

eHealth Psychological Interventions for Patients with Cardiovascular Diseases: A Systematic Review and Meta-analysis

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Submitted to: Journal of Medical Internet Research
on: February 14, 2024

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eHealth Psychological Interventions for Patients with Cardiovascular Diseases: A Systematic Review and Meta-analysis

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Abstract

Background: Psychological disorders are recognized as independent risk factors for cardiovascular diseases (CVDs), contributing to increased morbidity and mortality. While eHealth is increasingly used to deliver psychological interventions, their effectiveness for patients with or at high-risk of CVDs remains unclear.

Objective: This meta-analysis aimed to evaluate the effects of eHealth psychological interventions for patients with or at high-risk of CVDs.

Methods: Eligible studies were retrieved from five databases, covering the period from inception to Sep 2023. Randomized controlled trials (RCTs) investigating the effect of evidence-based eHealth psychological intervention to improve psychosocial wellbeing and cardiovascular outcomes for people with or at high-risk of CVDs were included. Cochrane Risk of Bias Assessment Tool V2 was used to judge the methodological quality of reviewed studies. RevMan 5.3 was used for meta-analysis. Quality of evidence was assessed using the GRADE approach.

Results: A total of 12 RCTs, including 2,319 participants from 10 countries were included in the review. The results demonstrated significant alleviation of depression for participants receiving eHealth psychological intervention compared to controls [$n=7$, $SMD=-0.30$, 95% CI $(-0.47, -0.14)$, $I^2=57\%$, $P < .001$]. More specifically, in six trials where Internet-based cognitive behavior therapy was delivered a significant alleviation of depression was achieved [$SMD=-0.39$, 95% CI $(-0.56, -0.21)$, $I^2=53\%$, $P < .001$]. There was no significant change in anxiety or quality of life. Synthesis without meta-analysis regarding stress, adverse events and cardiovascular events showed inconclusive findings.

Conclusions: eHealth psychological interventions, particularly internet-based cognitive behavioral therapy, can significantly reduce depressive symptoms among patients with or at high-risk of CVDs. A multi-disciplinary approach is crucial for comprehensively improving psychological and cardiovascular outcomes. Future research should explore integrating persuasive design elements into eHealth and involving mental healthcare professionals to support and guide intervention delivery. Clinical Trial: CRD42023452276

(JMIR Preprints 14/02/2024:57368)

DOI: <https://doi.org/10.2196/preprints.57368>

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Original Manuscript

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Abstract

Background: Psychological distress is recognized as independent risk factors for cardiovascular diseases (CVDs), contributing to increased morbidity and mortality. While eHealth is increasingly used to deliver psychological interventions, their effectiveness for patients with CVDs remains unclear.

Objective: This meta-analysis aimed to evaluate the effects of eHealth psychological interventions for patients with CVDs.

Methods: Eligible studies were retrieved from five databases (Embase, Medline, PubMed, CINAHL, and Cochrane Library), covering the period from inception to December 2024. Randomized controlled trials (RCTs) investigating the effect of evidence-based eHealth psychological intervention to improve psychosocial wellbeing and cardiovascular outcomes for people with CVDs were included. Cochrane Risk-of-Bias Assessment Tool V2 was used to judge the methodological quality of reviewed studies. RevMan 5.3 was used for meta-analysis.

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Conclusions: eHealth psychological interventions, particularly internet-based cognitive behavioral therapy, can significantly reduce depressive symptoms among patients with CVDs. A multi-disciplinary approach is crucial for comprehensively improving psychological and cardiovascular

outcomes. Future studies should explore integrating persuasive design features into eHealth and involving mental health professionals for intervention delivery.

Protocol registration: CRD42023452276

Keywords: Cardiovascular diseases, eHealth, psychological intervention, cognitive behavioral therapy, depression



Introduction

The interplay between cardiovascular diseases (CVDs) and psychological distress such as stress, anxiety, and depression present a profound challenge in medical care [1]. Notably, approximately 40% of patients with CVDs experience these psychological symptoms [2, 3], which not only impair their quality of life but also double their risk of severe cardiovascular events such as myocardial infarction, stroke, hospitalization, and premature death compared to those without such psychological disorders [4, 5]. These disorders exacerbate cardiovascular risks through multiple plausible biological mechanisms [6]. Autonomic nervous system dysfunction, triggered by psychological stress, leads to an imbalance favoring the sympathetic nervous system. This chronic activation results in elevated heart rate and blood pressure, reducing heart rate variability and increasing the risk of cardiovascular complications such as hypertension. Additionally, psychological distress activates the hypothalamic-pituitary-adrenal (HPA) axis, increasing cortisol production. Chronic stress can induce cortisol resistance, leading to unregulated inflammation marked by elevated levels of pro-inflammatory cytokines such as CRP, IL-6, and TNF-alpha [7]. This persistent inflammation contributes to the exacerbation of atherosclerosis, enhancing the likelihood of arterial plaque instability and rupture, thereby significantly increasing the risk of cardiovascular events [8].

Effectively managing these psychological symptoms is essential for reducing overall cardiovascular risk and enhancing patient outcomes yet complex, primarily due to poor adherence to prescribed treatments [9]. While both pharmacological and non-pharmacological interventions are shown to improve psychological well-being, the high costs, adverse side effects, and cessation challenges associated with psychoactive medications often hinder patient utilization [10, 11]. Additionally, the complexity of drug regimens and the delayed onset of benefits contribute to poor compliance, particularly in

populations already burdened with managing chronic cardiovascular conditions.

Non-pharmacological interventions, serving as a vital form of secondary prevention, have increasingly been utilized to improve psychological outcomes in individuals with or at risk for CVDs. Techniques such as cognitive behavioral therapy, mindfulness, problem-solving therapy, and stress management do not involve direct costs of medication and are devoid of the side effects associated with drugs, such that they are perceived as more acceptable to many patients [12]. These approaches also address psychological symptoms by teaching patients coping strategies and resilience skills, which are crucial for both immediate and long-term management of stress, anxiety, and depression. Moreover, non-pharmacological treatments can be tailored to individual needs and integrated into patient lifestyles more flexibly than medication regimes, enhancing adherence. They often include group sessions, which can reduce stigma by normalizing psychological challenges among peers. A comprehensive systematic review and meta-analysis of 35 trials highlighted that these interventions not only reduce cardiovascular mortality but also lead to significant improvements in symptoms of depression, anxiety, and stress among patients with coronary heart disease, compared to usual care [13].

Despite their proven efficacy, the implementation of these interventions is frequently hindered by limited awareness and resource constraints [5, 14]. Therefore, increasing education about these options for both healthcare providers and patients, and ensuring broader accessibility, are essential steps toward overcoming these hurdles. The inherent adaptability of non-pharmacological interventions makes them particularly well-suited to meet diverse patient needs, , ultimately conserving healthcare resources and improving long-term health outcomes [15].

eHealth has gained increasing popularity as a means to deliver psychological

interventions in a scalable and accessible way for CVDs. eHealth refers to the use of information and communication technology to support healthcare delivery [16]. The eHealth psychological interventions offer notable advantages: they maintain user anonymity, thereby reducing the fear of stigmatization; eliminate travel time and associated costs; and allow for tailoring interventions to individual preferences, needs, and unique contextual factors [17, 18]. Additionally, the interactive capabilities of eHealth platforms are particularly valuable due to the intense, persistent, and fluctuating nature of mental health challenges in patients with CVDs [19, 20]. This variability necessitates continuous self-assessment and monitoring to effectively track progress and prevent relapse. eHealth interventions facilitate real-time support from healthcare professionals, assisting in patient's active engagement,[21] overcoming geographical barriers [22], as well as promptly identifying non-adherence and subsequently addressing it [23].

There is an emerging body of primary research exploring the effects of eHealth psychological interventions in CVDs [24], such that it is now possible to conduct a first comprehensive systematic review and meta-analysis to synthesize this evidence and inform future care recommendations. This systematic review and meta-analysis, therefore, aims to investigate the impact of eHealth psychological interventions on psychological and CV outcomes in patients with or at high risk of CVDs.

Methods

Design

This review followed the Cochrane Handbook to formulate the research question, define eligibility criteria, conduct the comprehensive literature searches, assess risk of bias, and synthesize evidence. The PRISMA statement informed the reporting structure of this manuscript [25], ensuring all the key components of a high-quality systematic review were included, including that search strategies and data extraction methods were clearly

outlined. The protocol of this review was registered in PROSPERO (CRD42023452276) to enhance transparency, minimize bias and prevent duplication of efforts.

Eligibility criteria

Inclusion criteria were guided by the Populations, Interventions, Comparisons, Outcomes, and Study designs (PICOS) framework. **Population:** studies that included individuals with a medical diagnosis of CVD (including arrhythmia, heart failure, valve disease, cardiomyopathy) as well as studies included a mixture of patients with CVD and at high CVD risks. High CVD risks was defined as having at least two well-established CVD risk factors (e.g., body mass index >30, dyslipidemia in past month) [26]. **Intervention:** participation in a evidence-based psychological therapy (e.g., cognitive behavioral therapy) delivered through an eHealth platform (e.g., websites or apps) enabling structured therapy delivery; **Comparison:** standard care, waitlist control, placebo, or other active controls (e.g., health education); **Outcomes:** measures of psychological well-being (e.g., depressive symptoms, anxiety, stress), health-related quality of life (HRQoL), as well as adverse or cardiovascular events; and **Study design:** randomized controlled trials (RCTs) were included to ensure rigor [27]. Feasibility results were not used as eligibility criteria, as this study aims to investigate the effectiveness of the intervention. However, we extracted this information to inform future research.

The exclusion criteria were: studies with a quasi-experimental design, conference abstracts, or case studies, to ensure focus on robust experimental methodologies; total study sample size of less than 30, due to insufficient power to detect a true intervention effect [28]; Studies that solely used text message/phone calls as the intervention method

were excluded to prioritize comprehensive eHealth strategies. These strategies are characterized by multimedia and interactive features that significantly enhance user engagement.; Studies evaluating interventions based on psychological principles but primarily aimed at improving adherence to other treatments, such as tobacco cessation, were excluded to ensure our review's focus on direct psychological outcomes; Studies without full texts, despite efforts to contact authors, were excluded to ensure our analysis was based on fully accessible data.

Search strategy

A comprehensive literature search was conducted across five electronic databases: Embase (1910-), Medline (1946-), PubMed (1997-), CINAHL (1981-), and the Cochrane Library (1996-), covering the period from inception to December 2024. The selection of these databases aligns with the research question by ensuring broad coverage of medical, psychological, and health-related literature, maximizing the likelihood of identifying relevant studies. The search strategy utilized a combination of Medical Subject Headings (MeSH) terms and free-text keywords to capture variations in terminology. Boolean operators were applied to refine the search, combining terms such as 'cardiovascular disease' AND ('psychological intervention' OR 'eHealth') AND ('depression'). The search strategies for all databases are provided in Supplementary Material 1. Additionally, a hand search of bibliographies from relevant review articles was performed to identify any further studies [29].

Study selection

Endnote X9 was used to identify and remove duplicate records. Two reviewers (JJS and RL) independently screened studies by evaluating titles and abstracts against the predefined eligibility criteria, focusing on the relevance to the research question and the

predefined PICOS. Studies that meet the inclusion criteria or had unclear eligibility progressed to a full-text review. Disagreements between the two reviewers throughout the review process were resolved through discussion and, when necessary, adjudicated by a third researcher (LB). The third researcher's role ensured objectivity in the decision-making process and the transparency of study selection.

Study quality and risk of bias

Methodological quality was assessed independently by two researchers (JJS and RL) using the Cochrane risk of bias tool V2, evaluating each study across five domains: randomization, intervention deviations, missing data, outcome measurement, and selective reporting. Bias risk was categorized as 'low,' 'some concerns,' or 'high.' Studies with 'some concerns' in three or more domains were deemed high risk. Due to the limited number of studies, funnel plots were not generated. Publication bias was evaluated by comparing outcome variables presented in RCTs with their trial registry and published protocols

Data extraction

Study data were extracted independently by two authors (JJS, RL). The authors developed a table for data extraction, which included the following: (a) origin of the articles, including authors, year, and country; (b) sample characteristics, such as gender, sample size, age, setting, and diagnosis; (c) trial design, consisting of a brief description of the intervention and control groups, study duration; (d) data collection time points; and (f) feasibility data regarding recruitment, attrition, and adherence.

Recruitment, attrition and adherence

The overall rates of recruitment, attrition, and intervention adherence were documented using median, minimum, and maximum values. Predefined cutoff values for the feasibility criterion, specifically a recruitment rate of at least 20% and an attrition of less than 25%,

were determined based on the clinical relevance established in a previous study.[30]

Data analysis and synthesis

Review Manager 5.3 was used for data pooling due to its capacity for combining outcomes from multiple studies with varying sample sizes. Data pooling was conducted when ≥ 3 studies were reporting the same outcome; otherwise, synthesis without meta-analysis (SWiM) was conducted [31]. The standard deviation (SD), if unavailable, was calculated from the confidence interval. Psychological wellbeing was considered the primary outcome. Where the same study reported outcomes at multiple endpoints, those from immediately post-intervention were used to investigate the intervention effect. For continuous outcomes, intervention effects were expressed as standardized mean differences (SMD) using Cohen's d , which standardizes differences between groups, enabling comparison across studies with different measurement scales. Cohen's d values were interpreted as small (0.2–0.5), moderate (0.5–0.8), or large (>0.8) effect sizes, which provides a framework to understand the magnitude of the intervention impact on psychological outcomes. For dichotomous outcomes, intervention effects were summarized as risk ratios (RR) using the Mantel-Haenszel method, which accounts for study weights in pooled analyses and is appropriate for binary data.

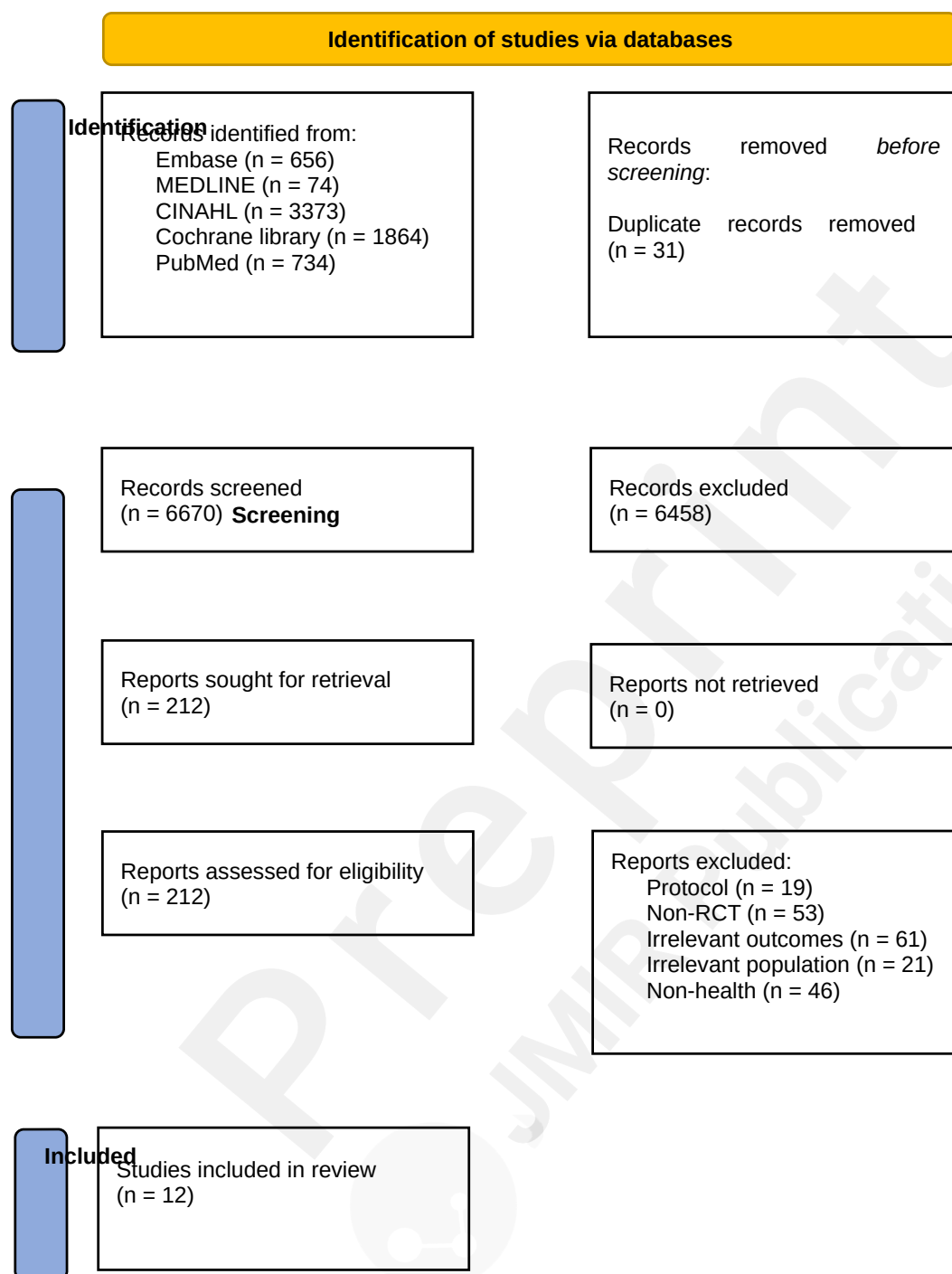
Statistical heterogeneity was assessed using the I^2 statistic, which quantifies the proportion of variability in effect estimates due to between-study differences rather than chance. I^2 values were interpreted as follows: 0–25% indicating low heterogeneity, 26–50% moderate heterogeneity, and $>50\%$ substantial heterogeneity. Random-effects models were used when substantial heterogeneity was detected, to provide more conservative estimates where heterogeneity was present. Leave-one-out sensitivity analysis was conducted where significant heterogeneity was observed to identify the impact of individual studies on the

overall findings, by systematically excluding one study at one time to detect outliers that disproportionately contribute to heterogeneity. Due to the limited number of studies, meta-regression and subgroup analysis were not performed [32].

Results

Figure 1 presents the PRISMA flow diagram illustrating the search results. Initially, 6701 articles were identified across the five databases. Following the removal of 31 duplicates, 6670 studies remained for relevance assessment. After screening titles and abstracts, the full texts of 212 studies were examined for eligibility. Ultimately, 12 trials were included in this review.

Figure 1. PRISMA flow diagram



RCT, randomized controlled trial.

Study characteristics

Supplementary Material 2 provides an overview of the included articles. Trials were conducted across 10 countries in Asia, Europe and North America, including a total of 2,319

participants, with study sample sizes ranged from 50 to 562. Participants had a mean age of 58.68 years, with a majority being male (62.8%). Participants were diagnosed with heart failure (n=111, 4.79% of the 2,319),[24, 33] coronary heart disease (628, 27.08%),[34-36] a mixture of patients with CVDs and at high CVD risks (n=562, 24.2%),[37] controlled arrhythmia (n=491, 21.17%),[38-40] and general CVDs (n=527, 22.72%).[30, 41, 42] Eight trials focused on individuals with mild to moderate levels of anxiety or depression (n=1561, 67.31%).[30, 33-38, 41] Outcomes were assessed immediately post-intervention. Long-term follow-up data, ranging from one to five years post-intervention, was only collected in three studies [34, 38, 39].

Risk of bias

Figure 2 shows the results of the risk of bias assessment. Most trials were at low risk regarding random sequence generation, deviations from intended interventions, and missing outcome data. 'Some concerns' were related to inadequate reporting. Specific issues around detection bias were noted in trials by He [40], Humphries [34], and Clay [24] where they explicitly stated that blinding was not implemented due to the behavioral nature of interventions. This lack of blinding raises concerns about potential bias in outcome measurement, as participants and data assessors may have been influenced by knowledge of intervention assignments. Selection bias was consistently rated as low across all studies. In summary, although some studies were categorized as low risk, the presence of high or unclear risks in certain domains necessitates a cautious interpretation of the compiled results. In addition, we recommend adherence to standardized reporting practices using the CONSORT guidelines, which provide a structured framework for transparent reporting of study design, procedures, and outcomes, reducing the potential for bias and improving replicability.

Figure 2. Risk of Bias Assessment

	Risk of bias domains					Overall
	D1	D2	D3	D4	D5	
Clay 2021	+	-	+	-	+	-
Davidson 2013	+	+	+	+	+	+
Glozier 2013	+	+	-	+	+	-
Humphries 2021	-	+	+	-	+	-
Johansson 2019	+	+	+	+	+	+
Lungren 2016	+	+	+	+	+	+
Norlund 2018	-	+	+	+	+	-
Habibović 2014	+	+	+	+	+	+
He 2023	+	+	+	-	+	-
Lambert 2021	+	-	-	+	+	-
Younge 2015	+	+	-	+	+	-
Jowik 2021	-	-	-	+	+	X

Study

Domains:
D1: Bias arising from the randomization process.
D2: Bias due to deviations from intended intervention.
D3: Bias due to missing outcome data.
D4: Bias in measurement of the outcome.
D5: Bias in selection of the reported result.

Judgement
X High
- Some concerns
+ Low

Intervention characteristics

Four types of psychological interventions were examined across the 12 trials, including most commonly internet-based cognitive behavioral therapy (ICBT) [24, 33-38, 41], followed by mindfulness-based interventions [40, 42], problem-solving therapy [39], and stress

management.[30]

For ICBT interventions, most incorporated core CBT techniques like behavioral activation, worry management, and problem-solving. Specific areas such as psychoeducation[33, 35] or the psychosocial aspects of Implantable Cardioverter Defibrillators[38] were the focus of some interventions. Additionally, certain programs integrated additional therapeutic methods, including Interpersonal Therapy [37] or mindfulness [24]. The interventions employed a variety of platforms, from multimedia supports to tele-monitoring devices and expert systems for automated guidance. Some featured interactive web-based group settings with discussion forums and secure email systems for queries. For instance, one study provided customization options that allowed participants to tailor their treatment paths after completing compulsory modules [34].

Mindfulness interventions also differed in their approaches. One employed a Brain-Computer Interface app with real-time EEG monitoring to facilitate dynamic monitoring over a 35-minute mindfulness exercise, such as body scanning and relaxation techniques [40]. The other offered a more traditional 12-week online course, encompassing various meditation types like self-reflection and yoga, supported by bi-weekly reminders [42]. The 12-week problem-solving therapy, focusing on psychoeducation, utilized bi-weekly emails to foster adherence [39]. For stress management, a two-stage strategy was adopted: participants initially engaged in either a self-guided or lay-coach-supported web program, with non-responders escalated to a more intensive program that included motivational interviewing [30].

The interventions were delivered by a diverse group of professionals as well as non-professionals. In four trials, the intervention was delivered by mental health professionals, including a mental health nurse [33], psychologists [35, 38, 39]; in other studies the

intervention was delivered by a multi-disciplinary team [24, 36], a therapist [34] nurses[40, 41] a trained lay coach,[30] and finally two had only a self-directed approach [37, 42].

Recruitment, attrition, and adherence

Recruitment and attrition rates were considered acceptable.[30] The included trials showed an overall recruitment rate of 42% (ranging from 10-85%). Regarding attrition, the median attrition rate was 19% (5-24%) in intervention groups and 8% (ranging from 3-43%) in control groups. In the intervention groups, there were 231 dropouts out of 1213 participants with 6 (4%) dropouts were due to health-related reasons, while 96% were due to unspecified non-health-related reasons. In the control groups, there were 108 dropouts out of 1106 participants, with 3 (6%) due to unspecified health-related reasons and 94% due to non-health-related reasons. It is noteworthy that unspecified non-health reasons were the most common cause of dropouts in both the intervention and control groups (Supplementary Material 3).

Adherence to the eHealth interventions varied across the interventions, ranging from 20% to 73%; two studies did not report the adherence rate.[36, 42] Key factors contributing to low adherence included technical issues (e.g., insufficient computer literacy),[24, 34] time constraints and emotional discomfort evoked by the intervention. In addition, one study found that coach calls, originally designed to last 10-15 minutes, often exceeded this time frame due to technical challenges.[30]

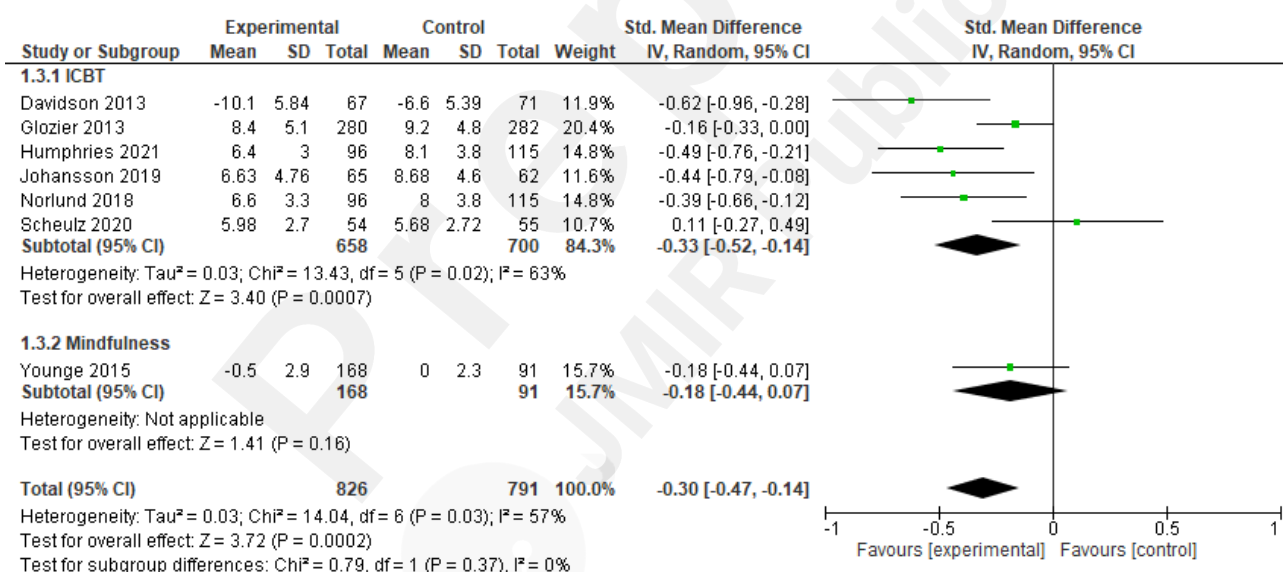
eHealth intervention effectiveness

Depressive symptoms

Figure 3a display the forest plot for the pooled results on depression. Depression was measured by eleven studies using the Hospital Anxiety and Depression Scale (HADS), [34, 35, 38, 42] Beck Depression Inventory,[24, 36] PHQ-9,[33, 37, 39, 41] or the

Depression, Anxiety, and Stress Scale (DASS).[30] Data pooling of seven trials revealed significant reduction in depression symptoms for participants receiving eHealth psychological intervention compared with the control group receiving usual care or active control (online education[37] and web-based discussion forum[41]) [standardized mean difference (SMD)=-0.30, 95% confidence interval (CI; -0.47,-0.14), $I^2=57\%$, $P < .001$]. Sensitivity analysis of the six studies where ICBT was provided revealed significant improvement in depression when compared to the control group [SMD=-0.39, 95%CI (-0.56, -0.21), $I^2=53\%$, $P<.001$]. Data pooling of five trials that compared eHealth psychological intervention with usual care suggested similar magnitude of effect [SMD= -0.32, 95% CI (-0.54, -0.1), $I^2=63\%$, $P<.01$]

Figure 3 a Forest Plot showing the efficacy of eHealth psychological interventions on depression.



SWiM was conducted for four trials. Of these two ICBT trials, one showed significant improvement in the percentage of participants with lower depression compared with usual care [24]; and one study reported significant within-group improvement in the intervention group but no significant between-group differences, since active control: website-based discussion forum was used [33]. The trial of problem-solving therapy[39] and stress

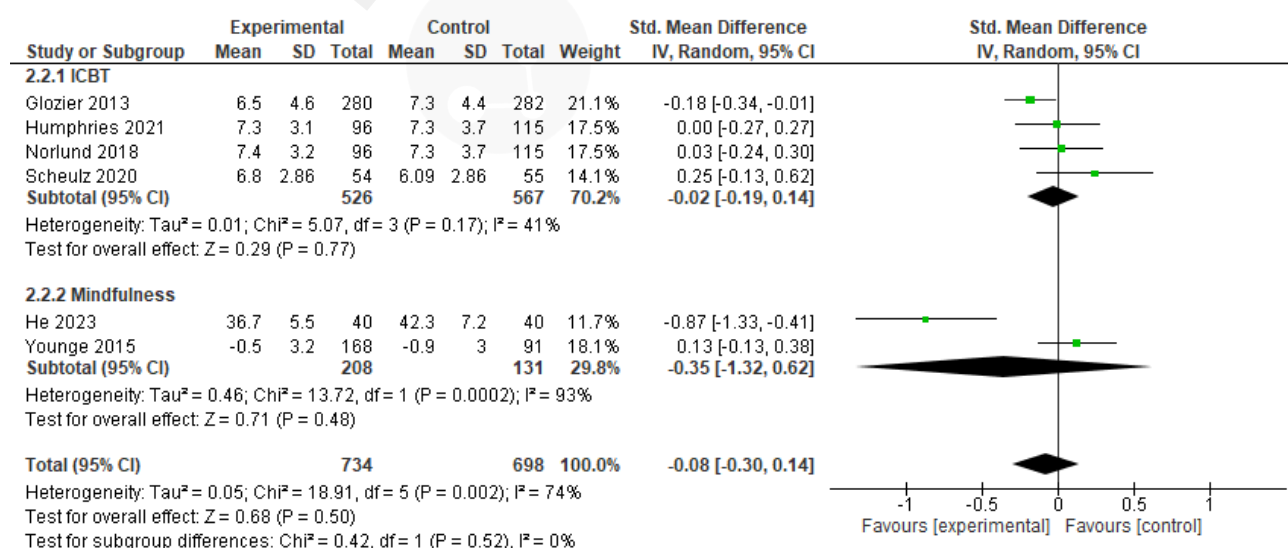
management [30] revealed no significant effect on depression compared to usual care.

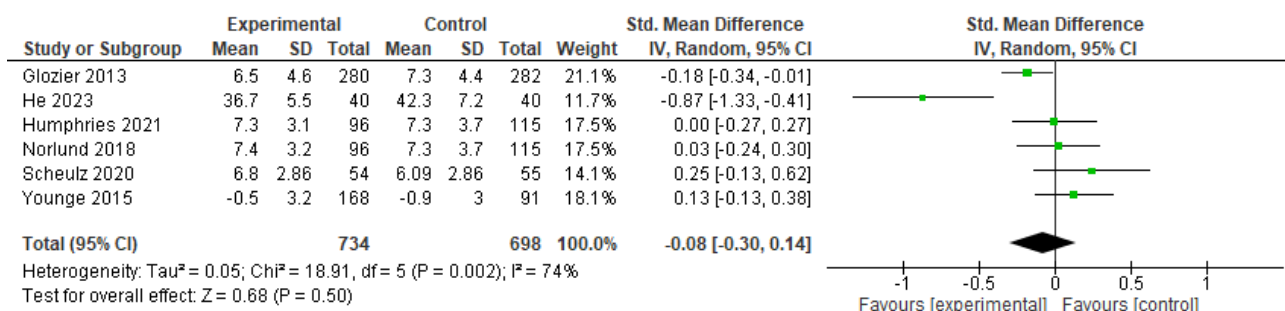
Anxiety

Eleven studies measured participants' anxiety level, using State-Trait Anxiety Inventory Form Y,[24] National Institutes of Health Patient Reported Outcomes Measurement Information System anxiety short form,[36] Cardiac Anxiety Questionnaire, [33-35, 37-39] State Anxiety Inventory,[40] HADS,[42] and DASS.[30]

Data pooling of six of these trials showed no significant improvement in anxiety symptoms among participants receiving eHealth psychological interventions of ICBT or mindfulness[42] (SMD=-0.08, 95% CI -0.13,0.14, $I^2=74\%$, $P=.50$) (Figure 3b). SWiM was conducted for five trials. Of these, one trial which provided ICBT with other lifestyle promotion showed significant reduction in anxiety level when compared to usual care ($P<.01$)[24] and two others also provided ICBT alone showed no significant improvement in anxiety level compared to usual care[36] or website-based discussion forum.[33] Problem-solving therapy[39] and stress management[30] had no significant effect on anxiety level compared to usual care.

Figure 3b: Forest Plot showing the efficacy of eHealth psychological interventions on anxiety.





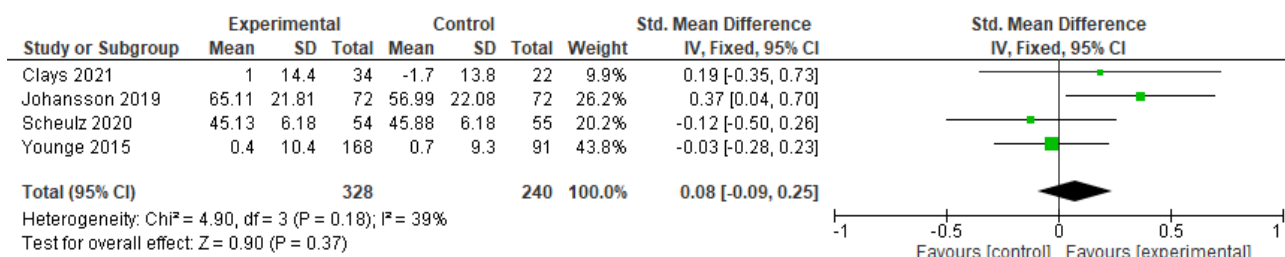
Stress

One trial delivering mindfulness training revealed no significant improvement in stress level as measured by Perceived Stress Scale compared to usual care [42]. In another trial delivering stress management, no significant improvement in stress level measured by the DASS was observed compared to usual care [30].

Health-related quality of life

Figure 3c displays the forest plot for the pooled results on HRQoL. Eight studies measured HRQoL, using either the Minnesota Living with Heart Failure Questionnaire,[24, 33] SF-12,[30, 36, 39] SF-36,[38, 42] and Euro Qol Visual Analogue Scale [41]. Data pooling of four trials reporting an overall score or the mental dimension (where the overall score was unavailable) revealed no significant improvement in HRQoL (SMD=0.08, 95% CI -0.09, 0.25, $I^2=39\%$, $P=.37$) compared to usual care [24, 38, 42] or website-based discussion forum.[41] Trials testing ICBT [33, 36], problem-solving therapy [39], and stress management [30] showed no significant effect on HRQoL when compared with usual care or website-based discussion forum [33].

Figure 3c: Forest Plot showing the efficacy of eHealth-based psychological interventions on health-related quality of life.



Adverse events and cardiovascular events

Three studies where ICBT was delivered reported on participants at risk of deliberate self-harm detected by a validated depression scale similar number (21 in the intervention group and 23 in the control group [37] and 2 in the intervention and 3 in the control group[35]) or fewer number (1 in the ICBT group, 2 in control group) [41].

Four trials comparing ICBT to usual care reported cardiovascular outcomes. One reported significant reductions in 1-year and 3-year mortality risk within group but not between group [24], another lower hospitalization-related costs non-significantly (-\$1010; 95%CI, -\$3294 to \$1274; $p = .39$) [36], yet another similar frequency in hospitalization,[38] and finally one showed a not significantly higher number of cardiovascular events (intervention group 36 cases and control group 25 cases) [34]. One study providing mindfulness training reported 5 and 10 participants with fluctuations of >50 mmHg in systolic blood pressure in the intervention and control groups, respectively [40].

Discussion

The aim of this review was to assess the effects of eHealth psychological interventions in improving psychological outcomes among individuals with CVDs. This is the first review of such interventions in CVD demonstrating they effectively reduce depression. The significant improvement identified could be attributed to the use of structured, evidence-based interventions, chiefly ICBT compared to usual care, website-based discussion forums or education. These findings are consistent with other reviews in more general populations or those with other chronic conditions on the benefits of ICBT [43]. While the effects of ICBT on anxiety were not significant, more data on the effects of other eHealth psychological interventions, as well as their effects on stress, HRQoL, and cardiovascular events are needed prior to drawing conclusions.

The effectiveness of eHealth psychological interventions in reducing depression among CVD patients is noteworthy. This finding is consistent with previous literature that reported the effectiveness of traditional (i.e., non-technologically based) non-pharmacological psychological interventions in alleviating depression among CVD patients [44]. Another similarity is that CBT is identified as the most commonly used psychological therapies for CVD patients, followed by mindfulness and other stress management intervention [44, 45]. However, previous CVD meta-analyses of traditional psychological intervention showed inconsistent outcomes regarding clinical outcomes, including cardiac events and mortality [45, 46]. One review found a small but nonsignificant effect of non-pharmacological psychological interventions in reducing cardiac mortality (relative risk 0.80, 95% CI = 0.64 to 1.00, $p = .56$, $I^2 = 0\%$) for patients with coronary heart disease [47]. Conversely, one meta-analysis suggested significant improvement in cardiac mortality (RR = 0.81, 95 % CI = 0.68 to 0.96) and the occurrence of cardiac events among

participants who received psychological interventions compared to control group participants [45]. In this review, the clinical outcomes were not assessed or reported by most of the included studies, which hindered evaluation of the effect of eHealth psychological intervention on this parameter.

The impact of eHealth interventions on anxiety and health-related QoL were inconclusive. This may be because the applied interventions did not fully address the inherent complexities of anxiety or the multifaceted nature of HRQoL faced by patients with CVDs [48]. For anxiety, specific therapeutic strategies -- such as exposure therapy or specialized CBT approaches tailored and proven effective for anxiety management [49] -- were not the primary focus of these trials. Additionally, improving HRQoL in CVD goes beyond psychological well-being to include improvement in physical endurance, social engagement, and daily functioning [48]. Effective interventions would need to integrate elements such as physical rehabilitation exercises, social skills training, and occupational therapy to holistically address HRQoL. This highlights a gap in the current therapeutic approaches and underscored the necessity for more integrative eHealth intervention designs tailored to such needs of CVD patients. The varied effectiveness likely also stems from the differing technology used and guidance levels in the interventions. For instance, mindfulness is shown to be effective in face-to-face sessions [50]; its key strengths - deep interaction and personalized adjustment - may not translate as effectively to eHealth formats.

This review supports recommendation of ICBT as a standard treatment for depression for CVD patients [51]. However, considering a previous review focusing on face-to-face CBT which showed comprehensive and significant improvements in depression as well as anxiety and HRQoL among patients with CVDs [52], patient concerns / diagnoses and preferences must be considered. Two factors might explain the differences: (1) the prior

review focused exclusively on participants diagnosed with mental disorders, whereas this review included a broader demographic of CVD patients, and (2) the inherent interpersonal interactivity and potential personalization of face-to-face CBT, which can help patients recognize and modify unhelpful thinking patterns, might be superior compared to online portals and discussion forums. Despite this, the resource-intensive and costly aspects of traditional CBT [53], coupled with the dynamic nature of mental health conditions among participants, highlight the potential of alternative delivery methods such as eHealth.

Moreover, a deeper examination of the eHealth modalities employed by the studies included in this review reveals several unique strengths compared to traditional methods. First, the temporal attributes of some ICBT interventions that allowed dynamic tele-monitoring and daily tracking of heart rate, skin response, temperature and physical activity levels as well as support systems to provide tailored advice based on participants' tele-monitoring results and progress are promising [24]. Second, in some trials, intervention adherence was tracked using built-in website counters of online course participation, with professionals providing individualized feedback on participants' ICBT assignments for cognitive restructuring and behavioral activation [24, 33-38, 41]. Cognitive restructuring requires participants continuously complete homework, identifying and modifying detrimental thought patterns as well as engaging in positive and meaningful activities. Thus, supporting participants to practice ICBT in their daily life coupled with the online support of professionals through time could be one unique strength of this mode, leading to sustainable effects [54]. Lastly, eHealth modality allows for a confidential platform whereby participants can reveal negative thinking patterns, and professionals can monitor progress and provide timely feedback or treatment plan adjustments. eHealth offers unique strengths in accessibility, scalability, and personalization [55].

When harnessing the capabilities of eHealth, it is important to note that technology

serves as a tool and cannot replace the therapeutic encounter and rapport. Mental health professionals play a crucial role as gatekeepers in the creation and implementation of eHealth psychological interventions [5, 56]. Their analysis of patients' self-monitoring data and provision of real-time feedback are crucial for quality care and outcome optimization. Additionally, these professionals are instrumental in tailoring treatment to the patient's context, such as for managing workplace stress, or other inciting factors in their physical and psychosocial environments, thereby enhancing intervention applicability and impact [56].

Implications

Some practice implications are important to consider. First, many CVD patients continue to suffer with unrecognized comorbid psychological conditions. With more patients adopting technology and with technological advances, adoption, acceptance, quality and efficacy of eHealth psychological interventions may improve. Second, it may be important to be more selective in allocating patients to eHealth psychological interventions, such that patients who do not prefer technology, or who have no, or severe psychological conditions should be provided with alternative intervention. Finally, in addition to considering patient preference, stepped care -- such as was implemented in one included trial -- should be pursued so non-responding patients can receive care through to remission and so that their excess cardiovascular risk is reduced [36].

Several implications for future studies are noteworthy. Studies may consider combining ICBT with antidepressants, as guidelines from the American Heart Association (AHA) and American Academy of Family Physicians (AAFP) recommend such combination for the treatment of post-ACS depression [57, 58], addressing both psychological and physiological causes as well as outcomes of depression in this population. Strategies such

as enhancing eHealth platform interactivity for real-time feedback, using adaptive algorithms for personalized therapy, and integrating virtual or augmented reality for immersive experiences could enable achievement of comparable benefits to traditional therapeutic sessions [59].

Limitations

The review is limited by the limited available trials in this field. Moreover, while publication bias was evaluated by comparing findings with registered trials and published protocols, meta-regression and funnel plot asymmetry assessment for publication bias was not possible. The participants were predominantly middle-aged or young-older adults from developed countries, which may limit the generalizability of the findings to older age groups or cultures unfamiliar with western psychological treatment approaches. Despite using a table to provide a clearer description of how psychological intervention was delivered via e-platforms, caution is needed in interpreting the results and replicating the interventions, as most included studies employ mixed eHealth approaches, combining multiple intervention modalities. Future studies should also ensure best practices are applied in terms of randomization, allocation, and blinding methods to enhance evidence quality.

Conclusion

In this first review of eHealth-based psychological interventions for CVD patients, these interventions, particularly ICBT, were established to significantly reduce depressive symptoms but not anxiety, with effects on stress, HRQoL, and cardiovascular events unclear. Urgent research is needed to assess the long-term impact, scalability, and accessibility of these interventions, which could play a transformative role in improving psychological well-being in this population. Collaboration among researchers, policymakers and multi-disciplinary cardiovascular health professionals is critical to advancing this field.

Incorporating persuasive design elements such as goal setting and motivational feedback, harnessing the temporal (time-sensitive) intervention attributes of eHealth, along with mental health professional involvement, will be key to maximizing the effectiveness of eHealth approach for CVD care.

Acknowledgments: This research was funded by the Ministry of Health, Czech Republic, conceptual development of research organization (FNBr 65269705). We also acknowledge the funding support from Sigma Theta Tau, 2023 Sigma Small Grant.

Data availability statement: Data sharing is not applicable to this systematic review and meta-analysis as no new data were created in this study.

Conflict of Interest: There is no conflict of interest

Author Contributions: **JJS:** Conceptualization, Data curation, Formal analysis, Investigation Methodology, Visualization, Writing – original draft; **RL:** Data curation, Investigation, Methodology, Visualization, Validation, Writing – original draft; **AKW:** Writing – review & editing; **LB:** Writing – review & editing; **SG:** Writing – review & editing

AI disclosure: No generative AI or automated tools were used in the writing, editing, or preparation of this manuscript.

Abbreviation

AHA:	American	Heart	Association
AAFP: American Academy of Family Physicians			
CI: Confidence interval			
CVD: cardiovascular diseases			
DASS: Depression, Anxiety, and Stress Scale			
HADS: Hospital Anxiety and Depression Scale			
HRQoL: health-related quality of life			
ICBT: internet-based cognitive behavioral therapy			
MeSH: Medical Subject Headings			
PHQ-9: Patient Health Questionnaire			
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses			
RCT: Randomized controlled trials			
RR: risk ratios			
SF-12:	Short	Form	12
SF-36: Short Form 36			

SMD: standardized mean difference



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Figure legend

Figure 1. PRISMA flow diagram

Figure 2. Risk of Bias Assessment

Figure 3 a Forest Plot showing the efficacy of eHealth psychological interventions on depression.

Figure 3b: Forest Plot showing the efficacy of eHealth psychological interventions on anxiety.

Figure 3c: Forest Plot showing the efficacy of eHealth-based psychological interventions on health-related quality of life.



Supplementary Files

Untitled.

URL: <http://asset.jmir.pub/assets/4d66d30400bd1fe8f473a09e88f4ccd6.docx>

Multimedia Appendixes

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