

# Engaging children and young people in digital mental health interventions: A systematic review of modes of delivery, facilitators, and barriers

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## Abstract

**Background:** There is a high prevalence of children and young people (CYP) experiencing mental health (MH) problems. Due to the accessibility, affordability and scalability, an increasing number of digital health interventions (DHIs) have been developed and incorporated into MH treatment. Studies show DHI's potential for improving MH outcomes in randomised controlled trials. However, modes of delivery used to engage CYP in digital MH interventions may differ, with implications for the extent to which findings pertain to the implementation and level of engagement with the DHI. Knowledge of the various modalities used to engage CYP could aid in the development of interventions that are acceptable and feasible.

**Objective:** This review aimed to 1) identify modes of delivery used in CYP digital MH interventions, 2) explore influencing factors to usage and implementation, and 3) investigate ways in which the interventions have been evaluated and whether CYP engages in DHIs.

**Methods:** A literature search was performed in the Cochrane Library, EMBASE, MEDLINE, and PsycINFO databases using three key concepts "child and adolescent mental health", "digital intervention", and "engagement". Preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines were followed utilising rigorous inclusion criteria and screening by at least two reviewers. The selected articles were quality assessed using the mixed methods appraisal tool (MMAT) and data were extracted to address the review aims. Data aggregation and synthesis was conducted and presented as descriptive numerical summaries and narrative synthesis.

**Results:** This study identified six modes of delivery of DHIs from 83 articles and 71 interventions for engaging CYP: 1) websites, 2) games and computer-assisted programs, 3) apps, 4) robots and digital devices, 5) virtual reality, and 6) mobile text messaging. Two themes emerged highlighting "intervention-specific" and "person-specific" barriers and facilitators to CYP's engagement. These themes encompassed factors such as suitability, usability, and acceptability of the DHIs and motivation, capability, and opportunity for the CYP using DHIs. The literature highlighted that CYP prefer DHIs with features such as videos, limited text, ability to personalise or create a profile, ability to connect with others, and options to receive text message reminders. The findings of this review suggest a high average retention rate of 79% in studies involving the various DHIs.

**Conclusions:** The development of DHIs are increasing and may be of interest to CYP, particularly in the area of MH treatment. With continuous technological advancements, it is important to know which modalities may increase engagement and help CYP facing MH problems. This review identified the existing modalities and highlighted influencing factors from the perspective of CYP. This knowledge provides information that can be used to design and evaluate new interventions and offers important theoretical insights into how and why CYP engage in DHIs. Clinical Trial: International Prospective Register of Systematic Reviews (PROSPERO) CRD42018094815

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Engaging children and young people in digital mental health interventions: A systematic review of modes of delivery, facilitators, and barriers

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## Abstract

**Background:** There is a high prevalence of children and young people (CYP) experiencing mental health (MH) problems. Due to the accessibility, affordability and scalability, an increasing number of digital health interventions (DHIs) have been developed and incorporated into MH treatment. Studies show DHI's potential for improving MH outcomes in randomised controlled trials. However, modes

of delivery used to engage CYP in digital MH interventions may differ, with implications for the extent to which findings pertain to the implementation and level of engagement with the DHI. Knowledge of the various modalities used to engage CYP could aid in the development of interventions that are acceptable and feasible.

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**Results:** This study identified six modes of delivery of DHIs from 83 articles and 71 interventions for engaging CYP: 1) websites, 2) games and computer-assisted programs, 3) apps, 4) robots and digital devices, 5) virtual reality, and 6) mobile text messaging. Two themes emerged highlighting “intervention-specific” and “person-specific” barriers and facilitators to CYP’s engagement. These themes encompassed factors such as suitability, usability, and acceptability of the DHIs and motivation, capability, and opportunity for the CYP using DHIs. The literature highlighted that CYP prefer DHIs with features such as videos, limited text, ability to personalise or create a profile, ability to connect with others, and options to receive text message reminders. The findings of this review suggest a high average retention rate of 79% in studies involving the various DHIs.

**Discussion:** The development of DHIs are increasing and may be of interest to CYP, particularly in the area of MH treatment. With continuous technological advancements, it is important to know which modalities may increase engagement and help CYP facing MH problems. This review identified the existing modalities and highlighted influencing factors from the perspective of CYP. This knowledge provides information that can be used to design and evaluate new interventions and offers important theoretical insights into how and why CYP engage in DHIs.

**Study Registration:** International Prospective Register of Systematic Reviews (PROSPERO) CRD42018094815

**Keywords:** mHealth; eHealth; technology; engagement; children; young people; mental health

## Engaging children and young people in digital mental health interventions: A systematic review of modes of delivery, facilitators, and barriers

### Introduction

#### Prevalence of mental health problems in children and young people

Mental health (MH) problems in childhood and adolescence are of great importance due to their prevalence, early-onset, and impact on different areas of the child's life [1]. The number of children and young people (CYP) who experience MH problems ranges from 10 to 20% worldwide [2]. An international study conducted in 27 countries estimated the worldwide-pooled prevalence of MH problems to be 13.4% among CYP [3]. Specifically, anxiety and disruptive behaviour disorders seem to be the most frequent presentations [3] (see Table 1). Estimates further suggest that approximately one in every three adolescents will meet the criteria for anxiety and depressive disorder [2], while one in four young people aged 16 to 24 years has experienced at least one MH problem in the past year [3].

**Table 1. Prevalence of mental health problems in children and young people (Adopted from [3]).**

Mental health problem	Prevalence (%)
Anxiety	6.5
Disruptive behaviour	5.7
Oppositional defiance disorder	3.6
Attention-deficit hyperactivity	3.4
Depression	2.6
Conduct	2.1

#### Benefits of digital health interventions (DHIs)

Addressing MH problems in CYP is a major public health concern [4, 5], which has been impaired by low levels of youth help-seeking behaviour [6]. Concerns about stigma and confidentiality, shame or embarrassment in discussing personal issues, financial costs, and/or limited access to services are among the many barriers to accessing help in this population [6-8]. In many instances, existing efficacious face-to-face interventions are adapted using digital technology as a means of addressing these barriers [9]. DHIs (e.g. internet programs, apps, virtual reality environments, robotic systems) have the potential to be effective, with advantages of accessibility, anonymity, prompt feedback, cost-effectiveness, applicability in real-life contexts, and high treatment fidelity [7, 10-15]. Therefore, considering the increased digital literacy and internet use among youth [18], DHIs may serve as a new way to increase accessibility to MH interventions in this population [16, 17].



### **Efficacy of digital health interventions (DHIs)**

The World Health Organization (WHO), the UK's National Health Service (NHS), and the U.S. National Institute of Mental Health (NIMH) have identified MH apps as cost-effective and scalable solutions to addressing the MH treatment gap [19]. The efficacy of online therapies is well established in the treatment of several MH problems, including, depression, anxiety, and substance misuse among adolescents [20-22]. Online treatment programs have also demonstrated comparable efficacy to face-to-face psychotherapy [23, 24]. Additionally, smartphone-based MH interventions have shown to be a promising self-management tool for depression [25], reducing symptoms similar to face-to-face interventions. Equivalent results were also found for anxiety-focused mobile apps [26]. Recent systematic reviews have shown that interventions based in computerized cognitive behaviour therapy (cCBT) are a promising and acceptable way to reduce anxiety and depression in CYP [16, 17]. Findings also support the clinical benefits of DHIs for other symptoms and disorders such as autism spectrum disorders, attention deficit, and behavioural disorders [29].

### **Research on CYP digital MH interventions**

Despite the growing interest in using mobile apps to deliver interventions, more research evidence is needed to support implementation in children and young people mental health (CYPMH) services [29, 30]. For instance, the evaluation of DHIs is increasingly discussed in electronic health (e-health) research. A recent review showed that the majority of registered DHI evaluation trials employ common methods, such as the randomized controlled trial (RCT) study design [31]. There is much debate in the literature on appropriate methods for evaluating the impact of DHIs [32]. For example, given the speed at which technologies advance, adaptive research designs may be more useful to increase usability and ability to respond in a timely manner to users' experiences [33]. Considering the limitations of traditional research designs, new methodological frameworks and research designs have been developed (e.g. Continuous Evaluation of Evolving Behavioural Intervention Technologies [34] and micro randomized trials [35]). In order to develop DHIs that are more useful and thereby more engaging for users, researchers agree that the impact of different functionalities on levels of engagement is important [93]. Engagement with digital behaviour change interventions has been defined in the literature as a subjective experience (the user-perceived state of "flow", characterized by temporal dissociation, focused attention, interest, and enjoyment), or as a behaviour (extent of usage of the DHI over time, or adherence) [95]. Perski et al. [95] proposed an integrated conceptualization of engagement that includes both the extent (e.g. amount, frequency, duration, depth) of usage and the subjective experience of "what it feels" to be engaged (e.g. attention, interest, and affect). However, engagement is usually assessed through the evaluation of the user interaction

with the DHI, either by user-reported tools (e.g. questionnaires, interview, or think-aloud studies), by automated recordings of use (e.g. logins, page views), or by the recording of physiological or psychophysical correlates of DHI interaction [95].

Despite the potential of DHIs, researchers have identified several limitations that influence practicality [36]. The main limitations identified are restricted tailoring to patient needs, challenges with managing comorbidity and acute crisis [37], and low patient engagement and high dropout rates [38]. Although efforts have been made to reduce these occurrences with strategies such as gamification, tailoring, and guided self-help, the aforementioned difficulties remain [29, 37, 38]. In addition, further challenges arise from professionals' cautious attitudes toward DHIs, such as failure to address important aspects of the disease, data security, and accessibility [39].

### **The rationale for the current review**

The rapid advancement of technology [43] and increasing interest of CYP in technology [18] calls for a better understanding and evaluation of DHIs used to “engage” CYP with MH problems. [40, 41]. Engagement is commonly referred to as the active involvement of participants with the intervention, also described in previous literature as “participation”, “adherence”, “noncompliance” or resistance” [42]. This knowledge is crucial to support the development and evaluation of DHIs that are acceptable and feasible in CYPMH settings. This review sets out to contribute to the growing body of knowledge on digital CYPMH interventions by investigating modes of delivery used in DHIs. While recent meta-analyses highlighted the potential effectiveness of CYPMH DHIs [16, 17, 27], this review aims to present information that might be of use in the development of real-world interventions that are more likely to increase engagement from CYP.

### **Aims**

The primary aim of the present study was to review the literature to identify modes of delivery used to engage CYP in digital MH interventions. Second, explore barriers and facilitators to usage and implementation of DHIs. The authors also aimed to investigate ways in which these interventions have been evaluated and whether CYP engage in DHI research. The following questions were addressed:

1. What modes of delivery are used for engaging CYP in digital MH interventions?
2. What are the barriers and facilitators to engaging CYP in digital MH interventions?

### 3. How do retention rates vary in CYP digital MH intervention research?

## Methods

### Literature search and search strategy

A literature search was conducted using the Cochrane Library, EMBASE, MEDLINE, and PsycINFO databases. All searches were carried out on the same day (December 27<sup>th</sup>, 2018) to control for daily updates. Three key concepts informed the search strategy: “child and adolescent mental health”, “digital intervention”, and “engagement”. Terms within similar categories were combined with “OR” and then the results from each category were combined with “AND” (see Multimedia Appendix 1). The search strategy was guided by similar reviews exploring technology or engagement in child and family mental health treatment [27, 42, 44], the review team discussions, and input from the University College London, Institute of Child Health librarian. Reference lists of relevant articles were also scanned for additional potential studies. An initial sample of articles identified through the database searching was screened first by titles and abstracts. Next, the full-text versions of potentially relevant studies were retrieved and examined in detail for eligibility at the review team meetings. Differences regarding study selection were resolved by discussion among the authors.

### Inclusion and exclusion criteria

Screened articles were included if: 1) the study targeted a CYP sample with a mean age less than 25 years, 2) the article described a DHI targeting an MH symptom (related to a primary physical/somatic condition) or the intervention was being used by CYP with MH problems, and 3) the study explored the development or testing of a DHI resulting in data on adherence, acceptability, or barriers and facilitators to engagement. Any study design was deemed acceptable for inclusion. Articles were excluded if: 1) the age of the participants were not defined or if the mean age of the sample was 25 years and above, 2) the intervention was for the sole purpose of communicating between a health care professional and the CYP (e.g. skype, email, teleconference, or messages for appointment reminders), 3) the outcome of the study was not clearly defined or did not provide sufficient detail to determine if the outcome was directly related to the intervention, and 4) the study had no human participants (e.g. discussion articles describing a novel intervention).

## Study selection process

In accordance with the Preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines [45], the flowchart presented in Figure 1 provides step-by-step details of our study selection process. After duplicates were removed, at least two members of the review team independently screened the titles and abstracts against the inclusion criteria. The full-text versions of the remaining potential articles were examined further by at least two reviewers for final inclusion. Articles excluded at this stage described interventions that were being used for communication purposes only, did not provide sufficient detail of the intervention, reviews or study protocols, age range not specified or above the cut-off, targeted a non-mental health condition only, or targeted parents or clinicians, or the outcome was not related to the intervention. Any disagreements were resolved through discussions.

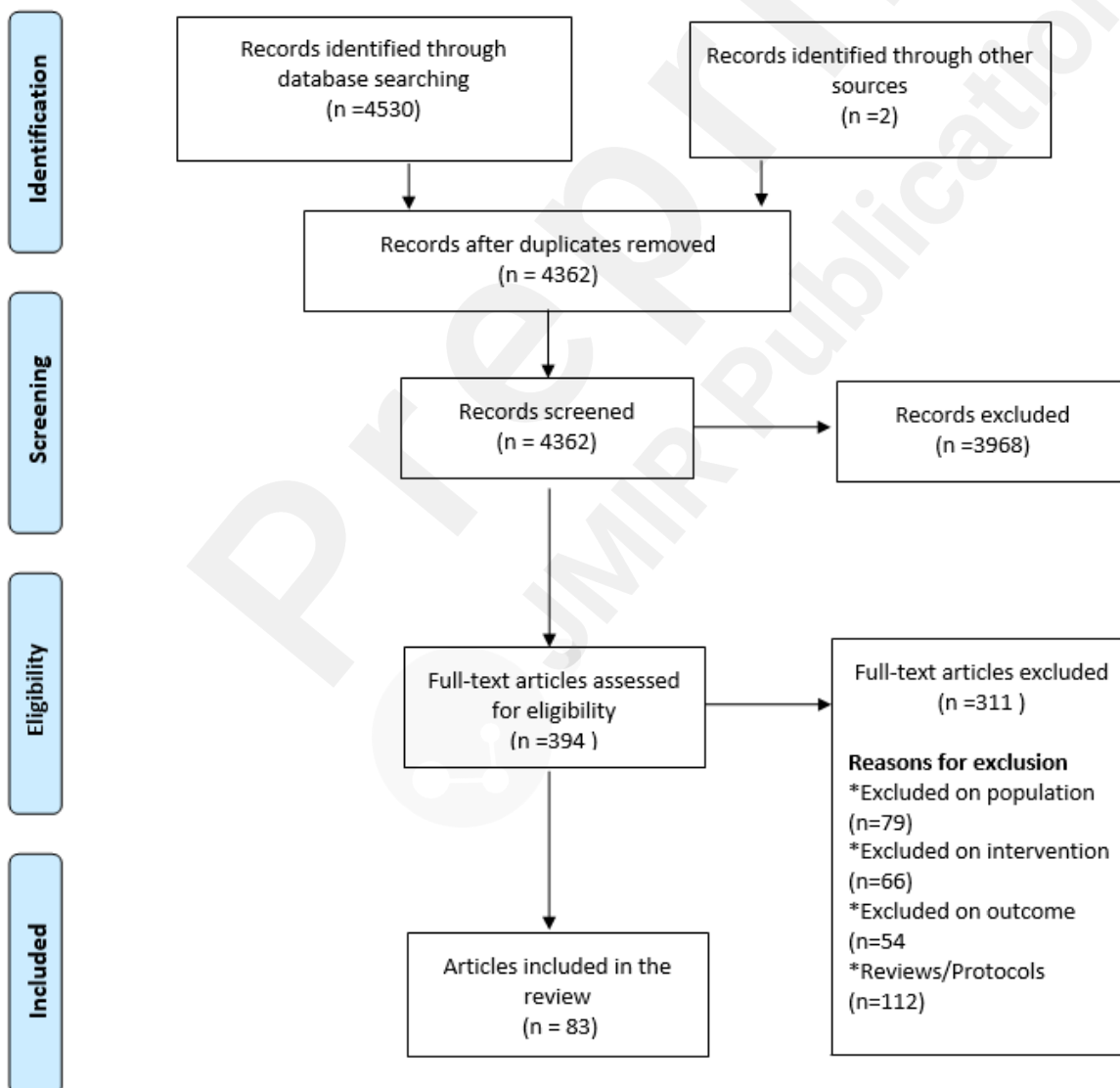


Figure 1. PRISMA flow chart of the study selection process.

### **Data extraction and quality assessment**

A standardised form [46] adapted and piloted by the review team was used to extract relevant information from each article including the following: reference, year, country, study aims, study design, sample size, setting, clinical characteristics, type of support including therapeutic treatment, retention rate, outcome, and descriptive characteristics of the sample and the intervention. Study-specific data for the second review question were also extracted at this stage to inform the thematic framework [47]. The mixed methods appraisal tool (MMAT-v2018) [48] was used to assess the methodological quality of each selected study. This tool was discussed in detail and selected based on its ability to report on the quality of varying study designs. Responses were rated on a categorical scale as “no”, “can’t tell”, or “yes” to any of the methodological quality criteria. The number of items rated “yes” were counted to provide an overall score out of a possible five [49]. If at least one of the MMAT quality criterion was met, the methodological quality of the study was considered acceptable and the record was included. SL and a second member of the review team independently extracted all data and independently conducted the quality assessment. The two reviewers discussed any discrepancies, and, if necessary, consulted a third team member to reach a final decision.

### **Data aggregation and synthesis**

Extracted data were collated and summarised to produce a narrative summary of the study characteristics that addressed the first review question. A descriptive numerical summary was presented to group articles by the primary digital platform used to deliver the intervention. SL completed a qualitative data-driven thematic analysis [50] in addition to inductive analysis informed by the Digital Behaviour Change Framework [51] to address the second review question. Moreover, this framework and the capability, opportunity, motivation, and behaviour (COM-B) model [52] were used to explore influencing factors on behaviour change and intervention design. The coding process involved moving backwards and forwards between the data and the emerging concepts. The first step generated initial codes from open coding in which units of meanings were derived from line-by-line analysis followed by axial coding to integrate and differentiate among subcategories. Qualitative findings relating to barriers and facilitators were coded in Nvivo [53]. The review team reviewed the coding process and any disagreements were discussed before reaching a consensus. There were no major disagreements and consequently the codes were developed into themes. For the purpose of addressing the third review question, the retention rate was defined as the number (%) of participants completing outcome measures for at least 1 follow-up time point. In studies where this was not explicitly mentioned we used the number (%) of participants continuing to engage with the

intervention after a specified period (i.e. a time period identified by the original author).

### Changes to protocol

Initially, the review team planned to investigate recruitment rates. However, the identified studies varied in recruitment strategies and did not provide sufficient detail to address this research question. In addition, although the review team acknowledges the potential of the grey literature (e.g. research not published in peer-reviewed journals) to broaden the scope of systematic reviews, the team agreed to only include articles published in peer-reviewed journals. This decision was due to different reasons: 1) the popularity of technological advancements in health care, 2) the resource constraints of this study, 3) some evidence of the scarce contribution of unpublished studies to the results of meta-analyses in child-relevant reviews [94], and 4) the consideration that the aim of this systematic review was not related to efficacy and safety, which could more be amenable to publication bias. No other substantial deviations from the registered protocol were made.

## Results

### Overview of included articles

The results of this systematic review are presented as a narrative synthesis [54] and, where applicable, descriptive numerical summaries are provided. 83 articles published between 2001 and 2018 met the inclusion criteria (see Multimedia Appendix 2) identifying 71 interventions (see Multimedia Appendix 3). Of the 83 articles reviewed almost two thirds were conducted in the USA and Canada or in Australia and New Zealand. The most common type of intervention incorporated CBT as the main therapeutic modality. The mean CYP's ages ranged from 2 to 24. Affective disorders (i.e. anxiety and depression including suicidality) were the most common presentation targets of the DHIs reviewed. Table 2 provides a summary of these findings.

Table 2. Characteristics of the included studies.

Characteristics	(%)
<b>Country</b>	
USA & Canada	37
Australia & New Zealand	28
Europe	25
Asia	8
Brazil	1
<b>Therapeutic modality</b>	
Cognitive behavioural therapy	47
Cognitive skills training mechanisms	11
Social skills training or social support	8
Applied Behaviour Analysis concepts	4
Single component or combinations <sup>a</sup>	30

Disorders	
Affective <sup>b</sup>	46
Attention deficit and hyperactivity	8
Autism spectrum	15
Eating disorders	5
Behavioural disorders <sup>c</sup>	12
Non-specific or multiple disorders	15

<sup>a</sup>Combinations of the following strategies: therapeutic support embedded in positive psychology, behaviour activation, self-regulation, learning theories, motivational interviewing, and mindfulness.

<sup>b</sup>Depression, anxiety, or suicidality.

<sup>c</sup>Obsessive compulsive disorder, substance abuse, selective mutism, social difficulties, and psychosis or schizophrenia.

A broad range of recruitment strategies were used to develop and test these DHIs including referrals from health or school professionals, self-referrals through social media and online advertising, university email lists, recruitment software, or in-person advertising through posters, flyers, newspaper adverts, word-of-mouth, and via existing research and support groups. The following section presents the modes of delivery for DHIs highlighting how they have been evaluated and their main features and purpose. Table 3 provides a summary of the six DHI categories identified in this review, corresponding features, and study designs adopted.

**Table 3. Summary of digital modes of delivery used in CYP MH intervention.**

Mode of delivery (n)	Goals: Features	Study design (n)
Website interventions (43)	<i>Communication:</i> Emails, text messages, social networking, online message boards, discussion forums. <i>Dissemination of information:</i> Text and multimedia channels (videos, animations, and audio), games and quizzes, homework tasks and online profile set up with customisations	RCT <sup>a</sup> (22), pre-post test (11), observational study-qualitative, quantitative or mixed methods approaches (10)
Games or computer-assisted interventions (23)	<i>Dissemination of information, skills development, psychoeducation:</i> Photos, stories, animations, quizzes, text messages, multimedia (audio and videos)	RCT (11), pre-post test (8), observational study – quantitative or mixed methods approaches (4)
Apps - web or mobile (10)	<i>Dissemination of information, skills development, peer to peer communication:</i> Text message reminders, text, photos and multimedia (audio and videos) plus opportunity to upload contents.	RCT (4), pre-post test (1), observational study – qualitative, quantitative or mixed methods approaches (5)
Robots and digital devices	<i>Dissemination of information:</i> audio and movement	RCT (1), feasibility study (1), mixed-

	(3) <i>Peer to peer communication:</i>	email method design (1) reminders
Virtual reality experiences	<i>Dissemination of information, skills development, therapeutic support:</i>	Pre-post test (2), post-test (1)
	(3) Gamification using multimedia (audio and images)	
Mobile text messages (1)	<i>Dissemination of information, skills development, social support:</i>	RCT (1) Text

\*Randomised Controlled Trial

## What modes of delivery are used for engaging CYP in digital MH interventions?

### Website interventions (n=43)

Thirty-three of the 43 articles adopted an interventional study design, (22 RCTs and 11 pre-post study designs) The remaining 10 studies adopted observational study designs utilising qualitative, quantitative or mixed methods approaches. The methodological quality of the included studies was acceptable. Qualitative studies were rated from 2 to 5 points (M=4), RCTs were rated 2 to 5 points (M=3.27), nonrandomised quantitative studies were also rated from 2 to 5 points (M=3.27), and mixed methods from 2 to 4 points (M=3.33).

The primary goal of the majority of the interventions (n=40) was to transmit specific MH information to a targeted population. Twelve of the 40 articles described interventions that were multipurpose, providing an additional opportunity for peer communication (n=7) or an opportunity for personal health tracking (n=4). YouthCHAT (see Multimedia Appendix 3 for definitions and descriptions of interventions) provided general information in addition to providing an opportunity for personal health tracking. However, SharpTalk's primary focus was to facilitate peer to peer communication through discussion forums, and MYLO functioned as a communication aid which provided an opportunity for personal health tracking.

Various features were adopted to achieve the above goals. Communication occurred digitally using emails, text messages, social networking, online message boards, and discussion forums. Dissemination of information occurred through text and multimedia channels (e.g. videos, animations, and audio). Some interventions also utilised games and quizzes, homework tasks, and online profile set up with customisations.

### Games or computer-assisted interventions (n=23)

Twenty of the 23 articles adopted an interventional study design, 11 RCTs and 8 pre-post study designs. The remaining 4 studies adopted observational study designs utilising quantitative or mixed-method approaches. The methodological quality of the included studies varied. RCTs were rated 2 to



5 points (M=3.54), nonrandomised quantitative studies from 2 to 4 points (M=3.33), and mixed methods from 3 to 5 points (M=4). No articles utilised qualitative methods only.

The primary goal of the majority of the interventions (n=18) was to transmit specific MH information to a targeted population. Four of the 18 interventions were multipurpose providing additional general information to the public (n=1) or an opportunity for personal health tracking (n=4). Eight interventions focused on cognitive training tasks. The Computer Assisted Instruction intervention was used as a facilitator to assist children in developing reading skills. The Social Stories accessed via tablets were also used for psychoeducational purposes.

The gamification approach used to achieve the above goals were accessed either online or offline and incorporated photos, stories, animations, quizzes, text messages, and videos.

### **Apps (n=10)**

Five of the 10 articles adopted an interventional study design, (4 RCTs and 1 pre-post study design). The remaining 5 articles adopted observational study designs utilising qualitative, quantitative or mixed methods approaches. The methodological quality of the included studies varied. Qualitative studies were rated either 4 or 5 points (M=4.5), RCTs were rated 1 to 4 points (M=2.75), the one nonrandomised quantitative study was rated 4 points, while the two mixed methods were rated 3 points.

The primary goal of most of the apps was to transmit specific MH information to a targeted population. Three apps were multipurpose providing an additional opportunity for personal health tracking. The TECH app further included peer to peer communication.

The included apps were either web apps or mobile apps and included text message reminders, text, photos, and multimedia (videos and audio). Users also had the opportunity to upload content such as videos and photos.

### **Robots and digital devices (n=3)**

Two of the 3 studies adopted an interventional study design, of which 1 (CommU) was an RCT. The study on The Fitbit Flex and Facebook adopted a mixed-method design. The study on ARIA adopted an observational study design as a pilot usability study. The methodological quality of the included studies was acceptable. ARIA was rated 3 points, CommU was rated 3 points, and The Fitbit Flex and Facebook was rated 5 points.

The primary goal of ARIA and CommU was to transmit specific MH information to a targeted population, while The Fitbit Flex and Facebook intervention additionally provided an opportunity for peer communication.

ARIA and CommU utilised audio and movement to achieve the above purpose. The Fitbit Flex and Facebook synced with 2 other approaches, an app and a website, and included email reminders to achieve its purpose.

### **Virtual reality experiences (n=3)**

Two interventions adopted pre-post test designs, while one adopted a post-test only design (VDI). No RCTs were found evaluating the identified interventions. CAVE also incorporated a mixed-method approach and obtained qualitative data. The methodological quality was acceptable. CAVE and CVE were both rated 3 points and VDI was rated as 4.

The primary goal of all 3 interventions was to transmit specific MH information to a targeted group or to facilitate skills training or provide therapeutic support. CVE also functioned as a communication aid to facilitate collaborations within the VR environment.

CAVE, CVE, and VDI utilised features of the gamification approach to engage CYP in a more real-life experience allowing for more immersion and movement.

### **Mobile text messages (n=1)**

One text messaging intervention was identified and evaluated in an RCT. The methodological quality was rated as 3. The ESQYIR aimed to transmit specific MH information to a targeted audience, to facilitate skills training or offer therapeutic support, to provide the opportunity for personal health tracking, and to signpost CYP to additional social support websites. No additional features, apart from text were described in the study. However, participants were contacted via phone as part of the study.

### **What are the barriers and facilitators to engaging CYP in digital MH interventions?**

Influencing factors presented as barriers and facilitators to engagement emerged as two broad themes encompassing 6 factors: intervention-specific influences (suitability, usability, acceptability) and person-specific influences (motivation, capability, opportunity). Overall, 30% of the included articles (24/83) provided data to support these themes, 13 studies provided data for suitability, 13 for usability, and 14 provided data for acceptability. Of the 24 articles, 8 provided data to inform motivation, 4 for capability, and 13 for opportunity. A summary of concepts corresponding to the individual factors within the major themes are presented in the Multimedia Appendix 4. Based on these findings, a conceptual framework (see Figure 2) was developed highlighting the specific components impacting engagement in CYP digital MH interventions, which can inform the development of, and research into, CYP DHIs.

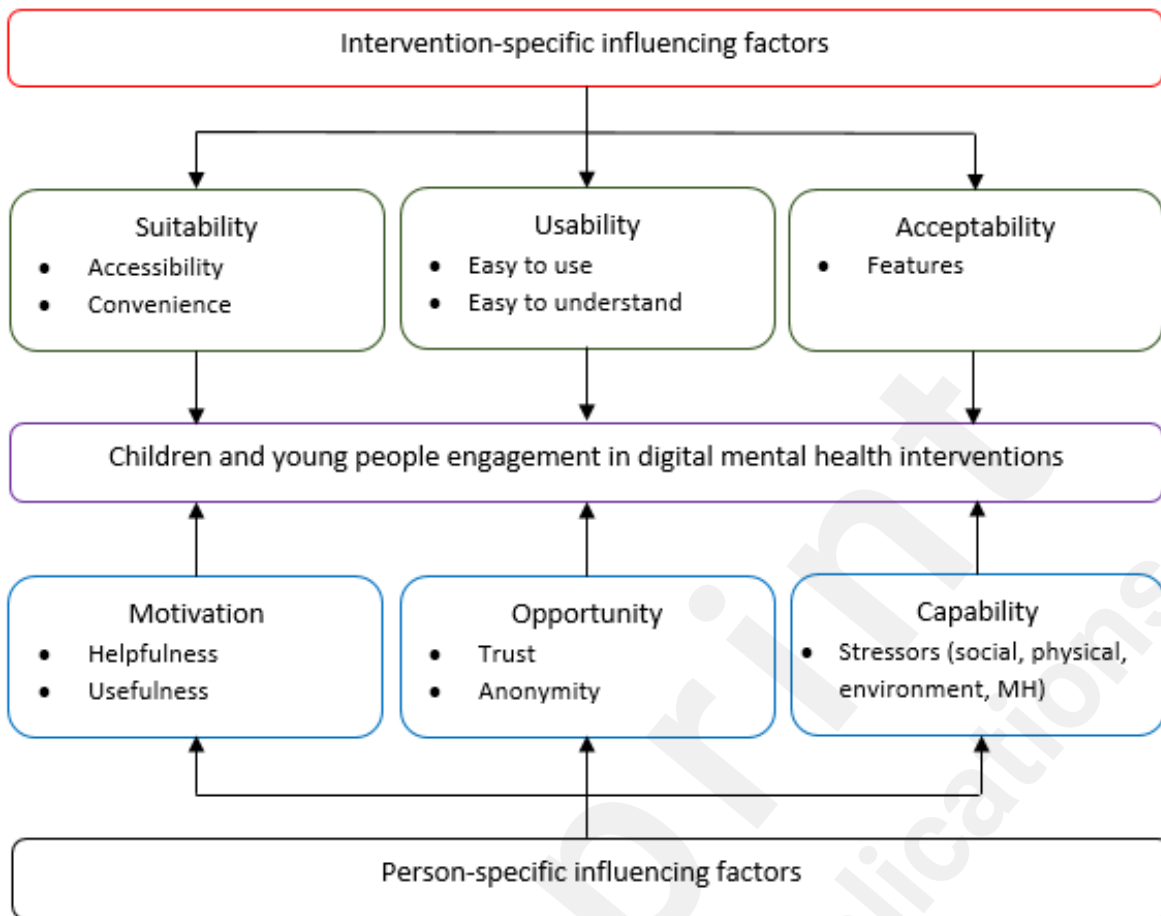


Figure 2. A framework of factors influencing engagement in CYPMH digital intervention.

### Theme1: Intervention-specific influences

CYP highlighted factors relating to the development of the intervention, which influenced whether they used the intervention or not. A prominent factor influencing the acceptability (i.e. willingness to use) of the intervention was the features, whereby CYP highlighted certain images, specific language, and interfaces that were unappealing to them. They made suggestions and highlighted features such as videos, having less text, ability to personalise or create a profile, and ability to connect with others or receive text message reminders as encouraging their use of the intervention. CYP also suggested that providing rewards could also be a motivating factor for engaging with DHIs. Similarly, usability (i.e. the degree to which the DHI was able to be used) was important for promoting engagement. Interventions that CYP favoured were described as self-paced, user-friendly, age-appropriate, simple, and straightforward. However, in situations where CYP had problems understanding the task, or if the intervention did not provide sufficient instructions on usage, they were less inclined to continue using the DHI.

Another main factor was the suitability (i.e. the degree to which the DHI is in line with daily activities) of the intervention to the CYP's lifestyle. Although CYP liked not having to travel to

access the intervention and the ability to use it while at home, they were ‘put off’ by technical issues, or having to use media such as emails or desktop computers which they used less frequently in their daily lives. Many CYP highlighted not participating in the intervention because of a lack of time and inability to integrate the task in their everyday life. They suggested that the flexibility concerning time and ability to bypass long waiting lists encouraged usage. Additionally, they highlighted that DHIs were convenient and welcomed as they spend most of their time online.

### **Theme 2: Person-specific influences**

Three of the 6 factors were associated with person-specific barriers and facilitators to behaviour change, in line with the COM-B model [52]. The opportunity for the intervention to be adopted was highlighted in 3 areas. First, feeling a sense of connectedness was important to CYP. They were more likely to use the intervention if it facilitated conversations with others because they wanted to know that others had similar experiences. Some CYP even indicated that they “felt alone” online without the support of a therapist. Trust was also of great importance to CYP, and they were reluctant to accept DHIs due to privacy concerns or uncertainties around its validity. CYP made suggestions to use trusted ‘brand names’ that they were familiar with. They were also more inclined to use the interventions if there was transparency or evidence provided to support its credibility. The concerns around trust also extended to their preference for anonymity. They highlighted that anonymity made it easier to talk to a stranger online without feelings of embarrassment.

The second major factor identified as a person-specific influence was motivation. Some tasks were of less interest to CYP, and sometimes they would have forgotten the existence of the intervention. However, they highlighted that curiosity and perceived need influenced their usage. Perceived usefulness of the intervention to address their needs was a major motivating factor, and therefore, if the resource was viewed as unhelpful or too general CYP were less interested in using it. However, although CYP were eager to use DHIs, the capability to engage with the intervention was sometimes affected by physical, environmental, and mental health stressors, representing another major influencing factor.

### **How do retention rates vary in CYP digital MH intervention research?**

Due to the heterogeneity in study design and intervention type, not all articles provided sufficient detail to estimate retention rates. Therefore, we were unable to include estimates for 16 of the included articles. The average retention rate across the remaining 67 articles showed almost 80% of CYP using DHIs or completing the follow-up measures. Results showed that the retention rates varied with 11.9% (8 out of 67) of articles achieving 100% retention and 8.95% (6 out of 67)

reporting less than 50% retention. Overall, 83.58% (56 out of 67) of the included articles had a retention rate of at least 70%. Subgroup analyses for approaches with a larger number of articles indicated that the average retention rate for games and computer-assisted intervention studies was 86.95%, followed by websites interventions with 78.87%, and apps with 78.45%. Multimedia Appendix 2 shows the distribution of retention rates across studies.

## Discussion

This review identified six modes of delivery of DHIs for CYP with mental health issues: websites, games and computer-assisted programs, apps, robots and digital devices, virtual reality, and mobile text messaging. Two themes emerged, highlighting intervention-specific and person-specific barriers and facilitators to engagement in DHIs. Additionally, the findings of this review suggest a high average retention rate of almost 80% when the identified modalities were evaluated. Knowledge of these approaches, including influencing factors to usage from the perspective of the CYP, provided information that can be used to design and evaluate new DHIs.

## Explanation of overall findings

From the articles reviewed, 59 contributions were published between 2013 and 2018, with 15 records published in 2018. This is consistent with the fact that interest in applying digital technologies to MH practice has been increasing since the early 2000s, and recommendations for research in this field were issued only in 2013 [79, 80]. With most of the studies reviewed being conducted in developed countries, digital responses to CYPMH seems unbalanced. Previous research [81-83] highlight the paucity of access to DHIs in low and middle-income countries. This inequality could be due to limited resources (both financial and human), shortage of skilled personnel, infrastructure problems leading to poor internet penetration and connectivity [84], or absence of specific CYPMH policy [85]. However, a strong association between severity of risk for mood disorders and social disadvantage has been documented [86, 87]. Anxiety is the most common psychiatric condition afflicting CYP in all societies [27, 88-90]. It may also co-occur with other disorders - both concurrently and sequentially - and lead to further health problems [89]. It is not surprising, therefore, that 46% of articles resulting from our literature search targeted CYP suffering from affective disorders.

The modes of delivery identified in this review are similar to those identified in other reviews exploring adolescent physical health [55, 56] and mental health [27]. The purpose of the interventions are also in line with WHO's classification of DHIs [57]. The intervention-specific and person-specific influences on CYP engagement identified in the present review mirror those of

previous research on the broader Technology Acceptance Model (TAM) [58-60], the conceptual framework for engagement in Digital Behaviour Change Interventions in adults [51, 61], and more recently, the application of social cognitive theory to understand engagement with DHIs for trauma recovery [93]. For these models, predictors included perceived need, engagement self-efficacy, outcome expectations, and symptom severity. The proposed model of CYP engagement in digital MH interventions, based on the findings of the present review, build on these models by highlighting the importance of the social context in which young people engage with DHIs. It also highlights major factors for researchers and developers in CYPMH to facilitate opportunities for a sense of connectedness. *Peer-connectedness* may be challenged by the necessary application of safeguarding measures. Indirect peer-connectedness where CYP can access appropriately anonymous and asynchronous stories from real CYP with similar experiences may be one such approach, as in SharpTalk [62]. Similarly, options for anonymous usage may be particularly important for CYP's *self-connectedness* in terms of sharing experience in a manner that mitigates the role of stigma and shame [91, 92]. *Professional-connectedness* was particularly important in DHIs as CYP wanted to connect with a trusted support provider in lieu of connecting with a professional in real life. A key facilitator of professional-connectedness was credibility in relation to evidence of the intervention's effectiveness and trust in the privacy and data security, which could be facilitated by using familiar 'brand names'. Although characterized as an intervention-specific factor in other models [51], we characterized this as part of opportunities for connectedness and therefore, as a person-specific factor. Future studies should explore the impact of new modes of delivery to promote a sense of connectedness in DHIs (e.g. more usage of features such as ChatBots, as in the MYLO intervention). Other barriers and facilitators that were identified in the present review also emphasize the importance of user-centred design methods when developing DHIs for CYP [51]. Through co-design workshops and focus-groups with CYP, developers can ensure that a DHI's design is age-appropriate, (e.g. little text and using youth engaging language) by putting a greater focus on videos and pictures, while keeping the platform user-friendly. Moreover, CYP mentioned factors such as reward systems and reminders, which fall under the umbrella of persuasive design methods and have been explored in previous research [61, 63]. The positive influence of these methods on user engagement and adherence to DHIs has been supported, however, quantifiable evidence from trials is still lacking [61, 63]. With respect to reminders, past research indicated a positive impact on engagement. Still, excessive and undue reminders have also been shown to have opposing effects [64]. Evidence from previous studies has suggested that specific behaviour change techniques, such as goal setting or self-monitoring tools, relate to higher engagement [65]. The present review did not

extensively investigate these techniques, and therefore cannot fully suggest their potential positive effects on CYP's engagement. However, the findings of this review justify that designing DHIs with CYP in mind would be ideal to promote usage, adherence, positive user experience, as well as to address the barriers that some of the reviewed studies suggest.

### **Comparison of research retention rates to other studies**

Our findings suggest that the retention rate of CYP digital MH interventions (mean retention rate of 79.2%) was superior to retention reported in face-to-face CYP MH outpatient care, where dropout affects between 20-60% of the cases [66]. However, a direct comparison with other studies is not clear-cut, given the diversity of criteria used for defining dropout. For instance, dropout percentages are lower when dropout is defined by the opinion of the therapist than when dropout is defined by the completion of a certain number of sessions [67, 68, 69]. Our definition of retention relied on completion of the first follow-up measure or engagement for a specified period of time, which may explain the higher retention found. In this review, retention rates also varied widely across the studies (range 15.79% - 100%). A similar heterogeneity in retention rates was found in previous reviews of studies with adults receiving Internet-based MH programs (17% - 98%) [66], as well as in face-to-face MH interventions with CYP [67], and adult population [70] (varying between 17%-72% and 17%-98%, respectively). Efficacy studies tend to present lower dropout rates than studies conducted in naturalistic settings [67]. Our review included a variety of empirical studies, which may have contributed to the diversity of retention rates found. Finally, the average retention rate for games and computer-assisted intervention studies was almost 10% higher than the other modalities, which may reflect the preference of children for interventions in game formats [71, 72].

### **CYP digital MH care and support**

DHIs were included at various stages of the provision of psychological support. Technology mediated programs and tools were part of prevention, assessment, treatment (psychoeducation, psychotherapy), and follow up of MH care. This extensive potential of DHIs can support the WHO's initiative to identify and intervene to lessen the MH treatment gap [73]. When used as part of initial assessment, support for shared decision-making, personalized goal setting, progression, or management of transitions, DHIs are able to support CYP by enhancing their sense of agency and control. This may in turn promote achieving greater involvement in the treatment process [74]. In several of the reviewed studies, DHIs targeting social skills training and joint attention training were used in the initial phase as a facilitator of the therapeutic process. For some specific conditions like social anxiety, selective mutism, autism spectrum disorders, and attention deficit conditions, the involvement of digitized programs in the preliminary phase of therapy may be an important

facilitator for therapeutic success [75, 76]. DHIs as part of the therapeutic process can be used in the periods between face-to-face treatment for interactive homework assignments, reminders, self-monitoring tools, individualized exercises, and real-time symptom assessment.

### **Implications and recommendations**

DHIs can be a helpful way to support and treat MH problems. Such tools can complement the various stages of the provision of psychological support or psychotherapy among CYP with MH problems. However, effective implementation and sustained usage will rely on the extent to which the design is appropriate for the intended purpose and how it will be used in practice. This understanding may help to minimise the risks associated with fear of usage that some end users experience by providing useful directions on how to design technologically-responsible therapeutic approaches [77]. As a result, the findings of this review suggest that the development of DHIs should be suitable for CYP's lifestyle, focusing on ease of access, such as the ability to use on their mobile devices at their convenience. Attention should also be given to the design of DHIs to ensure it is not too complex and that the features are attractive to CYP. Additionally, incorporating concepts that provide the CYP with a level of trust for the DHI and ability to connect with others should be carefully considered. To target concerns about usefulness, developers should work with clinicians and CYP to ensure suitable information is provided through the intervention. This collaborative approach can highlight specific ways to encourage CYP to continue to engage or increase engagement during stressful periods.

Although this study provides insight that is valuable for the development of new interventions, future research should: 1) not only focus on effectiveness but also investigate engagement, taking into account influencing factors, as an important component of research, 2) arrive at a consensus on defining engagement and how it should be measured, 3) provide adequate reporting of recruitment and retention rates, and 4) compare CYP preferences for various modes of delivery or therapeutic approaches. Lastly, this study also acknowledges the implications for practice. The findings suggest CYP interest in DHIs, and therefore: 1) efforts to improve engagement may be beneficial to CYPMH outcomes and 2) families including the CYP and clinicians should work together to identify DHIs that are suitable to the CYP's lifestyle.

### **Strengths and limitations**

This review adhered to established guidelines for systematic reviews [78] and adopted a comprehensive study design carried out by a team of researchers, allowing each stage of the review to be undertaken by at least two independent reviewers. Most importantly, this review highlighted the



range of modes of delivery, factors influencing usage, and the variation in study types and retention of CYP in digital MH intervention studies. Our findings contribute to a broader understanding of the CYP DHI literature. However, this review is not devoid of limitations. The review team attempted to identify and include as many articles as possible; however, unknowingly and unintentionally, some papers may have been missed. This can be partly due to the challenges and inconsistencies when defining the construct of engagement resulting in a wide variety of terms used [42]. Additionally, unpublished data were not included in the search strategy and this may have impacted the results of this review. Nevertheless, this approach was also seen as a further strength by ensuring that only peer-reviewed interventions were included. Moreover, the study team attempted to group interventions based on digital platforms to describe each approach. However, there may still be some variation within these groupings that make it difficult to categorise. This review was also limited as only sub-samples of the total number of included articles contributed to addressing research questions 2 and 3. Therefore, caution was taken when generalising findings and drawing overall conclusions. Additionally, due to variability in study designs, we were prudent when averaging retention rates for this review, as follow up measures were collected at varying time points across the selected records.

### **Conclusion**

DHIs may be of interest to CYP, particularly in the area of MH treatment. Research on retention rates suggests high engagement of CYP in digital MH interventions that may encourage further development of DHIs in the near future. CYPMH services could benefit from this development as the included studies indicate. However, the results of this review highlighted intervention-specific and person-specific factors that influence CYP usage of digital MH interventions that should be considered. With continuous technological advancements, it is desirable to know which modalities may increase usability and adherence to better support CYP facing MH challenges.

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**Abbreviations**

CYP- Children and young people

MH- Mental health

DHI- Digital health intervention

CYPMH- Children and young people mental health

CBT- Cognitive behaviour therapy

**Authors contribution**

Conceptualisation: SL and JEC

Selection of articles: SL, CPM, CS, AC, SC, CH, SS, SCC, PMP, GP, BM and JEC

Data extraction: SL, CPM, CS, AC, SC, CH, SS, SCC, PMP, GP, BM and JEC

Data analysis: SL, CPM, CS, AC, SC, CH, SS, SCC, PMP, GP, BM and JEC

Interpretation of results: SL, CPM, CS, AC, SC, CH, SS, SCC, PMP, GP, BM and JEC

Writing up- original draft: SL, CPM, CS, AC, SC, CH, SS, SCC, PMP, GP, BM and JEC

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### **Conflict of Interest**

The authors declare they have no conflicting interests. However, JEC is an author of one of the reviewed articles.

## References

1. Perou R, Bitsko RH, Blumberg SJ, Pastor P, Ghandour RM, Gfroerer JC, Hedden SL, Crosby AE, Visser SN, Schieve LA, Parks SE, Hall JE, Brody D, Simile CM, Thompson WW, Baio J, Avenevoli S, Kogan MD, Huang LN, Centers for Disease C, Prevention LN. Mental health surveillance among children--United States, 2005-2011. *Morbidity and mortality weekly report Surveillance summaries* (Washington, DC : 2002). 2013;62:1-35.
2. Kieling C, Baker-Henningham H, Belfer M, Conti G, Ertem I, Omigbodun O, Rohde LA, Srinath S, Ulkuer N, Rahman A. Child and adolescent mental health worldwide: evidence for action. *The Lancet*. 2011;378(9801):1515-25.
3. Polanczyk GV, Salum GA, Sugaya LS, Caye A, Rohde LA. Annual Research Review: A meta-analysis of the worldwide prevalence of mental disorders in children and adolescents. *Journal of Child Psychology and Psychiatry*. 2015;56(3):345-65.
4. Merikangas KR, He J-P, Burstein M, Swanson SA, Avenevoli S, Cui L, Benjet C, Georgiades K, Swendsen J. Lifetime Prevalence of Mental Disorders in U.S. Adolescents: Results from the National Comorbidity Survey Replication--Adolescent Supplement (NCS-A). *Journal of the American Academy of Child & Adolescent Psychiatry*. 2010;49(10):980-9.
5. Lawrence D, Johnson S, J H, Boterhoven de Haan K, M S, Ainley J, Zubrick S. *The Mental Health of Children and Adolescents: Report on the second Australian Child and Adolescent Survey of Mental Health and Wellbeing*. Canberra, Health Do; 2015. Report No.: Online ISBN: 978-1-76007-188-2; ISBN: 978-1-76007-187-5.
6. Gulliver A, Griffiths K, Christensen H. Perceived barriers and facilitators to mental health help-seeking in young people: a systematic review. *Bmc Psychiatry*. 2010;10(1).
7. Donker T, Petrie K, Proudfoot J, Clarke J, Birch M, Christensen H. Smartphones for Smarter Delivery of Mental Health Programs: A Systematic Review. *Journal Of Medical Internet Research*. 2013;15(11).
8. Clement S, Schauman O, Graham T, Maggioni F, Evans-Lacko S, Bezborodovs N, Morgan C, Rusch N, Brown J, Thornicroft G. What is the impact of mental health-related stigma on help-seeking? A systematic review of quantitative and qualitative studies. *Psychological Medicine*. 2015;45(1):11-27.
9. Wangelin BC, Szafranski DD, Gros DF. *Telehealth Technologies in Evidence-Based Psychotherapy* 2016. 119-40 p.
10. Lahiri U, Bekele E, Dohrmann E, Warren Z, Sarkar N. Design of a virtual reality based adaptive response technology for children with autism spectrum disorder. 2011. p. 165-74.
11. Diehl JJ, Schmitt LM, Villano M, Crowell CR. The clinical use of robots for individuals with Autism Spectrum Disorders: A critical review. *Research in Autism Spectrum Disorders*. 2011;6(1).
12. Van Voorhees BW, Mahoney N, Mazo R, Barrera AZ, Siemer CP, Gladstone TRG, Muñoz RF. Internet-based depression prevention over the life course: a call for behavioral vaccines. *The Psychiatric clinics of North America*. 2011;34(1):167-83.
13. Yuan SNV, Ip HHS. Using virtual reality to train emotional and social skills in children with autism spectrum disorder. *London Journal of Primary Care*. 2018;10(4):110-2.
14. Alvarez-Jimenez M, Alcazar-Corcoles MA, González-Blanch C, Bendall S, McGorry PD, Gleeson JF. Online, social media and mobile technologies for psychosis treatment: A systematic review on novel user-led interventions. *Schizophrenia Research*. 2014;156(1):96-106.

15. Olf M. Mobile mental health: a challenging research agenda. *European journal of psychotraumatology*. 2015;6:27882-.
16. Pennant ME, Loucas CE, Whittington C, Creswell C, Fonagy P, Fuggle P, Kelvin R, Naqvi S, Stockton S, Kendall T, the Expert Advisory G. Computerised therapies for anxiety and depression in children and young people: A systematic review and meta-analysis. *Behaviour Research and Therapy* , 67C 1 - 18 (2015). 2015.
17. Richardson T, Stallard P, Velleman S. Computerised Cognitive Behavioural Therapy for the Prevention and Treatment of Depression and Anxiety in Children and Adolescents: A Systematic Review. *Clin Child Fam Psychol Rev*. 2010;13(3):275-90.
18. Ofcom. Children and parents: Media use and attitudes report 2018 2018. URL: [https://www.ofcom.org.uk/data/assets/pdf\\_file/0024/134907/Children-and-Parents-Media-Use-and-Attitudes-2018.pdf](https://www.ofcom.org.uk/data/assets/pdf_file/0024/134907/Children-and-Parents-Media-Use-and-Attitudes-2018.pdf).
19. Chandrashekar P. Do mental health mobile apps work: evidence and recommendations for designing high-efficacy mental health mobile apps. *mHealth*. 2018;4:6-.
20. Donovan CL, March S. Computer-based Treatment Programs for Youth Anxiety: A Systematic Review. *Psychopathology Review*. 2014;a1(1):130-56.
21. Ebert DD, Zarski A-C, Christensen H, Stikkelbroek Y, Cuijpers P, Berking M, Riper H. Internet and computer-based cognitive behavioral therapy for anxiety and depression in youth: a meta-analysis of randomized controlled outcome trials. *PloS one*. 2015;10(3):e0119895-e.
22. Reyes-Portillo JA, Mufson L, Greenhill LL, Gould MS, Fisher PW, Tarlow N, Rynn MA. Web-Based Interventions for Youth Internalizing Problems: A Systematic Review. *Journal of the American Academy of Child & Adolescent Psychiatry*. 2014;53(12):1254-70.e5.
23. Christensen H, Batterham P, Clear A. Online interventions for anxiety disorders. *Current Opinion in Psychiatry*. 2014;27(1):7-13.
24. Sethi S. Treating Youth Depression and Anxiety: A Randomised Controlled Trial Examining the Efficacy of Computerised versus Face-to-face Cognitive Behaviour Therapy. *Australian Psychologist*. 2013;48(4):249-57.
25. Firth J, Torous J, Nicholas J, Carney R, Prapat A, Rosenbaum S, Sarris J. The efficacy of smartphone-based mental health interventions for depressive symptoms: a meta-analysis of randomized controlled trials. *World Psychiatry*. 2017;16(3):287-98.
26. Ly K, Topooco N, Cederlund H, Wallin A, Bergström J, Molander O, Carlbring P, Andersson G. Smartphone-Supported versus Full Behavioural Activation for Depression: A Randomised Controlled Trial. *PLoS One*. 2015;10(5):e0126559.
27. Hollis C, Falconer CJ, Martin JL, Whittington C, Stockton S, Glazebrook C, Davies EB. Annual Research Review: Digital health interventions for children and young people with mental health problems – a systematic and meta-review. 2017. p. 474-503.
28. Grist R, Porter J, Stallard P. Mental Health Mobile Apps for Preadolescents and Adolescents: A Systematic Review. *J Med Internet Res*. 2017;19(5):e176.
29. Wozney L, McGrath PJ, Gehring ND, Bennett K, Huguet A, Hartling L, Dyson MP, Soleimani A, Newton AS. eMental Healthcare Technologies for Anxiety and Depression in Childhood and Adolescence: Systematic Review of Studies Reporting Implementation Outcomes. *JMIR Ment Health*. 2018;5(2):e48.
30. Scholten H, Granic I. Use of the Principles of Design Thinking to Address Limitations of Digital Mental Health Interventions for Youth: Viewpoint. *J Med Internet Res*. 2019;21(1):e11528.
31. Pham Q, Wiljer D, Cafazzo JA. Beyond the Randomized Controlled Trial: A Review of

Alternatives in mHealth Clinical Trial Methods. *JMIR Mhealth Uhealth*. 2016;4(3):e107.

32. Michie S, Yardley L, West R, Patrick K, Greaves F. Developing and Evaluating Digital Interventions to Promote Behavior Change in Health and Health Care: Recommendations Resulting From an International Workshop *J Med Internet Res* 2017;19(6):e232

33. Mohr DC, Schueller SM, Riley WT, Brown CH, Cuijpers P, Duan N, Kwasny MJ, Stiles-Shields C, Cheung K. Trials of Intervention Principles: Evaluation Methods for Evolving Behavioral Intervention Technologies. *J Med Internet Res*. 2015;17(7):e166.

34. Mohr DC, Cheung K, Schueller SM, Hendricks Brown C, Duan N. Continuous Evaluation of Evolving Behavioral Intervention Technologies. *American Journal of Preventive Medicine*. 2013;45(4):517-23.

35. Klasnja P, Hekler EB, Shiffman S, Boruvka A, Almirall D, Tewari A, Murphy SA. Microrandomized Trials: An Experimental Design for Developing Just-in-Time Adaptive Interventions. *Health Psychology*. 2015;34(S):1220-8.

36. Vis C, Kleiboer A, Prior R, Bønes E, Cavallo M, Clark SA, Dozeman E, Ebert D, Etzelmüller A, Favaretto G, Zabala AF, Kolstrup N, Mancin S, Mathiassen K, Myrbakk VN, Mol M, Jimenez JP, Power K, van Schaik A, Wright C, Zanalda E, Pederson CD, Smit J, Riper H. Implementing and up-scaling evidence-based eMental health in Europe: The study protocol for the MasterMind project. *Internet Interventions - The application of information technology in mental and behavioural*. 2015;2(4):399-409.

37. Andersson G, Titov N. Advantages and limitations of Internet-based interventions for common mental disorders. *World Psychiatry*. 2014;13(1):4-11.

38. Musiat P, Tarrrier N. Collateral outcomes in e-mental health: a systematic review of the evidence for added benefits of computerized cognitive behavior therapy interventions for mental health. *Psychological Medicine*. 2014;44(15):3137-50.

39. Schuster R, Pokorny R, Berger T, Topooco N, Laireiter AR. The advantages and disadvantages of online and blended therapy: Survey study amongst licensed psychotherapists in Austria. *Journal of Medical Internet Research*. 2018;20(12):<xocs:firstpage xmlns:xocs=""/>.

40. Becker KD, Lee BR, Daleiden EL, Lindsey M, Brandt NE, Chorpita BF. The Common Elements of Engagement in Children's Mental Health Services: Which Elements for Which Outcomes? *Journal of Clinical Child & Adolescent Psychology*. 2015;44(1):30-43.

41. Gopalan G, Goldstein L, Klingenstein K, Sicher C, Blake C, McKay MM. Engaging families into child mental health treatment: updates and special considerations. *Journal of the Canadian Academy of Child and Adolescent Psychiatry = Journal de l'Academie canadienne de psychiatrie de l'enfant et de l'adolescent*. 2010;19(3):182.

42. Haine-Schlagel R, Walsh N. A Review of Parent Participation Engagement in Child and Family Mental Health Treatment. *Clin Child Fam Psychol Rev*. 2015;18(2):133-50.

43. Ericsson. Ericsson Mobility Report: 70 Percent of World's Population Using Smartphones by 2020 2015. URL: <https://www.ericsson.com/en/press-releases/2015/6/ericsson-mobility-report-70-percent-of-worlds-population-using-smartphones-by-2020>

44. Kim H, Munson M, McKay M. Engagement in Mental Health Treatment Among Adolescents and Young Adults: A Systematic Review. *Child Adolesc Soc Work J*. 2012;29(3):241-66.

45. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Annals of internal medicine*. 2009;151(4):264.

46. Munn Z, Aromataris E, Tufanaru C, Stern C, Porritt K, Farrow J, Lockwood C, Stephenson M, Moola S, Lizarondo L, McArthur A, Peters M, Pearson A, Jordan Z. The development of

software to support multiple systematic review types: the Joanna Briggs Institute System for the Unified Management, Assessment and Review of Information (JBI SUMARI). *International Journal Of Evidence-Based Healthcare*. 2019;17(1):36-43.

47. Gale NK, Heath G, Cameron E, Rashid S, Redwood S. Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC medical research methodology*. 2013;13:117-.

48. Hong QN, Fàbregues S, Bartlett G, Boardman F, Cargo M, Dagenais P, Gagnon M-P, Griffiths F, Nicolau B, O'Cathain A, Rousseau M-C, Vedel I, Pluye P. The Mixed Methods Appraisal Tool (MMAT) Version 2018 for Information Professionals and Researchers. *Education for Information*. 2018;34(4):285.

49. Pluye P, Gagnon M-P, Griffiths F, Johnson-Lafleur J. A scoring system for appraising mixed methods research, and concomitantly appraising qualitative, quantitative and mixed methods primary studies in Mixed Studies Reviews. *International Journal of Nursing Studies*. 2009;46(4):529-46.

50. Braun V, Clarke V. Using thematic analysis in psychology. *Qualitative Research in Psychology*. 2006;3(2):77-101.

51. Kayser L, Nøhr C, Bertelsen P, Botin L, Villumsen S, Showell C, Turner P. Theory and practice in digital behaviour change: A matrix framework for the co-production of digital services that engage, empower and emancipate marginalised people living with complex and chronic conditions. *Informatics*. 2018;5(4):<xocs:firstpage xmlns:xocs=""/>.

52. Michie S. The behaviour change wheel : a guide to designing interventions / Susan Michie, Lou Atkins, Robert West. Atkins L, West R, editors: Sutton : Silverback Publishing; 2014.

53. Jackson K. Qualitative data analysis with NVivo / Kristi Jackson & Pat Bazeley. 3rd edition. ed. Bazeley P, editor: London : Sage; 2019.

54. Popay J, Roberts H, Sowden A, Petticrew M, Arai L, Rodgers M, Britten N, Roen K, Duffy S. Guidance on the Conduct of Narrative Synthesis in Systematic Reviews: A product from the ESRC Methods Programme Bailrigg: Lancaster University; 2006.

55. Devine KA, Viola AS, Coups EJ, Wu YP. Digital Health Interventions for Adolescent and Young Adult Cancer Survivors. *JCO Clinical Cancer Informatics*. 2018(2):1-15.

56. Rose T, Barker M, Maria Jacob C, Morrison L, Lawrence W, StröMmer S, Vogel C, Woods-Townsend K, Farrell D, Inskip H, Baird J. A Systematic Review of Digital Interventions for Improving the Diet and Physical Activity Behaviors of Adolescents. *Journal of Adolescent Health*. 2017;61(6):669-77.

57. Organization WH. Classification of digital health interventions v1.0: A shared language to describe the uses of digital technology for health. 2018.

58. Venkatesh V, Morris MG, Davis GB, Davis FD. User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly*. 2003;27(3):425-78.

59. Davis FD. Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*. 1989;13(3):319-40.

60. Rahimi B, Nadri H, Lotfnezhad Afshar H, Timpka T. A Systematic Review of the Technology Acceptance Model in Health Informatics. 2018;9(3):604-34.

61. Perski O, Blandford A, West R, Michie S. Conceptualising engagement with digital behaviour change interventions: a systematic review using principles from critical interpretive synthesis. *Translational Behavioral Medicine*. 2017;7(2):254-67.

62. Jones R, Sharkey S, Ford T, Emmens T, Hewis E, Smithson J, Sheaves B, Owens C. Online discussion forums for young people who self-harm: user views. *The Psychiatrist*. 2018;35(10):364-8.

63. Kelders SM, Kok RN, Ossebaard HC, Van Gemert-Pijnen J. Persuasive System Design Does Matter: A Systematic Review of Adherence to Web-Based Interventions. *Journal Of Medical Internet Research*. 2012;14(6):17-40.
64. Haotian L, Xiaohang W. Intervention strategies for improving patient adherence to follow-up in the era of mobile information technology: a systematic review and meta-analysis. *PLoS ONE*. 2014;9(8):e104266.
65. Epton T, Currie S, Armitage CJ. Unique Effects of Setting Goals on Behavior Change: Systematic Review and Meta-Analysis. *Journal of Consulting and Clinical Psychology*. 2017;85(12):1182-98.
66. Melville KM, Casey LM, Kavanagh DJ. Dropout from Internet-based treatment for psychological disorders. *British Journal of Clinical Psychology*. 2010;49(4):455-71.
67. de Haan AM, Boon AE, de Jong JTVM, Hoeve M, Vermeiren RRJM. A meta-analytic review on treatment dropout in child and adolescent outpatient mental health care. *Clinical Psychology Review*. 2013;33(5):698-711.
68. Warnick EM, Gonzalez A, Robin Weersing V, Scahill L, Woolston J. Defining dropout from youth psychotherapy: how definitions shape the prevalence and predictors of attrition. *Child and Adolescent Mental Health*. 2012;17(2):76-85.
69. O’Keeffe S, Martin P, Goodyer IM, Wilkinson P, Consortium I, Midgley N. Predicting dropout in adolescents receiving therapy for depression. *Psychotherapy Research*. 2018;28(5):708-21.
70. Swift JK, Greenberg RP. Premature Discontinuation in Adult Psychotherapy: A Meta-Analysis. *Journal of Consulting and Clinical Psychology*. 2012;80(4):547-59.
71. Heidi P, Minna A, Lotta K, Kai K, Camilla L, Ville L, Anni P, Jouni S, Sanna S. The advantages and limitations of digital games in children’s health promotion. *Finnish Journal of eHealth and eWelfare*. 2014;6(4).
72. Olson CK. Children's Motivations for Video Game Play in the Context of Normal Development. *Review of General Psychology*. 2010;14(2):180-7.
73. Organization WH. mhGAP : Mental Health Gap Action Programme : scaling up care for mental, neurological and substance use disorders. Geneva; 2008.
74. Edbrooke-Childs J, Edridge C, Averill P, Delane L, Hollis C, Craven MP, Martin K, Feltham A, Jeremy G, Deighton J, Wolpert M. A Feasibility Trial of Power Up: Smartphone App to Support Patient Activation and Shared Decision Making for Mental Health in Young People. *JMIR Mhealth Uhealth*. 2019;7(6):e11677.
75. Grist R, Croker A, Denne M, Stallard P. Technology Delivered Interventions for Depression and Anxiety in Children and Adolescents: A Systematic Review and Meta-analysis. *Clin Child Fam Psychol Rev*. 2019;22(2):147-71.
76. Pihlaja S, Stenberg J-H, Joutsenniemi K, Mehik H, Ritola V, Joffe G. Therapeutic alliance in guided internet therapy programs for depression and anxiety disorders – A systematic review. *Internet Interventions*. 2018;11(C):1-10.
77. George MJ, Odgers CL. Seven Fears and the Science of How Mobile Technologies May Be Influencing Adolescents in the Digital Age. *Perspectives on psychological science : a journal of the Association for Psychological Science*. 2015;10(6):832-51.
78. Khan KS, Kunz R, Kleijnen J, Antes G. Five Steps to Conducting a Systematic Review. *Journal of the Royal Society of Medicine*. 2003;96(3):118-21.
79. Hatch A, Hoffman JE, Ross R, Docherty JP. Expert Consensus Survey on Digital Health



Tools for Patients With Serious Mental Illness: Optimizing for User Characteristics and User Support. *JMIR Ment Health*. 2018;5(2):e46.

80. Mohr DC, Burns MN, Schueller SM, Clarke G, Klinkman M. Behavioral intervention technologies: evidence review and recommendations for future research in mental health. *General hospital psychiatry*. 2013;35(4):332-8.

81. Sobowale K, Nguyen M, Weiss B, Van TTH, Trung LT. Acceptability of internet interventions for youth mental health in Vietnam. *Global Mental Health*. 2016;3.

82. Cummings J, Gaydos L, Mensa-Kwao A, Song M, Blake S. Perspectives on Caregiver-Focused mHealth Technologies to Improve Mental Health Treatment for Low-Income Youth with ADHD. *J technol behav sci*. 2019;4(1):6-16.

83. Eustache E, Gerbasi ME, Smith Fawzi MC, Fils-Aimé JR, Severe J, Raviola GJ, Legha R, Darghouth S, Grelotti DJ, Thérosme T, Pierre EL, Affricot E, Alcindor Y, Becker AE. High burden of mental illness and low utilization of care among school-going youth in Central Haiti: A window into the youth mental health treatment gap in a low-income country. *International Journal of Social Psychiatry*. 2017;63(3):261-74.

84. Chakrabarti S, Shah R. Telepsychiatry in the developing world: Whither promised joy? *Indian Journal of Social Psychiatry*. 2016;32(3).

85. Shatkin JP, Belfer ML. The Global Absence of Child and Adolescent Mental Health Policy. *Child and Adolescent Mental Health*. 2004;9(3):104-8.

86. McLaughlin KA, Costello EJ, Leblanc W, Sampson NA, Kessler RC. Socioeconomic status and adolescent mental disorders. *American journal of public health*. 2012;102(9):1742.

87. Hartwell H. Social inequality and mental health. *The journal of the Royal Society for the Promotion of Health*. 2008;128(3):98.

88. Patel V, Flisher AJ, Hetrick S, McGorry P. Mental health of young people: a global public-health challenge. *The Lancet*. 2007;369(9569):1302-13.

89. Langhaug L, Pascoe S, Mavhu W, Woelk G, Sherr L, Hayes R, Cowan F. High Prevalence of Affective Disorders among Adolescents Living in Rural Zimbabwe. *J Community Health*. 2010;35(4):355-64.

90. Merikangas KR, Nakamura EF, Kessler RC. Epidemiology of mental disorders in children and adolescents. *Dialogues in clinical neuroscience*. 2009;11(1):7-20.

91. Kaushik A, Kostaki E, Kyriakopoulos M. The stigma of mental illness in children and adolescents: A systematic review. *Psychiatry Research*. 2016;243:469-94.

92. Stangl A, Earnshaw V, Logie C, Van Brakel W, Simbayi L, Barré I, Dovidio J. The Health Stigma and Discrimination Framework: a global, crosscutting framework to inform research, intervention development, and policy on health-related stigmas. *BMC Medicine*. 2019;17.

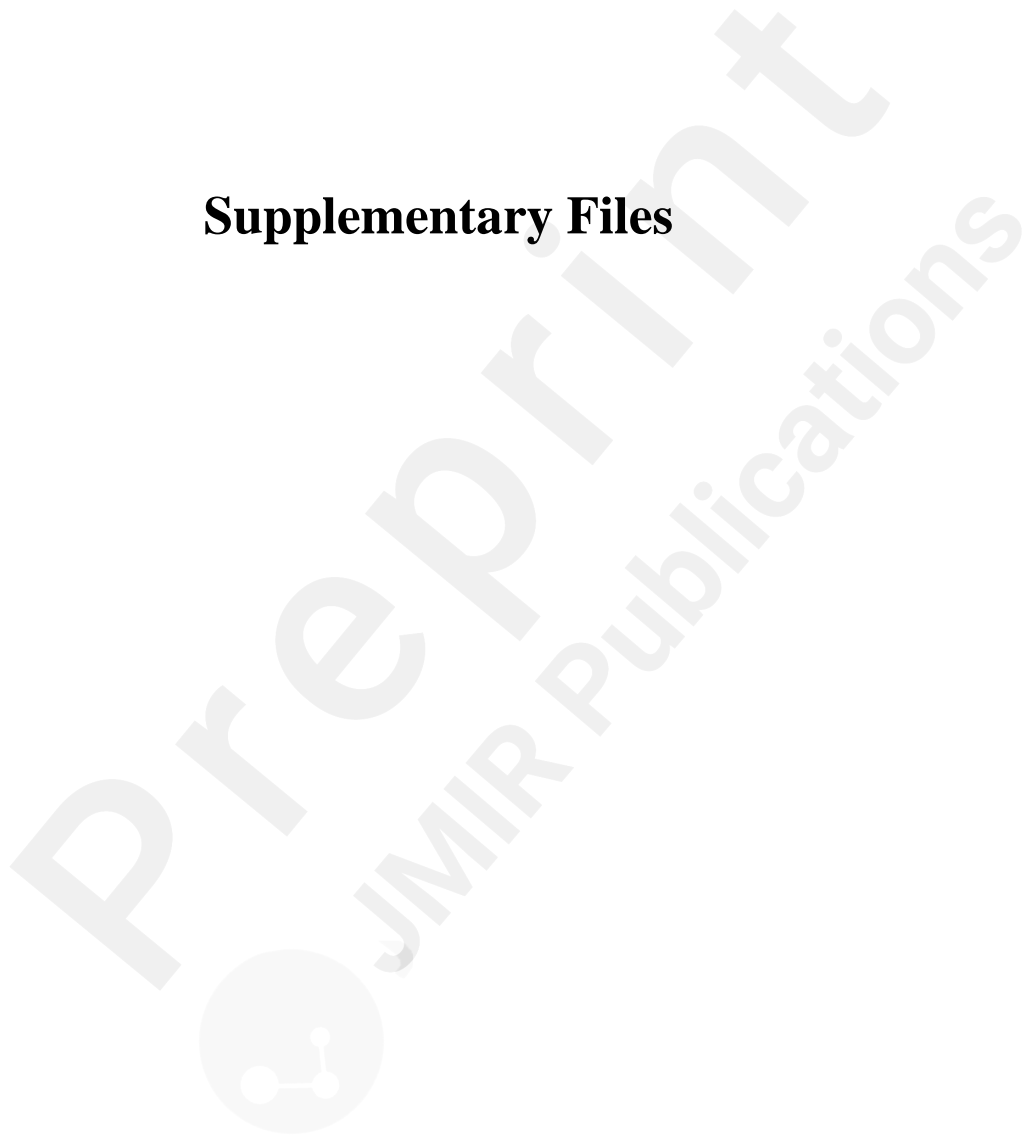
93. Yeager CM, Benight CC. If we build it, will they come? Issues of engagement with digital health interventions for trauma recovery. *mHealth*. 2018;4:37-.

94. Hartling L, Featherstone R, Nuspl M, Shave K, Dryden DM, Vandermeer B. Grey literature in systematic reviews: a cross-sectional study of the contribution of non-English reports, unpublished studies and dissertations to the results of meta-analyses in child-relevant reviews. *BMC Medical Research Methodology*. 2017;17(1):64.

95. Perski O, Blandford A, West R, Michie S. Conceptualising engagement with digital behaviour change interventions: a systematic review using principles from critical interpretive synthesis. *Translational behavioral medicine*. 2017;7(2):254-67.

## Reviewed Articles

## Supplementary Files



## Multimedia Appendixes

Search Strategy.

URL: <https://asset.jmir.pub/assets/8093d29aa72f5d329c720dab8b5a770d.pdf>

Characteristics of reviewed articles.

URL: <https://asset.jmir.pub/assets/65d864ba12be5fb346e9605d124dfd69.pdf>

Intervention characteristics.

URL: <https://asset.jmir.pub/assets/2e331d08c37df6a1ece41a7eb4a78a25.pdf>

Themes and supporting codes.

URL: <https://asset.jmir.pub/assets/9042e14123645d79f8948a09e9653704.pdf>

## Other materials for editor/reviewers onlies

Ms Revised Tracked Changes.

URL: <https://asset.jmir.pub/assets/5639b2b7d45523447b25f24acd5a1c76.doc>

Reviewer responses.

URL: <https://asset.jmir.pub/assets/f3c342534056ee6b8b345e7998b452d2.docx>

Revised Manuscript with tracked changes.

URL: <https://asset.jmir.pub/assets/75d9476f0b063042df32c4b47c160df1.docx>