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Smartphone apps for mental health: systematic review of the literature and five recommendations for clinical translation

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Review of Smartphone Apps for mental health

Abstract

Background: Providing adequate access to mental health services is a global challenge. A key aim of using smartphone apps for mental health is to provide cost-effective, available, and accessible tools for monitoring, supporting, and treating mental health conditions.

Objectives: This systematic review describes and evaluates the usage of smartphone apps across a wide range of mental health disorders in terms of clinical validity, feasibility, and acceptability.

Study selection and analysis: We conducted a systematic review to identify studies that evaluated the use of smartphone apps for mental health disorders. Treatment, self-monitoring, and multipurpose apps were evaluated. Studies were selected using Ovid and PubMed databases to select studies according to specified inclusion and exclusion criteria. Study characteristics and findings were extracted and a risk of bias assessment for each study was conducted.

Findings: The search identified a total of 4153 non-duplicate articles, with 31 studies meeting full-text eligibility criteria. Six studies used treatment apps, four used self-monitoring apps, and twenty-one used multipurpose apps for a range of mental health disorders. Fifteen out of the 31 included studies scored between some and high concern on the risk of bias assessment. Smartphone apps were found to be valid and acceptable but showed reduced feasibility over time.

Conclusions: Overall, the results suggest that smartphone apps are valid and acceptable tools, however they appear to show reduced feasibility over time. We discuss several aspects requiring further research, including issues of bias and underrepresented demographics, and propose five recommendations for enhancing clinical translation in future studies.

Key messages

What is already known on this topic

Smartphone apps are recognized as promising tools for mental health, offering cost-effective, accessible interventions. However, their long-term clinical validity, feasibility, and acceptability are not well established, with many studies prone to bias.

What this study adds

This systematic review confirms that while smartphone apps are valid and acceptable for mental health intervention, their feasibility tends to decrease over time. The review also highlights significant concerns regarding bias and underrepresentation of certain demographics.

How this study might affect research practice or policy

The findings highlight the need to address bias and demographic representation in future app-based mental health research. Our recommendation for enhancing clinical translation could guide the development of more effective and inclusive smartphone apps for mental health.

Introduction

Approximately 1 billion people worldwide are affected by mental disorders, posing a global challenge(1). The WHO estimates that 50% of people with mental disorders lack access to care in developed countries, and that this percentage increases to 85% in the developing world(2). One potential solution is through the use of smartphone-based mental health apps, which can provide support for individuals in need. Currently, there are 6.3 billion smartphone users globally, with over 90% using apps daily(3). A recent survey found that 71% of psychiatric patients wanted to use apps to supplement their clinical care(4). Therefore, it is no surprise that apps have gained substantial interest in healthcare settings, with currently over 20 thousand mental health apps available on the market(5).

There are three types of mental health apps: treatment, self-monitoring, and predictive(6,7). Treatment apps provide a variety of psychological interventions which have been shown to enhance psychiatric patients' quality of life(8), their recovery(9), and reduce their symptom severity(10). Self-monitoring apps allow patients to track changes in their mood and symptoms, which increases their emotional self-awareness (ESA)(11). Increasing ESA has a positive effect in psychiatric patients as it improves their coping skills and decreases the severity of their symptoms(12,13). Lastly, predictive apps monitor and predict clinical relapse, allowing for early intervention through preventing and stabilising symptoms(14). Additional features of mental health apps include improving healthcare efficiency(15), psychoeducation, clinical assessment, skills training, tracking treatment progress, and communication with healthcare professionals(16).

Using mental health apps offers several potential advantages. First, mental health apps are cost-effective(17) since they directly reduce hospital admission costs(18). Second, mental health apps are often readily available and accessible, unlike the conventional in-person interventions(19). Third, mental health apps provide access to an extensive population, including those who live in rural areas with limited access to mental health services(20). Fourth, mental

health apps lead to higher engagement with the services. Some people may prefer to communicate with mental health professionals via smartphones rather than in person. It is especially well suited for participants from 14 to 24 years old, who are usually most impacted by mental health issues and least likely to seek help, as mobile phones are their preferred mode of communication(21).

Assessing the clinical validity, feasibility, and acceptability of mental health apps is crucial for clinical integration(22–24). Clinical validity assesses app effectiveness compared to treatment-as-usual (TAU)(25,26). While previous reviews emphasised that mental health apps are highly valid in terms of improving functioning and quality of life and reducing symptoms(27–31), many included biased studies, leading to inconclusive results(32,33). Therefore, further systematic reviews on the clinical validity of mental health apps are needed.

Feasibility is an objective measures usage and retention rates among the patients(34), a crucial measure as mental health services prioritise apps with proven feasibility(35). A systematic review comparing seven studies demonstrated that mental health apps have high feasibility (92% retention rate, 72% response to prompts, and 3.95 interactions with the app per day)(36), but only for a narrow range of mental health disorders. This highlights the need to assess the feasibility of apps relating to a larger range of mental health disorders.

Acceptability is a subjective measure of patient usage and satisfaction(37). Prior studies frequently interchanged the terms ‘acceptability’ and ‘feasibility’(38), resulting in unclear findings. A systematic review comparing eight studies emphasised that using mental health apps is highly feasible(39). However, it did not clearly define feasibility, often mixing it with acceptability. Further research is needed to clearly differentiate between these concepts.

Aims and objectives

This systematic review assesses clinical validity (primary outcome), feasibility, and acceptability (secondary outcomes) of mental health apps compared to TAU. We address the

following research questions: (1) To what extent are current mental health apps clinically valid? (2) What is the feasibility of using mental health apps? (3) What is the acceptability of mental health apps?

Methods

Protocol

This systematic review followed the PRISMA guidelines(40) and the protocol was registered to the international Prospective Register of Systematic Reviews (PROSPERO, CRD42020193699)

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Inclusion and exclusion criteria

The inclusion criteria were: (1) randomized controlled trials (RCTs) reporting on a primary intervention using a mental health app (single- or multipurpose app) compared to TAU or no treatment; (2) articles reporting on clinical samples from an inpatient or community settings with various mental health disorders such as depression, anxiety, phobia, panic disorder, obsessive-compulsive disorder, post-traumatic stress disorder, psychosis, bipolar disorder, suicidal ideation/ behaviour, and self-harm. (3) original articles in peer-reviewed journals; (4) articles published in English.

The exclusion criteria were: (1) articles reporting on web-based interventions not requiring apps; (2) articles that used mental health apps in addition to interventions other than TAU; (3) articles on apps with a focus on physical health; (4) observational studies.

Information sources and search strategy

This systematic review conducted a comprehensive search that started in June 2020 and ended in January 2024 using PubMed and Ovid database (composed of APA PsycInfo, Global Health, Embase, and Ovid MEDLINE). The comprehensive search of RCTs using articles from PubMed, APA PsychInfo, Global Health, Embase and Ovid MEDLINE. Search terms relating to 1) mental health, 2) smartphones and 3) self-management were used (see Appendix A for full search strategy).

Selection and data collection process

Two reviewers independently conducted the search and screened articles based on the inclusion and exclusion criteria with a third reviewer resolving inconsistencies. Extracted data included article details (authors, publication year), participant information (sample size, gender, mean age, inclusion/exclusion criteria, diagnosis, diagnostic tool), mental health app information (name, type), and outcome measures (clinical validity, feasibility, acceptability).

Data items

The primary outcome of this review, clinical validity, is defined as the extent to which an app is useful(25). For self-monitoring apps, this was assessed by assessing the effect of treatment-as-usual compared with those who are also using self-monitoring apps. For treatment and prediction apps, clinical validity was represented by intention-to-treat analysis or analysis of covariance (ANCOVA).

Secondary outcomes of this review are with regards to feasibility and acceptability of mental health apps. Feasibility is defined as an objective measure indicating the ease of psychological intervention(34). The feasibility was measured by overall usage and retention/attrition rates. Acceptability is defined as a subjective measure of psychiatric patients'

attitudes toward mental health app usage (37), and was assessed through the use of satisfaction questionnaires.

Risk of Bias Assessment

This systematic review assessed errors and bias in the article's selection process. For example, randomization such as blinding degree, allocation and attrition were determined by the reviewer. In addition, to assess the risk of bias in the article's selection process, this systematic review used the revised Cochrane risk-of-bias tool for randomized trials (RoB 2)(41).

Synthesis of results

A narrative synthesis was conducted for the outcomes (i.e., the clinical validity, feasibility, and acceptability of mental health apps). This narrative synthesis consisted of all eligible articles that met the inclusion criteria and showed a comparison between mental health apps and TAU in their effectiveness in self-monitoring, treatment, and predicting.

Results

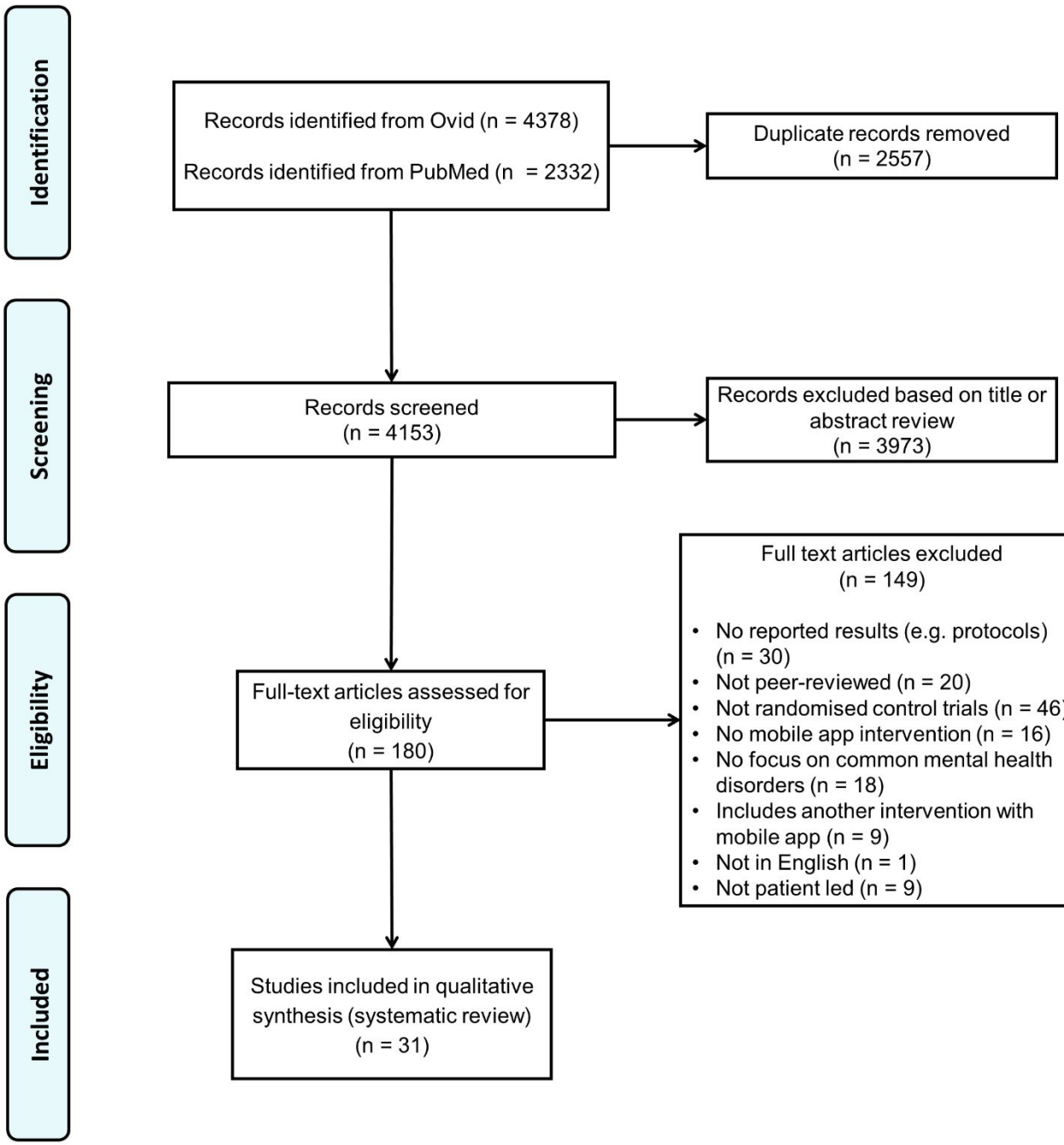
Study selection and characteristics

Figure 1 shows the PRISMA flowchart of the search results. Thirty-one articles reporting on 27 different mental health apps were identified. These articles are summarised in Table 1. Six articles discuss treatment applications, four article discusses self-monitoring applications, and the remaining 21 articles discuss multipurpose applications, including combination of either tracking, self-monitoring and/or treatment components.

This systematic review consisted of a total of 3660 participants with a mean age of 28.29 years. Most studies specified older than 18 years old and younger than 60 years old as eligibility criteria.

Twenty-four of thirty articles had more than 50% female participants. In addition, seven articles had more male participants due to the population of interest (i.e., veterans in Possemato et al.(42)).

Figure 1. PRISMA Flow Diagram



Risk of bias

This systematic review used RoB 2 to assess the risk of bias for included RCTs(41). Overall, 48.4% of RCTs had a low risk of bias, 29% raised some concerns, and 22.6% had a high risk of bias. Figure 2 shows a high risk of bias in the outcome measures (19.4 %), while missing outcome data, the randomisation process and the selection of reported results had lower bias (100%. 87.1% and 80.6% respectively).

The risk of bias for each RCT is described in-depth in Figure 3. Most RCTs presented low bias from the randomisation process, with the exception of Miner et al. (2016)(43), which lacked information about participant concealment, potentially affecting motivation and adherence in the control group.

Six RCTs raised concerns in the selection of reported results(44–49) possibly due to multiple analyses to assess changes in symptoms(46) or not pre-specifying their data analysis(45). Seven RCTs reported a high risk for bias for outcome measures(42,43,45,50–52), often due to unblinded assessors(45,50,52) or insufficient information(42,43,51).

Figure 2. Overall risk of bias.

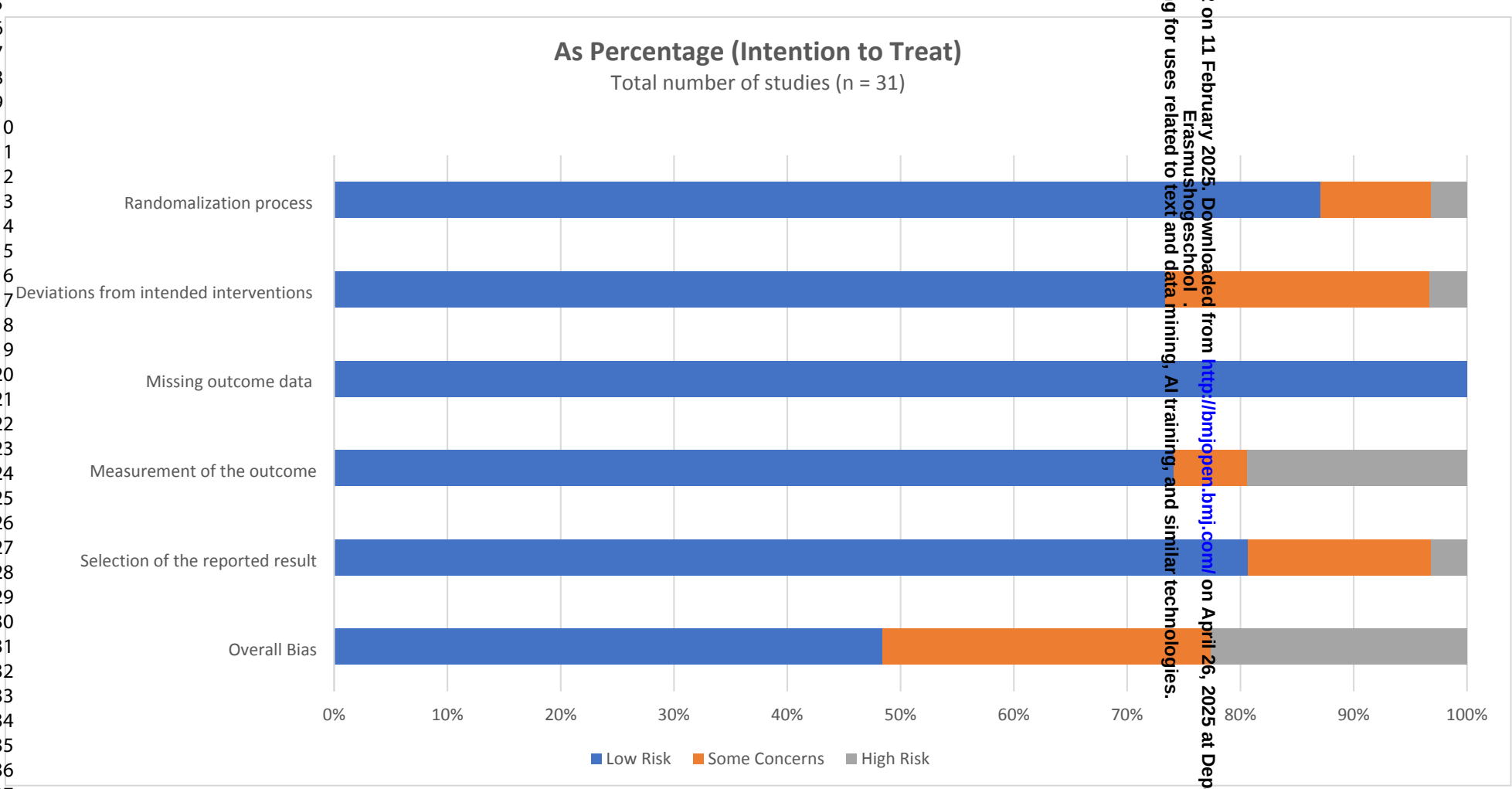
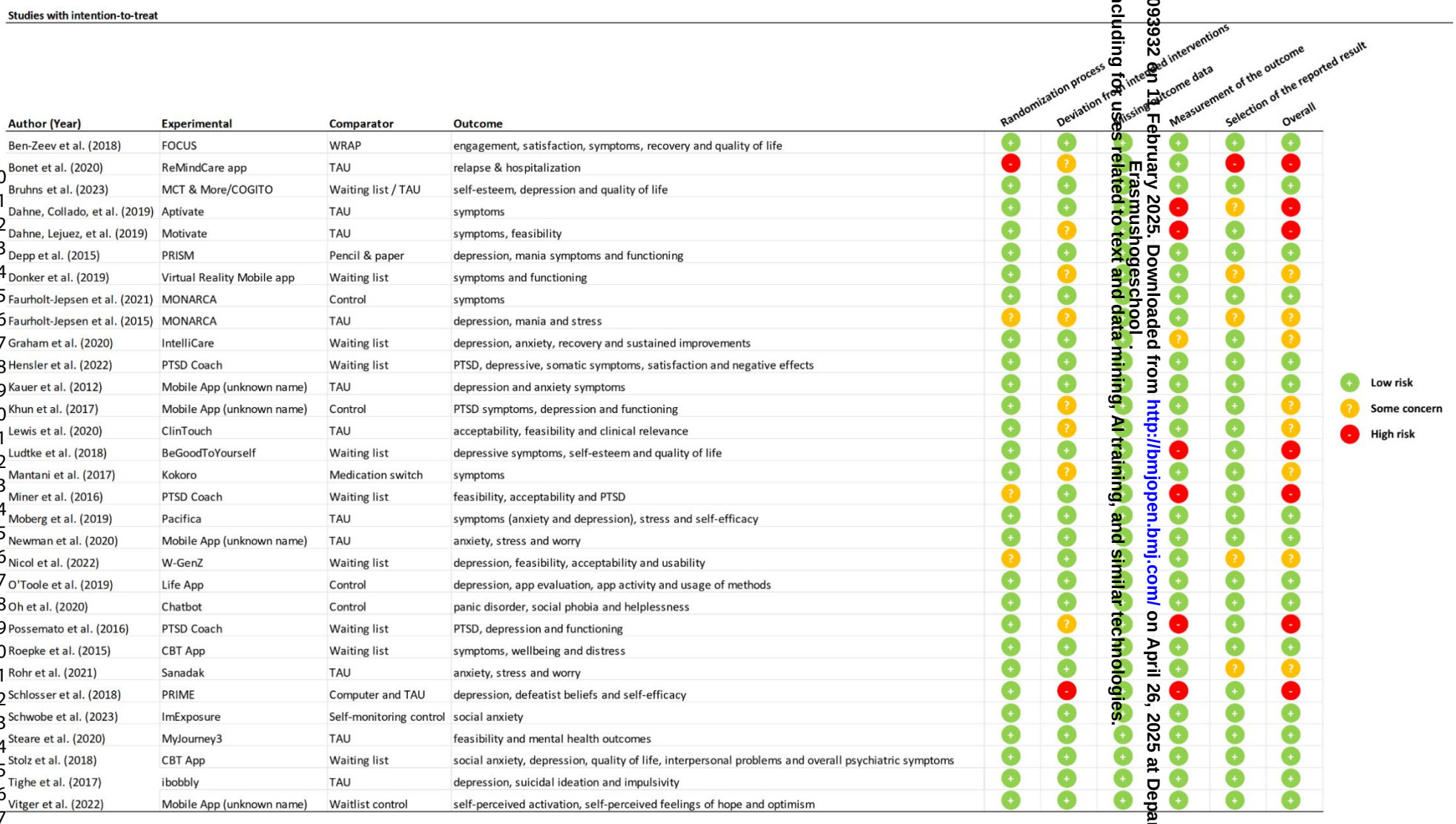


Figure 3. Individual risk of bias.



Author (Year)	Experimental	Comparator	Outcome
Ben-Zeev et al. (2018)	FOCUS	WRAP	engagement, satisfaction, symptoms, recovery and quality of life
Bonet et al. (2020)	ReMindCare app	TAU	relapse & hospitalization
Bruhns et al. (2023)	MCT & More/COGITO	Waiting list / TAU	self-esteem, depression and quality of life
Dahne, Collado, et al. (2019)	Aptívate	TAU	symptoms
Dahne, Lejuez, et al. (2019)	Motivate	TAU	symptoms, feasibility
Depp et al. (2015)	PRISM	Pencil & paper	depression, mania symptoms and functioning
Donker et al. (2019)	Virtual Reality Mobile app	Waiting list	symptoms and functioning
Faurholt-Jepsen et al. (2021)	MONARCA	Control	symptoms
Faurholt-Jepsen et al. (2015)	MONARCA	TAU	depression, mania and stress
Graham et al. (2020)	IntelliCare	Waiting list	depression, anxiety, recovery and sustained improvements
Hensler et al. (2022)	PTSD Coach	Waiting list	PTSD, depressive, somatic symptoms, satisfaction and negative effects
Kauer et al. (2012)	Mobile App (unknown name)	TAU	depression and anxiety symptoms
Khun et al. (2017)	Mobile App (unknown name)	Control	PTSD symptoms, depression and functioning
Lewis et al. (2020)	ClinTouch	TAU	acceptability, feasibility and clinical relevance
Ludtke et al. (2018)	BeGoodToYourself	Waiting list	depressive symptoms, self-esteem and quality of life
Mantani et al. (2017)	Kokoro	Medication switch	symptoms
Miner et al. (2016)	PTSD Coach	Waiting list	feasibility, acceptability and PTSD
Moberg et al. (2019)	Pacifica	TAU	symptoms (anxiety and depression), stress and self-efficacy
Newman et al. (2020)	Mobile App (unknown name)	TAU	anxiety, stress and worry
Nicol et al. (2022)	W-GenZ	Waiting list	depression, feasibility, acceptability and usability
O'Toole et al. (2019)	Life App	Control	depression, app evaluation, app activity and usage of methods
Oh et al. (2020)	Chatbot	Control	panic disorder, social phobia and helplessness
Possemato et al. (2016)	PTSD Coach	Waiting list	PTSD, depression and functioning
Roepke et al. (2015)	CBT App	Waiting list	symptoms, wellbeing and distress
Rohr et al. (2021)	Sanadak	TAU	anxiety, stress and worry
Schlosser et al. (2018)	PRIME	Computer and TAU	depression, defeatist beliefs and self-efficacy
Schwobe et al. (2023)	ImExposure	Self-monitoring control	social anxiety
Steare et al. (2020)	MyJourney3	TAU	feasibility and mental health outcomes
Stolz et al. (2018)	CBT App	Waiting list	social anxiety, depression, quality of life, interpersonal problems and overall psychiatric symptoms
Tighe et al. (2017)	ibobbly	TAU	depression, suicidal ideation and impulsivity
Vitger et al. (2022)	Mobile App (unknown name)	Waitlist control	self-perceived activation, self-perceived feelings of hope and optimism

Cognitive Behavioural Therapy (CBT); Treatment as usual (TAU)

Key findings

This systematic review assessed the clinical validity (primary outcome), feasibility, and acceptability (secondary outcomes) of mental health apps. Outcomes are assessed using data from treatment, self-monitoring, and multipurpose mental health apps, as no article assesses single-purpose predictive applications. The findings are shown in Table 2.

The validity, feasibility, and acceptability of treatment apps

This systematic review assessed six studies on treatment mental health apps in terms of validity, acceptability, and feasibility. Four studies demonstrated a statistically significant effect, reducing symptoms such as acrophobia(46), depression(53) and anxiety symptoms(54,55). However, Röhr et al.(48) found no impact on PTSD symptoms but significantly lowered self-stigma.

In terms of feasibility, Stolz et al.(54) found interaction levels with apps compared to personal computers (d=0.14, p=.01), suggesting greater feasibility. Similarly, Röhr et al.(48) reported low drop-out rates (12.8%), but Donker et al.(46) and Roepke et al.(53), found lower retention rates at post-test (59% and 26.15%, respectively) and follow-up (49% and 18.34%, respectively).

Lüdtke et al.(51) found treatment apps acceptable, with over 50% positive responses on the Client Satisfaction Questionnaire (ZUF-8; Schmidt et al.(56)), consistent with Donker et al.'s(46) user-friendliness scale(57) results.

The validity, feasibility, and acceptability of self-monitoring apps

This systematic review assessed three studies on self-monitoring mental health apps in terms of validity, acceptability, and feasibility. Bonet et al.(44) found that using a self-monitoring app is valid, resulting hospitalizations (χ^2=4.6, P=.03), relapses (χ2=13.7, P=.001), and urgent care visits (χ2=7.4, P=.006)(44), though Steare et al.(58) and Lewis et al.(59) reported inconsistent results.

Bonet et al.(44) and Steare et al.(58) found high feasibility with compliance rates between 85% - 100%. This finding is supported by Lewis et al.(59), who reported high compliance rates for participants (60%) and clinicians (100%).

Lewis et al.(59) and Steare et al.(58) found high acceptability, with 90% of the participants using the apps regularly with an 84% adherence rate. However, Bonet et al. (2020) noted lower acceptability for participants who suffer from delusions, with 33% suspicious and 40% disinterested in the app.

The validity, feasibility, and acceptability of multipurpose apps

Twenty-two studies investigated the use of multipurpose apps combining treatment components, self-monitoring or prediction components. Sixteen of these studies demonstrated treatment component validity compared to control conditions(43,45,47,49,52,60–70). However, Possemato et al.(42) and Bruhns et al.(71) found that treatment apps had no significant impact compared to other interventions. Self-monitoring component validity was shown in three studies(50,52,69) and the prediction component validity in one study(72).

Feasibility of multipurpose apps was assessed in fourteen studies, with eleven finding high compliance, retention and usage rates. For example, Dahne et al.(50) and Depp et al.(66) reported compliance rates of 65%, retention rates of 90% in the first week and 50% at eight weeks, and usage rates of 71%. Dahne et al.(45) and Graham et al.(67) reported high retention (81% and 72.2%) and usage rates (81.8%). These findings were supported by eight other studies(43,49,52,61,65,68,73,74). However, Possemato et al.(42) found higher retention with clinical support, while Moberg et al.(70) reported increased attrition rates in individuals with app access.

Acceptability of multipurpose apps was assessed in nine studies, with Depp et al.(66) reporting a higher acceptability rate (9/10) compared to controls (8/10). This was supported by several other

studies (42,49,61,63,64,71,74), with Miner et al.(43) greater convenience for self-monitoring symptoms compared to traditional methods.

Discussion

The present systematic review assessed the use of smartphone-based mental health apps for common mental health disorders focusing on clinical validity, feasibility and acceptability. We identified 31 articles reporting on 27 mental health apps for treatment, self-monitoring, and multiple clinical purposes. To our knowledge, this is the first review evaluating these aspects across a wide range of mental health disorders with a rigid risk of bias assessment.

To what extent are current mental health apps clinically valid?

The clinical validity of mental health apps, defined as the effectiveness of the app compared to TAU(26), was assessed for treatment, self-monitoring and multipurpose apps. Four of six studies found that treatment apps reduced symptoms and improved functioning and quality of life of psychiatric patients(46,53–55). Two studies found no significant effect on symptoms, but reduced PTSD self-stigma(48) and symptoms improved over time(51). However, biases affected results, and low-bias studies were inconclusive, showing significant improvements only with with clinical support(32,33). Further research into the effectiveness of treatment apps is required.

Self-monitoring apps showed mixed results. Only one app led to fewer hospitalizations, relapses and urgent care visits(44), but it had a high risk of bias. The finding was inconsistent with those of Steare et al.(58) and Lewis et al.(59) who found no significant differences between groups. Thus further development and validation are required.

Multipurpose apps were generally validated, but not all individual components were assessed separately. Treatment components were individually validated in some studies(43,45,47,49,52,60–70), but the inclusion of clinical support led to better outcomes(42). Self-monitoring components were

assessed by three studies, all of which found that they were clinically valid(50,52,69). A predictive feature showed validity in one study(72). However, as this was just a single study, more research is needed to make assertive conclusions.

Overall, most apps were clinically valid, but biases and the small number of studies suggests that further research is necessary.

Is it feasible to use mental health apps?

The feasibility of using mental health apps, defined by an objective measure of usage and retention rates(34), was high for some treatment apps, with higher interaction levels than personal computers(54) and low drop-out rates(48). However, long-term feasibility was low (46,53). These findings suggest that the feasibility of treatment apps might not endure over time and may just be feasible for short time periods. More studies are needed to assess long-term feasibility.

Three studies included in this review found high compliance rates of self-monitoring apps(44,58,59), with Lewis et al.(59) also finding high compliance rates with clinicians. However, as mental health services prioritise the deployment of feasible apps(35), more studies exploring feasibility of self-monitoring apps may be required.

Fourteen studies on multipurpose apps found high in compliance, usability and retention(43,45,49,50,52,54,61,65–68,73,74). Possemato et al.(42) found higher retention with clinical support, and Moberg et al.(70) reported increased attrition. It is noteworthy that the findings presented here likely depend on the overall study period and specific app features, also relating to the user acceptability.

What is the acceptability of mental health apps?

Acceptability, measured by patient usage and satisfaction with mental health apps(37), was high for treatment apps(46,51). Self-monitoring apps were generally acceptable(58,59), but Bonet et al.(44) found them less acceptable for participants who suffer from delusions.

Nine studies assessing multipurpose apps found high acceptability, with patients finding them easy to use, convenient, and helpful(42,43,49,61,63,64,71,74). Possemato et al.(42) noted improved satisfaction in those with clinical support. The findings in this systematic review are in line with previous research, which found that acceptability is high in multipurpose applications.

In summary, acceptability ratings were high, but evidence suggests they could improve with clinical support, indicating apps might be best used alongside TAU. Bonet et al.(44) found acceptability varies by target population, being less suitable for some disorders than others (such as those with delusions or paranoia). The small number of studies makes it challenging to analyse by disorder, highlighting a need for further research.

Limitations of current smartphone applications

Despite the many benefits, mental health apps have limitations. Firstly, while it is important to note that a majority of the global population use smartphones(3), most users come from higher-income households(75), limiting access for those with lower socio-economic status.

Secondly, some mental health applications are only available for either Android or iOS smartphone operating systems (e.g. Dahne, Collado, et al.(45) and Dahne, Lejuez, et al.(50)), highlighting the importance of multi-platform development for inclusivity.

Thirdly, the lack of integration with clinical practice is another issue, as data from apps are often not recorded into electronic health records. This data would be beneficial for clinicians to monitor their patients' conditions(50) and better understand the disorders, allowing for a more holistic approach to care for psychiatric patients.

Fourthly, involves data and privacy concerns(76,77). Some patients were wary of confidentiality(53,70,73), and in some instances, were uncomfortable responding to self-assessments in a public setting(53). This issue could be resolved by informing patients of the data protection laws and offer the option to complete assessments at a time when they are in a private setting(43,73).

Finally, a limitation of smartphone applications is missing data due to patient disinterest or lack of engagement. Schlosser et al.(52) found self-monitoring features were the least popular, seen as repetitive and tiresome. This can be mitigated by collecting passive data, and enhancing app design to increase adherence and engagement.

Strengths and weaknesses of the current systematic review

Our findings add to the growing literature on digital technologies for mental health distinguishing between clinical validity, acceptability, and feasibility, and using a robust risk of bias assessment(58).

However, there are several limitations in the current review. First, the sample was relatively homogenous, mostly middle-aged female participants. Only Kauer et al.(72) included adolescents, and no study included a sample with a mean age of above 50. Thus, the findings cannot be generalised to a wider population, highlighting an understudied group in digital technologies literature.

Second, the studies included are of relatively low accuracy, with 15 out of 31 studies showing some to high concern in the RoB 2 assessment. Despite the potential for low accuracy studies to yield positive results (32,33), the current review emphasised studies with low risk of bias it it's conclusions.

Lastly, no articles were found comparing smartphone applications to TAU for OCD, indicating a need for app development targeting OCD symptoms.

Five recommendations for clinical translations

In this last section, we propose five recommendations that should be implemented in future apps to assist with the treatment and monitoring of mental health disorders.

1. **Apps should be developed using a multiplatform framework to widen compatibility with a variety of devices:** Existing tools often support either Android or iOS operating systems. Considering the relatively even distribution of iOS and Android operating systems in certain markets (e.g. 50.5% iOS and 48.9% Android in the United Kingdom in March 2022; https://gs.statcounter.com/os-market-share/mobile/united-kingdom/#monthly-201112-202112, accessed April 2022), future smartphone applications should support both platforms to be inclusive of the psychiatric population as a whole.
2. **Apps should feedback information to clinicians and patients**: Existing tools often lack integration with patient electronic health records and predictive features. Feedback of data and predictive information to clinicians and patients would allow for a more responsive and effective treatment approach. Apps could also allow clinicians and patients to interact, for example, via messaging services, to allow clinicians to use the information during sessions.
3. **Privacy and data protection should be a core-value of the app:** Several studies discussed patients' concerns over the confidentiality of the data(53,70,73). Robust encryption and authentication methods to ensure patient confidentially should be implemented during the development of the app, and all data should be stored in accordance with data protection laws and guidelines.
4. **User experience of apps should be taken into careful consideration:** In previous studies, patients often reported disinterest when using mental health applications which resulted in missing data and decreased usage. User experience should be an important value during the development of smartphone applications to maximise feasibility and accessibility. Focusing on passive data collection and investing in the design of an app can increase the appeal of using an app.

5. **Involve people with lived experience of mental illness during development and validation:** While the current systematic review identified 27 studies evaluating the validity, feasibility and acceptability of existing mental health apps, previous studies have reported the benefits of involving service users during the development of mental health-based apps(32,78,79). Therefore, future mental health apps should involve service users early in the development stage.

Conclusion

A key aim of using smartphone apps for mental health is to provide tools that can monitor, support treatment, and predict future clinical outcomes. This review found a limited number of validated smartphone apps that have been assessed in terms of clinical validity, feasibility, and acceptability. Overall, smartphone apps are valid and acceptable tools, though feasibility may vary over time, and some studies show bias concerns. As the usage of digital technologies in several fields is quickly evolving, improving validity, feasibility and acceptability is crucial. Despite limitations, smartphone apps offer a cost-effective way to increase availability of resources and accessibility to care. We hope that this review will assist with the future development of valid, feasible and acceptable smartphone apps for mental health disorders.

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Author Contributions

All authors contributed to the work's design and conception, analysis and interpretation of the data, drafting of the manuscript and revising the key intellectual content. All authors approved the final version of the manuscript for submission.

Conflict of interest.

The authors declare no conflict of interest.

Data availability statement

Data sharing is not applicable to this article as no new data were created or analysed in this study.

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Appendix A – Full search strategy

1. (mental health OR psychiatric disorder OR mental illness OR mental condition OR mental disease OR psychopathy OR psychopathology OR anxiety OR depression* OR phobias OR obsessive-compulsive disorders OR panic disorders OR post-traumatic disorder OR bipolar OR psychotic disorders OR psychosis OR schizophrenia OR suicidal ideation OR suicidal behaviour OR self-harm)

2. AND (smartphone OR mobile phone OR cellphone OR iPhone OR mobile app* OR phone app* OR Android OR digital OR telephone)

3. AND (self-management OR self-care OR self-help OR self-aid OR self-manage* OR personal care OR self-sufficiency OR autonomy OR self-administrated OR self-monitoring OR self-support) AND (app* OR device OR instrument OR tool).

Table 1. Study Characteristics

Authors (Publication year)	N	Female % (Male %)	Mean age	Inclusion criteria	Exclusion criteria	Diagnosis	Diagnostic tool	Mobile application name	Type of mobile application
Ben-Zeev et al. (2018)	163	41% (59%)	49	Diagnosed with schizophrenia, schizoaffective disorder, bipolar disorder, major depressive disorder, age 18+, RAS[15] (>3)	Hearing, vision, or motor impairment, less than grade 5 English reading ability and exposed to WRAP or FOCUS before	Transdiagnostic	Chart diagnosis	FOCUS	Multipurpose application (treatment & tracking)
Bonet et al. (2020)	90	27% (73%)	32.8	Diagnosis according to the DSM-5, 17- 65 years old, smartphone ownership with an internet connection, less than 5 years of illness duration	Lack of ability to use mobile device and the internet, refusal to sign an informed consent form, level of Spanish or English not fluent	Psychosis	DSM-5[6]	ReMindCare App	Self-monitoring application
Bruhns et al. (2023)	159	55.4%(44 %)	39.04	Age 18+, diagnosis of depression according to ICD-10 and DSM-5, pending discharge after day care/inpatient informed consent, internet access and possession of a smartphone, willingness to participate all aspects of study	If inclusion criteria were not met	Depression	DSM-5[6] and ICD-10	MCT & More/ COGITO	Multipurpose application (treatment & tracking)
Dahne, Collado, et al. (2019)	42	67% (33%)	36	Age 18+,2 own smartphones, willingness to use a phone for examination purposes and be treated through phone check email at least once a day Spanish language preferences and fluency PHQ[5-]8 (>10) seen by a doctor in last year	Scoring BDI-2[14] (<13) psychotherapy, visually impaired endorse in suicidality	Depression	PHQ[5-]8	Aptívate! (BA[18])	Multipurpose application (treatment & tracking)
Dahne, Lejuez, et al. (2019)	52	85% (15%)	44	Age 18-65, willingness to use a phone for examination purposes, check email at least once a day, PHQ[5-]8 (<10)	Scoring BDI-2[14] (<13) and current or past month indication of suicidal ideation	Depression	PHQ[5-]8	Motivate (BA[18])	Multipurpose application (treatment & tracking)

Depp et al. (2015)	82	63% (37%)	48	Age 18+, outpatients and currently prescribed medications for bipolar disorder, no manual or visual disabilities	Substance use disorder hospitalized severe range for either depressive symptoms (>32) or manic symptoms (>20) and severe psychopathology	Bipolar Disorder	MADRS[2] and YMRS[3]	PRISM	Multipurpose application (treatment & tracking)
Donker et al. (2019)	193	67% (33%)	41	Age 18-65, scoring 45+ (AQ[1]), Android smartphone	Insufficient Dutch language skills, receiving treatment/medication, having severe depression, suicidality	Acrophobia	AQ[1]	Virtual Reality App	Treatment mobile application
Faurholt-Jepsen et al. (2021)	67	67% (33%)	29	BD diagnosis, 18-60 years old, HDRS-17 ≤17 and YMRS score ≤ 17	Pregnancy, a lack of Danish language skills, inability to learn the technicalities for using a smartphone, unwilling to use the trial smartphone as the primary cell phone, and severely physical illness or schizophrenia, schizotypal or delusional disorders according to the SCAN interview	Bipolar Disorder	ICD-10 and DSM-IV using SCAN interview	MONARCA	Multipurpose application (treatment & tracking)
Faurholt-Jepsen et al. (2015)	78	67% (33%)	29	Bipolar (ICD-10[13]), age18- 60, depression score (<17)	Pregnant, lack of Danish language skills, unwillingness to use a phone for examination purposes, severely ill (e.g., schizophrenia spectrum)	Bipolar Disorder	SCAN[4] interview	MONARCA	Multipurpose application (treatment & tracking)
Graham et al. (2020)	146	82% (18%)	42	Compatible smartphone (apple or smartphone), elevated symptoms of anxiety or depression	Acutely suicidal, unappropriated diagnosis, treatment for psychotherapy and if the medication was stable for over 2 weeks	Transdiagnostic	GAD7[10] & PHQ[5-8]	IntelliCare	Multipurpose application (treatment & tracking)
Hensler et al. (2022)	179	91.6% (8.4%)	42.3	Aged 18+, resident in Sweden with Swedish verbal	Life threatening or harmful living conditions, current or	PTSD	DSM-5[6]	PTSD Coach	Multipurpose application

				and written comprehension, has smartphone, traumatic event in past 2 years according to DSM5 and mild to severe symptoms using PTSD check list.	pending psychotherapy, medical treatment changes and medication with counter medication.			(treatment & tracking)
Kauer et al. (2012)	118	63% (37%)	17	Age 14-24, speak proficient English, mild to moderate mental health issue by GP K10[9](16>)	A psychiatric or medical condition that impedes to have informed consent	Depression	K10[9]	Mobile application (no name)	Self-monitoring application
Kuhn et al. (2017)	120	69% (31%)	39	Age 18 +, English language skills, owning a mobile phone, having been exposed to a traumatic event more than 1 month ago, PCL–C[8] (>35), and not currently being in PTSD treatment	Did not meet the inclusion criteria	PTSD	PCL–C[8]	PTSD Coach	Multipurpose application (treatment & tracking)
Lewis et al. (2020)	81	30.8% (69.1%)	40	Schizophrenia and related disorders diagnosis, age between 16-65, one or more psychotic episodes in the previous 2 years, including the first psychotic episode	Unable to speak English and/ or unable to give informed consent	Schizophrenia	DSM-5[6]	ClinTouch	Self-Monitoring application
Lüdtke et al. (2018)	90	78% (22%)	43	Need for intervention, age 18-65, using iPhone	Suicidal tendencies	Depression	PHQ[5]-9	Be Good to Yourself (CBT[19] third wave)	Treatment mobile application
Mantani et al. (2017)	81	55% (43%)	41	Age 25- 59 years, primary major depressive disorder without psychotic features antidepressant-resistant, BDI-2[14] (<10) after taking one or more antidepressants at an adequate dosage for four or more weeks (stage I, II, or III, not prescribed escitalopram or sertraline, or	Did not meet the inclusion criteria	Depression	DSM-5[6]	Kokoro	Multipurpose (treatment & tracking)

				received CBT[19] or interpersonal therapy				
Miner et al. (2016)	49	82% (18%)	46	18 +, English language, not currently receiving treatment for PTSD, having an active e-mail address, PCL–C[8] (>25)	Did not meet the inclusion criteria	PTSD	PCL–C[8]	PTSD Coach	Multipurpose application (treatment & tracking)
Moberg et al. (2019)	500	74% (22%)	30	Scoring GAD7[10](5-14) & PHQ[5]- 8 (5-14)	<5 & >14, respectively on GAD7[10] and PHQ8	Transdiagnostic	GAD7[10] & PHQ[5]-8	Pacifica	Multipurpose application (treatment & tracking)
Newman et al. (2020)	100	77% (23%)	21.71	Met diagnostic criteria for GAD	Did not meet diagnostic criteria for GAD	Anxiety	DSM-5[6]	Mobile application (no name)	Treatment mobile application
Nicol et al. (2022)	17	88.2% (5.9%)	14.7	Between 13-17 and had new diagnosis of depression and anxiety in the past 3 months.	Long history of severe depression substance use disorder psychotic illness, OCD, PTSD, panic disorder or specific phobia. Do not have guardian accompanied on visits, did not have access to mobile device for regular use and were unable to read and write English.	Depression and anxiety	DSM-5[6]	W-GenZ	Multipurpose application (treatment & tracking)
O'Toole et al. (2019)	129	44% (56%)	29	Age 18-65, Smartphone for application, symptoms which can indicate interventions period	Severe pathology, substance abuse, inpatient treatment, comorbidity with any other psychopathology apart from mild to moderate depression and anxiety	Suicidal Behaviour	MDI[11] & SSF[12]	Lifeapp	Multipurpose application (treatment & tracking)

Oh et al. (2020)	41	51% (49%)	41	Age 19 - 60, diagnosis of panic disorder, no changes in medication dosage	Pregnant, neurological illness, comorbid substance use	Panic Disorder	DSM-5[6]	Application (Chatbot)	Multipurpose application (treatment & tracking)
Possemato et al. (2016)	20	5% (95%)	42	Enrolled in VA primary care, PTSD military symptoms (PCL–C[8] (>40)	Had treatment in speciality care before study completion, cognitive impairments or suicidal attempt or intent in the previous 2 months, treatment outside of VA primary care or a new or change in dosage of drugs	PTSD	PCL–C[8]	PTSD Coach	Multipurpose application (treatment & tracking)
Roepke et al. (2015)	283	70% (30%)	40	Age18+, iPhone owner, clinical depression, CES-D[7] (>16)	Did not meet the inclusion criteria	Depression	CES-D[7]	CBT[19]-PPT SB and General SB	Treatment mobile application
Röhr et al. (2021)	133	38% (62%)	33.5	Syrian refugee residing in Germany, aged 18 to 65 years, experiencing at least one traumatic event and score of 11 to 59) on the Posttraumatic DSM-5, with mobile device	PTSD symptomatology outside inclusion criteria; severe depressive symptoms acute suicidal tendencies current psychotherapy, psychiatric Treatment, and/or psychotropic medication; or pregnancy	PTSD	DSM-5[6]	Sanadak	Treatment mobile application
Schlosser et al. (2018)	43	62% (38%)	24	Diagnosis of schizophrenia, schizophreniform, or schizoaffective disorder, early course of illness age16-36 not having substance dependence (6 months prior), clinically stable (1 month prior) ability to provide informed consent, no history of neurological disorders or severe head trauma, English language skills, IQ > 70	Did not meet the inclusion criteria	Schizophrenia	DSM-5[6]	PRIME	Multipurpose application (treatment & tracking)

Schwob & Newman (2023)	82	53.6% (46.4%)	19.4	Age 18+ or older, be fluent in English, own an iPhone and meet DSM -5 criteria for social anxiety disorder (SAD)	Excluded if they endorsed mania, psychosis, suicidality, alcohol or substance disorder or any medical or organic disorder that hindered their participation in the study or if currently in psychological or psychiatric treatment for anxiety or any other mental health issues	SAD	DSM-56	ImExpsoure	Multipurpose application (treatment & tracking)
Steare et al. (2020)	40	30% (70%)	29.7	Aged ≥16 years, had experienced at least one episode of psychosis, were currently on the caseload of an EIP service and owned a Smartphone with an Android operating system.	Lacked capacity to consent to participation, were unable to communicate and understand English, or were considered by their EIP service to pose a high risk to researchers during meetings, even on NHS premises	Psychosis	ICD-10	MyJourney3	Self-Monitoring Application
Stolz et al. (2018)	150	65% (35%)	35	Age 18+, own a computer and smartphone with internet; fluent in German; exceeded cut off points for SIAS[16] and SPS[17], primary diagnosis of social anxiety disorder	History of psychotic disorder, and medication increase for anxiety and depression in the past month and active suicide plans	Social Anxiety	DSM-5[6]	PC and Mobile app (CBT[19])	Treatment mobile application
Tighe et al. (2017)	61	63% (37%)	25	Age 18- 35, score PHQ[5]-9 (>10), K10[9](>25) and had suicidal thoughts in the previous week.	Did not meet the inclusion criteria	Suicidal Behaviour	PHQ[5]-9 & K10[9]	iBobbly	Multi-purpose application (treatment and tracking)
Vitger et al. (2022)	194	61.9% (33.5%)	23.4	Receiving treatment in OPUS had at least 6 months left of their programme access to a smartphone and understood Danish	Did not meet the inclusion criteria	Schizophrenia, schizotypal and delusional disorder	N/A	Mobile application (no name)	Multi-purpose application (treatment and monitoring)

Acrophobia Questionnaire[1], Montgomery Asberg Depression Rating Scale[2], Young Manic Rating Scale[3], Schedules for Clinical Assessment in Neuropsychiatry[4], Patient Health Questionnaire[5], Diagnostic and Statistical Manual of Mental Disorders 5[6], Centre for Epidemiological Studies Depression questionnaire[7], PTSD CheckList – Civilian Version[8], Kessler Psychological Distress Scale[9], General Anxiety Disorder-7[10], Major Depression Inventory[11], Suicide Attitudes Form[12], International Classification of Diseases[13], Becks Depression Inventory- 2[14], Recovery Assessment Scale[15], Social Interaction Anxiety Scale[16], Social Phobia Scale[17] , Behavioural Activation[18], Cognitive Behavioural Therapy[19]

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Table 1. Primary and Secondary outcomes

Authors (Publication Year)	Type of mobile application	Clinical validation	Feasibility	Acceptability
Ben-Zeev et al. (2018)	Multipurpose application (treatment & tracking)	Both conditions improved but no difference. WRAP was more significant in improving recovery (t=2.55, df=289, *p*=.01) and FOCUS in improving quality life scores (t=2.55, df=289, *p*=.001)	FOCUS more likely to commence treatment (90%) and remain fully engaged (56%) compared to WRAP (58% and 40%, respectively)	High satisfaction in both conditions FOCUS (*M*=25.76) and WRAP (*M*=25.56)
Bonet et al. (2020)	Self -Monitoring application	After 19 months, ReMindCare had fewer relapses (20% vs 58%) (χ^2=13.7, P=.001), had fewer visits to urgent care units (χ^2=7.4, P=.006) and fewer hospitalizations than TAU patients (χ^2=4.6, P=.03).	ReMindCare group had a compliance rate between 85% and 100%	Reason of discontinuation included 33% felt suspicious about technology (among these patients, 4 had a relapse while using the app); 40% perceived the app as boring and did not perceive any benefit; and 27% of patients left treatment and did not continue in the program.
Bruhns et al. (2023)	Multipurpose application (treatment & tracking)	No significant differences between the groups were found $\chi^2(3) = 1.77$;p=.622.	N/A	Slightly positive attitudes towards mobile based intervention. About 86.3% of participants believed that they would feel somewhat better after using the application. More positive side effects i.e. participants felt better using the self-help smartphone app and easier trusting others.
Dahne, Collado, et al. (2019)	Multipurpose application (treatment & tracking)	Depressive symptoms compared to TAU χ^2 = 34.66, df = 1, *p*<0.001; compared to time points χ^2 = 35.06, df = 14, *p* = 0.001.	Retention rates 72.7% (month 1) and 50% (months 2), post enrolment. 81.8% of used the app ≥8 times, and 36.4% used app ≥56 times.	N/A

Dahne, Lejuez, et al. (2019)	Multipurpose application (treatment & tracking)	*M* = −7.51 (3.14), p = .02 (Moodivate vs TAU) *M* = −7.68 (3.62), p = .03 (MoodKit vs TAU) Depression symptoms in Moodivate condition *F*(1, 19) = 4.15, *p* = .056 Unique Value (*M*= 6.10)	Retention rate 90% (week 1) 83% (week 2) 67% (week 3-6) 61% (week 7) 50% (week 8). 71% of participants enter self-assessment ≥18 times.	N/A
Depp et al. (2015)	Multipurpose application (treatment & tracking)	Effectiveness at 6 weeks t(223)=−2.2 p=0.031 and 12 weeks *t*(181)=−2.0, *p*=0.042 . Not effective at 24 weeks	Compliance rate (65%)	Satisfaction questionnaire scores: Intervention (*M*= 9); Control (*M*= 10)
Donker et al. (2019)	Treatment mobile application	*b*191 = −9.79; *p* < .001; adjusted R^2 = 0.52. NNT= 1.7.	Intervention retention rates: 59% (post-test) and 49% (follow up); Control retention rates: 91% (post-test and follow up)	SYSTEM USABILITY SCALE (M =75.35)
Faurholt-Jepsen et al. (2021)	Multipurpose application (treatment & tracking)	There was a significant positive association between daily smartphone-based patient-evaluated stress and the CAR (B: 134.14, 95% CI: 1.35; 266.92, p=0.048 (n=33)). significant positive association between patient-evaluated stress measured using the PSS and patient-evaluated stress measured using smartphones (B: 3.33, 95% CI: 2.02; 4.65, p < 0.0001 (n = 33).	N/A	N/A
Faurholt-Jepsen et al. (2015)	Multipurpose application (treatment & tracking)	Primary Analysis: B = −0.34, 95% CI −1.14 to 0.47, p= 0.41 Exploratory Analysis unadjusted B = 2.33, 95% CI 0.10–4.56, *p* = 0.040 and the adjusted *B* = 2.57, 95% CI 0.40–4.74, *p* = 0.020 in manic and non-remitting groups.	N/A	N/A

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Graham et al. (2020)	Multipurpose application (treatment & tracking)	Recovery from depression (OR, 3.25; 95% CI, 1.54-6.86) anxiety (OR 2.17; 95% CI, 1.08-4.36). Sustained at follow up for both depression (slope, 0.01; 95% CI, –0.09 to 0.10; *p*= .92) and anxiety (slope, 0.02; 95% CI, –0.08 to 0.12; *p*= .67)	Usage score (81% after 8 weeks follow up.	N/A
Hensler et al. (2022)	Multipurpose application (treatment & tracking)	Access to PTSD Coach led to a greater decrease in posttraumatic stress after 3 months compared with the waitlist (Cohen d=−0.45, 95% CI −0.70 to −0.20). Access to app show clinically significant improvement (χ21,150=4.62; P=.03) and less likely to fulfil the criteria for probable PTSD than participants on the waitlist after 3 months (χ21,150=7.74; P=.005). However, we detected no difference between conditions in remission from probable PTSD	N/A	Participants with access to PTSD Coach found the app slightly to moderately helpful. sum score on helpfulness was 23.11 (SD 14.32; n=71). Most participants (50/69, 72%) were moderately or very satisfied with the app (n=69, mean 2.22, SD 1.07).
Kauer et al. (2012)	Multipurpose mobile application (tracking & predicting)	Increase in emotional awareness χ2 = 11.3, p= .04 Awareness of emotion predicted depressive symptoms κ2=.54 (95% CI .426–.640).	N/A	N/A
Kuhn et al. (2017)	Multipurpose application (treatment & tracking)	PTSD symptoms (F(1, 117) = 4.55, p= .035), depression symptoms (F(1, 117) = 7.63, p = .007), and psychosocial functioning (F(1, 117) = 8.34, p=.005). Clinically significant PTSD symptom improvement (*p*=.018) than waitlist participants	*M*=1.29 days of use per week correlated with their self-reported average days used per week (r = .51, p =.01).	N/A

Lewis et al. (2020)	Self-Monitoring application	Overall, no differences. However, in London centre found significant reduction in positive symptoms after 12 weeks of ClinTouch-enhanced monitoring in the early psychosis subsample (adjusted mean difference –3.04; CI –5.49, –0.59; P=.016.	95% stayed in the trial for 12 weeks 84% responding to at least 33% of beep alerts adherence was 60%. Healthcare professionals (care coordinators) used ClinTouch-enhanced management in app in 100% of cases, with average of 24 times per patient.	90% continued to use it regularly at 3 months. In these patients, adequate adherence was 84%, defined as responding to >33% of item prompts
Lüdtke et al. (2018)	Treatment mobile application	Depression score $F(1;71) = 0.173$, $p = 0.678$; self-esteem score $F(1;71) = 1.464$, $p = 0.230$; quality of life score $F(1;70) = 0.041$, $p = 0.840$. Application and TAU increased self-esteem overtime ($p = 0.274$)	N/A	Client Satisfaction Questionnaire 57%
Mantani et al. (2017)	Multipurpose application (treatment & tracking)	Kokoro 2.48 points (95% CI 1.23-3.72, P<.001) lower on PHQ-9 and 4.1 points lower on (95% CI 1.5-6.6, P=.002) lower on BDI-2 and 0.76 points (95% CI –0.05 to 1.58, P=.07) lower on side effects. Mind maps *M*=11.2	N/A	N/A
Miner et al. (2016)	Multipurpose application (treatment & tracking)	Coach reduced PTSD symptoms (t(19) = -2.31, p= .031). 9 participants had clinically significant improvements to the postcondition assessment, compared to 4 in TAU	PTSD Coach usage (*M*=2.65; *SD*= 1.03) weekly and waitlist (*M*=2.50; SD= 0.83) weekly	Satisfaction 83% prefers to learn new tools to cope with their PTSD symptoms. Also, the app was more convenient than the paper condition
Moberg et al. (2019)	Multipurpose application (treatment & tracking)	The Pacifica group was lower in depression (-0.59; CI -0.86 to -0.3; $p<.001$) anxiety (-0.43; CI -0.71 to -0.15; $p = .003$), stress (-1.79; CI -2.74 to-0.84; $p<.001$) and higher on self- efficacy (1.55; CI 0.53 to 2.58; $p = .003$) compared to waiting list	Significant attrition rates in Pacifica condition compared to waiting list χ^2 (n=500)=7.7;p=.006.	N/A

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Newman et al. (2020)	Treatment mobile application	App group large-effect reductions in all symptom measures during the treatment period. No significant symptom changes across the six-month follow-up period in both conditions.	N/A	N/A
Nicol et al. (2022)	Multipurpose application (treatment & tracking)	PHQ-9 scores at 4 weeks decreased by 3.3 units in the intervention group and 2 units in the wait list control group. The percentage of participants achieving remission at both time points seemed to favour the active intervention, at 67% (2/3) and 0% (0/5) at 4 weeks and 50% (1/2) and 20% (1/5) at 12 weeks, respectively.	70% agreed with the statement "using the app in the treatment of depression seems possible"	80% agreed or completely agreeing with the statement "I like using the app"; mean usability score 21.4, SD 1.7, possible range 5 to 25
O'Toole et al. (2019)	Multipurpose application (treatment & tracking)	Lifeapp decrease in suicide risk end of treatment (F(1, 138.7) = 7.2, *p*= .008, d= 0.46) and 3 months follow up (F(1, 351.1) = 65.0, *p*= .001, d = 0.86) compared to TAU however No between group differences after treatment (*p* = .732, d = 0.05) and follow up (*p* = .467, d = 0.11)	N/A	N/A
Oh et al. (2020)	Multipurpose application (treatment & tracking)	Panic disorder symptoms Chatbot versus TAU (t20 = 2.68; *p* = 0.01); reduced phobia (t20 = −2.94; p < 0.01) and helplessness score (t20 = 2.16; p = 0.04)	Retention rate high 80% (SM; n= 8) and 100% (CS; n= 10). Usage (*M*=9 day for) over 4 weeks. Usability scores higher in Chatbot vs TAU (64.5 ± 11.0, and 69.5 ± 17.2, respectively; p= 0.35).	N/A
Possemato et al. (2016)	Multipurpose application (treatment & tracking)	SM and CS reduced PTSD score (SM= 2.8 (9), *p*=.02; CS= 5.4 (9), *p*≤.01) for social functioning in in CS (−2.0 (9), *p*=.02)	Feasibility was higher than control. Usage is higher in CS than SM over 8 weeks. 5.1 (*SD*= 1.9, range=1–8) PTSD symptoms and	HIGHER REFERRAL IN CS PTSD COACH VS SM PTSD COACH CONDITION (X2(1,18)=7.9 P≤ .01)

			11.7 (*SD*= 6.2, range=4–22) Learn topics, and then utilized 5.3 (*SD*=2.7, range=3–8) Manage categories.	
Roepke et al. (2015)	Treatment mobile application	Depressive symptoms compared to control $t(276) = -3.90$, $p < 0.001$	Retention rates were low with 26.15 % (post-test) and 18.34% (follow up)	N/A
Röhr et al. (2021)	Treatment mobile application	ITT no change in DSM-5 scores, but use of app showed low self-stigma after 4 weeks (SSMIS-stereotype agreement: d=0.86, 95% CI 0.46 to 1.25; stereotype application: d=0.60, 95% CI 0.22 to 0.99) and after 4 months (d=0.52, 95% CI 0.12 to 0.92; d=0.50, 95% CI 0.10 to 0.90), the IG showed significantly lower values in self-stigma than the CG.	Total attrition was 12.8% (17/133). usability score of 78.9	N/A
Schlosser et al. (2018)	Multipurpose application (treatment & tracking)	PRIME increasing motivated behaviour ($F(1,56) = 4.75$, $p = .03$), increasing likelihood of positive future outcomes ($F(1,56) = 4.66$, $p = .04$). PRIME compared to control had higher decrease of defeatist beliefs $F(1,57) = 5.58$, $p = .02$, depression ($F(1,56) = 7.06$, $p = .01$), and self -efficacy ($F(1,55) = 5.76$, $p = .02$)	PRIME usage 4/7 days. Completed Challenge rate PRIME (91.47%) compared to (83.58%). Self-monitoring higher in TAU (1.94) versus PRIME (1.74)	Satisfaction rated (*M*=8.21; SD= 1.9) for PRIME. The most popular was directly message coaches (*M* =8.38, *SD*= 2.5), and the least popular was self-monitoring (*M*= 6.33, *SD*= 2.4).
Schwob & Newman (2023)	Multipurpose application (treatment & tracking)	There was no significant difference. between self-monitoring (M =1.09; SD =1.17) and IE (M =1.17; SD = 0.72), β=0.54, SE =0.80, Z =0.68, p =.12 In reported number of social situations engaged in between prompts. However, the reported number of social situations avoided between prompts differed	Calculated compliance rates were 59% for IE (requested thrice daily completion) and 62% for self-monitoring (requested 8 times daily completion), which were not significantly different from each other, β =0.04, SE =0.08, Z =0.50, p=.21.	N/A

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		significantly by condition such that self-monitoring (M =1.24; SD =0.56) had more avoided situations on average than imaginal exposure (M =0.92; SD =0.43), β=1.24, SE =0.44, Z =2.82, p=.02.		
Steare et al. (2020)	Self-Monitoring Application	No difference in relapse (OR 1.41; 95% CI 0.21 to 9.58),	Participants accessed My Journey 3 on a median of 22% of the days it was available to them. Eight participants (40%) used My Journey 3 for longer than 30 min in total. 5 participants used app 5 months after downloading it; 1 participant never used the app after the training session 10 stopped using My Journey 3 within the first 3 months after the training session.	Most service user participants found My Journey 3 to be acceptable, and some participants reported a clear benefit from using it. Barriers affecting use lack of clinician support and concerns around data privacy. A key theme for staff did not have the time to provide regular support to participants with My Journey 3.
Stolz et al. (2018)	Treatment mobile application	Superior in all SAD measures (t(119.46)= 5.08, *p*= .01, d=1.07). No difference between App and PC. (t(120.75) =1.71, *p*=.09, d =0.30.). Diagnostic response rates higher in active (NNTPC= 3.33; NNTApp = 6.00) versus TAU.	App higher usage (D=4.14, *p*=.01) versus PC and spread throughout the day	N/A
Tighe et al. (2017)	Multipurpose application (treatment & tracking)	iBobbly increased depression and suicidality (t=2.40; df=58.1; p=0.0195) but reduced depressive symptoms (t=2.79; df=56.9; p=0.0072) and distress (t=2.44; df=57.5; p=0.0177) compared to waitlist. No difference in impulsivity (t=−1.82; df=29.1; p=0.0792)	High usage 85% of available data (40/61) completed all the activity.	N/A

Vitger et al. (2022)	Multi-purpose application (treatment and self-monitoring)	statistically significant difference between the intervention and control groups in self-perceived patient activation (mean difference 4.39, 95% CI 0.99-7.79; Cohen d=0.33; P=.01), favouring the intervention group.	N/A	High client satisfaction with mobile application with 44.8% of participants scoring more that 29 out of 32.

Primary and Secondary Outcomes; Mean (M); Significance level (p); Confidence Interval (CI); Standard Deviation (SD); Patient Health Questionnaire-9 (PHQ-9); Becks Depression Inventory 2 (BDI- 2).

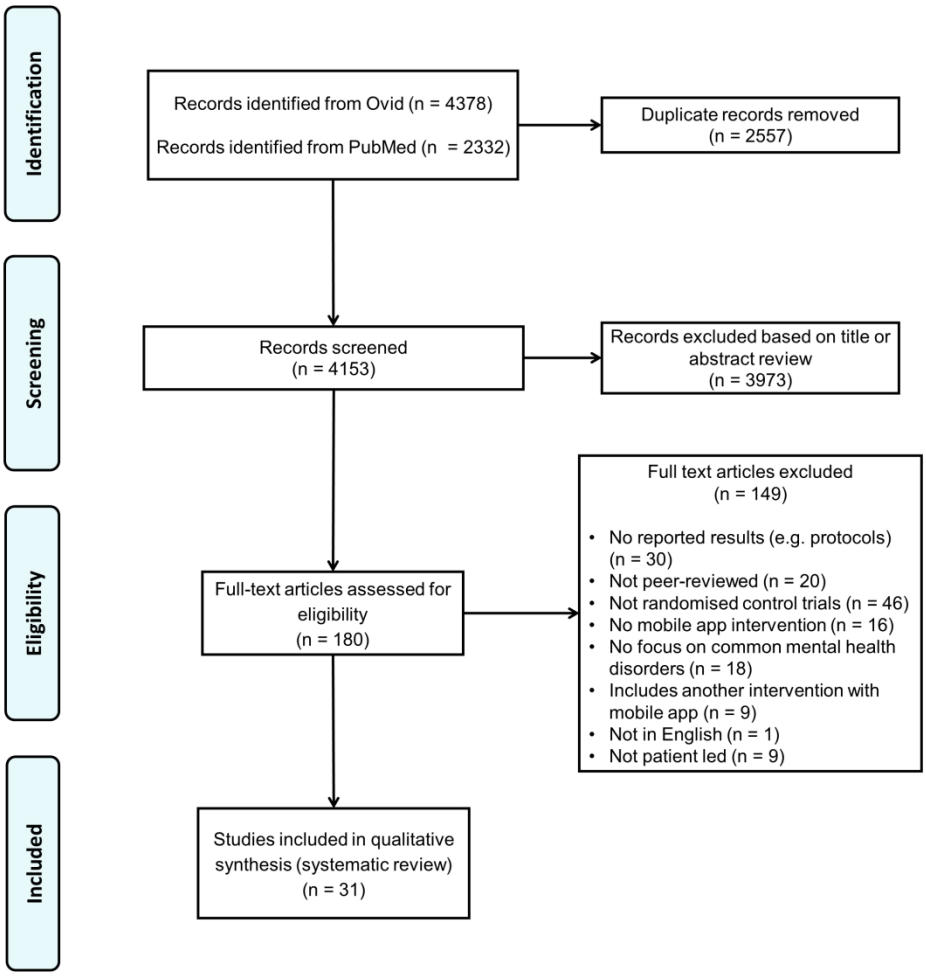

Figure 1. PRISMA Flow Diagram

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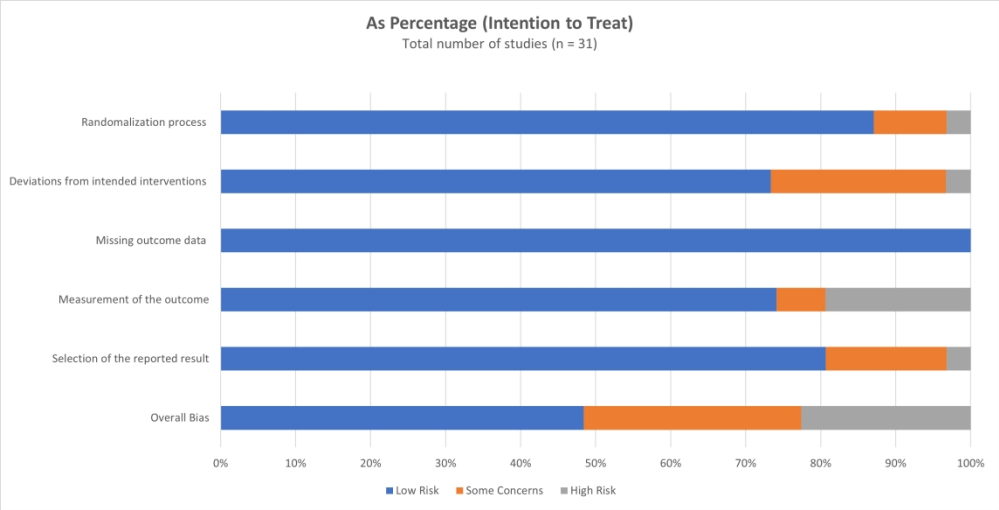

Figure 2. Overall risk of bias

654x334mm (130 x 130 DPI)

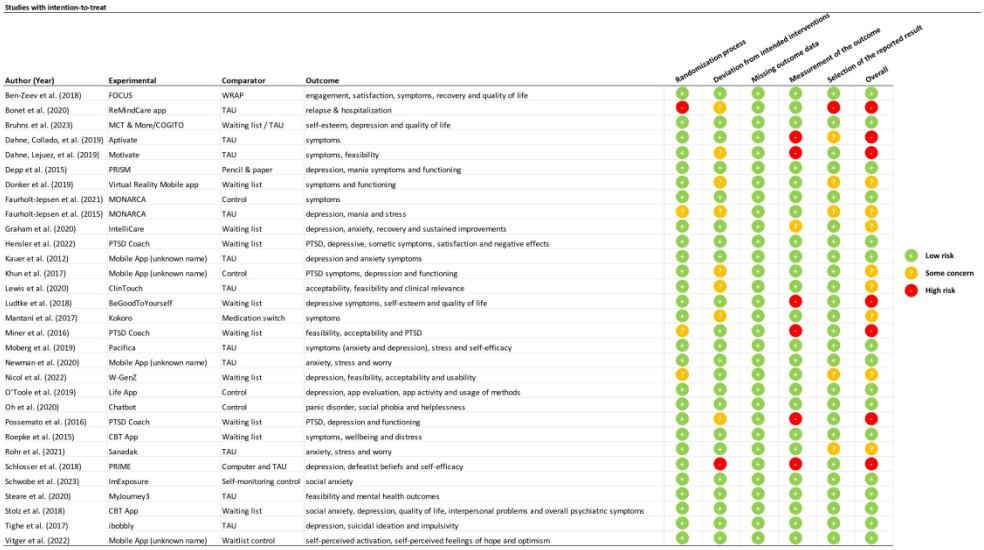

Figure 3. Individual risk of bias

1016x571mm (96 x 96 DPI)

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Smartphone apps for mental health: systematic review of the literature and five recommendations for clinical translation

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Smartphone apps for mental health: systematic review of the literature and five recommendations for clinical translation

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Review of Smartphone Apps for mental health

Abstract

Objectives: Providing adequate access to mental health services is a global challenge. Smartphone apps offer a potentially cost-effective, available, and accessible solution for monitoring, supporting, and treating mental health conditions. This systematic review describes and evaluates the usage of smartphone apps across a wide range of mental health disorders in terms of clinical effectiveness, feasibility, and acceptability.

Design: Systematic review of studies examining treatment, self-monitoring, and multipurpose smartphone apps for mental health disorders.

Data sources: Studies were identified through a comprehensive search of the Ovid and PubMed databases. Articles published up to 14 January 2024 were included based on predefined criteria.

Eligibility criteria: We included randomized controlled trials (RCTs) that comparing mental health apps (single- or multipurpose) to treatment-as-usual or no treatment for clinical populations with mental health disorders. Studies were excluded if they focused on web-based interventions, combined apps with non-TAU treatments, or targeted physical health apps.

Data extraction and synthesis: Two independent reviewers screened and selected studies, with a third reviewer resolving inconsistencies. Extracted data included study details, participant characteristics, app information, and outcome measures related to effectiveness, feasibility and acceptability. A risk of bias assessment for each study was conducted.

Results: Out of 4153 non-duplicate articles screened, 31 studies meeting full-text eligibility criteria. These included six studies on treatment apps, four used self-monitoring apps, and 21 on multipurpose apps for a range of mental health disorders. Fifteen were identified as having between some and high concern on the risk of bias assessment. While smartphone apps were generally effective and acceptable, their feasibility appeared to decline over time.

Conclusions: Smartphone apps are promising tools for mental health care, demonstrating effectiveness and acceptability. However, challenges such as reduced feasibility over time, potential biases, and underrepresented demographics require further research. This review proposes five recommendations for improving clinical translation in future studies.

Strengths and limitations of this study

- The review systematically evaluated smartphone apps for mental health using a comprehensive search strategy and robust risk of bias assessment.
- The studies were included from diverse clinical contexts, distinguishing between clinical effectiveness, feasibility, and acceptability.
- The included studies were limited by a relatively homogenous sample population, primarily middle-aged women, with reduced representation of adolescents and older adults.
- Many studies (15 of 31) raised concerns regarding risk of bias, potentially limiting the reliability of the findings.
- No studies addressed the use of smartphones for obsessive-compulsive disorder (OCD), highlighting a gap in app-based mental health interventions.

Introduction

Approximately 1 billion people worldwide are affected by mental disorders, posing a global challenge[1]. The WHO estimates that 50% of people with mental disorders lack access to care in developed countries, and this percentage increases to 85% in the developing world[2]. One potential solution is through the use of smartphone-based mental health apps, which can provide support for individuals in need. Currently, there are 6.3 billion smartphone users globally, with over 90% using apps daily[3]. A recent survey found that 71% of psychiatric patients wanted to use apps to supplement their clinical care[4]. Therefore, it is no surprise that apps have gained substantial interest in healthcare settings, with currently over 20,000 mental health apps available on the market[5].

There are three types of mental health apps: treatment, self-monitoring, and predictive[6,7]. Treatment apps provide a variety of psychological interventions, such as those based on cognitive-behavioural therapy (CBT). They have been shown to reduce symptoms like depression and anxiety[8–10], and enhance psychiatric patients' quality of life[8] and their recovery[9]. They can be used in conjunction with other therapeutic approaches or independently, particularly for managing milder cases or supporting users until they can access specialised care. Self-monitoring apps allow patients to track changes in their mood and symptoms, which increases their emotional self-awareness (ESA)[11]. Increasing ESA has a positive effect on psychiatric patients as it improves their coping skills and decreases the severity of their symptoms[12,13]. Lastly, predictive apps monitor and predict clinical relapse, allowing for early intervention through preventing and stabilising symptoms[14]. Additional features of mental health apps include improving healthcare efficiency[15], psychoeducation, clinical assessment, skills training, tracking treatment progress, and communication with healthcare professionals[16].

Using mental health apps offers several potential advantages. First, mental health apps are cost-effective[17] since they directly reduce hospital admission costs[18]. Second, mental health apps

are often readily available and accessible, unlike the conventional in-person interventions[19]. Third, mental health apps provide access to an extensive population, including those who live in rural areas with limited access to mental health services[20]. Fourth, mental health apps lead to higher engagement with mental health services. Some people may prefer to communicate with mental health professionals via smartphones rather than in person. It is especially well suited for participants from 14 to 24 years old, who are usually most affected by mental health issues and least likely to seek help, as mobile phones are their preferred mode of communication[21].

Despite the increasing number of mobile apps for mental health, actual usage rates and perceived usefulness remain relatively low. A recent systematic review found that while approximately 87% of individuals with mental disorders owned smartphones, only 23% used them for mental health purposes, suggesting significant barriers to uptake and usage[22]. Similarly, Kim et al. (2022) highlighted that while mobile apps can reduce symptoms of severe mental illness, challenges such as user engagement and operational complexity hinder their integration into clinical care. These barriers underline the importance of systematically assessing the clinical effectiveness, feasibility, and acceptability of mental health apps to support their broader adoption in mental health care settings[23–25]. Clinical effectiveness assesses app efficacy compared to treatment-as-usual (TAU)[26,27]. While previous reviews emphasised that mental health apps are effective in terms of improving functioning and quality of life and reducing symptoms[28–32], many included biased studies, leading to inconclusive results[33,34]. Therefore, further systematic reviews on the clinical effectiveness of mental health apps are needed.

Feasibility is an objective measures usage and retention rates among the patients[35], a crucial measure as mental health services prioritise apps with proven feasibility[36]. A systematic review comparing seven studies demonstrated that mental health apps have high feasibility (92% retention rate, 72% response to prompts, and 3.95 interactions with the app per day)[37], but only

for a narrow range of mental health disorders. This highlights the need to assess the feasibility of apps relating to a larger range of mental health disorders.

Acceptability is a subjective measure of patient usage and satisfaction[38]. Prior studies frequently interchanged the terms 'acceptability' and 'feasibility'[39], resulting in unclear findings. A systematic review comparing eight studies emphasised that using mental health apps is highly feasible[40]. However, it did not clearly define feasibility, often mixing it with acceptability. Further research is needed to clearly differentiate between these concepts.

Aims and objectives

This systematic review assesses clinical effectiveness (primary outcome), feasibility, and acceptability (secondary outcomes) of mental health apps compared to TAU. We address the following research questions: (1) To what extent are current mental health apps clinically effective? (2) What is the feasibility of using mental health apps? (3) What is the acceptability of mental health apps?

Methods

Protocol

This systematic review followed the PRISMA guidelines[41] and the protocol was registered to the international Prospective Register of Systematic Reviews (PROSPERO, CRD42020193699)

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Inclusion and exclusion criteria

The inclusion criteria were: (1) randomized controlled trials (RCTs) reporting on a primary intervention using a mental health app (single- or multipurpose app) compared to TAU or no treatment; (2) articles reporting on clinical samples from inpatient or community settings with various mental health disorders such as depression, anxiety, phobia, panic disorder, obsessive-compulsive disorder, post-traumatic stress disorder, psychosis, bipolar disorder, suicidal ideation/ behaviour, and self-harm. (3) original articles in peer-reviewed journals; (4) articles published in English.

The exclusion criteria were: (1) articles reporting on web-based interventions not requiring apps; (2) articles that used mental health apps in addition to interventions other than TAU; (3) articles on apps with a focus on physical health; (4) observational studies.

Information sources and search strategy

This systematic review conducted a comprehensive search that started in June 2020 and the final search was conducted on January 14, 2024, using PubMed and Ovid database (composed of APA PsycInfo, Global Health, Embase, and Ovid MEDLINE). The searches were run four times during this period to ensure that the results remained up to date as the review progressed and to incorporate newly published studies relevant to the topic. Search terms relating to 1) mental health, 2) smartphones and 3) self-management were used. Appendix A provides an example of the full search strategy, including applied limits for one of the searches (e.g., randomised controlled trials), while other searches used no additional filters.

Selection and data collection process

Two reviewers independently conducted the search and screened articles based on the inclusion and exclusion criteria with a third reviewer resolving inconsistencies. This process ensured the reliability and consistency of study selection. Extracted data included article details (authors, publication year), participant information (sample size, gender, mean age,

inclusion/exclusion criteria, diagnosis, and diagnostic tool), mental health app information (name and type), and outcome measures (clinical effectiveness, feasibility, and acceptability).

Data items

The primary outcome of this review, clinical effectiveness, is defined as the extent to which an app effectively achieves its intended purpose[26]. For self-monitoring apps, this was assessed by assessing the effect of treatment-as-usual compared with those who are also using self-monitoring apps. For treatment and prediction apps, clinical effectiveness was represented by intention-to-treat analysis or analysis of covariance (ANCOVA).

Secondary outcomes of this review are with regards to feasibility and acceptability of mental health apps. Feasibility is defined as an objective measure indicating the ease of psychological intervention[35]. The feasibility was measured by overall usage and retention/attrition rates. Acceptability is defined as a subjective measure of psychiatric patients' attitudes toward mental health app usage [38], and was assessed through the use of satisfaction questionnaires.

Risk of Bias Assessment

This systematic review assessed errors and bias in the article's selection process. For example, randomization such as blinding degree, allocation and attrition were determined by the reviewer. In addition, to assess the risk of bias in the article's selection process, this systematic review used the revised Cochrane risk-of-bias tool for randomized trials (RoB 2)[42].

Synthesis of results

A narrative synthesis was conducted for the outcomes (i.e., the clinical effectiveness, feasibility, and acceptability of mental health apps). This narrative synthesis consisted of all eligible articles that met the inclusion criteria and showed a comparison between mental health apps and TAU in their effectiveness in self-monitoring, treatment, and predicting.

Results

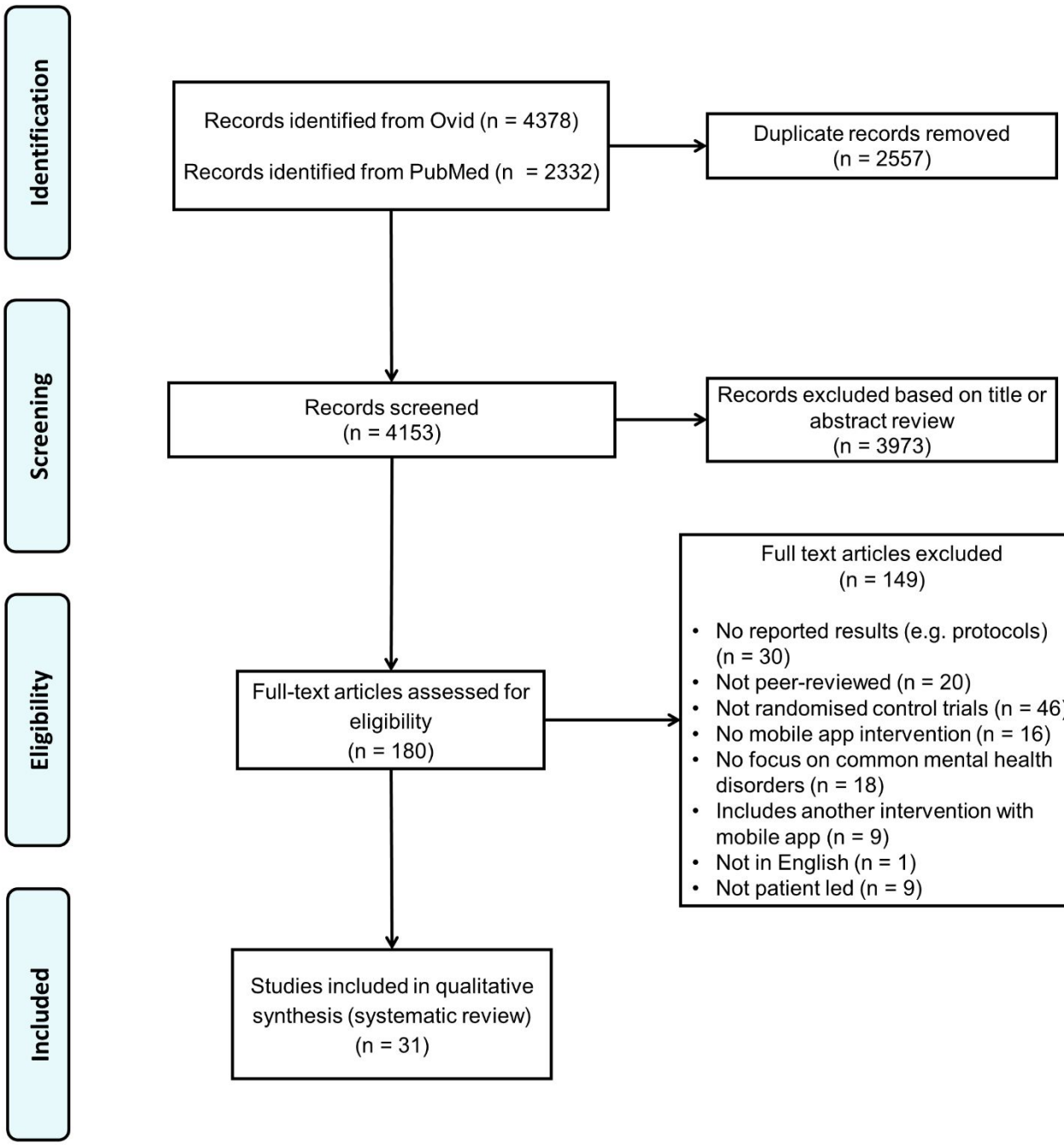
Study selection and characteristics

Figure 1 shows the PRISMA flowchart of the search results. Thirty-one articles reporting on 27 different mental health apps were identified. These articles are summarised in Supplementary Table 1. Six articles discuss treatment applications, four article discusses self-monitoring applications, and the remaining 21 articles discuss multipurpose applications, including a combination of tracking, self-monitoring and/or treatment components.

This systematic review consisted of a total of 3660 participants with a mean age of 28.29 years. Most studies specified eligibility criteria as participants older than 18 years and younger than 60 years.

Twenty-four of thirty articles had more than 50% female participants. In addition, seven articles had more male participants due to the population of interest (i.e., veterans in Possemato et al.[43]). Further details on the location of each study and duration of app usage can be found in Supplementary Table 3.

Figure 1. PRISMA Flow Diagram



Risk of bias

This systematic review used RoB 2 to assess the risk of bias for included RCTs[42]. Overall, 48.4% of RCTs had a low risk of bias, 29% raised some concerns, and 22.6% had a high risk of bias. Figure 2 shows a high risk of bias in the outcome measures (19.4 %), while missing outcome data, the randomisation process, and the selection of reported results showed lower bias (100%, 87.1%, and 80.6%, respectively).

The risk of bias for each RCT is described in-depth in Figure 3. Most RCTs presented low bias from the randomisation process, with the exception of Miner et al. (2016)[44], which lacked information about participant concealment, potentially affecting motivation and adherence in the control group.

Six RCTs raised concerns in the selection of reported results[45–50], possibly due to multiple analyses to assess changes in symptoms[47] or not pre-specifying their data analysis[46]. Seven RCTs reported a high risk for bias for outcome measures[43,44,46,51–53], often due to unblinded assessors[46,51,53] or insufficient information[43,44,52].

Key findings

This systematic review assessed the clinical effectiveness (primary outcome), feasibility, and acceptability (secondary outcomes) of mental health apps. Outcomes are assessed using data from treatment, self-monitoring, and multipurpose mental health apps, as no article assesses single-purpose predictive applications. The findings are shown in Supplementary Table 2.

The effectiveness, feasibility, and acceptability of treatment apps

This systematic review assessed six studies on treatment mental health apps in terms of effectiveness, acceptability, and feasibility. Four studies demonstrated a statistically significant effect, reducing symptoms such as acrophobia[47], depression[54], and anxiety symptoms[55,56]. Notably, several studies also reported improvements in quality-of-life metrics for patients[47,54–56]. However, Röhr et al.[49] found no impact on PTSD symptoms but significantly lowered self-stigma.

In terms of feasibility, Stolz et al.[55] found interaction levels with apps compared to personal computers (d=0.14, p=.01), suggesting greater feasibility. Similarly, Röhr et al.[49] reported low drop-out rates (12.8%), but Donker et al.[47] and Roepke et al.[54], found lower retention rates at post-test (59% and 26.15%, respectively) and follow-up (49% and 18.34%, respectively).

In terms of acceptability, Lüdtke et al.[52] found treatment apps acceptable, with over 50% positive responses on the Client Satisfaction Questionnaire (ZUF-8; Schmidt et al.[57]), consistent with Donker et al.'s[47] user-friendliness scale[58] results. While Donker et al.[47] reported a 'good' score on the user-friendliness scale, indicating overall user satisfaction and acceptability, there remains potential for further improvement to enhance user satisfaction.

The effectiveness, feasibility, and acceptability of self-monitoring apps

This systematic review assessed three studies on self-monitoring mental health apps in terms of effectiveness, acceptability, and feasibility. Bonet et al.[45] found that using a self-monitoring app is effective, reducing hospitalizations (χ^2=4.6, P=.03), relapses (χ2=13.7, P=.001), and urgent care visits (χ2=7.4, P=.006)[45], though Steare et al.[59] found no significant impact on clinical outcomes, noting that the trial was not statistically powered to detect effectiveness, and Lewis et al.[60] reported effectiveness primarily in early psychosis, with limited benefits for chronic illness.

Bonet et al.[45] and Steare et al.[59] reported compliance rates between 85% - 100%, suggesting strong engagements with their respective apps. In Lewis et al.[60], feasibility was reflected by a 95% retention rate over 12 weeks, with 84% of participants achieving acceptable adherence.

Lewis et al.[60] demonstrated high acceptability, with 84% of participants responding to at least 33% of alerts, indicating regular app usage. Similarly, qualitative feedback from Steare et al.[59] suggested that many participants found the app acceptable and reported clear benefits. However, Steare et al.[59] noted that participants expressed concerns around data privacy and lack of clinician support, which may have impacted long-term engagement. Bonet et al. (2020) also observed lower acceptability for participants who were suspicious of technology (33%) or found the app boring and not beneficial (40%).

The effectiveness, feasibility, and acceptability of multipurpose apps

Twenty-two studies investigated the use of multipurpose apps combining treatment components, self-monitoring or prediction components. Sixteen of these studies demonstrated treatment component effectiveness compared to control conditions[44,46,66–71,48,50,53,61–65]. For example, Ben-Zeev et al.[72] showed improvements in quality of life (t=2.55, p=.001), and Graham et al.[62] reported recovery odds for depression (OR: 3.24, 95% CI: 1.54, 6.86) and anxiety (OR: 2.17, 95% CI: 1.08, 4.36). However, Possemato et al.[43] and Bruhns et al.[73] found that treatment apps had no significant impact

compared to other interventions. Self-monitoring component effectiveness was shown in three studies[51,53,64] and the prediction component effectiveness in one study[74].

Feasibility of multipurpose apps was assessed in fourteen studies, with eleven finding high compliance, retention and usage rates. For example, Dahne et al.[51] reported retention rates of 90% in the first week and 50% at eight weeks, and usage rates of 71%. While Depp et al.[61] reported retention rates of 93% after 12 weeks, they indicated that retention had dropped by week 24. Dahne et al.[46] and Graham et al.[62] reported high retention (81% and 72.2%) and usage rates (81.8%). These findings were supported by eight other studies[44,50,53,63,67,71,72,75]. However, Possemato et al.[43] found higher retention with clinical support, while Moberg et al.[65] reported increased attrition rates in individuals with app access.

Acceptability of multipurpose apps was assessed in nine studies, with Depp et al.[61] reporting a higher acceptability rate (9/10) compared to controls (8/10). This was supported by several other studies [43,50,67,69,70,72,73], with Miner et al.[44] greater convenience for self-monitoring symptoms compared to traditional methods.

Discussion

The present systematic review assessed the use of smartphone-based mental health apps for common mental health disorders focusing on clinical effectiveness, feasibility and acceptability. We identified 31 articles reporting on 27 mental health apps for treatment, self-monitoring, and multiple clinical purposes. To our knowledge, this is the first review evaluating these aspects across a wide range of mental health disorders with a rigid risk of bias assessment.

To what extent are current mental health apps clinically effective?

The clinical effectiveness of mental health apps, defined as the effectiveness of the app compared to TAU[27], was assessed for treatment, self-monitoring and multipurpose apps. Four of six

studies found that treatment apps reduced symptoms and improved functioning and quality of life of psychiatric patients[47,54–56]. Two studies found no significant effect on symptoms; however, PTSD self-stigma was reduced[49], and symptoms improved over time[52]. However, biases affected results, and low-bias studies were inconclusive, showing significant improvements only with with clinical support[33,34]. Further research into the effectiveness of treatment apps is required.

Self-monitoring apps showed mixed results. Only one app led to fewer hospitalizations, relapses and urgent care visits[45], but it had a high risk of bias. The finding was inconsistent with those of Steare et al.[59] and Lewis et al.[60] who found no significant differences between groups. Thus, further development and validation are required.

Multipurpose apps were generally effective, but not all individual components were assessed separately. Treatment components were individually effective in some studies[44,46,66–71,48,50,53,61–65], but the inclusion of clinical support led to better outcomes[43]. Self-monitoring components were assessed by three studies, all of which found that they were clinically effective[51,53,64]. A predictive feature showed effectiveness in one study[74]. However, as this was just a single study, more research is needed to make assertive conclusions.

Overall, most apps were clinically effective, but biases and the small number of studies suggests that further research is necessary.

Is it feasible to use mental health apps?

The feasibility of using mental health apps, defined by an objective measure of usage and retention rates[35], was high for some treatment apps, with higher interaction levels than personal computers[55] and low drop-out rates in certain studies[49]. However, attrition remains a common challenge for mental health apps. For example, Roepke et al.[54] reported retention rates as low as 26.15% at post-test and 18.34% during a 6-week follow-up, highlighting the difficulty in sustaining engagement over time. Similarly, Dahne et al.[51] reported retention rates of 90% in the first week and

50% at eight weeks. This decline in feasibility may be due to poor user engagement, repetitive tasks, and privacy concerns. Torous et al.[76] noted that many mental health apps suffer from poor usability, and lack of user-centric design. Such issues can make apps difficult or unenjoyable to use, leading to a loss of interest over time. Aryana et al.[77] emphasised the importance of designing apps that adapt to diverse user contexts and involve user feedback during development. This suggests that while short-term feasibility is promising, long-term retention requires further exploration, potentially through strategies such as enhanced app design and clinical support. More studies are needed to assess long-term feasibility.

Three studies included in this review found high compliance rates of self-monitoring apps[45,59,60], with Lewis et al.[60] also finding high compliance rates with clinicians. However, as mental health services prioritise the deployment of feasible apps[36], more studies exploring feasibility of self-monitoring apps may be required.

Fourteen studies on multipurpose apps found high in compliance, usability and retention[44,46,71,72,75,50,51,53,55,61–63,67]. Possemato et al.[43] found higher retention with clinical support, and Moberg et al.[65] reported increased attrition. It is noteworthy that the findings presented here likely depend on the overall study period and specific app features, also relating to the user acceptability.

What is the acceptability of mental health apps?

Acceptability, measured by patient usage and satisfaction with mental health apps[38], was high for treatment apps[47,52]. Self-monitoring apps were generally acceptable[59,60], but Bonet et al.[45] found them less acceptable for participants who suffer from delusions.

Nine studies assessing multipurpose apps found high acceptability, with patients finding them easy to use, convenient, and helpful[43,44,50,67,69,70,72,73]. Possemato et al.[43] noted improved satisfaction in those with clinical support. However, differences in app design, target populations, and clinical

contexts may influence overall acceptability, highlighting the importance of tailoring apps to user needs[76,77].

In summary, acceptability ratings were high, but evidence suggests they could improve with clinical support, indicating apps might be best used alongside TAU. Bonet et al.[45] found acceptability varies by target population, being less suitable for some disorders than others (such as those with delusions or paranoia). The small number of studies makes it challenging to analyse by disorder, highlighting a need for further research.

Limitations of current smartphone applications

Despite the many benefits, mental health apps have limitations. Firstly, while it is important to note that a majority of the global population use smartphones[3], most users come from higher-income households[78], limiting access for those with lower socio-economic status. While mental health apps can improve accessibility, particularly for individuals in areas with limited mental health services, their effectiveness may be hindered by barriers such as unreliable internet connectivity in rural regions, which can restrict their functionality and impact[79]. Furthermore, digital literacy and the risk of digital exclusion present significant challenges, especially in individuals who are still unfamiliar with smartphones or apps[80].

Secondly, some mental health applications are only available for either Android or iOS smartphone operating systems (e.g. Dahne, Collado, et al.[46] and Dahne, Lejuez, et al.[51]), highlighting the importance of multi-platform development for inclusivity.

Thirdly, a lack of integration with clinical practice is another issue, as data from apps are often not incorporated into electronic health records. This data would be beneficial for clinicians to monitor their patients' conditions[51] and better understand the disorders, allowing for a more holistic approach to care for psychiatric patients.

Fourthly, data and privacy concerns present a significant challenge[81,82]. Some patients expressed wariness about confidentiality[54,65,75], and in some instances, were uncomfortable responding to self-assessments in a public setting[54]. Additionally, data breaches or unauthorised access to sensitive health information could significantly erode trust in mental health apps, a significant barrier to user engagement[76]. These concerns can be mitigated by providing transparent privacy policies, adhering to robust encryption standards, and complying with regional data protection laws. Additionally, offering the option to complete assessments at a time when they are in a private setting[44,75] can further address privacy concerns. Addressing these concerns is critical for safeguarding user trust, ensuring confidence, and supporting sustained app usage.

Finally, a limitation of smartphone applications is missing data due to patient disinterest or lack of engagement. Schlosser et al.[53] found self-monitoring features were the least popular, seen as repetitive and tiresome. This can be mitigated by collecting passive data and enhancing app design to increase adherence and engagement.

Strengths and weaknesses of the current systematic review

Our findings add to the growing literature on digital technologies for mental health distinguishing between clinical effectiveness, acceptability, and feasibility, and using a robust risk of bias assessment[59].

However, there are several limitations in the current review. First, the sample was relatively homogenous, mostly middle-aged female participants. Only Kauer et al.[74] included adolescents, and no study included a sample with a mean age of above 50. This underrepresentation of older adults is particularly notable, given the barriers associated with this demographic. Older adults may face additional challenges, such as lower digital literacy and unfamiliarity with smartphone apps[83], which could impact the feasibility and acceptability of these interventions for these groups. Thus, the findings cannot be generalised to a wider population, highlighting an understudied group in digital

technologies literature. Future research should prioritise the inclusion of older adults to ensure mental health apps are developed and validated for diverse age groups.

Furthermore, the geographic distribution of the studies (Supplementary Table 3) also limits the generalisability of the findings. Fourteen of the 31 studies were conducted in the United States, with relatively few studies from low- and middle-income countries. This geographic bias means that the findings may not be fully applicable to populations in developing countries, where mental health apps could be crucial due to a lack of mental health services, resources, and access to care. This underscores the need for further research that includes a greater diversity of locations, particularly in regions where digital health interventions could have a significant impact.

Second, the studies included are of varying quality, with 15 out of 31 studies showing some to high concern in the RoB 2 assessment. The varying levels of bias have important implications for interpreting the findings, as high or unclear risks of bias may overestimate the effectiveness, feasibility, or acceptability of mental health apps. For example, while some high-risk studies, such as Bonet et al.[45], reported high effectiveness with reductions in hospitalisations and relapses, these must be interpreted with caution due to methodological limitations. Issues such as inadequate randomisation, lack of blinding, and selective reporting were observed in several studies, limiting the robustness of their results and emphasising the need for standardized measures. Despite the potential for low-accuracy studies to yield positive results [33,34], the current review prioritised studies with low risk of bias in its conclusions. These limitations highlight the need for future research to adopt robust study designs and transparent reporting to strengthen the evidence base for mental health apps.

Third, this review did not include single-purpose predict applications due to a lack of such studies. However, one study incorporated a predictive feature within a multipurpose app, demonstrating clinical effectiveness through improved emotional self-awareness and reductions in depressive symptoms[74]. This finding highlights the potential of predictive applications in mental health

and suggests a need for more focused research to explore their effectiveness, acceptability and feasibility within digital health interventions.

Lastly, the review excluded certain mental health conditions, such as substance use disorders and neurodevelopmental disorders, as these were outside the scope of the current review which focused on common mental health disorders. As a result, the findings may not be generalisable to these populations. Additionally, no articles were found comparing smartphone applications to TAU for OCD, indicating a need for app development targeting OCD symptoms.

Five recommendations for clinical translations

In this last section, we propose five recommendations that should be implemented in future apps to assist with the treatment and monitoring of mental health disorders.

1. **Apps should be developed using a multiplatform framework to widen compatibility with a variety of devices:** Existing tools often support either Android or iOS operating systems. Considering the relatively even distribution of iOS and Android operating systems in certain markets (e.g. 50.5% iOS and 48.9% Android in the United Kingdom in March 2022; https://gs.statcounter.com/os-market-share/mobile/united-kingdom/#monthly-201112-202112, accessed April 2022), future smartphone applications should support both platforms to be inclusive of the psychiatric population as a whole.
2. **Apps should provide feedback to clinicians and patients**: Existing tools often lack integration with patient electronic health records and predictive features. Feedback of data and predictive information to clinicians and patients would allow for a more responsive and effective treatment approach. Apps could also allow clinicians and patients to interact, for example, via messaging services, to allow clinicians to use the information during sessions.
3. **Privacy and data protection should be a core-value of the app:** Several studies highlighted patients' concerns over the confidentiality of their data[54,65,75]. Robust encryption and

authentication methods to ensure patient confidentially should be implemented during the development of the app, with frequent security audits to maintain trust. Developers should provide transparent, accessible privacy policies and data use statements. All data should be stored in accordance with data protection laws and guidelines.

4. **User experience of apps should be taken into careful consideration:** In previous studies, patients often reported disinterest when using mental health applications which resulted in missing data and decreased usage[45]. User experience should be an important value during the development of smartphone applications to maximise feasibility and accessibility. Focusing on usability, reducing repetitive tasks incorporating a user-centric design can improve feasibility[76]. Focusing on passive data collection and investing in the design of an app can increase its appeal and support long-term retention. Additionally, involving end-users, particularly those from diverse demographic groups who may face challenges with digital literacy, can ensure apps are tailored to meet varying needs.
5. **Involve people with lived experience of mental illness during development and validation:** While the current systematic review identified 27 studies evaluating the effectiveness, feasibility and acceptability of existing mental health apps, previous studies have reported the benefits of involving service users during the development of mental health-based apps[33,84,85]. Therefore, future mental health apps should involve service users early in the development stage.

Conclusion

A key aim of using smartphone apps for mental health is to provide tools that can monitor, support treatment, and predict future clinical outcomes. This review found a limited number of validated smartphone apps that have been assessed in terms of clinical effectiveness, feasibility, and acceptability. Overall, smartphone apps are effective and acceptable tools, though feasibility may vary

over time, and some studies show bias concerns. As the usage of digital technologies in several fields is quickly evolving, improving effectiveness, feasibility and acceptability is crucial. Future studies should focus on identifying and addressing barriers to long-term feasibility, while emphasising the inclusion of diverse populations. Despite these limitations, smartphone apps offer a cost-effective means to expand resource availability and improve access to care. We hope that this review will assist with the future development of effective, feasible and acceptable smartphone apps for mental health disorders.

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Author Contributions

All authors contributed to the work's design and conception, analysis and interpretation of the data, drafting of the manuscript and revising the key intellectual content. All authors approved the final version of the manuscript for submission. Andrea Mechelli acted as guarantor.

Conflict of interest.

The authors declare no conflict of interest.

Data availability statement

Data sharing is not applicable to this article as no new data were created or analysed in this study.

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Appendix A – Full search strategy

Search strategy for PubMed:

1. (mental health[All Fields] OR psychiatric disorder[All Fields] OR mental illness[All Fields] OR mental condition[All Fields] OR mental disease[All Fields] OR psychopathy[All Fields] OR psychopathology[All Fields] OR anxiety[All Fields] OR depressi*[All Fields] OR phobias[All Fields] OR obsessive-compulsive disorders[All Fields] OR panic disorders[All Fields] OR post-traumatic disorder[All Fields] OR bipolar[All Fields] OR psychotic disorders[All Fields] OR psychosis[All Fields] OR schizophrenia[All Fields] OR suicidal ideation[All Fields] OR suicidal behaviour[All Fields] OR self-harm[All Fields])

2. AND (smartphone[All Fields] OR mobile phone[All Fields] OR cellphone[All Fields] OR iPhone[All Fields] OR mobile app*[All Fields] OR phone app*[All Fields] OR Android[All Fields] OR digital[All Fields] OR telephone[All Fields])

3. AND (self-management[All Fields] OR self-care[All Fields] OR self-help[All Fields] OR self-aid[All Fields] OR self-manage*[All Fields] OR personal care[All Fields] OR self-sufficiency[All Fields] OR autonomy[All Fields] OR self-administrated[All Fields] OR self-monitoring[All Fields] OR self-support[All Fields]) AND (app*[All Fields] OR device[All Fields] OR instrument[All Fields] OR tool[All Fields]).

Limits: Randomized Controlled Trials

Figure 1. PRISMA Flow Diagram

Figure 2. Overall risk of bias.

Figure 3. Individual risk of bias.

Review of Smartphone Apps for mental health

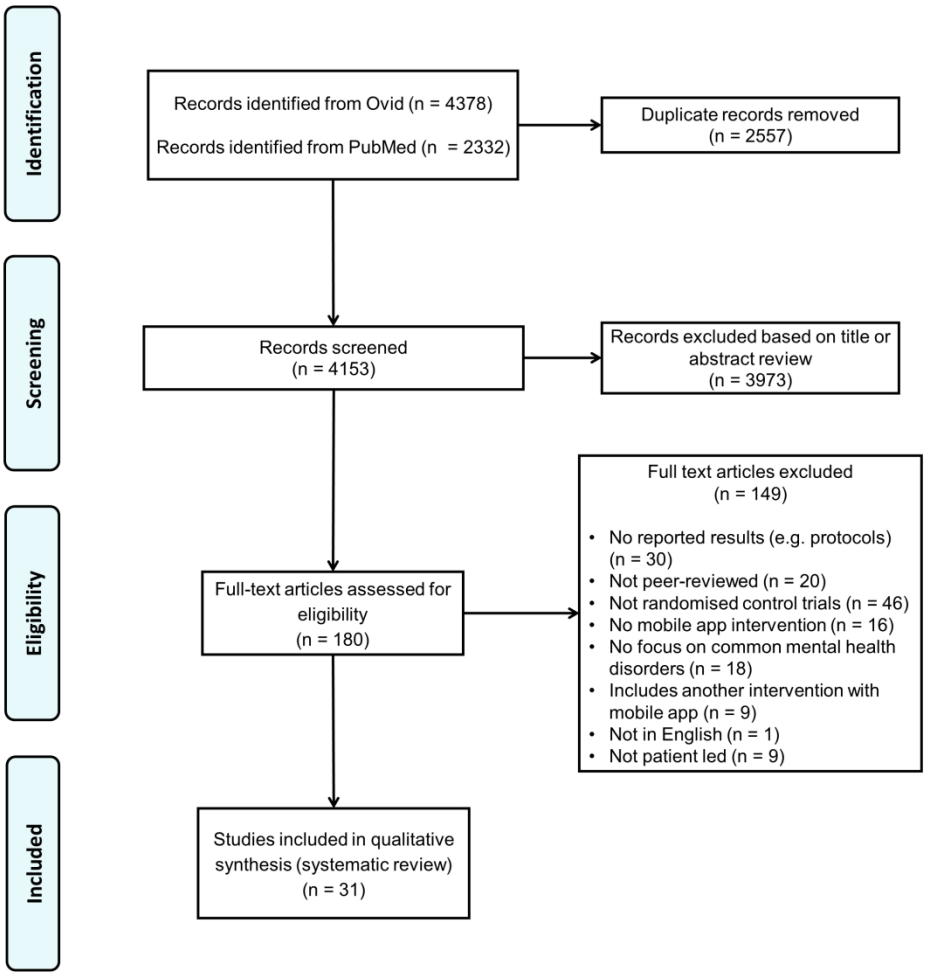

Figure 1. PRISMA Flow Diagram

619x650mm (96 x 96 DPI)

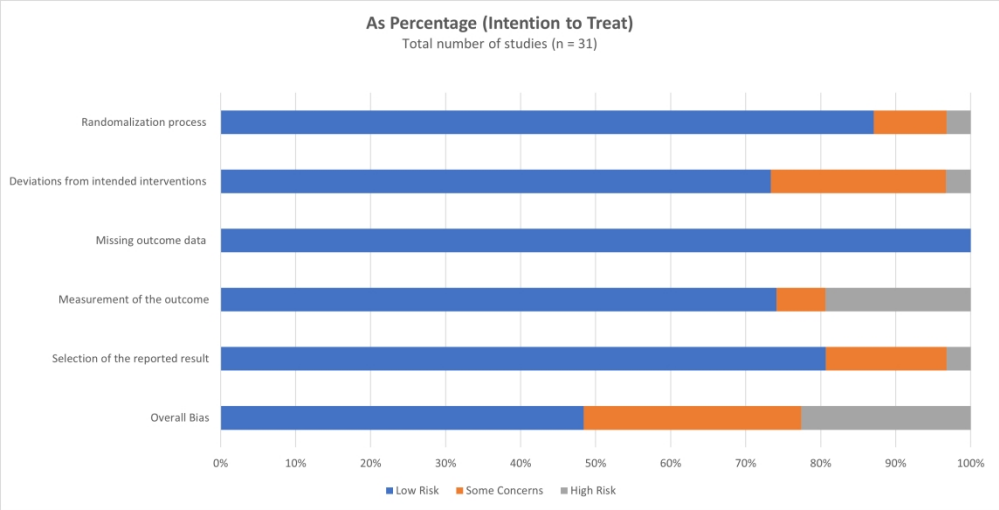

Figure 2. Overall risk of bias

654x334mm (130 x 130 DPI)

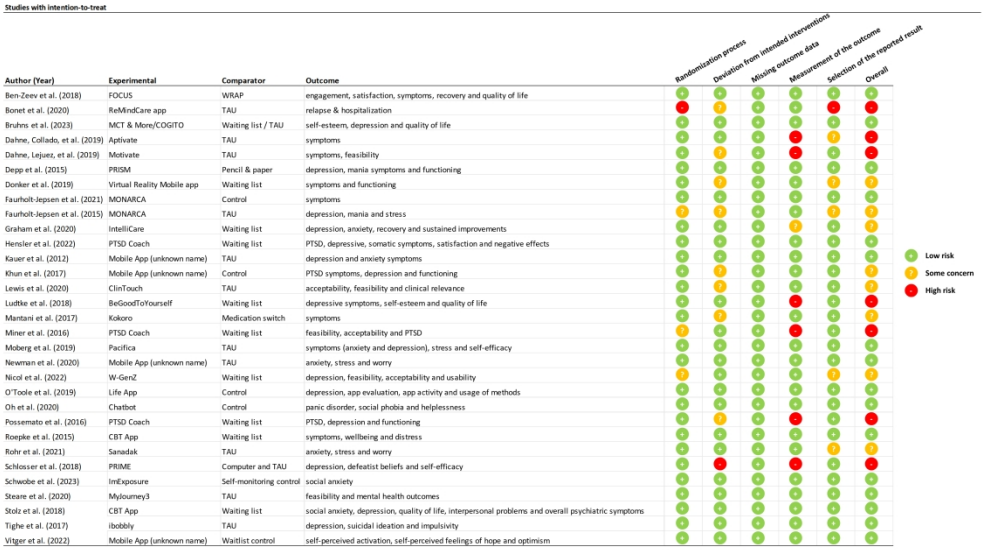

Figure 3. Individual risk of bias

1016x571mm (96 x 96 DPI)

Supplementary Table 1. Study Characteristics

Authors (Publication year)	N	Female % (Male %)	Mean age	Inclusion criteria	Exclusion criteria	Diagnosis	Diagnostic tool	Mobile application name	Type of mobile application
Ben-Zeev et al. (2018)	163	41% (59%)	49	Diagnosed with schizophrenia, schizoaffective disorder, bipolar disorder, major depressive disorder, age 18+, RAS[15] (>3)	Hearing, vision, or motor impairment, less than grade 5 English reading ability and exposed to WRAP or FOCUS before	Transdiagnostic	Chart diagnosis	FOCUS	Multipurpose application (treatment & tracking)
Bonet et al. (2020)	90	27% (73%)	32.8	Diagnosis according to the DSM-5, 17- 65 years old, smartphone ownership with an internet connection, less than 5 years of illness duration	Lack of ability to use mobile device and the internet, refusal to sign an informed consent form, level of Spanish or English not fluent	Psychosis	DSM-5[6]	ReMindCare App	Self-monitoring application
Bruhns et al. (2023)	159	55.4% (44%)	39.04	Age 18+, diagnosis of depression according to ICD-10 and DSM-5, pending discharge after day care/inpatient informed consent, internet access and possession of a smartphone, willingness to participate all aspects of study	If inclusion criteria were not met	Depression	DSM-5[6] and ICD-10	MCT & More/ COGITO	Multipurpose application (treatment & tracking)
Dahne, Collado, et al. (2019)	42	67% (33%)	36	Age 18+,2 own smartphones, willingness to use a phone for examination purposes and be treated through phone check email at least once a day Spanish language preferences and fluency PHQ[5-]8 (>10) seen by a doctor in last year	Scoring BDI-2[14] (<13) psychotherapy, visually impaired endorse in suicidality	Depression	PHQ[5-]8	Aptívate! (BA[18])	Multipurpose application (treatment & tracking)
Dahne, Lejuez, et al. (2019)	52	85% (15%)	44	Age 18-65, willingness to use a phone for examination purposes, check email at least once a day, PHQ[5-]8 (<10)	Scoring BDI-2[14] (<13) and current or past month indication of suicidal ideation	Depression	PHQ[5-]8	Moodivate (BA[18])	Multipurpose application (treatment & tracking)
Depp et al. (2015)	82	63% (37%)	48	Age 18+, outpatients and currently prescribed medications for bipolar disorder, no manual or visual disabilities	Substance use disorder hospitalized severe range for either depressive symptoms (>32) or manic symptoms (>20) and severe psychopathology	Bipolar Disorder	MADRS[2] and YMRS[3]	PRISM	Multipurpose application (treatment & tracking)
Donker et al. (2019)	193	67% (33%)	41	Age 18-65, scoring 45+ (AQ[1]), Android smartphone	Insufficient Dutch language skills, receiving treatment/medication, having severe depression, suicidality	Acrophobia	AQ[1]	ZeroPhobia	Treatment mobile application

Faurholt-Jepsen et al. (2021)	67	67% (33%)	29	BD diagnosis, 18-60 years old, HDRS-17 ≤17 and YMRS score ≤ 17	Pregnancy, a lack of Danish language skills, inability to learn the technicalities for using a smartphone, unwilling to use the trial smartphone as the primary cell phone, and severely physical illness or schizophrenia, schizotypal or delusional disorders according to the SCAN interview	Bipolar Disorder	ICD-10 and DSM-IV using SCAN interview	MONARCA	Multipurpose application (treatment & tracking)
Faurholt-Jepsen et al. (2015)	78	67% (33%)	29	Bipolar (ICD-10[13]), age18- 60, depression score (<17)	Pregnant, lack of Danish language skills, unwillingness to use a phone for examination purposes, severely ill (e.g., schizophrenia spectrum)	Bipolar Disorder	SCAN[4] interview	MONARCA	Multipurpose application (treatment & tracking)
Graham et al. (2020)	146	82% (18%)	42	Compatible smartphone (apple or smartphone), elevated symptoms of anxiety or depression	Acutely suicidal, unappropriated diagnosis, treatment for psychotherapy and if the medication was stable for over 2 weeks	Transdiagnostic	GAD7[10] & PHQ[5-8]	IntelliCare	Multipurpose application (treatment & tracking)
Hensler et al. (2022)	179	91.6% (8.4%)	42.3	Aged 18+, resident in Sweden with Swedish verbal and written comprehension, has smartphone, traumatic event in past 2 years according to DSM5 and mild to severe symptoms using PTSD check list.	Life threatening or harmful living conditions, current or pending psychotherapy, medical treatment changes and medication with counter medication.	PTSD	DSM-5[6]	PTSD Coach	Multipurpose application (treatment & tracking)
Kauer et al. (2012)	118	63% (37%)	17	Age 14-24, speak proficient English, mild to moderate mental health issue by GP K10[9](16>)	A psychiatric or medical condition that impedes to have informed consent	Depression	K10[9]	Mobiletype	Self-monitoring application
Kuhn et al. (2017)	120	69% (31%)	39	Age 18 +, English language skills, owning a mobile phone, having been exposed to a traumatic event more than 1 month ago, PCL–C[8] (>35), and not currently being in PTSD treatment	Did not meet the inclusion criteria	PTSD	PCL–C[8]	PTSD Coach	Multipurpose application (treatment & tracking)
Lewis et al. (2020)	81	30.8% (69.1%)	40	Schizophrenia and related disorders diagnosis, age between 16-65, one or more psychotic episodes in the previous 2 years, including the first psychotic episode	Unable to speak English and/ or unable to give informed consent	Schizophrenia	DSM-5[6]	ClinTouch	Self-Monitoring application

Lüdtke et al. (2018)	90	78% (22%)	43	Need for intervention, age 18-65, using iPhone	Suicidal tendencies	Depression	PHQ[5]-9	Be Good to Yourself (CBT[19] third wave)	Treatment mobile application
Mantani et al. (2017)	81	55% (43%)	41	Age 25- 59 years, primary major depressive disorder without psychotic features antidepressant-resistant, BDI-2[14] (<10) after taking one or more antidepressants at an adequate dosage for four or more weeks (stage I, II, or III, not prescribed escitalopram or sertraline, or received CBT[19] or interpersonal therapy	Did not meet the inclusion criteria	Depression	DSM-5[6]	Kokoro	Multipurpose (treatment & tracking)
Miner et al. (2016)	49	82% (18%)	46	18 +, English language, not currently receiving treatment for PTSD, having an active e-mail address, PCL–C[8] (>25)	Did not meet the inclusion criteria	PTSD	PCL–C[8]	PTSD Coach	Multipurpose application (treatment & tracking)
Moberg et al. (2019)	500	74% (22%)	30	Scoring GAD7[10](5-14) & PHQ[5]- 8 (5-14)	<5 & >14, respectively on GAD7[10] and PHQ8	Transdiagnostic	GAD7[10] & PHQ[5]-8	Pacifica	Multipurpose application (treatment & tracking)
Newman et al. (2020)	100	77% (23%)	21.71	Met diagnostic criteria for GAD	Did not meet diagnostic criteria for GAD	Anxiety	DSM-5[6]	Mobile application (no name)	Treatment mobile application
Nicol et al. (2022)	17	88.2% (5.9%)	14.7	Between 13-17 and had new diagnosis of depression and anxiety in the past 3 months.	Long history of severe depression substance use disorder psychotic illness, OCD, PTSD, panic disorder or specific phobia. Do not have guardian accompanied on visits, did not have access to mobile device for regular use and were unable to read and write English.	Depression and anxiety	DSM-5[6]	W-GenZ	Multipurpose application (treatment & tracking)
O'Toole et al. (2019)	129	44% (56%)	29	Age 18-65, Smartphone for application, symptoms which can indicate interventions period	Severe pathology, substance abuse, inpatient treatment, comorbidity with any other psychopathology apart from mild to moderate depression and anxiety.	Suicidal Behaviour	MDI[11] & SSF[12]	LifeApp'tite	Multipurpose application (treatment & tracking)
Oh et al. (2020)	41	51% (49%)	41	Age 19 - 60, diagnosis of panic disorder, no changes in medication dosage	Pregnant, neurological illness, comorbid substance use	Panic Disorder	DSM-5[6]	Todaki (Chatbot)	Multipurpose application (treatment & tracking)

Possemato et al. (2016)	20	5% (95%)	42	Enrolled in VA primary care, PTSD military symptoms (PCL–C[8] (>40)	Had treatment in speciality care before study completion, cognitive impairments or suicidal attempt or intent in the previous 2 months, treatment outside of VA primary care or a new or change in dosage of drugs.	PTSD	PCL–C[8]	PTSD Coach	Multipurpose application (treatment & tracking)
Roepke et al. (2015)	283	70% (30%)	40	Age18+, iPhone owner, clinical depression, CES-D[7] (>16)	Did not meet the inclusion criteria.	Depression	CES-D[7]	CBT[19]-PPT SuperBetter & General SuperBetter	Treatment mobile application
Röhr et al. (2021)	133	38% (62%)	33.5	Syrian refugee residing in Germany, aged 18 to 65 years, experiencing at least one traumatic event and score of 11 to 59) on the Posttraumatic DSM-5, with mobile device	PTSD symptomatology outside inclusion criteria; severe depressive symptoms acute suicidal tendencies current psychotherapy, psychiatric Treatment, and/or psychotropic medication; or pregnancy.	PTSD	DSM-5[6]	Sanadak	Treatment mobile application
Schlosser et al. (2018)	43	62% (38%)	24	Diagnosis of schizophrenia, schizophreniform, or schizoaffective disorder, early course of illness age16- 36 not having substance dependence (6 months prior), clinically stable (1 month prior) ability to provide informed consent, no history of neurological disorders or severe head trauma, English language skills, IQ > 70	Did not meet the inclusion criteria.	Schizophrenia	DSM-5[6]	PRIME	Multipurpose application (treatment & tracking)
Schwob & Newman (2023)	82	53.6% (46.4%)	19.4	Age 18+ or older, be fluent in English, own an iPhone and meet DSM -5 criteria for social anxiety disorder (SAD)	Excluded if they endorsed mania, psychosis, suicidality, alcohol or substance disorder or any medical or organic disorder that hindered their participation in the study or if currently in psychological or psychiatric treatment for anxiety or any other mental health issues.	SAD	DSM-56	ImExpsoure	Multipurpose application (treatment & tracking)

Steare et al. (2020)	40	30% (70%)	29.7	Aged ≥16 years, had experienced at least one episode of psychosis, were currently on the caseload of an EIP service and owned a Smartphone with an Android operating system.	Lacked capacity to consent to participation, were unable to communicate and understand English, or were considered by their EIP service to pose a high risk to researchers during meetings, even on NHS premises.	Psychosis	ICD-10	My Journey 3	Self-Monitoring Application
Stolz et al. (2018)	150	65% (35%)	35	Age 18+, own a computer and smartphone with internet; fluent in German; exceeded cut off points for SIAS[16] and SPS[17], primary diagnosis of social anxiety disorder	History of psychotic disorder, and medication increase for anxiety and depression in the past month and active suicide plans.	Social Anxiety	DSM-5[6]	PC and Mobile app (no name)	Treatment mobile application
Tighe et al. (2017)	61	63% (37%)	25	Age 18- 35, score PHQ[5]-9 (>10), K10[9](>25) and had suicidal thoughts in the previous week.	Did not meet the inclusion criteria.	Suicidal Behaviour	PHQ[5]-9 & K10[9]	ibobbly	Multi-purpose application (treatment and tracking)
Vitger et al. (2022)	194	61.9% (33.5%)	23.4	Receiving treatment in OPUS had at least 6 months left of their programme access to a smartphone and understood Danish	Did not meet the inclusion criteria.	Schizophrenia, schizotypal and delusional disorder	N/A	Mobile application (no name)	Multi-purpose application (treatment and monitoring)

Acrophobia Questionnaire[1], Montgomery Asberg Depression Rating Scale[2], Young Manic Rating Scale[3], Schedules for Clinical Assessment in Neuropsychiatry[4], Patient Health Questionnaire[5], Diagnostic and Statistical Manual of Mental Disorders 5[6], Centre for Epidemiological Studies Depression questionnaire[7], PTSD CheckList – Civilian Version[8], Kessler Psychological Distress Scale[9], General Anxiety Disorder-7[10], Major Depression Inventory[11], Suicide Status Form[12], International Classification of Diseases[13], Becks Depression Inventory- 2[14], Recovery Assessment Scale[15], Social Interaction Anxiety Scale[16], Social Phobia Scale[17] , Behavioural Activation[18], Cognitive Behavioural Therapy[19]

Supplementary Table 1. Primary and Secondary Outcomes

Authors (Publication Year)	Type of mobile application	Clinical effectiveness	Feasibility	Acceptability
Ben-Zeev et al. (2018)	Multipurpose application (treatment & tracking)	Both conditions improved but no difference. WRAP was more significant in improving recovery (t=2.55, df=289, *p*=.01) and FOCUS in improving quality life scores (t=2.55, df=289, *p*=.001)	FOCUS more likely to commence treatment (90%) and remain fully engaged (56%) compared to WRAP (58% and 40%, respectively)	High satisfaction in both conditions FOCUS (*M*=25.76) and WRAP (*M*=25.56)
Bonet et al. (2020)	Self -Monitoring application	After 19 months, ReMindCare had fewer relapses (20% vs 58%) (χ^2=13.7, P=.001), had fewer visits to urgent care units (χ^2=7.4, P=.006) and fewer hospitalizations than TAU patients (χ^2=4.6, P=.03).	ReMindCare group had a compliance rate between 85% and 100%	Reason of discontinuation included 33% felt suspicious about technology (among these patients, 4 had a relapse while using the app); 40% perceived the app as boring and did not perceive any benefit; and 27% of patients left treatment and did not continue in the program.
Bruhns et al. (2023)	Multipurpose application (treatment & tracking)	No significant differences between the groups were found $\chi^2(3) = 1.77$;p=.622.	N/A	Slightly positive attitudes towards mobile based intervention. About 86.3% of participants believed that they would feel somewhat better after using the application. More positive side effects i.e. participants felt better using the self-help smartphone app and easier trusting others.
Dahne, Collado, et al. (2019)	Multipurpose application (treatment & tracking)	Depressive symptoms compared to TAU χ^2 = 34.66, df = 1, *p*<0.001; compared to time points χ^2 = 35.06, df = 14, *p* = 0.001.	Retention rates 72.7% (month 1) and 50% (months 2), post enrolment. 81.8% of used the app ≥8 times, and 36.4% used app ≥56 times.	N/A
Dahne, Lejuez, et al. (2019)	Multipurpose application (treatment & tracking)	*M* = –7.51 (3.14), p = .02 (Moodivate vs TAU) *M* = –7.68 (3.62), p = .03 (MoodKit vs TAU) Depression symptoms in Moodivate condition *F*(1, 19) = 4.15, *p* = .056 Unique Value (*M*= 6.10)	Retention rate 90% (week 1) 83% (week 2) 67% (week 3-6) 61% (week 7) 50% (week 8). 71% of participants enter self-assessment >18 times.	N/A

Depp et al. (2015)	Multipurpose application (treatment & tracking)	Effectiveness at 6 weeks t(223)=−2.2 p=0.031 and 12 weeks *t*(181)=−2.0, *p*=0.042 . Not effective at 24 weeks	Compliance rate: 65%)	Satisfaction questionnaire scores: Intervention (*M*= 9); Control (*M*= 10)
Donker et al. (2019)	Treatment mobile application	*b*191 = −9.79; *p* < .001; adjusted R^2 = 0.52. NNT= 1.7.	Intervention retention rates: 59% (post-test) and 48% follow up); Control retention rates: 91% (post-test and follow up)	SYSTEM USABILITY SCALE (M =75.35)
Faurholt-Jepsen et al. (2021)	Multipurpose application (treatment & tracking)	There was a significant positive association between daily smartphone-based patient-evaluated stress and the CAR (B: 134.14, 95% CI: 1.35; 266.92, p=0.048 (n=33)). significant positive association between patient-evaluated stress measured using the PSS and patient-evaluated stress measured using smartphones (B: 3.33, 95% CI: 2.02; 4.65, p < 0.0001 (n = 33).	N/A	N/A
Faurholt-Jepsen et al. (2015)	Multipurpose application (treatment & tracking)	Primary Analysis: B = −0.34, 95% CI −1.14 to 0.47, p= 0.41 Exploratory Analysis unadjusted B = 2.33, 95% CI 0.10–4.56, *p* = 0.040 and the adjusted *B* = 2.57, 95% CI 0.40–4.74, *p* = 0.020 in manic and non-remitting groups.	N/A	N/A
Graham et al. (2020)	Multipurpose application (treatment & tracking)	Recovery from depression (OR, 3.25; 95% CI, 1.54-6.86) anxiety (OR 2.17; 95% CI, 1.08-4.36). Sustained at follow up for both depression (slope, 0.01; 95% CI, –0.09 to 0.10; *p*= .92) and anxiety (slope, 0.02; 95% CI, –0.08 to 0.12; *p*= .67)	Usage score (81%) after 8 weeks follow up.	N/A
Hensler et al. (2022)	Multipurpose application (treatment & tracking)	Access to PTSD Coach led to a greater decrease in posttraumatic stress after 3 months compared with the waitlist (Cohen d=−0.45, 95% CI −0.70 to −0.20). Access to app show clinically significant improvement (χ21,150=4.62; P=.03) and less likely to fulfil the criteria for probable PTSD than participants on the waitlist after 3 months (χ21,150=7.74; P=.005). However, we detected no difference	N/A	Participants with access to PTSD Coach found the app slightly to moderately helpful. sum score on helpfulness was 23.11 (SD 14.32; n=71). Most participants (50/69, 72%) were moderately or very satisfied with the app (n=69, mean 2.22, SD 1.07).

		between conditions in remission from probable PTSD		
Kauer et al. (2012)	Multipurpose mobile application (tracking & predicting)	Increase in emotional awareness $\chi 2$ = 11.3, p= .04 Awareness of emotion predicted depressive symptoms $\kappa 2$=.54 (95% CI .426–.640).	N/A	N/A
Kuhn et al. (2017)	Multipurpose application (treatment & tracking)	PTSD symptoms (F(1, 117) = 4.55, p= .035), depression symptoms (F(1, 117) = 7.63, p = .007), and psychosocial functioning (F(1, 117) = 8.34, p=.005). Clinically significant PTSD symptom improvement (*p*=.018) than waitlist participants	*M*=1.29 days of use per week correlated with their self-reported average days used per week (r = .51, p =.01).	N/A
Lewis et al. (2020)	Self-Monitoring application	Overall, no differences. However, in London centre found significant reduction in positive symptoms after 12 weeks of ClinTouch-enhanced monitoring in the early psychosis subsample (adjusted mean difference –3.04; CI –5.49, –0.59; P=.016.	95% stayed in the trial for 12 weeks 84% responding to at least 33% of beep alerts adherence was 60%. Healthcare professionals (care coordinators) used ClinTouch-enhanced management in app in 100% of cases, with average of 24 times per patient.	90% continued to use it regularly at 3 months. In these patients, adequate adherence was 84%, defined as responding to >33% of item prompts
Lüdtke et al. (2018)	Treatment mobile application	Depression score *F*(1;71) = 0.173, *p* = 0.678; self-esteem score *F*(1;71) = 1.464, *p* = 0.230; quality of life score *F*(1;70) = 0.041, *p*= 0.840. Application and TAU increased self-esteem overtime (*p* = 0.274)	N/A	Client Satisfaction Questionnaire 57%
Mantani et al. (2017)	Multipurpose application (treatment & tracking)	Kokoro 2.48 points (95% CI 1.23-3.72, P<.001) lower on PHQ-9 and 4.1 points lower on (95% CI 1.5-6.6, P=.002) lower on BDI-2 and 0.76 points (95% CI –0.05 to 1.58, P=.07) lower on side effects. Mind maps *M*=11.2	N/A	N/A

Miner et al. (2016)	Multipurpose application (treatment & tracking)	Coach reduced PTSD symptoms (t(19) = -2.31, p= .031). 9 participants had clinically significant improvements to the postcondition assessment, compared to 4 in TAU	PTSD Coach usage (*M*=2.65; *SD*= 1.03) weekly and waitlist (*M*=2.50; SD= 0.83) weekly	Satisfaction 83% prefers to learn new tools to cope with their PTSD symptoms. Also, the app was more convenient than the paper condition
Moberg et al. (2019)	Multipurpose application (treatment & tracking)	The Pacifica group was lower in depression (-0.59; CI -0.86 to -0.3; *p*<.001) anxiety (-0.43; CI -0.71 to -0.15; *p* = .003), stress (-1.79; CI -2.74 to-0.84; *p*<.001) and higher on self- efficacy (1.55; CI 0.53 to 2.58; *p* = .003) compared to waiting list	Significant attrition rates in Pacifica condition compared to waiting list (χ^2 (n=500)=7.7, p=.006.	N/A
Newman et al. (2020)	Treatment mobile application	App group large-effect reductions in all symptom measures during the treatment period. No significant symptom changes across the six-month follow-up period in both conditions.	N/A	N/A
Nicol et al. (2022)	Multipurpose application (treatment & tracking)	PHQ-9 scores at 4 weeks decreased by 3.3 units in the intervention group and 2 units in the wait list control group. The percentage of participants achieving remission at both time points seemed to favour the active intervention, at 67% (2/3) and 0% (0/5) at 4 weeks and 50% (1/2) and 20% (1/5) at 12 weeks, respectively.	70% agreed with the statement "using the app in the treatment of depression seems possible"	80% agreed or completely agreeing with the statement "I like using the app"; mean usability score 21.4, SD 1.7, possible range 5 to 25
O'Toole et al. (2019)	Multipurpose application (treatment & tracking)	LifeApp'tite decrease in suicide risk end of treatment (F(1, 138.7) = 7.2, *p*= .008, d= 0.46) and 3 months follow up (F(1, 351.1) = 65.0, *p*= .001, d = 0.86) compared to TAU however No between group differences after treatment (*p* = .732, d = 0.05) and follow up (*p* = .467, d = 0.11)	N/A	N/A
Oh et al. (2020)	Multipurpose application (treatment & tracking)	Panic disorder symptoms Chatbot versus TAU (t20 = 2.68; *p* = 0.01); reduced phobia (t20 = −2.94; p < 0.01) and helplessness score (t20 = 2.16; p = 0.04)	Retention rate high 86% (SM; n= 8) and 100% (CS; n= 10). Usage (*M*=9 day for) over 4 weeks.	N/A

			Usability scores higher in Chatbot vs TAU (64.5 ± 15.0, and 69.5 ± 17.2, respectively; p = 0.35).	
Possemato et al. (2016)	Multipurpose application (treatment & tracking)	SM and CS reduced PTSD score (SM= 2.8 (9), p=.02; CS= 5.4 (9), p≤.01) for social functioning in in CS (−2.0 (9), p=.02)	Feasibility was higher than control. Usage is higher in CS than SM over 8 weeks. 11 (*SD*= 1.9, range=1–8) PTSD symptoms and 11.7 (*SD*= 6.2, range=4–22) Learn topics, and they utilized 5.3 (*SD*=2.7, range=3–8) Manage category	HIGHER REFERRAL IN CS PTSD COACH VS SM PTSD COACH CONDITION (X2(1,18)=7.9 P≤ .01)
Roepke et al. (2015)	Treatment mobile application	Depressive symptoms compared to control $t(276) = - 3.90$, $p < 0.001$	Retention rates were low with 26.15 % (post-test) and 18.34% (follow-up)	N/A
Röhr et al. (2021)	Treatment mobile application	ITT no change in DSM-5 scores, but use of app showed low self-stigma after 4 weeks (SSMIS-stereotype agreement: d=0.86, 95% CI 0.46 to 1.25; stereotype application: d=0.60, 95% CI 0.22 to 0.99) and after 4 months (d=0.52, 95% CI 0.12 to 0.92; d=0.50, 95% CI 0.10 to 0.90), the IG showed significantly lower values in self-stigma than the CG.	Total attrition was 12.8% (17/133). usability score of 78.9	N/A
Schlosser et al. (2018)	Multipurpose application (treatment & tracking)	PRIME increasing motivated behaviour ($F(1,56) = 4.75$, p = .03), increasing likelihood of positive future outcomes ($F(1,56) = 4.66$, p = .04). PRIME compared to control had higher decrease of defeatist beliefs $F(1,57) = 5.58$, p = .02, depression ($F(1,56) = 7.06$, p = .01), and self -efficacy ($F(1,55) = 5.76$, p = .02)	PRIME usage 4/7 days. Completed Challenge rate PRIME (91.47%) compared to (83.58%). Self-monitoring higher in TAU (1.94) versus PRIME (1.74)	Satisfaction rated (M=8.21; SD= 1.9) for PRIME. The most popular was directly message coaches (M =8.38, SD= 2.5), and the least popular was self-monitoring (M= 6.33, SD= 2.4).
Schwob & Newman (2023)	Multipurpose application (treatment & tracking)	There was no significant difference. between self-monitoring (M =1.09; SD =1.17) and IE (M =1.17; SD = 0.72), β=0.54, SE =0.80, Z =0.68, p =.12 In reported number of social situations engaged in between prompts. However,	Calculated compliance rates were 59% for IE (requested thrice daily completion) and 62% for self-monitoring (requested 8 times daily completion), which were not significantly different from each	N/A

		the reported number of social situations avoided between prompts differed significantly by condition such that self-monitoring (M =1.24; SD =0.56) had more avoided situations on average than imaginal exposure (M =0.92; SD =0.43), β=1.24, SE =0.44, Z =2.82, p=.02.	other, β =0.04, SE =0.08, Z =0.50, p=.2.	
Steare et al. (2020)	Self-Monitoring Application	No difference in relapse (OR 1.41; 95% CI 0.21 to 9.58),	Participants accessed My Journey 3 on a median of 3.22% of the days it was available to them. Eight participants (44%) used My Journey 3 for longer than 30 min in total. 5 participants used app 5 months after downloading it; 1 participant never used the app after the training session 10 stopped using My Journey 3 within the first 3 months after the training session.	Most service user participants found My Journey 3 to be acceptable, and some participants reported a clear benefit from using it. Barriers affecting use lack of clinician support and concerns around data privacy. A key theme for staff did not have the time to provide regular support to participants with My Journey 3.
Stolz et al. (2018)	Treatment mobile application	Superior in all SAD measures (t(119.46)= 5.08, *p*= .01, d=1.07). No difference between App and PC. (t(120.75) =1.71, *p*=.09, d =0.30.). Diagnostic response rates higher in active (NNTPC= 3.33; NNTApp = 6.00) versus TAU.	App higher usage (*D*=.14, *p*=.01) versus PC and spread throughout the day	N/A
Tighe et al. (2017)	Multipurpose application (treatment & tracking)	ibobbly reduced depressive symptoms (t=2.79; df=56.9; p=0.0072) and distress (t=2.44; df=57.5; p=0.0177) compared to waitlist. No difference in impulsivity (t=−1.82; df=29.1; p=0.0792)	High usage 85% of available data (40/61) completed all the activity.	N/A
Vitger et al. (2022)	Multi-purpose application (treatment and self-monitoring)	Statistically significant difference between the intervention and control groups in self-perceived patient activation (mean difference 4.39, 95% CI 0.99-7.79; Cohen d=0.33; P=.01), favouring the intervention group.	N/A	High client satisfaction with mobile application with 44.8% of participants scoring more that 29 out of 32.

Primary and Secondary Outcomes; Mean (M); Significance level (p); Confidence Interval (CI); Standard Deviation (SD); Patient Health Questionnaire-9 (PHQ-9); Becks Depression Inventory 2 (BDI-2).

Supplementary Table 3. Location and Study Duration

Authors (Publication Year)	Type of mobile application	App name	Location	Duration of app usage
Ben-Zeev et al. (2018)	Multipurpose application (treatment & tracking)	FOCUS	United States of America	12 weeks
Bonet et al. (2020)	Self -Monitoring application	ReMindCare App	Spain	12 months
Bruhns et al. (2023)	Multipurpose application (treatment & tracking)	MCT & More/ COGITO	Germany	2 weeks
Dahne, Collado, et al. (2019)	Multipurpose application (treatment & tracking)	Aptívate! (BA[18])	United States of America	9 weeks
Dahne, Lejuez, et al. (2019)	Multipurpose application (treatment & tracking)	Moodivate (BA[18])	United States of America	8 weeks
Depp et al. (2015)	Multipurpose application (treatment & tracking)	PRISM	United States of America	10 weeks
Donker et al. (2019)	Treatment mobile application	ZeroPhobia	The Netherlands	3 weeks
Faurholt-Jepsen et al. (2021)	Multipurpose application (treatment & tracking)	MONARCA	Denmark	6 months
Faurholt-Jepsen et al. (2015)	Multipurpose application (treatment & tracking)	MONARCA	Denmark	6 months
Graham et al. (2020)	Multipurpose application (treatment & tracking)	IntelliCare	United States of America	8 weeks
Hensler et al. (2022)	Multipurpose application (treatment & tracking)	PTSD Coach	Sweden	3 months
Kauer et al. (2012)	Multipurpose mobile application (tracking & predicting)	Mobiletype	Australia	2-4 weeks
Kuhn et al. (2017)	Multipurpose application (treatment & tracking)	PTSD Coach	United States of America	3 months
Lewis et al. (2020)	Self-Monitoring application	ClinTouch	United Kingdom	12 months
Lüdtke et al. (2018)	Treatment mobile application	Be Good to Yourself (CBT[19] third wave)	Germany	4 weeks
Mantani et al. (2017)	Multipurpose application (treatment & tracking)	Kokoro	Japan	9 weeks

Miner et al. (2016)	Multipurpose application (treatment & tracking)	PTSD Coach	United States of America	1 month
Moberg et al. (2019)	Multipurpose application (treatment & tracking)	Pacifica	United States of America	1 month
Newman et al. (2020)	Treatment mobile application	Mobile application (no name)	United States of America	3 months
Nicol et al. (2022)	Multipurpose application (treatment & tracking)	W-GenZ	United States of America	12 weeks
O'Toole et al. (2019)	Multipurpose application (treatment & tracking)	LifeApp'tite	Denmark	2 weeks
Oh et al. (2020)	Multipurpose application (treatment & tracking)	Todaki (Chatbot)	South Korea	4 weeks
Possemato et al. (2016)	Multipurpose application (treatment & tracking)	PTSD Coach	United States of America	2 weeks
Roepke et al. (2015)	Treatment mobile application	CBT[19]-PPT SuperBetter & General SuperBetter	United States of America	1 month
Röhr et al. (2021)	Treatment mobile application	Sanadak	Germany	4 weeks
Schlosser et al. (2018)	Multipurpose application (treatment & tracking)	PRIME	United States of America, Canada and Australia	12 weeks
Schwob & Newman (2023)	Multipurpose application (treatment & tracking)	ImExpsoure	United States of America	7 days
Steare et al. (2020)	Self-Monitoring Application	My Journey 3	United Kingdom	12 months
Stolz et al. (2018)	Treatment mobile application	PC and Mobile app (no name)	Switzerland (deduced from ethical approval and author affiliations)	12 weeks
Tighe et al. (2017)	Multipurpose application (treatment & tracking)	ibobbly	Australia	6 weeks
Vitger et al. (2022)	Multi-purpose application (treatment and self-monitoring)	Mobile application (no name)	Denmark	6 months

Acrophobia Questionnaire[1], Montgomery Asberg Depression Rating Scale[2], Young Manic Rating Scale[3], Schedules for Clinical Assessment in Neuropsychiatry[4], Patient Health Questionnaire[5], Diagnostic and Statistical Manual of Mental Disorders 5[6], Centre for Epidemiological Studies Depression questionnaire[7], PTSD CheckList – Civilian Version[8], Kessler Psychological Distress Scale[9], General Anxiety Disorder-7[10], Major Depression Inventory[11], Suicide Status Form[12], International Classification of Diseases[13], Becks Depression Inventory- 2[14], Recovery Assessment Scale[15], Social Interaction Anxiety Scale[16], Social Phobia Scale[17], Behavioural Activation[18], Cognitive Behavioural Therapy[19]