Effectiveness of Online Mindfulness-based Interventions for Cancer Patients: A Systematic Review and Meta-Analyses

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Abstract

Background: Online mindfulness-based interventions (MBIs) are increasingly being used in complex oncology. However, we are still at the early stages of understanding how effective online MBIs are for cancer patients, and what delivery modes are most efficient.

Objective: This systematic review aims to examine the feasibility and efficacy of online MBIs in improving the mental health and quality of life of patients with cancer, to describe intervention characteristics and delivery modes of these programs, and to summarize the results of the included studies in terms of predictors of efficacy, adherence, and attrition.

Methods: A comprehensive literature search was conducted using Cochrane Library, Web of Science, PubMed (National Library of Medicine), Embase, SinoMed, CINAHL Complete (EBSCOhost), Scopus (Elsevier), APA PsycINFO (EBSCOhost) from database inception to December 9, 2022.studies were eligible if a mental health outcome (e.g., FCR, PTG, anxiety, depression, distress, stress, sleep) and quality of life was assessed.

Results: The results of the meta-analysis showed that compared with the control group, the quality of life (standardized mean difference SMD[], 0.33; 95% CI, 0.14 to 0.51; p<.0001) and post-traumatic Growth (SMD, 0.17; 95%CI , -0.07 to 0.40; p=.16) of cancer patients was significantly improved and the fear of cancer recurrence (SMD ,-0.30; 95% CI, -1.04 to 0.44; p=.39), sleep (SMD ,?0.36; 95% CI, ?0.71 to -0.01; p=.04), anxiety(SMD, -0.38; 95% CI, ?0.67 to -0.09; p= .01), depression(SMD, -0.36; 95% CI, ?0.61, -0.11; p=.005), distress(SMD, -0.50; 95% CI , -0 .75 to -0.26; p<.0001) and perceived stress (SMD,-0.89; 95% CI,-1.33 to -0.45; p= .0001) of the online MBIs group was significantly alleviated after the intervention. Most interventions are multi-component, web-based health self-management programs.

Conclusions: The study concludes that online mindfulness interventions show promise for improving mental health and quality of life outcomes in cancer patients, and further research is needed to optimize and customize these interventions for individual physical and mental symptoms. Clinical Trial: CRD 42022382219

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ABSTRACT

Background: Cancer has emerged as a significant global health concern, contributing substantially to both morbidity and mortality. While continuous advancements in medical technology have effectively addressed the physical symptoms of cancer patients, there remains an insufficient focus on treating their psychological issues. Recognizing the urgent need to enhance the overall well-being and quality of life for these patients, researchers have turned to online mindfulness-based interventions within the complex field of oncology. Despite the increasing utilization of online Mindfulness-based interventions, there is still a need for a deeper understanding of their effectiveness for cancer patients and the most efficient modes of delivery, representing an ongoing exploration in this crucial area of research.

Objectives: This systematic review aims to evaluate the effectiveness and feasibility of online mindfulness interventions for cancer patients, assessing various outcomes including psychological, physiological, and quality of life aspects. Through a comprehensive analysis, we aim to fill gaps in the literature and provide insights into the potential implementation and sustainability of these interventions in real-world settings.

Methods: We conducted searches across eight electronic databases, including the Cochrane Library, Web of Science, PubMed, Embase, SinoMed, CINAHL Complete, Scopus, and APA PsycINFO, until December 30, 2022. We included randomized controlled trials involving cancer patients aged ≥ 18 years, utilizing mindfulness-based interventions delivered online or via smartphone apps, compared to standard care. Outcome measures included mental health or quality of life indicators. Exclusion criteria comprised non-randomized studies, interventions targeting health professionals or caregivers, and studies lacking sufficient data for analysis. Two independent authors screened and selected articles, extracted data using standardized forms, and assessed the risk of bias in the studies using the Cochrane Bias Risk Assessment Tool. Meta-analyses were performed using Review Manager software and the meta package in R software. Standardized mean differences were utilized to determine the effects of interventions. Descriptive synthesis was undertaken for studies that were not suitable for meta-analysis. The RE-AIM framework was employed to assess the potential implementation and sustainability of these interventions in real-world settings.

Results: Among 4349 articles screened, 15 studies were included. The total population comprised 1613 participants of which 870 participants were in the experimental conditions and 743 in the control conditions. The results of the meta-analysis showed that compared with the control group, the quality of life (standardized mean difference, 0.37; 95% CI, 0.18 to 0.57; $P < .001$), sleep

(standardized mean difference, -0.36; 95% CI, -0.71 to -0.01; *P* = .04), anxiety(standardized mean difference, -0.48; 95% CI, -0.75 to -0.20; *P* = .0006), depression(standardized mean difference, -0.36; 95% CI, -0.61, -0.11; *P* =.005), distress(standardized mean difference, -0.50; 95% CI , -0.75 to -0.26; *P* < .0001) and perceived stress (standardized mean difference, -0.89; 95% CI, -1.33 to -0.45; *P* = .003) of the online mindfulness-based interventions group in cancer patients was significantly alleviated after the intervention. However, no significant differences were found in the fear of cancer recurrence (standardized mean difference, -0.30; 95% CI, -1.04 to 0.44; *P* = .39) and post-traumatic growth (standardized mean difference, 0.08; 95% CI , -0.26 to 0.42; *P* = .66). Most interventions are multi-component, web-based health self-management programs, widely utilized by international and multilingual cancer patients.

Conclusions: The study concludes that online mindfulness interventions show promise for improving mental health and quality of life outcomes in cancer patients, and further research is needed to optimize and customize these interventions for individual physical and mental symptoms. Limitations include heterogeneity in outcome measures and intervention characteristics, potentially affecting comparability and generalizability. Language barriers potentially limiting the comprehensiveness of the findings.

Trial Registration: PROSPERO CRD 42022382219; https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=382219

Keywords

Cancer; Mindfulness-Based Interventions; Mental health; Randomized controlled trial; Systematic review; Meta-analysis.

Introduction

The 2020 Global Cancer Statistics Report estimates that there are 19.3 million new cases of cancer worldwide and close to 10 million cancer-related deaths[1]. The leading cause of disease and mortality among humans today is cancer[2, 3]. The physical symptoms of cancer patients have been alleviated due to the continuous advancement of medical technology, but the psychological problems of cancer patients have not been adequately treated. The process of treating cancer is typically complex, with many patients experiencing negative side effects of cancer treatments such as chemotherapy and radiation therapy that may impact their mental health, quality of life (QoL), and sleep quality. Targeted interventions to address these cancer-related symptoms can reduce the psychological burden of cancer treatment and diagnosis, which is critical to improving patients' quality of life and promoting their health[4]. With an increasing number of cancer patients and a desire for physical and mental health, cancer care research is focusing on identifying cancer patients'

psychological problems and developing and implementing patient-centered psychological care plans[5, 6]. Cancer patients' rehabilitation increasingly employs mental health as a therapeutic strategy, effective psychological intervention strategies are still urgently needed to satisfy the demands of cancer patients[7].

Mindfulness-based interventions(MBIs) have emerged as a promising intervention technique for cancer patients. Mindfulness can be defined as the ability to observe thoughts, bodily sensations or feelings in the present moment with an open and accepting orientation toward one's experiences[8]. MBIs, which incorporate mindfulness practices into various therapies in the field of mental health care, have been found to increase psychological flexibility and alleviate intense emotional states. MBIs can include additional mental training, as in the case of such as Mindfulness-based stress reduction (MBSR)[9], and acceptance and commitment therapy (ACT)[10], addresses psychological issues by increasing psychological flexibility[11]. Cognitive-behavioural therapy has been combined with MBSR, resulting in mindfulness-based cognitive therapy (MBCT) for preventing depression relapses[12]. Mindfulness-based cancer recovery (MBCR), an adaptation of MBSR, comprises contents tailored for cancer patients[13]. Through facilitating awareness and non-judgmental acceptance of moment-to-moment experiences, these MBIs are assumed to alleviate intense emotional states. Mindfulness intervention has been proved to improve the psychological status of cancer patients[14, 15].

The rapid development of information technologies has led to the delivery of MBIs via the internet, which is more practical than face-to-face interaction and can overcome time and geographic barriers and it has been established that online mindfulness intervention is more suitable for people with psychological and physical symptoms[16]. Implementing psychological interventions through online or remote health can be a potential cost benefit for current referral pathways and treatment models[17]. Online mindfulness interventions can be used as the adjunctive therapy in cancer patients to manage cancer-related symptoms[18].

Despite the increasing popularity of online mindfulness-based therapies for cancer patients and the growing number of randomized controlled trials (RCTs) examining such programs, there has not yet been a systematic review of these studies and their descriptions of the interventions in terms of their characteristics, such as delivery mode and approach. To date, there have been only two systematic reviews addressing the impact of online therapy on health outcomes in cancer patients. However, these reviews have notable limitations. The first review[19] only searched four databases, potentially leading to publication bias and compromising the reliability of the findings. Furthermore, this systematic review did not conducted sensitivity, subgroup, or meta-analyses. The second review[20] evaluated the validity of online MBIs on only four health outcomes, specifically on four health outcomes: anxiety, depression, Quality of Life (QoL), and mindfulness. However, the

restricted quantity of randomized controlled trials and papers within each subgroup analysis poses a challenge in reaching definitive conclusions. Moreover, the external validity, such as generalizability or applicability, based on the RE-AIM framework, has not been examined in online mindfulness interventions for cancer patients. In conclusion, attempts to synthesize the literature on the impact of online Mindfulness-based interventions on cancer patients' health are limited, and there is a lack of analysis of the barriers and facilitators to the development of current online MBIs.

This systematic review aims to synthesize the effectiveness of online mindfulness interventions for cancer patients, comprehensively assessing a wide range of outcomes including psychological, physiological, and quality of life aspects. We conducted a comprehensive search to evaluate the validity of online MBIs on psychological outcomes in cancer patients, using high-quality RCTs to assess many health outcomes before and after treatment. Additionally, this study aims to provide an overview of the outcomes related to the interventions, including their effectiveness and potential for implementation and sustainability in real-world settings, we used the RE-AIM framework[21] to evaluate the potential for implementation and sustainability of these interventions in real-world settings. By using this framework, we can provide a comprehensive evaluation of an intervention's potential impact and identify common traits of effective interventions. Overall, this study fills gaps in the literature by comprehensively evaluating the effectiveness and potential for implementation and sustainability of online MBIs for cancer patients.

Methods

Search strategy

The protocol of this review was registered in PROSPERO (PROSPERO registration number: CRD 42022382219) and written following the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) reporting guideline. The methods outlined in the protocol were strictly adhered to throughout the experimental procedures. The databases were searched until December 30, 2022. In order to identify relevant studies for inclusion in our systematic reviews, we developed comprehensive search strategies and utilized six databases: Cochrane Library, Web of Science, PubMed, Embase, SinoMed, CINAHL Complete, Scopus, APA PsycINFO. The search language of the literature is limited to Chinese and English. The search strategies used a combination of subject headings (e.g., MeSH in PubMed) and keywords for the following five concepts: mindfulness, carcinoma, intervention, telemedicine, and randomly. Data Supplement 1 shows detailed database search strategies. Reference lists of included studies and relevant systematic reviews were also manually searched for additional relevant studies. Search results were captured using citation management software, and duplicates were removed.

Inclusion and exclusion criteria

Due to the explorative nature of this meta-analysis, we opted for rather broad inclusion criteria. We included studies that: (1) population of cancer patients(aged ≥ 18 years) with any cancer type/stage, including those receiving anticancer treatment, those in remission, those considered cured, and those in the terminal phases of the disease; (2) employed MBIs (including MBSR, MBCT and MBCR); administered the MBI via the Internet (including such as websites, virtual classrooms, online games, and online video) or smartphone application; (3) eligible controls were required to receive standard care or usual care; (4) studies were eligible if a mental health outcome (e.g., FCR, PTG, anxiety, depression, distress, stress, sleep) or quality of life was assessed; (5) randomized controlled trials in English or Chinese.

Exclusion criteria: (1) other types of studies (e.g., were observational and review, protocol, case reported); (2) studies of health professionals, caregivers, or mixed populations where outcomes for cancer survivors could not be extracted; (3) insufficient information to calculate an effect size or determine eligibility.

Screening and Data extraction

Two reviewers independently screened all titles and abstracts, then, independently screened full-text articles, conflicts were resolved by consensus. Data were independently extracted by two reviewers using a data extraction form adapted from the Cochrane Handbook[22] and reported using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines[23]. We extracted data from included trials using standardized data extraction forms. Study-level variables included the year of publication, country of study, age of participants, cancer diagnosis, delivery mode, reminder, cancer-adapted MBIs, primary and secondary outcomes, intervention and follow-up durations, intervention and control group details, outcome measurement metrics and outcomes scores up to post-intervention. Any discrepancy or uncertainties were resolved through regular meetings and discussion among the research team.

Risk of bias assessment

Risk of bias was independently assessed by two reviewers using the Cochrane risk-of-bias tool, with differences reconciled through discussion[24]. Six domains encompassed random sequence generation, allocation concealment, blinding of participants/personnel, blinding of outcome assessment, incomplete outcome data and selective outcome reporting. Each domain was judged as low, high or unclear risk. Discrepancies in assessments between the 2 reviewers were resolved by consensus or by a third reviewer as required.

Meta-analytic method

This study conducted a meta-analysis utilizing Review Manager 5.4 software and the meta package in R software. Primary and secondary outcome means and standard deviations (SDs) at postintervention follow-up for intervention and control groups were converted to standardized mean difference (SMD), using Hedges' G. The value of SMD less than 0.5 would be interpreted as small, SMD ≥ 0.5 as medium and SMD ≥ 0.8 as large effect size[25]. Authors of studies with missing data were contacted through email. However, if no data were provided, a narrative synthesis would be conducted. The I^2 statistic was used to estimate the percentage of heterogeneity across the primary studies not attributable to random sample error alone. A value of 0% indicated no heterogeneity, values of 25%, 50% and 75% reflected low, moderate and high degrees of heterogeneity, respectively[26]. Acknowledging differences across studies because of the varied population, length of intervention and length of follow-up, meta-analyses were performed fitting random-effects models[27]. Additionally, subgroup analyses were conducted to examine effect sizes across different subgroups, the specific moderating variables included technology, sex, intervention type, intervention duration, study quality, and scale.

RE-AIM Framework

The RE-AIM framework is a valuable tool for evaluating interventions in healthcare[28]. Its five dimensions assess an intervention's potential for large-scale adoption, implementation, and sustainability, providing a comprehensive evaluation of its real-world efficacy and viability[29]. Reach refers to the extent of successfully targeting and engaging the intended audience, evaluated using the percentage of eligible patients enrolled in the study (n enrolled/n eligible). Efficacy measures the effect on outcomes such as mental health and quality of life. Effect sizes (95% confidence intervals) for the primary outcome were used to assess efficacy. Adoption measures the extent to which organizations or healthcare providers are willing and able to offer the intervention to their patients or clients, and barriers to adoption are evaluated by who recruited participants and where the intervention was offered. Implementation evaluates how effectively the intervention is delivered and received by patients, including factors such as adherence and fidelity, and is evaluated by measures such as adherence to intervention, percentage of dropouts of the most complex intervention (n postintervention follow-up/n baseline × 100), intervention cost, and author-reported plans to upscale or implement. Maintenance measures the extent to which the intervention can be sustained over time and integrated into routine care, and is evaluated by the duration of results and the author-reported availability of the intervention[30].

Results

Description of Studies

The systematic search revealed 4349 original articles, fifty-four articles were assessed at full-text level and 15 studies were included in the final synthesis. Figure 1 displays the study flowchart of the search results. The total population comprised 1613 participants of which 870 participants were in the experimental conditions and 743 in the control conditions. In most studies, the majority of participants were women. Participants' average ages ranged from 41.84 to 66.45 years. Four studies were based on MBCR, three on MBCT, two on MBSR and six on Mindfulness-based program. The six studies included interventions that were indeed rooted in mindfulness practices, however, they did not strictly adhere to the conventional frameworks of MBCT, MBCR, or MBSR. Instead, they utilized a variety of mindfulness-based approaches tailored to their respective study populations. Furthermore, these studies did not specify the exact intervention methods used but categorized them under the umbrella term "Mindfulness-based program". Given the unique nature of these interventions, we cannot determine whether they belong to MBCT, MBCR, or MBSR interventions, we have categorized them as "Mindfulness-based programs," encompassing diverse methodologies beyond the traditional MBCT, MBCR, or MBSR frameworks. Trials used usual care (8 trials) and waitlist (7 trials) equally as comparators. Six studies had participants with breast cancer, seven with mixed cancer types and two with other cancer types. Five studies were conducted in the China, five in United States and one each in the Netherlands, Denmark, Iran, Australia and Canada.

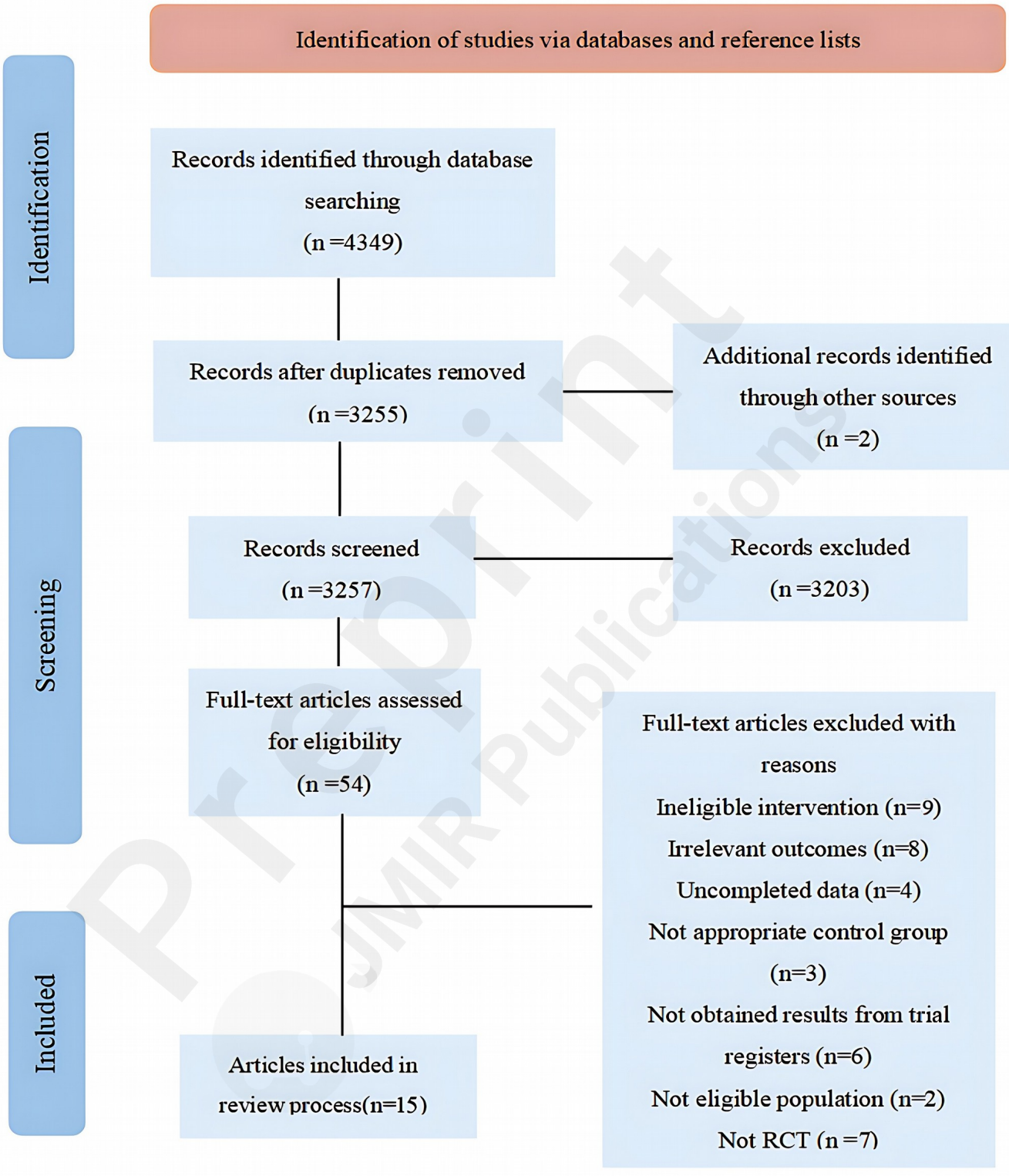
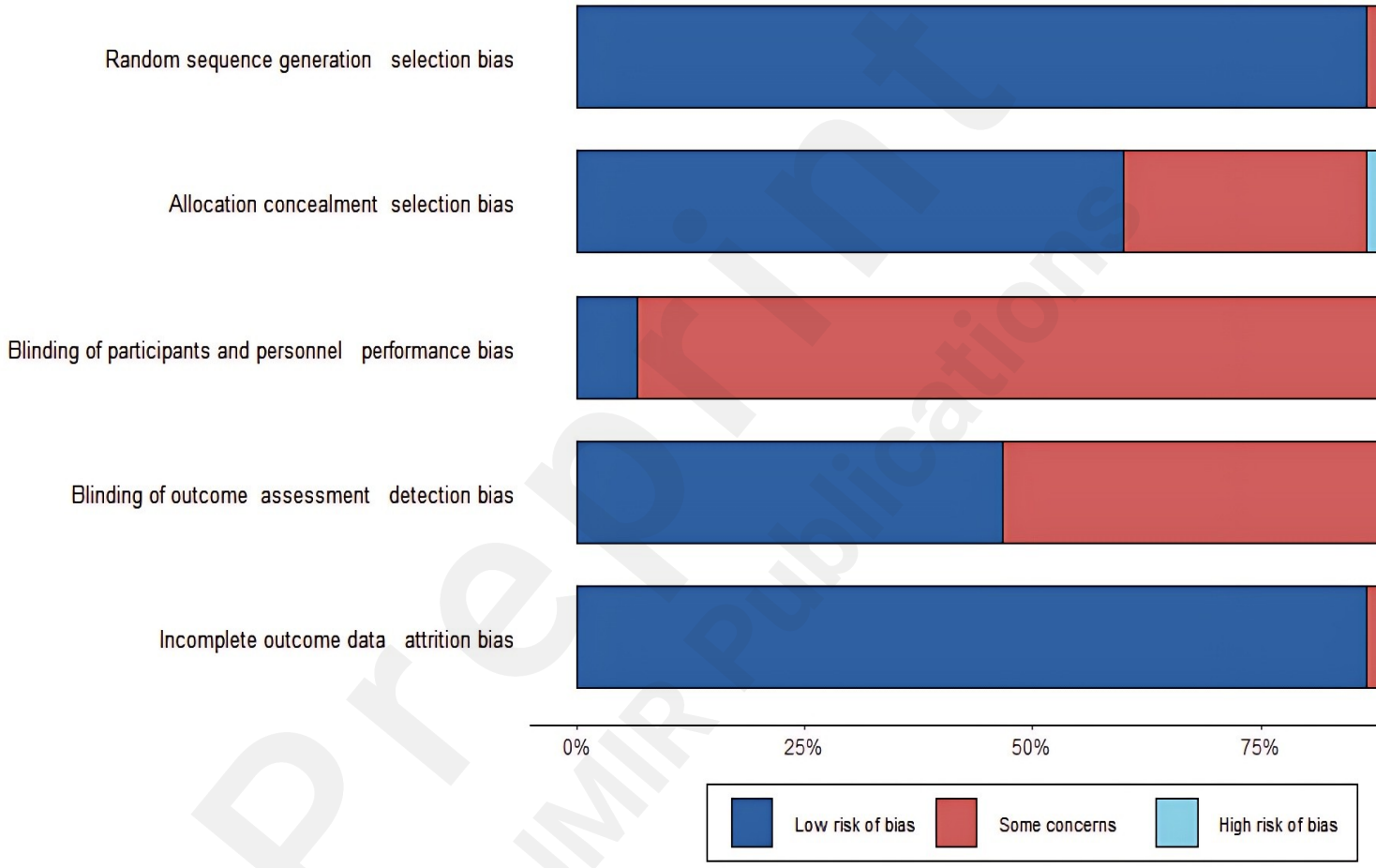


Figure 1. Flow Diagram of Trial Identification and Selection.

Risk of Bias

The risk of bias assessment is presented in table 2 in the Supplement. Most studies adequately generated and concealed allocation(Figure 2). In most studies, Patient blinding was not possible

because of the nature of online-MBIs interventions and was not considered to increase risk of bias. However, 8 studies [31-38](53%) presented insufficient information to decide regarding researcher and/or outcome assessor blinding, and seven reported blinding researchers[39-45] (low risk). Fourteen studies reported complete outcome data (low risk)，one had insufficient detail[32] (unclear risk). In one studies[36], attrition was high and comparisons or reasons for attrition were not provided. Finally, 10/15 (66%) did not reference a protocol or trial registration (unclear risk).



. Cochrane risk of bias scores (%low, unclear, and high risk) across bias domains (selective reporting, plete outcome data, blinding, allocation concealment, and random sequence generation) for the 15 included online Mindfulness-based intervention studies.

2. Characteristics of Included Studies.

lean age D/range) nder(n%)	**Interven tion (n)**	**Delivery mode**	**Reminders**	**intervention duration n sessions**	**Interventio n dose**	**cancer-adapted**	**Technolo gy**	**Control group (n)**
1(12.03) emale: 100%	MBSR[a] (n=41)	online software; digital interactive whiteboard	NS[b]	6 weeks 6 sessions	2h weekly	NS	Website	wait-list (n=26)

7(10.7) emale: 85%	MBCT[d] (n=90)	E-mail; meditation audio file; written feedback	NS	8 weeks NS	40-45 min daily and twice daily	NS	Website	usual care(n=78)
7(14.35) emale: 68%	Mindfulness-based program (n=54)	Audio instruction; lecture videos; Foundation Course	Study staff made phone calls if an intervention participant completed fewer than three	8 weeks NS	2h weekly	Specifically for individuals affected by cancer	APP	usual care(n=43)
45(9.65) emale: 69%	Mindfulness-based program (n=52)	Online virtual classroom; online manual	App can send reminders using push notifications, study staff made phone calls if an intervention participant completed fewer than three	6 weeks NS	2h weekly	Cancer pack, which was designed specifically for individuals affected by cancer	APP	usual care(n=51)
.69 (8) emale: 22%	MBCT (n=61)	We-chat audio; online platforms	Everyday (text-message)	6 weeks NS	20 min daily and 5 days weekly	Adoption of the main issues and needs of HCC patients	APP	wait-list (n=61)
(10.58) emale: 76%	MBSR (n=11)	Guided meditation audio clips; brief textual lessons	NS	6 weeks NS	average duration of 12 min for each session	N	Website	usual care(n=10)
9(12.13) emale: 91%	MBCT (n=104)	Website written material, audio exercises, writing tasks videos	NS	10w 10 sessions	2h weekly 45 and minutes daily	Program adjustments to meet cancer survivors needs	Website	wait-list (n=46)
34(2.91) emale: 100%	Mindfulness-based program (n =30)	Website meeting 5P Medical App	NS	6 weeks 6 sessions	1.5h weekly	Based on specific considerations for cancer survivors	APP	usual care(n=30)
(10.32) emale: 100%	Mindfulness-based program (n=48)	Audio and video course practice packs app-based	General checkin emails were sent weekly	9 weeks NS	NS	NS	APP	wait-list (n=47)

4(10.29) emale: 100%	Mindfulness-based program (n=57)	APP audio and animated video	Weekly check in email	9weeks NS	NS	NS	APP	wait-list (n=55)
4 (13.1) emale: 54%	Mindfulness-based program (n=46)	Embedded short videos; PDF transcript of the videos; MP3 audio email	Automatically generated email reminders twice daily	6 weeks NS	NS	survey to understand the knowledge with meditation among people with melanoma	Website	wait-list (n=23)
36(7.52) emale: 100%	MBCR[aa] (n =37)	Online course WeChat group; Audio video materials and picture	Everyday (text-message)	8 weeks 8 sessions	6 days weekly and 15 minutes daily	Combine rich experience in rehabilitation psychotherapy of breast cancer	APP	usual care(n=40)
.8 (7.9) emale: 100%	MBCR (n =51)	Web-based courses and intervention materials	NS	4 weeks 4 sessions	1.5 hours per week and 30 minutes daily	on the basis of the problems in the pilot study and participant feedback, adjusted iMBCR program	Website	usual care(n=52)
90 (6.64) emale: 42%	MBCR (n=25)	Online session	Alert reminder message was sent 2 hours before each session	9 weeks 9 sessions	90 min weekly	cancer-specific MBSR program was used in the study	Website	usual care(n=25)
(10.66) emale: 72%	MBCR (n=30)	Virtual online classroom; Guided meditation recordings and videos	NS	8 weeks 8 sessions	45 min daily	cancer-adapted MBSR	Website	wait-list (n=32)

R: mindfulness-based stress reduction.

ot specified in the study.

S-21: Depression, Anxiety, and Stress Scale.

T: mindfulness-based cognitive therapy.

S: Hospital Anxiety and Depression Scale.

Fear of Cancer Recurrence.

: Fear of Cancer Recurrence Inventory.

Quality of Life.

: 12-item Short-Form health survey.

N: National Comprehensive Cancer Network Distress Thermometer.

post-traumatic growth.

21-item Posttraumatic Growth Inventory.

MIS: The 8-item PROMIS Sleep Disturbance scale.

T-G: 27-item Functional Assessment of Cancer Therapy General Scale.

T-Pal: 46-item Functional Assessment of Chronic Illness Therapy - Palliative Care.

ollow-up.

: Pittsburgh Sleep Quality Index.

T-Hep:Functional Assessment of Cancer Therapy-Hepatobiliary Carcinoma.

Perceived Stress Scale.

S-SF :Profile of Mood States-Short Form.

-Y: State–Trait Anxiety Inventory Y-Form.

I: Beck Depression Inventory.

nsomnia Severity Index.

-SF: Fear of Cancer Recurrence Inventory- Short Form.

-Qlq-C30: European Organization for Research and Treatment of Cancer questionnaire.

T-B: Functional Assessment of Cancer Therapy—Breast version 4.

R: Mindfulness-based cancer recovery.

S: Chinese version of the Perceived Stress Scale.

Self-Rating Anxiety Scale.

IS: Profile of Mood States.

SI: Calgary Symptoms of Stress Inventory.

Meta-analysis

Effects on QoL

A total of eight studies reported the effects of Internet-based mindfulness interventions on QoL among cancer patients. To measure quality of life in cancer patients, four health-related QoL measures were utilized, including the Functional Assessment of Chronic Illness Therapy[40], the Functional Assessment of Cancer Therapy[35-37, 41, 44], the Short-Form 12[39] and the European Organization for Research and Treatment of Cancer questionnaire[33], all of which have been validated in this patient population. Higher scores reflected higher quality of life. Because the physical and psychological components of the scale were measured separately and it was not possible to determine the overall change in the quality of life, the data from one study[39] were not summarized. Seven studies including 569 participants were evaluated in the meta-analysis. No

significant heterogeneity was found between studies (P = .23, I^2 = 26%) (Figure 3). The intervention group had a significant QOL improvement compared to the control group (SMD = 0.37, 95% CI, 0.18 to 0.57, P < .001). Additionally, exclusion of any single study at one time did not change the pooled results markedly.

Effects on sleep

Five studies investigated the impact of online MBIs on sleep quality using three assessment tools: 8-item PROMIS Sleep Disturbance scale[37], Insomnia Severity Index[32, 34], Pittsburgh Sleep Quality Index[41, 42]. Higher score indicated a worse sleep quality. Moderate heterogeneity of effect sizes was observed (P = .05; I^2 = 58%) (Figure 3). Grouping the studies by type of technology, scale and Intervention type did not resolve heterogeneity, so a random effects model was chosen to pool results. The result revealed online-MBIs could alleviate patients' sleep, with statistical difference (SMD = -0.36, 95% CI = -0.72, -0.01, P = .04). One outliers were detected[42]. After omitting the studies from the analysis, the effect size dropped to SMD = -0.25, (95% CI, -0.54 to 0.04, P = .09), and heterogeneity reduced substantially (I^2 = 38%). The possible reason for this change may be attributed to the fact that small sample sizes tend to yield more pronounced effects.

Effects on FCR

Three studies measured fear of cancer recurrence, the pooled data included 224 participants. Two FCR measures were used: the Fear of Cancer Recurrence Inventory[39, 43], The Short Form of the Fear of Cancer Recurrence Inventory[33]. Higher score indicated a higher level of FCR. There is great heterogeneity among the studies (I^2 = 86%, P = .009) (Figure 3). After the data of Russell[43] are eliminated by the method of eliminating one by one, significantly lower heterogeneity (P = .70, I^2 = 0%). The possible reason is that Russell 's study adjusted the program of mindfulness intervention by pre-surveying cancer patients, so the intervention on fear of cancer recurrence is more effective. The results showed that the difference between the network-based mindfulness intervention and the control group was not statistically significant (SMD = -0.30, 95% CI = -1.04 to 0.44, P =.39).

Effects on post-traumatic growth

Two studies examined the effect of online-MBIs intervention on post-traumatic growth, with a total of 134 participants. The measurement tool exclusively utilized across two studies to assess post-traumatic growth was the Post-traumatic Growth Inventory[37, 45]. Higher scores indicated greater post-traumatic growth. No significant heterogeneity was found between studies (P = .38, I^2 = 0%) (Figure 3). We found that online-MBIs intervention did not lead to significant increase in post-traumatic growth score (SMD = 0.08, 95%CI = -0.26 to 0.42, P = .66).

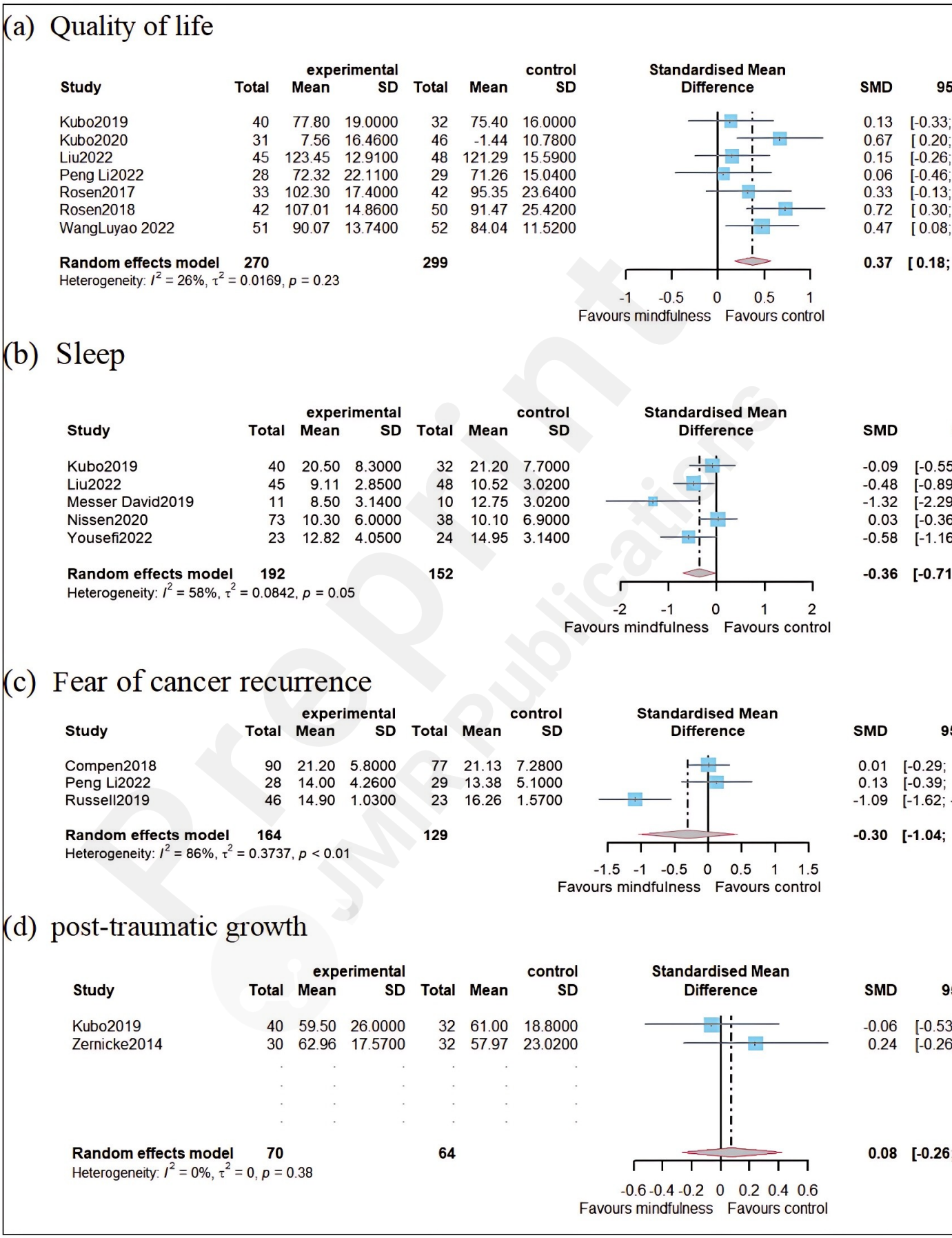


Figure 3. Meta-analysis on (a) quality of life (b) sleep (c) fear of cancer recurrence (d) post-

traumatic growth.

Effects on anxiety

Anxiety levels were assessed in six studies using a total of five validated scales. These scales include the Hospital Anxiety and Depression Scale (HADS)[37, 40], the Depression Anxiety Stress Scale Depression Inventory[38], the State-Trait Anxiety Inventory Y-Form[34], Self-rating anxiety scale[31], Profile of Mood States[45]. Higher scores on these scales indicated elevated levels of anxiety. Meta-analysis showed online-mindfulness intervention lead to significant reduction in anxiety (SMD = -0.48, 95% CI = -0.75 to -0.20, P <.001) (Figure 4). Moderate heterogeneity was found between studies, I^2= 52%, P =.006. Grouping the studies by type of technology and intervention duration did not resolve heterogeneity (Table 3). Furthermore, when we examined subgroups based on sex, we found that studies including female participants had a significantly larger pooled effect size (SMD = -0.67, 95% CI = -1.01, -0.33) than the studies including both male and female participants (referred to as the mixed-gender subgroup) (SMD = -0.39, 95% CI = -0.76, -0.02) (Figure 4). The differences across these two subgroups were statistically non-significant (Chi^2 = 1.19, P = .28).

Effects on depression

Depression was assessed across five studies utilizing various standardized instruments. These included the Depression Anxiety Stress Scale-21 (DASS-21)[38], HADS[37, 40], Beck Depression Inventory[34], Profile of Mood States[45]. Elevated levels of depression were indicated by higher scores on these scales. The pooled data included 384 participants and showed a significant difference in improvement between the intervention and control groups (SMD = -0.36, 95% CI = -0.61, -0.11, P = .005) (Figure 4). Moderate heterogeneity of effect sizes was observed (P = .21, I^2 = 31%). In the sensitivity analysis using the one-study-out method, we found that the pooled estimates were not significantly altered when any one research was omitted in turn, with a range from 0.0001 to 0.03, indicating that the summary effect size is robust.

Effects on Perceived stress.

Six studies investigated the effects of Internet-based psycho-educational interventions on stress. Four distress measures were used: Perceived Stress Scale[34, 41, 43], Chinese-version Perceived Stress Scale[31], Depression and stress scale[32], Calgary Symptoms of Stress Inventory[45]. Five studies including 366 participants were evaluated in the meta-analysis. The data from one study was not pooled because the mean values and standard deviation of outcomes were not reported[41], between-study heterogeneity was found (P = .003, I^2 = 75%) (Figure 4). This meta-analysis revealed a reduction in stress of -0.89 (-1.33 to -0.45) when comparing the intervention group to the control

group at the post-intervention stage.

In order to further explore the potential sources of heterogeneity, we conducted subgroup analyses by type of technology and Intervention type (Table 3).

The two studies utilizing apps (SMD = -1.02, 95% CI: -1.50 to -0.55, heterogeneity = 0) were found to have low heterogeneity, whereas the three studies based on website-based technologies (SMD = -0.87, 95% CI: -1.44 to -0.29, P = 0.002) exhibited higher heterogeneity. After conducting sensitivity analysis and eliminating one study at a time, the exclusion of the Nissen's study[34] resulted in significantly lower heterogeneity (P = .28, I^2 = 21%). The possible reason may be that the research of Nissen providing iMBCT as a routine offer based on a screening procedure may have included less motivated participants in the study compared with studies with self-referral and Nissen's study screened the study population using a lower cutoff value, which could have resulted in a floor effect.

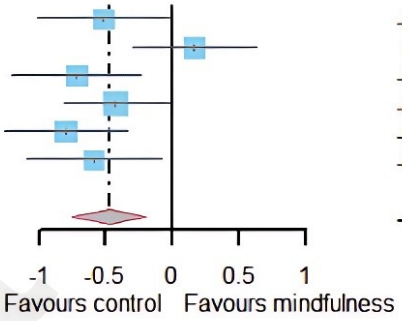
Effects on distress

In the analysis of distress (involving five study), HADS[39, 41, 42], the National Comprehensive Cancer Network Distress Thermometer[37, 40] were utilized to assess the current distress level. Low heterogeneity was found between studies (I^2 = 30%, P = .22) (Figure 4) and the random-effects model indicated that online mindfulness intervention was associated with reduced distress level in patients with cancer (SMD = -0.50, 95% CI = -0 .75 to -0.26, P < .0001).

(e) Anxiety

Study	experimental Total	Mean	SD	control Total	Mean	SD	SMD
Chang2022	41	10.02	4.0400	26	11.88	2.6300	-0.52
Kubo2019	40	7.20	3.9000	32	6.60	3.3000	0.16
Kubo2020	30	-1.23	2.1800	42	0.31	2.0700	-0.72
Nissen2020	72	37.50	8.9000	38	41.80	11.9000	-0.43
Shenaomei2021	37	32.58	4.7060	40	38.10	8.3190	-0.80
Zernicke2014	30	17.16	30.7200	32	35.69	31.5200	-0.59
Random effects model	**250**			**210**			**-0.48**

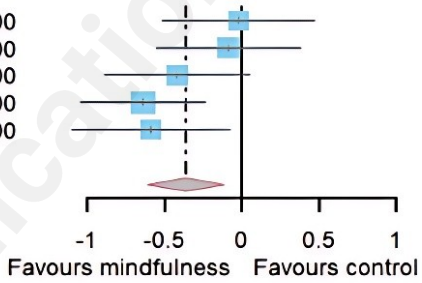
Heterogeneity: I^2 = 52%, τ^2 = 0.0612, p = 0.07



(f) depression

Study	experimental Total	Mean	SD	control Total	Mean	SD	SMD
Chang2022	41	10.61	4.3300	26	10.69	2.1300	-0.02
Kubo2019	40	4.60	3.6000	32	4.90	3.1000	-0.09
Kubo2020	30	-1.10	3.4800	45	0.04	2.0100	-0.42
Nissen2020	72	10.70	6.6000	38	15.60	9.2000	-0.64
Zernicke2014	30	17.16	30.7200	32	35.69	31.5200	-0.59
Random effects model	**213**			**173**			**-0.36**

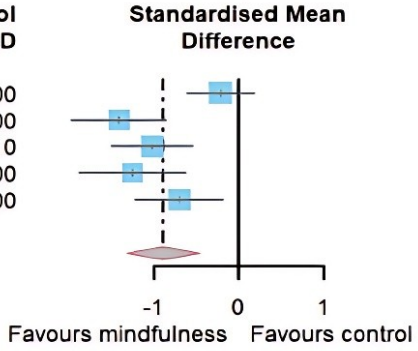
Heterogeneity: I^2 = 31%, τ^2 = 0.0265, p = 0.21



(g) Perceived stress.

Study	experimental Total	Mean	SD	control Total	Mean	SD	SMD
Nissen2020	73	15.70	5.9000	38	17.00	6.3000	-0.21
Russell2019	46	13.46	1.0600	23	15.30	1.6600	-1.41
shenaomei2021	37	23.47	5.7090	40	29.90	6.6410	-1.02
Yousefi2022	23	10.30	2.1100	24	12.75	1.7200	-1.25
Zernicke2014	30	36.83	21.8700	32	58.72	37.3800	-0.70
Random effects model	**209**			**157**			**-0.89**

Heterogeneity: I^2 = 75%, τ^2 = 0.1792, p < 0.01



(h) Distress

Study	experimental Total	Mean	SD	control Total	Mean	SD	SMD
Compen2018	75	11.87	6.1600	70	16.37	6.5000	-0.71
Kubo2019	40	4.20	2.6000	32	4.40	2.0000	-0.08
Kubo2020	31	-0.81	2.2000	46	0.48	2.6900	-0.51
Liu2022	45	11.97	2.8800	48	13.74	4.6500	-0.45
Messer David2019	11	10.00	2.4900	10	17.80	10.5200	-1.00
Random effects model	**202**			**206**			**-0.50**

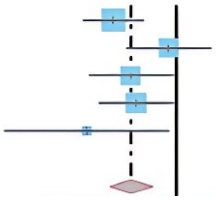


Figure 4. Meta-analysis on (e) anxiety (f) depression (g) perceived stress (h)distress.

Subgroup analysis

Table 3 displays the results of subgroup analyses that were conducted to investigate the heterogeneity in the association between anxiety, perceived stress, and sleep in the context of mindfulness interventions. To explain the variability in the effects of mindfulness, we examined various moderating variables, such as technology, sex, intervention type, intervention duration, study quality, and scale. No statistically significant variables were found in the subgroup analysis of anxiety, whereas type of intervention (P = .0008) was a significant moderating variable for perceived stress, study quality (P = .009) were significant moderating variables for sleep.

Table 3. Subgroup analyses of anxiety, Perceived Stress and sleep.

Subgroup	Stratification	No. of studies	SMD (95% CI)	*P* value for heterogeneity	I^2	*P* value for pooled results	*P* value for interaction
Anxiety							
Technology	Website	3	-0.57 [-0.82,-0.31]	.47	0	.0001	.54
	App	3	-0.38 [-0.93,0.18]	.02	74	.18	
Intervention duration	<8w	2	-0.62 [-0.97,-0.27]	.57	0	.0005	.43
	≥8w	4	-0.41 [-0.81, -0.01]	.03	67	.04	
Sex	female	2	-0.67[-1.01,-0.33]	.41	0	.0001	.28
	mixed	4	-0.39[-0.76,-0.02]	.05	62	.04	
Intervention type	MBCR	2	-0.70[-0.05,-0.36]	.55	0	<.0001	.67
	MBCT	1	-0.43[-0.82,0.03]	-[b]	-	.04	
	MBIs	2	-0.28[-1.14,0.59]	.01	85	.53	
	MBSR	1	-0.52[-1.02,-0.02]	-	-	.04	
study quality	B	4	-0.39 [-0.78,-0.01]	.03	65	.05	.32
	C	2	-0.66 [-1.01, -0.31]	.71	0	.0002	
Perceived stress							
Technology	Website	4	-0.87[-1.44,-0.29]	.002	80	.003	.68

	App	1	-1.02[-1.50,-0.55]	-	-	<.0001	
Intervention type	MBCR	3	-0.96[-1.27,-0.66]	.39	0	<.0001	.0008
	MBCT	1	-0.21[-0.61,0.18]	-	-	.29	
	MBIs	1	-1.41[-1.97,-0.86]	-	-	<.00001	
Sleep							
Scale	PROMS	1	-0.09[-0.55, 0.38]	-	-	.72	.33
	PSQI	2	-0.78[-1.58, 0.02]	.11	60	.05	
	ISI	2	-0.23[-0.83, 0.36]	.09	65	.44	
Technology	Website	3	-0.52[-1.22, 0.19]	.02	75	.15	.20
	App	2	-0.02 [-0.32,0.28]	.70	0	.91	
Intervention duration	<8w	2	-0.78 [-1.58, -0.02]	.11	60	.05	.16
	≥8w	3	-0.16 [-0.49, 0.17]	.23	32	.35	
study quality	B	3	-0.60 [-0.92, -0.28]	.28	20	.0002	.009
	C	2	-0.02 [-0.32, 0.28]	.70	0	.91	

Abbreviations: [b]Not applicable; SMD, standardized mean difference.

Publication bias

Funnel plots and statistical tests were not performed as any of the outcomes had at least 10 studies to ensure sufficient power in detecting asymmetry[46]. However, we reduced the possibility of publication bias by conducting a thorough search across multiple databases to identify published studies[47].

RE-AIM Framework

The results are presented in Data Supplement 3. Fourteen (93%) studies reported 13%-92% of eligible patients. Efficacy (effect size [95%CI] of primary outcome) was reported in 5/15 (33%) studies[34-37, 41] (Cohen’s d or eta-squared). For adoption barriers, health professionals or researchers conducted recruitment for all studies and 8/15(53%) studies[31-34, 41-44] recruited participants in-person (hospital and cancer center). For implementation, intervention adherence ranged from 59%-100% of participants completing all scheduled components. Dropouts of most complex intervention ranged from 0% to 48%, with 6/15 (40%) studies[31, 33, 35, 36, 38, 45] having

under 10% dropouts. Cost was reported in four studies[35-37, 40], including the paid app (priced at $77 for 6 months and $69.99 for 12 months) and the app already publicly available. 7 out of 15 studies(46%) [32-36, 41, 44] reported maintenance of results, 7 out of 15 studies (46%)[32-36, 41, 44] sustaining results for 1-9 months. Four studies[35-37, 40] explicitly reported on the potential for the interventions to remain accessible or whether there were plans for their continued implementation.

Discussion

The objective of this study is to assess the effectiveness of MBIs in improving the mental health and QoL of cancer patients. We discovered that patients' quality of life can be greatly enhanced by online MBIs, which also significantly lowers psychological distress, sleep problems, anxiety, depression, and perceived stress. The current systematic review of meta-analyses and the RE-AIM framework demonstrate that online interventions have a wide range of effects and are highly utilized by different (international and multilingual) cancer patients. However, the use and accessibility of online MBIs for cancer patients has been constrained due to service fees and patient mobility limitations[48], online MBIs mainly carried out in developed countries. The possible explanation is the distinction between communication and economy, some developed countries may have national health services in place to promote online MBIs, whereas poor countries may not. Study shows that in many low- and middle-income countries, the accessibility of evidence-based mental health treatments remains limited[49]. The time commitment, teacher shortage, and high cost of classic mindfulness interventions may have hindered efforts to spread the associated benefits to individuals in developing countries[50]. For instance, Indonesia has yet to implement evidence-based internet-based mindfulness therapy, emphasizing the need for expanding evidence-based mental health interventions in resource-constrained settings.

The results of this study suggest that an online MBIs is effective in improving quality of life and reducing anxiety and depressive symptoms in cancer patients, which is consistent with previous meta-analyses[18, 20]. A possible explanation for this is that online mindfulness interventions can alleviate negative emotions, enhance positive emotions, and increase mindfulness skills among cancer patients, as elaborated by previous research[51]. Moreover, the sleep quality of cancer patients also improved after MBIs. This outcome may be attributed to the inclusion of techniques in the program that target sleep difficulties[7] and the non-judging aspect of mindfulness, which can enhance sleep quality by mitigating stress and everyday tensions. Previous studies[52] have confirmed the moderate effect of mindfulness interventions on sleep quality, which suggests that the use of online MBIs to manage QoL and sleep in cancer patients should be further supported.

Online MBIs have shown potential in helping cancer patients develop emotional regulation

skills and cope with the distress associated with diagnosis and treatment[53]. It makes patients feel better emotionally and physically and helps cancer patients reduce their psychological distress[54]. Incorporating MBIs into oncological treatment can promote emotional and physical well-being and alleviate psychological distress[55]. MBIs have been found to regulate biological variables associated with stress[56], such as immune function, hypothalamic-pituitary-adrenal regulation, and autonomic nervous system activity, thereby reducing pressure on patients. The data from this review showed that MBCR appeared to be particularly effective in reducing perceived stress, whereas MBCT was not effective in reducing stress after the intervention[51]. This finding was unexpected, given that many previous studies have suggested the effectiveness of MBCT in reducing stress[57]. However, due to the limited number of included studies, it is difficult to draw a definitive conclusion regarding the comparative effectiveness of different MBIs.

However, although not statistically significant, online mindfulness intervention can improve the level of post-traumatic growth and fear of cancer recurrence in cancer patients. FCR is one of the commonest problems of cancer survivors, it has been known that FCR can persist throughout the treatment and survival trajectory[58], thus specific intervention is needed for cancer survivors who suffer from clinically significant FCR. Previous meta-analysis showed that cognitive therapy and mindfulness exercises are very suitable for combating the fear of cancer recurrence[59]. Numerous psychological and behavioral mechanisms of change within mindfulness interventions have been suggested, encompassing acceptance, emotion regulation skills, and the reduction of ruminative thoughts[60]. Gu's meta-analysis provided empirical confirmation that rumination significantly mediate the impact of MBIs on mental health outcomes[61], Butow's study also identified rumination as a crucial psychological mechanism associated with FCR[62]. Therefore, the study suggests that the effectiveness of mindfulness interventions in addressing the FCR may be attributed to their potential to improve patients' levels of rumination. The improved post-traumatic growth observed in this study may be explained by the systematic training in moment-by-moment awareness and MBIs focus on viewing thoughts and feelings as mental events[63]. Such a “decentred” relationship enables a perception of mental events as aspects of experience moving through awareness, showing that mindfulness practice supports personal growth and transformation.

In this study, it was observed that short-term MBIs with a duration of less than 8 weeks exhibited a larger effect size concerning the outcomes of anxiety and sleep. In Wang et al.'s[44] study, short-term MBIs were found to be more effective in improving physical health compared to long-term MBIs, interventions lasting less than 8 weeks demonstrated a greater effect size, possibly attributed to the increased participant engagement resulting from the shorter intervention duration and simplified intervention complexity. Shorter interventions may be more feasible and acceptable for patients with cancer who are dealing with a range of physical and emotional challenges[64].

Future research should aim to replicate and expand on these results, including investigating the optimal duration and timing of online MBIs for cancer patients.

Recommendations for Future Research

To the best of our knowledge, this study represents the first meta-analysis utilizing the RE-AIM framework, systematically reviewing and synthesizing the effectiveness of mindfulness-based interventions for cancer patients across various types of interventions. By accurately reporting the RE-AIM dimensions, this study seeks to enhance the replicability and universality of mindfulness interventions in oncology settings. Our assessment of interventions based on online mindfulness for cancer patients, conducted within the framework of RE-AIM, reveals that the participation rates of eligible patients range from 13% to 92%. The calculated median participation rate, at 62%, emphasizes the effectiveness of the interventions in reaching a substantial portion of the target population. However, only a minority of studies reported on efficacy, limiting our ability to draw conclusions on overall effectiveness. Recruitment was primarily conducted by health professionals or researchers, and over half of the studies recruited participants in-person, potentially limiting generalizability. Intervention adherence was generally high, but dropout rates varied widely, indicating that certain interventions may be more challenging for some patients. Cost was reported in only a few studies, with implications for accessibility. Long-term effects were reported in just over half of the studies, highlighting the need for further research. This study underscore the importance of considering the RE-AIM framework in the implementation and evaluation of these interventions. Further research is needed to fully understand their potential benefits and limitations in real-world settings.

Internet-based interventions have previously been shown to be effective for anxiety disorders and fear-related disorders, and have achieved the same effect as face-to-face treatment[65]. Consistent with the results of this study, delivery via the Internet, group or app is feasible and effective. Our results suggest that among forms of online mindfulness interventions for cancer patients, the most widely studied type utilized was website-based online interventions, followed by app -based online interventions. This observation is in line with an analysis conducted in recent years[66], which indicated that the most widely studied type of telehealth for breast cancer patients was Internet-based interventions. Web-based mindfulness interventions may offer more content, functionality, and instruction than mobile-based interventions, which may enhance user engagement, learning, and practice of positive thinking skills[67, 68]. Web-based MBI had higher completion rates and lower attrition rates compared to app-based interventions, which may be due to factors such as convenience, accessibility, engagement, and personalization[69]. Finally, in our review, an website-based study[43] that greatly improved FCR and stress highlighted the sustainability and self-

management of the intervention and enabled flexible navigation by accessing website content according to user preferences. As a result, online mindfulness interventions may offer more opportunities for personalization and tailoring interventions to individual needs.

In our analysis, 8 out of 15 studies implemented a weekly or daily reminder system through various channels such as email, text messages, applications, or smartphone notifications to facilitate online mindfulness-based interventions. However, the prevalence of reminder systems in the studies under review is relatively limited (68%), a finding consistent with the investigation by Matis[19]. Matis conducted a systematic evaluation in this field, discussing the limited prevalence of reminder systems in reviewed studies and highlighting the current lack of direct comparisons between interventions with and without reminders. The study also found that the frequency of reminders was positively associated with the magnitude of the intervention effect[70]. Consequently, in order to promote patient involvement in online mindfulness-based interventions, it is vital to set reminders[67]. Some studies have also set up expert feedback, answers, and a variety of supervision methods to avoid reduced patient compliance. Therefore, web-based mindfulness interventions can enhance engagement by using features such as reminders, feedback, personalization, and facilitator-led components. However, it's important to note that the specific frequency, timing, and content of the reminders may vary depending on the individual and the context of the intervention. Our study results reveal heterogeneity in the types, frequencies, and content of reminder systems, preventing the establishment of specific standards for their effectiveness. Despite the evident practicality of reminder systems, a more comprehensive investigation into their types, frequencies, and effectiveness is imperative within the context of online mindfulness-based interventions.

The current systematic review found that most online interventions have adopted online classrooms, application-based measures to implement mindfulness interventions, and multi-component interventions that include audio, video, and documents. However, the study did not clarify which factors affect behavioral changes. Despite these differences, 67% of interventions are designed specifically for the cancer population and provide customizable interventions. For example, as demonstrated by Wang[44], a pilot online mindfulness-based intervention was conducted for cancer patients, this is an adapted version of MBSR specifically tailored for individuals dealing with cancer-related stressors. The MBCR program retains the core principles and practices of MBSR while integrating specific intervention materials to address challenges associated with cancer, such as common experiences related to cancer, sleep issues, pain, and the fear of cancer recurrence, which is greatly beneficial for improving the physical and mental symptoms of cancer patients. MBCR will provide a platform for cancer patients to engage in discussions and address challenges related to cancer. Future online interventions should take into account the characteristics of patients and determine which intervention plan is most suitable for cancer patients, emphasizing feedback

sessions and communication with therapists to enable patients to learn self-management and make intervention plans sustainable.

Limitations

Although the current review summarizes international RCTs for various outcomes, there are limitations. Firstly, because the research results are measured by various tools, it may hinder the comparability of research outcomes. Secondly, in the 15 trials, there are differences in the personnel, duration, and methods of online mindfulness-based interventions in various studies. Patients included in these studies have different characteristics. Thirdly, The inability to access or adequately translate studies in languages beyond English and Chinese may introduce bias into the selection process, potentially limiting the comprehensiveness of the findings. Finally, in the subgroup analysis, the study of each subgroup is limited, which may reduce the ability to draw conclusions on the differences in the consistency of intervention effects between subgroups. The above factors may lead to heterogeneity between studies, which is closely related to the summary results, so these results need to be interpreted carefully. Nevertheless, the meta-analysis included RCTs only, and used random effect model to pool results, so as to give the most conservative estimates. Also, subgroup analysis and sensitivity analysis were conducted and showed that the pooled estimations were relatively robust.

Conclusion

This meta-analysis provides definite evidence regarding the efficacy of online mindfulness-based interventions for cancer patients. Our findings have implications whereby online MBIs interventions may be effective in improving quality of life, sleep and mental health and can be used as a part of stepped care in clinical practice. Future experiments should pay more attention to the development of intervention programs based on the wishes and characteristics of cancer patients, and to study how to further optimize interventions and customize interventions based on individual physical and mental symptoms.

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Contributions Authors Ting Wang and Xiaoman Jiang developed the key ideas for the manuscript

and the hypotheses. Author Ting Wang developed the search strategy and conducted the literature searches. Authors Yinning Guo, Xiaoman Jiang and Chulei Tang conducted screening and coding. Author Qin Xu, Chulei Tang, Shuqin Zhu contributed to Writing—review and editing. Author Ting Wang conducted the statistical analyses, summarized the findings and wrote the first draft of the manuscript. All authors contributed to and approved the final manuscript.

Declaration of Competing Interest The authors declare no competing interests.

Data availability Data will be made available on request.

SUPPLEMENT

Table 1. Search Strategy

Table 2. Characteristics of included studies

Table 3. Summary of the Risk of Bias of Studies Included in the Systematic Review

Table 4. RE-AIM Framework

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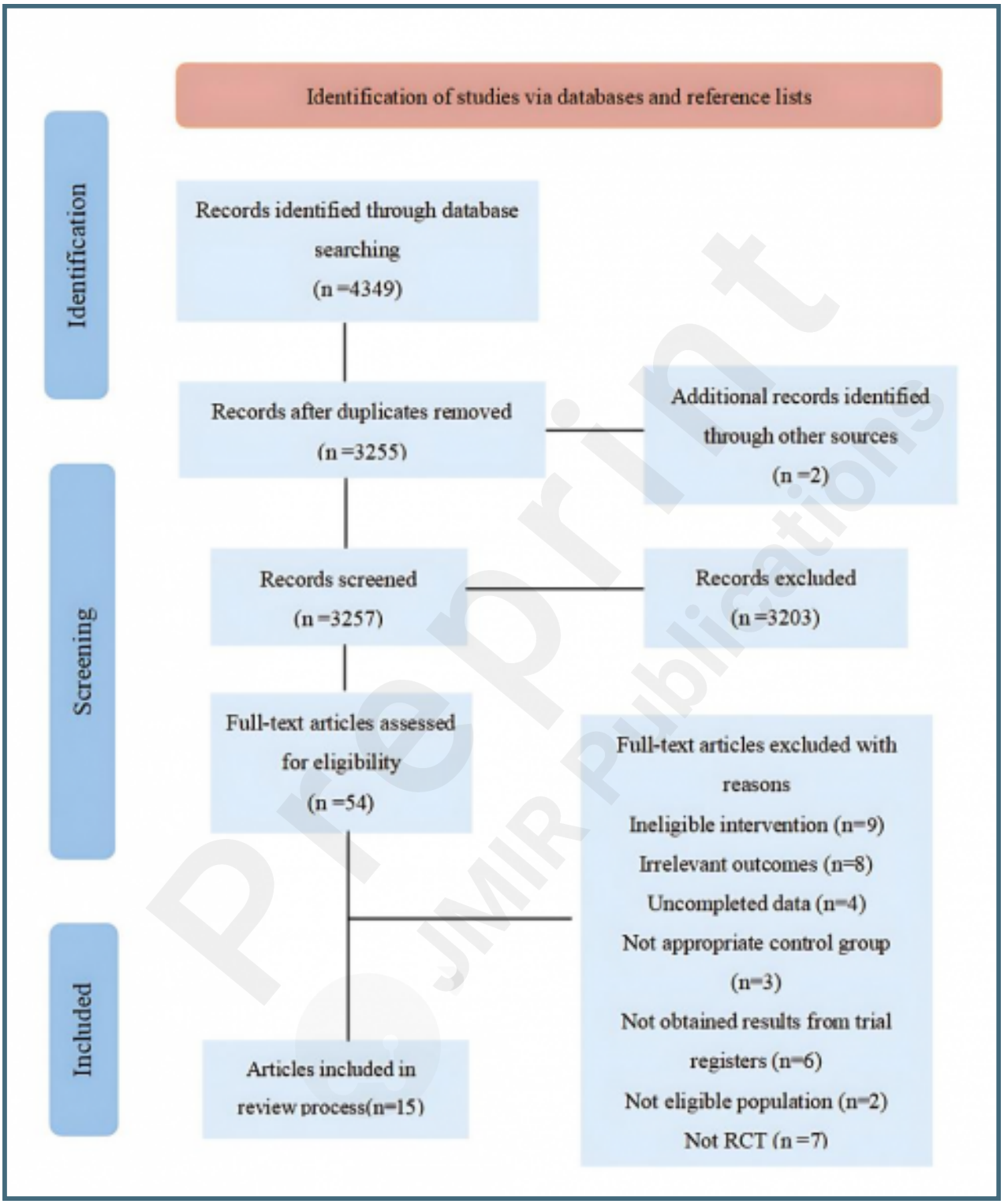
Supplementary Files

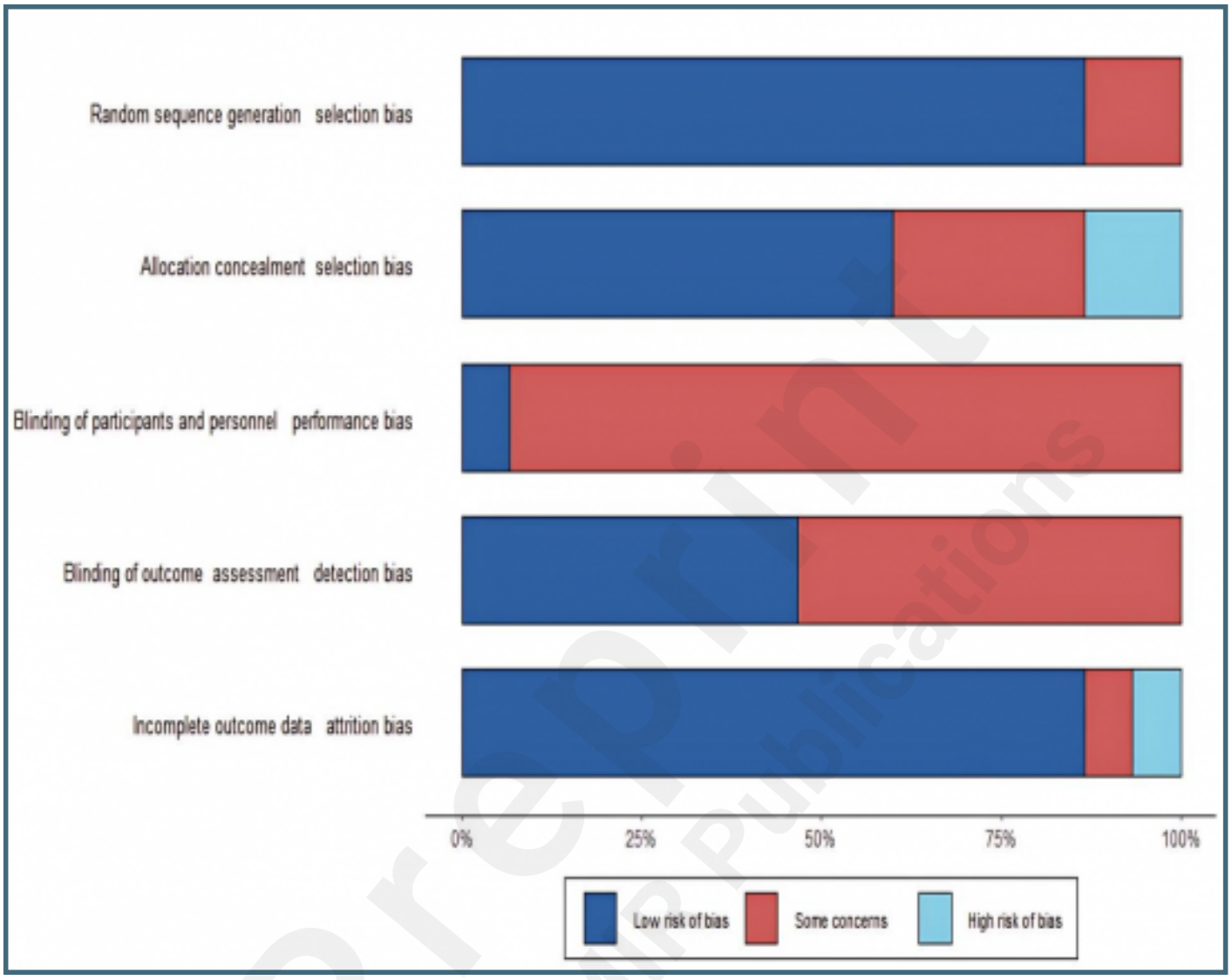
Untitled.
URL: http://asset.jmir.pub/assets/505f382bae33de716db98aef7640d26f.doc

Figures

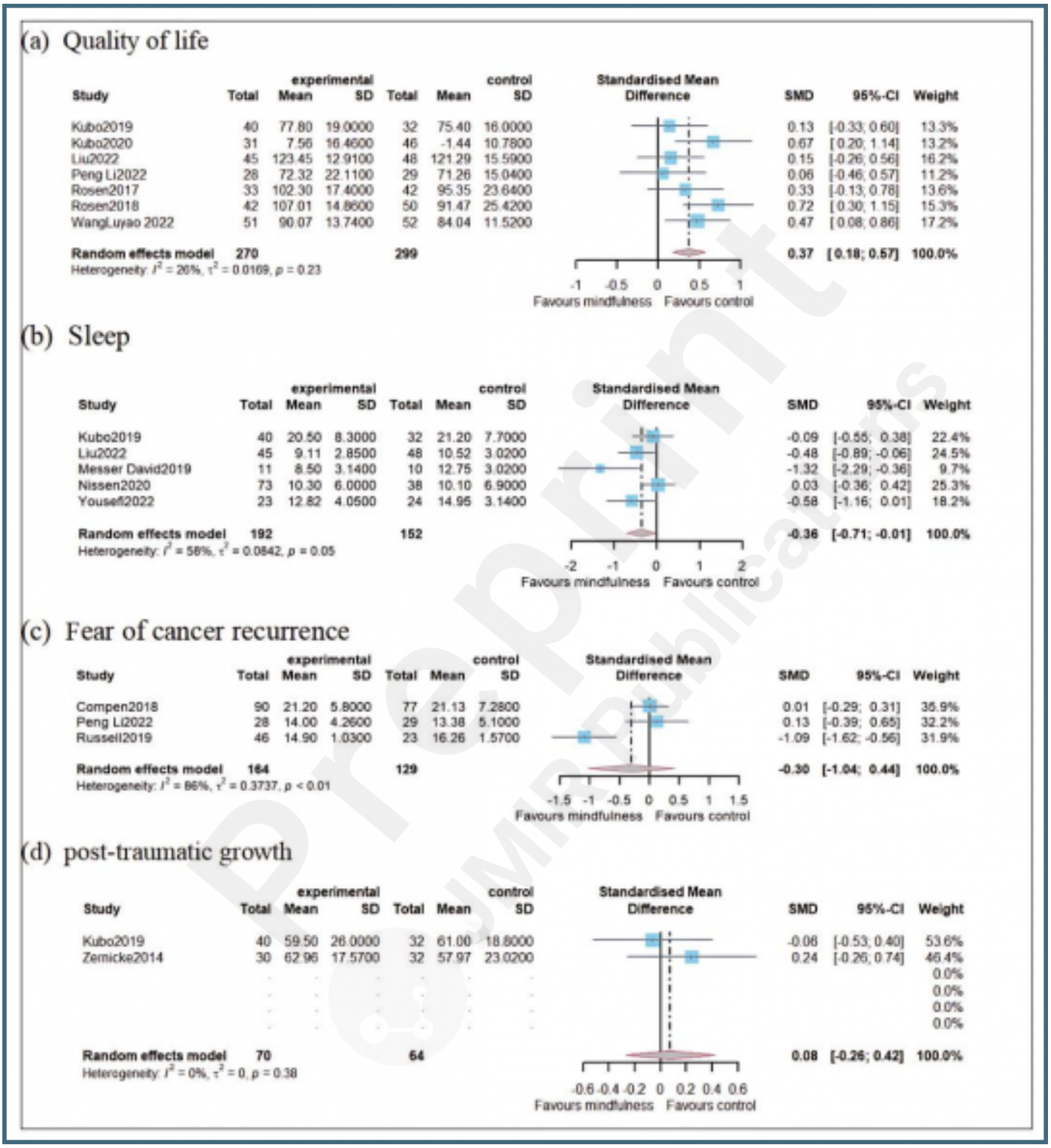
Flow Diagram of Trial Identification and Selection.



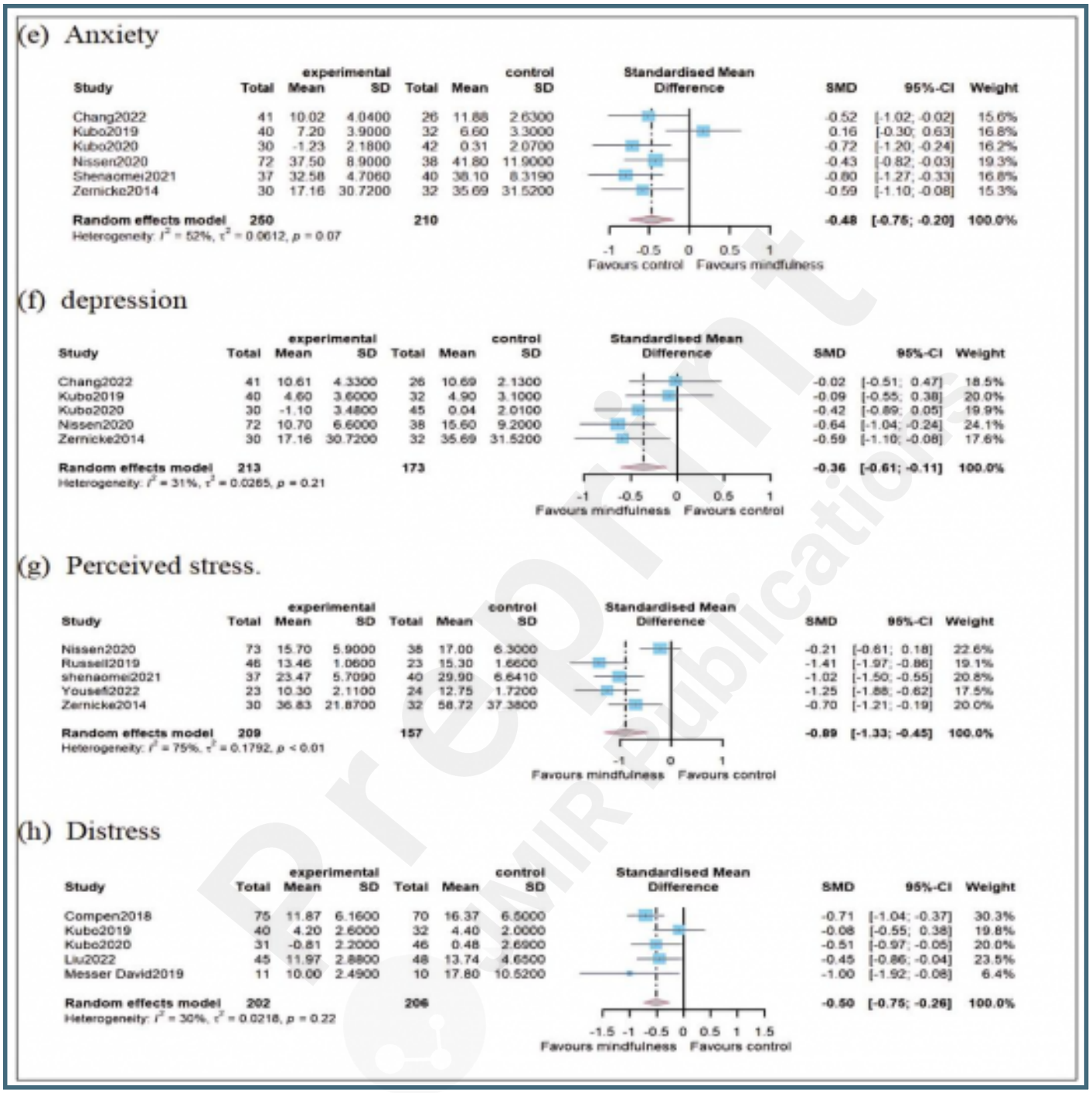
Risk of bias assessment for the randomized controlled trials.



Meta-analysis on (a) quality of life (b) sleep (c) fear of cancer recurrence (d) post-traumatic growth.



Meta-analysis on (e) anxiety (f) depression (g) perceived stress (h)distress.



Multimedia Appendixes

All examples of search strategies.
URL: http://asset.jmir.pub/assets/2ae65c848f7509b736632de8c7e4d638.doc

Cochrane Risk of Bias Supporting Evidence.
URL: http://asset.jmir.pub/assets/6e0bc4c02064a6dc5ca141b45d80a3e8.doc

Characteristics of included studies.
URL: http://asset.jmir.pub/assets/0ec9d0837d3d7748992c53bf1847d7d2.doc

RE-AIM Framework.
URL: http://asset.jmir.pub/assets/35b986cb3f796d8c835f85d25bbcdfa0.doc

CONSORT (or other) checklists

completed PRISMA-ScR checklist.
URL: http://asset.jmir.pub/assets/4bc4e0f92fe29538a5e1206803be3d8a.pdf