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Effectiveness of digital psychological and psychoeducational interventions to prevent anxiety: Systematic review and meta-analysis of randomized controlled trials

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Review Article

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Abstract

The high incidence of new cases of anxiety disorders highlights the need for scalable preventive interventions, which can be achieved through information and communication technologies. To our knowledge, no meta-analysis has been conducted to evaluate purely digital preventive interventions for anxiety in all types of populations. The aim of this study was to assess the effectiveness of digital interventions for the prevention of anxiety disorders. Systematic searches were conducted in six electronic databases (PubMed, PsycINFO, EMBASE, Web of Science, OpenGrey, and CENTRAL) from inception to December 12, 2024. Inclusion criteria for the studies were as follows: (1) randomized controlled trials (RCTs), (2) psychological or psychoeducational digital interventions to prevent anxiety, and (3) all types of populations without anxiety at baseline of the study. A total of 15 studies (19 comparisons; 6093 participants) were included in the systematic review. One study was identified as an outlier and was therefore excluded from the meta-analysis. The pooled analysis showed a small effect in favor of preventive interventions among non-anxious and varied populations (standardized mean difference = −0.32, 95% confidence interval: −0.44 to −0.20; $p < 0.001$). Sensitivity analyses supported the robustness of this finding. We found no evidence of publication bias. Heterogeneity was high, however, a meta-regression that included one variable (country, the Netherlands) explained 100% of the variance. All RCTs, except two, had a high risk of bias, and the quality of the evidence, according to Grading of Recommendations Assessment, Development, and Evaluation, was very low. There is a need to develop and evaluate new digital preventive interventions with a rigorous methodology.

Introduction

In 2019, an estimated 301 million people worldwide were living with anxiety disorders, representing a 54.64% increase between 1990 and 2019 (GBD 2019 Mental Disorders Collaborators, 2022). Moreover, among mental disorders, anxiety disorders account for 22.9% of disability-adjusted life years (DALYs), second only to depression, and are the eighth leading cause of years lived with disability (GBD 2019 Mental Disorders Collaborators, 2022). In 2020 alone, anxiety disorders caused 44.5 million (30.2–62.5) DALYs globally (COVID-19 Mental Disorders Collaborators, 2021). In 2012, the estimated costs derived from anxiety in Europe were approximately €74,380 million, of which 62.2% were direct medical costs, 0.2% were direct nonmedical costs, and 37.6% were indirect costs (Olesen, Gustavsson, Svensson, Wittchen, & Jönsson, 2012).

Although there are many effective treatments available for anxiety disorders (Bandelow et al., 2015), often people do not have access to them for a variety of reasons, such as diagnostic errors, poor treatment adherence, or inadequate treatment (Chapdelaine, Carrier, Fournier, Duhoux, & Roberge, 2018; Fernández et al., 2007). This is particularly problematic because, while efforts to reduce the burden of anxiety disorders have largely focused on closing the 'treatment gap', recent analyses suggest that this alone may not be sufficient. Beyond increasing access to treatment,

addressing a 'quality gap' – ensuring treatments meet clinical guidelines and reach those in greatest need – is also crucial. Additionally, a 'prevention gap' may exist, where resources for reducing incidence through prevention have lagged behind treatment efforts (Jorm, Patten, Brugha, & Mojtabai, 2017). There seems to be a lack of awareness of the importance of prevention programs and mental health promotion, leading to a disproportionate allocation of funding and resources toward treatment rather than prevention in most countries (WHO, 2021).

Different psychological and educational interventions have proven to be effective in preventing anxiety disorders, yielding a small but significant effect, standardized mean difference (SMD) = −0.31 (95% confidence interval [CI]: −0.40 to −0.21; $p < 0.001$), according to a previous meta-analysis that included data from 29 randomized controlled trials (RCTs) (Moreno-Peral et al., 2017). However, to effectively reduce the incidence of anxiety, these interventions must be accessible to a broad population. Information and communication technology is emerging as a reliable solution to address some of these issues. In 2023, a total of 5.16 billion people were Internet users, equivalent to 64.4% of the world's total population (We Are Social & Meltwater, 2023). Computerized interventions offer a more cost-effective way of scaling up preventive interventions. They also offer several additional advantages over traditional methods such as anonymity, enhanced flexibility and accessibility, allowing users to access them at any time and from virtually any location, lower costs compared to face-to-face interventions, the ability to bridge geographic distances, and the option to revisit therapy material as needed (Khanna, Aschenbrand, & Kendall, 2007; Schuster, Topooco, Keller, Radvogin, & Laireiter, 2020).

As a result, the number of digital mental health interventions is rapidly accelerating. This method has already been proven effective for the treatment of anxiety disorders, showing that online interventions can be as effective as face-to-face treatments, with a combined effect size (*Hedge's g*) of approximately 0.80, and disorder-specific effect sizes between 0.62 and 1.31 (Andrews et al., 2018; Eilert et al., 2020; Pauley, Cuijpers, Papola, Miguel, & Karyotaki, 2023). A recent meta-analysis by Pauley et al. (2023) also performed subgroup analyses comparing guided versus unguided online interventions for the treatment of anxiety and found no differences in effectiveness between these delivery methods, suggesting that even self-administered digital interventions can be as effective as face-to-face therapy.

Evidence on the effectiveness of digital interventions for the prevention of anxiety remains limited, with few meta-analyses specifically addressing these types of programs. One of these, by Pennant et al. (2015), reviewed the evidence for all types of computerized interventions for anxiety and depression in children and young people (5–25 years of age). The results highlighted potential benefits for the general population of young people (SMD = −0.15), although the effect sizes were smaller compared to those observed in participants with mild to moderate anxiety or those considered 'at risk' (SMD = −0.77). Later, Sander, Rausch, and Baumeister (2016) conducted a systematic review and meta-analysis to evaluate the effectiveness of existing Internet-based preventive interventions for mental disorders, supporting effective preventive interventions for subthreshold anxiety. Another meta-analysis conducted by Deady et al. (2017), which assessed eHealth interventions for the prevention of depression and anxiety in the general population (18–64 years old), found a similar small but significant effect size for both outcomes, with an overall mean difference of 0.31 for anxiety symptoms. Most recently, a meta-analysis conducted by Edge, Watkins, Limond, and Mugadza (2023) on self-guided computerized interventions for the prevention of anxiety and/or depression in adults (>16 years of age) found a small but significant effect of these interventions on reducing anxiety symptomatology (overall SMD = −0.21, $p < 0.001$). Nevertheless, these studies were limited to specific age ranges (Deady et al., 2017; Edge et al., 2023; Pennant et al., 2015), had very specific inclusion criteria (such as including only self-guided interventions) (Edge et al., 2023), did not limit inclusion solely to studies on the prevention of anxiety but also encompassed its treatment, or only reported mean scores without clearly stating that participants did not exceed clinical cut-offs at baseline (Edge et al., 2023; Pennant et al., 2015). For these reasons, a meta-analysis should be carried out with the most recent data, including only purely preventive studies, that is, those that include participants without a diagnosis of anxiety disorder at baseline/before enrolling in the study. Thus, we aimed to conduct a meta-analysis of RCTs assessing the effectiveness of digital psychological interventions for the prevention of anxiety disorders in all types of populations.

Materials and methods

This study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for reporting systematic reviews and meta-analyses (Page et al., 2021). This meta-analysis is also registered with the International Prospective Register of Systematic Reviews (registration number: CRD42022307194).

Selection criteria

Among all the experimental designs that can be used to measure effectiveness, we selected RCTs since they have the lowest risk of bias (Piantadosi, 2005). We focused on psychoeducational and/or psychological interventions. Studies or arms that compared other types of interventions were excluded. Psychoeducational interventions consist of providing information about anxiety through lectures or fact sheets, whereas psychological interventions attempt to change how people think, their behaviors, and their learning skills by using a variety of strategies or therapeutic approaches (e.g. cognitive behavioral therapy [CBT] or systemic therapy).

We only included those studies that excluded participants with an anxiety disorder at baseline, or those that provided separate results for non-anxious participants at baseline, by using a standardized interview (e.g. Structured Clinical Interview for DSM Disorders), or validated self-reports with standard cut-off points (e.g. Beck Anxiety Inventory II). In these cases, only the non-anxious participants were included in the analysis. We included studies in all types of populations, regardless of age, sex, clinical, or health condition (e.g. pregnancy) and regardless of where they are recruited (general population, primary care, mental health clinics, etc.). The allowed comparators were care-as-usual, no intervention, waiting list for intervention, or attention control. The intervention had to be entirely digital; therefore, combined digital and face-to-face sessions ('blended interventions') were excluded. Outcomes included the incidence of new cases of any DSM-5 anxiety disorder and/or the reduction in anxiety symptomatology measured by standardized interviews or validated symptom scales. There were no restrictions on the language or setting of the studies.

Search strategy

In this meta-analysis, we searched six electronic databases including PubMed, PsycINFO, EMBASE, Web of Science, OpenGrey (System for Information on Grey Literature in Europe, which links

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to DANS Easy Archive), and CENTRAL (Cochrane Central Register of Controlled Trials) from inception to December 12, 2024. The specific search strategies used in each database are provided in Appendix A. Additionally, the reference list of existing systematic reviews on the topic (Andrews et al., 2018; Deady et al., 2017; Edge et al., 2023; Eilert et al., 2020; Linardon et al., 2024; Moreno-Peral et al., 2017; Newby, Twomey, Yuan Li, & Andrews, 2016; Noh & Kim, 2023; Pauley et al., 2023; Pennant et al., 2015; Sander, Rausch & Baumeister, 2016; Seegan, Miller, Heliste, Fathi, & McGuire, 2023) was manually revised, in order to find additional studies. Online trial registers were also consulted, specifically ClinicalTrials.gov and Australia New Zealand Clinical Trials Register. We also consulted experts in the field to identify any new studies that met our inclusion criteria.

Study selection

After removing duplicates, all studies were initially reviewed based on their title and abstract by two pairs of reviewers (PMP and CGH, SCC, and CMV). Studies that did not meet the eligibility criteria were excluded. Potentially eligible studies then underwent a full-text review for final inclusion, using the same method. Any discrepancies were discussed and resolved by consensus.

Data extraction

The data extracted from each selected study were compiled in an evidence table. Specifically, we extracted data concerning: (a) bibliographic information (such as author, year, country); (b) characteristics of the participants (such as mean age, symptoms of anxiety); and (c) characteristics of the RCTs (such as sample size, type of intervention, type of comparator, or outcome). This process was also conducted by two reviewers (PMP and SCC) and replicated by another two (CGH and CMV). Any discrepancies were discussed and resolved by consensus.

Risk of bias

The quality of each included RCT was assessed in accordance with the Cochrane Collaboration's Risk-of-Bias (RoB) 2.0 tool, based on five dimensions: (1) bias arising from the randomization process; (2) bias due to deviations from the intended interventions; (3) bias due to missing outcome data; (4) bias in measurement of the data; and (5) bias in selection of the reported result. This tool classifies each RCT as having *low risk of bias*, if all dimensions are categorized as low risk; *some concern of bias*, if one or more dimensions are categorized as some concerns, but none are classified as high risk; or *high risk of bias*, if at least one dimension is categorized as high risk, or multiple domains are categorized as some concerns in a way that substantially reduces confidence in the results (Sterne et al., 2019). Each of the five dimensions was assessed both qualitatively (categorized as low risk of bias, some concerns, or high risk of bias) and quantitatively (receiving zero, one, or two points, respectively). This assessment was conducted in duplicate by two researchers (PMP and SCC), and any discrepancy was resolved through consensus.

Statistical analysis

All analyses were carried out using the STATA statistical package (version 14.2) and Comprehensive Meta-Analysis (CMA version 2.2.064).

When the outcome was differences in anxiety symptoms, the mean scores and standard deviations were extracted, and SMDs between the intervention and the control groups were calculated and used to estimate the pooled effect size. When an RCT only provided data on the incidence of anxiety, the CMA package was used to convert it into an SMD. We used the SMD because most of the RCTs included in our meta-analysis reported differences in anxiety symptoms. For each RCT, SMD was calculated by combining this parameter from the different post-intervention follow-up assessments into a mean estimated difference, and its 95% CI. For any RCT that included two different intervention groups and a single control group, standard errors in nested comparisons in the same RCT were inflated, following the recommendation of Cates (Rücker, Cates, & Schwarzer, 2017). Negative SMDs indicated an improved outcome (reduction of anxiety symptoms) in the intervention group. Cohen proposed the following interpretation of effect sizes as −0.2 small, −0.5 medium, and −0.8 large (Lachenbruch & Cohen, 1989). A priori, a random-effects model was used to estimate the pooled effect size on the assumption that the RCTs included in our meta-analysis were conducted in heterogeneous populations. Moreover, RCTs with disproportionately high effect sizes were excluded a priori to minimize the impact of extreme outliers on the pooled results.

Heterogeneity was assessed using the I^2 statistic, where an I^2 of 0%–40% indicates not important heterogeneity; 30%–60% moderate heterogeneity; 50%–90% substantial heterogeneity; and 75%–100% considerable heterogeneity, according to the Cochrane Handbook (Higgins et al., 2019). To determine whether differences in the effect sizes of the individual studies exceeded those that would be expected due to chance, we used the Q-test, considering $p > 0.10$ as nonsignificant heterogeneity.

We evaluated publication bias by assessing funnel plot asymmetry using the Duval and Tweedie (2000) trim-and-fill procedure. This procedure yields an adjusted pooled effect size after accounting for missing studies due to publication bias. To objectively assess this asymmetry, we also performed the rank correlation test (Begg & Mazumdar, 1994) and the Egger test.

Subgroup analyses were performed using a mixed-effects model according to:

(a) Characteristics of the sample: continent, mean age, recruitment setting, and sample size.
(b) Characteristics of the intervention: type of prevention (universal, selective, or indicated), therapeutic approach (e.g. CBT, psychoeducation), presence of guidance, number of sessions, and intervention format (e.g. web-based, videoconference).
(c) Methodological characteristics: type of outcome (primary/secondary), type of outcome measure (symptom scale vs. standardized diagnostic interview), comparator, adherence rate, risk of bias, and duration of follow-up.

We conducted sensitivity analyses at the first and last follow-up, using Hedge's *g*, and excluding from the analysis the RCT that caused the greatest increase in heterogeneity.

We also performed bivariate random-effects meta-regressions (with only one moderator included in each model), which enables the estimation of robust standard errors for random effects (Knapp & Hartung, 2003). The post hoc analysis strategy to explain the maximum heterogeneity consisted of obtaining the most parsimonious meta-regression model (including the least number of variables) with the best goodness of fit. We used the Higgins and Thompson permutation-test approach to calculate *p* values, taking into account multiplicity adjustments (Higgins & Thompson, 2004).

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The quality of evidence

The quality of the evidence was assessed using the 'Grading of Recommendations Assessment, Development, and Evaluation' (GRADE) working group methodology. This method evaluates the following domains: risk of bias, consistency, directness, precision, and publication bias (Balshem et al., 2011).

Results

Study selection

After concluding the search in six databases, and consulting experts and references from previous research, a total of 6793 articles were retrieved. After removing 1116 duplicates, 5677 studies were reviewed based on their titles and abstracts. Of these, 208 underwent full-text review, ultimately resulting in the selection of 11 RCTs that met the inclusion criteria for the meta-analysis. In addition, four RCTs that met all criteria except for excluding participants with anxiety at baseline were included after the author(s) provided data specific to participants who did not exceed the anxiety threshold at the beginning of the study. This resulted in a final sample of 15 RCTs (Bendtsen, Müssener, Linderoth, & Thomas, 2020; Calear, Christensen, Mackinnon, Griffiths, & O'Kearney, 2009; Christensen et al., 2014; Cukrowicz & Joiner, 2007; Fledderus, Bohlmeijer, Pieterse, & Schreurs, 2012; Fonseca, Alves, Monteiro, Gorayeb, & Canavarro, 2020; Garcia-López et al., 2024; Howell, Rheingold, Uhde, & Guille, 2019; Lokman et al., 2017; Mak et al., 2024; Monteiro, Pereira, Canavarro, & Fonseca, 2020; Schotanus-Dijkstra et al., 2017; Topper, Emmelkamp, Watkins, & Ehring, 2017; Vivas-Fernández et al, 2023; Zarski et al., 2024). The selection process is detailed in a flowchart presented in Figure 1.

Study characteristics

Table 1 describes the characteristics of the 15 RCTs included in the systematic review. All were published between 2007 and 2024; four were conducted in the Netherlands, two in Spain, two in Australia, two in Portugal, two in the United States, one in China, and one in Sweden. The total number of participants included in the studies was 6093, and the sample size ranged between 68 and 1239 (median = 275, interquartile range = 410) and was comprised of adolescents and adults. Two studies focused specifically on postpartum women as their target population. Five of the studies focused on universal prevention, eight on selective prevention, and two on indicated prevention. The majority of studies (11) were based on CBT strategies for their interventions, two of them in positive psychology, one in acceptance and commitment therapy, and one combined CBT with other therapies. Comparators were a waiting list in eight RCTs, active control in six, and care as usual in one. Anxiety assessment was the primary outcome for eight of the RCTs, and the secondary outcome for another seven. Guidance was present in nine of the interventions and absent in the other six. The intervention format was web-based in ten studies, video conference in two, e-mail in two, and text messages in one. Anxiety outcomes were measured by symptomatology scales in all RCTs except one, which used a standardized diagnostic interview. The follow-up periods ranged between 8 and 52 weeks. Recruitment settings in these RCTs were general population in seven, educational in seven, and medical in one. Exclusion of anxiety cases at baseline was performed using symptom scales in seven trials, diagnostic interviews in four, and in four cases, the authors provided the data for participants without anxiety at the beginning of the study (those with a score below the cutoff in a validated symptom scale).

Study risk of bias

Of the 15 studies, 13 presented an overall high risk of bias, and only two (Garcia-López et al., 2024; Zarski et al., 2024) presented a low risk of bias. Regarding the randomization process, two studies had some concerns of bias, and the rest presented a low risk of bias. All the RCTs had a low risk of bias derived from deviations from the intervention. With respect to missing data, five studies presented a low risk of bias, whereas the rest presented a high risk. The measurement of the outcome led to a low risk of bias in five studies, and a high risk in the remaining 11. Finally, the risk of bias associated with the selection of the results was low in most of the studies, with some concerns in two studies (Table B.1, Appendix B).

Primary analysis

Figure 2 contains the forest plot. Although 15 studies were included in the systematic review, one (Lokman et al., 2017) was excluded from the meta-analysis because it reported an excessively large effect size and was identified as an outlier. After removing this study, the primary analysis shows a small preventive effect size SMD = −0.325 (95% CI: −0.44 to −0.20, $p < 0.001$). Between-outcomes heterogeneity was high I^2 = 72.4% (95% CI: 56%–83%) and statistically significant (Q-test $p < 0.001$).

Sensitivity analysis

Sensitivity analyses were conducted to assess the robustness of the results. Hedge's g indicates a small preventive effect size of −0.324 (95% CI: −0.447 to −0.200, $p < 0.001$). The effect size suffered a minimal decrease when using the results from the first post-intervention evaluation SMD = −0.311 (95% CI: −0.437 to −0.185, $p < 0.001$). When using data from the last follow-up, the pooled effect size remained practically unchanged SMD = −0.326 (95% CI: −0.453 to −0.200, $p < 0.001$) as compared to the primary analysis. Regarding age groups, smaller effect sizes were found in studies focusing exclusively on adolescents (SMD = −0.265), as well as in those in which the mean age of participants fell within the young adult range (SMD = −0.242). For studies targeting adult populations (mean age ≥ 30 years), the effect size increased compared to the primary analysis (SMD = −0.420). These results are presented in Table 2.

Publication bias

Regarding publication bias, two RCTs were imputed to enhance funnel plot symmetry. As a result, the adjusted pooled effect size increased, SMD_{adj} = −0.367(CI: −0.492 to −0.241; $p < 0.001$). Publication bias was statistically nonsignificant (Egger test, p = 0.978; Begg test p = 0.909). Figure C.1 (Appendix C) provides the adjusted funnel plot.

Subgroup analysis

Subgroup analyses revealed statistically significant between-group differences based on several factors including continent, sample mean age, sample size, recruitment setting, type of prevention, intervention format, therapeutic approach, guidance, type of anxiety outcome, and adherence rate. Further information can be found in Table D.1 (Appendix D).

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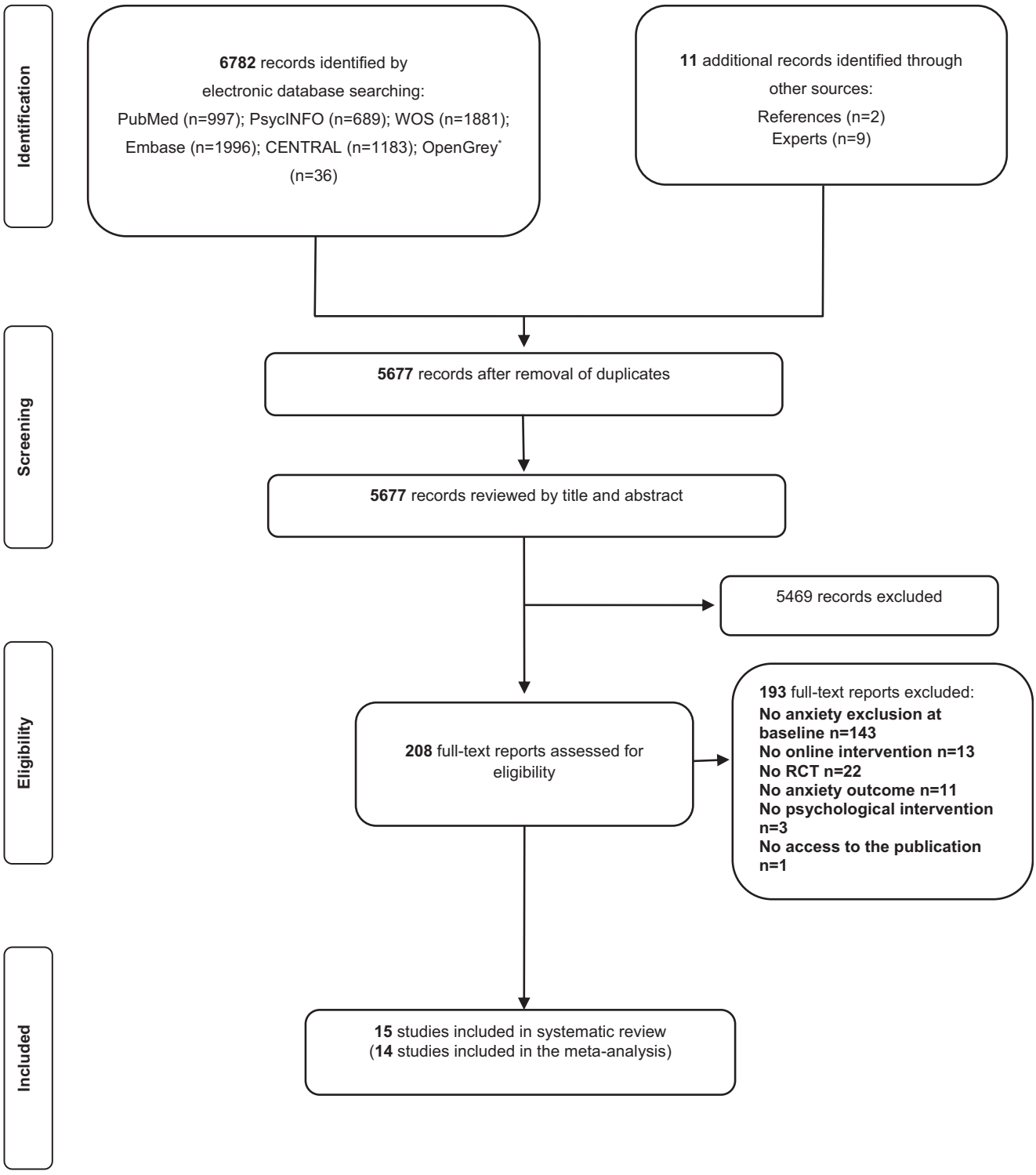

Figure 1. Flowchart of the inclusion of records in the systematic review and meta-analysis, according to the PRISMA guidelines.

Meta-regression

The results obtained by performing bivariate regressions can be found in Table E.1 (Appendix E). The final meta-regression model (Table 3) included only one variable, the country (The Netherlands) [$\beta = -0.538$ (95% CI: -0.708 to -0.368); $p < 0.001$], which was associated with a higher preventive effectiveness. This model explained 100.0% of the variance, and its goodness of fit was good (Figure F.1, Appendix F).

Quality of evidence

The initial quality of the evidence was rated as high, as we only included RCTs in this meta-analysis. Heterogeneity was considerable, and although this was fully explained by meta-regression, we reduced the rating from high to moderate. We further reduced the rating from moderate to low because only one study was assessed as having a low risk of bias. Conversely, no statistical

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Table 1. Characteristics of the studies included

Author/Year/ Country	Target population/ Type of prevention[a]/ Recruitment setting	Exclusion criteria for baseline anxiety	Sample (intervention/ control)	Inclusion criteria related to anxiety or to anxiety and depression	Conditions Intervention (1) – Control (2)	Intervention format	Guidance format	Primary outcome	Symptomatology/ incidence	Follow-up
·Bendtsen et al. (2020) ·Sweden	·University students ·Universal ·Educational	Anxiety symptomatology (score ≥ 10 on both subscales of the HADS)	654 (306 /348)	None	(1) 10 weeks of mHealth positive psychology multicomponent intervention aimed to enhance users' positive mental health. (2) Treatment as usual	Text messages (text and links to interactive exercises and further reading)	Unguided	·Positive mental health (14-item MHC-SF) ·Anxiety symptoms (HADS-A)	Symptomatology	·3 months
·Calear et al. (2009) ·Australia	·Adolescent school-based population (12–17 years old) ·Universal ·Educational	None. Clinical levels of anxiety (score RCMAS ≥19) for the analysis of one subgroup of participants.	1239 (767/ 472)[b]	None	(1) 5-week MoodGYM program based on cognitive-behavioral therapy. (2) Waiting-list	Web-based intervention	Human-Guided	·Anxiety symptoms (RCMAS), and depressive symptoms (CES-D)	Symptomatology	·Post-intervention ·6 months
·Christensen et al. (2014) ·Australia	·Young adults (18–30 years) ·Indicated ·Digital	Diagnosis of generalized anxiety disorder, panic disorder, social phobia, or post-traumatic stress disorder (MINI)	558 (IG1: 111/ IG2: 110/ IG3: 113/ CG4: 113/ CG5:111)	Mild to moderate anxiety symptoms (GAD–7 score > 5)	(1) 10-week structured intervention program of psychoeducation, CBT, relaxation, and physical activity promotion. Group 1: Active website. Group 2: Active website with telephone calls. Group 3: Active website with email reminders. (2) Active control. Group 4: Placebo website. Group 5: Placebo website with telephone calls.	Web-based intervention	Unguided	·Anxiety symptoms (GAD–7), and GAD caseness (MINI)	Symptomatology & incidence	·Post-intervention ·6 months ·12 months
·Cukrowicz and Joiner (2007) ·United States	·Young adults (18–24 years) ·Universal ·Educational	Anxiety symptoms (BAI score > 18)	152 (81/71)	None.	(1) Six 20 minutes segments of psychoeducation about anxiety and depression following the CBT principles and CBASP as an intervention model. (2) Active control: Same sessions of similar but extended educational information on anxiety disorders and depressive disorders.	Web-based intervention and reminder e-mails.	Human-Guided	·Depressive and anxiety symptoms (BAI, BDI, PANAS, and STAI-S), and a mastery test with questions about the material covered in the program	Symptomatology	·2 months

(*Continued*)

Table 1. (*Continued*)

Author/Year/ Country	Target population/ Type of prevention[a]/ Recruitment setting	Exclusion criteria for baseline anxiety	Sample (intervention/ control)	Inclusion criteria related to anxiety or to anxiety and depression	Conditions Intervention (1) – Control (2)	Intervention format	Guidance format	Primary outcome	Symptomatology/ incidence	Follow-up
·Fledderus, et al. (2012) ·Netherlands	·Adults (≥18 years) ·Indicated ·General population	Anxiety symptoms (score > 15 on the HADS-A)	376 (IG1: 125/ IG2: 125/ CG: 126)	Mild to moderate depressive symptoms (score > 10 and < 39 on the CES-D) and mild to moderate anxiety symptoms (score > 3 and < 15 on the HADS-A)	(1) 9 week third-generation therapy. Group 1: ACT self-help book support with extensive mail support. Group 2: ACT self-help book with minimal email support or counseling. (2) Waiting-list.	E-mail counseling/ support (extensive or minimal).	Human-Guided	·Depressive symptoms (CES-D) ·Anxiety symptoms (HADS-A)	Symptomatology	·9 weeks ·3 months
·Fonseca et al. (2020) ·Portugal	·Postpartum women ·Selective ·Medical/ general population	None. Data of the participants without clinically significant symptoms of anxiety (score < 8 on the HADS-A) at baseline provided by the authors.	125 (72/53)[b]	Postnatal depression risk (score > 5.5 on the PDPI-R) and/or symptoms (score > 10 on the EPDS).	(1) Five sessions CBT program targeting changes and emotional reactions, managing negative thoughts, values and social support, couple relationship and risk, symptoms and asking for help. (2) Waiting-list.	Web-based intervention	Unguided	·Depressive (EPDS) and anxiety symptoms (HADS-A)	Symptomatology	·8 weeks
·Garcia-López et al. (2024) ·Spain	·Adolescents (12–18 years) ·Indicated ·Educational	Diagnosis of anxiety and/or mood disorders (ADIS–5 C/P)	64 (36/28)	Score above the limit on the emotional problems scale of the SDQ, and above the normative data for overall depressive or anxious symptomatology or any of the subscales on the RCADS–30: separation anxiety disorder, social phobia, generalized anxiety disorder, panic disorder, obsessive compulsive disorder, and low mood (major depressive disorder.	(1) PROCARE: eight-session evidence-based CBT strategies targeting emotional disorders +1 booster session. (2) Active control: Psychoeducation and discussion groups, no coping strategies or CBT strategies were provided.	Teletherapy via videoconference	Human-Guided	·Emotional and behavioral problems (SDQ), and anxiety and depressive symptoms (RCADS–30).	Symptomatology	·Post-intervention ·6 months ·7 months

(*Continued*)

Table 1. (*Continued*)

Author/Year/ Country	Target population/ Type of prevention[a]/ Recruitment setting	Exclusion criteria for baseline anxiety	Sample (intervention/ control)	Inclusion criteria related to anxiety or to anxiety and depression	Conditions Intervention (1) – Control (2)	Intervention format	Guidance format	Primary outcome	Symptomatology/ incidence	Follow-up
·Howell et al. (2019) ·United States	·Medical and health science graduate students ·Universal ·Educational	Anxiety symptoms (GAD–7 score ≥ 10)	943 (475/468)	None.	(1) Four modules webCBT interactive intervention aiming to facilitate an understanding of the interplay between thoughts, emotions, and behaviors, to teach cognitive restructuring techniques and problem-solving strategies. (2) Active control: Automated clinical feedback about their anxiety scores.	Web-based intervention	Unguided	·Anxiety (GAD–7-) and depressive symptoms (PHQ–9-)	Symptomatology	· 3 months
·Lokman et al. (2017) ·The Netherlands	·Adults (≥18 years) ·Selective ·General population	None. Data of the participants without clinically significant symptoms of anxiety (GAD–7 score < 10) at baseline provided by the authors.	156 (79/77)[b]	Mild to moderate depressive symptoms (score > 14 and < 38 on the IDS-SR).	(1) Complain-directed mini-intervention (CDMI) consisting of one of three web-based self-help interventions: 'sleep better', 'stress less', and 'worry less', based on cognitive-behavioral techniques with elements from solution-focused therapy, mindfulness, and positive psychology. (2) Waiting-list.	Web-based intervention	Unguided	·Depressive symptoms (IDS-SR) ·Anxiety symptoms (GAD–7)	Symptomatology	·3 months ·6 months
·Mak et al. (2024) ·China	·Adults (≥18 years) ·Selective ·General population	Diagnosis of current or past generalized anxiety disorder (MINI)	256 (IG1: 93/ IG2: 82/ CG:81)	Elevated levels of worry or rumination symptoms (score ≥ 50 on the PSWQ or ≥ 40 on the RRS)	(1) Group 1: Six-module online Rumination Focused Cognitive-Behavioral Therapy program (three to five sessions per module). Group 2: Six-module online Mindfulness based intervention. (2) Active control: Psychoeducation.	Web-based intervention	Human-Guided	·Frequency of rumination (RRS) and pathological worry (PSWQ) ·Anxiety symptoms (GAD–7)	Symptomatology	·Post-intervention ·3 months ·9 months
·Monteiro et al. (2020) ·Portugal	·Postpartum women ·Universal ·General population	None. Data of the participants with normal to mild symptoms of anxiety (HADS-A < 10) at baseline	348 (180/168)[b]	Low risk for post-partum depression (score < 5.5 on the PDPI-R).	(1) Five CBT-based sequential modules (Changes and Emotional Reactions; Cognitions; Values and Social Support; Couple's Relationship; PPD Alert	Web-based intervention	Human-Guided	·Positive mental health (MHC-SF) ·Anxiety symptoms (HADS-A)	Symptomatology	·Post-intervention

(*Continued*)

Table 1. (*Continued*)

Author/Year/ Country	Target population/ Type of prevention[a]/ Recruitment setting	Exclusion criteria for baseline anxiety	Sample (intervention/ control)	Inclusion criteria related to anxiety or to anxiety and depression	Conditions Intervention (1) – Control (2)	Intervention format	Guidance format	Primary outcome	Symptomatology/ incidence	Follow-up
		provided by the authors.			Signs and Professional Help-seeking) plus reminder e-mails. (2) Waiting-list					
·Schotanus-Dijkstra et al. (2017) ·The Netherlands	·Adults (≥18 years) ·Selective ·General population	Moderate or severe anxiety symptoms (score > 10 on the HADS-A)	275 (138/137)	Low or moderate well-being (score < 4 on every emotional well-being item of the MHC-SF, or score < 4 on at least six of the remaining 11 items).	(1) 8- to 12-week self-help book, and weekly email support from a personal counselor based in Positive Psychology. (2) Waiting-list	E-mail support	Human-Guided	·Well-being (MHC-SF and FS) ·Anxiety symptoms (HADS-A)	Symptomatology	·3 months ·6 months ·12 months
·Topper et al. (2017) ·The Netherlands	·Adolescents (15–18 years) and young adults (18–22 years) ·Selective ·Educational	Current diagnosis of generalized anxiety disorder as assessed by the GADQ-IV.	169 (84/85)	Elevated levels of worry and rumination (score ≥ 50 on the PSWQ or score ≥ 40 on the RRS, and score ≥ 47on the PSWQ or score ≥ 38 on the RRS)	(1) 6 week rumination-focused CBT (RFCBT) and personalized feedback by a therapist following a functional-analytic approach. (2) Waiting list.	Web-based intervention and online feedback	Human-Guided	·Repetitive negative thinking (PSWQ and RRS), depressive and anxiety symptoms (MASQD–30, BDI-II) and depressive and anxiety caseness (PHQ–9 and GADQ-IV)	Incidence	·Post-intervention ·3 months ·12 months
·Vivas-Fernandez et al. (2023) ·Spain[c]	·Adolescents (12–18 years) at risk for emotional problems ·Selective ·Educational	Scores in the RCADS–30: separation anxiety ≥7, social phobia ≥8, generalized anxiety disorder ≥9 or panic disorder ≥8. Diagnosis of anxiety and/or mood disorders (ADIS–5 C/P).	208 (IG1: 72/ IG2: 70/ CG: 66)	Possible risk of emotional problems reported by the SDQ. Presence of at least one risk factor (social exclusion, stress-related situations, unhealthy lifestyle habits, parental–child interaction).	(1) Group 1 (PROCARE): eight-session evidence-based CBT strategies targeting emotional disorders +1 booster session. Group 2 (PROCARE+): included PROCARE as well as additional modules for adolescents and parents, tailored according to the risk factor evidenced by the adolescents. (2) Active control: Psychoeducation and discussion groups, no coping strategies or CBT strategies were provided.	Teletherapy via videoconference	Human-Guided	·Emotional risk (SDQ emotional problems subscale) ·Anxiety symptoms (RCADS Generalized Anxiety Disorder Subscale, Social Phobia Subscale, and Panic Disorder Subscale)	Symptomatology	·Post-intervention ·6 months ·7 months ·12 months

(*Continued*)

Table 1. (*Continued*)

Author/Year/ Country	Target population/ Type of prevention[a]/ Recruitment setting	Exclusion criteria for baseline anxiety	Sample (intervention/ control)	Inclusion criteria related to anxiety or to anxiety and depression	Conditions Intervention (1) – Control (2)	Intervention format	Guidance format	Primary outcome	Symptomatology/ incidence	Follow-up
·Zarski et al. (2024) ·Germany	·Adults (≥18 years) ·Indicated ·General population	Diagnosis of an anxiety disorder currently or in the previous 6 months (assessed by the MINI)	566 (IG1: 186/ IG2: 189/ CG: 191)	Subclinical anxiety (GAD–7 score ≥ 5) and/or depression (CES-D score ≥ 16).	(1) Seven-session transdiagnostic program addressing anxiety and depression included: need orientation, behavioral activation, psychoeducation, cognitive restructuring, problem-solving, and exposure and relapse prevention. Booster session with eight transdiagnostic elective modules. Group 1: received feedback messages by an eCoach. Group 2: received standardized manualized feedback. (2) Waiting-list.	Web-based intervention and smartphone app.	Guided (IG1: Human-guided, IG2: Auto-guided)	· Observer-Rated Anxiety and Depression Symptom Severity (HAM-A, SIGH-A, and QIDS-C)	Symptomatology	·8 weeks after randomization ·6 months ·12 months

Note. HADS = Hospital Anxiety and Depression Scale; MHC-SF = Mental Health Continuum Short Form; CES-D = Center for Epidemiologic Studies of Depression; RCMAS = Revised Children's Manifest Anxiety Scale; MINI = Mini-International Neuropsychiatric Interview; GAD-7 = Generalized Anxiety Disorder questionnaire (7 items); BAI = Beck Anxiety Inventory; BDI = Beck Depression Inventory; PANAS = Positive and Negative Affect Schedule; STAI-S = State–Trait Anxiety Inventory (State anxiety scale); HADS-A = Hospital Anxiety and Depression Scale (Anxiety subscale); PDPI-R = Postpartum Depression Predictors Inventory-Revised; EPDS = Edinburgh Postnatal Depression Scale; HADS = Hospital Anxiety and Depression Scale; PHQ-9 = Patient Health Questionnaire-9; IDS-SR = Inventory of Depressive Symptomatology Self-Report; HADS-D = Hospital Anxiety and Depression Scale (depression subscale); FS = Flourishing Scale; MASQD-30 = Mood and Anxiety Symptoms Questionnaire (30 items); BDI-II: Beck Depression Inventory version 2; GADQ-IV = Generalized Anxiety Disorder Questionnaire IV; SDQ = Strengths and Difficulties Questionnaire; ACT = Acceptance and Commitment Therapy; CBASP=Cognitive-Behavioral Analysis System of Psychotherapy; Strengths and Difficulties Questionnaire; RCADS-30 = Revised Children's Anxiety and Depression Scale; PSWQ = Penn State Worry Questionnaire; RRS = Rumination Response Scale; PSS = Perceived Stress Scale; STAIX-I = State–Trait Anxiety Inventory (State anxiety scale, X version); WEMWBS = Warwick-Edinburgh Mental Wellbeing Scale; MW-S = Mind Wandering Spontaneous; DERS = Difficulties in Emotion Regulation Scale; RS-14 = Resilience Scale (14 items); ACS-S = Attention Control Scale (Shifting scale); ACS-D = Attention Control Scale (Distraction scale); ADIS-5 C/P = Anxiety and Related Disorders Interview Schedule for DSM-5; HAM-A = Hamilton Anxiety Rating Scale; SIGH-A = Structured Interview Guide for the Hamilton Anxiety Scale; QIDS-C = Quick Inventory of Depressive Symptomatology.

[a]Type of prevention: Indicated: patients with subthreshold anxiety; Selective: patients with a risk factor for anxiety; Universal: general population.

[b]Subsample of participants without clinical anxiety at baseline proportioned by the authors.

[c]These data are from two different articles, both from Vivas-Fernández et al., (2023).

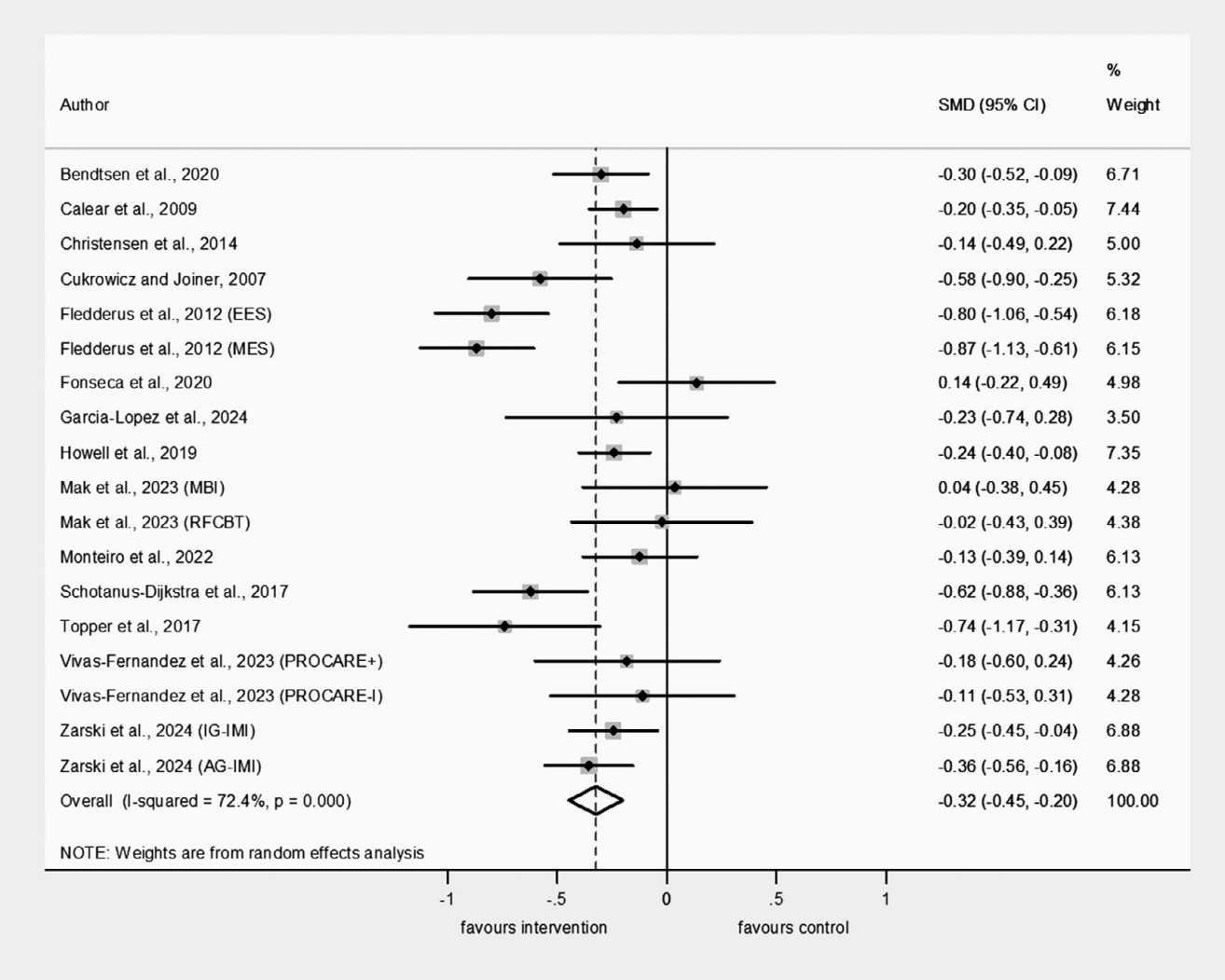

Figure 2. Forest plot.
Note: SMD = standardized mean difference.

Table 2. Primary and sensitivity analyses of the effectiveness of digital interventions in preventing anxiety

	N	SMD (95% CI)	P	I^2 (95% CI); p value
Primary analysis				
DerSimonian and Laird (D-L) random effects	18	−0.325 (−0.449 to −0.201)	<0.001	72.4% (56%–83%); p < 0.001
Sensitivity analyses				
Hedge's *g*	18	−0.324 (95% CI: −0.447 to −0.200)	<0.001	72.4% (56%–83%); p < 0.001
At first post-intervention evaluation	18	−0.311 (−0.437 to −0.185)	<0.001	75.3%; (61%–84%); p < 0.001
At last post-intervention evaluation	18	−.0326 (−0.453 to −0.200)	<0.001	72.8%; (57%–83%); p < 0.001
Adolescents (< 18 years)	5	−0.265 (−0.453 to −0.078)	0.006	31.4% (0%–74%); p = 0.212
Young adults (19–29 years)	6	−0.242 (−0.384 to −0.100)	0.001	33.4% (0%–73%); p = 0.186
Adults (≥30 years)	7	−0.420 (−0.662 to −0.177)	0.001	84.9% (71%–92%); p < 0.001
Including the outlier (Lokman et al., 2017)	19	−0.447 (−0.656 to −0.238)	<0.001	90.9% (87%–94%); p < 0.001

evidence of publication bias was identified. Although the number of studies included was small, it was adequate to ensure the precision of the meta-analysis. Indirectness was very low because, although we searched for all types of populations, we found no trials targeting mature adults or the elderly; therefore, the results do not represent all types of populations, which was our primary

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Table 3. Final meta-regression model

Final model[a]	β (95% CI)[b]	P
Country (The Netherlands)	−0.538 (−0.708 to −0.368)	<0.001

[a]I^2 residual = 0.99%; adjusted R^2 = 100%.
[b]Knapp and Hartung method for the estimation of standard error and 95% CI.

interest. In summary, the quality of evidence according to GRADE was very low.

Discussion

Main findings

This systematic review identified 15 RCTs, including a total of 6093 participants from America, Asia, Europe, and Oceania, with most interventions grounded in CBT principles. One study was excluded from the quantitative synthesis because it reported an excessively large effect size and was considered an outlier. The subsequent meta-analysis of the remaining 14 RCTs showed that digital psychological and psychoeducational interventions exert a small preventive effect on anxiety. Publication bias was nonsignificant, between-study heterogeneity was high, and the certainty of evidence according to GRADE was very low.

Strengths

To our knowledge, this is the first meta-analysis of RCTs to assess the effectiveness of digital interventions for the prevention of anxiety in non-anxious and varied populations. Our strict selection criteria ensured that we only evaluated preventive psychological interventions, and not treatments, in diverse populations. A broad selection of complementary databases, combined with a wide range of search terms, allowed a highly sensitive screening process, thus maximizing the inclusion of all studies meeting the selection criteria. This process was carried out by trained, independent reviewers. Moreover, no language or population restrictions were applied. PRISMA criteria were followed throughout the entire development of this meta-analysis, and GRADE criteria were used to assess the quality of the evidence. We also performed sensitivity analyses, which support the robustness of a small but still statistically significant pooled SMD. Finally, the meta-regression was able to explain 100% of the heterogeneity.

Limitations

This meta-analysis has some limitations: (i) the overall high risk of bias of the RCTs included in this study demonstrates the need for further evaluation of computerized interventions for the prevention of anxiety following more rigorous methodologies; (ii) only one RCT used a standardized diagnostic interview, a more valid method to measure anxiety outcomes, with the remainder using symptom scales; (iii) four of the RCTs represent a subsample of participants without anxiety at baseline, as provided by the authors of the studies that did use this as an exclusion criterion; (iv) the included RCTs used four different therapeutic approaches, with CBT being the most common; this concentration of evidence on CBT limits the generalizability of our findings, as the effectiveness of alternative interventions remains underexplored and warrants further investigation; (v) older populations are not represented in these studies due to the nature of the interventions and the existence of a digital divide; (vi) all RCTs were conducted in high-income countries, which does not allow us to assess whether these results may differ in low- and middle-income regions; (vii) only two studies provided incidence data, however, even when incidence data are not provided, symptom assessment using clinical scales is a reliable predictor of the incidence of new cases in depression (Institute of Medicine (US) Committee on Prevention of Mental Disorders, 1994; Cuijpers & Smit, 2004); (viii) follow-up periods were short in the majority of the studies, with a maximum of 1 year; and (ix) only 14 RCTs were included in this MA, due to the exclusion of an outlier RCT.

Comparison with previous research

These results are in line with previous research indicating that digital preventive interventions have a small but significant effect on preventing anxiety symptoms (Edge et al., 2023; Sander et al., 2016). However, evidence on their impact on the incidence of anxiety disorders remains limited, as only two RCTs provided information on new anxiety cases (Christensen et al., 2014; Topper et al.) in addition to symptomatology scores. This is also consistent with previous meta-analyses of online interventions, in which most of the results were provided in terms of symptomatology levels (Edge et al., 2023; Pauley et al., 2023; Sander et al., 2016). In this line, the overall aim of the three types of preventive intervention – universal, selective, and indicated – is the reduction of the occurrence of new cases. Usually, this is done through a risk-reduction model, and even though outcomes are in the distant future and the goal of fewer cases has not yet been established, the decrease in risk and/or increase in protective factors can be documented (Institute of Medicine (US) Committee on Prevention of Mental Disorders, 1994), even including estimations of the individual probability of suffering anxiety in the future (Moreno-Peral et al., 2014). Depressive symptoms are a good predictor of future incidence of depression (Cuijpers & Smit, 2004), and their reduction can be seen as an indicator of decreased risk. Additionally, the aims of indicated preventive interventions might be to reduce the duration of early symptoms and to halt progression of severity so that the individuals do not meet, nor come close to meeting, DSM diagnostic levels (Institute of Medicine (US) Committee on Prevention of Mental Disorders, 1994). Therefore, from this conceptual framework, using differences in anxiety symptoms as an outcome does not, in itself, imply that the term 'anxiety prevention' cannot be used.

Other meta-analyses of anxiety prevention, such as the one conducted by Moreno-Peral et al. (2017), reported a small effect size (SMD = −0.31), including both digital and face-to-face interventions. In contrast, a meta-analysis by Pauley et al. (2023) of computerized interventions for anxiety disorders, covering treatment and prevention, found a larger effect size (g = −0.80).

Our findings show no differences in effect sizes between the first posttreatment assessment and the last follow-up, and both were similar to the overall effectiveness of the interventions. This is contrary to previous research on anxiety prevention, which showed that preventive effects have a tendency to diminish over

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time (Moreno-Peral et al., 2017; Zalta, 2011). Nonetheless, this may be affected by the short duration of the follow-up assessments of the included studies.

In terms of therapeutic approach, no differences were found regarding the effectiveness of the interventions. There is mixed evidence on the role of the intervention model in relation to the effectiveness of the intervention, with some meta-analysis finding CBT to be associated with a major effect size when assessing apps to treat generalized anxiety symptoms as the primary outcome (Linardon et al., 2024), while others find no significant differences in psychological interventions for the prevention of anxiety (Moreno-Peral et al., 2017). This highlights the need for further studies testing other orientations and combined orientation interventions.

No significant effect was found in terms of intervention format. This is in line with the results of a meta-analysis on internet-based psychotherapeutic interventions conducted by Barak, Hen, Boniel-Nissim, and Shapira (2008). Although video conferencing interventions differ from other digital approaches to anxiety prevention, particularly by providing real-time relational experiences that more closely mimic face-to-face sessions, they also share several key features and advantages with other digital formats. Like web-based or self-guided interventions, video therapy reduces geographical barriers, increases accessibility for individuals with limited mobility or those in underserved areas, and offers greater scheduling flexibility compared to in-person therapy (Nalongo-Bina, 2024). Both formats rely on digital infrastructure and remote delivery, enabling scalable implementation and potential cost-effectiveness. Despite offering a more synchronous and familiar therapeutic environment, video conferencing still falls within the broader category of digital interventions. Evidence suggests that video therapy can be as effective as in-person therapy (Stubbings, Rees, Roberts, & Kane, 2013), whereas the effectiveness of other digital interventions may vary depending on the users level of engagement (Gan, McGillivray, Han, Christensen, & Torok, 2021). Given the distinct characteristics of each format, further research is needed to refine comparisons between digital intervention formats and to better understand their specific strengths, limitations, and optimal contexts for application. This could help determine, for instance, whether certain delivery channels are more suitable for universal prevention of anxiety disorders, while others are better for indicated or selective prevention, or whether the effectiveness of different delivery formats varies across age groups.

Selective prevention appears to be the most common preventive intervention for anxiety, with nine RCTs included in this review, a tendency that does not differ from previous literature (Edge et al., 2023; Moreno-Peral et al., 2017). The type of prevention, however, did not show a significant effect on the effectiveness of the intervention. This aligns with previous literature, which offers inconclusive evidence regarding the association between the type of prevention and effect size. Some meta-analyses have found no association (Deady et al., 2017; Fisak, Richard, & Mann, 2011; Zalta, 2011), whereas others suggest that selective and/or indicated interventions tend to be more effective (Teubert & Pinquart, 2011). Conversely, some studies report universal prevention as more effective (Stockings et al., 2016).

Our findings on adolescents and young adults showed small effect sizes in studies exclusively with adolescents and in those in which the mean age corresponded to young adults. There are not many meta-analyses on the effectiveness of preventive interventions for anxiety exclusively in these populations. However, these results are consistent with those of previous meta-analyses focusing on the treatment of anxiety in similar samples. For example, a meta-analysis of 10 studies found an overall positive effect of digital interventions on reducing anxious symptoms (SMD = 0.440; 95% CI: 0.20–0.67; I^2 = 82.9%) (Fischer-Grote, Fössing, Aigner, Fehrmann, & Boeckle, 2024) in children, adolescents, and young adults. Although this effect size is slightly higher than that observed in our analysis, the high heterogeneity suggests considerable variability between studies, reinforcing the need to interpret these results in terms of intervention type, population, and methodological design. Unlike previous meta-analyses on the prevention of depression and anxiety (Campos-Paíno et al., 2023; Moreno-Peral et al., 2017) and on their treatment (Andrews et al., 2018; Newby, Twomey, Yuan Li, & Andrews, 2016), the comparator had no significant effect on the results. Similarly, the effectiveness of the intervention was not affected by the duration of the program, which is consistent with findings from a recent meta-analysis by Seegan et al. (2023) of applications for anxiety and depression.

Even though the majority of the studies included had a high risk of bias, this variable proved to be nonsignificant in relation to the effectiveness of the interventions. This is in line with previous literature (Campos-Paíno et al., 2023; Pauley et al., 2023; Rigabert et al., 2020), showing that risk of bias is not associated with the effect sizes of various types of interventions.

Similarly, the duration of the interventions had no impact on the effectiveness, which is consistent with a recent meta-analysis of applications for anxiety and depression (Seegan et al., 2023). Finally, differences in effect sizes were not significantly related to the measurement method, the presence of guidance in the intervention, or the adherence rate.

Conclusions

The growing importance of developing and assessing the effectiveness of preventive interventions stems from the high incidence and costs associated with anxiety disorders. Recognizing digital interventions as a plausible solution paves the way for reducing the high disease burden linked to anxiety disorders.

This meta-analysis provides evidence supporting the preliminary effectiveness of digital interventions for the prevention of anxiety, although with a small effect and very low quality of evidence. There is a need to develop innovative digital interventions targeting anxiety prevention and to conduct new RCTs to assess their effectiveness using rigorous methodologies to ensure the validity of the results.

Supplementary material. The supplementary material for this article can be found at http://doi.org/10.1017/S0033291725102262.

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