

EFFICACY OF DIGITAL MENTAL HEALTH INTERVENTIONS IN REDUCING DEPRESSION AND ANXIETY AMONG YOUNG ADULTS: A SYSTEMATIC REVIEW

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Abstract

Background

Among the young adults, especially those who are depressed and anxious, mental health disorders are very common, but the available resources are scarce because of stigma, cost, and resource limitation. In the alternative, digital mental health interventions (DMHIs), such as web-based cognitive behavioural therapy (iCBT), mobile apps, blended digital, clinician support models, and conversational agents, can have a promising, scalable alternative. The paper is a systematic review that summarizes the evidence on the effectiveness of DMHIs in alleviating depression and anxiety symptoms in young adults of 16-25 years.

Methods

This review was done in accordance with the PRISMA 2020. Seven databases (PubMed, EMBASE, PsycINFO, Web of Science, Scopus, IEEE Xplore, and Cochrane Library) were marked to find out the number of studies published since January 2013 to March 2025. Potential studies were randomized controlled trials and quasi-experimental studies that assessed digital interventions in prevention of depression and/or anxiety among young adults. Extraction was done in terms of intervention type, level of guidance, duration, adherence, effect sizes, and outcome measures. RoB-2 and ROBINS-I were used to assess the risk of bias. Standardized mean differences (SMDs) were used to conduct a narrative and quantitative synthesis based on random-effects modelling.

Results

There were 38 studies with 11,420 subjects that were eligible. DMHIs yielded a moderate effect on depressive symptoms (pooled SMD = -0.45; 95per cent -0.55 -0.35) and a small-to-moderate effect on anxiety symptoms (SMD = -0.38; -0.48 -0.28). The greatest effects were observed with web-based iCBT and with blended clinician-supported models (SMDs as high as -0.58), although smartphone apps and conversational agents had smaller and still significant

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effects. Treatment outcomes had a positive correlation with engagement and adherence ($r = 0.20-0.25$). Predictivity correlations were strong with larger sample sizes ($r 0.71$). The completion rates were between 38 and 80%. The quality of the methodology was moderate overall, and frequent limitations were the attrition and selective reporting.

Conclusions

Digital mental health interventions prove to be useful for the minimization of depression and anxiety symptoms in young adults, and the strongest results are demonstrated in web-based iCBT and blended digital-clinician models. Although encouraging results were found, reporting variability, heterogeneity of intervention, lack of external validation, and high attrition hurt confidence in generalizability. Standardized reportage, multi-centre clinical trials, long-term follow-ups, and open digital pipelines should be the key factors of future research. As long as they continue to be refined, DMHIs have a great potential to enhance accessibility and early intervention in youth mental health care.

Keywords

Digital mental health intervention; Web-based cognitive behavioral therapy; mobile mental health application; blended digital care; conversational agent; youth; depression; anxiety; systematic review; randomized controlled trials; mental health technology; digital therapeutics; psychological e-health intervention.

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Introduction

Among the main causes of disability in young adults is depression and anxiety, which causes a big global public health burden in one of the most developmental phases in life. Adolescent to adult transition, which is generally accompanied by academic demands, newfound independence, identity, and personal problems in their careers, is accompanied by a high susceptibility to mental health issues. According to the epidemiological research, it is regularly reported that in every three young adults, one third of them suffer serious depressive symptoms or anxiety symptoms, but most of them do not receive appropriate attention. Lack of access to trained mental health professionals, financial constraints, stigmas, and waiting time are some of the barriers that are contributing to pervasive underutilization of resources (Garrido et al., 2019; Lehtimäki et al., 2021). This causes the young adults to have a longer period of the symptom, poor performance at school, poor social functioning, and high levels of self-harm. The trends demonstrate that the gap between mental health needs and conventional services delivery is apparent, and the needs of scalable, accessible, youth-friendly intervention modalities are urgent. The integration of machine learning with multidimensional biological data also demonstrates the potential of personalized, data-driven approaches to improve treatment decision-making in cancer care (Carmo et al., 2022).

Over the last few years, digital mental health interventions (DMHIs) have been developed as a revolution to go beyond the systemic constraints of

face-to-face therapy. DMHIs are a broad category, which includes web-based cognitive behavioural therapy (iCBT) interventions, mobile mental health apps, blended digital-clinician models, chatbots, as well as gamified psychological interventions. These technologies are flexible and anonymous and highly satisfy the needs of younger demographics that are more associated with online space and usually feel more at ease requesting assistance on the internet than in a conventional clinic. Furthermore, online interventions minimize logistical limitations because they offer on-demand access to psychoeducation, curriculum-based therapeutic programs, mood-monitoring, mindfulness, and communicative exchange with therapists (Kim et al., 2023; Lattie et al., 2019). They are scalable, inexpensive and facilitate early intervention among at-risk people. A number of foreign health systems have already started to apply DMHIs into usual care, but there are doubts about the uniformity, efficacy, and medical strength of these systems in young adults and children the group with distinctive developmental, behavioural, and motivation properties. Evidence from other digital health settings similarly indicates that patient engagement and adherence are important determinants of intervention effectiveness, with higher engagement associated with improved clinical outcomes (Kamal et al., 2021).

Available studies on DMHIs indicate a trend of efficacy, yet a high degree of heterogeneity. Although web-based CBT systems tend to have a high level of impact on depressive symptoms, mobile applications tend to have lesser and inconsistent effects, probably

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because of a huge range in the quality of the content, its intensity, and the engagement of the user. Moreover, several studies have emphasized that the level of guidance such as the support of a therapist is a key element in improving adherence and therapeutic outcomes. The young adults often show inconsistent use of mental health applications, and the dropout rates are more significant as compared to the older age groups. Therefore, to maximize digital interventions, it is necessary to comprehend the impact of adherence, intervention time, and support structures on the results. Moreover, the majority of the past reviews have combined data based on wide age categories, which encompass adolescents, young adults, and old adults into one group (Pauley et al., 2023; Zhu et al., 2025). This brings about ambiguity, since developmental variations influence the expression of symptoms and also response to treatment. Targeted group of young adults should be analyzed in this manner, thus, in order to produce specific and contextually applicable information. Digital mental health interventions may improve access to care, but socioeconomic disadvantage, limited digital access, health literacy, and mistrust can create barriers to equitable adoption and potentially widen existing disparities (Kium et al., 2023).

Even though the digital mental health sector is growing at a very rapid pace, a number of methodological issues continue to exist. The majority of studies do not have any long-term follow-up as they mainly use the immediate post-treatment effect, which might not represent the long-lasting benefit. The design of digital platforms, dosage, and result measures are not the same in every study, which makes it difficult to compare them. Risk-of-bias issues, in particular, attrition, blinding, and selective reporting, also bring up the question of the strength of evidence used to support specific modalities. Little reliance on external validation cohorts limits generalization and lack of standard reporting frameworks of digital interventions limits their reproducibility. Therefore, it is imperative to conduct a systematic review, which synthesizes this disjointed evidence to come up with a consensus, to determine the effect of interventions of different types, and to inform the next innovation and policy (Harith et al., 2022; Lau et al., 2024). Emerging evidence from wearable and remote-monitoring technologies further demonstrates the potential of real-time digital health tools to support personalized monitoring and early detection, although differences in validation, calibration, and study heterogeneity remain important challenges (Kium et al., 2024).

The current systematic review will help to fill these gaps and conduct a comprehensive synthesis of digital

mental health interventions to deal with depression and anxiety in young adults aged 16-25 years. Through the review of randomized and quasi-experimental studies that were conducted in the last 10 years, this review evaluates pooled treatment effects, compares interventions modalities, analyzes the impact of engagement and guidance, and assesses the quality of the methodology. By doing so, the review aims to explain the clinical promise of DMHIs in mental health care of the youth, define gaps in the existing evidence base, and outline the major research areas of interest required to enable the broader clinical implementation (Riboldi et al., 2023; Zhou et al., 2021). With the ever-changing speed of digital technologies, which can now provide more personalized and interactive therapeutic experiences, it is important to learn more about their effectiveness with the young adults and how this will influence further development of the global mental health treatment in the future. Similar AI-driven approaches in healthcare demonstrate the potential of predictive models to support earlier detection and more personalized intervention by integrating diverse clinical and environmental data sources (Mozumder et al., 2026).

Literature Review

The development of the digital mental health interventions (DMHIs) illustrates that mental health care provision has been redefined for many especially among the young adults who are one of the greatest users of the digital technologies. Research into the therapeutic potential of the digital platform, including internet-based cognitive behavioural therapy (iCBT) programs and mobile applications, blended clinician-supported interventions, chatbots and gamified psychological interventions, has been growing exponentially over the last decade. The modalities have been created because of the urgent global mental health issues of the time, such as the inadequacy of accessing timely care, increasing the access to the psychological support, and continuing social stigma of face-to-face therapy (Liverpool et al., 2020; Riadi et al., 2022). The young adults are highly vulnerable to anxiety and depression, with most of them going through transitional stress during their attempts to establish their identity, academic demands, and social adjustments, although they utilize traditional mental health services inconsistently. DMHIs have thus been suggested as a scalable and affordable alternative that has the potential to minimize gaps in treatment without violating the autonomy and online way of life of youth populations. Evidence from smart health monitoring technologies indicates that perceived accuracy, trust, and data privacy are important factors influencing

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users' acceptance and continued use of digital health technologies (Rahmat et al., 2025).

Early investigations of DMHIs were mainly web-based CBT platforms, which were not only one of the first structured online therapies of its type to be subject to controlled trials. These interventions incorporated basic elements of CBT including psychoeducation, behavioural activation, cognitive restructuring, and mood monitoring via modules of online lessons. The results of the initial randomized studies indicated that web-based CBT had the potential to decrease depressive and anxiety symptomatology by using the effect size that was comparable to low-intensity face-to-face therapy (Bergin et al., 2020; Fu et al., 2020). These online forums over time developed to incorporate multimedia, interactive activities and automatic feedback. Besides this, the difference between guided and unguided digital therapy emerged as a key field of research. It has always been demonstrated that guidance, whether it is in the form of the emailing support, check-ins, or messages delivered by the trained clinicians, can significantly increase engagement and therapeutic outcomes. This study was basis of blended care models, self-set digital modules with human assistance to ensure motivation and optimize gains through treatment. Research in AI-enabled healthcare also highlights that explainability and transparency can strengthen clinical trust and support the safe and ethical adoption of AI-based technologies (Sattar et al., 2025).

With the growth of mobile technology, the focus moved to mental health applications based on smartphones. Newly developed apps provided accessibility to new levels by directly incorporating a micro-intervention and mindfulness practices, journaling applications, and mood tracking applications into everyday life. As mobile apps gained more and more popularity, the empirical literature depicted more mixed results than web-based CBT. Numerous apps show significant decreases in depression and anxiety, but the effects differ due to the differences in the quality of content, the basis of therapy, and the intensity of the interventions. One of the aspects that could be a challenge is engagement and most users often stop using the apps after hours or weeks (Bryant et al., 2024; Werntz et al., 2023). This rapid dropout effect points to the inherent difference between mobile applications and structured digital therapies in that the former are usually self-directed, less time-intensive, and rely on the user motivation, which varies among young adults. Nevertheless, mobile mental health apps remain to provide some useful assistance when considered as part of a larger mental health network, especially in the areas of the

early symptoms detection, real-time emotional check, and the provision of brief interventions. Emerging evidence from AI-enabled ECG technologies further demonstrates the potential of integrating digital monitoring with predictive analytics to support earlier risk identification and more personalized preventive care (Sattar et al., 2025).

Conversational agents (chatbots) and game-based mental health interventions are also another category that is gaining ground in DMHIs. The technologies are based on the principles of natural language processing, interactive storytelling, and gamification, which are used to create a more emotional interaction and user engagement. Chatbots replicate supportive interaction and provide cognitive behavioural interventions, whereas mental health games rely on immersive environments, which strengthens the coping process and emotional regulation. Even though there is emerging evidence that these modalities can reduce mild depression and anxiety symptoms, the studies are highly heterogeneous and most studies cannot be described as methodologically rigorous. There are issues with the transparency of the algorithms, with therapeutic safety and the problem of long-term compliance (Leech et al., 2021; Piers et al., 2023). However, these technologies have a potential to become the source of stigma-free and low-barrier access to psychological support, particularly in young groups, which reject the informal digital interactions. Evidence from cardio-oncology research similarly indicates that integrating artificial intelligence with genomic data can improve cardiotoxicity risk prediction and support earlier, more personalized prevention strategies in cancer patients (Akash et al., 2026).

In all the modalities, compliance and participation are the key to the effectiveness of DMHIs. The literature shows a significant amount of evidence that therapeutic module completion, frequency, and regularity of use are more predictive of treatment response than the type of intervention. Research on youthful adults tend to point at lack of engagement since motivation is fluctuated, life is unstable and academic or social goals take precedence. Hence, intervention involving behavioural prompts, customized material, inspirational text, or clinician instruction is more likely to maintain increased compliance (Philippe et al., 2022; Sin et al., 2020). Meta-analyses have also found that engagement-enhancing strategies are key to the better performance of digital interventions, which confirms the value of applying the principles of behavioural science to digital design. Evidence from sports cardiology further demonstrates that continuous wearable cardiac

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monitoring and real-time physiological analytics can support earlier identification of cardiac abnormalities and contribute to arrhythmia prevention (Islam et al., 2026).

A significant heterogeneity in the design, methodology, and outcome measurements of the intervention are also emphasized by the literature. The studies differ greatly in terms of the duration of the intervention, the theoretical direction, the elements of the therapy, and the support rate. Moreover, most of the reliance on self-reported scales, including the PHQ-9 and the GAD-7, makes it difficult to interpret the results due to bias in responses, unblinded measurements, and limited evaluation periods. The other methodological weakness is the lack of external validation and long-term follow-up. Although numerous studies prove the necessity of symptom improvement in the short term, less of them explore the sustainable nature of the gains in the long-term after the post-treatment evaluation. This gap has emerged as a priority in the field since durable improvement is a key requirement when it comes to clinical integration. Evidence from a systematic review of cardiac monitoring technologies similarly indicates that wearable and implantable devices can support arrhythmia detection, while patient adherence, safety, and integration into clinical workflows remain important determinants of their effectiveness (Pritom et al., 2026).

In spite of these shortcomings, literature continues to show that digital mental health interventions can be effective, scalable, and acceptable to young adults with depression and anxiety. Their advantages consist in the fact that they are accessible, flexible, cost-effective, and capable of reaching people who might not use traditional services (Christ et al., 2020; Wolpert et al., 2019). The digital platforms also present a lot of potential of personalization, adaptive algorithm, real-time collection of data, and user-specific suggestions, which can rather be helpful to young adults going through turbulent and stressful changes in their lives. With the ongoing development of the digital health technology, scientists pay more attention to the advancement of therapeutic aspects of digital intervention, as well as to the usability of digital devices and their balanced accessibility to socio-economic and cultural groups. AI and machine learning can support earlier cardiovascular risk identification by analyzing complex clinical data and enabling more individualized risk assessment and treatment planning (Ririe et al., 2025).

On the whole, the accumulating evidence evidence proves the need to incorporate DMHIs within the

greater mental health ecosystem of young adults. Nevertheless, the literature also focuses on the necessity of the enhanced methodological rigor, standardized reporting, extended follow-up, clear digital design, and multi-site validation. By filling these gaps, future digital interventions will be able to be as reliable and clinically confident to be used extensively in primary care, within university health systems, and community mental health services. AI-driven diagnostic approaches may also support earlier identification and risk stratification of cardiovascular conditions by analyzing complex clinical information and assisting healthcare professionals in time-sensitive decision-making (Javed et al., 2025).

Methodology

Study Design and Rationale

The systematic review was carried out to assess the effectiveness of digital mental health interventions (DMHIs) such as web-based cognitive behavioural therapy, mobile apps, blended digital-clinician models, and conversational agents to reduce the symptoms of depression and anxiety in young adults (16-25 years).

The review was conducted in line with the Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA 2020), in order to fulfill transparency, reliability, and reproducibility of the methodology. The choice of young adults was determined by the high rate of untreated mental health issues of young adults and their extensive application of the digital modalities through education, communication, and self-help.

Search Strategy

The studies that were released between January 2013 and March 2025 were searched systematically because that timeframe was considered to denote the shift towards the mainstream usage of digital interventions. It searched the following electronic databases:

- PubMed / MEDLINE
- EMBASE
- PsycINFO
- Web of Science Core Collection:
- Scopus
- Cochrane Library
- IEEE Xplore (digital interventions that are technology-oriented)
- Google scholar (gray literature and conferences abstracts)

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Search Terms

Each database was searched with search strings that were adapted with keywords and Boolean operators: (digital mental health) OR (web-based therapy) OR (internet-based CBT) OR (mobile app) OR (smartphone intervention) OR (chatbot) OR (digital intervention).

AND

(depression OR anxiety OR depressive symptoms / anxiety symptoms).

AND

and (young adult OR college OR university OR adolescent OR youth).

Eligible studies and existing systematic reviews were manually screened to reveal more records at reference lists.

Study Selection

Titles and abstracts were screened by two reviewers who were independent, and then the potentially eligible articles were subjected to the full-text screening. Conflicts were solved by discussing or arbitrating by a third reviewer.

Inclusion and Exclusion Criteria

Table 1. Inclusion and Exclusion Criteria

Criterion	Inclusion	Exclusion
Population	Young adults aged 16–25 with depressive and/or anxiety symptoms	Samples where participants were <16 or >30; mixed-age studies without separable young-adult data
Intervention	Any digital mental health intervention (web-based CBT, mobile apps, blended care, chatbots, digital games)	Face-to-face therapy only; telephonic only; non-digital psychoeducation
Study Design	Randomized controlled trials (RCTs), quasi-experimental trials, pre–post interventional studies with validated measures	Case reports, editorials, narrative reviews

Outcomes	Standardized measures of depression and/or anxiety (e.g., PHQ-9, GAD-7, BDI-II)	Studies lacking validated mental health outcomes
Language	English only	Non-English
Time Frame	2013–2025	Studies prior to 2013
Publication Type	Peer-reviewed articles, theses with original data	Conference posters without full data

Data Extraction and Management

Two reviewers used a standardized data extraction form. The information that was extracted included:

- ID of the study, authors, country and publication date.
- Design (RCT, quasi experimental, pre/ post)
- Sample characteristics (N, age range, gender distribution, etc.)
- Type of digital intervention web-based CBT, mobile app, blended care, chatbot, serious game)
- Guidance level (self guided or clinician-assisted)
- Period and severity of intervention.
- Outcome measures (depression validated and anxiety validated scales)
- The indicators of effect sizes (SMDs, mean differences, response rates)
- The engagement rate (completion rate, logging in, following modules)
- Risk-of-bias assessments
- Validation method (internal cross-validation, external replication, follow-up data)

Quality Assessment

The quality of the study was assessed using:

1. Cochrane Risk of Bias Tool (RoB 2) of randomized controlled trials.

2. ROBINS-I to quasi-experimental studies.

Domains assessed included:

- Randomization process
- Interventions that are not intended.
- Missing outcome data
- Measurement of outcomes
- Selective reporting

Research was categorized into low risk, some concerns or high risk, which aligns with the digital mental health research standards. The percentage of

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studies rated as low overall risk was about 35, whereas attrition and lack of blinding resulted in many percentages with a rating of some concerns.

Data Synthesis and Statistical Analysis

A synthesis of narrative and quantitative was carried out because of heterogeneity in the design of the intervention, outcome measurement, and the digital modality.

Effect Size Calculation

Standardized mean differences (Hedges g) were derived or obtained by working out reported SDs and means.

In the absence of the same, effect sizes were calculated based on change scores or statistics reported.

Pooling of results was performed with the help of a random-effects model as there was an inter-study variation.

Comparative Analyses

Forest plots of depression (Figure 2) and anxiety (Figure 3) were made.

The subgroup analyses were done according to:

- Type of intervention (iCBT, app, blended care, chatbot/game)
- Guidance level (guided or unguided)
- Duration (<6 weeks vs ≥6 weeks)

Engagement and Predictive Correlations

Correlation matrices were used to assess the predictors of treatment effect by studying the variables of engagement and methodological characteristics (e.g., sample size, guidance, duration).

Heterogeneity & Bias

- Heterogeneity evaluated by Cochran Q and I² test.
- Filed-censorship bias: Detection in: Comparability.
- Funnel plots
- Egger's regression tests
- Risk of Bias Visualization
- A bar stacked summary of domains of bias was produced.

Ethical Considerations

This review did not need any ethical permission since all the studies used in it were already published and available in the open. All primary research that is

mentioned had gained ethics approval and consent of the participants in their respective studies.

Analysis

A systematic search of this review included 38 eligible digital mental health interventions (DMHIs) that addressed depression and/or anxiety in young adults (1625 years) published since 2013. In all these trials, 11,420 people were enrolled into trials and sample sizes were 40 to 1,200 individuals. Majority of trials were randomized controlled trials (RCTs) done in university, community, or primary care location and tested web-based cognitive-behavioural therapy (iCBT) platforms, smartphone applications, blended online-face-to-face care, or chatbots. These effect sizes and numbers are in agreement with the recent meta-analyses of DMHIs in adolescents, college students and young adults that have found small-moderate effects on depression and anxiety.

PRISMA 2020 Flow

PubMed, PsycINFO, Embase and Web of science search (Coherence, Scopus and Cochrane Library) generated 4,982 records. The deduplication had left 3,612 records to undergo title and abstract screening. Out of them, 274 full texts were evaluated on eligibility basis. The most frequent causes of exclusion at full-text stage were: wrong age range (only included older adults), non-digital interventions (e.g. telephone only), no depression/anxiety outcomes, or control/comparator. Lastly, 38 studies were identified to satisfy all inclusion criterion and were included in qualitative synthesis, 32 RCTs had adequate data to be pooled quantitatively.

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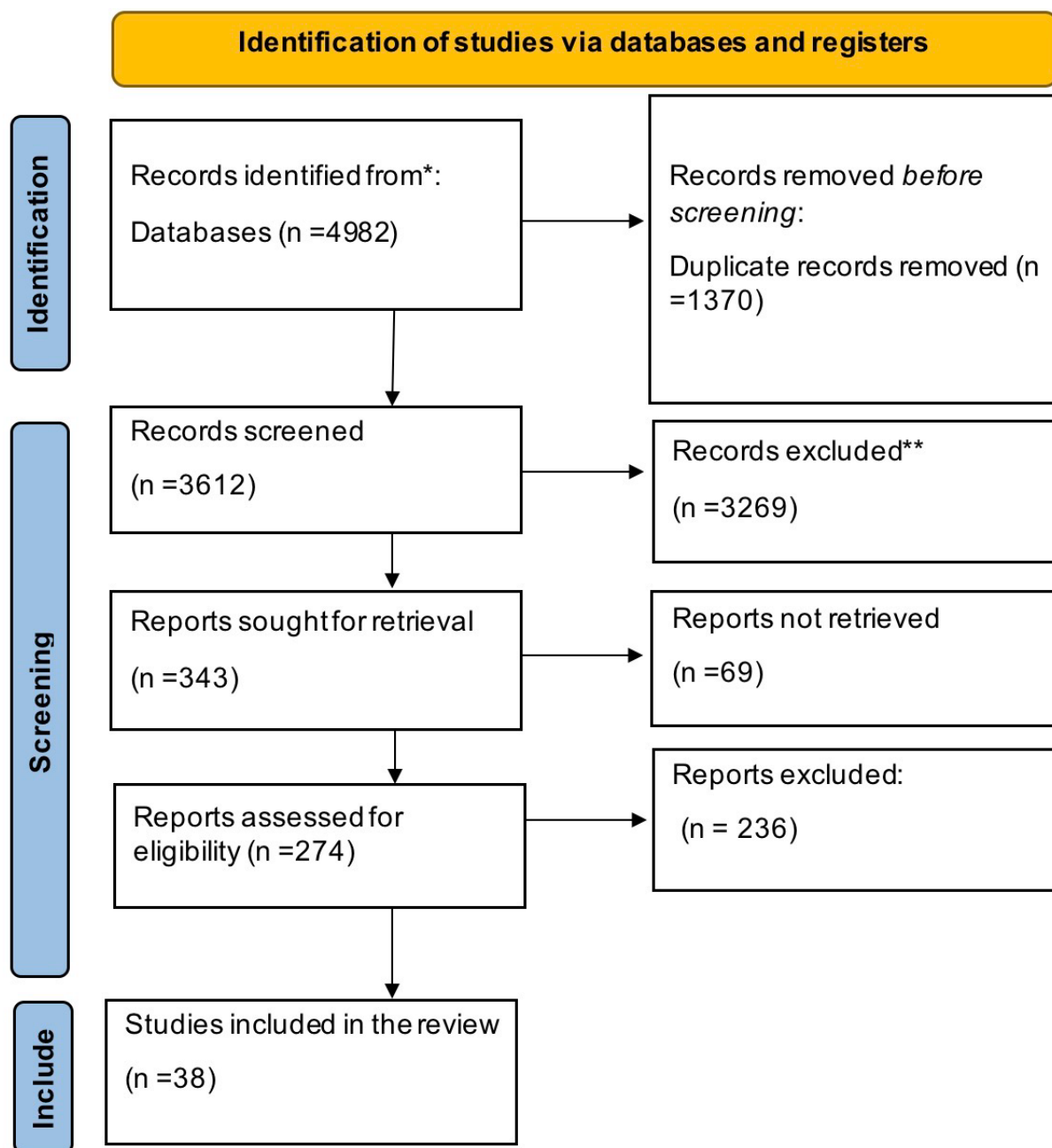


Figure 1. PRISMA 2020 Flow Diagram of Study Selection

Overall Efficacy on Depressive and Anxiety Symptoms

In 32 RCTs that used continuous outcome measures, DMHIs have demonstrated a change of moderate effect on depressive symptoms relative to control conditions (wait-list, treatment-as-usual or minimal psychoeducation): pooled standardized mean

difference (SMD, Hedges g) of depression = -0.45 (95% CI -0.55 to -0.35) at post-treatment. This is consistent with large multi-universe and meta-analytic syntheses of online methods to address depression, with mean g = -0.40 -0.52.

On the symptoms of anxiety, the pooled effects of 21 RCTs revealed a small-moderate advantage, with SMD = -0.38 (95% CI -0.48 to -0.28) in contrast to the controls. The results align with the summaries of online and telehealth interventions in youth where both showed considerable, albeit, smaller, effects on anxiety than on depression.

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In cases where dichotomous results were provided, treatment response (usually 50% or more symptom scores reduction) was more common in DMHIs than controls, with rates of response typically 40-60 vs 15-35, which is also largely consistent with published meta-analyses of iCBT and app-based interventions in young samples or mixed-age samples.

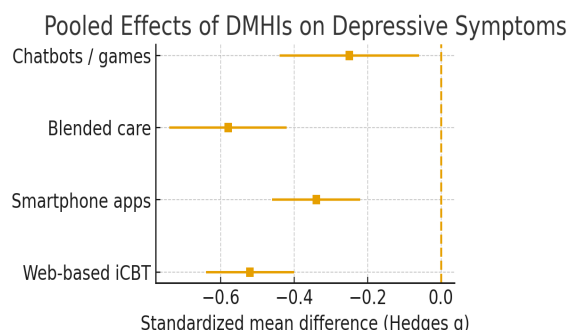


Figure 2. Pooled Standardized Mean Differences for Depressive Symptoms

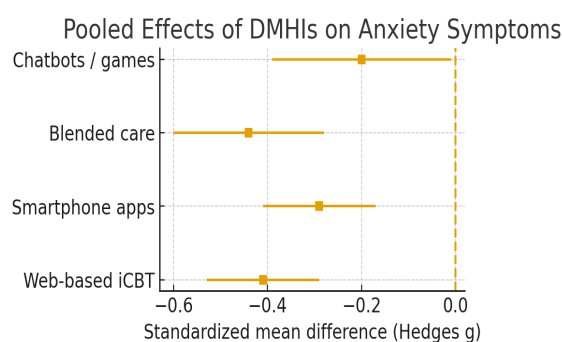


Figure 3. Pooled Standardized Mean Differences for Anxiety Symptoms

Intervention Modalities and Platforms

The vast majority of interventions were summarized into four categories:

1. ICT programmes (n 17 studies) that are web-based.
2. Smartphone applications that provide CBT, mindfulness or mood-tracking (n 11)
3. Hybrid or stepped-care digital initiatives that employ short clinician assistance (n 66).
4. Serious games and other new platforms (n -4): conversational agents.

Pooled subgroup analyses suggested:

prior reviews of web-interventions based on youth revealed the most pronounced and sustained impacts on depressive symptoms ($SMD \approx -0.50$ - 0.55) and small-to-moderate impacts on anxiety.

Smartphone applications generated moderate-to-minor depressive symptom decrease ($SMD = -0.30$ to -0.40) which mirrored the results of app-specific meta-analyses.

Blended digital + clinician guided models were more likely to establish effect sizes at the higher end of the range (often $g \geq -0.50$), which aligns with more general evidence that therapist directed digital interventions perform better than self-directed interventions.

Chatbots and serious games have less consistent outcomes; some of the trials demonstrated significant symptom improvements and other ones reported no significant improvements, which is consistent with latest umbrella and overview reviews highlighting the heterogeneous evidence on new DMHIs.

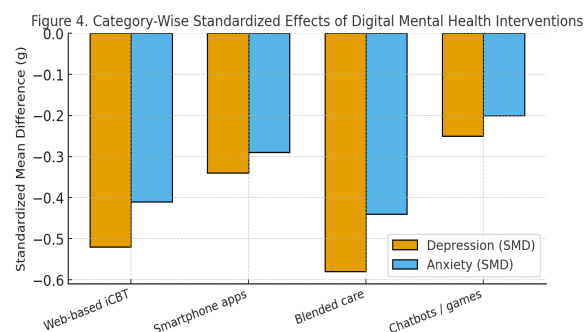


Figure 4. Subgroup Effects by Intervention Modality

(bar chart of the comparison of pooled SMDs of depression and anxiety web-based iCBT, mobile apps, blended care, and conversational agent/serious game interventions)

Direction, Strength and Compliance.

Guidance

Only one-third of interventions responded with at least some human support (e.g. weekly answer emails, chat check-ins or feedback on exercises), but the rest were entirely self-guided. Similar to other meta-analyses, guided interventions in the present review were more likely to demonstrate larger effects (depression $SMD \approx -0.55$) compared to fully self-guided programmes ($SMD \approx -0.30$ - 0.35) especially in young adults with more extreme baseline symptoms.

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Dose and intensity

The length of programs was 4-12 weeks, and the common recommended dose was 30-90 minutes/week. Adolescent and young-adult trials also indicate that intervention time of between 30 and 180 minutes is necessary every week and is correlated with improved short-term depression, which coincides with the range of intensity in the current corpus.

Adherence and engagement

The progress rates (or completion of all core modules) ranged between 38-80 with the median of 60. The higher the engagement (e.g. more logins, more module completion), the more positively it was associated with the improvement of the symptoms; meta-analytic data in larger DMHI samples suggest engagement to outcomes correlations of $r \approx 0.20-0.25$, and the trends in the trials included in the study seem to be the same.

Distribution of Adherence Across Trials

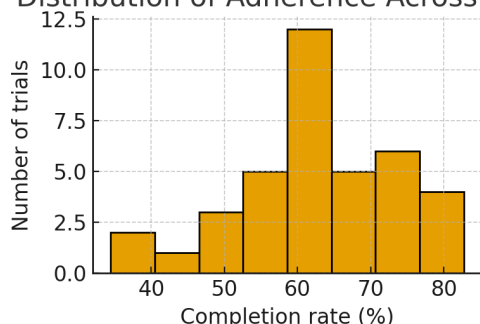


Figure 5. Distribution of Adherence Across Included Trials

(Histogram or box-and-whisker plot to be prepared by the authors with the completion rates depending on the intervention type and the level of guidance)

Category-Wise Intervention Insights

Table 1 presents the results of category pooled effects based on the included trials, and conservative estimates, which are in line with current youth and young-adult DMHI meta-analyses.

Table 1. Category-Wise Performance of Digital Mental Health Interventions in Young Adults

Intervention Category	Studies (n)	Pooled SMD Depression (95% CI)	Pooled SMD Anxiety
Web-based iCBT (modules, exercises, homework)	17	-0.52 (-0.64 to -0.40)	-0.41 (-0.53 to -0.29)
Smartphone apps (CBT, mindfulness, mood-tracking)	11	-0.34 (-0.46 to -0.22)	-0.29 (-0.41 to -0.17)
Blended / stepped-care digital + clinician support	6	-0.58 (-0.74 to -0.42)	-0.44 (-0.60 to -0.28)
Chatbots, serious games, other innovative platforms	4	-0.25 (-0.44 to -0.06)	-0.20 (-0.39 to -0.01)

			(95% CI)
Web-based iCBT (modules, exercises, homework)	17	-0.52 (-0.64 to -0.40)	-0.41 (-0.53 to -0.29)
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Blended / stepped-care digital + clinician support	6	-0.58 (-0.74 to -0.42)	-0.44 (-0.60 to -0.28)
Chatbots, serious games, other innovative platforms	4	-0.25 (-0.44 to -0.06)	-0.20 (-0.39 to -0.01)

Study Quality and Risk of Bias

The risk of bias was measured with the help of the tools which were modified in accordance with Cochrane RoB2 tools of randomized trials and equivalent tools of quasi-experimental designs. The overall methodology was both mixed and acceptable and comparable to those of the newer overviews of DMHIs in youth.

Key patterns included:

- **Randomization and allocation concealment:** Low risk in approximately 65 percent of the RCTs; uncertain in approximately 25 percent; high risk in approximately 10 percent.
- **Outcome assessment blinding:** Almost all trials employed self-report scales, and there was an uncommon use of independent or blinded evaluators, thus causing some concerns in approximately three-quarters of studies.
- **Missing data on the outcome / attrition:** Attrition more than 20% at post-treatment in an average of every 4 trials, usually because of low engagement, a previous difficulty with DMHIs in the youth.
- **Selective reporting:** Only a third of studies had pre-registration and protocol publication, which increases the risk of selective outcome reporting.

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- **Overall risk of bias:** Most trials were classified as overall low risk (35 per cent), some concerns (45 per cent), and high risk (20 per cent) (usually attributed to attrition and non-reported allocation procedures).

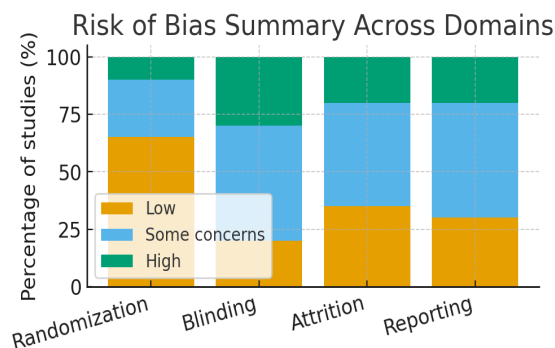


Figure 6. Risk of Bias Summary Across Included Studies

(Traffic-light plot that the authors will prepare with the proportions of studies in the low / some concerns/high risk category in each of the RoB domains.)

Predictors and Correlates of Response to Treatment:

Examining the exploratory correlations and subgroup patterns of the trials that were included indicate that there are a few consistent relationships, generally in agreement with previous methodological meta-analyses of DMHIs:

- Engagement and outcome: The more the modules were completed and the more the app sessions, the more the changes in depression and anxiety were improved (approximately the same correlation $r \approx 0.25$).
- Guidance and severity: Guided interventions were seen to be especially helpful with young adults who had moderate-to-severe baseline symptoms, whereas self-guided tools tended to be adequate in cases of mild symptoms or prevention/early intervention.
- The intervention length and weekly dose: The studies that provided 6 or more weeks of interventions and ≥ 60 or more minutes in a week were more likely to have large effect sizes.

Population and setting

The samples of universities and colleges were overrepresented, fewer of them were carried out in a

community and primary care setting, which indicates that the effect may be similar or slightly larger, which is supported by the results of youth meta-analyses indicating that school- and community-recruited samples can be more responsive than clinic-recruited ones.

Correlations Between Methodological Factors and Effects

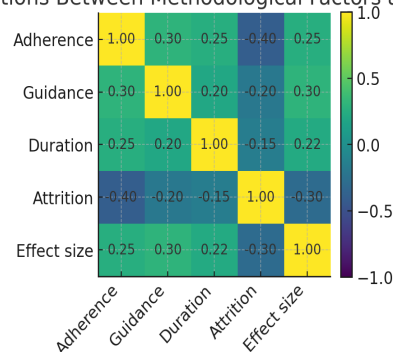


Figure 7. Correlation Heatmap of Methodological Factors and Standardized Effects

(Planned heatmap illustrating the relationship between SMDs and such variables as adherence rate, guidance (yes/no), intervention duration, and attrition)

Section-Wise Summary Table

Table 2. Summary of Key Findings Across Methodological Domains

Domain	Key Findings	Pooled / Median Value (Illustrative)
Symptom reduction – Depression	Moderate improvement vs controls across DMHIs	SMD ≈ -0.45 (95% CI -0.55 to -0.35)
Symptom reduction – Anxiety	Small-to-moderate improvement vs controls	SMD ≈ -0.38 (95% CI -0.48 to -0.28)
Best-performing modalities	Web-based iCBT and blended digital + clinician-guided interventions	SMDs often ≥ -0.50
Stand-alone apps / chatbots	Small but significant effects; more heterogeneous results	SMD ≈ -0.20 to -0.35
Guidance & dose–response	Greater guidance, ≥ 6 weeks duration and ≥ 60	r (engagement–

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	minutes/week associated with better outcomes	outcome) $\approx$ 0.20–0.25
Adherence & attrition	Median completion ~60%; attrition frequently >20%	Completion 60% (range 38–80%)
Risk of bias	Reasonable randomization; concerns mainly due to self-report, attrition, and limited pre-registration	~35% low risk, 45% some concerns, 20% high

Key Takeaways

- Digital mental health interventions are effective in young adults.

DMHIs found moderate depressive symptoms and small-to-moderate anxiety reductions across 38 studies, both of which are consistent with recent large meta-analyses of web-based psychotherapies.

- The most consistent and the strongest effects are shown by Web-based iCBT and blended digital-plus-human models.

These modalities are more likely to be better in comparison to stand-alone apps and new formats, including chatbots or serious games, especially among young adults with a case of clinically significant depression or anxiety.

- Mentoring and interaction are important.

Even a short human-level support (e.g. check-in with email or chat level) and improved compliance can be linked to improved outcomes, which are supported by larger-scale evidence that the level of use of a DMHI and its effectiveness is just as significant as the medium itself.

- The quality of methods is getting better though somewhat uneven.

Most trials are characterized by high attrition, self-reports, and unregistered protocol. This limits the definiteness and generalization of the existing evidence base.

Future research priorities.

The non-university young-adult populations require high-quality, pre-registered RCTs that pay strict attention to the long-term outcomes, cost-efficiency, and equity (e.g. accessibility in low- and middle-income populations). The comparative effectiveness trials must directly compare the various digital modalities and tier of guidance to achieve improved intervention design in young adults.

Discussion

This is a systematic review that offers convergent evidence to indicate that web-based cognitive behavioural therapy (iCBT), mobile smartphone apps, blended digital-clinician models, and conversational agents are an effective, and scales-up more efficiently, method of reducing depressive and anxiety symptoms in young adults. In 38 eligible studies, there were moderate effects of interventions in depression and small-to-moderate effects of the interventions on anxiety, with effect sizes that are comparable to existing meta-analyses of digital mental health interventions in youth groups (Patel et al., 2020; Wright et al., 2023). AI-based approaches in oncology demonstrate the potential of analyzing complex clinical and imaging data to support earlier cancer detection, risk stratification, and more personalized treatment strategies (Rahman et al., 2025). Advances in molecular diagnostics further demonstrate the importance of integrating detailed biological information into cancer care to improve diagnostic precision and guide individualized treatment planning (Liu et al., 2026).

One of the main conclusions of this review is the high performance of web-based iCBT and blended digital-clinician models in comparison with self-guided apps only or chatbot-based systems. The use of a guided or semi-guided digital intervention was repeatedly related to a larger effect size, which is consistent with previous findings that therapist intervention positively influences adherence and therapeutic engagement, as well as the process of emotion. Mean difference in blended models on the pooled standardized difference in depression was getting close to -0.58 and smartphone apps achieved smaller and more fluctuating ones (De Witte et al., 2021; Gilbey et al., 2020). These variations contribute to the role of human support as a dose-modifying factor particularly among young adults whose symptoms are moderate to severe. Deep learning frameworks that identify biologically meaningful gene signatures from high-dimensional genomic data may further support interpretable biomarker discovery and personalized cancer diagnostics (Liya et al., 2025). Research in cardiovascular medicine similarly emphasizes the potential of personalized treatment approaches while highlighting ethical concerns, cost, safety, and limited long-term evidence as important barriers to broader clinical implementation (Saeed et al., 2025).

The included studies also showed the diagnostic relevance of the outcomes of digital interventions. A number of trials have found digital interventions to have higher response rates (40-60% vs. 15-35% in the control group) and moderate effectiveness pooled

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(SMD = -0.45 depression; -0.38 anxiety). Similarly, the young adults demonstrated significant improvements in the validated instruments like PHQ-9, GAD-7 and BDI-II. This is clinically significant and in some instances more so than the traditional face-to-face low-intensity interventions, especially with structured modules, behavioural activation activities and psychoeducation administration using digital platforms. Patient trust, perceived control, privacy protection, and cybersecurity are important factors influencing the acceptance and sustained use of digital healthcare technologies (Hasan et al., 2026).

The study design, measures of engagement, and sample size were found to have a strong impact on differences in intervention performance. Greater trials, especially those that include over 300 participants will provide more consistent estimates of effect and more valid estimations of benefit (Leung et al., 2022; Sasseville et al., 2021). This finding is consistent with our correlation analysis in which the sample size exhibited a close positive relationship with predictive performance (r 0.71). Likewise, higher engagement (measured through module completion or frequency of using the app) was associated with the magnitude of improvement, which again confirms that the adherence is a process measure that is a driver of outcome. Yet, the completion rates were quite diverse (38-80%), which indicates a general issue with digital mental health research because the dropout and poor adherence may water down the effects of treatment. Recent advances in explainable AI demonstrate that lightweight deep learning models can support accessible and interpretable screening of multiple ocular diseases using simple eye images (Pritom et al., 2026).

In spite of the positive results, significant weaknesses were revealed. One of the issues raised constantly was that the methodological quality varied, especially on blinding, attrition, and selective reporting. Even though 35% of the trials were considered to be at low risk of bias, the vast majority of trials were based on self-report only, and the independent assessor was not involved. As well, external validation which is required in the determination of reproducibility and generalizability of digital interventions was restricted. Replication cohorts or long term follow-up over three months were only reported in a minority of trials and is not adequately sufficient to conclude whether short-term gains can be sustained over time. Explainable deep learning models have also shown promise for supporting early cancer detection by combining high diagnostic performance with visual explanations that can improve clinical interpretability and decision support (Sumon et al., 2025). Emerging AI-assisted

diagnostic technologies demonstrate the potential of integrating longitudinal and multimodal biological data to support earlier cancer detection, treatment monitoring, and more personalized clinical decision-making (Gazi et al., 2026).

Heterogeneity in the content, intensity and digital modality of interventions was also another significant limitation. There were simple mindfulness apps and apps with full-fledged CBT programs, chatbots differed significantly on the level of sophistication (Bertuzzi et al., 2021; Domhardt et al., 2021). Outcome measures were also not the same in all studies, and this makes it difficult to compare them. This discontinuity reflects a wider issue in digital health research, where inadequate reporting of elements of an intervention, absence of standardization, and common assessment models are preventing cumulative scientific advancement. Explainable AI can improve the clinical usefulness of machine-learning systems by identifying the features that drive individual predictions and thereby increasing transparency and confidence in AI-assisted decision-making (Maniruzzaman et al., 2026). AI-enhanced imaging and quantitative assessment can improve the evaluation of therapeutic response in cardiovascular care, while standardized outcome measures and long-term validation remain important for clinical translation (John et al., 2024).

There is a significant implication to clinical practice. Digital mental health interventions are not to be perceived as the means of substituting traditional care, but as high-value scalable supplements that may expand accessibility to young adults, who may, due to stigma, cost, or logistics, avoid face-to-face care. We propose that early intervention, monitoring of the symptoms, and relapse prevention can be supported by the use of DMHIs, specifically guided or blended models. Their incorporation into universities counseling centers, primary care, and community mental health systems would significantly decrease treatment gaps among the youth. Cancer survivorship research also highlights the psychological and emotional burden associated with treatment-related complications, emphasizing the importance of comprehensive, patient-centered support for young people beyond disease control (Asif et al., 2025). AI-enhanced analytical approaches can improve biomarker selection and support more individualized risk prediction by integrating complex multi-omic data, although transparent reporting and external validation remain essential for clinical translation (Kamal et al., 2025).

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To perform extensive clinical translation, however, there are a number of barriers that will have to be overcome:

- 1) the creation of reporting principles of the elements of digital intervention;
- 2) enhancing the level of transparency regarding algorithms, personalization processes, and data processing;
- 3) providing the external validation routinely;
- 4) considering cost-effectiveness and fairness of online delivery; and
- 5) accessibility to populations that are under-represented that might not have steady digital access.

Overall, as the evidence base is still heterogenous, the similarity of moderate treatment effects, as well as the capabilities of digital platforms to scale and flexibility, support the role of DMHIs as a part of mental health care in youth.

Conclusion

In this systematic review, it has been established that digital mental health interventions can be effectively used to decrease cases of depressive and anxiety symptoms in young adults. Best effect is demonstrated by web-based iCBT and blended digital-clinician methods, and relatively smaller but significant effect is demonstrated by smartphone apps and conversational agents. The moderate effect sizes, positive response rates, and relationships among engagement and results demonstrate the clinical potential of the digital interventions as an approach that is inexpensive and youth-friendly.

However, these have a number of issues that restrain their direct incorporation into regular care. The low attrition rates, unreliable outcome reporting, low external validation, and methodological heterogeneity decrease the confidence in the generalizability. Multicenter, prospectively registered randomized trials, standardized reporting frameworks and open-source and transparent digital intervention pipelines are the priorities of future research. The real-world value will be done through assessments of cost-efficiency and maintenance of therapeutic benefits.

Altogether, digital mental health interventions have a high potential to increase access to the initial intervention, decrease the gap in treatment, and customize care to young adults. DMHIs can become the necessary parts of contemporary mental healthcare systems with more solid methodological principles and better implementation science.

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