Effectiveness of Digital Health on Psychological Well-being in Parents of Children with Cancer: A Systematic Review and Meta-Analysis

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Abstract

Background: Digital health has shown significant potential in enhancing the psychological health of parents whose children are diagnosed with cancer. The aim was to evaluate its effectiveness in addressing PTSD, anxiety, depression, and stress among these parents.

Objective: This study aims to assess the efficacy of DHT in addressing post-traumatic stress disorder, anxiety, depression, and stress among parents of children with cancer.

Methods: RCTs were reviewed in six electronic databases, including PubMed, Embase, Web of Science, CENTRAL, PsycINFO, and CINAHL Plus, from inception to March 2024.

Results: Six RCTs were conducted. The meta-analysis revealed that digital health technologies improved PTSD [SMD= -0.35, 95%CI -0.66, -0.03], anxiety [SMD= -0.42, 95%CI -0.71, -0.13], and depression [SMD= -0.55, 95% CI -0.83, -0.27] among parents of children with cancer. Only one study assessed the stress outcomes, precluding a meta-analysis. Except for unstable sensitivity analysis results for PTSD, other findings were stable.

Conclusions: Digital health demonstrates promise in ameliorating post-traumatic stress disorder, anxiety, and depression among parents of children with cancer, although its efficacy in mitigating stress remains unclear.

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Keywords

digital health, neoplasms, paediatrics, parents, psychological, meta-analysis

1. Introduction

The annual incidence of childhood cancers is increasing worldwide. According to the World Health Organization, approximately 400,000 children and adolescents are diagnosed with cancer annually[1]. Cancer treatment is arduous, time-consuming, and prone to recurrence[2]. Parents of affected children endure immense psychological pressure during diagnosis and treatment. They bear numerous responsibilities for their children: disease supervision, clinical decision-making,

psychological counselling, and financial support[3][4]. These factors can readily induce negative emotions, such as post-traumatic stress disorder, anxiety, depression, and stress[5-8]. A meta-analysis found that the comorbidity rates of post-traumatic stress disorder, anxiety, and depression among parents of children with cancer were 26%, 21%, and 28%, respectively[9]. This not only jeopardises the psychological well-being of parents, but also indirectly impacts the quality of life and prognosis of affected children[10-12]. Hence, there is an urgency to provide support to parents of children with cancer to improve their psychological well-being and enhance family welfare[11].

In modern healthcare, digital health has emerged as an innovative tool to support family caregivers[13]. Digital health is an umbrella term that encompasses the systematic application of information and communication technologies, computer science, and data to support informed decision-making by individuals, healthcare workers, and health systems[14]. In the context of the current scarcity of paediatric specialists and limited medical resources[15], digital health can reduce reliance on medical professionals and facilitate the remote delivery of services, including disease consultation, health education, and psychological guidance. This enhances the efficient allocation and optimisation of medical resources[16]. Moreover, many families of children with cancer reside far from healthcare facilities, which can lead to increased financial costs[5][12] and a lack of substitute caregivers[17] when parents seek healthcare services. Digital health overcomes the conventional care constraints of time and space, not only reducing healthcare costs[18] but also facilitating interdisciplinary collaboration in healthcare. This enables family caregivers to conveniently and promptly access high-quality healthcare services[19].

Recently, digital health has been widely used in paediatric oncology[20][21]. However, while most studies have primarily focused on interventions for children with cancer, few have addressed parental health outcomes[17][22][23]. These studies aimed to provide disease management knowledge, health education, and psychosocial support through digital health. The results indicate

that these interventions enhanced parental resilience and mitigated negative emotions. However, due to variations in the form and content of interventions, as well as differences in the methods used for outcome evaluation, the effectiveness of digital health remains inconclusive.

Currently, only a limited number of systematic reviews are available in this field. Most of these provide descriptive summaries of the findings[24][25], and meta-analyses have not been conducted to quantify study outcomes. Given the limitations of previous reviews, we conducted a systematic review and meta-analysis. This study aimed to assess the effectiveness of digital health in addressing post-traumatic stress disorder, anxiety, depression, and stress among parents of children with cancer. This study provides insights into clinical practice and contributes to the optimisation of psychological health support systems for families of children with cancer.

2. Methods

This systematic review is reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines[26] and has been registered in PROSPERO with a specific identifier.

2.1 Search strategy

Two researchers conducted a comprehensive search of the following six databases: PubMed, Web of Science, PsycINFO, Embase, Cochrane Library, and CINAHL Plus with Full Text. In addition, relevant references were manually searched. The search strategy used Medical SubjectHeadings (MeSH) terms and free words. Multimedia Appendix 1 provides the details of the search strategy. Searches were conducted from the inception of each database until March 2024 and were restricted to studies published in English.

2.2 Study eligibility criteria

The inclusion criteria were as follows: (1) parents of children diagnosed with cancer (aged < 18 years); (2) interventions administered via Internet, apps, or other digital health technologies; (3) control groups receiving usual care or on a waitlist; (4) outcomes comprising at least one of the following indices: post-traumatic stress disorder, anxiety, depression, or stress; and (5) studies designed as randomised controlled trials. The exclusion criteria were as follows: (1) duplicate publication, (2) inability to access relevant data, and (3) studies assessed as having low quality ratings.

2.3 Study selection and data extraction

All relevant literature was imported into EndNote X9 (a literature management software) to remove duplicates. Two researchers independently conducted an initial screening of titles and abstracts to assess their compliance with the predefined inclusion and exclusion criteria. Subsequently, the researchers meticulously reviewed the full text to further assess its suitability. Any disagreements regarding the inclusion of literature were resolved through consultation with a third researcher. The two authors independently extracted data and recorded them in a predesigned form, which encompassed the following elements: first author, year of publication, study location, age of the parents, sample size, patient type, control measures, intervention content and format, study duration and follow-up period, and time of outcome assessment. Any disagreements were resolved through discussion or by a third researcher. In cases of missing data or incomplete information, the corresponding author of the study was contacted.

2.4 Quality assessment

Two researchers independently evaluated the methodological quality of the included studies using the Cochrane Risk of Bias Tool[27], which assessed seven domains: (1) random sequence generation, (2) allocation concealment, (3) blinding of participants and personnel, (4) blinding of

outcome assessment, (5) incomplete outcome data, (6) selective reporting, and (7) other biases. Each study was categorised as "low risk", "unclear risk", or "high risk". Disagreements were resolved through discussion or consultation with a third researcher.

2.5 Data analysis

Data were only extracted from the final measurement during the intervention period for inclusion in the analysis. When the initial data were reported as medians and quartiles, the mean and standard deviation were computed using an online calculator[28] based on formulas compiled by Wan et al. (2014)[29] and Luo et al. (2018)[30]. Heterogeneity tests and meta-analyses were performed using Review Manager 5.4 software. The effects of the intervention were evaluated using the standard mean differences (SMD) and 95% confidence intervals (CI), and the results were depicted in forest plots. The overall effect was considered statistically significant when the P-value of the two-sided test was < 0.05. Heterogeneity was evaluated using the I^2statistic (I^2 values of 25 %, 50 %, and 75 % were considered low, moderate, and high heterogeneity, respectively) and the P-value ($P< 0.10$ indicates heterogeneity). If $I^2< 50\%$ and $P\geq 0.10$, a fixed effects model was used for data merging; otherwise, a random effects model was used. Additionally, we performed a sensitivity analysis using a one-study-out method to assess the robustness and reliability of the combined results.

3. Results

3.1 Search results and selection

Following an initial search of electronic databases, 3,057 articles were retrieved. After removing 1,074 duplicates, 1,949 articles were excluded based on their titles and abstracts as they were irrelevant to the topic, leaving 34 documents for a full-text review. Six documents[31-36] met the inclusion criteria. The screening process is illustrated in Figure 1.

3.2 Description of included studies

3.2.1 Study characteristics

The characteristics of the included studies are summarised in Table 1. These studies were conducted in four countries and were published between 2015 and 2024: Sweden (two), China (two), the Netherlands (one), and Iran (one). Three of these studies referred to theoretical intervention models, namely the Sound Heart Model[31], the Cognitive Behaviour Therapy Model (CBT)[32] [34], and Acceptance and Commitment Therapy (ACT)[34].

3.2.2 Characteristics of parents

A total of 471 parents of children with cancer participated in the studies; the number of participants per study ranged from 21[35] to 146[33]. The parents varied between 31.0 and 49.9 years. The types of paediatric cancer included acute leukaemia, osteosarcoma, eye tumours, neurological cancers, and Wilms' tumor.

Table 1: The characteristics of included studies

Study	Country	Participants			Type of patient	Intervention		Control	Duration	Follow up	Outcome	
		Age (m(SD))	Sample Size I/C	M/ F		Content	Format			(Months)	Scale	Assessment time
Asadzandi 2020[31]	Iran	33.08(6.29)/ 35.66(5.25)	36/36	/	leukaemia, eye tumour, nervous system cancer, Wilms tumour	Cancer education and Spiritual counselling	Website	routine care	16 weeks	/	DASS 21	post-intervention
Cernvall 2015[32]	Sweden	40.0(7.4)/ 36.0(6.6)	31/27	19/39	Cancer	Psychoeducation was conducted based on CBT principles	Website	waitlist	10 weeks	/	BDI-II, BAI, PCL-C	post-intervention
Duan 2024[33]	China	33.0(26.0-44.0)/ 31.0 (25.0-44.0) †	74/72	73/73	acute lymphoblastic leukaemia	Provide mental and physical health training and regular feedback to parents	App	routine care	6 months	/	SAS, SDS	1 month, 3 months, 6 months
Joosten 2024[34]	Netherlands	41.6 (6.9)/ 42.2 (8.0)	43/46	12/77	Cancer	Teach active coping skills	Website	waitlist	6 weeks	6, 12	Patient-reported Outcomes Measurement Information System	6 weeks, 6 months, 12 months
Sveen 2021[35]	Sweden	49.9(5.8)/ 45.6(5.5)	10/11	7/14	Cancer	Internet-delivered CBT for insomnia with therapist support and weekly tasks	Website	routine care	9 weeks	9, 18	MADRS, PCL-5, GAD-7	post-intervention, 9 months, 18 months
Wu 2022[36]	China	41.0(37.0-46.0)/ 41.0(37.0-43.5) ª	44/41	40/45	Osteosarcoma	Health guidance and education on discharge, online counselling and share information	App	routine care	6 months	/	HADS, IES-R	1 months, 3 months, 6 months

Note: a: median (IQR)

Abbreviations: I=Intervention, C=Control; M, male; F, female; CBT, cognitive behavioural therapy

DASS 21=Depression, Anxiety, and Stress Scale

BDI-II=Beck Depression Inventory-II

BAI=Beck Anxiety Inventory

PCL-C=PTSD Checklist Civilian Version

SAS= Self-rating Anxiety Scale

SDS= Self-rating Depression Scale

MADRS=Montgomery-Asberg Depression Rating Scale

PCL-5=PTSD Checklist for DSM-5

GAD-7=Generalized Anxiety Disorder-7

HADS= Hospital Anxiety and Depression Scale

IES-R=Impact of Event Scale-Revised

3.2.3 Characteristics of digital health interventions

The intervention duration ranged from six weeks[34] to six months[33][36]. Researchers in four studies delivered interventions via websites. Asadzandi et al. (2020) [31] implemented an intervention based on the Sound Heart Model, which used web-based educational software to foster optimism, hope, and courage in parents of children with cancer to enhance their mental health. Cernvall et al. (2015)[32] conducted an Internet-based guided self-help intervention programme that taught parents of children with cancer coping strategies for psychological stress through an online course. Joosten et al. (2024)[34]used Op Koers Online to teach positive coping skills through chat sessions to help parents of children with cancer reduce or prevent mental health problems. In addition, Sveen et al. (2021)[35] provided Internet-based cognitive behavioural therapy for parents who have lost a child to cancer to manage insomnia. Researchers in two other studies have used an APP to deliver interventions. Wu et al. (2022)[36] provided disease information, online education, and relevant counselling to the parents of children with osteosarcoma based on a We-Chat platform. After two years, Duan et al. (2024)[33] similarly used the We-Chat platform to offer a comparable intervention to parents of children with acute lymphoblastic leukaemia.

3.2.4 Characteristics of controls

All participants in the control group received usual care. Additionally, two studies[32][34] permitted parents in the control group to use appropriate digital health devices after the study ended.

3.3 Risk of bias

All studies explicitly described the randomisation method. However, four studies[31][34-36] lacked allocation concealment details, potentially introducing selection bias. Owing to the difficulty in blinding researchers and participants in digital health interventions, four studies[31-33][36] had an elevated risk of performance bias. None of the studies mentioned blinding of the outcome assessors; hence, detection bias assessment was not possible. Additionally, three studie[32-34] were deemed to be at a substantial risk of attrition bias due to high dropout rates or a lack of proper data handling methods. Finally, all the studies were free of selective reporting or other biases. A risk-of-bias diagram is shown in Figure 2.

3.4 Meta-analysis results

3.4.1 Post-traumatic stress disorder

Three studies assessing post-traumatic stress disorder were included for meta-analysis[32][35][36]. Since there was low heterogeneity among the studies (I^2= 8%, *p*= 0.34), they were combined using a fixed-effects model. The results demonstrated that digital health interventions were superior to usual care in improving post-traumatic stress disorder symptoms, with a statistically significant difference [SMD= -0.35, 95%CI -0.66, -0.03, *P*= 0.03], see Figure 3(A). Sensitivity analysis revealed that excluding the study by Cernvall et al. (2015)[32] rendered the combined results insignificant[SMD= -0.18, 95%CI -0.57, 0.21, *P*= 0.37], as shown in Figure 4(A).

3.4.2 Anxiety

Six studies were included in the meta-analysis[31-36] and owing to moderate heterogeneity between studies (I^2= 54%, *P*= 0.05), we used a random-effects model. A statistically significant

difference was observed between digital health interventions and usual care in reducing anxiety symptoms [SMD= -0.42, 95%CI -0.71, -0.13, *P*= 0.005], see Figure 3(B). Sensitivity analysis demonstrated that individual trials did not change the results. Furthermore, after excluding the study by Asadzandi et al. (2020)[31], I^2 decreased to 0%, as shown in Figure 4(B).

3.4.3 Depression

Six studies were included in the meta-analysis[31-36]. Due to moderate heterogeneity between studies (I^2= 50%, *p*= 0.08), we used a random-effects model. The results showed that digital health interventions can improve depression symptoms, and the difference was statistically significant [SMD= -0.55, 95% CI -0.83, -0.27, *P*< 0.0001], see Figure 3(C). Sensitivity analysis revealed that individual studies did not alter the overall results. Similarly, after excluding the study by Asadzandi et al. (2020)[31], I^2 decreased to 0%, as shown in Figure 4(C).

3.4.4 Stress

Only one study[31] assessed stress levels, the results showed that digital health reduced stress compared to the control group, with a statistically significant difference (t= 3.12, *p*= 0.003).

4. Discussion

4.1 Main findings

The findings of this review suggest that digital health has the potential to alleviate post-traumatic stress disorder, anxiety, and depression in parents of children with cancer. However, only one study has evaluated the impact on stress; while the results suggest a positive effect, the efficacy of

this outcome remains uncertain owing to the scarcity of relevant studies. The sensitivity analysis results indicated that the outcomes related to post-traumatic stress disorder were unstable, and further data synthesis is required for a more comprehensive investigation. In addition, a study by Asadzandi et al. (2020)[31] was identified as a source of heterogeneity. This divergence may be attributed to the utilisation of the Sound Heart Model in spiritual counselling, which aims to enhance relationships with God, the self, others, and nature. This methodology diverges from conventional psychological and educational interventions employed in other studies.

The findings of this review align with those of previous studies[32][37][38]. Canter et al.[37] developed the Electronic Surviving Cancer Competently Intervention programme, which delivers psychological interventions to parents of children with cancer through eHealth. This intervention mitigated the symptoms of post-traumatic stress disorder and anxiety, demonstrating high feasibility and acceptability (80%)[37]. A systematic review and meta-analysis conducted by MacKinnon et al. [38] further demonstrated that eHealth interventions had a small-to-moderate effect on enhancing anxiety, depression, and stress levels in parents of young children (overall SMD= 0.368, 95% CI 0.228, 0.509)[38]. Ozturk et al. offered a relaxation programme based on mobile health for mothers of children with cancer, which not only decreased anxiety but also enhanced their ability to cope with stress[39].

Parents of children with cancer commonly encounter psychological challenges, such as post-traumatic stress disorder, anxiety, depression, and heightened stress[7]. These challenges are associated with unmet supportive care needs[3][40][41]. Surveys indicate that up to 83% of parents of

children with cancer experience more than 10 unmet needs[3], encompassing information acquisition, psychological support, social assistance, spiritual care, and financial aid. Among these, information requirements are predominant[3]. Parents frequently experience anxiety stemming from concerns about their children’s deteriorating condition or poor prognosis. Consequently, they actively seek information about the disease to ensure optimal healthcare[3]. Digital health facilitates real-time communication between parents and healthcare providers. These technologies can monitor children's daily health status, deliver disease information and health education, and aid parents in clinical decision-making[19][24][25]. The utilisation of this technology not only effectively addresses parents' information needs[25] but also facilitates real-time data sharing and analysis, enabling the medical team to evaluate disease progression and treatment efficacy more accurately. This allows for modifications to the treatment plans based on the various stages of the child's disease, rendering more precise intervention plans[42].

Second, digital health can offer effective psychological support to parents of affected children [25] by assisting them in regulating their emotions. A literature review suggests that cognitive behavioural therapy[32][35] and stress management skills[33][34] delivered through the Internet and mobile apps can rectify individuals' distorted perceptions of traumatic events and foster positive reflection[43], thereby mitigating the symptoms of post-traumatic stress disorder, anxiety, and depression. This immediate and easily accessible support tool augments the efficacy of the relevant training[33], offering significant benefits to users. Furthermore, emotional, and social support delivered through digital health has shown promising efficacy. For example, the We-Chat platform,

which facilitates experience sharing and emotional exchange among peers, has effectively alleviated parental anxiety and depression[33][36]. Peer support provided on this platform can also assist parents in maintaining social connections, alleviating loneliness, and relieving stress symptoms[41].

Finally, over 90% of children worldwide reside in low- and middle-income countries[44], where resources for paediatric healthcare are unevenly distributed[45][46]. Particularly in remote, resource-limited areas, paediatric patients and their families encounter numerous challenges in accessing essential healthcare services[45][47]. They may need to disrupt their daily routines, relocate to new cities, endure long waiting times, and bear high treatment costs, commuting, and accommodation expenses[8][41]. This not only increases the financial burden but also elevates the risk of depression and stress among parents[8][41][48]. Digital health offers an effective way to address these issues. Its implementation has the potential to reduce commuting and waiting times, thereby improving accessibility to specialist healthcare services[14]. Furthermore, it enhances the cost-effectiveness of healthcare services through optimised resource allocation and reduces reliance on unnecessary in-person consultations[18]. The utilisation of this technology not only reduces treatment expenses and enhances treatment efficacy but also contributes to promoting social equity in global medical services[46]. This significantly enhances the psychological well-being in parents of children with cancer.

4.2 Study limitations

Our study has several limitations. First, some of the included studies required data conversion, which may have affected the precision of the meta-analysis. Second, the small number of randomized

controlled trials and the small sample size did not allow for a meta-analysis of stress, and the results for post-traumatic stress disorder showed instability. Therefore, the results of this review should be cautiously extrapolated. Third, due to limited follow-up data, we did not assess the long-term effectiveness of the interventions. High-quality, large-sample prospective studies are required to investigate the effects of this application. Additionally, future research should compare the effectiveness of distinct types of digital health (e.g. mobile apps, online psychotherapy, and virtual reality) in supporting the psychological well-being of parents of children with cancer.

4.3 Clinical implications

The results of this study demonstrate the effectiveness of digital health in improving the psychological well-being of parents of children with cancer. We recommend integrating digital health into these parents' daily care to enhance the mental health support system for families of children with cancer. When implementing interventions, careful consideration should be given to the study duration and the frequency of outcome monitoring to avoid over-intervention, which could exacerbate the psychological burden on parents. Moreover, the success of digital health interventions relies on user willingness. Therefore, intervention designs should align closely with the preferences of the study population[14]. Finally, researchers should minimise the cost of utilising digital health to alleviate the financial burden on research participants and ensure its widespread adoption[49].

Conclusion

Our findings suggest that digital health can alleviate the symptoms of post-traumatic stress

disorder, anxiety, and depression in parents of children with cancer. Although its effect on stress remains uncertain, digital health demonstrates significant potential as a valuable tool for providing psychological support. When traditional interventions are limited, digital health can serve as a feasible alternative to support the parents of children with cancer. In the future, large-sample, high-quality prospective studies are required to further validate these findings and explore the effectiveness of various digital health approaches. Long-term follow-up studies are needed to assess the durability of these interventions.

Figure legends

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart.

Figure 2. Risk of bias in each study.

Figure 3: Forest plot: telemedicine versus control group. (A) Caregiver burden; (B) Anxiety; (C) Depression; (D) Quality of life.

Figure 4: Sensitivity Analyses. (A) Caregiver burden; (B) Anxiety; (C) Depression; (D) Quality of life.

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Conflicts of Interest

There are no conflicts of interest to declare.

Ethics statement

Ethical approval was not applicable for this systematic review.

CRediT authorship contribution statement

Xiaoyu Yang: Conceptualization, Methodology, Software, Formal analysis, Investigation, Resources, Writing - Original Draft, Writing - Review & Editing, Visualization.

Shanshan Jiang: Software, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization.

Rong Wang: Writing - Original Draft, Writing - Review & Editing.

Pan Li: Writing - Original Draft, Writing - Review & Editing.

Xinying Yu: Writing - Review & Editing , Supervision, Project administration, Funding acquisition.

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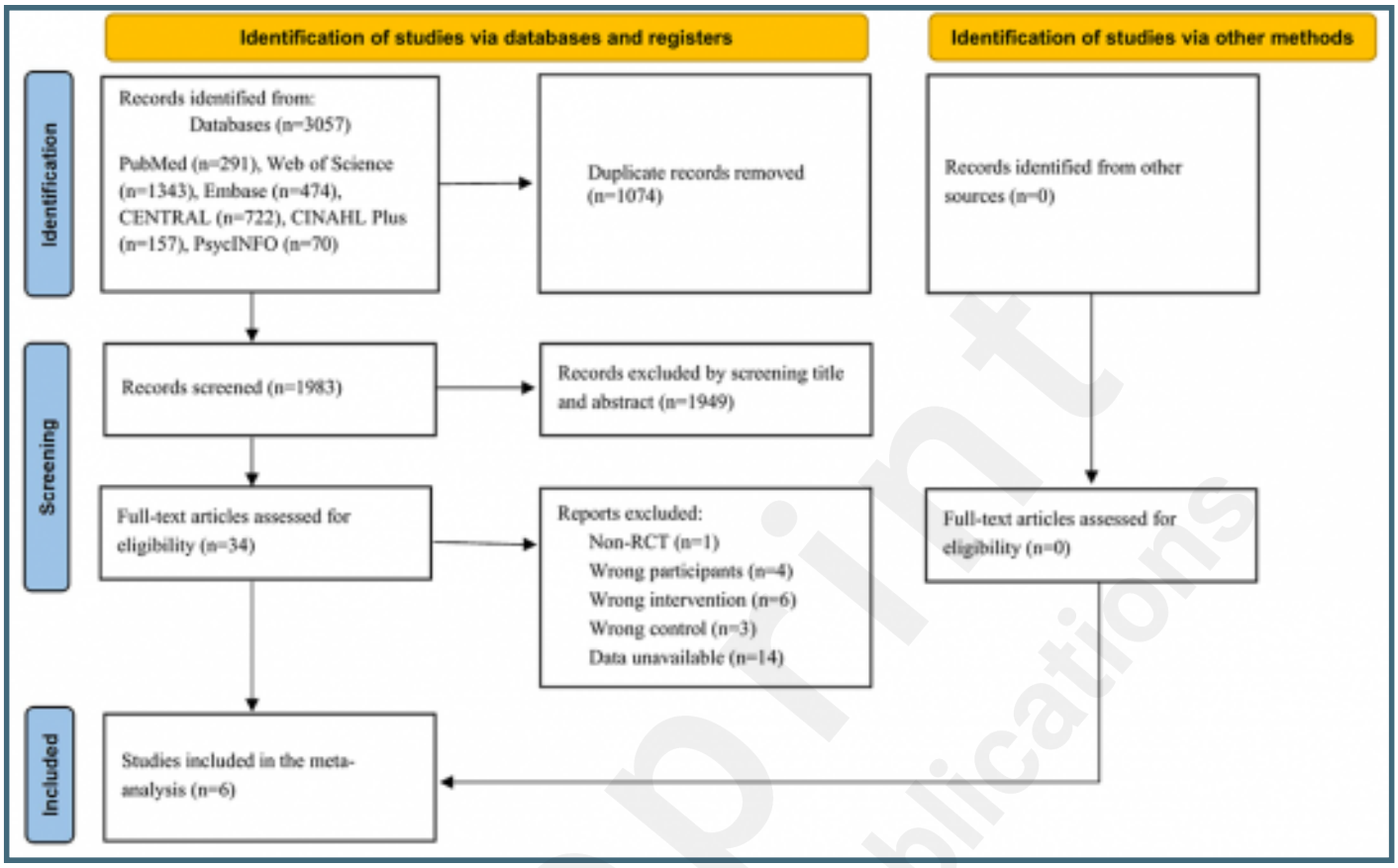
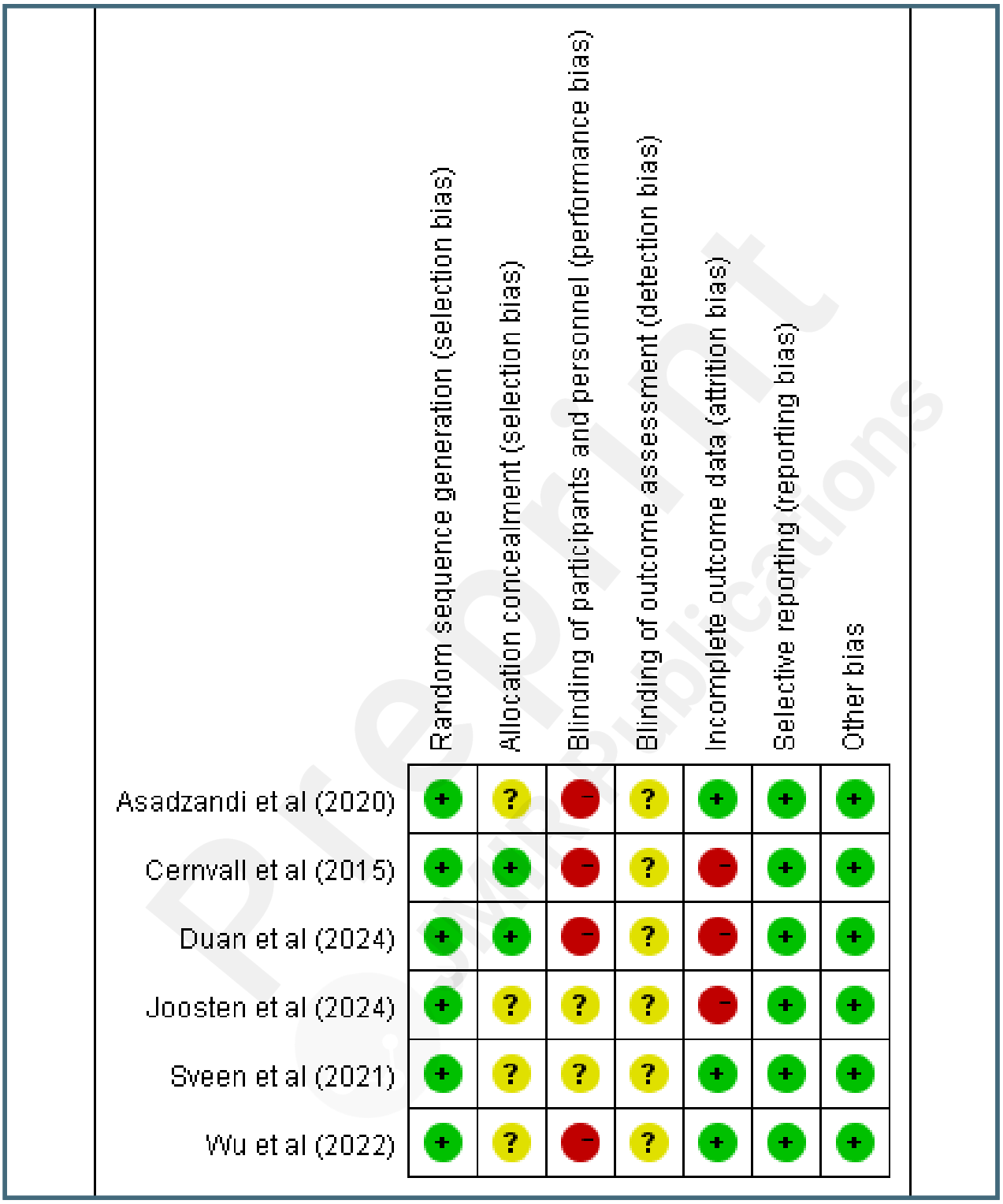
Supplementary Files

Figures

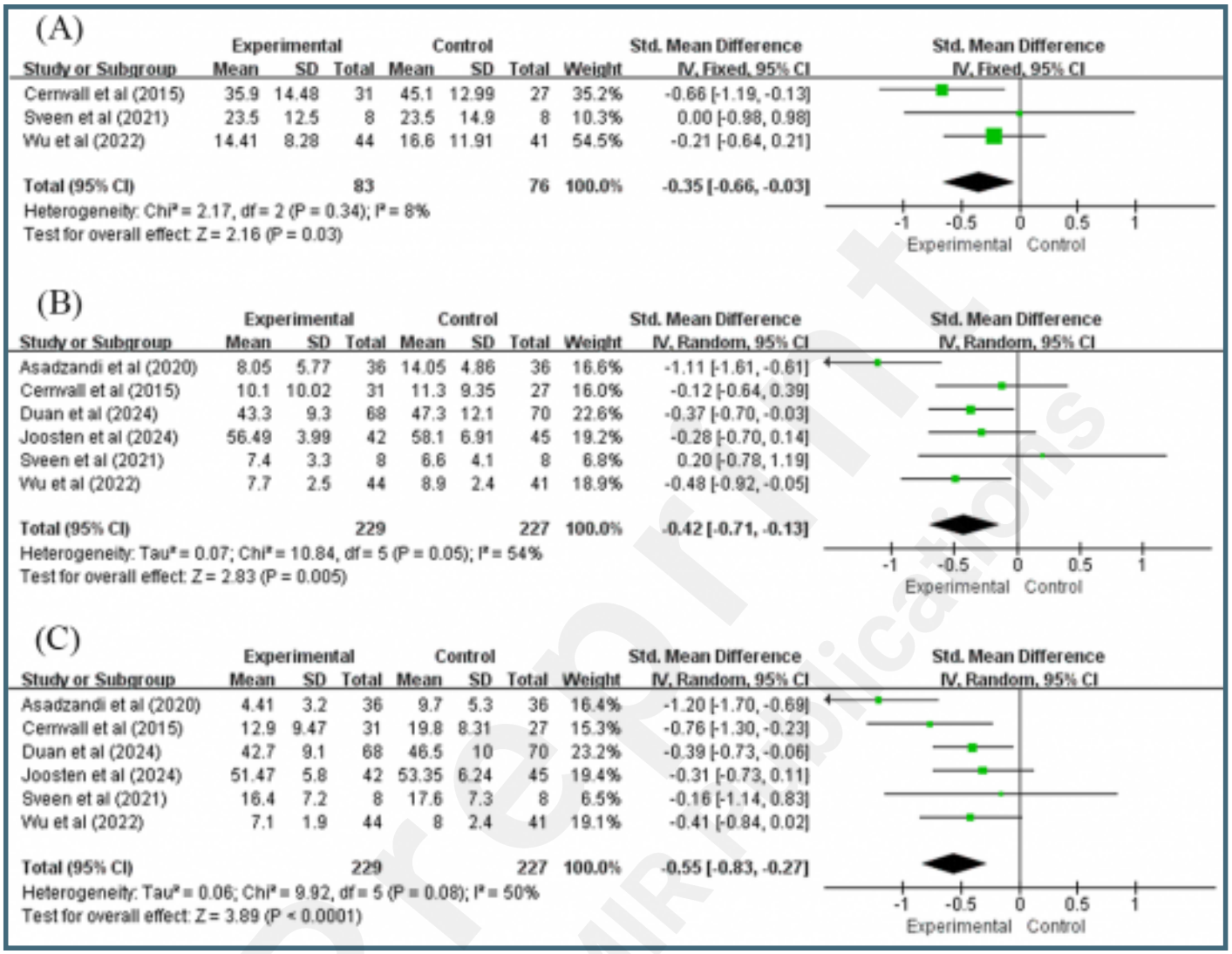
PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart.



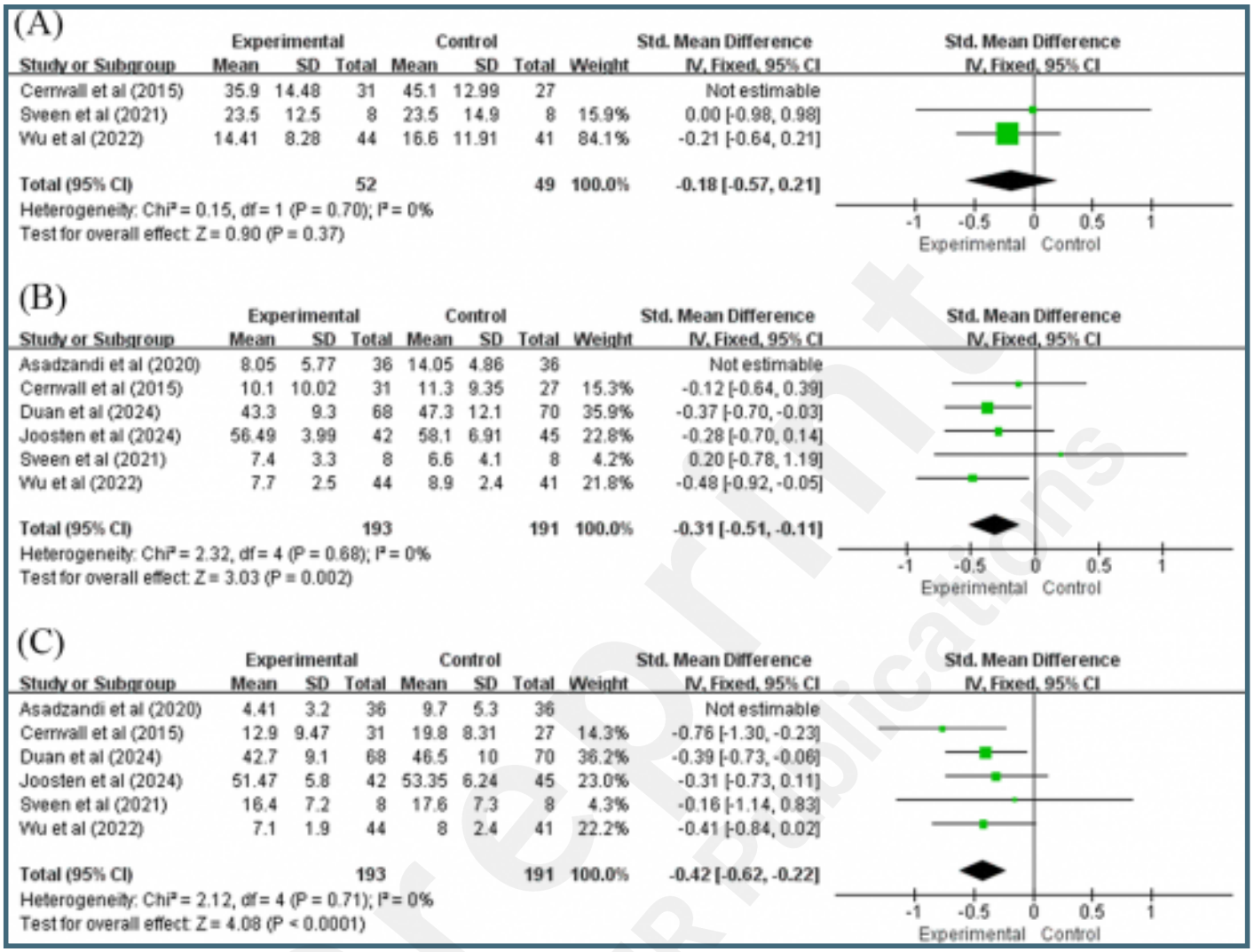
Risk of bias in each study.



Forest plot: telemedicine versus control group. (A) Caregiver burden; (B) Anxiety; (C) Depression; (D) Quality of life.



Sensitivity Analyses. (A) Caregiver burden; (B) Anxiety; (C) Depression; (D) Quality of life.



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PRISMA.
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Multimedia Appendixes

Search strategy.
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