


Effective elements of eHealth interventions for mental health and well-being in children and adolescents: A systematic review

DIGITAL HEALTH
Volume 10: 1–34
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DOI: 10.1177/20552076241294105
journals.sagepub.com/home/dhj



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Abstract

Background: Mental health problems among children and adolescents increased in recent years, while mental health services are overburdened with long waiting lists. eHealth interventions, that is, interventions delivered digitally via apps or websites, offer a promising approach to prevent and efficiently treat emerging mental health problems in youth. Over the past years, rapid technological progress has led to diverse eHealth interventions for youth mental health. However, a structured overview of effective eHealth elements and mechanisms through which interventions aim to improve mental health is lacking. The aim of this pre-registered systematic review is to identify elements of eHealth interventions that improve mental health and well-being in children and adolescents aged 10–25 from both clinical and general populations.

Methods: This systematic review conducted in April 2023 in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analysis guidelines identified 108 studies and 103 distinct interventions between 2011–2023. The overall sample size was 33,435 participants (30.7% male, mean age = 18.4 years, $SD = 2.5$). Most studies (64.8%) were randomized controlled trials (RCTs) to test the interventions. The remaining studies utilized a pre-post or group-comparison design (non-RCTs).

Results: The interventions were heterogeneous in design, method of delivery, target group and outcome measures. Overall, 77.7% of the studies showed a positive significant association between eHealth intervention and mental health or well-being. Elements that were often related to improved mental health and well-being were cognitive behavioural therapy (CBT) or self-monitoring as therapeutic principles, blended approaches combining eHealth with traditional therapy, peer/parental involvement and technological gamification elements, such as rewards.

Conclusions: Elements of youth eHealth interventions that appear to positively impact mental health or well-being are (a) CBT-based, (b) self-monitoring (c) blended interventions, (d) peer or parental involvement or (e) gamification. Future directions for the development and implementation of eHealth interventions for youth are discussed.

Keywords

eHealth intervention, effective elements, children, adolescents, systematic review, mental health, well-being

Submission date: 28 March 2024; Acceptance date: 10 October 2024

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Introduction

Adolescence includes the life transition from childhood to adulthood and is marked by an increased vulnerability to mental health problems.¹ Currently, an estimated 13–25% of European adolescents suffer from depression or anxiety.² Current societal challenges, demands and major crises such as the COVID-19 pandemic, may further increase the risk of mental health problems.^{3–6} One of the major challenges ahead is the overburdened healthcare system; timely identification and treatment of mental health problems are difficult, with a shortage of healthcare professionals, long waiting lists for treatment and lack of effective prevention strategies.⁷ Moreover, stigma associated with mental health problems and help-seeking, and complex ‘pathways to care’ further delay treatment.^{8,9} Overall, for adolescents with mental health problems, it may take several years to be diagnosed and receive adequate treatment.^{10,11} Therefore, alternative, easily accessible and sustainable approaches to promote resilience and prevent the onset of mental health problems in children and adolescents are urgently warranted.^{12,13}

A promising approach to prevent and treat mental health problems and to build resilience in adolescents is eHealth. eHealth can be defined as ‘health services and information delivered or enhanced through the Internet and related technologies’.¹⁴ Advantages of eHealth compared to face-to-face therapy for mental health problems include lower invasiveness, potential higher cost-effectiveness, lower threshold for help-seeking and efficient delivery of therapy.^{15,16} The field of eHealth for mental health has evolved rapidly, with an enormous increase in the number of eHealth interventions in recent years.^{17,18} This has resulted in a diverse range of existing eHealth interventions, varying in design, mode of delivery, content and mechanisms through which interventions aim to improve mental health. However, most eHealth interventions lack scientific substantiation.¹⁹ To develop evidence-based future-proof and sustainable eHealth interventions it is essential to understand which elements are effective. In this study, we review the literature on different elements (mode of delivery, therapeutic principles, blended intervention and/or involvement of others and interactive elements) of eHealth interventions aimed at enhancing mental health or well-being in children and adolescents.

Elements of eHealth interventions

The first element we investigate in this review is the mode of delivering interventions, that is, via smartphone applications, web-based or text messages. Earlier eHealth interventions targeting mental health were mainly computerized versions of cognitive behavioural therapy (CBT) or included additional telecommunications (i.e. text messages or emailing) to face-to-face therapy. Some contemporary

eHealth interventions still include these elements. However, the rapid technological development and the rise of mobile technology in the last decade led to the development of eHealth interventions via websites or smartphone applications. Currently, there are around 20,000 mental health apps in the app store and the popularity continues to grow.²⁰ Importantly, providing eHealth interventions appears particularly useful and feasible for youth, since the vast majority (~95%) of adolescents in the United States and Europe have access to smartphones or laptops.²¹

The second element in this review includes the therapeutic principles of eHealth interventions. According to recent systematic reviews of randomized controlled trials (RCTs), most eHealth interventions for youth are based on CBT and are related to improved mental health in children and adolescents.^{22,23} CBT is a treatment approach that aims to identify and modify maladaptive patterns of thinking, emotional responses and behaviours.²⁴ An essential element of CBT is the learning and application of adaptive coping strategies, such as seeking social support, self-acceptance, positive distractions and problem solving. In adolescents, CBT is commonly used to treat depressive symptoms and disorders and has been found to be effective in reducing mental health problems and increasing well-being in youth.^{25,26}

The efficacy of eHealth interventions based on other therapeutic principles than CBT, such as positive psychology, mindfulness or self-monitoring, are less frequently investigated, resulting in inconclusive evidence.²⁷ However, there is empirical evidence on these therapeutic principles in regular care (non-eHealth contexts), which might be interesting to study further. Specifically, positive psychology is the scientific study of what makes life most worth living, focusing on both individual and societal well-being.²⁸ Interventions based on positive psychology specifically aim to enhance well-being instead of reducing psychopathological symptoms and can be used to complement clinical psychological interventions for mental health symptoms. Well-known examples of positive psychology interventions include practicing gratitude or forgiveness, being kind to others, writing about positive, meaningful or successful experiences and finding flow. Systematic reviews and meta-analyses found positive psychology interventions to be effective in increasing well-being, as well as decreasing depression and anxiety symptoms.^{29,30} Moreover, originating from Buddhist practice and philosophy, mindfulness can be described as the state of being attentive to and aware of what is taking place in the present.³¹ Interventions to increase mindfulness often include meditation or relaxation practices and have been related to various mental health and well-being outcomes, both in adults³² and youth.³³ Furthermore, self-monitoring can be used as an element to improve mental health by enhancing emotional self-awareness.^{34,35} Self-monitoring is nowadays mostly done via the experience sampling method (ESM) using the smartphone of the participant.

ESM includes the repeated assessment of mood, behaviour and context per day. The collection of data on momentary positive and negative affect multiple times per day is thought to enhance self-insight and self-management, allowing for early identification of mood problems. Mood patterns can reveal important information for both the participant and the therapist if applied in a clinical setting.³⁵

The third element in this review is the addition of face-to-face therapy or inclusion of parents/peers in eHealth interventions. eHealth interventions can be administered as stand-alone (e.g. patients themselves play a mindfulness app), supported by peers or parents or blended in combination with face-to-face therapy. Recent reviews suggest that interventions are more likely to be effective when they include a face-to-face component compared to self-administered interventions.^{22,23} However, conclusive evidence based on more studies is needed.

Lastly, the fourth element in eHealth interventions include advanced gamification or interactive elements. Technological advancements have resulted in the development of chatbots and serious gamification.^{36,37} Chatbots are automated artificial intelligence (AI)-driven software. Through interactive interfaces, people can engage in conversations with chatbots via text or speech. Chatbots recently emerged in psychotherapy, providing guided psychotherapy via automated script-based dialogue.³⁶ In adults, chatbot-delivered psychotherapy seems to reduce depressive symptoms.³⁸ Gamification refers to the use of gaming elements in healthcare and digital health. It involves serious gaming, that is, teaching skills or knowledge through games and integrating game-like elements, such as earning points, rewards, challenges, group competition, to engage and motivate users in their healthcare activities.^{39–41} A meta-analysis of 42 studies showed a positive effect of gamification on mental health in children, adolescents and adults.³⁶ The effect was consistent across platforms (smartphone vs website) and goals of the game (mental health enhancement, physical health enhancement or learning). Similarly, gamification was effective in samples with different characteristics, that is, age and clinical status, indicating the potential of gamification in eHealth interventions in diverse populations.

Taken together, despite a strong increase in eHealth tools, it is not yet clear which elements improve mental health and well-being in children and adolescents. Previous systematic reviews suggest that eHealth interventions are effective in improving mental health and well-being, but these interventions are mostly limited to CBT targeting depression and anxiety.^{22,23,42} Other therapeutic principles, such as positive psychology, mindfulness or self-monitoring and other measures of mental health problems and well-being are not taken into account. This focus on CBT-based interventions leaves a significant gap in our understanding of how these alternative therapeutic approaches, which may offer unique benefits, contribute to mental health outcomes. Moreover,

the rapid technological advancements and heightened interest in eHealth due to the COVID-19 pandemic have likely increased the variety and number of eHealth interventions beyond those previously reviewed. Therefore, there is a pressing need to evaluate these emerging interventions to identify which elements are most effective across different therapeutic approaches and outcomes.

Aims

In this systematic review, we describe elements of eHealth interventions aiming to reduce mental health problems and enhance well-being in children and adolescents aged 10–25 years both from clinical and general populations. We explicitly chose this broad age range from adolescence to young adulthood to provide a complete review that reflects the diversity of eHealth interventions available across different developmental stages (instead of focusing on only one developmental stage). This is in line with recent work that expanded the definition and timeframe of adolescence to include young adulthood, because adolescence mostly extends into the early 20 s, as more youth in modern societies are postponing traditional adult responsibilities such as starting a family, securing full-time employment or purchasing a house. By systematically exploring a broad range of therapeutic principles, we aim to provide a comprehensive understanding of the effective components of eHealth interventions. In particular, we include studies on eHealth interventions (both RCTs and non-RCTs) based on different therapeutic principles, assessing a wide range of mental health and well-being outcomes in clinical samples and samples from the general population. Understanding these elements is important for advancing the field, as it can inform the development of more targeted and effective eHealth solutions. First, we describe the elements of existing eHealth interventions, including the (a) *mode of delivery*, that is, smartphone application, web-based or text messages, (b) *therapeutic principle* of the intervention, such as CBT, mindfulness and positive psychology, (c) *blended interventions and/or involvement of others*, such as parents or peers and (d) *interactive elements*, such as chatbots or gamification. Second, we describe the mental health and well-being outcomes. Finally, we evaluate the effect of the different elements in improving mental health or well-being in children and adolescents.

Method

Search strategy and selection criteria

This systematic review is conducted and reported in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analysis guidelines (Moher et al., 2009). Hypotheses and methods were pre-registered in PROSPERO (https://www.crd.york.ac.uk/prospero/display_

record.php?ID=CRD42023404110). The search was conducted in 02/2022 and updated in 04/2023 by the medical library of the Erasmus MC Rotterdam, The Netherlands. The electronic databases Embase, Medline ALL, PsycINFO, Web of Science, Cochrane and Google Scholar were used (see online supplemental materials A1 and A2 for search string queries).

Inclusion criteria included studies that investigated eHealth interventions aimed at reducing mental health problems (e.g. depression, anxiety and stress) or improving well-being in children and adolescents aged 10–25 years. Additionally, studies were included if they assessed the intervention effects using quantitative measures of mental health or well-being rather than qualitative approaches.

Exclusion criteria were: (a) focus on a very specific target group (e.g. pregnant teenagers or paediatric patients), (b) no digital intervention, (c) intervention primarily targeting the support system of children/adolescents (e.g. parents), (d) evaluation via qualitative data, (e) no English article or full-text availability or (f) study protocols, systematic reviews, letters, case reports or conference abstracts.

Figure 1 provides an overview of the selection process and the reasons for exclusion. After the initial search, duplicates were manually removed. All remaining articles were assessed for relevance based on titles and abstracts. To ensure a robust selection process, five independent reviewers (SvE, ED, FB, MvdE, AV) participated, with a mean interrater reliability of 81.3%, indicating a strong

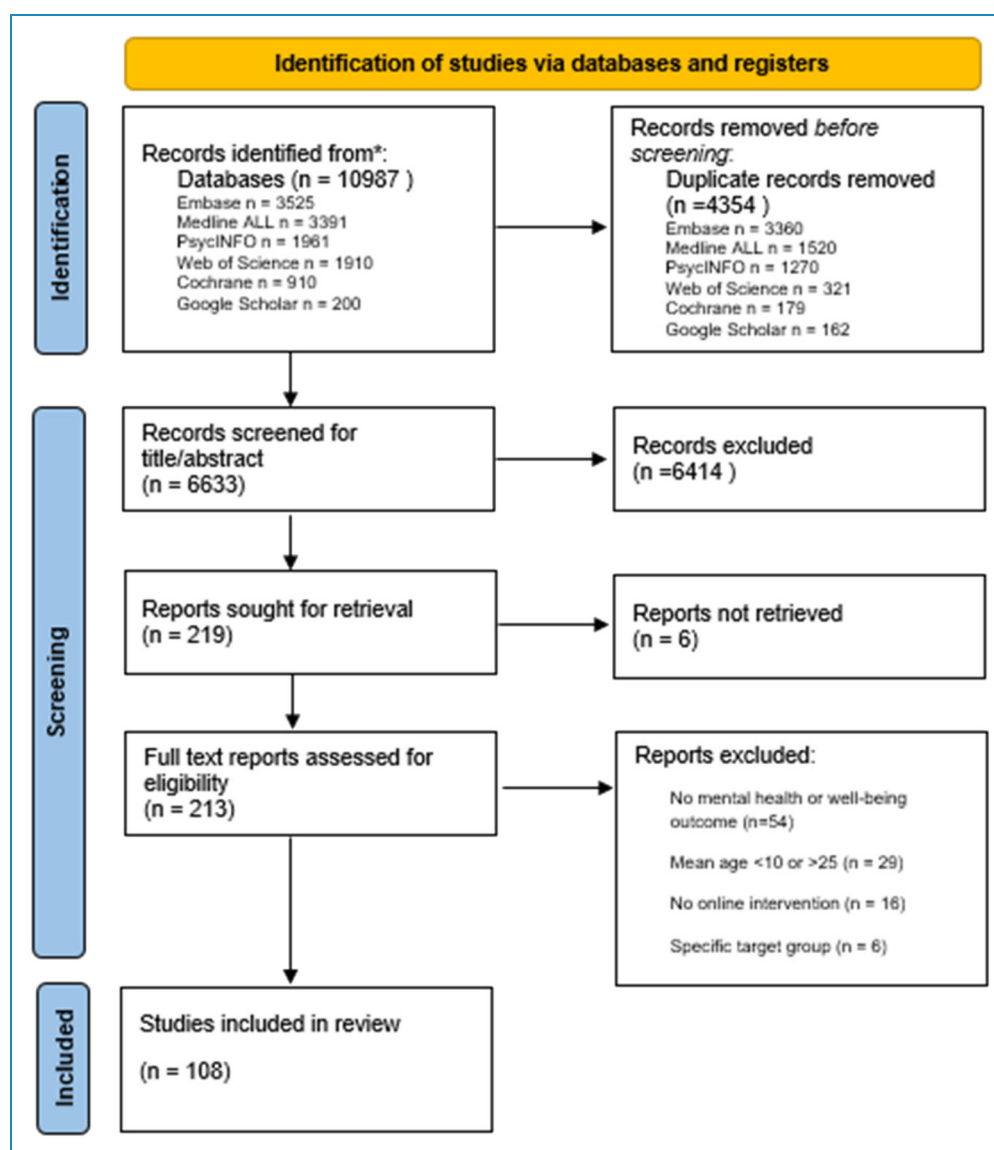


Figure 1. PRISMA flow diagram of the search and selection process. PRISMA: Preferred Reporting Items for Systematic Review and Meta-Analysis.

level of agreement. Any discrepancies were resolved through consensus between two reviewers (SvE, ED). Full-text papers of the included 108 articles were independently assessed by two reviewers (SvE, ED) with a strong mean interrater reliability of 94.4%. Data extraction from all included papers was carried out by LdV, with validation and cross-checking performed by SvE and ED.

Data extraction and quality assessment

Data on descriptives, design, elements and efficacy were extracted from the included studies. Quality assessment and risk of bias in the included studies were performed using the national institute of health Quality Assessment tool (<https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools>). This tool consists of a checklist with 14 (RCT) or 12 (non-RCT: pre-post/group comparison studies) questions, which can be answered with ‘yes’, ‘no’, or ‘cannot determine/not reported/not applicable’. To determine the quality rating of the studies, scores were assigned based on the percentage of items answered ‘yes’: >80% was considered good, 60–80% was considered fair, and <60% was considered poor quality (see online supplemental materials for details). The quality assessment was conducted by three reviewers (SvE, ED, LdV). Each study was evaluated by two reviewers. Initially, the reviewers individually rated the studies and, in case of inconsistencies between ratings, the differences were resolved through discussions until agreement was reached.

Results

Characteristics of studies and participants

In total, 108 studies were included. Table 1 shows the characteristics of the included studies. The studies were published between 2011 and 2023. The overall sample size was 33,435 participants. The average age of the participants ranged from 9.5 to 24.3 years, resulting in a mean age of 18.4 ($SD=2.5$). The proportion of males was on average 30.7%. Studies were mostly conducted in Europe ($k_{\text{number of studies}}=34/108$) followed by North America ($k=33/108$), Oceania ($k=23/108$), Asia ($k=17/108$) and Africa ($k=1/108$). Quality assessment indicated that a small proportion (17%) of the RCTs were considered to have poor quality, 64% had fair quality, and 19% had good quality (see Table A3 in the online supplemental materials). Of the non-RCTs, 50% of the studies had poor quality, and respectively, 37% and 13% of the studies had fair or good quality (see Table A4 in the online supplemental materials). Regarding power, among the RCTs, 53% (37/70) had an adequate sample size for detecting differences with at least 80% power. In non-RCTs, 32% (12/38) reported sufficient power. Over all studies, this means that 55% of the studies did not have an adequate sample size to detect effects. Furthermore,

only 54% (58/108) of the studies pre-registered their methods and analyses.

The 108 studies, including 103 distinct interventions, include a description of 112 evaluations of interventions (i.e. four studies compared two different interventions). The interventions Grow It! and Headspace were evaluated three times in different studies and samples, and the interventions Bite Back, CARE, EMCompass, Intellect, and Whitu were each evaluated twice. Few eHealth interventions (24/103, 23.3%) were developed in co-creation or co-design with youth. The duration of the interventions differed substantially and ranged from a single session to 300 days, with an average of 54.4 days ($SD=46.2$, median = 42 days).

Of the included studies, 70 (64.8%) were RCTs, 35 (32.4%) used a pre-post design (non-RCT), and the remaining three were group comparisons (non-RCT). Of the RCTs, 34 had a passive control group (assessment-only, $k=12$, or a waitlist group, $k=22$) and 37 studies had an active control group (attention-matched intervention, $k=27$) or treatment as usual, $k=10$). We report RCT results separately from non-RCT results because RCTs offer more rigorous control over confounding variables, reducing bias and providing clearer insights into the efficacy of interventions. The target population differed. Several studies (43/108; 39.8%) recruited children and adolescents from the general population, whereas 35.2% of the studies (38/108) included children or adolescents in clinical outpatient settings, and 25.0% (27/108) targeted participants at risk for mental health problems, such as adolescents exposed to family violence or those with parents diagnosed with mood disorders.

Elements

Tables 2 and 3 display the results regarding the elements of eHealth interventions in respectively RCT and non-RCT studies.

1. Mode of delivery. Approximately half of the interventions (54/103, 52.4%) were delivered through smartphone applications and this increased substantially over time (see Table 2) and Figure 2). Furthermore, 36/103 interventions (35.0%) delivered the intervention via websites, whereas seven studies, mostly older studies, utilized text messages. The remaining studies used a combination of either applications and websites ($k=4$) or websites and text messages ($k=2$).
2. Therapeutic principles. The different therapeutic principles of the interventions can be found in Figure 3. The interventions mostly included CBT (57/103, 53%), self-monitoring of daily mood (17/103, 13%), mindfulness (14/103, 13%) or positive psychology (10/103, 9%). The remaining interventions included content based on a range of theories and therapies, including motivational interviewing, dialectical behavioural therapy,

Table 1. Descriptive characteristics of included studies in the systematic review.

Reference	Intervention	Co-creation	Registration	RCT	Intervention group					Control group					Quality			
					Country	Group	N	% male	Age		Country	Group	N	% male		Age		
									Mean	SD						Mean	SD	Range
⁴³ Aboody et al.	2020 GGBI	N.R.	✓	✓	ISR	G.P.	48	0.0	23.3	1.5	19-28	42	0.0	23.8	1.5	19-28	AO	71%
⁴⁴ Akin-Sari et al.	2022 GGcov	N.R.	×	✓	TUR	G.P.	25	22.2	22.2	7.1	18-63	22	18.5	24.7	8.5	18-63	WL	64%
⁴⁵ Alvarez-Jimenez et al.	2020 MOST+	✓	✓	×	AUS	A.R.	157	23.0	19.1	2.3	16-25	-	-	-	-	-	-	64%
⁴⁶ Anastasiadou et al.	2020 TCApp	N.R.	×	✓	ESP	C.P.	53	9.4	17.3	3.5	N.R.	53	7.7	18.9	7.8	N.R.	TAU	50%
⁴⁷ Andrews et al.	2022 Climate Schools	✓	✓	✓	AUS	G.P.	1272	N.R.	13.6	N.R.	N.R.	1267	N.R.	13.5	N.R.	N.R.	AO	79%
⁴⁸ Arps et al.	2018 N.R	✓	×	×	NZL	G.P.	57	15.0	18.1	1.7	16-21	62	15.0	18.1	1.7	16-21	AM	86%
⁴⁹ Babiano-Espinosa et al.	2021 N.R	×	×	×	NOR	C.P.	25	44.0	13.1	2.9	8-17	-	-	-	-	-	-	79%
⁵⁰ Badesha et al.	2023 Sanvello	×	✓	×	GBR	A.R.	5	0.0	16.2	0.8	15-17	-	-	-	-	-	-	64%
⁵¹ Bannink et al. a	2014 E-health4Uth	×	✓	✓	NLD	G.P.	392	56.9	15.8	0.7	15-16	434	51.4	15.8	0.7	15-16	AO	64%
⁵¹ Bannink et al. b	2014 E-health4Uth + consultation	×	-	✓	NLD	G.P.	430	56.0	16.0	0.7	15-16	434	51.4	15.8	0.7	15-16	AO	
⁵² Bohleber et al.	2016 Companion app	✓	×	×	CHE	G.P.	619	49.0	17.1	1.8	15-17	515	-	-	-	15-17	AO	79%
⁵³ Bruehlman et al.	2020 Nod	×	✓	✓	USA	G.P.	100	43.0	18.7	0.3	18-25	121	38.0	18.7	0.4	18-25	WL	71%
⁵⁴ Buccini et al.	2018 Actisist	✓	✓	✓	GBR	C.P.	24	62.5	20.2	7.4	16+	12	25.0	18.3	7.0	16+	AM	71%
⁵⁵ Burckhardt et al. a	2015 Bite Back	N.R.	✓	✓	AUS	G.P.	94	0.0	13.8	1.6	12-18	90	0.0	13.8	1.6	12-18	AM	79%
⁵⁵ Burckhardt et al. b	2015 Bite Back	N.R.	-	✓	AUS	G.P.	72	100.0	14.6	0.4	12-18	54	100.0	14.6	0.4	12-18	AM	
⁵⁶ Cliffe et al.	2020 Sleepio	N.R.	×	×	GBR	C.P.	39	28.0	15.6	1.2	14-17	-	-	-	-	-	-	71%

(continued)

Table 1. Continued.

Reference	Intervention	Co-creation	Registration	RCT	Intervention group										Control group										Quality
					Country	Group	N	% male	Age			% male	N	Range	Mean	SD	Range	Mean	SD	Range	Type				
									Mean	SD	Range														
Deady et al.	2016 DEAL project	N.R.	✓	✓	AUS	A.R.	60	40.0	21.9	2.3	18-25	44	41.0	21.6	2.1	18-25	AM	57%							
Dietvorst et al. a	2022 Grow It! I	✓	✓	×	NLD	G.P.	462	32.0	16.7	3.1	12-25	-	-	-	-	-	-	71%							
Dietvorst et al. b	2022 Grow It! II	✓	-	×	NLD	G.P.	733	19.0	18.7	3.7	12-25	-	-	-	-	-	-	-							
Donovan et al. a	2017 BRAVE-ONLINE	N.R.	×	✓	AUS	C.P.	34	44.4	9.5	1.4	7-12	29	44.4	9.5	1.4	7-12	WL	57%							
Donovan et al. b	2017 BRAVE-ONLINE	N.R.	-	✓	AUS	C.P.	44	39.4	13.9	1.7	12-18	27	39.4	13.9	1.7	12-18	WL	-							
Fish et al.	2019 Headspace	×	×	✓	USA	G.P.	33	4.0	21.0	N.R.	18-48	39	4.0	21.0	N.R.	18-48	AO	71%							
Fitzpatrick et al.	2017 Woebot	N.R.	×	✓	USA	A.R.	34	21.0	22.6	2.4	18-28	36	7.0	21.8	2.2	18-28	AM	64%							
Flett et al.	2020 Headspace	×	✓	✓	NZL	G.P.	124	29.0	17.9	0.5	17-20	126	33.0	17.9	0.5	17-20	WL	71%							
Flett et al. a	2019 Headspace	×	✓	✓	NZL	G.P.	72	33.3	20.2	3.1	18-41	75	27.4	19.8	1.1	18-25	AM	86%							
Flett et al. b	2019 Smiling Mind	×	-	✓	NZL	G.P.	63	28.6	20.2	4.0	18-49	75	27.4	19.8	1.1	18-25	AM	-							
Frohlich et al.	2021 Take Care of Me	N.R.	×	✓	CAN	A.R.	114	30.7	24.8	4.4	18-35	108	33.3	24.3	4.3	18-35	AM	86%							
Gonsalves et al.	2021 POD Adventures	N.R.	×	×	IND	A.R.	248	50.0	15.6	N.R.	13-19	-	-	-	-	-	-	57%							
Haeger et al.	2022 ACT daily	N.R.	×	×	USA	C.P.	11	18.2	23.6	5.1	20-38	-	-	-	-	-	-	71%							
Haug et al.	2017 ready4life	N.R.	×	×	CHE	G.P.	877	41.7	17.4	2.7	16+	-	-	-	-	-	-	79%							
Haug et al.	2021 SmartCoach	N.R.	✓	✓	CHE	G.P.	750	43.6	15.4	1.0	14-17	723	46.1	15.5	1.0	14-17	AO	86%							
Heshmati et al. a	2023 N.R.	N.R.	×	✓	USA	G.P.	51	31.9	N.R.	N.	18-22	55	31.9	N.R.	N.	18-22	AM	64%							

(continued)

Table 1. Continued.

Reference	Intervention	Co-creation	Registration	RCT	Intervention group					Control group					Quality				
					Country	Group	N	% male	Mean	SD	Range	N	% male	Mean		SD	Range	Type	
⁶⁹ Heshmati et al. b	2023 N.R	N.R.	-	√	USA	G.P.	54	31.9	N.R.	N.R.	N.	18-22	55	31.9	N.R.	N.	18-22	AM	
⁷⁰ Hides et al.	2019 Music eEscape	√	√	√	AUS	G.P.	85	21.2	20.0	2.6	16-25	84	20.2	19.9	2.4	16-25	WL	79%	
⁷¹ Hilt et al.	2021 CARE	N.R.	×	×	USA	A.R.	80	53.8	14.0	1.0	12-25	-	-	-	-	-	-	-	79%
⁷² Hoek et al.	2012 Internet-based guided self-help intervention	N.R.	√	√	NLD	C.P.	22	31.8	15.8	N.	12-21	23	17.4	16.4	N.R.	12-21	WL	57%	
⁷³ Hong et al.	2018 RAW HAND	N.R.	×	×	KOR	C.P.	15	46.7	24.4	5.4	10-40	15	46.7	22.5	2.1	10-40	-	43%	
⁷⁴ Huberty et al.	2019 Calm	×	√	√	USA	G.P.	41	12.2	20.4	2.3	18+	47	8.5	21.9	6.3	18+	WL	50%	
⁷⁵ Jeong et al.	2020 Brake of my mind	√	×	×	KOR	C.P.	3	0.0	N.R.	N.R.	15-19	-	-	-	-	-	-	43%	
⁷⁶ Jolstedt et al.	2018 BiP Anxiety	N.R.	×	×	SWE	C.P.	19	37.0	10.5	1.6	8-12	-	-	-	-	-	-	71%	
⁷⁷ Jones et al.	2020 MoodHwb	√	×	×	GBR	A.R.	43	21.0	16.3	2.4	13-23	-	-	-	-	-	-	79%	
⁷⁸ Karyotaki et al.	2022 iCare Prevent	√	×	√	NLD	C.P.	48	20.8	21.8	2.7	18+	52	17.3	22.1	2.5	18+	TAU	64%	
³⁴ Kauer et al.	2012 Mobile Tracking of Young People's Experiences	×	√	√	AUS	C.P.	69	22.1	18.5	3.2	14-24	49	37.0	17.4	3.2	14-24	AM	93%	
⁷⁹ Kenny et al.	2020 CopeSmart	N.R.	√	√	GBR	G.P.	385	43.0	16.0	0.7	15-18	175	27.0	16.2	1.0	15-18	AO	71%	
⁸⁰ Kramer et al.	2014 PratenOnline	N.R.	√	√	NLD	C.P.	131	20.6	19.4	1.6	12-22	132	22.0	19.6	1.8	12-22	WL	57%	
⁸¹ Lattie et al.	2020 IntelliCare	N.R.	√	×	USA	G.P.	20	15.0	24.2	6.0	18+	-	-	-	-	-	-	79%	

(continued)

Table 1. Continued.

Reference	Intervention	Co-creation	Registration	RCT	Intervention group										Control group										Quality			
					Country	Group	N	% male	Mean	SD	Range	N	% male	Mean	SD	Range	Type	Age										
																			Age									
82	2014 BiP OCD	×	✓	×	SWE	C.P.	21	38.1	14.4	2.6	12-17	-	-	-	-	-	-	-	-	-	-	-	-	-	71%			
83	2020 N.R.	×	×	✓	USA	A.R.	45	22.1	21.8	5.9	18+	45	20.0	21.7	3.3	18+	WL	-	-	-	-	-	-	-	-	64%		
83	2020 N.R.	×	-	✓	USA	A.R.	46	26.1	22.3	4.6	18+	45	20.0	21.7	3.3	18+	WL	-	-	-	-	-	-	-	-	-	-	
83	2020 N.R.	×	-	✓	USA	A.R.	45	33.3	23.3	6.1	18+	45	20.0	21.7	3.3	18+	WL	-	-	-	-	-	-	-	-	-	-	
84	2020 N.R.	×	✓	✓	SWE	C.P.	38	18	16.6	1.1	15-18	38	21	16.5	1.1	15-18	AM	-	-	-	-	-	-	-	-	-	79%	
85	2019 N.R.	N.R.	×	✓	USA	C.P.	22	0	22.5	6.0	18-42	24	0	22.5	6.0	18-42	AM	-	-	-	-	-	-	-	-	-	86%	
86	2022 XiaoNan	×	×	✓	CHN	A.R.	41	41.5	23.4	1.8	19-28	42	47.6	22.8	1.7	19-28	AM	-	-	-	-	-	-	-	-	-	86%	
87	2019 My Student Mindfulness App	×	✓	✓	AUS	G.P.	45	26.0	20.2	N.R.	18-24	45	39.0	20.2	N.R.	18-24	AM	-	-	-	-	-	-	-	-	-	93%	
88	2021 JoyPop	✓	×	×	CAN	G.P.	156	21.2	19.0	2.9	16-38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50%	
89	2014 Bite Back	N.R.	✓	✓	AUS	G.P.	62	35.5	15.5	1.6	12-18	92	30.4	15.3	1.7	12-18	AM	-	-	-	-	-	-	-	-	-	-	57%
90	2018 BRAVE Self-Help	✓	×	×	AUS	A.R.	4425	31.8	13.0	3.0	7-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	79%	
91	2021 Peer Network Counseling-txt	N.R.	×	✓	USA	A.R.	34	33.0	15.2	1.4	13-18	35	33.0	15.2	1.4	13-18	WL	-	-	-	-	-	-	-	-	-	64%	
92	2023 CBT-txt	N.R.	×	✓	USA	A.R.	53	17.0	22.0	2.0	18-25	49	17.0	22.0	2.0	18-25	WL	-	-	-	-	-	-	-	-	-	71%	
93	2018 Overcome Social Anxiety	N.R.	×	✓	CAN	A.R.	30	37.0	21.5	4.1	17-46	35	20.0	22.1	6.5	17-46	WL	-	-	-	-	-	-	-	-	-	64%	
94	2019 BeyondNow	✓	×	×	AUS	C.P.	36	33.3	19.9	6.0	16-42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	64%	

(continued)

Table 1. Continued.

Reference	Intervention	Co-creation	Registration	RCT	Intervention group				Control group				Quality				
					Country	Group	N	% male	Mean	SD	Range	N		% male	Mean	SD	Range
⁹⁵ Mens et al. a	2022 Grow It!	✓	✓	×	NLD	G.P.	476	23.9	16.2	3.0	12-25	-	-	-	-	71%	
⁹⁵ Mens et al. b	2022 Grow It!	✓	-	×	NLD	G.P.	814	17.2	18.5	3.4	12-25	-	-	-	-	-	
⁹⁶ Na et al.	2022 MEndorphins	✓	✓	×	KOR	G.P.	35	34.3	21.7	1.7	18-25	-	-	-	-	79%	
⁹⁷ Nagamitsu et al.	2022 Mugimaru	N.R.	✓	✓	JPN	G.P.	71	37.9	N.R.	N.R.	13-18	72	37.9	N.R.	13-18	AO	
⁹⁸ Newman et al.	2021 Lantern	N.R.	✓	✓	IND	C.P.	117	69.2	20.1	1.7	18-30	105	68.6	19.7	1.4	18-30	WL
⁹⁹ Nicol et al.	2022 W-GenZ	N.R.	✓	✓	USA	C.P.	10	10.0	14.7	1.7	13-17	7	0.0	14.8	1.7	13-17	WL
¹⁰⁰ Nicolaidou et al.	2021 Friends	×	×	×	CYP	G.P.	20	55.0	N.R.	N.R.	9-10	21	47.7	N.R.	9-10	AO	
¹⁰¹ Nordh et al.	2021 ICBT	N.R.	✓	✓	SWE	C.P.	51	20.0	13.6	2.0	10-17	52	27.0	14.5	2.1	10-17	TAU
¹⁰² O'Dea et al.	2020 WeClick	×	✓	✓	AUS	G.P.	98	13.3	14.8	1.0	12-16	95	13.7	14.9	0.9	12-16	WL
¹⁰³ Ofogebu et al.	2020 N.R.	N.R.	×	✓	NGA	A.R.	56	44.2	24.2	5.2	17+	56	55.8	23.8	4.4	17+	AO
¹⁰⁴ Ong et al.	2022 Intellect	N.R.	✓	✓	SGP	G.P.	149	34.2	21.7	2.1	18-30	161	29.0	21.5	2.0	18-30	AM
¹⁰⁵ PazCastro et al.	2022 N.R.	N.R.	✓	✓	CHE	G.P.	750	43.6	15.4	1.0	14+	723	46.1	15.5	1.0	14+	AO
¹⁰⁶ Pinto et al.	2016 eSMART-MH	N.R.	✓	✓	USA	A.R.	12	33.0	22.0	2.5	18-25	16	33.0	22.0	2.5	18-25	AM
¹⁰⁷ Ranney et al.	2018 iDOVE	N.R.	×	✓	USA	A.R.	58	41.4	14.8	1.2	13-17	58	41.4	15.1	1.1	13-17	AM
¹⁰⁸ Rauschenberg et al.	2021 EMcompass	×	×	×	NLD	C.P.	10	30.0	20.3	3.8	14-25	-	-	-	-	79%	
¹⁰⁹ Reid et al.	2011 mobiletype	N.R.	✓	✓	AUS	C.P.	68	22.1	17.4	3.2	14-24	46	37	18.5	3.2	14-24	AM

(continued)

Table 1. Continued.

Reference	Intervention	Co-creation	Registration	RCT	Intervention group				Control group				Quality					
					Country	Group	N	% male	Mean	SD	Range	Age		Mean	SD	Range	Age	Type
¹¹⁰ Reininghaus et al.	2023 EMIcompass	×	×	✓	DEU	C.P.	46	23.9	21.3	2.8	14–25	46	30.4	22.0	2.1	14–25	TAU	79%
¹¹¹ Rice et al.	2018 Rebound	✓	×	×	AUS	C.P.	42	50	18.5	2.1	15–24	-	-	-	-	-	-	86%
¹¹² Rickhi et al. a	2015 LEAP project	N.R.	✓	✓	AUS	A.R.	18	22.2	15.3	N.R.	12–18	13	7.69	15.2	N.R.	13–17	WL	50%
¹¹² Rickhi et al. b	2015 LEAP project	N.R.	-	✓	CAN	A.R.	15	46.7	21.0	N.R.	19–24	16	37.5	20.9	N.R.	19–24	WL	
¹¹³ Riggs et al.	2018 Marijuana eCHECKUPTOGO	N.R.	×	✓	USA	A.R.	144	54.9	20.0	2.0	18+	154	47.4	20.0	2.0	18+	AM	58%
¹¹⁴ Rodriguez-De-Dios et al.	2021 CompDig	N.R.	×	×	ESP	G.P.	126	53.5	13.2	1.0	12–16	118	53.5	13.2	1.0	12–16	AO	58%
¹¹⁵ Roncero et al.	2019 GGRO	×	✓	✓	ESP	G.P.	51	25.5	22.9	9.2	18–65	46	10.9	20.1	2.7	18–65	WL	33%
¹¹⁶ Rushing et al.	2021 BRAVE	✓	✓	✓	USA	G.P.	509	33.7	N.R.	N.R.	15–24	521	33.7	N.R.	N.R.	15–24	AM	67%
¹¹⁷ Ryan et al.	2022 N.R.	N.R.	×	×	USA	C.P.	27	15.0	N.R.	N.R.	12–17	-	-	-	-	-	-	50%
¹¹⁸ Sakata et al.	2022 Resilience	N.R.	✓	×	JPN	A.R.	1093	42.0	21.6	3.0	18–39	-	-	-	-	-	-	67%
¹¹⁹ Schlosser et al.	2018 PRIME	N.R.	×	✓	USA	C.P.	22	60.0	24.3	2.6	16–36	21	65.0	23.8	4.5	16–36	TAU	58%
¹²⁰ Schulte et al.	2022 Boozebuster	✓	✓	✓	NLD	G.P.	252	12.3	22.9	3.3	18–30	251	12.4	23.1	3.5	18–30	AM	67%
¹²¹ Schwinn et al.	2021 Vamos	N.R.	×	✓	USA	G.P.	321	39.4	14.2	1.1	12–15	323	39.5	14.0	1.1	12–15	AO	58%
¹²² Serlachius et al.	2021 Whitu	✓	×	×	NZL	G.P.	20	25.0	21.3	3.3	16–25	-	-	-	-	-	-	58%
¹²³ Sethi et al. a	2013 MoodGYM	N.R.	×	✓	AUS	C.P.	21	38.0	20.3	1.4	18–25	23	43.0	19.5	1.3	18–25	AO	58%

(continued)

Table 1. Continued.

Reference	Intervention	Co-creation	Registration	RCT	Intervention group				Control group				Quality				
					Country	Group	N	% male	Mean	SD	Range	N		% male	Mean	SD	Range
¹²³ Sethi et al. b	2013 MoodGYM	N.R.	-	✓	AUS	C.P.	23	17.0	20.8	1.2	18-25	23	43.0	19.5	1.3	18-25	AO
¹²³ Sethi et al. c	2013 MoodGYM	N.R.	-	✓	AUS	C.P.	22	31.0	19.6	1.4	18-25	23	43.0	19.5	1.3	18-25	AO
¹²⁴ Shrier et al.	2014 MOMENT	N.R.	×	×	USA	A.R.	27	30.0	19.2	N.R.	15-24	-	-	-	-	-	50%
¹²⁵ Shroff et al.	2023 YES	✓	✓	×	USA	G.P.	894	39.9	N.R.	N.R.	11-17	-	-	-	-	-	67%
¹²⁶ Silk et al.	2020 SmartCAT2.0	✓	×	×	USA	C.P.	34	50.0	11.4	1.6	9-14	-	-	-	-	-	58%
¹²⁷ Srivastava et al.	2020 Smartteen	N.R.	×	✓	IND	C.P.	11	81.8	16.0	1.5	13-19	10	70.0	16.1	1.3	13-19	TAU
¹²⁸ Stallard et al.	2018 BlueIce	✓	×	×	GBR	C.P.	44	9.0	16.0	1.4	12-17	-	-	-	-	-	83%
¹²⁹ Stevens et al.	2022 Kooth	×	×	×	GBR	A.R.	302	12.6	16.7	N.R.	13-21	-	-	-	-	-	75%
¹³⁰ Suffoletto et al.	2021 MoST-MH	N.R.	✓	✓	USA	C.P.	34	21.0	18.7	0.4	18+	18	0.0	18.7	0.5	18+	TAU
¹³¹ Sun et al.	2022 Mindfulness	✓	✓	✓	CHN	A.R.	57	26.3	22.2	2.7	18+	57	26.3	22.2	2.7	18+	AM
¹³² Sun et al.	2022 SME	✓	✓	✓	CHN	G.P.	152	55.9	12.8	1.1	N.R.	238	52.5	13.3	1.2	N.R.	WL
¹³³ Takahashi et al.	2019 SPSRS	N.R.	✓	×	JPN	A.R.	22	72.7	20.0	0.6	18-24	-	-	-	-	-	58%
¹³⁴ Thabrew et al.	2022 Whitu	✓	✓	✓	NZL	G.P.	45	6.7	22.7	3.7	16-30	45	13.3	24.6	3.7	16-30	WL
¹³⁵ Toh et al.	2022 Intellect	N.R.	✓	✓	SGP	G.P.	135	27.7	22.9	6.3	18-59	129	21.7	22.0	4.3	18-59	AM
¹³⁶ Topocco et al.	2019 Iterapi	N.R.	✓	✓	SWE	C.P.	35	9.0	17.5	1.1	15-19	35	0.0	17.5	1.2	15-19	AM
¹³⁷ Torok et al.	2022 LifeBuoy	N.R.	✓	✓	AUS	C.P.	228	16.7	21.4	2.2	18-25	227	14.5	21.7	2.2	18-25	AM

(continued)

Table 1. Continued.

	Reference		Intervention		Co-creation		Registration		RCT		Intervention group				Control group				Quality
	Year	Intervention	Country	Group	N	%	male	Mean	SD	Range	N	%	male	Mean	SD	Range	Type		
																		Age	
vanRosmalen-Nooijens et al.	¹³⁸ 2017	Feel the ViBe	NLD	A.R.	20	5.0	5.0	18.4	3.6	12-25	20	0.0	0.0	18.2	3.0	12-25	TAU	33%	
vanVoorhees et al.	¹³⁹ 2020	CATCH-IT	USA	A.R.	193	N.R.	N.R.	15.4	1.5	13-18	176	N.R.	N.R.	15.4	1.5	13-18	AM	83%	
Waite et al.	¹⁴⁰ 2019	BRAVE ONLINE	GBR	C.P.	30	46.7	44.2	14.2	1.4	13-18	30	23.3	15.2	1.3	13-18	WL	58%		
Webb et al.	¹⁴¹ 2022	CARE	USA	A.R.	72	38.9	13.7	0.9	0.9	12-15	80	43.8	13.8	0.9	12-15	AM	50%		
Webb et al.	¹⁴² 2021	CARE	USA	G.P.	80	53.8	14.0	1.0	1.0	12-15	-	-	-	-	-	-	-	67%	
Weintraub et al.	¹⁴³ 2022	N.R.	USA	C.P.	31	38.7	15.1	1.5	1.5	13-17	-	-	-	-	-	-	-	58%	
Whiteside et al.	¹⁴⁴ 2019	Anxiety Coach	USA	C.P.	8	25.0	12.6	2.8	2.8	8-17	-	-	-	-	-	-	-	67%	
Whittaker et al.	¹⁴⁵ 2017	MEMO	NZL	G.P.	426	31.7	14.3	0.9	0.9	13-17	429	31.7	14.3	0.9	13-17	AM	83%		
Wijler et al.	¹⁴⁶ 2020	ThoughtSpot	CAN	G.P.	241	18.9	22.9	3.4	3.4	17-29	240	19.6	23.2	3.1	17-29	TAU	67%		
Wisman et al.	¹⁴⁷ 2023	N.R.	NLD	C.P.	21	23.8	16.5	1.3	1.3	13-18	18	22.2	16.3	1.2	13-18	TAU	83%		
Zanden et al.	¹⁴⁸ 2012	MYM	NLD	C.P.	121	16.5	20.8	2.2	2.2	16-25	123	14.6	21.0	2.3	16-25	WL	67%		
Zheng et al.	¹⁴⁹ 2021	REAP	CHN	G.P.	485	52.3	13.5	0.5	0.5	N.R.	469	52.3	13.5	0.5	N.R.	AO	58%		

Note: N.R.: not reported; Group: G.O./A.R./C.P.; G.O.: general population, A.R.: at risk, C.P.: clinical population; Type: WL/TAU/AO; WL: waitlist, TAU: treatment as usual, AO: assessment only, AM: attention matched. The country abbreviations can be found at https://en.wikipedia.org/wiki/ISO_3166-1_alpha-3. Quality = >80% yes answers were considered good (green), 60%-80% were considered fair (yellow) and <60% were considered poor quality (red). Registration: pre-registration by means of a clinical trial registration for RCT or analyses pre-registration.

Table 2. Results of randomized controlled trials on elements of eHealth interventions.

Reference	Intervention	Elements				Efficacy			
		Duration	Method	Principles	Gamification	Blended	Others involved	Mental health	Well-being
Aboudy et al.	2020 GGBI	14	App	CBT	-	-	-	✓	✓
Akin-Sari et al.	2022 GGrov	12	App	CBT	-	-	-	✓	-
Anastasiadou et al.	2020 TCApp	84	App	CBT, self-monitoring with feedback	Badges, points	Therapy	-	×	×
Andrews et al.	2022 Climate Schools	6 sessions	Website	CBT	-	Classroom	-	×	-
Bannink et al.	2014 E-health4Uth	1 session	Website	Tailored feedback	-	Classroom	-	✓	✓
Bannink et al.	2014 E-health4Uth + consultation with nurse	1 session	Website	Tailored feedback	-	Classroom, therapy	-	✓	×
Bruehlman-Senechal et al.	2020 Nod	28	App	Positive psychology, mindfulness, CBT	-	-	-	×	-
Bucci et al.	2018 Acfissist	84	App	CBT, self-monitoring with feedback	-	-	-	✓	×
Burckhardt et al.	2015 Bite Back	42	Website	Positive psychology	-	Classroom	-	×	×
Deady et al.	2016 DEAL project	28	Website	CBT, motivational interviewing	-	-	-	✓	-
Donovan et al.	2017 BRAVE-ONLINE	70	Website	CBT	Games	Therapy	Parents	-	-
Fish et al.	2019 Headspace	14	App	Mindfulness	Badges, points, buddies	-	-	✓	-
Fitzpatrick et al.	2017 Woehot	14	App	CBT, chatbot	Rewards	-	-	✓	×
Flett et al.	2019 Headspace	10	App	Mindfulness	Badges, points, buddies	-	-	✓	✓
Flett et al.	2019 Smiling Mind	10	App	Mindfulness	×	-	-	✓	✓
Flett et al.	2020 Headspace	92	App	Mindfulness	Badges, points, buddies	-	-	✓	✓
Haug et al.	2021 Smartcoach	154	Website, text messages	Social cognitive therapy	Rewards, points, competition	-	-	✓	×
Haug et al.	2017 ready4life	183	Website, text messages	Social cognitive therapy	Rewards, points, competition	-	-	✓	✓
Heshmati et al.	2023 N.R.	15	App	Positive psychology	-	-	-	-	×
Heshmati et al.	2023 N.R.	15	App	Positive psychology + meditation	-	-	-	-	×
Hides et al.	2019 Music eScape	30	App	Music, self-monitoring with feedback	-	-	-	×	×
Hoek et al.	2012 N.R.	35	Website	Problem-solving	-	-	-	×	-

(continued)

Table 2. Continued.

Reference	Intervention	Duration		Elements		Efficacy			
		Duration	Method	Principles	Gamification	Blended	Others involved	Mental health	Well-being
Huberty et al.	2019 Calm	56	App	Mindfulness, CBT	-	-	-	✓	✓
Karyotiaki et al.	2022 iCare Prevent	49	Website	CBT	-	-	-	×	×
Kauer et al.	2012 Mobile Tracking of Young People's Experiences		App	Self-monitoring with feedback	-	-	-	✓	✓
Kenny et al.	2020 CopeSmart	28	App	ESM	-	-	-	×	×
Kramer et al.	2014 PratenOnline	5 sessions	Website	Solution-focused brief therapy	-	-	-	✓	-
Levin et al.	2020	42	Website	ACT	-	-	-	✓	✓
Lindqvist et al.	2020	56	Website	Psychodynamic therapy	-	-	-	✓	✓
Littleton et al.	2019	9 sessions	Website	CBT	-	-	-	✓	-
Liu et al.	2022 XiaoNan	112	App	Chatbot based on CBT	-	-	-	✓	×
Lyzwinski et al.	2019 My Student Mindfulness App	77	App	Mindfulness	-	-	-	✓	✓
Manicavasagar et al.	2014 Bite Back	42	Website	Positive psychology	-	-	-	✓	✓
Mason et al.	2021 Peer Network Counseling-txt	28	Text messages	Peer network Counseling-txt: focuses on peer relations	-	-	Parents	✓	✓
Mason et al.	2023 CBT-txt	28	Text messages	CBT	-	-	-	✓	-
McCall et al.	2018 Overcome Social Anxiety	28	Website	CBT	-	-	-	✓	×
Nagamitsu et al.	2022 Mugimaru	14	App	CBT	-	-	-	✓	×
Newman et al.	2021 Lantern	92	Website	CBT	-	-	-	✓	-
Nicol et al.	2022 W-GenZ (Woebot for adolescents)	84	App	Chatbot based on CBT, interpersonal psychotherapy, and dialectical behaviour therapy	-	-	-	×	×
North et al.	2021 iCBT	10 sessions	Website	CBT	-	-	Parents	✓	✓
O'Dea et al.	2020 WeClick	28	App	Avatars, serious game	-	-	-	×	✓
Ojoebu et al.	2020	70	Website	CBT	-	-	-	✓	-
Ong et al.	2022 Intellect	9	App	-	-	-	-	✓	✓

(continued)

Table 2. Continued.

Reference	Intervention	Duration	Elements		Principles	Gamification	Blended	Others involved	Efficacy	
			Method	Method					Mental health	Well-being
PazCastro et al.	2022	154	Website		Social cognitive therapy	-	-	-	✓	×
Pinto et al.	2016	84	Web-based (avatar digital therapeutic)		CBT	Avatar, serious game to learn skill	-	-	×	-
Ramey et al.	2018	56	Text messages		motivational interviewing, CBT	-	-	-	✓	-
Reid et al.	2011	14-28	App		Self-monitoring with feedback	-	GP	-	×	✓
Reininghaus et al.	2023	42	App		Compassion focused, CBT	-	Therapy	-	✓	✓
Rickhi et al.	2015	56	Website		Spiritually informed principles	-	-	-	✓	×
Riggs et al.	2018	42	Website		Personalized feedback + PBS	-	-	-	✓	-
Roncero et al.	2019	15	App		CBT	-	-	-	✓	✓
Rushing et al.	2021	56	Text messages		CBT	-	-	-	×	×
Schlusser et al.	2018	84	App		CBT, behavioural activation, mindfulness	-	Coach	Peers	✓	✓
Schulte et al.	2022	42	App		PNF, MI, and PBS	-	-	-	×	-
Schwinn et al.	2021	~135	App		Social learning theory, MI, and bicultural competence	-	-	-	✓	✓
Sethi et al.	2013	35	Website		CBT	-	Therapy	-	✓	-
Srivastava et al.	2020	84	App		CBT and self-monitoring with feedback	Serious game to learn skills	Therapy	-	✓	✓
Suffoletto et al.	2021	92	Text messages		positive psychology, CBT, DBT	-	-	-	✓	×
Sun et al.	2022	Mindfulness for Growth and Resilience	30	App	Mindfulness	-	Therapy	Peers	✓	✓
Sun et al.	2022	Sharing Mind and Enjoyment (SME)	30	App	Family based	Badges, points, personalization	-	Parents	✓	×
Thabrew et al.	2022	Whitu	28	App	Positive psychology, CBT	Badges, avatars	-	-	✓	✓
Toh et al.	2022	Intellect	8	App	CBT	-	-	-	✓	-

(continued)

Table 2. Continued.

Reference	Intervention	Duration	Elements		Principles	Blended	Others involved	Efficacy	
			Method	Method				Mental health	Well-being
Topooco et al.	2019 Iterapi	56	Website		CBT	Therapy	-	✓	-
Torok et al.	2022 LifeBuoy	42	App		DBT	-	-	✓	×
vanRosmalen-Nooijens et al.	2017 Feel the Vibe	84	Website		Psychoeducation, peer-support	-	-	×	-
vanVoorhees et al.	2020 CATCH-IT		Website		CBT and interpersonal psychotherapy	-	Parents	×	-
Waite et al.	2019 BRAVE for teenagers ONLINE	70	Website		CBT	Therapy	Parents	×	-
Webb et al.	2022	21	App		Mindfulness	-	-	✓	-
Whittaker et al.	2017 MEMO	63	Mobile phone		CBT	-	-	×	-
Wijler et al.	2020 ThoughtSpot	183	Mobile and web app		Information about nearby mental health and wellness services, self-monitoring	-	-	✓	×
Wisman et al.	2023	6 sessions	Website		Emotion regulation and CBT	Therapy	-	✓	✓
Zanden et al.	2012 Master your mood (MYM)	42	Website		CBT	-	Peers	✓	✓
Zheng et al.	2021 REAP	14	App		Physical activity	-	-	✓	×

Note: ×: not significant, -: no outcome found/not available, ✓: yes, significant. *Duration is in days, unless otherwise specified. ACT: acceptance and commitment therapy; DBT: dialectical behaviour therapy; MI: motivational interviewing; PBS: protective behavioural strategies; PNF: personalized normative feedback.

Table 3. Results of non-RCT studies on the elements of eHealth interventions.

Reference	Intervention	Elements			Efficacy				
		Duration	Method	Principles	Gamification	Blended	Others involved	Mental health	Well-being
Alvarez-Jimenez et al.	2020 MOST+	7-63	Website	Strengths based approach	Serious game to learn skills, chat with peers	-	Peers	✓	✓
Arps et al.	2018 N.R.	28	Text messages	Positive psychology	-	-	-	×	✓
Babiano-Espinosa et al.	2021 N.R.	98	App	CBT	-	Therapy	Parent	✓	-
Badesha et al.	2023 Sanvello	35	App	CBT	-	Therapy	-	×	×
Bohleber et al.	2016 Companion app	300	App	CBT	-	-	-	×	×
Cliffe et al.	2020 Sleepio	~60	App, website	CBT	-	-	-	✓	-
Dietvorst et al.	2022 Grow It! Cohort I	42	App	CBT, ESM	Serious game (challenges) to learn skill, points, gifts, chat with peers, personalization	-	-	✓	✓
Dietvorst et al.	2022 Grow It! Cohort II	21	App	CBT, ESM	Serious game (challenges) to learn skill, points, gifts, chat with peers, personalization	-	-	✓	✓
Frohlich et al.	2021 Take Care of Me vs psychoeducation control program	56	Website	ESM, CBT, motivational interviewing	-	-	-	✓	✓
Gonsalves et al.	2021 POD Adventures	21	App	Problem solving	Gamified stories	-	-	✓	✓
Haeger et al.	2022 ACT daily	14	App	Acceptance and commitment therapy, ESM	-	-	-	✓	✓
Hilt et al.	2021 CARE	21	App	ESM, mindfulness	-	-	-	✓	-
Hong et al.	2018 RAW HAND	21	App	Exposure and response prevention	Serious game to learn skills	-	-	✓	-
Jeong et al.	2020 Brake of my mind	N.R.	App	Theory of planned behaviour	-	-	-	✓	-
Jolstedt et al.	2018 BiP Anxiety	84	Website	CBT	-	Therapy	Parents	✓	✓
Jones et al.	2020 MoodHwb	60	App, website	CBT, positive psychology, behavioural change theory	-	-	Parents	×	×
Lattie et al.	2020 IntelliCare	56	App	CBT	-	-	-	✓	✓
Lenhard et al.	2014 BiP OCD	84	Website	CBT	-	Therapy	Parents	✓	-

(continued)

Table 3. Continued.

Reference	Intervention	Duration	Elements			Efficacy			
			Method	Principles	Gamification	Blended	Others involved	Mental health	Well-being
MacIsaac et al.	JoyPop	28	App	Self × regulation, ESM, journal, breathing exercises, game, art	Serious game to induce flow	-	-	✓	✓
March et al.	BRAVE Self-Help	140	Website	CBT	-	-	-	✓	-
Meivlin et al.	BeyondNow	61	App	Safety plan	-	Therapy	-	✓	✓
Mens et al.	Grow It!	21–42	App	ESM, CBT	Serious game (challenges) to learn skill, points, gifts, chat with peers, personalization	-	-	✓	✓
Na et al.	MEndorphins	7	App	Behavioural activation	-	-	-	✓	-
Nicolaïdou et al.	Friends	42	Website	CBT	-	-	-	✓	✓
Rauschenberg et al.	EMCompass	21	App	Compassion focused intervention, CBT	-	Therapy	-	✓	×
Rice et al.	Rebound	84	Website	Positive psychology, mindfulness, strength × based intervention	Serious game to learn skills	Therapy	Peers	✓	✓
Rodríguez-De-Dios et al.	CompDig	1 session	App	Narrative persuasion theory	Badges, points, personalization	Classroom	-	✓	✓
Ryan et al.		30	Text messages	Brief caring text messages	-	-	-	✓	-
Sakata et al.	Resilience training	56	App	CBT	Serious game to learn skills	-	-	✓	✓
Seriachius et al.		14	App	CBT, positive psychology	Badges, avatars	-	-	✓	×
Shrier et al.		14	App	Motivational enhancement therapy	-	Therapy	-	✓	-
Shroff et al.	YES	1 session	Website	'Project Personality' (which teaches that personal traits are malleable), 'The ABC Project' (which teaches values × based activity engagement to elicit pleasure and accomplishment), and 'Project CARE' (which teaches the benefits of self × kindness in social and academic success)	-	-	-	✓	-
Silk et al.	SmartCAT2.0	56	App	CBT	Rewards, points	Therapy	-	✓	✓
Stallard et al.	BlueIce	84	App	DBT, CBT, mood diary	-	Therapy	-	✓	-
Stevens et al.	Kooth	30	Website	Digital professional and peer support	-	-	-	✓	✓

(continued)

Table 3. Continued.

Reference	Intervention	Duration	Elements		Principles	Gamification	Blended	Others involved	Efficacy	
			Method	Method					Mental health	Well-being
Takahashi et al.	2019 SPSRS	35	App	App	Behavioural activation	-	-	-	✓	×
Webb et al.	2021 CARE	21	App	App	Mindfulness, ESM	-	-	-	×	-
Weintraub et al.	2022	63	App	App	Family focused therapy, CBT	Serious game (challenges), rewards, points	-	Parents	✓	✓
Whiteside et al.	2019 Anxiety Coach	84	App, website	App, website	Parent X Coached Exposure Therapy (PC X Exp)	-	Therapy	Parents	×	-

Note: ×: no(t) significant, -: no outcome found/not available, ✓: yes, significant. *Duration is in days, unless otherwise specified.

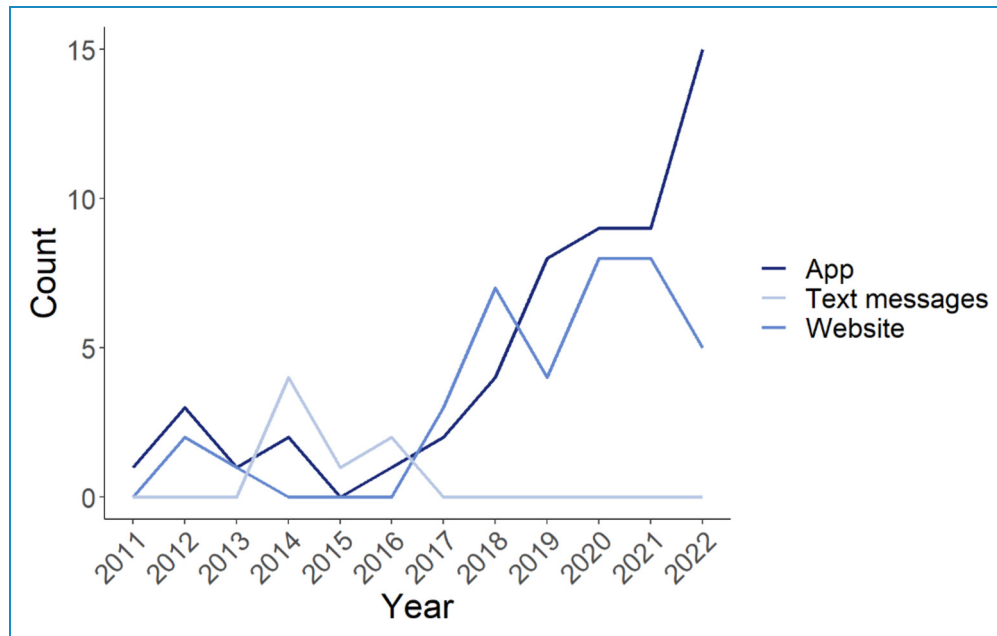


Figure 2. Mode of delivery used to deliver interventions by year. Note that the search was until April 2023, but in this figure, we included studies until 2022 to only include complete years.

acceptance and commitment therapy and family focused therapy. One-third of the interventions (35/103, 33%) combined content from different therapeutic principles, for example, both CBT and positive psychology. For more information on the intervention elements used in the studies, see Table A5 in the online supplemental materials.

3. Blended interventions and/or involvement of others. In 32 studies (28.6%), eHealth interventions were studied in a blended form, either by offering additional sessions with a therapist (26/32), classroom teaching (5/32), or in combination with a coach (1/32) or general practitioner (1/32). In 12 studies, parents were involved in the eHealth intervention and in five studies peers were involved.
4. Interactive elements. In three interventions (3/103) a chatbot was included. The chatbots were Woebot (Fitzpatrick et al., 2017; Nicol et al., 2022) and XiaoNan (Liu et al., 2022). Both chatbots are CBT-based and help adolescents to understand and regulate their emotions, thoughts and behaviours via tailored conversations.

Of the 103 interventions, 21 (20.4%) included one or more gamification elements (see online supplemental material A6). In 12 interventions, serious games were included to learn a specific skill, such as coping, exposure or communication. In 11 interventions, rewards, like badges or virtual gifts were included to enhance adherence. Similarly, in nine interventions the participants could earn points. In six interventions, participants could choose an

avatar or personalize the intervention in another way. Finally, there was the opportunity to interact with peers, via a chat or buddy system in three interventions.

Mental health and well-being outcomes

Different outcome measures were used for mental health and well-being (see Figure 4 and Table A5 in the online supplemental materials). The most frequent mental health outcome measures included depressive symptoms or disorder (in 56% of the evaluations of interventions one or more measures of depression were included), anxiety (43%), alcohol use (13%) and stress (22%). The most frequent outcome measures of well-being included general well-being, such as quality of life or positive affect (32%), self-efficacy/self-esteem (16%), resilience (6%) and mindfulness (7%).

All studies included a follow-up assessment shortly or directly after the intervention to assess the intervention effects. In addition, 48 studies of interventions (45%) included one or more *extra* follow-up assessments. This follow-up time was on average 4.0 months ($SD = 3.2$, range = 1–18 months).

Effects of eHealth intervention on well-being and mental health

Overall, 77.7% (84/108 studies) of the studies reported a significant positive association between the eHealth intervention and one or more mental health or well-being outcome measures. The percentage of studies showing a positive effect of the eHealth intervention on mental

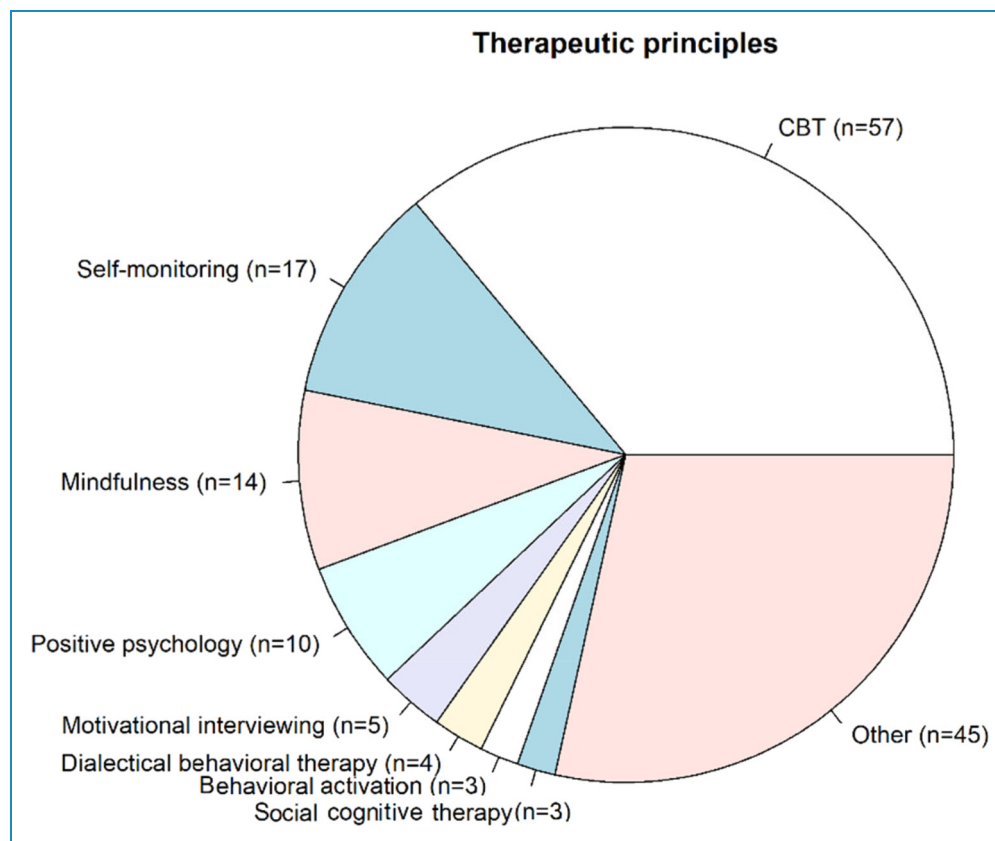


Figure 3. The number of interventions that included the different therapeutic principles.

Note: Principles mentioned in only one article are not included in this figure. All therapeutic principles are listed in online supplemental material A6.

health or well-being varied based on the elements (mode of delivery, therapeutic principles, blended intervention and/or involvement of others, interactive elements) as described below.

1. Effects of mode of delivery

Of the 62 studies on interventions delivered via smartphone apps, 50 showed improved mental health or well-being (80.6%). Among the 37 web-based interventions, 28 studies showed improved mental health or well-being (75.7%). Interventions utilizing text messages improved mental health or well-being in 85.7% (six out of seven) of the studies. Finally, four out of six intervention studies (66.7%) combining different modes of delivery, for example, smartphone application and web-based) showed an improvement in mental health or well-being.

2. Effects of therapeutic principles

Figure 5 shows the therapeutic principles of the interventions in four categories (CBT, self-monitoring, mindfulness and positive psychology) and the proportion of studies

reporting improved mental health or well-being. A darker color indicates a higher proportion of studies that reported a significant positive effect of the eHealth intervention on the outcome measure. In 58% of the studies, a positive significant association between CBT and any mental health or well-being measure was reported. Similarly, across all outcomes, 59% of the studies reported improved mental health or well-being due to interventions including self-monitoring. Interventions based on mindfulness showed positive significant associations with mental health and well-being in 50% of the studies and interventions based on positive psychology only in 32% of the studies.

Besides the four described therapeutic principles, a large part of the studies included interventions based on other therapeutic principles, including motivational interviewing, dialectical behavioural therapy, acceptance and commitment therapy, or family focused therapy. The percentage of interventions based on these therapeutic principles that showed a positive significant association with mental health or well-being was not computed as this is uninformative due to the limited number of studies.

Taking into account the sustainability of intervention effects, we looked at the 48 intervention trials that

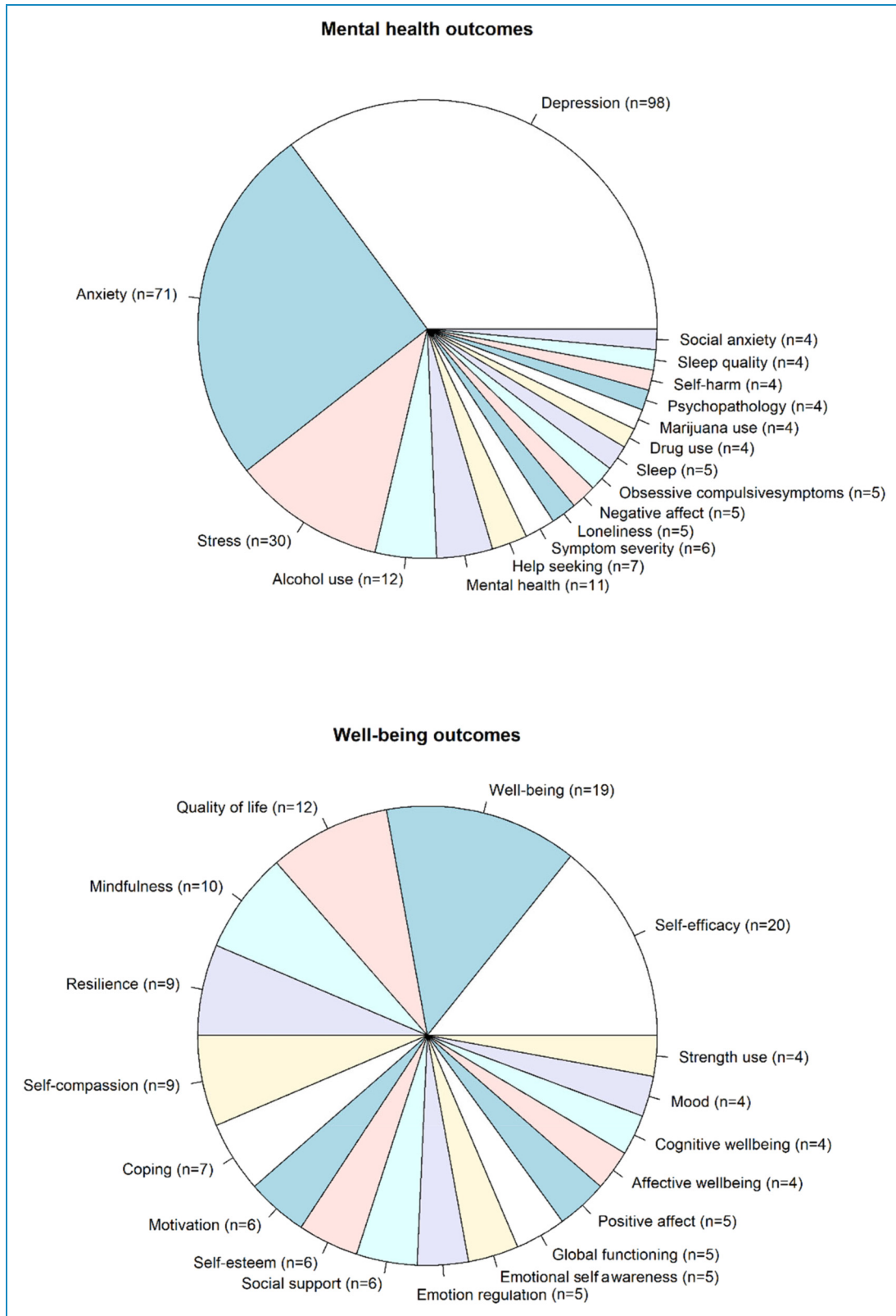


Figure 4. Pie charts of different mental health (top) and well-being outcomes (bottom) used in the included studies to assess the efficacy of the different interventions.

Note: Elements mentioned in three or less studies are not considered in this figure but are listed in online supplemental material A6.

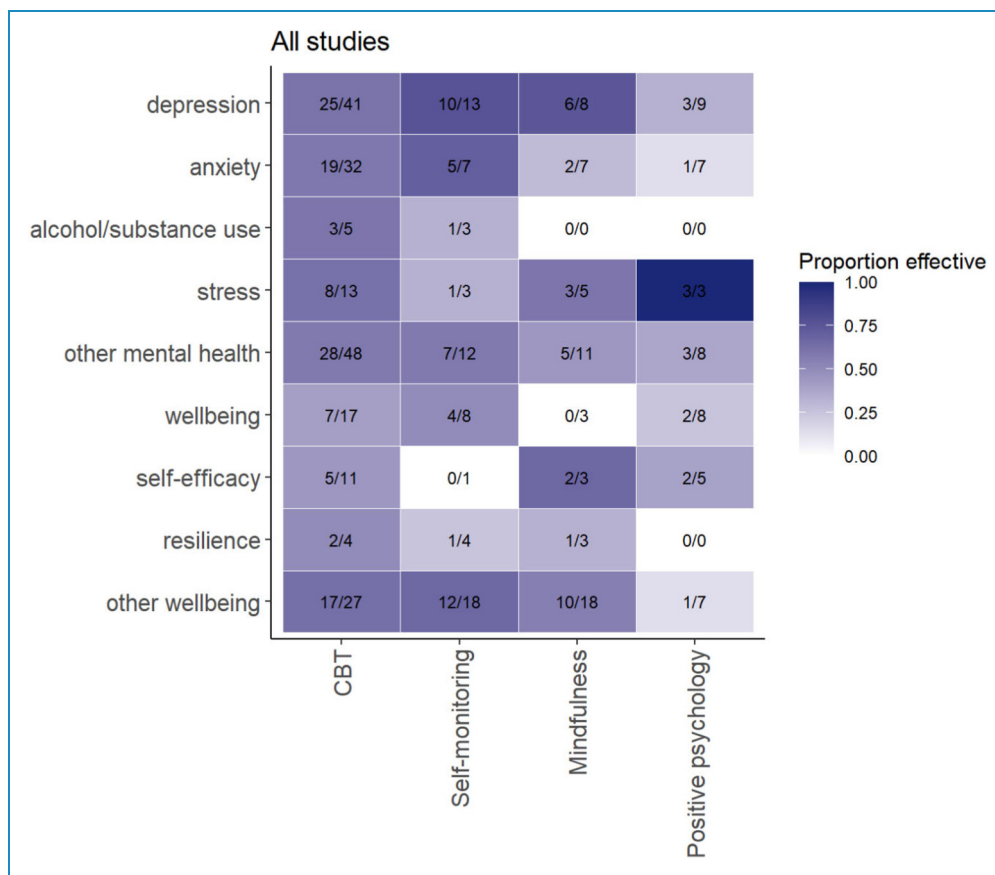


Figure 5. Effect of the therapeutic elements on mental health and well-being outcomes. The colours in the cells show the proportion of studies that reported improvements in mental health or well-being. A darker color indicates higher proportion of studies that reported a significant positive effect of the eHealth intervention on the outcome measure.

Note: Interventions often included multiple therapeutic principles (e.g. CBT and mindfulness) and studies often included multiple outcome measures (e.g. depression, anxiety and quality of life). The results were reported separately for each therapeutic principle and each outcome measure. Therefore, the numbers in the heatmaps do not add up to the total evaluations of studies.

included one or more additional follow-up assessments. Thirty of these trials included a CBT intervention, and 70% still showed effects on well-being and mental health 4 weeks to 6 months later. There were not enough follow-up assessments for other intervention elements to be able to say anything about sustainability.

3. Effects of blended interventions and/or involvement of others

Eighty studies provided the intervention as a stand-alone, and 60 (75%) of these showed a significant improved mental health or well-being. In 22/25 studies (88%) that combined the eHealth intervention with face-to-face therapy, there was an improvement in mental health or well-being. Additional classroom teaching, or sessions with a general practitioner (Reid et al., 2011) or coach (Schlosser et al., 2018), improved mental health or well-being in four of the six (67%) studies. The majority of the studies that involved parents (8/11, 72.7%) or peers (5/5 100%) in the intervention showed an improvement in mental health or well-being.

4. Effects of interactive elements

Of the three interventions that included a chatbot, two studies showed reduced depression^{61,86} versus.⁹⁹ Of the interventions with one or multiple gamification elements, 88.5% (23/26) reported improved mental health or well-being, compared to 74.4% (64/86) of interventions without gamification.

Discussion

There is an enormous increase in available eHealth applications, mounting over 20,000 mental health apps in the app store.²⁰ However, few of them have a solid scientific body of evidence. In this systematic review, we evaluated scientific studies on eHealth interventions for mental health and well-being in children and adolescents and reviewed which elements (mode of delivery, therapeutic principles, blended intervention and/or involvement of others, interactive elements) are effective in improving mental health and well-

being. In total, 103 distinct interventions over a total of 33,435 participants were studied. Overall, in 77.7% of the studies eHealth interventions were related to improved mental health or well-being. Elements that were often reported to result in improved mental health and well-being were CBT and self-monitoring as therapeutic principle, a blended approach of combining eHealth with traditional therapy, parent/peer involvement and gamification elements, such as rewards. This suggests that these elements can be effective in enhancing mental health and well-being in youth via eHealth interventions. However, the quality of the studies varied, and the majority of the studies did not have sufficient power to detect an effect. These results emphasize that eHealth is often studied and can be effective in improving mental health and well-being in youth, but the quality of the research design and methodology should be taken into account.

Effective elements of eHealth interventions

In contrast to what can be found in the app store, all of the here described apps were based on scientific insights. Compared to the earlier reviews mainly focusing on CBT,^{22,23,42} we evaluated a diverse range of therapeutic principles including CBT (57%), self-monitoring (13%), mindfulness (13%) and positive psychology (11%). One third of the interventions combined multiple therapeutic principles. We found that over half of the studies examining CBT-based eHealth interventions (58%) reported a significant improvement of mental health or well-being. This is comparable to findings described in earlier reviews.^{22,23,42} However, CBT-based interventions differed widely in their exact content. Due to large heterogeneity in the exact content and outcome measures, we did not dive into these differences. However, we expect that disorder-specific content may enhance the efficacy of an eHealth CBT-based intervention. Furthermore, whereas for anxiety and depressive disorders specific content related to mental health and a long-term treatment might be needed,^{25,26} improvements in well-being may require other content and possibly shorter interventions. Future research with standardized measures per outcome is needed to effectively compare such CBT-based eHealth interventions.

Significant improvements in mental health and well-being were reported in 59% of studies of eHealth interventions that included self-monitoring. The working mechanism of self-monitoring is improving mental health by enhancing emotional self-awareness, self-insight and self-management.^{34,35} However, accurate self-monitoring depends on sufficient compliance; that is, participants should complete mood surveys when requested. Yet, adherence and compliance are challenging in both offline and online interventions.¹⁵⁰ Options to maximize compliance include active monitoring of compliance and personalizing questionnaires. In clinical settings, self-monitoring can be stimulated as part of a collaborative process

between the patient and clinician, in which discussion of mood surveys is part of the treatment.¹⁵¹ Importantly, there were more non-RCT studies that reported a positive effect of self-monitoring (79% of 42 studies) than RCTs (30% of 27 studies; see online supplemental material A5). Although we did not conduct a meta-analysis and these results are not directly comparable, the difference in effectiveness between non-RCTs and RCTs is noteworthy. In RCTs, bias is reduced and cause-effect relationships between interventions and outcomes can be interpreted with more certainty than in non-RCTs. However, insights from studies in a less controlled environment ('real world studies' such as pre-post designs) on the intrinsic motivation for sustained engagement with a preventive app is essential if eHealth interventions are to be made publicly available for wider implementation. Therefore, evaluations in RCTs and non-RCTs could lead to different pieces of the puzzle in understanding the working mechanisms and effects of eHealth interventions.

Interventions based on mindfulness and positive psychology showed a positive significant effect on mental health or well-being in respectively 50% and 32% of the studies. The findings on mindfulness are partly in line with a meta-analysis of 20 studies on the effect of face-to-face mindfulness on anxiety, depression and stress among children.³³ The authors found that mindfulness had positive effects in 5/20 studies and reported a moderate meta-analytic effect of mindfulness ($d=0.37$). The diversity in duration and exact content of mindfulness interventions differed. Therefore, the optimal conditions to benefit from mindfulness are not clear yet and need further investigation. Similarly, the effectiveness of positive psychology interventions in increasing mental health and well-being need future research.^{29,30} Interventions based on positive psychology specifically aim to enhance well-being and can be used to complement clinical psychological interventions for mental health problems.²⁸ An explanation for the relatively low percentage of effective interventions could be the diverse positive psychology interventions, from practicing gratitude or forgiveness, being kind to others, writing about positive or meaningful experiences, to finding flow. This indicates that more research is needed to the effective elements within positive psychology.

Reviewing studies on blended eHealth interventions seem to suggest effectiveness. Combining eHealth interventions with face-to-face therapy, 88% of the studies showed improved mental health or well-being. Furthermore, 73% of the studies with involvement of parents showed an improvement in mental health or well-being, whereas all five interventions with involvement of peers showed positive effects. These findings are in line with earlier reviews^{22,23} and indicate the potential importance of human interaction, and especially peers, in eHealth interventions for youth mental health.

Finally, interactive or gamification elements, such as rewards or avatars, were only included in 20% of the

interventions described in this review. These elements might improve mental health or well-being: a slightly larger percentage of interventions with gamification elements showed improved mental health and well-being (89% versus 74% of interventions without gamification), replicating the consistent positive effects of gamification in the review of Cheng and colleagues.³⁶ One explanation of the mechanism behind the effects of gamification is that gamification increases adherence to the eHealth intervention due to positive reinforcement via rewards or points. This mechanism may be similar to face-to-face CBT where progress is recognized and rewarded in various ways, for example, using a sticker chart or praising the progress of behavioural change.¹⁵² Positive reinforcement as part of the therapist toolkit is associated with higher self-esteem and self-efficacy.¹⁵³ In contrast to face-to-face CBT that is mostly individual, gamification in eHealth interventions allows for team elements, such as contact with peers, to further increase adherence and user experience.^{36,41} This indicates that gamification appears to have potential in eHealth interventions for mental health in youth. For a more detailed discussion about the role of gamification in eHealth see the focused review of Cheng and colleagues.³⁶

Strengths, limitations and future directions

In this systematic review we extend previous reviews^{22,23,42} by including the most recent eHealth studies and more diverse interventions and outcome measures. For example, whereas Garrido et al.²² and Hollis et al.⁴² only included RCTs to assess the efficacy of eHealth interventions, we included both RCTs and non-RCT studies to review newer interventions with more advanced technology; for new interventions, (pilot) non-RCT studies are often the first step to test efficacy and RCTs are not always available.

This study also has limitations. First, a quantitative meta-analysis to test the effect size of different elements of the eHealth interventions was not possible, because the studies were too heterogeneous in study methods, outcomes, therapeutic principles, analyses and reported effect sizes. To increase opportunities for meta-analyses, we advocate for strict adherence to standardized reporting of eHealth interventions and evaluations, such as CONSORT-EHEALTH.¹⁵⁴ These guidelines require complete reporting of the theoretical framework of the intervention, as well as content, duration, mode of delivery, involvement of others, outcome measures, implementation and analyses methods.

Without a meta-analysis we could not directly compare results between studies. Instead, we report the proportion of studies that found significant effects of interventions on mental health and well-being. However, publication bias could have influenced the results and limited the generalizability of our findings. Studies with significant outcomes

are more likely to be published, while those with null or negative results may remain unpublished. The high percentage of studies that reported a significant positive association between the eHealth intervention and one or more mental health or well-being outcome measures (77.7%) could indicate a publication bias. This selective reporting can lead to an overestimation of effects and limit the interpretation of effective elements. Second, we focused on the effects of single elements of eHealth interventions. However, most eHealth interventions included multiple elements; for example CBT, self-monitoring and gamification. By describing the individual effects, it is possible that we miss the interactive effects of the different elements. Therefore, future research should study the potential accumulative effect of specific combinations of different eHealth elements on mental health and well-being. Conducting factorial designs or intervention mapping approaches could provide insights into the specific mechanisms underlying these interactions.^{155,156}

Furthermore, although we grouped the therapeutic principles into commonly used definitions, such as CBT or mindfulness, the operationalization differed in various ways. For example, the content of CBT interventions widely differed between studies (e.g. conversations with chatbot, group-sessions or psychoeducation). Also, the duration of the intervention (8–300 days) differed widely. It is possible and likely that these differences in operationalization lead to differences in outcomes. The adherence to standardized reporting of eHealth interventions and evaluations as described above could help to further investigate associations between intervention designs and outcomes.

In addition, pre-registration should play an important role in new eHealth studies. Pre-registration can be seen as an indicator of the dedication to be transparent, rigorous and reproducible. The process of publicly registering study plans, hypotheses and methods, before conducting the study mitigates biases and enhances credibility of findings.¹⁵⁷ Of the studies included in this review only 54% of the studies was pre-registered. Furthermore, a substantial number of the studies had poor quality ratings. This could have affected the findings, as poor-quality studies may introduce various biases and errors that skew results. The high proportion of studies with poor quality, particularly among the non-RCT studies (50%), indicate the need for more high-quality research in this field. Similarly, power was not sufficient or not reported in 55% of the studies, limiting the reliability of the findings. Therefore, the overall conclusions drawn from this review should be considered with caution, and future research should focus on improving study quality to provide more evidence on the effectiveness of eHealth interventions.

In this review we included studies in adolescents between 12–25 years of age, and to be able to generalize the results to different populations, we included studies with adolescents from the general population, at-risk

youth and clinical samples. The distribution of samples across these categories was mostly equal (39.8% general population, 35.2% clinical samples and 25.0% at risk for mental health problems). However, in other aspects the results could be less generalizable to the whole population. For example, the studies mostly included older adolescents (mean age of 18.4 years) mostly females (mean = 69.3%), and mostly adolescents from Europe and the United States. This indicates that future studies to eHealth interventions should include more diverse samples with respect to these sample characteristics.

Another important aspect to take into account is the perspective of youth on eHealth interventions themselves. Incorporating this perspective is important to ensure interventions are appealing for the target audience and working as intended.^{158,159} However, in most of the studies included (77%) the involvement of youth or co-creation was not reported or not included in the development of eHealth interventions. Earlier experience with co-creation of the Grow It! intervention app¹⁶⁰ in our research group proved this approach valuable in understanding the world through the lens of future generations. Co-creation can be applied in different ways, depending on the desired involvement of the youth in the different stages of developing an eHealth intervention. For example, incorporating youth perspectives in eHealth development can be done through discussion groups and iterative feedback sessions to optimize an intervention that is already developed. Alternatively, in what is also called Participatory Action Research, youth are included at the start of the study and act as experience experts during all stages of the developmental process.¹⁶¹ Involving youth in some way in the process helps to ensure the intervention is user-friendly and relevant and this can enhance the effectiveness of the eHealth intervention. Therefore, we recommend co-creation with youth in the development of future eHealth interventions.

Furthermore, in recent years, the field of youth mental health has seen significant advancements through the integration of technology. This technological progress allows the inclusion of advanced elements in eHealth interventions, such as the use of generative AI and integration of large language models (LLMs) into mental healthcare.¹⁶² An application of LLMs in mental health care are chatbots. As described, the chatbot Woebot seems to positively affect adolescent mental health.^{61,99} Woebot is based on CBT and uses generative AI to chat with users and to deliver personalized, in-the-moment support. The quick developments in the field of AI and LLM hold promise for creating more interactive, engaging and effective mental health interventions. These technologies can potentially provide scalable, accessible mental health support, bridging gaps in traditional care and reaching underserved populations. As AI continues to evolve, future research should focus on optimizing these tools, ensuring ethical standards and

evaluating long-term impacts on youth mental health outcomes. For the opportunities and risk for AI-driven interventions in mental health see recent publications.¹⁶²

Technological advances can be used to further personalize interventions. Personalization can increase the involvement and therefore the efficacy of an intervention. For example, adolescents' feeling of control can be enhanced by having them decide who will be involved (e.g. parent, peer, therapist) in different modules. Just-in-time adaptive interventions (JITAI) take personalization a step further. Unlike traditional interventions that follow a fixed schedule or set of rules, JITAIs dynamically adjust the intervention based on real-time data regarding an individual's current state or needs. The intervention can thus continuously evolve and delivers the right type of intervention precisely when it is needed. This adaptive approach aims to optimize its impact on the individual's mental health and well-being.¹⁶³

The next challenge of eHealth tools is to implement such tools in (clinical) practice.¹⁶⁴ While eHealth interventions hold significant promise for youth mental health, several challenges can hinder their successful implementation. For example, ensuring the privacy and security of users is crucial. To mitigate privacy risks, during the development of eHealth tools, attention should be paid to the anonymity of user data and adherence to strict data protection regulations, that is, the general data protection regulation.¹⁶⁵ Another challenge is the availability and continuity of technological support. If needed, support should be available for healthcare providers and users, but also continuous updates are needed to maintain the eHealth intervention.¹⁶⁶ Another important aspect of implementation is the target group. eHealth tools developed to be integrated in the clinical context have their own challenges such as the preference of patients and health-care professionals, and legal and ethical considerations.¹⁶⁷ Preventive eHealth tools aimed to be publicly available require a different dissemination strategy and face challenges in adoption and scale-up.¹⁶⁴ This review points to promising directions for effective eHealth interventions. However, the implementation of such tools in different groups remains challenging and requires future research. An eHealth implementation guideline has been developed that can help assess the determinants of successful eHealth intervention prior to the implementation.¹⁶⁶

Conclusion

Most of the 108 reviewed studies, covering 103 eHealth interventions, showed positive effects of eHealth interventions on mental health or well-being in children and adolescents. Specific elements of eHealth interventions that often enhance mental health or well-being include CBT, self-monitoring, a blended approach, involvement of parents or peers and gamification. More research to these potential effective elements and the accumulative effect of specific

combinations of different elements, with standardized outcome measures are needed to understand under which circumstances and in which target groups eHealth interventions can be implemented in clinical practice and as preventive tool. With the continuing developments in technology, the development of eHealth interventions is expected to accelerate in the near future.

Key points and relevance

- Youth mental health problems are increasing and mental health services are overburdened. eHealth tools can be promising to address mental health problems.
- Rapid technological progress has led to diverse eHealth interventions.
- A structured overview of effective eHealth elements through which interventions aim to improve mental health and well-being is lacking.
- We show elements of eHealth interventions aimed at improving mental health and well-being in children and adolescents aged 10–25 years from clinical and general populations.
- This review suggests that CBT and self-monitoring as therapeutic principles, blended interventions in combination with face-to-face therapy or the involvement of parents or peers, and gamification elements, such as rewards, can be effective elements of eHealth interventions for children and adolescents.

Acknowledgements: The authors wish to thank Dr Sabrina (S.T.G.) Meertens-Gunput from the Erasmus MC Medical Library for developing and updating the search strategies. We would like to thank Famke Bos and Maaïke van der Eijk for their invaluable contributions in coding the title and abstract, as well as to Kim van den Dool for her assistance in the coding.

Declaration of conflicting interests: The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding: This work is supported by the Sophia Foundation (grant number B18-05). This publication is part of the ‘eHealth junior’ project (with project number [NWA.1292.19.226]) of the NWA research program ‘Research on Routes by Consortia (Onderzoek op Routes door Consortia)’, which is funded by the Netherlands Organization for Scientific Research (NWO). Furthermore, this research is part of the PROTECT ME project funded by Convergence, the alliance between Erasmus Medical Center Rotterdam, Erasmus University Rotterdam and Delft University of Technology.

Consent statement: Ethical approval and informed consent were not applicable for this systematic review as it involved the collection and analysis of data from previously published studies. All data

were publicly available, and no primary data collection or direct involvement of human participants occurred.

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Supplemental material: Supplemental material for this article is available online.

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