



Review

The application of eHealth in cancer survivorship care: A review of web-based dyadic interventions for post-treatment cancer survivors and caregivers

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ABSTRACT

Objective: Both cancer survivors and caregivers often experience a range of problems and unmet needs during the post-treatment survivorship. Web-based dyadic interventions may be critical for cancer survivors and their caregivers. This article aims to systematically explore existing web-based dyadic interventions for post-treatment cancer survivors and caregivers in terms of intervention focus, content, delivery, and outcomes and to provide valuable recommendations for future research.

Methods: A comprehensive literature search was conducted to identify articles published in English or Chinese in the English databases PubMed, EMBASE, MEDLINE, PsycINFO, and Cochrane Library, and the Chinese databases CNKI and Wanfang Data, from database inception to March 2022. The literature references were also manually searched for additional eligible articles.

Results: Thirteen studies were included for analysis in this review. Cancer couple dyads were the main target of the interventions that were included. Information support, psychotherapy, self-management skills training, dyadic coping, and social support were the main intervention treatment elements. The combined results in this review support the feasibility, usability, and acceptability of eHealth interventions and showed trends in positive intervention effects for cancer survivors and caregivers in terms of self-efficacy, quality of life, physical health, mental health, and dyadic relationship.

Conclusions: This review identifies the positive outcomes of web-based dyadic interventions for post-treatment cancer survivors and caregivers. Further development and refinement of post-treatment cancer survivor-caregiver dyadic web-based interventions, with personalized online platforms and multiple components for supportive care needs, should be promoted.

Introduction

With aging populations and advances in cancer screening and treatment technologies, the number of cancer survivors (i.e., people who have been diagnosed with cancer but are still alive) has increased substantially in recent decades worldwide. For example, the number of cancer survivors in the United States increased from 13.7 million in 2012 to 15.5 million in 2018 and is expected to continue increasing to 26 million by 2040.^{1,2} Among cancer survivors, due to new drugs and therapies, it is estimated that approximately 70% have survived for over five years, 40% have survived for over 10 years, and 15% have survived for more than 20 years.² The growing number of cancer survivors and long-term survivorship has led to cancer survivors and cancer survivorship being the

focus of numerous studies.

Although the phases involved in cancer survivorship vary from study to study, recent emphasis has been on the critical period following the end of active treatment, known as post-treatment survivorship,³ which is the focus of this review. According to the three-phase model of cancer survivorship proposed by Mullan, post-treatment survivorship typically includes the following two phases: “extended survivorship” (the time when patients focus on monitoring for disease recurrence, and managing physical and psychological concerns after completing active treatment) and “permanent survivorship” (a period of long-term remission when patients live with cancer as a chronic disease).⁴ It can be seen that survivors in post-treatment survivorship (extended and permanent survivorship) enter a period when they need to shift their focus from

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“treatment” to “normal life”.⁴ During the transition, survivors may encounter a variety of survival problems as a result of cancer and its treatment, which prevent them from returning to normal life. Common survival problems reported by post-treatment cancer survivors include fatigue, pain, impaired body image and dysfunction (eg., hair loss and endocrine dysfunction), fear of disease recurrence, sleep disturbance, and uncertainty about returning to work.^{3,5} Additionally, cancer survivors are at risk of permanent (eg., infertility) and late treatment effects (eg., organ dysfunction and secondary cancers).⁶ As a result of these survival problems, cancer survivors may experience impaired physical, psychological, and social functioning.² Furthermore, medical teams are usually less involved in post-treatment survivorship, resulting in unmet needs for supportive care involving health information, and physical, and psychosocial support for survivors.^{2,5,7}

In response to the unmet needs of cancer survivors, it is common for survivors to rely on someone as an unpaid informal caregiver during post-treatment survivorship. An unpaid informal caregiver is usually the survivor's spouse, family member, or friend, whose responsibilities typically include symptom management, rehabilitation assistance, monitoring side effects, and providing emotional support.^{8,9} Moreover, in addition to serving as a caregiver for cancer survivors, caregivers generally need to maintain their family roles (eg., cooking) as well as social norms (eg., maintaining a career), leading to caregiving role burden.¹⁰ Caregivers often find satisfaction in taking on these responsibilities to relieve their loved ones, but inevitably suffer from heavy caregiving, multiple role, and financial burdens.¹¹ As a result, caregivers may experience physical, emotional, and social problems (eg., increased blood pressure, fatigue, lack of confidence in care, anxiety, and isolation) during the caregiving process.⁸ It can be seen that survivorship care programs should consider not only the needs of survivors but also the supportive care needs of caregivers of cancer survivors in terms of physical and psychological health, knowledge, and caregiving skills.¹²

Further, growing evidence has revealed that cancer survivors' coping styles and adaptation outcomes (eg., physical and psychological health) and those of their caregivers can be interdependent, emphasizing the “unit” nature between cancer survivors and caregivers.^{11,13} Given the needs of both post-treatment cancer survivors and their caregivers, and the “unit” nature between survivors and caregivers, dyadic interventions for cancer survivor-caregiver dyads have emerged over the past few decades.¹¹ Traditional face-to-face cancer survivor-caregiver dyadic interventions have been shown to be effective in improving the physical, emotional, and relationship functioning of both members of a dyad.^{14,15} However, traditional face-to-face delivery can be inflexible, costly, and difficult to disseminate, leading to barriers for cancer dyads.¹⁶ With the rapid development of technology, the Internet has become an expanding source of information and support available to patients and their caregivers.^{17,18} In particular, the global COVID-19 pandemic led to a dramatic shift in healthcare delivery, with the rapid uptake and adoption of web delivery media for supportive interventions (eHealth).¹⁹ Web delivery media, typically including computers, personal mobile devices, and other Internet-related technologies, are convenient, cost-effective, and private for users.^{8,20} Thus, web-based dyadic interventions that can reduce the barriers of traditional face-to-face interventions may also be critical for cancer survivors and their caregivers. In this article, web-based interventions are defined as those using the Internet for delivery, such as websites, videoconferencing, smartphone applications, email, and other online platforms.⁸

Several reviews have identified the feasibility, acceptability, and effectiveness of web-based dyadic interventions for patients with cancer (most of whom are in active treatment) and informal caregivers. For example, a critical literature review by Luo et al concluded that web-based interventions were feasible and had positive effects on both cancer patients and caregivers in terms of physical, psychological, and social functioning.²¹ Another review of online interventions for couples with cancer suggested that online interventions can provide flexible platforms and programs to help address couples' educational needs, while

strengthening couples' coping.²² However, to the best of our knowledge, no researchers have reviewed web-based dyadic interventions for post-treatment cancer survivor-caregiver dyads. Little is currently known about the development, characteristics (eg., intervention focus, content, and dosage), and effectiveness of existing web-based dyadic interventions specifically targeting post-treatment cancer survivors and their caregivers.

Consequently, we have focused on unexplored areas in this review and aim to (1) explore the specific characteristics of existing post-treatment cancer survivor-caregiver dyadic web-based interventions in terms of intervention focus, content, and delivery; (2) summarize the outcomes of existing web-based interventions for post-treatment cancer survivor-caregiver dyads; (3) provide valuable recommendations for future research on developing post-treatment cancer survivor-caregiver web-based interventions.

Methods

Search strategy

According to the guidance of the Preferred Reporting Items for Systematic reviews and Meta-Analyses statement,²³ a comprehensive literature search was conducted to identify articles published in English or Chinese (languages spoken by the authors) in the English databases PubMed, EMBASE, MEDLINE, PsycINFO, and Cochrane Library, and the Chinese databases CNKI and Wanfang Data, from database inception to March 2022. Considering the fact that the most common cancer caregiver relationship is spousal,⁸ this review included post-treatment survivorship web-based interventions for cancer couple dyads and any cancer survivor-caregiver dyads that were not limited to spousal or partnered couples. The following key terms and their combinations in the title or abstract were used to search for articles published in English: “cancer” or “tumor” or “oncology” or “carcinoma” or “neoplasm” and “survivor” or “survival” or “survivorship” or “post-treatment” or “after treatment” or “following treatment” and “caregiver” or “care giver” or “carer” or “care partner” or “caregiving” or “informal care” or “non-medical care” or “couple” or “dyad” or “spouse” or “spousal” or “partner” and “Internet” or “web” or “mHealth” or “eHealth” or “telemedicine” or “telehealth” or “computer” or “online” or “smartphone” or “social media” or “mobile application” or “email” and “intervention” or “program” or “programme” or “training” or “therapy” or “treatment” or “project” or “education”. In the Chinese databases, “癌症” OR “肿瘤” (meaning cancer) AND “照顾” OR “照护” OR “夫妻” OR “伴侣” OR “配偶” (meaning caregiver or spouse) AND “移动健康” OR “移动医疗” OR “网络” OR “手机” OR “网站” (meaning telemedicine) were used to search for articles published in Chinese. The literature references were also manually searched for additional eligible articles. The Preferred Reporting Items for Systematic reviews and Meta-Analyses flowchart of the search and selection process is shown in Fig. 1.

Selection criteria

The inclusion criteria for articles were (1) studies focused on web-based interventions delivered through websites, videoconferencing, smartphone applications, email, and other online platforms, including both experimental (covering both intervention design characteristics and intervention outcomes) and protocol studies (which described only the design characteristics of interventions) that helped characterize interventions; (2) intervention studies specifically for post-treatment cancer survivors (patients with any cancer type at any stage who had completed active treatments and were in post-treatment survivorship); (3) study participants included both adult (age 18 or older) cancer survivors and their spouses or caregivers in any other relationship with survivors (parents, adult children, other relatives, or friends); (4) articles were complete reports published in English or Chinese in peer-reviewed journals.

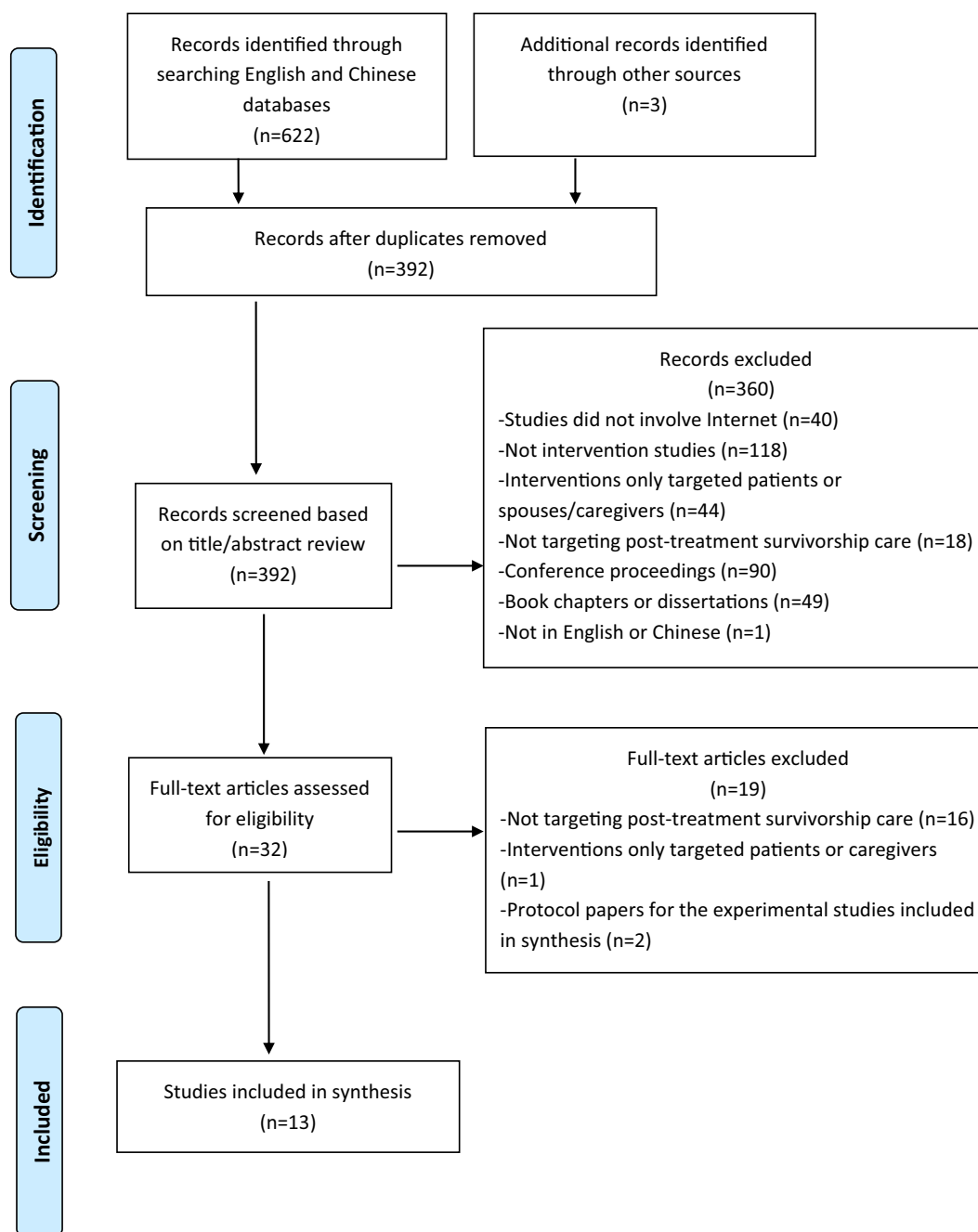


Fig. 1. PRISMA flow diagram identifying the literature. PRISMA, Preferred Reporting Items for Systematic reviews and Meta-Analyses.

The exclusion criteria for articles were (1) study participants included patients with cancer undergoing active treatments or non-cancer survivors, which made it difficult to characterize interventions in terms of focus, content, and delivery that were specific to the post-treatment survivorship phase; (2) interventions only for cancer survivors or caregivers; (3) studies that were reviews, dissertations, conference proceedings, editorials, or commentaries.

Data extraction

Literature screening and data extraction were independently performed by two reviewers. Based on the selection criteria, the two independent reviewers screened titles and abstracts for relevance and conducted full-text reviews of relevant studies for eligible literature. A standard table, including author, year of publication, the country where

the research was conducted, study aims, study design, target population, theoretical framework, intervention content, delivery format, and intervention dosage, was designed to extract the study characteristics of eligible literature (see Table 1). Another table, with items such as outcome measurements/measurement intervals, program evaluation outcomes, intervention effects, and quality assessment, was prepared to extract the literature outcomes (Table 2). In Table 2, program evaluation outcomes were related to program feasibility, acceptability, usability, and participant satisfaction, while intervention effects included outcomes related to changes in study variables.

Quality assessment

The Effective Public Health Practice Project was independently used by two reviewers to assess the quality of the studies that were included.

Table 1
Web-based intervention characteristics ($n = 13$).

Author (year) Country [reference]	Study aims	Study design	Target population (cancer diagnosis, no. of dyads, refusal %, attrition %)	Theoretical framework	Intervention content	Delivery format (who and how)	Intervention dosage
Akkol-Solakoglu et al (2021) Ireland ²⁶ (Protocol study)	-To evaluate the effectiveness of the intervention on depression and anxiety symptoms in breast cancer survivors; -To evaluate changes in carers' cancer communication and relationship quality; -To evaluate the acceptability and program satisfaction among cancer survivors and their main carers.	Randomized controlled trial (RCT): (1) iCBT (Internet-delivered cognitive-behavioral therapy) intervention; (2) Treatment-as-usual control	Breast cancer; Intervention group: 36 survivor-caregiver dyads; Control group: 36 survivor-caregiver dyads; Not reported; Not reported	Not reported	Multicomponent: information support (IS), psychotherapy, skills training (ST) (1) IS: getting started (providing information about breast cancer, depression, and anxiety, and why do they occur in breast cancer survivors). (2) Psychotherapy: understanding feelings; spotting thoughts; challenging thoughts; managing worry. (3) ST: boosting behavior.	- Master's level students; - Web links, audio.	- Seven weekly modules (each 60 min); 7 weeks.
Badr et al (2016) USA ³⁵	- To describe the development and formative evaluation (usability and user testing) of the intervention program.	Single-group study: a web-based CARES (Computer Assisted oral cancer REhabilitation and Support)	Oral cancer; 6 survivors and 5 caregivers including spouses and adult children (at least 5 dyads); Not reported; Not reported	Self-determination theory	Multicomponent: IS, psychotherapy, ST, dyadic coping (DC), social support (SS) (1) IS: ACT: taking charge after oral cancer; managing oral care and oral side effects; managing nutrition and swallowing problems; managing social and emotional concerns; maintaining a healthy lifestyle after cancer (each module provides: a clear rationale for recommendations; a variety of behavioral strategies and options to encourage choice and elaboration; shared and tailored content based on the person's role as a survivor or caregiver). (2) Psychotherapy: audio guide practicing relaxation techniques; exercise to identify and challenge irrational thoughts. (3) ST: skills for self-management, caregiving, and the coordination of care: TRACK: action planning and behavioral monitoring tools; alerts via text or email to remind users of a desired behavior; video segments illustrating swallowing exercises. (4) DC: TRACK, SHARE: joint homework and activities to encourage teamwork and adaptive	- Experts in the areas of head and neck surgical, medical, and radiation oncology, survivor, and caregiver quality of life, multimedia production/web design, social work, speech pathology, and nutrition; - Website.	Not reported

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Table 1 (continued)

Author (year) Country [reference]	Study aims	Study design	Target population (cancer diagnosis, no. of dyads, refusal %, attrition %)	Theoretical framework	Intervention content	Delivery format (who and how)	Intervention dosage
Beer et al (2020) USA ²⁷	- To explore attitudes and acceptance of survivors of lung cancer and their family members toward a dyad-focused mHealth mindfulness-based intervention (MBI).	Single-group study: app-based MBI: Breathe Easier app	Lung cancer; 11 survivors and 8 family caregivers (at least 8 dyads); Not reported; Not reported	Community-based participatory research principles	communication; a survivor-caregiver sharing function (5) SS : SHARE: providing opportunity to solicit and offer support to peers and each other, facilitated bulletin boards. Multicomponent: IS, psychotherapy, SS (1) IS : introduction to dyspnea and COPD, physical activity and fatigue, insomnia, body balance, stress, communication, mindfulness, and mindful activities (meditation, gentle movements, and breathing exercises) (2) Psychotherapy : mindful activities: practicing meditation, gentle movements (yoga), and breathing exercises. (3) SS : community features: Testimonials, Public Discussion, Private Discussion, FAQs, and Resources.	- Not reported; - App.	- Eight weekly modules; 8 weeks.
Carmack et al (2021) USA ³¹	- To test the feasibility of this couples-based (CB) intervention and compare its efficacy to the same program delivered to the survivor-only (SO).	RCT(1) CB web-based diet and exercise intervention; (2) SO web-based diet and exercise intervention	Breast, prostate, and colorectal cancer; Intervention group : 12 survivor-spouse dyads; Control group : 10 survivor-spouse dyads; 87.3%; 11.4%	Social cognitive theory	Multicomponent: psychotherapy, DC (1) Psychotherapy : cognitive-behavioral strategies for healthy behavior change: problem-solving; relapse prevention; goal-setting; cognitive restructuring; and time management. (2) DC : communal coping, joint problem-solving, and healthy communication.	- Counselors who have a master's degree, psychologist; - Web-based videoconference; - Tailored workbook and tailored print newsletters.	- 9 online sessions (the first 3 sessions were weekly; sessions changed to every other week after session 3; and then monthly after session 5).
Pauwels et al (2012) Belgium ³⁴	- To describe the development and the process evaluation of an intervention; - To determine which sociodemographic, medical, and psychosocial characteristics of survivors and partners are associated with the use of the website.	Single-group study: a tailored informative website	Breast cancer; 37 survivors and 19 spouses (at least 19 dyads); 44.0%; 34.1%	Not reported	Single-component: IS - Survivor section: information about breast cancer; physical consequences; psychological consequences; social consequences; work and financial; life style; help guide. - Partner section: information about breast cancer; my complaints; help guide; understanding my partner; supporting my partner.	- Not reported; - Website.	- 10-12 weeks.

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Table 1 (continued)

Author (year) Country [reference]	Study aims	Study design	Target population (cancer diagnosis, no. of dyads, refusal %, attrition %)	Theoretical framework	Intervention content	Delivery format (who and how)	Intervention dosage
Pekmezi et al (2021) USA ³⁰ (Ongoing study)	- To describe the rationale, design, and recruited sample for an ongoing efficacy trial of intervention.	RCT (1) A dyadic, web-based, weight loss lifestyle intervention (DUET); (2) Waitlist control	A range of cancer types; Intervention group: 28 survivor-caregiver dyads (caregivers included daughters, mothers, and others together); Control group: 28 survivor-caregiver dyads; 41.9%; Not reported	Social cognitive theory	Multicomponent: IS, ST, DC (1) IS: Tools: including tracking forms, online calculators, planning guides, tip sheets, and other healthy eating and exercise resources; News You Can Use: summarizing updates on recent findings from salient research on diet, exercise, and/or weight loss for cancer prevention and control. (2) ST: strategies for healthy eating, physical activity, and exercise. (3) DC: Team Support: offering practical tips on how dyads can support each other to promote lifestyle change (e.g., active listening).	- Research team; - Website, equipment, text messages.	- 24 weekly sessions; 6 months.
Porter et al (2018) USA ³³	- To test the acceptability of a novel couples-based physical activity intervention delivered via videoconference and feasibility of conducting an RCT among breast and prostate cancer survivors and their partners.	RCT (1) Physical activity videoconference sessions; (2) Waitlist control	Breast and prostate cancer; Intervention group: 10 survivor-spouse dyads; Control group: 10 survivor-spouse dyads; 18%; 8%	Interdependence theory and a communal coping approach	Multicomponent: psychotherapy, DC 4 sessions about training in communication and support skills and behavior change techniques: (1) Psychotherapy: behavior change techniques included goal-setting, self-monitoring of behavior, and prompted for practice; they were adapted to a communal coping approach. (2) DC: communication and support skills included training in skills for effective speaking and listening, joint problem-solving, and application of these skills to help the couple identify and implement effective support strategies to assist each other in their physical activity goals.	- Not reported; - Videoconference.	4 sessions (each 60 min); 6 weeks.
Price-Blackshear et al (2020) USA ²⁸	- To examine the feasibility, acceptability, and effectiveness of an online MBI.	RCT (1) Online couples-MBI (C-MBI); (2) Online individual-MBI (I-MBI) (only survivors)	Breast cancer; Intervention group: 36 survivor-spouse dyads; Control group: 41 survivor-spouse dyads; 57.8%; 26.0%	Not reported	Multicomponent: psychotherapy, DC (1) Psychotherapy: mindful activities: meditation, mindful yoga. (2) DC: partner interactions: couple activities such as partner yoga, mindful touch exercises, dyadic eye gazing, and mindful	- Research staff; - Email, video-links, audio-links, study manuals.	- Eight weekly videos (each 60 min); 8 weeks.

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Table 1 (continued)

Author (year) Country [reference]	Study aims	Study design	Target population (cancer diagnosis, no. of dyads, refusal %, attrition %)	Theoretical framework	Intervention content	Delivery format (who and how)	Intervention dosage
Schover et al (2012) USA ³²	- To enhance both partners' sexual satisfaction and help them integrate effective treatments for erectile dysfunction into their sex lives.	RCT (1) Internet-based group (WEB); (2) Face-to-face group (FF); (3) Waitlist group	Prostate cancer; Intervention group: WEB: 55 survivor-spouse dyads, FF: 60 survivor-spouse dyads; Control group: 48 survivor-spouse dyads; Not reported; 25.0%	Not reported	communication with partner. Multicomponent: ST, psychotherapy, SS (1) ST: training to improve sexual expression, sexual communication, comfort in initiating sexual activity, and facilitate resuming sex without performance anxiety. (2) Psychotherapy: cognitive-behavioral techniques to address negative beliefs about sexuality. (3) SS: Homework exercises had standardized report forms completed online and submitted to therapists, therapist emailed feedback to the couples, participants also could e-mail their therapists at any time.	- Therapists; - Website.	- 12 weeks.
Song et al (2015) USA ³⁸	- To evaluate the feasibility and acceptability of a web-based education intervention in improving couples' quality of life.	Single-group study: a couples-focused, web-based intervention for symptom management called Prostate Cancer Education and Resources for Couples (PERC).	Prostate cancer; 26 survivor-spouse dyads; 49.0%; 15.4%	Stress and coping framework	Multicomponent: IS, ST, DC (1) IS: PERC website included seven education modules, two modules were mandatory, providing information about how couples work as a team and survivorship issues, five optional modules focused on the management of symptoms; Prostate Cancer Resource Center with web links to different organizations and online resources. (2) ST: symptom management skills: links to videos demonstrating relevant skills (e.g., Kegel exercises); encouraging couples to practice skills they learned from the module. (3) DC: assignments were available to encourage couples to share personal experiences with symptoms and to collaboratively develop management strategies; couples were encouraged to review modules and complete the assignments together.	- A team of nurses, physicians, a psychologist, a media specialist, web designers, and programmers; - Website (audio-enhanced Microsoft PowerPoint® presentations, video clips, text).	- 7 weekly modules; maximum of 8-week period.

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Table 1 (continued)

Author (year) Country [reference]	Study aims	Study design	Target population (cancer diagnosis, no. of dyads, refusal %, attrition %)	Theoretical framework	Intervention content	Delivery format (who and how)	Intervention dosage
Song et al (2021) USA ³⁷	<ul style="list-style-type: none"> - To examine the feasibility of a web-based intervention; - To examine the preliminary effects of the intervention. 	RCT (1) Enhanced survivorship care plan (ESCP) (a couple-focused, tailored web-based mHealth education program); (2) SCP that contained a link to general information on the National Cancer Institute website.	Prostate cancer; Intervention group: 31 survivor-spouse dyads; Control group: 31 survivor-spouse dyads; 58.4%; 9.7%	- The modified transactional theory of stress	Multicomponent: ST, DC, SS (1) ST: symptom management skills: modules about assess and manage prostate cancer treatment-related side effects and symptoms (including urinary and bowel problems, sexual dysfunction, hormonal symptoms, pain, fatigue, sleep disturbance, and stress); improve healthy behaviors. (2) DC: modules about how couples can work effectively as a team. (3) SS: providing post-module assignments, a moderated online forum, meetings with a health educator, a resource center that connects couples to tools for symptom tracking and monitoring, as well as local and national support groups and resources.	<ul style="list-style-type: none"> - Nurses; - Website (can be accessed on smartphone, tablet, or computer). 	Not reported
Sun et al (2018) USA ³⁶ (Protocol study)	<ul style="list-style-type: none"> - To describe the design of a telehealth-based ostomy self-management training (OSMT) program; - To determine whether activation, self-efficacy, ostomy-related knowledge, and health-related quality of life will be improved and sustained over time. 	RCT (1) OSMT; (2) Usual care	A range of cancer types; Intervention group: 81 survivor-caregiver dyads; Control group: 81 survivor-caregiver dyads; Not reported; Not reported	- Chronic care model	Single-component: ST Self-management skills: - Session 1: understanding self-care, equipment, appliances, and stoma/skin care, practice with equipment, pouches, and belts; - Session 2: problem-solving skills training focuses on creating an emergency kit for public outings; social well-being concerns, including social/interpersonal relationships, intimacy, sexuality, and communicating with family and friends, management of comorbidities and other long-term effects of treatment are discussed (the caregiver session also include support for caregiver adjustment and improving comfort level with ostomy care); - Session 3: for survivors: the program promotes a	<ul style="list-style-type: none"> - Study investigators, educators (wound, ostomy, and continence nurses, peer ostomates), and support personnel; - Video conferencing (Zoom meeting platform, have access to a computer, laptop, tablet or smartphone equipped with a webcam, microphone). 	<ul style="list-style-type: none"> - Four weekly sessions (each 120 min); 4 weeks.

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Table 1 (continued)

Author (year) Country [reference]	Study aims	Study design	Target population (cancer diagnosis, no. of dyads, refusal %, attrition %)	Theoretical framework	Intervention content	Delivery format (who and how)	Intervention dosage
Winters-Stone et al (2022) USA ²⁹	- To describe the feasibility, preliminary efficacy, and safety of live online group training and compare to in-person training.	RCT (1) Live online group training; (2) In-person training	Breast cancer; Intervention group: 19 survivor-spouse dyads; Control group: 12 survivor-spouse dyads; 13.8%; 5.0%	Not reported	healthy lifestyle through nutritional management, physical activity recommendations, psychological health, and improving attitudes. Problem-solving training focuses on tips for ostomy care while traveling; - Session 4: discussions are driven by group demands and remaining questions, attainment of personal goals for participation in OSMT program is discussed.	- Certified fitness instructors; - Video conferencing.	- Twice a week.

CARES, computer-assisted oral cancer rehabilitation and support; CB, couples-based; DC, dyadic coping; ESCP, enhanced survivorship care plan; FF, face-to-face; iCBT, Internet-delivered cognitive-behavioral therapy; IS, information support; MBI, mindfulness-based intervention; OSMT, ostomy self-management training; PERC, prostate cancer education and resources for couples; RCT, randomized controlled trial; SO, survivor-only; SS, social support; ST, skills training.

The Effective Public Health Practice Project is a reliable and valid tool for detecting bias in a range of intervention study designs, such as pre-post single-group studies and randomized controlled trials (RCTs), and has been reported to be available for the systematic reviews of intervention studies.^{24,25} Fig. 2 presents the details of the quality assessment tool. Any inconsistencies in terms of literature screening, data extraction, and quality assessment were resolved through team discussion and consensus.

Results

Study selection process

A total of 625 articles was initially retrieved by manual search, and 233 duplicates were removed. The titles and abstracts of the remaining 392 articles were compared with the inclusion criteria. Of those 392 articles, 360 articles were removed and 32 studies were retained for full-text review. Finally, 13 studies were included for analysis in this review. The selection process details are shown in Fig. 1. Most articles were excluded because they were not an intervention study or did not target post-treatment cancer survivor-caregiver dyads. Moreover, to avoid duplication, two eligible protocol papers were excluded, as they were protocols of experimental studies covering both intervention design characteristics and intervention outcomes that had been included in the synthesis.

Study methodological quality

Fig. 2 shows the quality assessment of the included studies. Two studies were rated as “strong”, six studies had a global rating of “moderate”, while the remaining five studies (including two protocol studies) received a “weak” rating. The main factor influencing study quality was selection bias caused by a low response rate from the target participants. Although the methodological quality of the included studies was variable, we did not remove any studies because the number of eligible studies included in this review was limited, and this article's focus included two aspects: exploring intervention design characteristics and intervention outcomes.

Intervention characteristics

All 13 studies that focused on post-treatment survivorship web-based interventions for cancer survivor-caregiver dyads were conducted in Western countries, including the U.S. (n = 11, 84.6%), Ireland (n = 1, 7.7%), and Belgium (n = 1, 7.7%). Of the 13 studies, seven were RCTs and four were pre-post single-arm studies. The other two studies were protocols that only described the RCT intervention design.

Target population

Of the 13 studies included in this review, a single cancer type was targeted in nine (69.2%) studies, including breast cancer (n = 4, 30.8%),

Table 2Web-based intervention outcomes ($n = 13$).

Author (year) Country [reference]	Study design	Outcome measurements Measurement intervals	Program evaluation outcomes (feasibility, acceptability, usability, and participant satisfaction)	Intervention effects ($P < 0.05$ indicates statistical significance)	QR
Akkol-Solakoglu et al (2021) Ireland ²⁶ (Protocol study)	Randomized controlled trial (RCT)	Primary outcome measures - Anxiety and depression symptoms: hospital anxiety and depression scale (HADS). Secondary outcome measures - Cancer-related quality of life (QOL): European Organization for Research and Treatment of Cancer Quality of Life Core Questionnaire*; - Fear of recurrence: Cancer Worry Scale*; - Coping: brief coping orientation to problems encountered*; - Perceived social support: Medical Outcomes Study*; - Cancer-related communication: family communication subscale; - Relationship quality: a scale ranging between 0 and 10. Baseline, at the end of the intervention, 2 months after the intervention. Other measures - Acceptability of the program: helpful aspects of therapy form (qualitative questions); - Satisfaction with the program: satisfaction with online treatment (qualitative and quantitative questions). At the end of the intervention.	Not reported	Not reported	W
Badr et al (2016) USA ³⁵	Single-group study	Usability Testing - "Task analysis" method. User Testing - Qualitative interview; - 25-item evaluation survey, which assessed attractiveness, controllability, efficiency, intuitiveness and learnability (5-point Likert-type scale). At the end of the intervention.	Usability - There were 35 system errors/ navigation problems that needed improvement. User - They found the content to be relevant and helpful and would suggest that other survivors and caregivers use the website; - Users rated the website favorably on each of the usability dimensions and gave the site a total usability score of 80/100.	Not reported	W
Beer et al (2020) USA ²⁷	Single-group study	Attitudes and acceptance - Semi-structured discussion; - System Usability Scale; - Technology Acceptance Questionnaire. At the end of the intervention.	Attitudes and acceptance - Overall, participants mentioned perceived benefits more than concerns; - Convenience, health, and guidance in care were the top benefits of using the app, while cost, difficulty of use, sustainability, and privacy were the top concerns; - Survivors mentioned benefits more than their family members did; - Participants felt positively about adding a community network to the app; - Participants expected to hear about Breathe Easier from their care provider.	Not reported	W
Carmack et al (2021) USA ³¹	RCT	Feasibility - Recruitment rate, retention rate, session attendance, and the monitoring of adverse events. Acceptability	Feasibility - Recruitment rate: 12.7%, retention rate: 88.6%; - Survivors attended 94% of sessions with no significant differences between study conditions, spouses	Within-group pre-post comparison. Primary outcomes - Physical health: survivors in both the couples-based (CB) ($m = 73.3$ vs. 81.4 ; $P = 0.01$) and survivor-only (SO) ($m = 67.0$ vs. 70.4 ; $P = 0.02$) groups improved health behaviors and related outcomes; spouses in the	M

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Table 2 (continued)

Author (year) Country [reference]	Study design	Outcome measurements Measurement intervals	Program evaluation outcomes (feasibility, acceptability, usability, and participant satisfaction)	Intervention effects ($P < 0.05$ indicates statistical significance)	QR
		<ul style="list-style-type: none"> - A question with answers "Yes", "Maybe", and "No". At the end of the intervention. <p>Exploratory outcome measures</p> <ul style="list-style-type: none"> - Physical activity: 3-item modified version of the Godin leisure-time exercise questionnaire; - Physical performance: 6-min walk test, 2-min step test, 30-s chair stand test, 8-foot up-and-go assessment, 3-m time up-and-go test; - Weight: stadiometer and electronic scale; - Diet: Automated Self-administered 24-h Dietary Recall. Baseline, 6 months after the intervention. 	<p>attended an average of 91% of sessions.</p> <p>Acceptability</p> <ul style="list-style-type: none"> - As a result, 92% of survivors and 80% of spouses responded that they would recommend participating to other cancer survivors. 	<p>CB intervention demonstrated significant improvements in health behaviors and related outcomes ($m = 80.2$ vs. 89.8; $P = 0.03$), while those examined as part of the SO group (i.e., did not receive an intervention) demonstrated none ($P = 0.70$).</p>	
Pauwels et al (2012) Belgium ³⁴	Single-group study	<p>Process evaluation</p> <ul style="list-style-type: none"> - Questionnaire (five-point Likert scale: 1 = 'I don't agree at all' to 5 = 'I totally agree') assessed the website's user-friendly, well built, interesting and so on; - Rating the main menus of the website on a scale from 1 to 10. At the end of the intervention. 	<ul style="list-style-type: none"> - Generally, participants believed the website was user-friendly, well built, interesting, informative, understandable and new; - Survivors and partners generally evaluated website's content and layout positively. 	Not reported	M
Pekmezci et al (2021) USA ³⁰ (Ongoing study)	RCT	<p>Acceptability and satisfaction</p> <ul style="list-style-type: none"> - Telephone interview. At the end of the intervention. <p>Primary outcome measures</p> <ul style="list-style-type: none"> - Body Weight: Zoom® images. <p>Secondary outcome measures</p> <ul style="list-style-type: none"> - Waist circumference: ribbon; - Diet Quality: dietary assessment web-based tool; - Physical activity: actigraphs, Godin leisure-time exercise questionnaire; - Physical performance testing: senior fitness battery. Baseline, 6 months after the intervention. 	Not reported (only reported participant characteristics)	Not reported	W
Porter et al (2018) USA ³³	RCT	<p>Acceptability</p> <ul style="list-style-type: none"> - 3-item scale, including helpfulness in increasing physical activity, improving communication, and recommend to other. Items were rated from 1 (not at all/definitely would not recommend) to 5 (extremely/definitely would recommend). <p>Primary outcome measures</p> <ul style="list-style-type: none"> - Physical activity: Godin Leisure-Time Exercise Questionnaire; - Partner support: 15-item scale that measures the degree to which one's partner provides instrumental and emotional support for exercise habits; - Physical well-being: Functional Assessment of Chronic Illness Therapy-General scale (FACT-G)*. Baseline, at the end of the intervention. 	<p>Acceptability</p> <ul style="list-style-type: none"> - Acceptability: mean ratings were all greater than 4.0 on the 5-point scale. 	<p>Between-group comparisons of pre-post change.</p> <p>Primary outcomes</p> <ul style="list-style-type: none"> - Physical health: greater improvements in physical activity in intervention arm than control arm for survivors (Cohen's $d = 0.179$) and caregivers (Cohen's $d = 0.625$); greater improvements in physical well-being in intervention arm than control arm for survivors (Cohen's $d = 0.517$). - Dyadic relationship: greater improvement in partner support in intervention arm than control arm for survivors (Cohen's $d = 0.78$) and partners (Cohen's $d = 0.95$). 	S
Price-Blackshear et al (2020) USA ²⁸	RCT	<p>Feasibility and acceptability</p> <ul style="list-style-type: none"> - Questionnaire (five-point Likert scale) and open-ended questions. At the end of the intervention. <p>Primary outcome measures</p> <ul style="list-style-type: none"> - Individual-level variables: stress: Perceived Stress Scale; anxiety and depression: PROMIS short-form depression and anxiety; dispositional 	<p>Feasibility and acceptability</p> <p>Online delivery appeared to be feasible and widely acceptable: 75% survivors and 87% partners agreed that the online instruction format was satisfactory; 63% of survivors and 69% of partners indicated that they would recommend the study to a friend; 77% of survivors and 69% of partners reported watching all eight assigned videos; 90% of survivors and 89% of partners reported using the supplemental guided</p>	<p>Within-group pre-post comparison.</p> <p>Primary outcomes</p> <ul style="list-style-type: none"> - Mental health: both survivors and their partners in experimental group reported less stress and anxiety (for survivors: $P < 0.01$; for partners: $P < 0.01$), and more mindfulness (for survivors: $P < 0.01$; for partners: $P < 0.01$) after the intervention, compared to baseline. In the control group, the survivors' level of anxiety decreased but their partners' did not. 	M

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Table 2 (continued)

Author (year) Country [reference]	Study design	Outcome measurements Measurement intervals	Program evaluation outcomes (feasibility, acceptability, usability, and participant satisfaction)	Intervention effects ($P < 0.05$ indicates statistical significance)	QR
		mindfulness: Mindful Attention and Awareness Scale; - Couples-level variables: dyadic adjustment: Dyadic Adjustment Scale (DAS), Quality of Marriage Index; Interpersonal Mindfulness Scale. Baseline, at the end of the intervention.	meditations; 91% of survivors and 92% of partners reported completing some or all of the homework assignments.	- Dyadic relationship: survivors reported lower levels of dyadic adjustment ($P < 0.01$) after the intervention, and their partners showed relatively no change ($P = 0.15$); both members of a couple reported increase in interpersonal mindfulness (for survivors: $P < 0.01$; for partners: $P = 0.01$).	
Schover et al (2012) USA ³²	RCT	Primary outcome measures - Sexual function: International Index of Erectile Function, a 15-item assessment of sexual function and satisfaction*; Female Sexual Function Inventory#; - Distress: Brief Symptom Inventory-18; - Dyadic adjustment: DAS. Baseline, at the end of the intervention, 3, 6, and 12 months after the intervention.	Not reported	Within-group pre-post comparison. Primary outcomes - Physical health: for survivors, sexual function improved significantly across time in WEB group (Cohen's $d = 0.35$, $P = 0.004$). No group significantly improved partners' physical health. - Mental health: no effect on distress for survivors or partners. - Dyadic relationship: no effects on dyadic adjustment and marital happiness for survivors or partners.	M
Song et al (2015) USA ³⁸	Single-group study	Feasibility and acceptability - Recruitment and retention rates, pre- and post-pilot assessments (perceived ease of use), and website activity data tracking (e.g., number of logins, time spent on the site); - Semi-structured interviews with a subset of couples. Outcome measures - QOL: FACT-G; - General symptoms: 21-item symptom scale; - Dyadic communication: a 21-item, five-point Likert-type Mutuality and Interpersonal Sensitivity Scale; - Relationship satisfaction: Relationship Assessment Scale. Baseline, at the end of the intervention.	Feasibility and acceptability - Recruitment rate: 51%, retention rate: 85%; - Participants rated website as easy-to-use and understand, engaging, of high-quality, and relevant; - Couples were satisfied with website and reported that it improved their knowledge about symptom management and communication as a couple.	Pre-post comparison. Primary outcomes - QOL: improvement in social QOL was promising for survivors (Cohen's $d = 0.32$) and partners (Cohen's $d = 0.25$). - Physical health: there were small improvements in general symptoms for survivors (Cohen's $d = 0.21$) and for partners (Cohen's $d = 0.38$). - Dyadic coping: for survivors, cancer communication was reduced (Cohen's $d = -0.23$). There was no pre-post-intervention change in cancer communication for partners (Cohen's $d = 0.09$). - Dyadic relationship: for both survivors and their partners, relationship satisfaction declined (for survivors: Cohen's $d = -0.21$; for partners: Cohen's $d = -0.24$).	M
Song et al (2021) USA ³⁷	RCT	Feasibility - Participant enrollment and retention rates; - Website usage; - Program satisfaction and perceived ease of use: Usability Scale. Primary outcome measures - QOL: FACT-G. Secondary outcome measures - Appraisal of symptoms: prostate cancer symptoms: Prostate cancer Index Composite; general symptoms: 21-item Risk of Distress General Symptom Scale; - Self-efficacy: 9-item Cancer Self-Efficacy Scale; Baseline, 4–6 months later.	Feasibility - Recruitment rate = 42%, retention rate = 90%; - Website usage: 70% of the individuals/couples reviewed relevant webpages; - Patients in the intervention group reported significantly greater program satisfaction and perceived easier navigation of website than those in the control group.	Between-group comparisons of pre-post change (linear mixed effect model). Primary outcomes - QOL: compared with the control group, couples in the experimental group improved their QOL, but not statistically (coefficient $B = 0.65$, $P = 0.35$). - Physical health: experimental survivors reported better urinary symptom scores than control survivors (coefficient $B = 8.04$, $P = 0.01$). Secondary outcomes - Self-efficacy: compared with the control group, there was a trend toward less deterioration in self-efficacy in symptom management in experimental couples (coefficient: $B = 2.21$, $P = 0.10$).	M
Sun et al (2018) USA ³⁶ (Protocol study)	RCT	Primary outcome measures - Physical health: Patient Activation Measure; - Self-efficacy: Self-Efficacy to Perform Ostomy Self-Management Behaviors; - QOL: City of Hope-Quality of Life-Colorectal; - Knowledge related to care: Ostomy Knowledge Questionnaire; - Anxiety and depression: HADS;	Not reported	Not reported	W

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Table 2 (continued)

Author (year) Country [reference]	Study design	Outcome measurements Measurement intervals	Program evaluation outcomes (feasibility, acceptability, usability, and participant satisfaction)	Intervention effects ($P < 0.05$ indicates statistical significance)	QR
Winters-Stone et al (2022) USA ²⁹	RCT	- Burden: Burden of Ostomy Care Tool. Baseline, at the end of the intervention, and 6 months after the intervention. Feasibility - Attendance rate; - Retention rate. Primary outcome measures - Physical health: chair stand time. Baseline, and 6 months after the intervention.	Feasibility - Intervention group: attendance rate: 86.2% ± 11.7%, retention rate: 95.0%; - Control group: attendance rate: 81.1% ± 13.2%, retention rate: 80.0%.	Between-group comparisons of pre-post change. Primary outcomes - Physical health: improvements in chair stand time were nearly the same between intervention group (training online) and control group (in-person) (chair stand time: % change: for survivors: -7.1% vs. -13.9%; for partners: -9.1% vs. -10.7%)	S

CB, Couples-Based; DAS, Dyadic Adjustment Scale; FACT-G, Functional Assessment of Chronic Illness Therapy-General scale; HADS, Hospital Anxiety and Depression Scale; M, moderate; QOL, Quality of Life; QR, Quality Rating; RCT, Randomized Controlled Trial; S, strong; SO, Survivor-Only; W, weak; *indicates survivor only; #indicates spouse/caregiver only.

prostate cancer ($n = 3, 23.1\%$), oral cancer ($n = 1, 7.7\%$), and lung cancer ($n = 1, 7.7\%$). Researchers tested multiple types of cancer in the remaining four studies (30.8%). The number of samples varied widely, ranging from five to 163 cancer survivor-caregiver dyads. As shown in Table 1, of the 13 studies, eight intervention studies were based on cancer couple dyads, and five were for any cancer survivor-caregiver dyads and were not limited to spousal or partnered couples. Across the interventions for any cancer survivor-caregiver dyads, caregivers'

relationships with cancer survivors included spouses, parents, adult children, and other relatives.

Study aims and intervention focus

Examining the feasibility and acceptability of a web-based intervention program and determining the preliminary efficacy of a web-based intervention on participants were common goals in the studies that

Quality assessment of the included studies using the EPHPP tool

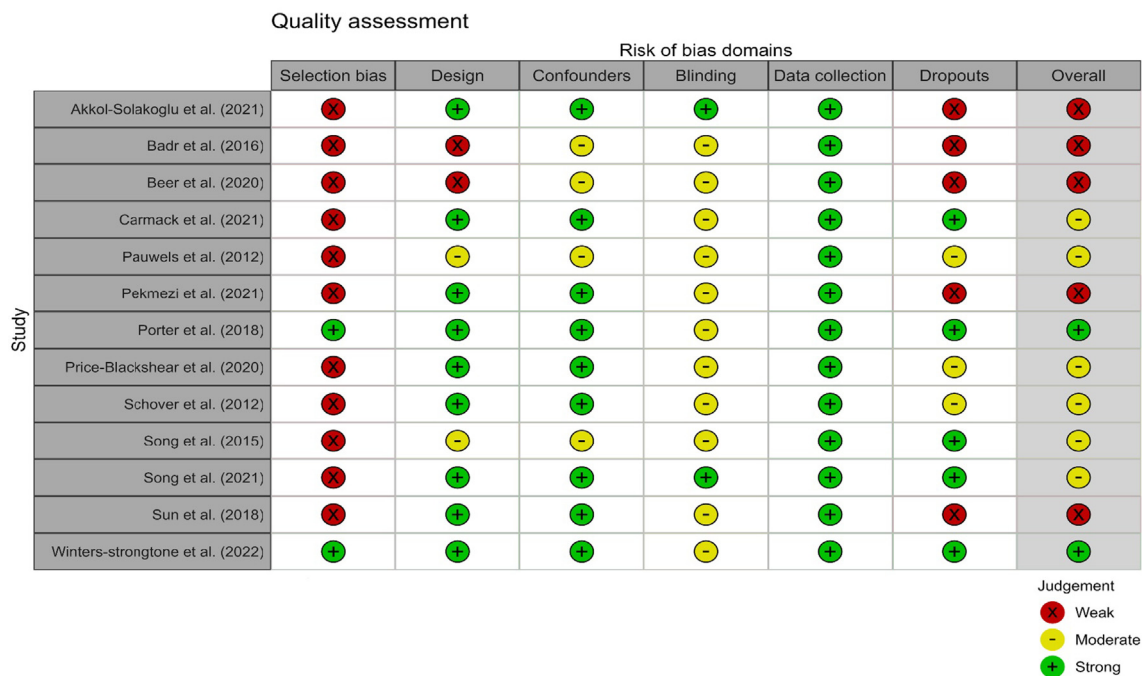


Fig. 2. Study quality assessment using the EPHPP tool, Selection bias: Strong-very likely to be representative of the target population and greater than 80% participation rate; Moderate-somewhat likely to be representative of the target population and 60%–79% participation rate; Weak - all other responses or not stated. Design: Strong-RCT and CCT; Moderate-cohort analytic, case-control, cohort, or an interrupted time series; Weak-all other designs or design not stated. Confounders: Strong-controlled for at least 80% of confounders; Moderate-controlled for 60%–79% of confounders; Weak-confounders not controlled for, or not stated. Blinding: Strong-blinding of outcome assessor and study participants to intervention status and/or research question; Moderate-blinding of either outcome assessor or study participants; Weak-outcome assessor and study participants are aware of intervention status and/or research question. Data collection methods: Strong-tools are valid and reliable; Moderate-tools are valid but reliability not described; Weak-no evidence of validity or reliability. Withdrawals and dropouts: Strong-follow-up rate of >80% of participants; Moderate-follow-up rate of 60%–79% of participants; Weak-follow-up rate of <60% of participants or withdrawals and dropouts not described. Quality rating: S: strong; M: moderate; W: weak. Strong: If a study had no weak ratings and at least four strong ratings, then it was considered strong; Moderate: If the study had fewer than four strong ratings and one weak rating, it was rated moderate; Weak: If a study had two or more weak ratings, it was considered weak.

were included. In terms of intervention focus, in three intervention studies, researchers focused on promoting the psychological well-being of cancer survivor-caregiver dyads through cognitive-behavioral therapy or online mindfulness activities.^{26–28} Three studies, which were lifestyle behavior change programs, were conducted to improve diet, physical activity, and weight management for both cancer survivors and their caregivers.^{29–31} Researchers in two studies aimed to strengthen dyadic communication and dyadic support between survivors and their caregivers,^{32,33} and one study was aimed at increasing cancer knowledge and the psychosocial functioning of cancer survivors and caregivers by providing high-quality online information.³⁴ The other four studies were primarily used to promote self-management^{35,36} and symptom management^{37,38} in cancer survivor-caregiver dyads.

Theoretical framework of the interventions

Eight of the 13 studies described specific theoretical frameworks that were used to guide the research. Social cognitive theory, emphasizing that one's behavior is influenced by personal expectations and confidence in performing tasks, grounded two studies.^{30,31} The stress and coping framework and the modified transactional theory of stress, which focus on individual-level stress-coping processes, were used in two studies.^{37,38} A dyad-level model called interdependence theory, which emphasizes the ways in which interacting partners influence each other's outcomes, grounded one study.³³ Other theoretical frameworks used in the studies included self-determination theory,³⁵ chronic care model,³⁶ and community-based participatory research principles.²⁷ Although most studies involved theoretical frameworks, none described in detail how the interventions were designed based on these theories.

Intervention content

Based on the content of previous systematic reviews of dyadic interventions^{21,39} and a synthesis of the intervention studies that were included, we grouped the post-treatment survivorship dyadic web-based interventions reviewed here into the following five treatment elements according to intervention focus: information support, psychotherapy, individual-level skills training, dyadic coping, and social support.

Information support

The main content of information support was supportive information related to disease and survivorship management. Information provided by the post-treatment survivorship web-based interventions mainly included the following aspects: cancer-related information (eg., tailored content on cancer, post-treatment symptoms, symptom management, side effect management, and nutritional management),^{26,27,34,35,38} introduction to psychological consequences and their causes,^{26,34} information on common survivorship issues (eg., recurrence and return to work),^{34,38} introduction to self-care strategies (eg., information on healthy eating, exercise, behavioral change strategies, emotional management, and mindfulness activities),^{27,30,34,35} introduction to caregiver tips,³⁴ introduction to strategies for coping together (eg., information about open communication, mutual understanding, mutual support, and working as a team),^{27,34,38} health resources,³⁰ cancer survivorship news,³⁰ web links to other websites,³⁸ and a help guide.^{30,34}

Psychotherapy

Psychotherapy focused on providing strategies to address the unmet emotional and psychological needs of cancer survivors and their caregivers.⁴⁰ Among the included interventions, psychotherapy mainly included strategies to identify and challenge irrational thoughts,^{26,35} relaxation techniques,³⁵ mindfulness activities (meditation, gentle movements, and breathing exercises),^{27,28} and cognitive-behavioral strategies.^{31–33}

Individual-level skills training

The purpose of most individual-level skills training was to practice the self-care and caregiver strategies learned in "Information support". Skills training in the web-based interventions can be divided into physical exercises and problem-solving skills training. Specifically, physical exercises included swallowing exercises,³⁵ aerobic exercise,³⁰ Kegel exercises,³⁸ resistance exercise training,²⁹ and exercises for improving couples' sex life.³² Problem-solving training referred to side effect management training,³⁷ symptom management training,³⁷ stoma/skin care,³⁶ and equipment use practice.³⁶

Dyadic coping

Dyadic coping refers to the stress-coping process in which both survivors and their caregivers respond and use coping strategies as a unit (at a dyadic-level).⁴¹ Dyadic coping mainly included the following topics: survivor-caregiver sharing/communication (eg., sharing personal experiences, learning and practicing effective speaking and listening skills, and discussing management strategies together),^{30,31,33,35,38} joint activities to encourage teamwork (eg., partner yoga, mindful touch exercises, dyadic eye gazing, and mindful communication with caregiver),^{28,35,38} communal coping,^{31,37} joint problem-solving,^{31,33} and mutual support.³⁰

Social support

Social support primarily refers to the opportunities for participants to receive support from peers or medical professionals. In the post-treatment survivorship web-based interventions, social support included the following aspects: providing bulletin boards to solicit and offer support to peers and one another,³⁵ community feature modules, including testimonials, public discussions, private discussions, Frequently Asked Questions,²⁷ online contact with therapists,³² online forum,³⁷ and online meetings with health educators.³⁷

It should be noted that although the majority of the intervention studies that were included ($n = 10$, 76.9%) involved multiple intervention components (ie., multicomponent interventions), only one study covered all of the above five treatment elements.³⁵

Delivery of web-based interventions

Intervention deliverers were reported in 10 studies (76.9%). Of these 10 studies, four studies (30.8%) were delivered by multidisciplinary teams (eg., including experts in multiple fields -oncology, psychology, and web design).^{31,35,36,38} The other studies were delivered by research teams ($n = 2$, 15.4%), trained therapists or instructors ($n = 2$, 15.4%), nurses ($n = 1$, 7.7%), and masters-level students ($n = 1$, 7.7%). Web-based intervention delivery formats were varied. Of the three single-component web-based interventions, two provided skills training via web-based videoconferencing^{29,36} and one provided information support via a website.³⁴ Across multicomponent interventions, a website was the most common delivery format and was used in six intervention studies.^{26,30,32,35,37,38} Other web-based delivery formats used in multicomponent interventions included online video conferencing,^{31,33} applications,²⁷ and email.²⁸ Presentation formats for the web-based interventions included Microsoft PowerPoint, text, pictures, audio, video, and web links. In addition to the web-based presentation formats, three studies used workbooks,³¹ intervention text messages,³⁰ and study manuals²⁸ as additional intervention materials, respectively.

Intervention dosage

The number and/or duration of web-based intervention modules/sessions was reported in 10 studies. The number of intervention modules/sessions ranged from four to 24, with an average of 8.9. Most intervention modules/sessions were weekly ($n = 6$, 46.2%). Three studies showed that each module/session lasted 60 min,^{26,28,33} one study

showed that each session lasted 120 min,³⁶ and the duration of each module/session in the other interventions was not specified by researchers but was self-guided by the participants.^{27,30–32,34,38} The intervention duration varied from four to 24 weeks, with an average of 11.1 weeks. Most of the interventions included in this review had a single follow-up period, including immediately after intervention ($n = 7$, 53.8%), four to six months ($n = 1$, 7.7%), and six months ($n = 3$, 23.1%). The other two studies followed up at multiple periods.^{32,36}

Intervention outcomes

Program evaluation outcomes

In addition to attendance, retention, and utilization, qualitative interviews,³⁰ assessment questionnaires,^{28,31,33,34,37} or a combination of qualitative interviews and assessment questionnaires^{27,35,38} were common intervention program evaluation methods. Program evaluation outcomes in terms of feasibility,^{28,29,31,37,38} acceptability,^{27,28,31,33,38} usability,³⁵ and participant satisfaction.^{27,34,35} were reported in nine studies. The attendance rate of the interventions that were included ranged from 12.7% to 86.2%, with an average of 53.7%. The retention rate ranged from 65.9% to 95%, with an average of 83.2%. Most dyads in the interventions viewed some or all of the relevant online sessions, and they generally rated the web-based programs as convenient, understandable, engaging, high-quality, relevant, and useful.^{27,28,34,37,38}

Intervention effects

Intervention effects on survivor-caregiver dyads were reported in seven studies. Based on synthesizing the outcomes reported in the studies, we present and summarize intervention effects in terms of dyadic mediator, dyadic coping, and dyadic adjustment as follows (Table 2). $P < 0.05$ indicates statistical significance.

Dyadic mediator. Dyadic mediator refers to the sense of self-efficacy or daily enrichment events that can encourage relationship-enhancing behaviors in cancer dyads.⁴² Only self-efficacy was reported as a secondary outcome, in one study.³⁷ Results showed a trend toward less deterioration in symptom management self-efficacy for couples in the experimental group (a couples-focused, tailored web-based mHealth education program) than for couples in the control group (a web-based program that only linked to the National Cancer Institute website) at the six-month follow-up, with coefficient $B = 2.21$, $P = 0.10$ (linear mixed effect model).

Dyadic coping. Dyadic coping as an outcome variable typically describes the level of survivor-caregiver communication and joint coping. Survivor-caregiver dyadic communication was reported as a primary outcome in a pre-post single-group study.³⁸ Surprisingly, the results showed a decrease in couples' communication about cancer, with an effect size of Cohen's $d = -0.23$ (pre-post comparison).

Dyadic adjustment. Dyadic adjustment refers to the adaptation outcomes of cancer dyads in response to stress, which is generally measured from four dimensions: quality of life, physical health, mental health, and dyadic relationship.^{39,42}

Quality of life. Quality of life was reported in two studies focusing on prostate cancer education for couples.^{37,38} The pre-post single-group study showed improved quality of life for both survivors and their spouses, with effect sizes of Cohen's $d = 0.32$ for survivors and 0.25 for spouses (pre-post comparison).³⁸ The results from another study indicated an expected improvement in participant quality of life in the experimental group, compared to the control group, at the six-month follow-up, but it was not statistically significant, with coefficient $B = 0.65$, $P = 0.35$ (linear mixed effect model).³⁷

Physical health. Physical health was reported as a primary outcome in six studies, including physical performance,³¹ physical activity,^{29,33} sexual function,³² general symptoms,^{37,38} and disease-specific

symptoms.^{37,38} These studies yielded consistent results that web-based dyadic interventions had positive impacts on the physical health of survivors and their caregivers. Three couple-based intervention studies showed that participants who received a web-based dyadic intervention improved their physical health between pre-intervention and post-intervention.^{31,32,38} The effect sizes of Cohen's d ranged from 0.21 to 0.38 (pre-post-intervention). Notably, Carmack et al found that spouses in the couples-focused web-based dyadic intervention demonstrated significant improvements in physical performance between pre-intervention and post-intervention ($P = 0.03$), while those examined as part of the survivor-only intervention group demonstrated none ($P = 0.70$).³¹ Two RCTs showed that survivors and caregivers in the intervention group reported better physical outcomes than control participants.^{33,37} Specifically, Porter et al found that participants in the intervention group tended to report greater improvements in physical activity than those in the control group, with effect sizes of Cohen's d ranged from 0.179 to 0.625.³³ Song et al showed that experimental survivors had better pre-post change in disease-specific symptom scores than control survivors ($P < 0.01$).³⁷ In addition, Winters-Stone et al found that improvements in chair stand time were nearly the same between the intervention group (training online) and the control group (in-person).²⁹ Specifically, the percent change in chair stand time for survivors and spouses in the intervention group was -7.1% and -9.1% , respectively (pre-post intervention, negative values indicated improved chair stand performance, and better lower body strength).

Mental health. In two RCTs, mental health was reported as stress,²⁸ anxiety and depression,^{28,32} and mindfulness.²⁸ Of the two studies, one study indicated that, in the web-based couples intervention, both survivors and their spouses reported less stress, anxiety, and depression, and more mindfulness after the intervention compared to baseline, but in the control group (survivor-only intervention), spouses of cancer survivors did not improve their mental health.²⁸ Researchers in the other study did not find a significant intervention effect on the distress of either cancer couple partner in any group.³²

Dyadic relationship. Among the studies that were included, dyadic relationship was reported in terms of partner support³³ and relationship satisfaction.^{28,32,38} Results related to dyadic relationship were inconsistent. The study by Porter et al showed improved partner support in the intervention arm compared to the control arm for survivors (between-group comparison, effect size of Cohen's $d = 0.78$) and spouses (between-group comparison, effect size of Cohen's $d = 0.95$).³³ The study by Schover et al showed no intervention effect on the dyadic relationship of couples in any group (pre-intervention-12 months follow-up).³² However, researchers in two other studies found that couples' relationship satisfaction declined after the couples-focused web-based interventions.^{28,38}

Discussion

Compared with traditional face-to-face dyadic interventions, web-based dyadic interventions can break the constraints of time and space and may better address the supportive care needs of cancer survivors and their caregivers during post-treatment survivorship. In this review, we synthesized evidence from 13 studies to provide an overview of the characteristics and outcomes of existing post-treatment cancer survivor-caregiver dyadic web-based interventions.

Overall, the combined results in this review support the feasibility, usability, and acceptability of eHealth intervention programs and show a trend in terms of the positive effects of these interventions on cancer survivor-caregiver dyads. These positive outcomes may partially be attributed to online delivery platforms, appropriate intervention content based on survivorship supportive care needs, and survivor-caregiver dyad interactions.

As shown by the results integrated in this review, the mean attendance and retention rates for the interventions that were included were 53.7% and 83.2%, respectively, comparable to the mean enrollment

(53%) and retention (80%) rates obtained from reviews of traditional face-to-face dyadic interventions.^{39,43} In addition, to a certain extent, these web-based interventions showed positive intervention outcomes, which is consistent with the findings of previous reviews of face-to-face interventions.^{39,43} Based on the understanding that web-based dyadic interventions are feasible, acceptable, and effective, online delivery platforms used in the web-based interventions have unique advantages, such as being remote, multifunctional, optional, and personalized. This could solve the traditional face-to-face delivery problems of inflexibility, single form, and “one-size-fits-all”. The convenience of the remote online platforms was often reported by participants as a perceived benefit, by reducing their participation burden (such as limited time and travel restrictions), enabling them to access programs at a convenient time and place, regardless of location.^{27,34} Most online platforms used in the interventions that were included were multifunctional, providing participants not only with textual materials but also with video, audio, and social networking, to engage participants in the online sessions and increase their adherence to the web-based program.^{26,27,30,32,34–36,38} Furthermore, some online platforms were optional and personalized, with features allowing each visitor to choose the information he/she needed and to generate personalized intervention content based on visitor choices.^{30,34,38} To a certain extent, the optionality and personalization of the online platforms solved the “one-size-fits-all” issue of traditional interventions, making cancer survivors and caregivers feel more relevant and show a strong interest in tailored web-based interventions.^{34,38} It can be seen that online platforms with these advantages were critical to high retention rates and positive participant evaluations of web-based programs, and were possible advantages of web-based interventions over traditional face-to-face interventions. However, it should be noted that optional and personalized online platforms were employed in only three of the interventions that were included.^{30,34,38} This suggests that in general, personalized online platforms are still few and far between, and research teams need to utilize advanced technologies to design online platforms with more personalized features.

As the focus of post-treatment cancer survivors shifts from treating cancer, to recovery, health, well-being, and return to work, the focus of supportive interventions also needs to shift, from a clinically-led approach to one that emphasizes supportive self-management and appropriate support based on individual needs.³ Physical exercises and problem-solving training involved in skills training were designed to enhance survivors’ self-management in terms of physical function and treatment consequences, contributing to quality of life and the prevention of recurrence, new cancers, and late effects of treatments.^{29–31,35–38} In addition, caring skills training improved caregiver skills, further helping caregivers to better assist survivors with self-management.³⁵ Beyond skills training, information support met the information needs of both survivors and caregivers in terms of the disease, emotions, and practices^{30,34,35}; psychotherapy provided education on negative emotion management²⁶; dyadic coping focused on the coping efficiency needs of cancer survivor-caregiver dyads^{30,31,37}; and social support was designed to meet survivor and caregiver needs for social engagement and professional support.^{35,37} These treatment elements addressed the broad range of physical, psychological, and social supportive care needs of cancer survivors and their caregivers, leading to the potential for interventions to help improve survival adaptations for survivors and their caregivers. However, only one study covered all of the above five treatment elements.³⁵ Future post-treatment survivorship web-based interventions could be developed to include sessions with all five treatment elements (i.e., information support, psychotherapy, skills training, dyadic coping, and social support) to comprehensively address the supportive care needs of survivors and caregivers, which may contribute to comprehensive positive survival outcomes covering dyadic mediator, dyadic coping, and dyadic adjustment.

In two RCTs included in this review, researchers compared the efficacy of a dyadic intervention with the same program offered only to

survivors, and both found that the dyadic intervention was more beneficial for cancer survivor-caregiver dyads than the survivor-only intervention.^{28,31} Compared to individual-only interventions, dyadic interventions provided participants with the opportunity to set an example for each other, offer each other support to overcome barriers together and increase personal confidence when observing the other’s success.^{28,31} The interactions between survivors and caregivers motivated cancer survivor-caregiver dyads to complete interventions and improved their learning efficiency.³¹ We can see that dyadic interventions are important to stimulate cancer survivor-caregiver interactions, leading to positive intervention outcomes for both survivors and their caregivers. Future dyadic interventions could include more modules that promote cancer survivor-caregiver interactions, such as survivor-caregiver sharing and two-player games. Further, individual interventions focus only on survivor or caregiver outcomes, limiting interpretations of the differential effects of interventions on survivors and caregivers.³⁹ Researchers in dyadic interventions reported dyadic-level outcomes, including self-efficacy, coping levels, and adaptation outcomes for both survivors and caregivers, enabling a dyadic perspective to explore the impacts of illness and supportive interventions on survivors and their caregivers. Due to the “unit” nature of cancer survivors and caregivers, it may be necessary to explore the dyadic interdependence of survivor and caregiver outcomes. Out of all of the interventions included in this review, none of the researchers measured dyadic interdependence. In the future, researchers could employ statistical techniques, such as the actor-partner interdependence model, to measure post-treatment cancer survivor-caregiver dyad interdependence in dyadic interventions.

Although this review identified the positive outcomes of post-treatment cancer survivor-caregiver dyadic web-based interventions in terms of feasibility, usability, acceptability, and intervention effects, low response rates from target participants (ranging from 12.7% to 86.2%, with an average of 53.7%) were the major factor contributing to selection bias, influencing the quality of the intervention studies. Limited eHealth literacy was a common barrier to participation in web-based intervention programs for eligible cancer survivors and their caregivers.^{27,29} Significant predictors of low eHealth literacy often include low socioeconomic status, lack of education on how to use the Internet, and older age.^{19,44,45} Rural area residents, those with less than a college degree, or older adults are likelier to decline to participate in web-based programs, influencing intervention participation rates.⁴⁴ To expand access to web-based interventions for people with low eHealth literacy, it is important to develop an online platform with a simple interface and easy operation.^{19,34} In addition, developing strategies to enhance the target population’s knowledge and skills in using online platforms may also be an essential function for research teams, to maximize the delivery of web-based supportive programs.¹⁹

Recommendations for future interventions

Based on the summarized characteristics of existing post-treatment cancer survivor-caregiver dyadic web-based interventions, we make several recommendations that we hope will guide future interventions:

- (1) Intervention region: All of the included interventions were conducted in Western countries, reminding us that future research on post-treatment cancer survivor-caregiver web-based interventions could be conducted in different regions, such as in Asia.
- (2) Intervention design: Most of the included intervention studies were feasibility tests, reminding us that more large-scale longitudinal RCTs of post-treatment cancer survivor-caregiver web-based interventions are required in the future.
- (3) Theoretical framework: There should be specific theoretical frameworks to guide intervention design. Notably, although most of the included studies involved theoretical frameworks, none described in detail how interventions were designed based on these theories. Future intervention research needs to articulate

how the intervention is developed according to theoretical frameworks, to enable further replication studies.

- (4) Intervention content: Multicomponent intervention content covering all five treatment elements (i.e., information support, psychotherapy, individual-level skills training, dyadic coping, and social support) is recommended to comprehensively address the supportive care needs of post-treatment cancer survivors and their caregivers.
- (5) Intervention delivery: Self-guided by participants, combined with professional support from a multidisciplinary team, is recommended. Multiple presentation formats combining Microsoft PowerPoint, text, pictures, audio, video, and web links need to be included in online platforms to increase engagement and understanding.
- (6) Intervention dosage: A reasonable dosage of a web-based intervention needs to be adjusted according to the intervention content. The recommended intervention period is nine to 11 weeks (weekly modules/sessions), as summarized in this review.
- (7) Outcome measurement: Outcomes measured in the intervention should include dyadic mediator (self-efficacy), dyadic coping, and dyadic adjustment (quality of life, physical health, mental health, and dyadic relationship).

Limitations

It should be acknowledged that this review has some limitations. First, only articles published in English and Chinese were searched, which may have resulted in important studies in other languages, as well as unpublished studies, being excluded from this review. Second, the heterogeneity of the studies that were included, in terms of the target population, study design, and study quality, may have affected the comparability of the intervention outcomes. Therefore, we could not perform a meta-analysis. Moreover, most of the studies that were included were feasibility tests with small sample sizes, limiting the statistical power of the intervention results. We need to be cautious about the intervention effect outcomes.

Conclusions

Both cancer survivors and their caregivers may experience a range of physical, psychological, and social problems during post-treatment survivorship, demonstrating the importance of dyadic interventions to support cancer survivor-caregiver dyads. Thanks to the development of technology, eHealth is becoming a trend. This review identifies the positive outcomes of post-treatment cancer survivor-caregiver dyadic web-based interventions, reminding us of the need to develop such interventions to improve adaptation outcomes for both cancer survivors and their caregivers. Additionally, this review provides valuable insights for researchers to develop post-treatment survivorship dyadic web-based interventions in future. Based on the available evidence, further development and refinement of web-based dyadic interventions with personalized, easy-to-use online platforms, and multiple components for supportive care needs should be promoted, for both post-treatment cancer survivors and their caregivers.

Author contributions

Meizhen Chen: Conceptualization, Methodology, Investigation, Data Curation, Writing - Original Draft. **Jiali Gong:** Investigation, Data Curation, Writing - Original Draft. **Qiuping Li:** Data Curation, Writing - Review & Editing, Supervision. All authors read the final draft of this manuscript and approve its submission for publication.

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Declaration of competing interest

None declared.

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