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Review

Effects of a computer-based applications intervention on anxiety, depression and quality of life among lung cancer patients: A systematic review and meta-analysis

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Abstract: Objectives: Lung cancer is associated with higher anxiety and depression than other cancers, accelerating the deterioration of the quality of life (QoL). There is a limited comprehensive evaluation about computer-based intervention (CBI) which uses technological approaches to manage these issues. This meta-analysis sought to evaluate the efficacy of CBI in mitigating anxiety and depression while enhancing quality of life among lung cancer patients. **Methods:** This systematic review and meta-analysis were conducted following PRISMA guidelines; it has been registered with PROSPERO (CRD42023397575). Randomized controlled trials (RCTs) published up to 31 December 2024 were searched from PubMed, Cochrane Library, and the Embase database. The primary outcomes assessed were quality of life, anxiety, and depression. The results are presented as standardized mean differences (SMD) with a 95% confidence interval. **Results:** A total of 3018 patients were included in 12 randomized controlled trials. The primary outcome of this meta-analysis demonstrated a statistically significant difference between CBI and usual care, significantly improved QoL (SMD = 3.92, 95% CI: 2.36 to 5.47, $p < 0.00001$, $I^2 = 97\%$), anxiety (SMD: −0.63, 95% CI: −1.04 to 0.22, $p = 0.002$, $I^2 = 79\%$) and depression (SMD: −0.47, 95% CI: −0.57 to −0.36, $p < 0.00001$, $I^2 = 0\%$). **Conclusions:** Computer-based applications intervention has been demonstrated to significantly reduce anxiety and depression and improve QoL among lung cancer patients.

Keywords: meta-analysis; mobile health; anxiety; depression; quality of life; lung cancer patients

1. Introduction

Lung cancer remains the leading cause of cancer-related deaths, accounting for approximately 20% of cancer deaths in males and 21% in females [1]. In 2024, of the 125,070 projected lung cancer deaths [2]. The 5-year relative survival rate for lung cancer is 25%, which is higher only than pancreatic cancer (13%) and cancers of the liver and esophagus (22%) [1]. Advances in early detection and treatment have accelerated the decline in lung cancer mortality rates [3,4], However, lung cancer still causes more deaths annually than colorectal, breast, and prostate cancers combined [1].

Quality of life (QOL) is a critical concern for cancer patients [5]. Compared to other cancers, lung cancer is associated with a higher symptom burden [6,7], and extensive research has documented the link between this burden and poorer QOL [6–9]. When anxiety and depression are not properly managed, they can

further deteriorate QOL, creating a harmful cycle of emotional distress that negatively impacts overall well-being. This highlights the need for a special focus on patient-centered care to address these challenges effectively [10].

For lung cancer patients, anxiety is almost inevitable as they face significant psychosocial challenges. Patients with lung cancer have a higher prevalence of depression compared to those with other cancers [11]. The clinical importance of assessing and treating emotional distress and mood disorder has received much attention from patient advocacy groups and health care providers, including consideration of distress as the sixth vital sign in cancer care [12]. Unfortunately, the psychological and emotional impact of lung cancer has been understudied.

Based on research demonstrating the relationship between distress and worse physical, functional, and QOL outcomes in cancer patients, requires all comprehensive cancer centers to assess, identify, and provide treatment for managing physical and psychological state in cancer patients [13,14]. However, implementation of this recommendation in a busy clinical practice can be a challenge, particularly since research studies often focus on multi-item questionnaires to assess symptom burden, QOL, and emotional distress.

Communication between cancer patients and care providers can't often meet the needs of patients [15]. Computer-based interventions (CBI) are those that use technology in some form to provide an interactive, multisensory learning experience, employing a variety of methods supported by mobile devices, such as mobile phones, patient monitoring devices, and other wireless technologies [16]. This study adopts this definition to examine the role of CBI in improving psychological outcomes and quality of life among lung cancer patients. The growing field of CBI utilizes mobile devices (e.g., monitoring devices, smartphones, and other wireless technologies) to deliver interventions via video, audio, and interactive apps. These approaches overcome time and space constraints, enable real-time monitoring, and reduce healthcare costs [17]. However, the findings of these studies have demonstrated a lack of complete consistency [18–29]. The outcomes of previous meta-analyses evaluating the efficacy of CBI in cancer populations remain inconclusive. While certain studies emphasize notable improvements in anxiety, depression, and QoL among cancer patients utilizing CBI, others have reported variable or minimal effects. These discrepancies may be attributed to methodological constraints and the heterogeneity of intervention designs [30,31].

This systematic review and meta-analysis aimed to investigate the possible impact of computer-based tools for lung cancer patients, provide an up-to-date summary of outcomes, comprehensively assess the effectiveness of CBI in improving anxiety, depression, and QoL.

2. Methods

This study followed a protocol-based systematic review and meta-analysis design, aiming to assess the efficacy of computer-based interventions in improving quality of life (QOL), anxiety, and depression among patients with lung cancer. The protocol was registered with PROSPERO (CRD42023397575) and conducted in accordance with the Cochrane Handbook for Systematic Reviews of Interventions.

The reporting adhered to the 27-item checklist of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [32], ensuring comprehensive and transparent reporting of all relevant aspects of the review process.

2.1. Identification and selection of studies

We searched from PubMed, Cochrane Library and Embase databases, all publications from inception to 31 December 2024 were initially retrieved. A search strategy was performed based on the PICO principle (participants, intervention, comparison, outcome, and study design), and incorporated a combination of subject-specific terms and free-text keywords related to computer-based applications, anxiety, depression, quality of life, and patients with lung cancer.

The search process was conducted independently by two researchers (Ju Qingmei and Liu Yang), with both researchers following a pre-established, standardized approach. The search was iterative, with any discrepancies in database retrieval resolved through regular discussions and consultations with a third researcher. In total, the search yielded a significant number of studies, which were then screened for relevance according to predefined inclusion and exclusion criteria.

2.2. Study eligibility and inclusion/exclusion criteria

The document management process was carried out using EndNote (X9) software, with two researchers independently evaluating the project's eligibility. An initial screening of titles and abstracts was performed, followed by a full-text review of the selected articles. Only randomized controlled trials were included in the review, provided they met the following inclusion criteria: (1) Individuals diagnosed with lung cancer, regardless of the stage of the disease or the treatments undergone, and the follow-up period was more than two weeks; (2) aged 18 years or older; (3) computer-based interventions, defined as "use technology in some form to provide an interactive, multisensory learning experience, employing a variety of methods supported by mobile devices, such as smartphones, tablets, mobile applications (apps), and web-based platforms to deliver healthcare services"; (4) usual care referred to the usual oncology care; (5) reported outcomes included at least one of the following: QOL, anxiety or depression; (6) experimental studies: randomized controlled trials (RCTs). Exclusion criteria encompassed: (1) Individuals with cognitive impairments that could hinder their capacity to provide reliable outcome data; (2) articles with non-English language were excluded.

2.3. Data extraction and risk of bias assessment

Two researchers independently performed evaluations, initial screenings, and verifications of the literature using a consistent and standardized approach. Based on predefined criteria, studies were either included or excluded, and data were subsequently extracted. The risk of bias in the included studies was evaluated by two independent reviewers in accordance with the Cochrane risk of bias (ROB) Tool [33]. Disagreements between reviewers were resolved through consultation or by involving a third researcher. RevMan 5.4 software was used to facilitate the risk of bias assessment. The overall risk of bias for a trial was determined based on these

assessments, with classifications of “low”, “unclear”, or “high” risk. A trial was deemed to have a low risk of bias only if all domains were rated as low risk. For more information on the specific methods used for the literature search, please see the Appendix (**Table A1**).

2.4. Statistical analyses

Data analysis was performed using RevMan 5.4 software, which was selected for its robust capabilities in performing meta-analyses. For continuous outcomes, the standardized mean difference (SMD) was used as the effect size measure to compare intervention and control groups. Statistical heterogeneity between studies was assessed using the I^2 statistic, which quantifies the proportion of total variation across studies due to heterogeneity rather than chance. An I^2 value greater than 50% was considered indicative of significant heterogeneity.

To account for the potential variability between studies, a random-effects model was used when the *p*-value was less than 0.01 and the I^2 exceeded 50%, reflecting the assumption of variability in effect sizes across studies [34]. When these criteria were not met, a fixed-effects model was applied, which assumes a common effect size across studies.

In addition to the I^2 statistic, other measures of heterogeneity, such as Tau^2 and Cochran’s Q test, were also applied to further assess the degree of variation across studies. A *p*-value of less than 0.05 was considered statistically significant.

3. Results

The systematic literature search identified 1619 studies, with 856 removed due to duplication. Following a review of titles and abstracts, 717 records were excluded. After screening 46 full-text articles, 12 randomized controlled trials studies were deemed eligible. The final analysis included a total of 3018 patients (**Figure 1**).

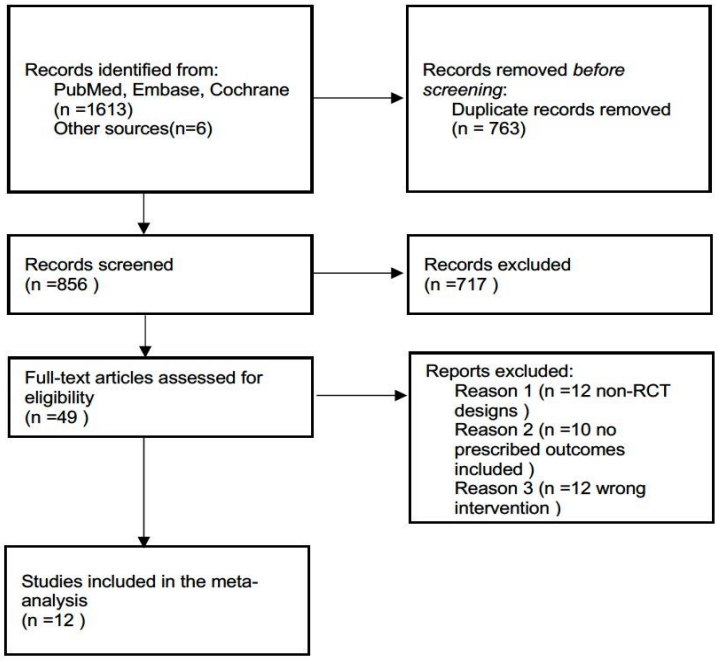

Figure 1. Selection diagram of the selection of the included studies.

The key characteristics of the included trials are summarized in **Table 1**. All studies were randomized controlled trials (RCTs) published between 2014 and 2024. Three trials were conducted in the United States, three in the Netherlands, two from China and Germany respectively, and one from France.

Table 1. Summary of outcomes found in the included studies.

Num	Author (year)	Design	Country	N (I/C)	Participants	Intervention	Control	Outcomes
1	Schuit et al., 2022 [18]	RCT	Netherlands	69/69	lung cancer, and other types of cancer	Oncokompas (eHealth application)	Usual care	Quality of life
2	Huang et al., 2022 [19]	RCT	China	27/28	lung cancer	Web-based health education	Usual care	Quality of life, anxiety and depression
3	Walker et al., 2014 [20]	RCT	United Kingdom	68/74	lung cancer	Telemedicine and telephone monitoring	Usual care	Anxiety and depression
4	Sui et al., 2019 [21]	RCT	China	1000/100	lung cancer	WeChat app-based education	Usual care	Quality of life, anxiety and depression
5	Weemaes et al., 2024 [22]	RCT	Netherlands	46/50	lung cancer, and other types of cancer	Remote coaching	Usual care	Quality of life, anxiety and depression
6	Spahrkäs et al., 2020 [23]	RCT	Netherlands	519/280	lung cancer, and other types of cancer	Untire Mobile App (evidence-based methods)	Usual care	Quality of life
7	Greer et al., 2020 [24]	RCT	United states	91/90	lung cancer, and other types of cancer	Mobile App	Usual care	Quality of life, anxiety and depression
8	Greer et al., 2019 [25]	RCT	United states	72/73	lung cancer, and other types of cancer	CBT (cognitive-behavioral therapy) Mobile App	Usual care	Quality of life, anxiety and depression
9	Neubert et al., 2023 [26]	RCT	Germany	78/79	lung cancer, and other types of cancer	Video sequence	Usual care	Anxiety and depression
10	Bash et al., 2016 [27]	RCT	United states	441/325	lung cancer, and other types of cancer	Tablet computers	Usual care	Quality of life
11	Denis et al., 2017 [28]	RCT	France	60/61	lung cancer, and other types of cancer	Web-Mediated follow up	Routine Surveillance	Quality of life
12	Springer et al., 2024 [29]	RCT	Germany	99/119	lung cancer, and other types of cancer	Mika App (digital therapeutic)	Usual care	Quality of life, anxiety and depression

Note: I/C: Intervention group/control group.

Quality of life was assessed in 11 trials involving 2491 patients, we confirmed that CBI was associated with improved QoL (SMD = 3.92, 95% CI: 2.36 to 5.47, $p < 0.00001$, $I^2 = 97\%$) based on the moderate quality of evidence (**Figure 2**). Five of twelve trials calculated the anxiety outcomes (SMD: −0.63, 95% CI: −1.04 to 0.22, $p = 0.002$, $I^2 = 79\%$) (**Figure 3**) and six trials for depression (SMD: −0.47, 95% CI: −0.57 to −0.36, $p < 0.00001$, $I^2 = 0\%$) (**Figure 4**). These showed that there is a significant difference between CBI and compared to control group decreased anxiety and depression.

We used RevMan 5.4 to evaluate the impact of individual studies on the overall pooled estimates for each predefined outcome. The results of the risk of bias assessment for these trials are provided in the Appendix. The symmetry of the funnel

plot indicates no significant publication bias. In terms of quality appraisal, twelve studies achieved the highest possible score, underscoring the strength and reliability of the research conclusions drawn in this meta-analysis.

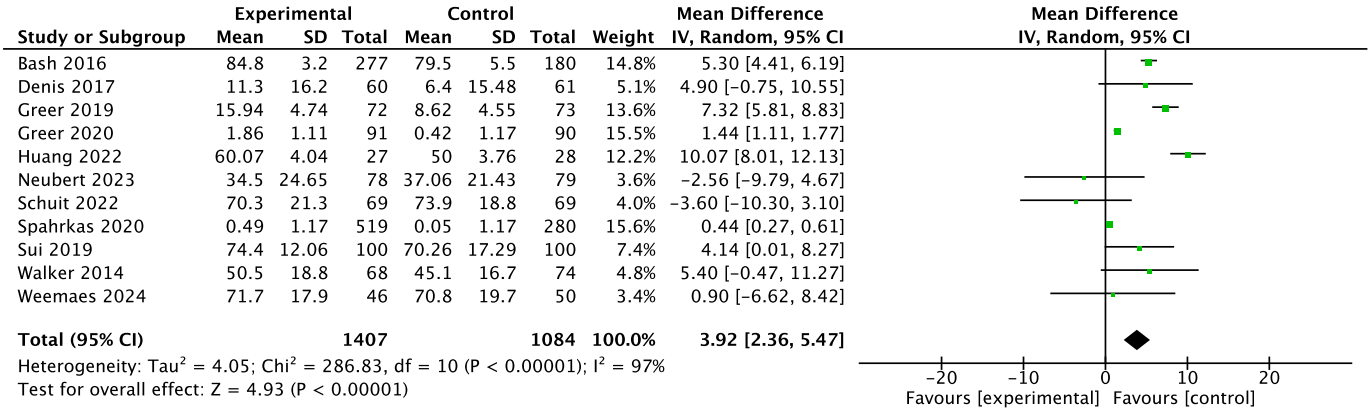

Figure 2. Forest of plot showing the quality of life.

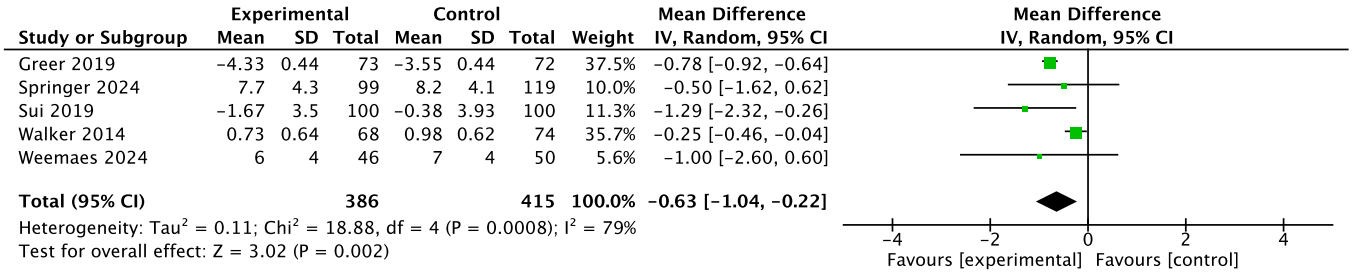

Figure 3. Forest of plot showing the anxiety.

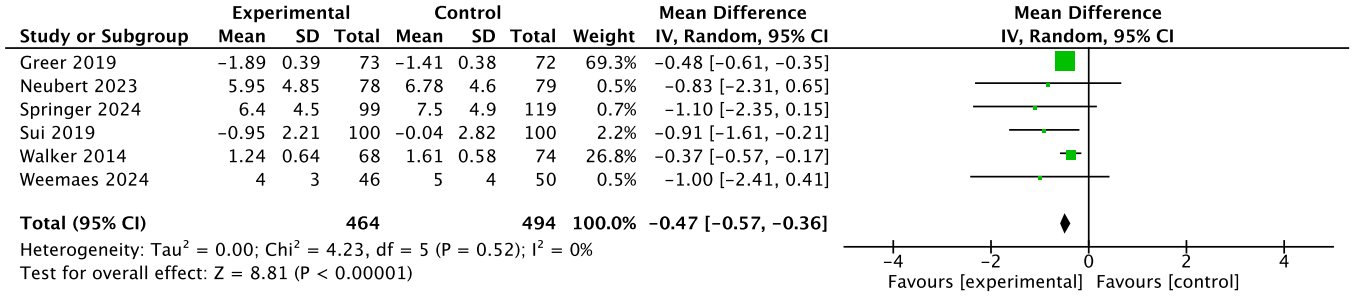

Figure 4. Forest of plot showing the depression.

We utilized RevMan 5.4 to assess the influence of individual studies on the overall pooled estimate for each predefined outcome. A summary of the risk of bias assessment for these trials is provided in Appendix (**Figures A1** and **A2**), all studies were evaluated as having a low risk of bias. The funnel plots (**Figures A3–A5**) suggest no significant publication bias among the included studies. Additionally, Begg's test further supported this finding for QoL (Begg's $Z = -0.31$, $p = 0.75$), anxiety (Begg's $Z = 0.24$, $p = 0.80$), and depression (Begg's $Z = 0.00$, $p = 1.00$).

4. Discussion

This systematic review and meta-analysis offers robust evidence on the

effectiveness of computer-based interventions (CBI) in improving anxiety, depression, and quality of life among lung cancer patients. The results of our study underscore the potential of computer-based applications as a valuable supportive tool in enhancing various aspects of care for these patients. The distinction between this study and previous research is that our survey targeted lung cancer patients and interventions based on computer-based interventions [35,36]. The study population is defined more precisely, which lends credence to the notion that the results will be even more reliable and accurate. Our study's findings diverge from those of the aforementioned research in that CBI has been demonstrated to be a more efficacious intervention in improving QoL, reducing anxiety and depression than receiving usual oncology care among lung cancer patients.

Lung cancer patients, the emotional burden can be further compounded by the physical and psychological demands of cancer treatments, such as chemotherapy, radiotherapy, surgery, and immunotherapy; these can induce significant anxiety and depression at various stages of the treatment process. Side effects and uncertainties about outcomes can also trigger emotional upheaval, making it difficult for patients to maintain psychological balance. Psychological well-being is an integral part of overall health, anxiety and depression, which are among the most prevalent psychological conditions, often manifesting as a spectrum of fluctuating emotions in patients navigating the challenges of serious diseases. Research by Vogt et al. [37], Macia et al. [38] both emphasize the heavy emotional toll that a diagnosis of incurable cancer can have, with many patients experiencing significantly heightened levels of anxiety and depression. Depression, in particular, is a leading cause of the global mental health-related burden of disease [39]. As such, addressing these psychological challenges is critical for improving the overall well-being of lung cancer patients.

The emotional toll of cancer treatment can significantly impact patients' quality of life and their ability to cope with the disease. This is where computer-based applications present a promising solution. The independence and flexibility afforded by these digital tools offer a novel way to meet the psychological and informational needs of patients. Compared to traditional care methods, CBI interventions provide distinct advantages, especially when integrated with just-in-time adaptive technologies. These applications can deliver personalized, timely information tailored to the individual needs and preferences of patients, which is crucial in managing symptoms, alleviating psychological distress, and improving overall QoL. By ensuring that patients receive up-to-date, relevant information, these technologies help them stay engaged with their care while adapting to their changing circumstances.

One of the key strengths of computer-based applications is its ability to improve communication between cancer patients and healthcare providers, ensuring patients receive timely, efficient, and user-friendly guidance and support. More importantly, they empower patients to take an active role in their healthcare decisions, by providing access to content tailored to their unique symptoms, concerns, and preferences. This personalized approach can be especially beneficial for patients who feel stressed or overwhelmed by their illness, offering them a sense of control over their treatment plan and improving their psychological well-being.

Furthermore, CBI offers a practical way to enhance access to medical care, especially for outpatient populations and those residing in rural or underserved

areas [40]. In these settings, where traditional healthcare services may be limited, computer-based applications serve as a vital link, connecting patients with essential care. The scalability and cost-effectiveness of these platforms make them a feasible solution for improving healthcare access, particularly for those who face geographical or financial barriers to traditional care. This capability positions CBI as a transformative tool in reducing healthcare disparities and improving the overall quality of life for lung cancer patients.

Integrating psychological care into routine cancer treatment is essential for addressing the comprehensive needs of lung cancer patients. It is not only about alleviating anxiety and depression but also enhancing overall quality of life. Incorporating psychological care into cancer treatment allows for a holistic approach that addresses both the physical and emotional dimensions of the disease. By focusing on both mental and physical health, healthcare providers can help patients navigate the challenges of their illness with greater resilience, a sense of control, and improved hope for the future. This integrated approach ensures that cancer care is truly patient-centered, providing support for both the body and mind throughout the treatment journey.

5. Conclusions

This study provides a broad overview of computer-based applications interventions by analyzing 12 randomized controlled trials, which offers useful insights for future clinical practice. The key strengths of this study include: (1) Rigorous methodology, ensuring the reliability of findings through a comprehensive systematic review and meta-analysis; (2) multidimensional evaluation, assessing not only psychological outcomes but also quality of life, thereby providing a holistic understanding of computer-based applications interventions; and (3) clinical and policy relevance, offering valuable insights for the integration of digital health solutions into oncology care.

There are some important limitations to keep in mind. First, the search for studies was limited to English-language publications and did not include grey literature, which may have reduced the number of studies available and affected the results. Second, even though many studies were included, there’s a possibility of publication bias, as studies with positive findings are more likely to be published than those with negative or neutral results. Finally, most of the studies had short follow-up periods, making it hard to determine whether computer-based applications interventions are effective in the long term. These limitations should be considered when interpreting the findings.

CBI has been demonstrated to have a positive effect on improving QoL, anxiety and depression among lung cancer patients. Future studies should aim to improve how long these interventions last, how they are delivered, and examine their long-term effects on patients with the ongoing advancements in computer-based applications. Therefore, integrating computer-based applications into regular care could greatly enhance the mental and emotional well-being of lung cancer patients. Given the demonstrated benefits of computer-based interventions, policymakers should consider incorporating computer-based applications into cancer care guidelines to improve psychological support and remote health management; and fostering interdisciplinary

collaboration among healthcare providers, technology developers, and policymakers to optimize computer-based applications implementation in oncology.

5.1. Limitations

There are some limitations of this study. First, more RCTs with larger samples and multiple follow-up times should be adopted. Second, this study is impossible to conduct a meta-analysis by subgroups and evaluate publication bias, which limited the evaluation of the simulation on outcomes.

5.2. Inclusions

This systematic review and meta-analysis identified a positive association between mobile health interventions and improved quality of life among cancer patients receiving palliative care. Additionally, the findings emphasized the effectiveness of mobile health in alleviating caregivers' negative mood. However, the evidence for its impact on reducing anxiety and depression was not statistically significant, suggesting that mobile health palliative care interventions should prioritize addressing mental health needs more effectively. Implementing early mobile health palliative care interventions for cancer patients in clinical settings is both necessary and timely to enhance overall patient and caregiver well-being.

Ethical approval: Not applicable.

Informed consent statement: Not applicable.

Conflict of interest: The authors declare no conflict of interest.

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Appendix

Table A1. Search strategy.

Electronic database	Search strategy
PubMed & Cochrane Library	(“Telemedicine” [MeSH] OR “Mobile Applications” [MeSH] OR “Internet-Based Intervention” [MeSH] OR (“mobile health” [Title/Abstract] OR “mHealth” [Title/Abstract] OR “smartphone” [Title/Abstract] OR “mobile app” [Title/Abstract] OR “digital” [Title/Abstract] OR “Web-based” [Title/Abstract])) AND (“Anxiety” [MeSH] OR “Depression” [MeSH] OR “anxiety” [Title/Abstract] OR “depression” [Title/Abstract]) AND (“Quality of Life” [MeSH] OR “QoL” [Title/Abstract] OR “quality of life” [Title/Abstract]) AND (“Lung Neoplasms” [MeSH] OR “lung cancer” [Title/Abstract] OR “lung neoplasm” [Title/Abstract])
Embase	(‘telemedicine’/exp OR ‘mobile applications’/exp OR ‘internet-based intervention’/exp OR (‘mobile health’:ab,ti OR ‘mHealth’:ab,ti OR ‘smartphone’:ab,ti OR ‘mobile app’:ab,ti OR ‘digital’:ab,ti OR ‘web-based’:ab,ti)) AND (‘anxiety’/exp OR ‘depression’/exp OR ‘anxiety’:ab,ti OR ‘depression’:ab,ti) AND (‘quality of life’/exp OR ‘QoL’:ab,ti OR ‘quality of life’:ab,ti) AND (‘lung neoplasms’/exp OR ‘lung cancer’:ab,ti OR ‘lung neoplasm’:ab,ti)

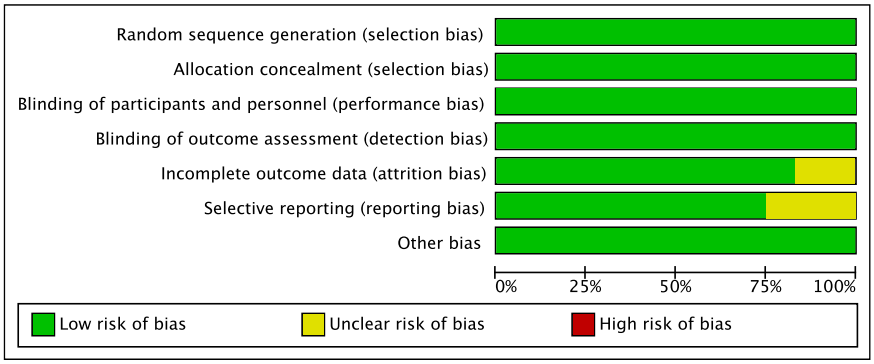

Figure A1. Risk of bias graph.

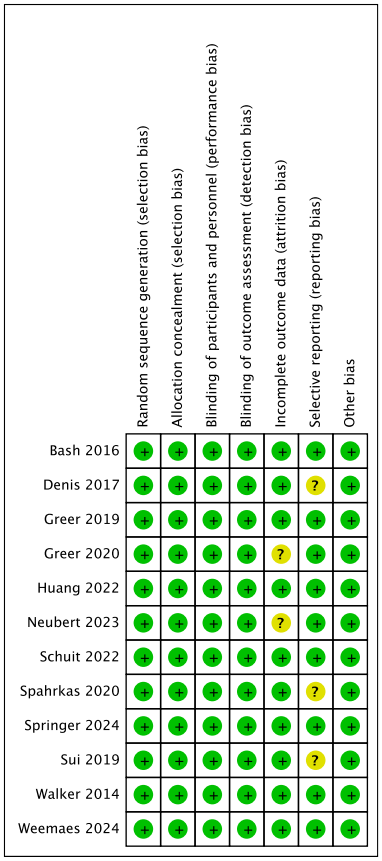

Figure A2. Risk of bias graph.

Funnel plot showing publication bias (**Figures A3–A5**).

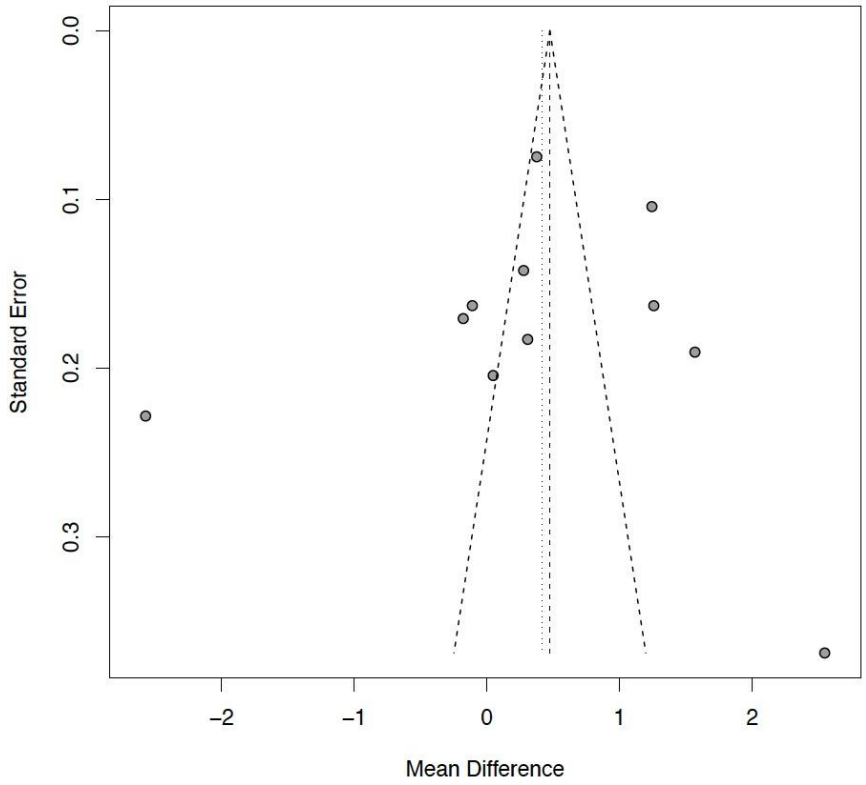

Figure A3. Funnel plot showing publication bias of quality of life.

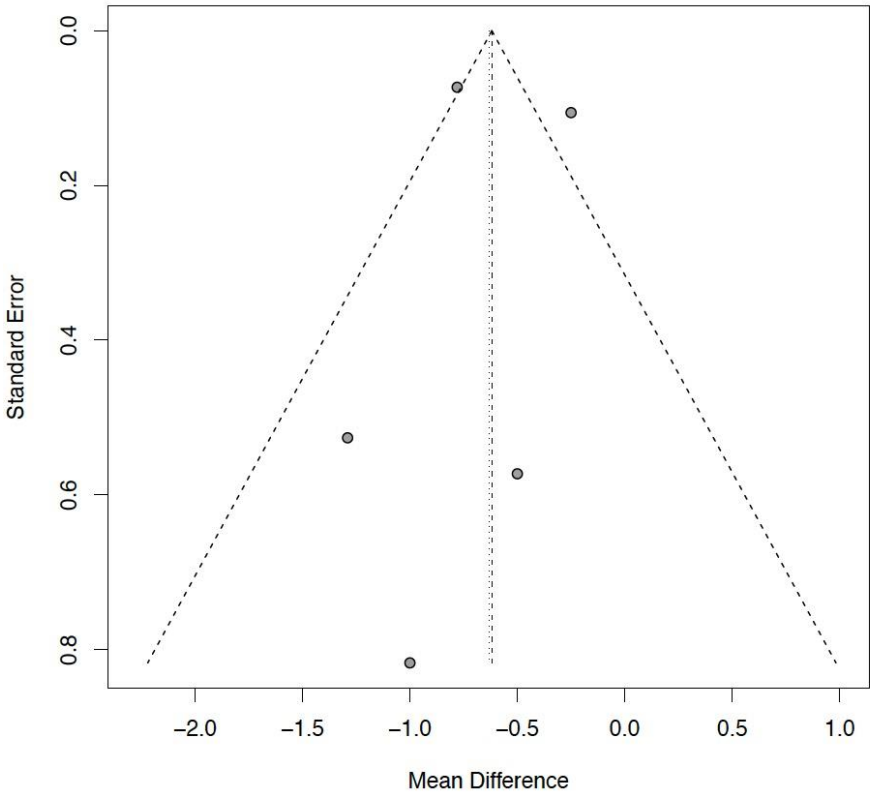

Figure A4. Funnel plot showing publication bias of anxiety.

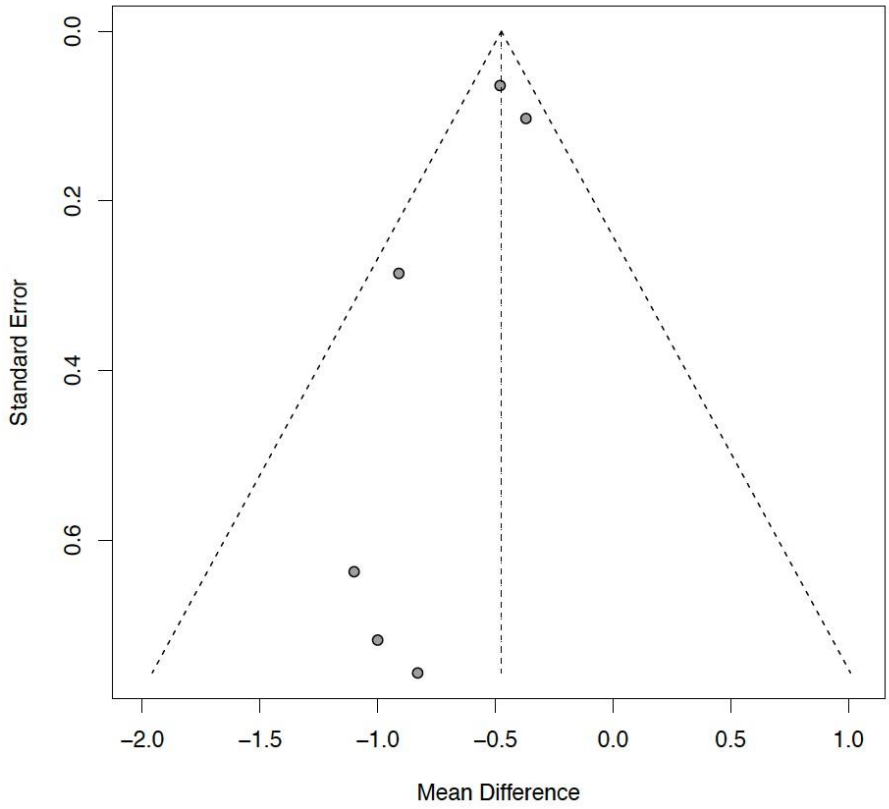

Figure A5. Funnel plot showing publication bias of depression.