHIs for treating mental disorders in YP in LMICs.

The specific objectives of the review are to:

1. Evaluate the clinical effectiveness of DMHIs on mental health symptoms for YP in LMICs.
2. Assess the availability and quality of the current evidence on DMHIs focusing on YP’s mental health outcomes based in LMICs.
3. Provide practice and research recommendations for the use of DMHIs focusing on YP’s mental health outcomes based in LMICs.

Methods

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) reporting criteria were followed (Page *et al.*, 2021).

Eligibility criteria

Eligibility criteria for this study (Table 1) were based on a modified version of the Population, Intervention, Control, Outcome framework (CRD, 2009; Methley *et al.*, 2014).

Search strategy and selection criteria

The review was conducted using a predefined protocol based on the PRISMA reporting criteria (Page *et al.*, 2021), with key stages being identification, screening, assessing eligibility and inclusion of studies (Figure 1). JA conducted an electronic review of the literature from the MEDLINE, Embase, Web of Science and PsycINFO databases, based on recommendations from the London School of Hygiene & Tropical Medicine (LSHTM) library staff (Table 2). DC re-ran all the searches as the second reviewer to minimise bias. JA and DC also hand-searched reference lists of all identified full text studies to manually identify relevant publications.

The authors used a combination of keywords such as (“digital,” “mHealth,” “eHealth,” “web-based,” “internet-based,” “mobile phone,” “text message,” “SMS,” “artificial intelligence”) AND (“adolescen*,” “youth” “young,” “child,” “student”) AND (“mental health,” “wellbeing”). An LMIC filter was used to select relevant studies. For a full list of search terms, please see Supplementary Material S1.

Identified references were screened by JA by conducting an abstract and title search based upon the eligibility criteria (Table 1). Full texts were assessed for final inclusion by JA. This process was repeated by the second reviewer (DC), reaching the same conclusions.

Table 1. Eligibility criteria for studies

| | Inclusion criteria | Exclusion criteria |
|--------------|--|--|
| Population | <ul style="list-style-type: none"> Average age of participants between 10 and 24 years (as per WHO definition of YP; WHO, 2024) Participants diagnosed with specific mental health conditions (as per ICD-11 criteria; WHO, 2023) and/or participants reporting generalised mental health outcomes (e.g., psychological distress, functioning/functional disability, quality of life and locally defined mental health outcomes) Mental health conditions are the primary disorders in the study | <ul style="list-style-type: none"> Average age <10 or >24 years. (Studies were also excluded if they included data from YP that were not disaggregated with data from other age groups.) Studies focus on the parents/carers of YP with mental health problems Mental health conditions are the secondary disorders in the study |
| Intervention | <ul style="list-style-type: none"> DMHIs defined as ‘information, support, and therapy for mental health conditions delivered through an electronic medium with the aim of treating, alleviating or managing (mental health) symptoms’ (Torous et al., 2021) All study types including randomised controlled trials, pilot trials, case control studies and naturalistic studies Primary data DMHI is the main component of intervention Interventions aim at treating YP with mental health conditions | <ul style="list-style-type: none"> Trial protocols, opinion pieces, case studies, qualitative content analysis, clinical guidelines and literature reviews Secondary data Digital intervention is not the main component of the intervention Intervention is not digitally based Interventions aim at screening/preventing mental health conditions rather than providing treatment |
| Control | <ul style="list-style-type: none"> Active control (e.g., non-digital intervention) or passive control (e.g., placebo/waitlist control/no treatment) | |
| Outcome | <ul style="list-style-type: none"> Clinical effectiveness of mental health interventions (measured using validated scales, e.g., depression scales such as PHQ-9, or anxiety scales such as GAD-7) | <ul style="list-style-type: none"> Other outcome measures e.g., feasibility, acceptability |
| Setting | <ul style="list-style-type: none"> LMICs (as per World Bank criteria for 2023; The World Bank, 2023) | <ul style="list-style-type: none"> HICs (as per World Bank Criteria for 2023; The World Bank, 2023) |
| Publication | <ul style="list-style-type: none"> Published in academic journals English language No time limits were applied | <ul style="list-style-type: none"> Grey literature Non-English literature |

Abbreviations: DMHI, Digital Mental Health Intervention; GAD-7, general anxiety disorder-7; HICs, high income countries; ICD-11, international classification of diseases 11th revision; LMIC, low- and middle-income country; PHQ-9, patient health questionnaire-9; YP, young people.

Data extraction

JA extracted data from the studies, using a data extraction form (Table 3). Data were collected on the study context; population group; outcome(s) of interest; methods (sample size, study design,

intervention type, control group, theoretical approach); targets (inclusion/exclusion criteria, participant characteristics); intervention (mental health issues addressed, technological approaches used, study setting, number of sessions, content, presence of mental health support) and impacts (evaluation methods, primary/secondary outcome measures and key findings).

As only randomised control trials (RCTs) were identified, JA used Critical Appraisal Skills Programme’s (CASP’s) RCT criteria as a validated quality assessment framework to appraise the quality of identified studies (see [Supplementary Material S2](#)) (CASP, 2020). CASP was selected over other assessment tools as it focuses on study validity, results and clinical relevance, which align with the review’s objectives (CASP, 2020). We utilised Vogel’s (2013) criteria to evaluate the quality of studies, categorising them as high, medium or low quality. Although we initially planned to exclude any study identified as “low quality,” none met this criterion upon evaluation. Consequently, all studies were included in the analysis.

Data synthesis

A descriptive analysis was conducted, based on the study objectives. Due to the expected heterogeneity of the included interventions, outcome types, measures and study designs, a quantitative synthesis (meta-analysis) of the findings was not deemed appropriate. JA therefore synthesised evidence from the articles describing the clinical effectiveness of DMHIs using a narrative synthesis approach.

Results

Selection of included studies

The initial search yielded 283 results. After excluding duplicate references, the number of articles was reduced to 166. The manual search yielded an additional four articles for eligibility assessment. A total of seven articles were finally included (Wannachaiyakul et al., 2017; Moeini et al., 2019; Ofoegbu et al., 2020; Osborn et al., 2020; Salamanca-Sanabria et al., 2020; Newman et al., 2021; Sun et al., 2022) (see [Figure 1](#) for PRISMA flowchart [Page et al., 2021]).

Characteristics of included studies

Details of the final seven eligible studies are provided in [Table 3](#). The studies were all conducted between the years 2017 and 2022 in five geographic regions (Africa n = 2, Southeast Asia n = 2, South Asia n = 1, South America n = 1, Middle East n = 1). The mean age of participants varied from 16.2 (Moeini et al., 2019) to 24.21 years (Ofoegbu et al., 2020). Several studies were based in universities (Ofoegbu et al., 2020; Salamanca-Sanabria et al., 2020; Newman et al., 2021; Sun et al., 2022); however, other settings such as schools (Moeini et al., 2019), high schools (Osborn et al., 2020) and a youth detention centre (Wannachaiyakul et al., 2017) were also studied. All studies used a RCT design. Three studies were specifically focused on depression, and four studies on depression and anxiety. Notably, no studies were found evaluating DMHIs focussed on any other psychopathology. All but one study only included participants with mild–moderate symptoms, excluding those with severe symptoms or comorbidities.

Studies used different theoretical concepts to underpin interventions, such as mindfulness (n = 1), cognitive behavioural therapy (CBT; n = 5) and social cognitive theory (n = 1) All reviewed interventions were accessible from mobile devices or computers and

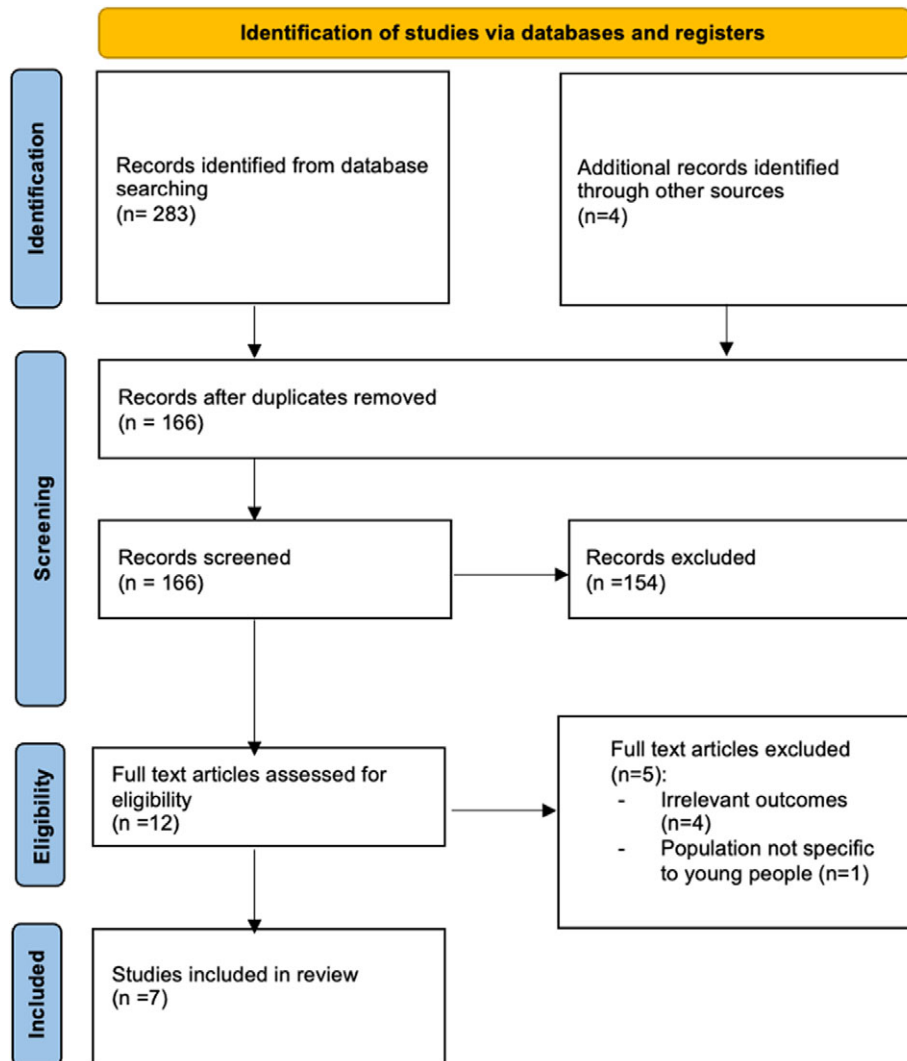


Figure 1. PRISMA flowchart.

Table 2. Number of articles found

| Name of journal | Number of articles found |
|-----------------|--------------------------|
| Medline | 99 |
| Psychinfo | 53 |
| Embase | 114 |
| Web of Science | 17 |

used internet-based platforms, except for a computerised platform evaluated by Wannachaiyakul *et al.* (2017). All identified interventions also involved either new content and/or adaptations of existing evidence-based psychosocial treatments. For example, Salamanca-Sanabria *et al.* (2020) culturally adapted an existing programme to create a Colombian version of internet-based CBT (iCBT), while Sun *et al.* (2022) used a popular Chinese social media platform (WeChat) to deliver a mindfulness intervention. Digital interventions included a range of content (e.g., challenging core beliefs, increasing knowledge about mental health, value affirmation exercises) using a range of multimedia options (e.g., videos, animations, presentations). All interventions were externally guided or supported. The interventions lasted

between a single session (Osborn *et al.*, 2020) and 6 months (Moeini *et al.*, 2019). Dropout rates in the intervention group ranged from 9% (Sun *et al.*, 2022) to 91% (Salamanca-Sanabria *et al.*, 2020). Two studies (Wannachaiyakul *et al.*, 2017; Osborn *et al.*, 2020) had no loss to follow-up. No studies reported on the cost-effectiveness or design elements of DMHIs.

Studies were found to have selection bias through loss to follow-up (e.g., Moeini *et al.*, 2019 reported a 30% drop out rate in the intervention group), and recruitment via self-selection (e.g., Osborn *et al.*, 2020 recruited all students who were interested in the study). Only three studies (Wannachaiyakul *et al.*, 2017; Moeini *et al.*, 2019; Newman *et al.*, 2021) reported sample size calculations, and six studies (Wannachaiyakul *et al.*, 2017; Moeini *et al.*, 2019; Osborn *et al.*, 2020; Salamanca-Sanabria *et al.*, 2020; Newman *et al.*, 2021; Sun *et al.*, 2022) had small sample sizes that may have led to underpowered results. Moreover, only four studies (Ofoegbu *et al.*, 2020; Osborn *et al.*, 2020; Salamanca-Sanabria *et al.*, 2020; Sun *et al.*, 2022) reported precision estimates. There may also have been an element of placebo or Hawthorn effect in some studies. For example, those in the (waitlist) control group in the Newman *et al.* (2021) study also experienced a statistically significant reduction in their anxiety scores.

Table 3. Included studies

| Author | Country | Sample size (n), study design, intervention type | Control group | Theoretical basis | Participant characteristics | Mental health outcome(s) | Platform | Setting | Frequency/duration of intervention | Content | Evaluation methods | Primary and (relevant) secondary outcome measures | Key findings (clinical effectiveness) |
|----------------------|---------|--|---------------|-----------------------------|---|--------------------------|---|------------|---|---|--------------------|--|---|
| Moeini et al. (2019) | Iran | n = 128 RCT Depression improvement programme (guided) | Not specified | Social Cognitive Theory/CBT | Mean age in the intervention and control groups were 16.2 and 16.5, respectively | Depression | Internet-based intervention | Schools | Eight 30-min sessions over 6 months. | 1) Modules on: awareness-raising, positive psychology, problem-solving, thoughts and feelings, relaxation, physical exercise and lifestyle modifications 2) Delivered via videos, animations and PowerPoint slides | ITT | Primary outcome: Depressive symptoms (measured using CES-D tool) | DMHI group reported a statistically significant ($p < 0.05$) improvement on the CES-D score at baseline (Mean = 22.6, SD = 10.9) to 12 weeks (Mean = 18.5, SD = 14.0). However, these results seem to have attenuated by 24 weeks (Mean = 19.5, SD = 10.9) |
| Newman et al. (2021) | India | n = 222 RCT Guided, Internet-based self-help intervention for GAD symptoms ('Lantern') | Waitlist | CBT | Mean age was 19.90 years, 153 males (68.9%), 68 females (30.8%), and one trans female | GAD, Depression | Internet-enabled computer, mobile phone or tablet | University | 3 month long intervention consisting of 40 10-min sessions) | Modules on: introduction to anxiety, automatic thoughts, cognitive reframing, introduction to behaviour change, imaginal exposure, situational exposure, mindfulness, and habit formation | ITT | Primary outcome measure: GAD symptom severity (measured using GAD-Q-IV) Secondary outcome measures: 1) Worry (measured using PSWQ) 2) Depressive symptoms (measured using DASS depression subscale) | 1) DHMI group experienced significant reductions on the GAD-Q-IV ($\beta = -3.27$, SE = .31, $Z = -10.44$, $p < .001$, $d = -1.96$), PSWQ ($\beta = -7.66$, SE = 1.73, $Z = -4.43$, $p < .001$, $d = -.62$), and DASS depression ($\beta = -3.65$, SE = .70, $Z = -5.24$, $p < .001$, $d = -.75$) 2) Participants in the control group experienced a statistically significant but smaller reduction on the GAD-Q-IV ($\beta = -1.94$, SE = .33, $Z = 5.91$, $p < .001$, $d = -.84$) and did not experience significant reductions on the PSWQ ($\beta = .37$, SE = 1.91, $Z = .20$, $p = .841$, $d = .03$) or DASS Depression ($\beta = .25$, SE = .79, $Z = .32$, $p = .753$, $d = .04$) |

(Continued)

Table 3. (Continued)

| Author | Country | Sample size (n), study design, intervention type | Control group | Theoretical basis | Participant characteristics | Mental health outcome(s) | Platform | Setting | Frequency/ duration of intervention | Content | Evaluation methods | Primary and (relevant) secondary outcome measures | Key findings (clinical effectiveness) |
|-----------------------|---------|--|-----------------------------------|-------------------|--|--------------------------|-----------------------------|-------------|-------------------------------------|--|--------------------|---|---|
| Ofoegbu et al. (2020) | Nigeria | n = 192 RCT Guided internet-assisted intervention (GIAI) | Usual care | CBT | Average age in treatment group 24.21 and non-treatment group 23.78 | Depression | Internet-based | University | 10 week intervention | Self-guided (videos, audios, and print materials for depression treatment) with support from therapists (twice a week) Sessions focussed on psychoeducation, interactive peer support, cognitive disputation, behavioural homework assignments, roleplay, and depression management | ANOVA | Primary outcome measure: Depressive symptoms (measured using BDI-II scale) | 1) Significant reduction in depressive symptoms among the participants in the treatment group when compared to their counterparts in the usual-care control group, $F(1111) = 254.56$, $p < .001$, $h2p \frac{1}{4}: 956$ 2) At follow-up (4 weeks post intervention) there was a significant reduction in depressive symptoms among participants in the treatment group compared to those in the usual-care control group, $F(1111) = 261.89$, $p < .001$, $h2p \frac{1}{4}: 960$ |
| Osborn et al. (2020) | Kenya | n = 103 RCT Digital single session intervention ('Shamiri') (guided) | Study-skills control intervention | Not stated | Not stated | Depression, anxiety | Internet-based intervention | High school | One session | Mindset, gratitude, and value affirmation exercises | ITT | Primary outcome measures: 1) Adolescent depressive symptoms (measured using PHQ-8 scores), 2) Adolescent anxiety symptoms (measured using GAD-7 scores) 2) Adolescent mental well-being (measured using WEMWBS 3) Happiness and Optimism (measured using EPOCH scale) Secondary outcome measures: 1) Depressive symptoms for the subsample with | 1) Compared to the control group, participants in the DMHI group experienced greater reduction in adolescent depression symptoms in both the full sample ($p = 0.028$, $d = 0.50$) and a sub-sample of youths with moderate-to-severe depression symptoms ($p = 0.01$, $d = 0.83$) from baseline to 2-week follow-up |

(Continued)

Table 3. (Continued)

| Author | Country | Sample size (n), study design, intervention type | Control group | Theoretical basis | Participant characteristics | Mental health outcome(s) | Platform | Setting | Frequency/duration of intervention | Content | Evaluation methods | Primary and (relevant) secondary outcome measures | Key findings (clinical effectiveness) |
|----------------------------------|----------|--|--|-------------------|---|--------------------------|--|------------|------------------------------------|---|--------------------|---|--|
| | | | | | | | | | | | | elevated depressive symptoms at baseline (PHQ-9) 2) Anxiety symptoms for the subsample with elevated anxiety symptoms at baseline (GAD-7) | 2) The DMHI had no significant effects on anxiety symptoms, well-being or happiness |
| Salamanca–Sanabria et al. (2020) | Colombia | n = 214 RCT Culturally adapted cognitive behavioural internet-delivered treatment (guided) | Waitlist control | CBT | Total average age 22.15 | Depression, anxiety | Internet-based intervention | College | 3 months of iCBT | Seven modules of CBT self-monitoring, behavioural activation, cognitive restructuring, and challenging core beliefs | ITT | Primary outcome measure: Depression (as measured by the PHQ-9) Secondary outcome measure: Anxiety (as measured by the GAD-7 questionnaire) | 1) PHQ-9: those in the treatment group showed statistically significant reductions in depressive symptom scores (p < 0.001) following treatment that were maintained at 3 month follow-up 2) GAD-7: significant differences in the GAD-7 score change recorded from baseline to posttreatment between the groups (p ≤ .03) in favour of the treatment group |
| Sun et al. (2022) | China | n = 114 RCT Mindfulness-based mobile health intervention (guided) | Time- and attention matched social support-based mHealth control | MBI | Mean age 22.21 years old. Majority female | Depression, anxiety | Internet-based delivery using apps (Zoom and WeChat) | University | Four weekly, 1 hour long sessions | Experiential and group learning of mindfulness, didactic learning about mindfulness and audio-based daily practice | ITT | Primary outcomes: 1) Anxiety (measured using GAD-7) 2) Depression (measured using PHQ-9) | 1) In terms of anxiety, a greater reduction was found in the intervention group from baseline to follow-up (proportion reduced from 63.2% to 9.6%), which was greater than the control group (57.9% to 27.7%). The difference between groups was statistically significant (p = .020) 2) Reduction of depressive symptoms in intervention group |

(Continued)

Table 3. (Continued)

| Author | Country | Sample size (n), study design, intervention type | Control group | Theoretical basis | Participant characteristics | Mental health outcome(s) | Platform | Setting | Frequency/duration of intervention | Content | Evaluation methods | Primary and (relevant) secondary outcome measures | Key findings (clinical effectiveness) |
|------------------------------|----------|--|------------------------------|-------------------|---|--------------------------|-----------------------|------------------------|--|--|---|--|--|
| | | | | | | | | | | | | | from baseline to follow-up (73.7% to 17.3%) compared to the control group (71.9% to 34.0%) was not statistically significant (p = .056) |
| Wannachaiyakul et al. (2017) | Thailand | n = 84 RCT Computerised CBT programme for reducing depression among YPs with delinquency problems (guided) | Usual activity control group | CBT | The mean age in the experimental and control groups were both 17.74 years. Most of participants were male; finished junior high school; in confinement for the first time; and involved in drug cases | Depression | Computerised platform | Youth detention centre | One session per week lasting 45–60 min for 6 weeks | Tasks focusing on learning about depression, mood monitoring and developing emotional literacy using case studies, interactive exercises and self-reflection | ANOVA, T test (did not specify if ITT/per protocol methods were used) | Primary outcome: Symptoms of depression (as measured by the PHQ-9) | Participants in the intervention group after entering the program, and 1 and 2 months after the intervention had significantly (p < 0.05) lower mean scores of depression than before receiving the programme. Additionally, those in the intervention group had a significantly lower mean score of depression than that of the control group immediately after completing the programme (p < 0.05) |

Abbreviations: ANOVA, analysis of variance; BDI-II, Beck's Depression Inventory; CBT, cognitive behavioural therapy; CES-D, centre for epidemiologic studies depression scale; DASS, depression anxiety and stress scale; DMHI, Digital Mental Health Intervention; GAD, generalised anxiety disorder; GAD-7, general anxiety disorder-7; GAD-Q-IV, generalised anxiety disorder questionnaire IV; HICs, high income countries; iCBT, internet-based cognitive behavioural therapy; ICD-11, international classification of diseases 11th revision; ITT, intention-to-treat analysis; LMIC, low- and middle-income country; MBI, mindfulness based intervention; mHealth, mobile health; PHQ-8, patient health questionnaire-8; PHQ-9, patient health questionnaire-9; PSWQ, Penn State Worry Questionnaire; RCT, randomised control trial; WEMWBS, Warwick-Edinburgh Mental Wellbeing Scale; YP, young people.

Effectiveness of DMHIs for depression and anxiety

Three studies focussed specifically on depression. Ofoegbu et al. (2020) evaluated a 10-week long internet-based intervention with Nigerian university students using CBT principles. They found significant reductions in depression scores ($p < .001$), which were maintained at 4-week follow-up ($p < .001$). Moeini et al. (2019) administered a web-based intervention to school children underpinned by social cognitive theory/CBT principles in Iran over 6 months. Statistically significant improvement in depressive symptoms between baseline and 12 weeks were found ($p < .05$). This improvement did not continue past 24 weeks. Wannachaiyakul et al. (2017) utilised a 6-week long computerised intervention with inmates at a youth detention centre in Thailand. They found that depression scores reduced after entering the programme, and at 1- and 2-month follow-up ($p < .05$).

Four studies addressed both anxiety and depression. Newman et al. (2021) evaluated a CBT-informed intervention for Indian university students with generalised anxiety disorder over 3 months. The intervention was associated with statistically significant reductions in anxiety ($p < .001$) and depressive symptoms ($p < .001$). Sun et al. (2022) administered a mindfulness-based digital intervention using apps to Chinese university students with depression and anxiety symptoms over 4 weeks. This digital intervention led to statistically significant reductions in anxiety ($p < .05$), but not in depressive symptoms. Salamanca-Sanabria et al. (2020) implemented a 3-month long CBT-based digital intervention among Colombian university students with depression. They found that treatment with iCBT led to significant reductions in depression ($p < .001$) and anxiety ($p < .05$) symptoms. Osborn et al. (2020) utilised a single session internet-based intervention on adolescents in a Kenyan high school. The intervention produced a statistically significant reduction in depressive symptoms from baseline to 2 week follow-up ($p < .05$), but not in anxiety symptoms. This was the only study to include those with moderate to severe depressive symptoms. Given the heterogeneity of included studies, comparing efficacy among interventions was not possible.

Quality assessment of included studies

The author assessed studies based on the CASP criteria (see Appendix 2) (CASP, 2020). All seven studies were judged to be of moderate quality. Aspects of the CASP criteria that studies performed well in were clearly addressing a focused research question ($n = 6$); detailing the method of randomisation ($n = 7$); accounting for loss to follow-up ($n = 5$); ensuring that both intervention and control groups were treated equally apart from the intervention ($n = 7$); ensuring comprehensive reporting of intervention effects ($n = 7$) and ensuring that the benefits of the trial outweighed the harms/costs ($n = 7$). However, areas of weakness included a lack of blinding of participants ($n = 3$); a lack of reporting around similarity between groups at the start of the trial ($n = 4$) and a lack of reporting on the precision of the treatment effect ($n = 4$).

Discussion

The present systematic review aimed to evaluate the clinical effectiveness of DMHIs on the mental health symptoms of YP in LMICs, assess the availability and quality of the current body of evidence on the topic, and provide practice and research recommendations for the use of DMHIs for YP in LMICs. With regard to the effectiveness of DMHIs, all studies included in this review reported statistically

significant improvements in YP's mental health outcomes. The use of the 'gold standard' RCT methodology in all identified studies supports confidence in their results. Notably, no studies were found reporting a worsening of symptoms, negative acceptability or dissatisfaction with DMHIs. However, this lack of negative findings may reflect publication bias favouring positive results. Future reviews could use a funnel chart to evaluate this. Regardless, we must apply caution when drawing conclusions from these studies, given the limitations of the studies reviewed.

No DMHIs identified in the review targeted other types of psychopathology aside from depression and anxiety. This is consistent with findings from a literature review focussing on DMHIs for adults in LMICs (Carter et al., 2021). All but one study excluded those with severe symptoms, comorbidities, and those on psychotropic medication, psychological treatment or displaying self-harm/suicidal ideation. These factors limit the generalisability of the findings in three ways. Firstly, symptoms that were excluded from studies such as suicidal ideation are common in YP with depression/anxiety (Avenevoli et al., 2015). By excluding these participants, study findings could only apply to a small subset of patients. Secondly, comorbid mental health conditions are common in YP (Angold and Costello, 1993), further limiting the target population for these studies. Thirdly, the study findings are not applicable to a significant proportion of YP with more severe mental health issues (Tsehay et al., 2020). The studies in this review also largely targeted university students, making it difficult to draw conclusions about the effectiveness of DMHIs for children and adolescents. The heterogeneity in intervention types, outcome measures and study durations limited the possibility of conducting a meta-analysis, which could have strengthened conclusions about DMHIs' effectiveness.

Considering the high recurrence rates and chronicity of common mental disorders, it is also vital to understand whether DMHIs have long-term effects (Koopmans et al., 2011). This review found that DMHIs were not always able to sustain improvements in mental health symptoms. Moreover, the lack of meaningful long-term follow-up periods found in this review (mostly under 6 months), similar to the findings from a review of studies on DMHIs in HICs (Lehtimäki et al., 2021), does not allow for a valid assessment of sustained treatment effects (Clarke et al., 2015). Despite the paucity of long-term data, a meta-analysis of HIC studies found three DMHIs showing significant improvements in depressive symptoms in YP after 6 months (Välimäki et al., 2017). However, the quality of data from HICs may be worse than that from LMICs. HIC studies were judged to have 'consistently low quality' in a large systematic overview (Lehtimäki et al., 2021), while no studies were judged to be of low quality in this review. Furthermore, a systematic review (Grist et al., 2017) identified key limitations in HIC studies that were similar to those found in this review, such as small sample sizes, limited participant blinding and recruitment via self-selection.

Although all studies included in this review reported statistically significant improvements in YP's mental health outcomes, the current review found varying effect sizes. This may be due to variations in recruitment strategy (Harith et al., 2022), as web-based recruitment generally shows larger effect sizes than subject pool recruitment (Harrer et al., 2019). Sun et al. (2022) (reporting a large effect size) recruited online, while Moeini et al. (2019) (reporting a small effect size) recruited via a subject pool. Those recruited online may already be more interested in DMHIs and could engage better with interventions than those recruited from a subject pool, leading to larger effect sizes.

Variation in effect size may also be influenced by participant adherence, as higher rates of adherence are generally associated with better treatment outcomes (Conley et al., 2016). Participants who adhere to an intervention may receive an increased ‘dose’ of an intervention leading to improved outcomes compared to those that drop out. The small effect size in the Moeini et al. (2019) study might therefore be related to the high dropout rate (30%) in the intervention group. Comparably to this review’s findings, literature from HICs reported low adherence and high dropout rates (Lehtimäki et al., 2021). Completion rates in this review varied from 9% to 100%, similar to completion rates of 10%–94% found in a systematic review of DMHIs in HICs (Välimäki et al., 2017). Notably, the two studies that reported no loss to follow-up in our review either used a single session intervention (Osborn et al., 2020) or an incarcerated population that may have had limited choice regarding participation (Wannachaiyakul et al., 2017). Although HIC data also show that loss to follow-up could be lowered by using supported interventions, this review’s findings showed that supported interventions can still report high dropout rates (Clarke et al., 2015).

Although intervention design may impact the effectiveness of DMHIs (Chandrashekar, 2018), it is difficult to evaluate the effectiveness of specific styles of intervention design in this review as none of the studies reported on specific design elements used. iCBT has been found to be as effective or more in treating YP’s anxiety and depression than traditional CBT in HICs (Ebert et al., 2015; Podina et al., 2016). This review’s outcomes support these findings. However, contrary to this review, Lehtimäki et al. (2021) found that apart from iCBT, there was inconclusive evidence for other types of DMHIs (e.g., mobile apps) in treating YP’s mental health issues in HICs. This could be because other digital interventions are highly tailored to the population group, country, and setting, which might have hindered appropriate comparisons between interventions.

HIC literature also supports the review’s findings on the lack of published data on DMHIs’ cost-effectiveness (Lehtimäki et al., 2021). This could act as a barrier to implementing DMHIs in LMICs, as decision-makers may be reluctant to invest in an intervention when return on investment is unclear. Moreover, given financial constraints in LMICs, proving that an intervention is cost-effective could be key to its implementation.

Recommendations for future research and practice in LMICs

This review confirms the clinical effectiveness of DMHIs for YP in low-resource settings. They are potentially cost-effective treatment options that could permit large-scale dissemination and reduce healthcare worker burden (De Kock et al., 2022). With most of the world’s social media users located in LMICs (Shewale, 2023), there is significant potential to use DMHIs to reach large numbers of YP and support mental health promotion efforts and service delivery in these settings (Naslund et al., 2020). However, despite the compelling evidence presented in this review, uptake and integration of DMHIs in health systems remains low, especially in LMICs (Torous et al., 2018). Moreover, framing DMHIs as innovative approaches may lead to inappropriate enthusiasm to develop and implement technological solutions over other forms of intervention (WHO, 2020), further exacerbating health inequalities.

As per WHO digital health system strengthening guidelines (WHO, 2019), careful evaluation of benefits and harms is vital to avoid negative impacts on LMICs. Digital interventions that are

incompatible with the needs and preferences of YP in LMICs may lead to inappropriate resource use, reduced clinical efficacy, and exacerbation of health inequalities (WHO, 2019). Given the digital divide between HICs and LMICs, the implementation of DMHIs without being coupled with campaigns (e.g., the United Nations’ Sustainable Development Goal [SDG] 9.c: “strive to provide universal and affordable access to the Internet in least developed countries by 2020”; [UN, 2015; UNDP, 2017]) to increase internet access may also exacerbate inequalities in access to mental health care and outcomes (UNICEF, 2017; ITU, 2023). Despite increases in global internet access and mobile phone use, connectivity in low-resource contexts still remains behind that of high-income contexts and international targets set under the Connect 2020 Agenda (ITU, 2014; UNDP, 2017; GSMA, 2022).

There are also inequalities in internet access within LMICs. For example, in low resource contexts, women, rural residents, older adults, persons with disabilities and those from lower socio-economic groups have the lowest rates of internet access (Naslund et al., 2019; GSMA, 2021, 2022). There are also regional and sub-regional inequalities in internet access within LMICs. For instance, sub-Saharan Africa has the lowest internet connectivity globally, and within this region, central Africa specifically has the lowest mobile broadband coverage on the continent (GSMA, 2022). Disparities in internet access between HICs and LMICs in addition to those within LMICs may therefore act as a barrier to the uptake of these technologies by vulnerable populations in low resource settings.

Given the digital divide in low resource contexts, opportunities for effective implementation of DMHIs in these settings may be maximised by equitably allocating resources (e.g., electricity, connectivity, and data) to address disparities in internet connectivity (ITU, 2021, Public Health Insight, 2023). Governments should deliver targeted policies to increase the uptake of DMHIs in underserved groups (e.g., increasing women’s internet connectivity through increasing access to digital resources, financial support and digital literacy skills; UNCTAD, 2023). Governments should also strategically align mental health care priorities with existing SDGs related to increasing internet access (ITU, 2021; Public Health Insight, 2023). For example, maximising access to technology (outlined in SDG 9) could also increase access to evidence-based mental health services (SDG 3) (UN, 2015; ITU, 2021; van Kessel et al., 2022; ITU and UNDP, 2023; Public Health Insight, 2023). By highlighting the co-benefits of digital health technologies, it may improve funding, roll out and implementation of innovative DMHIs in LMICs.

DMHIs may also increase the burden on healthcare staff. In this review, all identified interventions involved some level of external support. Although associated with improved treatment efficacy, implementation of an intervention with external support may be inappropriate in resource-constrained LMIC contexts (Grist et al., 2019). Investment in DMHIs may also be associated with an opportunity cost, potentially leading to reductions in funding to other elements of already strained LMIC health systems (WHO, 2019). Finally, given the lack of data on the cost-effectiveness of DMHIs, it is difficult to assess the financial burden of DMHIs on LMIC health systems (Lehtimäki et al., 2021). A potential method of minimising costs and maximising benefits to LMIC healthcare systems could be to use trained non-specialist helpers to reduce resource use while providing digital support, which may increase the intervention’s efficacy and adherence (Hoeft et al., 2018). A DMHI called ‘Step-by-Step’ created by

the WHO for adult Syrian refugees in Lebanon has already used this approach, leading to improvements in depressive symptoms (Cuijpers et al., 2022).

Although data show that some DMHIs are as effective as traditional mental health services (Karyotaki et al., 2017; Petersen et al., 2017), poor adherence may limit their efficacy in the real world. This review highlighted the low levels of treatment adherence in five studies, agreeing with HIC data (e.g., in their review, Andrews et al., 2018 found that iCBT adherence ranged from 6% to 100%). Notably, adherence also tends to be higher in research studies than in real-world scenarios (Baumel et al., 2019). Additionally, DMHI acceptability tends to be lower than that for traditional mental health services (Kaltenthaler et al., 2008). Strategies to improve YP's engagement could involve co-designing interventions with YP, as highlighted by WHO guidelines (WHO, 2020). Co-design could also be key to ensure user buy-in, and to ensure that digital technologies are contextually and culturally relevant, and are integrated and adopted effectively into health systems (Economist Impact, 2022; NHS Race and Health Observatory, 2023). Effective co-design should utilise a multidisciplinary and multisectoral approach involving ministries of health, clinicians, carers and YP with lived experience of mental health conditions to capture the broad range of stakeholders involved in the digital mental health ecosystem (WHO, 2020; Sanz, 2021).

Given the challenges identified above, there is a need for increased research on this topic. Specifically, more rigorous RCTs with larger sample sizes are needed to increase confidence in the clinical significance and power of results, and permit synthesis of high-quality evidence through meta-analysis. Future studies should have a broader geographic coverage (especially focussing on unrepresented areas such as from Oceania, the Caribbean or Central Asia). The scope of studies should also be increased. Studies should focus on a broader range of mental health interventions apart from iCBT. Future research should also include participants with a wider range of psychopathologies, symptom severity, comorbidities and on psychotropic medication to increase the generalisability of study findings and ability to implement findings in real-world healthcare settings.

The quality of studies could be improved by ensuring that studies report standardised effect sizes and statistical significance to allow for findings to be compared across studies and meaningful conclusions to be made. Studies should aim to reduce self-selection during recruitment, attempt to reduce loss to follow-up, and ensure that participants and researchers are blinded. Studies should also focus on neglected yet important aspects of DMHIs, such as reporting on intervention design to evaluate the impact of design elements on treatment efficacy, and cost-effectiveness to improve potential for implementation. Studies should also report follow-up periods and aim to produce long-term follow-up data by ensuring follow-up for over 6 months. Such efforts could generate new and important findings about methods of action for effective interventions, enhance intervention acceptability, improve intervention generalisability and ensure that new technologies are more sustainable and can be better integrated into existing mental health systems.

It is also key for future studies to examine the implementation processes of intervention studies to help support understanding on their effectiveness and mechanisms of impact. As per UK Medical Research Council guidelines (Craig et al., 2008; Skivington et al., 2021), ensuring that implementation is considered early in the intervention process and throughout intervention development, feasibility testing, process and outcome evaluation are key. This increases the potential of developing interventions that can be adopted and sustained in a real-world context.

Limitations

This review has a number of limitations. It is notable that four out of the seven included papers were found via handsearching and not identified in the database search. This implies a lack of sensitivity in the search strategy. The author was not able to identify the reason for this, despite ensuring the key terms from hand-searched papers were included in the main search strategy and checking the search strategy with LSHTM library staff. Moreover, due to the large variation in outcome measures, intervention types and study durations, it was not possible to conduct a quantitative synthesis of findings and meta-analysis, which limits the validity of the review's conclusions. Finally, excluding non-English language studies in the search may have led to the authors missing key articles in other languages.

Conclusions

The present systematic review is the first to identify and synthesise the current body of literature evaluating the clinical effectiveness of DMHIs for YP in LMICs. The findings suggest the effectiveness of digital technologies, especially iCBT-based interventions, to address depression and anxiety in this population. Importantly, the findings are also consistent with growing evidence on DMHIs from HICs that show potential for DMHIs to improve mental health conditions in YP. However, the evidence in this review is limited to only seven studies and should be treated with caution.

This review, combined with emerging recent evidence, highlights opportunities for DMHIs to address the burden of mental illness and global inequalities in effective mental health care for YP. It also identifies the need to improve the quantity and quality of available evidence on the topic through increased rigorous research. Finally, this review also highlights opportunities to utilise evidence-based policy mechanisms to increase the impact of DMHIs in LMICs.

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References

- Andrews G, Basu A, Cuijpers P, Craske MG, McEvoy P, English CL and Newby JM (2018) Computer therapy for the anxiety and depression disorders is effective, acceptable and practical health care: An updated meta-

- analysis. *Journal of Anxiety Disorders* 55, 70–78. <https://doi.org/10.1016/j.janxdis.2018.01.001>.
- Angold A and Costello EJ** (1993) Depressive comorbidity in children and adolescents: Empirical, theoretical, and methodological issues. *American Journal of Psychiatry* 150(12), 1779–1791. <https://doi.org/10.1176/ajp.150.12.1779>.
- Avenevoli S, Swendsen J, He JP, Burstein M and Merikangas KR** (2015) Major depression in the National Comorbidity Survey–Adolescent Supplement: Prevalence, correlates, and treatment. *Journal of the American Academy of Child and Adolescent Psychiatry* 54(1), 37–44. <https://doi.org/10.1016/j.jaac.2014.10.010>.
- Baumel A, Edan S and Kane JM** (2019) Is there a trial bias impacting user engagement with unguided e-mental health interventions? A systematic comparison of published reports and real-world usage of the same programs. *Translational Behavioral Medicine* 9(6), 1020–1033. <https://doi.org/10.1093/tbm/ibz147>.
- Becker AE and Kleinman A** (2013) Mental health and the global agenda. *The New England Journal of Medicine* 369(1), 66–73. <https://doi.org/10.1056/NEJMr1110827>.
- Carter H, Araya R, Anjur K, Deng D and Naslund JA** (2021) The emergence of digital mental health in low-income and middle-income countries: A review of recent advances and implications for the treatment and prevention of mental disorders. *Journal of Psychiatric Research* 133, 223–246. <https://doi.org/10.1016/j.jpsychires.2020.12.016>.
- Centre for Reviews and Dissemination (CRD)** (2009) *Systematic Reviews: CRD's Guidance for Undertaking Reviews in Health Care*. University of York: Centre for Reviews and Dissemination.
- Chandrashekar P** (2018) Do mental health mobile apps work: Evidence and recommendations for designing high-efficacy mental health mobile apps. *mHealth* 4(6). <https://doi.org/10.21037/mhealth.2018.03.02>.
- Clarke AM, Kuosmanen T, and Barry MM** (2015) A systematic review of online youth mental health promotion and prevention interventions. *Journal of Youth and Adolescence* 44, 90–113. <https://doi.org/10.1007/s10964-014-0165-0>.
- Conley CS, Durlak JA, Shapiro JB, Kirsch AC and Zahniser E** (2016) A meta-analysis of the impact of universal and indicated preventive technology-delivered interventions for higher education students. *Prevention Science* 17, 659–678. <https://doi.org/10.1007/s11121-016-0662-3>.
- Craig P, Dieppe P, Macintyre S, Mitchie S, Nazareth I and Petticrew M** (2008) Developing and evaluating complex interventions: The new Medical Research Council guidance. *BMJ* 337, a1655. <https://doi.org/10.1136/bmj.a1655>.
- Critical Appraisal Skills Programme (CASP)** (2020) CASP randomised controlled trial checklist. Available at <https://casp-uk.net/casp-tools-checklists/> (accessed 29 March 2022).
- Cuijpers P, Heim E, Abi Ramia J, Burchert S, Carswell K, Cornelisz I, Knaevelsrud C, Noun P, van Klaveren C, van't Hof E, Zoghbi E, van Ommeren M and El Chammay R** (2022) Effects of a WHO-guided digital health intervention for depression in Syrian refugees in Lebanon: A randomized controlled trial. *PLoS Medicine* 19(6), e1004025. <https://doi.org/10.1371/journal.pmed.1004025>.
- De Kock JH, Latham HA, Cowden RG, Cullen B, Narzisi K, Jerdan S, Munoz S, Leslie SJ, Stamatis A and Eze J** (2022) Brief digital interventions to support the psychological well-being of NHS staff during the COVID-19 pandemic: 3-arm pilot randomized controlled trial. *JMIR Mental Health* 9(4), e34002. <https://doi.org/10.2196/34002>.
- Duarte CS, Lovero KL, Sourander A, Ribeiro WS and Bordin IAS** (2022) The child mental health treatment gap in an urban low-income setting: Multi-sectoral service use and correlates. *Psychiatric Services* 73(1), 32–38. <https://doi.org/10.1176/appi.ps.202000742>.
- Ebert DD, Zarski AC, Christensen H, Stikkelbroek Y, Cuijpers P, Berking M and Riper H** (2015) Internet and computer-based cognitive behavioral therapy for anxiety and depression in youth: A meta-analysis of randomized controlled outcome trials. *PLoS One* 10(3), e0119895. <https://doi.org/10.1371/journal.pone.0119895>.
- Economist Impact** (2022) The intersection of digital health and equity. Available at https://impact.economist.com/perspectives/sites/default/files/ei241_va_report_v3_illustration.pdf (accessed 12 April 2024).
- Firth J, Torous J, Nicholas J, Carney R, Prapat A, Rosenbaum S and Sarris J** (2017) The efficacy of smartphone-based mental health interventions for depressive symptoms: A meta-analysis of randomized controlled trials. *World Psychiatry* 16(3), 287–298. <https://doi.org/10.1002/wps.20472>.
- Gire N, Farooq S, Naeem F, Duxbury J, McKeown M, Kundi PS, Chaudhry IB and Husain N** (2017) mHealth based interventions for the assessment and treatment of psychotic disorders: A systematic review. *mHealth* 3, 33. <https://doi.org/10.21037/mhealth.2017.07.03>.
- Grist R, Croker A, Denne M and Stallard P** (2019) Technology delivered interventions for depression and anxiety in children and adolescents: A systematic review and meta-analysis. *Clinical Child and Family Psychology Review* 22, 147–171. <https://doi.org/10.1007/s10567-018-0271-8>.
- Grist R, Porter J and Stallard P** (2017) Mental health mobile apps for pre-adolescents and adolescents: A systematic review. *Journal of Medical Internet Research* 19(5), e176. <https://doi.org/10.2196/jmir.7332>.
- GSMA** (2021) Connected Women: The Mobile Gender Gap Report 2021. Available at <https://www.gsma.com/r/wp-content/uploads/2021/07/The-Mobile-Gender-Gap-Report-2021.pdf> (accessed 12 April 2024).
- GSMA** (2022) The State of Mobile Internet Connectivity 2022. Available at <https://www.gsma.com/r/wp-content/uploads/2022/12/The-State-of-Mobile-Internet-Connectivity-Report-2022.pdf> (accessed 12 April 2024).
- Harith S, Backhaus I, Mohbin N, Ngo HT and Khoo S** (2022) Effectiveness of digital mental health interventions for university students: An umbrella review. *PeerJ* 10, e13111. <https://doi.org/10.7717/peerj.13111>.
- Harrer M, Adam SH, Baumeister H, Cuijpers P, Karyotaki E, Auerbach RP, Kessler RC, Bruffaerts R, Berking M and Ebert DD** (2019) Internet interventions for mental health in university students: A systematic review and meta-analysis. *International Journal of Methods in Psychiatric Research* 28(2), e1759. <https://doi.org/10.1002/mpr.1759>.
- Henrich J, Heine SJ and Norenzayan A** (2010) Most people are not WEIRD. *Nature* 466, 29. <https://doi.org/10.1038/466029a>.
- Hoefl TJ, Fortney JC, Patel V and Unützer J** (2018) Task-sharing approaches to improve mental health care in rural and other low-resource settings: A systematic review. *The Journal of Rural Health* 34(1), 48–62. <https://doi.org/10.1111/jrh.12229>.
- Institute for Health Metrics and Evaluation (IHME)** (2023) GBD compare. Available at <http://vizhub.healthdata.org/gbd-compare> (accessed 26 July 2022).
- International Telecommunication Union (ITU)** (2014) Connect 2020 agenda. Available at <https://www.itu.int/en/ITU-D/LDCs/Pages/Connect-2020-Agenda.aspx> (accessed 5 August 2022).
- International Telecommunication Union (ITU)** (2021) Digital technologies to achieve the UN SDGs. Available at <https://www.itu.int/en/mediacentre/back-grounds/Pages/icts-to-achieve-the-united-nations-sustainable-development-goals.aspx> (accessed 14 April 2024).
- International Telecommunication Union (ITU)** (2023) Measuring digital development. Facts and figures: focus on least developed countries. Available at https://www.itu.int/hub/publication/d-ind-ict_mdd-2023/ (accessed 20 October 2023).
- International Telecommunication Union (ITU) and United Nations Development Programme (UNDP)** (2023) SDG Digital Acceleration Agenda. Available at <https://www.undp.org/publications/sdg-digital-acceleration-agenda> (accessed 12 April 2024).
- Jansen S, White R, Hogwood J, Jansen A, Gishoma D, Mukamana D and Richters A** (2015) The “treatment gap” in global mental health reconsidered: Sociotherapy for collective trauma in Rwanda. *European Journal of Psychotraumatology* 6(1), 28706. <https://doi.org/10.3402/ejpt.v6.28706>.
- Kalntenthaler E, Sutcliffe P, Parry G, Beverley C, Rees A and Ferriter M** (2008) The acceptability to patients of computerized cognitive behaviour therapy for depression: A systematic review. *Psychological Medicine* 38(11), 1521–1530. <https://doi.org/10.1017/S0033291707002607>.
- Kar SK, Oyetunji TP, Prakash AJ, Ogunmola OA, Tripathy S, Lawal MM, Sanusi ZK and Arafat SMY** (2020) Mental health research in the lower-middle-income countries of Africa and Asia during the COVID-19 pandemic: A scoping review. *Neurology, Psychiatry and Brain Research* 38, 54–64. <https://doi.org/10.1016/j.npbr.2020.10.003>.
- Kardefelt Winther D, Livingstone S and Saeed M** (2019) *Growing Up in a Connected World, Innocenti Research Report*. Florence: UNICEF Office of

- Research - Innocenti. Available at <https://www.unicef-irc.org/publications/1060-growing-up-in-a-connected-world.html> (accessed 2 October 2023).
- Karyotaki E, Riper H, Twisk J, Hoogendoorn A, Kleiboer A, Mira A, Mackinnon A, Meyer B, Botella C, Littlewood E, Andersson G, Christensen H, Klein JP, Schröder J, Bretón-López J, Scheider J, Griffiths K, Farrer L, Huibers MJH, Phillips R, Gilbody S, Moritz S, Berger T, Pop V, Spek V and Cuijpers P (2017) Efficacy of self-guided internet-based cognitive behavioral therapy in the treatment of depressive symptoms: a meta-analysis of individual participant data. *JAMA Psychiatry* 74(4), 351–359. <https://doi.org/10.1001/jamapsychiatry.2017.0044>.
- Kemp S (2020) Digital 2020: Global digital overview. Available at <https://datareportal.com/reports/digital-2020-global-digital-overview> (accessed 24 October 2023).
- Kessler RC, Berglund P, Demler O, Jin R, Merikangas KR and Walters EE (2005) Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the national comorbidity survey replication. *Archives of General Psychiatry* 62(6), 593–602. <https://doi.org/10.1001/archpsyc.62.6.593>.
- Kieling C, Baker-Henningham H, Belfer M, Conti G, Ertem I, Omigbodun O, Rohde LA, Srinath S, Ulkuer N and Rahman A (2011) Child and adolescent mental health worldwide: Evidence for action. *The Lancet* 378(9801), 1515–1525. [https://doi.org/10.1016/S0140-6736\(11\)60827-1](https://doi.org/10.1016/S0140-6736(11)60827-1).
- Koopmans PC, Biltmann U, Roelen CAM, Hoedeman R, Van Der Klink JJJ and Groothoff JW (2011) Recurrence of sickness absence due to common mental disorders. *International Archives of Occupational and Environmental Health* 84, 193–201. <https://doi.org/10.1007/s00420-010-0540-4>.
- Larsen ME, Huckvale K, Nicholas J, Torous J, Birrell L, Li E and Reda B (2019) Using science to sell apps: Evaluation of mental health app store quality claims. *npj Digital Medicine* 2(18). <https://doi.org/10.1038/s41746-019-0093-1>.
- Lehtimäki S, Martic J, Wahl B, Foster KT and Schwalbe N (2021) Evidence on digital mental health interventions for adolescents and young people: Systematic overview. *JMIR Mental Health* 8(4), e25847. <https://doi.org/10.2196/25847>.
- Mazur A, Brindis CD and Decker MJ (2018) Assessing youth-friendly sexual and reproductive health services: A systematic review. *BMC Health Services Research* 18(216). <https://doi.org/10.1186/s12913-018-2982-4>.
- Methley AM, Campbell S, Chew-Graham C, McNally R and Cheraghi-Sohi S (2014) PICO, PICOS and SPIDER: A comparison study of specificity and sensitivity in three search tools for qualitative systematic reviews. *BMC Health Services Research* 14(579). <https://doi.org/10.1186/s12913-014-0579-0>.
- Moeini B, Bashirian S, Soltanian AR, Ghaleiha A and Taheri M (2019) Examining the effectiveness of a web-based intervention for depressive symptoms in female adolescents: Applying social cognitive theory. *Journal of Research in Health Sciences* 19(3), e00454.
- Naslund JA, Bondre A, Torous J and Aschbrenner KA (2020) Social media and mental health: Benefits, risks, and opportunities for research and practice. *Journal of Technology in Behavioral Science* 5, 245–257. <https://doi.org/10.1007/s41347-020-00134-x>.
- Naslund JA, Gonsalves PP, Gruebner O, Pendse SR, Smith SL, Sharma A and Raviola G (2019) Digital innovations for global mental health: Opportunities for data science, task sharing, and early intervention. *Current Treatment Options in Psychiatry* 6, 337–351. <https://doi.org/10.1007/s40501-019-00186-8>.
- Naslund JA, Marsch LA, McHugo GJ and Bartels SJ (2015) Emerging mHealth and eHealth interventions for serious mental illness: A review of the literature. *Journal of Mental Health* 24(5), 321–332. <https://doi.org/10.3109/09638237.2015.1019054>.
- Newman MG, Kanuri N, Rackoff GN, Jacobson NC, Bell MJ and Taylor CB (2021) A randomized controlled feasibility trial of internet-delivered guided self-help for generalized anxiety disorder (GAD) among university students in India. *Psychotherapy* 58(4), 591–601. <https://doi.org/10.1037/pst0000383>.
- NHS Race and Health Observatory (2023) Digital apps and reducing ethnic health inequalities: Driving progress through digital, design, and organisational transformation. Available at <https://www.nhs.uk/research/digital-apps-and-reducing-ethnic-health-inequalities/> (accessed 12 April 2024).
- Ofoegbu TO, Asogwa U, Otu MS, Ibenegbu C, Muhammed A and Eze B (2020) Efficacy of guided internet-assisted intervention on depression reduction among educational technology students of Nigerian universities. *Medicine* 99(6), e18774. <https://doi.org/10.1097/MD.00000000000018774>.
- Osborn TL, Rodriguez M, Wasil AR, Venturo-Conerly KE, Gan J, Alemu RG, Roe E, Arango GS, Otieno BH, Wasanga CM, Shingleton R and Weisz JR (2020) Single-session digital intervention for adolescent depression, anxiety, and well-being: Outcomes of a randomized controlled trial with Kenyan adolescents. *Journal of Consulting and Clinical Psychology* 88(7), 657–668. <https://doi.org/10.1037/ccp0000505>.
- Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, Chou R, Glanville J, Grimshaw JM, Hróbjartsson A, Lalu MM, Li T, Loder EW, Mayo-Wilson E, McDonald S, McGuinness LA, Stewart AL, Thomas J, Tricco AC, Welch VA, Whiting P and Moher D (2021) The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *International Journal of Surgery* 88, 105906. <https://doi.org/10.1136/bmj.n71>.
- Patel V, Flisher AJ, Hetrick S and McGorry P (2007) Mental health of young people: A global public-health challenge. *The Lancet* 369(9569), 1302–1313. [https://doi.org/10.1016/S0140-6736\(07\)60368-7](https://doi.org/10.1016/S0140-6736(07)60368-7).
- Petersen I, Marais D, Abdulmalik J, Ahuja S, Alem A, Chisholm D, Egbe C, Gureje O, Hanlon C, Lund C, Shidhaye R, Jordans M, Kigozi F, Mugisha J, Upadhya N and Thornicroft G (2017) Strengthening mental health system governance in six low-and middle-income countries in Africa and South Asia: Challenges, needs and potential strategies. *Health Policy and Planning* 32(5), 699–709. <https://doi.org/10.1093/heapol/czx014>.
- Podina IR, Mogoase C, David D, Szentagotai A and Dobrea A (2016) A meta-analysis on the efficacy of technology mediated CBT for anxious children and adolescents. *Journal of Rational-Emotive and Cognitive-Behavior Therapy* 34, 31–50. <https://doi.org/10.1007/s10942-015-0228-5>.
- Public Health Insight (2023) UN Sustainable Development Goal 3: Achieving Universal Health Coverage Through Digital Transformation. Available at <https://thepublichealthinsight.com/un-sustainable-development-goal-3-achieving-universal-health-coverage-through-digital-transformation-2/> (accessed 14 April 2024).
- Racine N, McArthur BA, Cooke JE, Eirich R, Zhu J and Madigan S (2021) Global prevalence of depressive and anxiety symptoms in children and adolescents during COVID-19: A meta-analysis. *JAMA Pediatrics* 175(11), 1142–1150. <https://doi.org/10.1001/jamapediatrics.2021.2482>.
- Rathod S, Pinninti N, Irfan M, Gorczynski P, Rathod P, Gega L and Naeem F (2017) Mental health service provision in low- and middle-income countries. *Health Services Insights* 10, 1178632917694350. <https://doi.org/10.1177/1178632917694350>.
- Rootes-Murdy K, Glazer KL, Van Wert MJ, Mondimore FM and Zandi PP (2018) Mobile technology for medication adherence in people with mood disorders: A systematic review. *Journal of Affective Disorders* 227, 613–617. <https://doi.org/10.1016/j.jad.2017.11.022>.
- Salamanca-Sanabria A, Richards D, Timulak L, Connell S, Mojica Perilla M, Parra-Villa Y and Castro-Camacho L (2020) A culturally adapted cognitive behavioral internet-delivered intervention for depressive symptoms: Randomized controlled trial. *JMIR Mental Health* 7(1), e13392. <https://doi.org/10.2196/13392>.
- Sanz MF, Acha BV, García MF (2021) Co-Design for people-centred care digital solutions: A literature review. *International Journal of Integrated Care* 21(2), 16. <https://doi.org/10.5334/ijic.5573>.
- Semrau M, Evans-Lacko S, Koschorke M, Ashenafi L and Thornicroft G (2015) Stigma and discrimination related to mental illness in low- and middle-income countries. *Epidemiology and Psychiatric Sciences* 24(5), 382–394. <https://doi.org/10.1017/S2045796015000359>.
- Shewale R (2023) Social Media Users - Global Demographics (2023). Available at <https://www.demandsage.com/social-media-users/> (accessed 2 October 2023).
- Shortliffe EH (2016) Digital medicine and biomedical informatics: What's in a name? *Methods of Information in Medicine* 55(5), 389–391. <https://doi.org/10.3414/ME15-22-0005>.
- Skivington K, Matthews L, Simpson SA, Craig P, Baird J, Blazeby JM, Boyd KA, Craig N, French DP, McIntosh E, Petticrew M, Rycroft-Malone J, White M and Moore L (2021) A new framework for developing and evaluating complex interventions: Update of Medical Research Council guidance. *The BMJ* 374, n2061. <https://doi.org/10.1136/bmj.n2061>.
- Sun S, Lin D, Goldberg S, Shen Z, Chen P, Qiao S, Brewer J, Loucks E and Operario D (2022) A mindfulness-based mobile health (mHealth)

- intervention among psychologically distressed university students in quarantine during the COVID-19 pandemic: A randomized controlled trial. *Journal of Counseling Psychology* **69**(2), 157–171. <https://doi.org/10.1037/cou0000568>.
- The WHO World Mental Health Survey Consortium** (2004) Prevalence, severity, and unmet need for treatment of mental disorders in the World Health Organization world mental health surveys. *JAMA* **291**(21), 2581–2590. <https://doi.org/10.1001/jama.291.21.2581>.
- The World Bank** (2023) World Bank Country and Lending Groups. Available at <https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups> (accessed 27 July 2022).
- The World Bank** (2024) Mobile Cellular Subscriptions. Available at <https://data.worldbank.org/indicator/IT.CEL.SETS> (accessed 26 July 2022).
- Torous J, Bucci S, Bell IH, Kessing LV, Faurholt-Jepsen M, Whelan P, Carvalho AF, Keshavan M, Linardon J and Firth J** (2021) The growing field of digital psychiatry: Current evidence and the future of apps, social media, chatbots, and virtual reality. *World Psychiatry* **20**(3), 318–335. <https://doi.org/10.1002/wps.20883>.
- Torous J, Nicholas J, Larsen ME, Firth J and Christensen H** (2018) Clinical review of user engagement with mental health smartphone apps: Evidence, theory and improvements. *Evidence-Based Mental Health* **21**(3), 116–119. <https://doi.org/10.1136/eb-2018-102891>.
- Tsheh M, Necho M and Mekonnen W** (2020) The role of adverse childhood experience on depression symptom, prevalence, and severity among school going adolescents. *Depression Research and Treatment* **2020**, 5951792. <https://doi.org/10.1155/2020/5951792>.
- United Nations (UN)** (2015) Transforming our world: the 2030 Agenda for Sustainable Development. Available at <https://sdgs.un.org/2030agenda> (accessed 25 October 2023).
- United Nations Children's Fund (UNICEF)** (2017) The State of the World's Children 2017: Children in a Digital World. Available at <https://www.unicef.org/reports/state-worlds-children-2017> (accessed 26 July 2022).
- United Nations Children's Fund (UNICEF)** (2021) Mental Health. Available at <https://data.unicef.org/topic/child-health/mental-health/> (accessed 26 July 2022).
- United Nations Conference on Trade and Development (UNCTAD)** (2023) How to unlock women's potential in the digital economy. Available at <https://unctad.org/news/how-unlock-womens-potential-digital-economy> (accessed 25 April 2024).
- United Nations Development Programme (UNDP)** (2017) Human Development Report 2016, Human Development for Everyone. Available at <https://www.un-ilibrary.org/content/books/9789210600361> (accessed 25 October 2023).
- United Nations Population Fund (UNFPA)** (2014) The power of 1.8 billion. Adolescents, youth and the transformation of the future. UNFPA state of world population 2014. Available at <https://www.unfpa.org/publications/state-world-population-2014> (accessed 10 November 2023).
- Välämäki M, Anttila K, Anttila M and Lahti M** (2017) Web-based interventions supporting adolescents and young people with depressive symptoms: Systematic review and meta-analysis. *JMIR mHealth and uHealth* **5**(12), e180. <https://doi.org/10.2196/mhealth.8624>.
- van Kessel R, Wong BLH, Clemens T, and Brand H** (2022). Digital health literacy as a super determinant of health: More than simply the sum of its parts. *Internet Interventions* **27**, 100500. <https://doi.org/10.1016/j.invent.2022.100500>.
- Vogel J** (2013) Effective gender-based violence screening tools for use in primary health care settings in Afghanistan and Pakistan: A systematic review. *Eastern Mediterranean Health Journal* **19**(3), 219–227.
- Wainberg ML, Scorza P, Shultz JM, Helpman L, Mootz JJ, Johnson KA, Neria Y, Bradford JME, Oquendo MA and Arbuckle MR** (2017) Challenges and opportunities in global mental health: A research-to-practice perspective. *Current Psychiatry Reports* **19**(28). <https://doi.org/10.1007/s11920-017-0780-z>.
- Wallin EEK, Mattsson S and Olsson EMG** (2016) The preference for internet-based psychological interventions by individuals without past or current use of mental health treatment delivered online: A survey study with mixed-methods analysis. *JMIR Mental Health* **3**(2), e5324. <https://doi.org/10.2196/mental.5324>.
- Wannachaiyakul S, Thapinta D, Sethabouppha H, Thungjaroenkul P and Likhitsathian S** (2017) Randomized controlled trial of computerized cognitive behavioral therapy program for adolescent offenders with depression. *Pacific Rim International Journal of Nursing Research* **21**(1), 32–43.
- World Health Organization (WHO)** (2019) WHO guideline: Recommendations on digital interventions for health system strengthening. Geneva. Available at <https://www.who.int/publications/i/item/9789241550505> (accessed 25 October 2023).
- World Health Organization (WHO)** (2020) Youth-centred digital health interventions: a framework for planning, developing and implementing solutions with and for young people. Geneva. Available at <https://www.who.int/publications/i/item/9789240011717> (accessed 24 October 2023).
- World Health Organization (WHO)** (2023) ICD-11. International Classification of Diseases 11th Revision. Available at <https://icd.who.int/en> (accessed 2 October 2023).
- World Health Organization (WHO)** (2024) Adolescent health in the South-East Asia Region. Available at <https://www.who.int/southeastasia/health-topics/adolescent-health> (accessed 26 July 2022).