Review

Supportive Care Interventions for People With Cancer Assisted by Digital Technology: Systematic Review

Michael Marthick[1], PhD; Deborah McGregor[2], MHS; Jennifer Alison[3,4], PhD; Birinder Cheema[5], PhD; Haryana Dhillon[6], PhD; Tim Shaw[1], PhD

[1]Research in Implementation Science and eHealth Group, Faculty of Medicine and Health, University of Sydney, Camperdown, Australia

[2]Faculty of Science, Medicine and Health, University of Wollongong, Wollongong, Australia

[3]Faculty of Medicine and Health, University of Sydney, Sydney, Australia

[4]Sydney Local Health District, Sydney, Australia

[5]School of Health Sciences, Western Sydney University, Penrith, Australia

[6]Centre for Medical Psychology & Evidence-based Decision-making, School of Psychology, University of Sydney, Sydney, Australia

Corresponding Author:
Michael Marthick, PhD
Research in Implementation Science and eHealth Group
Faculty of Medicine and Health
University of Sydney
Charles Perkins Centre
John Hopkins Dr
Camperdown, 2006
Australia
Phone: 61 (02) 9351 2222
Email: mmar7320@uni.sydney.edu.au

Abstract

Background: Although relatively new, digital health interventions are demonstrating rapid growth because of their ability to facilitate access and overcome issues of location, time, health status, and most recently, the impact of a major pandemic. With the increased uptake of digital technologies, digital health has the potential to improve the provision of supportive cancer care.

Objective: This systematic review aims to evaluate digital health interventions for supportive cancer care.

Methods: Published literature between 2000 and 2020 was systematically searched in MEDLINE, PubMed, Embase, PsycINFO, Cochrane Central Register of Controlled Trials, and Scopus. Eligible publications were randomized controlled trials of clinician-led digital health interventions to support adult cancer patients. The interventions included were determined by applying a digital health conceptual model. Studies were appraised for quality using the revised Cochrane risk of bias tool.

Results: Twenty randomized controlled trials met the inclusion criteria for the analysis. Interventions varied by duration, frequency, degree of technology use, and applied outcome measures. Interventions targeting a single tumor stream, predominantly breast cancer, and studies involving the implementation of remote symptom monitoring have dominated the results. In most studies, digital intervention resulted in significant positive outcomes in patient-reported symptoms, levels of fatigue and pain, health-related quality of life, functional capacity, and depression levels compared with the control.

Conclusions: Digital health interventions are helpful and effective for supportive care of patients with cancer. There is a need for high-quality research. Future endeavors could focus on the use of valid, standardized outcome measures, maintenance of methodological rigor, and strategies to improve patient and health professional engagement in the design and delivery of supportive digital health interventions.

Trial Registration: PROSPERO CRD42020149730; https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=149730

(J Med Internet Res 2021;23(10):e24722) doi: 10.2196/24722

KEYWORDS

digital health; telehealth; eHealth; neoplasm; supportive care; systematic review; mobile phone

Introduction

Background

Approximately 18.1 million new cancer cases and 9.6 million cancer-related deaths occurred globally in 2018 [1]. The rising tide of cancer diagnoses in many developed countries has been attributed to both population aging and the increasing prevalence of primary risk factors, including physical inactivity, obesity, and metabolic disease [1,2]. As the cancer population continues to grow, there is an urgent need to improve supportive care services [2].

Supportive care focuses on assisting people with cancer and their families to cope with the disease and its treatment [3]. The management of cancer treatment-related symptoms and side effects and the maintenance of health-related quality of life from early diagnosis to end-of-life are key aims of supportive cancer care [3,4]. Supportive care interventions vary and may involve multidisciplinary team support, including doctors, nurses, pharmacists, and allied health professionals [5]. Recently, a shared follow-up approach between primary and secondary providers has been promoted to successfully meet increasing demands for survivorship care [6,7], as innovative methods for long-term cancer care are constantly needed [2].

There have been ongoing attempts to improve access to supportive care cancer services through the use of digital health technology [8]. Digital health interventions, with telemedicine as its oldest form dating back to the 1920s, have been increasing dramatically in recent years [9]. The terms *digital health* and *eHealth* are frequently used interchangeably, with numerous varied definitions. Eysenbach [10] defined eHealth as *an emerging field in the intersection of medical informatics, public health, and business, referring to health services and information delivered or enhanced through the internet and related technologies*. Elbert [11] and McLean et al [12] assert 3 key elements of digital health: (1) data obtained from the patient, (2) electronic transfer of data over a distance, and (3) patient-tailored feedback from a health care professional. Furthermore, a recent conceptual model proposed by Shaw et al [13] acknowledges the role of telehealth consultations, web-based forums, mobile devices and apps, and social media, in enabling real-time communication between health professionals and consumers.

Recent systematic reviews evaluating the impact of digital health interventions on health and health care costs provide promising evidence of effectiveness and cost-effectiveness [11,14]. Digital health has demonstrated potential in engaging people in their care [15], including as a tool for the treatment and self-management training of chronically ill patients [16,17]. Digital health interventions have been shown to be effective for managing cancer-related fatigue [18], may improve physical activity among cancer survivors [19], and can lead to positive effects addressing the supportive cancer care needs of individuals with different preferences and priorities [20]. Cancer survivors have been found to have a positive attitude toward digital health [21], suggesting that digital health interventions have the potential to overcome common challenges associated with access to supportive care in this population. Health professional-led, digital health–enabled, supportive care interventions may prove particularly useful in increasing accessibility of services to those with limited access because of location, health, time, and public health emergencies [22-30]. Despite the abundance of recent digital health literature, there remains an acknowledged lack of quality evidence regarding the effectiveness of supportive digital health care interventions for people with cancer [19,20,31-33].

Objective

Over the past several decades, studies have investigated the implementation and effects of digital health interventions in people with cancer. In previous systematic reviews evaluated in 2013, the design features of supportive digital health interventions for patients with cancer [20]; in 2014, the use of technology in cancer follow-up [31]; in 2015 and 2017, the effect of telehealth interventions in cancer survivors' general quality of life [32,34], and in 2020, the benefits and limits of digital health for optimal supportive care in oncology [35]. The last review by Aapro et al [35] conducted an article search up to November 2018 and focused on the technical features of digital technologies. This is a rapidly growing area of health care because of advances in information technology and the uptake of digital technologies by both health professionals and patients. Therefore, this systematic review aims to explore the effect of supportive care interventions assisted by digital technologies on the outcomes of patients with cancer.

Methods

Search Strategy

This systematic review was registered in the PROSPERO (International Prospective Register of Systematic Reviews) and PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [36]. A search was performed in August 2020, using the following web-based databases: MEDLINE (OvidSP, Wolters Kluwer), PubMed (National Center for Biotechnology Information, US National Library of Medicine), Embase (OvidSP, Wolters Kluwer), PsycINFO (American Psychological Association), Cochrane Central Register of Controlled Trials (John Wiley & Sons), and Scopus (SciVerse, Elsevier). Three main keywords were searched: *supportive care*, *digital health*, and *cancer patients*. Additional search terms were included based on synonyms of these keywords and medical subject headings. Multimedia Appendix 1 indicates the search strategy used.

Inclusion Criteria

The inclusion criteria were as follows: (1) studies in English describing a randomized controlled trial (RCT), published between January 2000 and August 2020; (2) intervention recipients were adults with a diagnosis of cancer; (3) involved clinician-led digital health interventions; and (4) interventions implemented to provide supportive cancer care.

The determination of digital health interventions was on the basis of the conceptual model of Shaw et al [13], which consists of 3 core domains:

1. Health in our hands: Using digital technologies to monitor, track, and inform health, for example, smartphones, tablets, clinical devices, mobile sensors and wearables, apps, social media, and web-based information.
2. Interacting for health: Using digital technologies to enable health communication among practitioners and between health professionals and clients or patients, for example, traditionally dominated by teleconferencing and videoconferencing, this domain increasingly includes a range of synchronous and asynchronous tools, such as SMS and push notifications from mobile apps, dedicated portals, social media platforms, and virtual or simulated therapy tools.
3. Data enabling health: Collecting, managing, and using digital health data, for example, technologies that provide expanded knowledge and insights about the health of an individual, community, or population.

To be included in the review, it was essential that the intervention satisfied the 2 domains *health in our hands* and *interacting for health*. The third domain, *data enabling health* was deemed nonessential because of the known inconsistent reporting of these criteria. The essential criterion *health in our hands* was captured in the *Intervention* column and outlines the nature of digital health experience. *Interacting for health* was captured in the *Interactions* column of review data and outlines the individuals involved in any form of communicative exchange that supports the health and well-being of the patient and caregiver.

Studies with interventions involving automated systems, such as interactive voice response and similar web-based systems, to monitor symptoms were included if the intervention featured an internet or web-based component and triggered health professional or researcher involvement when a threshold, such as a pain score, was reached.

Exclusion Criteria

Studies were excluded if they were (1) not RCTs; (2) reported only self-managed interventions, patient-to-patient interventions, prevention tools, or alternative treatments, or (3) focused solely on interventions involving telephone delivery that replicated a clinical service.

Data Extraction and Synthesis

Two reviewers (MM and DM) independently reviewed the titles and abstracts, followed by a full-text review of all publications. In cases of disagreement, a consensus was sought through discussion. Disagreement persisted for 4 studies; therefore, a third reviewer (TS) was consulted to adjudicate.

Endnote software (Clarivate Plc) [37] was used to manage references, and Covidence software (Veritas Health Innovation Ltd) was used to import and extract studies [38]. Two reviewers (MM and DM) independently applied the revised Cochrane risk of bias tool (The Cochrane Collaboration) [39] to establish the quality of the included studies. A matrix was developed by the authors and applied in the collection and analysis of structured data. Matrix criteria also included whether a study adhered to the CONSORT (Consolidated Standards of Reporting Trials) eHealth Checklist [40], a tool developed to improve the standard of reporting in digital health trials.

Quality Assessment

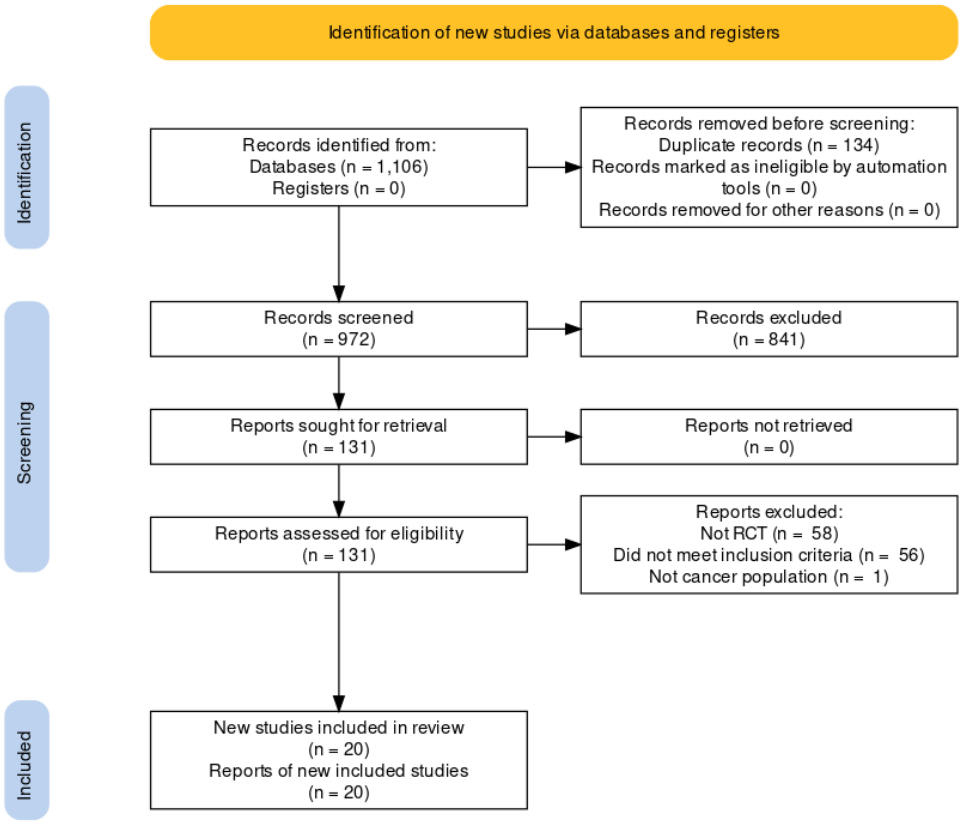
Using the revised Cochrane Collaboration's tool for assessing risk of bias (RoB) in randomized trials (Risk of Bias 2.0) [39], each study's methodological quality was assessed in 5 major domains: randomization process, deviation from intentional interventions, missing outcomes, measurement of outcomes, and selection of reported results. The RoB for each domain was rated as *some concerns*, *low*, or *high*. The overall RoB for each study was rated as *some concerns* or *high*.

Results

Study Selection

The initial search generated 972 records. After title and abstract review, 135 publications were retained. The full text for each of these 135 publications was reviewed for eligibility, resulting in the identification of 17 publications. Three additional studies were found using a reference search, generating a total of 20 digital health–enabled supportive cancer care interventions for inclusion in the review (Figure 1).

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram of the search and study selection process. RCT: randomized controlled trial.



Study Characteristics

Population

Details of the study design and characteristics are given in Multimedia Appendix 2 [41-60]. Although the search was published in 2000, the earliest result identified was published in 2007, and the remaining included studies were published after 2009. A total of 20 studies were conducted across 8 countries [41-48], with 11 from the United States. The sample sizes ranged from 52 to 516 participants, with a median of 118.

Of the 20 included studies, 12 (60%) were designed for participants within a single tumor stream. Interventions for breast cancer were dominant, with a total of 9 studies [43,46-53]. A total of 2 studies identified were for lung cancer [54,55]. Of those targeting multiple tumor types, 1 recruited participants with breast or prostate cancer [45], and 1 recruited participants with lung, breast, or colorectal cancer [44]. The remaining 8 studies included several tumor types, such as participants living with any type or stage of cancer [42,56-58] or those with solid tumors attending ambulatory oncology clinics for chemotherapy [59,60].

Intervention Design and Features

The duration of interventions ranged from 4 weeks to 12 months, with a variable frequency of clinician-patient interactions ranging from biweekly to every 3 months. There were 5 studies involving the use of a web-based portal or web-based experience [45,46,48,55,57]; 8 studies included the use of a telephone or smartphone [43,44,47,52-54,59,60]; 2 studies used a combination of web-based and telephone interactions [51,58]; 2 studies used social media networks or social networks [51,55]; and 4 studies used wearable activity trackers [42,51-53]. Multidisciplinary care was identified in 30% (6/20) of the publications [44,46,47,55,56,58]. The study by Børøsund et al [46] was nurse-led, with referrals to either physicians or social workers. Uni-disciplinary interactions dominated, with 5 nurse-led [45,48,50,56,60], 1 social worker-led [49], and 1 led with a medical specialist experienced in mindfulness program delivery [42]. Bruggeman-Everts et al [41] involved a psychologist or physiotherapist assigned to participants in different arms of the study. Steel et al [57] outlined a collaborative care intervention, whereby a care coordinator provided information to the patient's medical team, as well as patients and caregivers. The interventions included digital health tutoring, psychotherapy, nursing support, remote exercise or rehabilitation program delivery, and digital mindfulness.

Digital supportive care interventions included interactive voice response, tele and video counseling, internet-based patient-provider communication, exercise based on the internet, support systems, symptom monitoring, and self-management, mobile phone-based remote monitoring, and activity monitoring with tracking devices. The programs included digital health tutoring, psychotherapy, nursing support, remote exercise, rehabilitation program delivery, and digital mindfulness interventions. All varied in terms of design, features, and use of multimedia components. Only 2 publications referred to the CONSORT Digital Health Checklist [46,55].

RoB Assessment

With regard to the overall RoB, no included studies were rated as *low* overall RoB; instead, 8 had *some concerns*, and 12 were *high risk*. A summary of the RoB assessment can be found in Multimedia Appendix 3 [41-60], describing the methodological quality of each domain according to the Cochrane tool for assessing RoB in randomized trials (RoB 2.0). Figures 2 and 3 describe a graphical representation of the RoB assessments. Figure 2 includes studies in which an intention-to-treat analysis was performed, whereas Figure 3 contains studies with a per-protocol analysis.

Figure 2. Risk of bias in studies with intention-to-treat analysis.

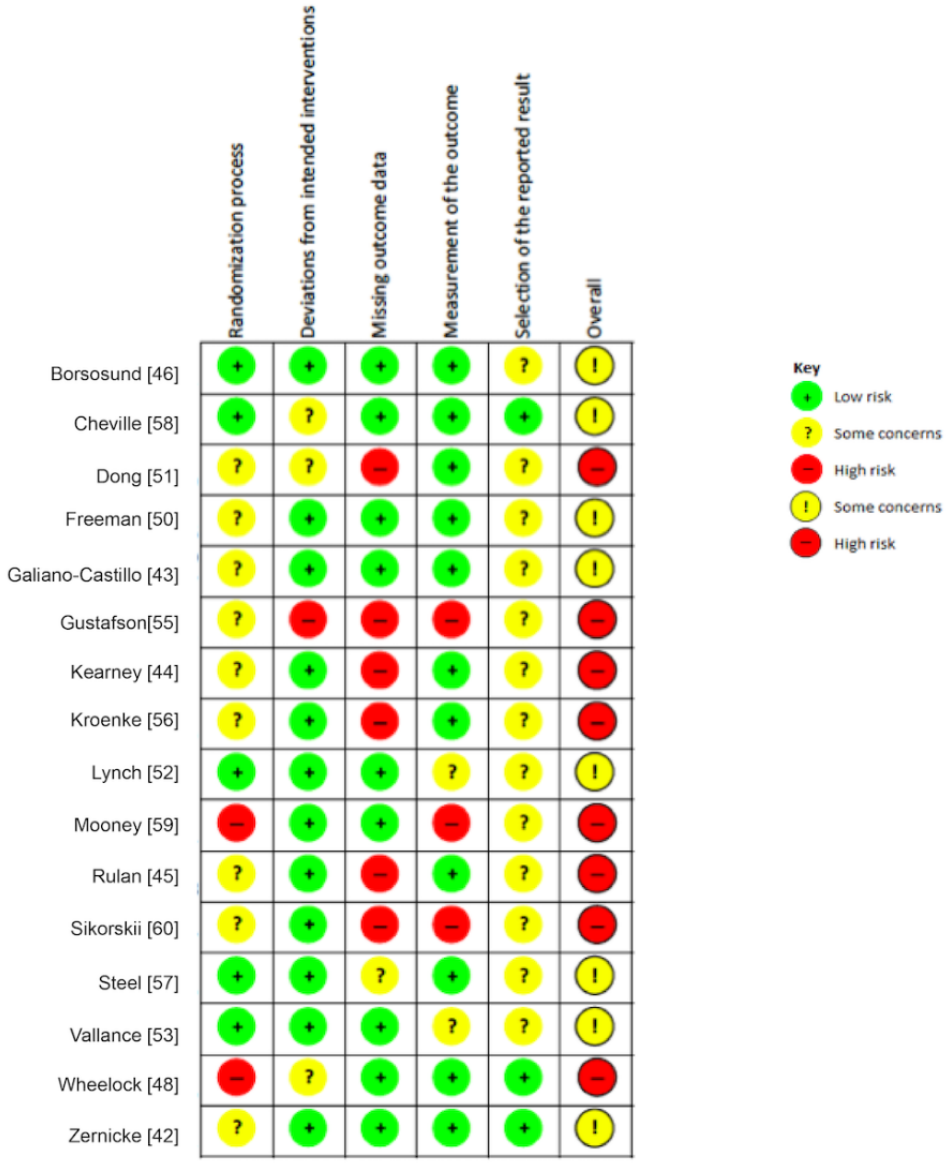
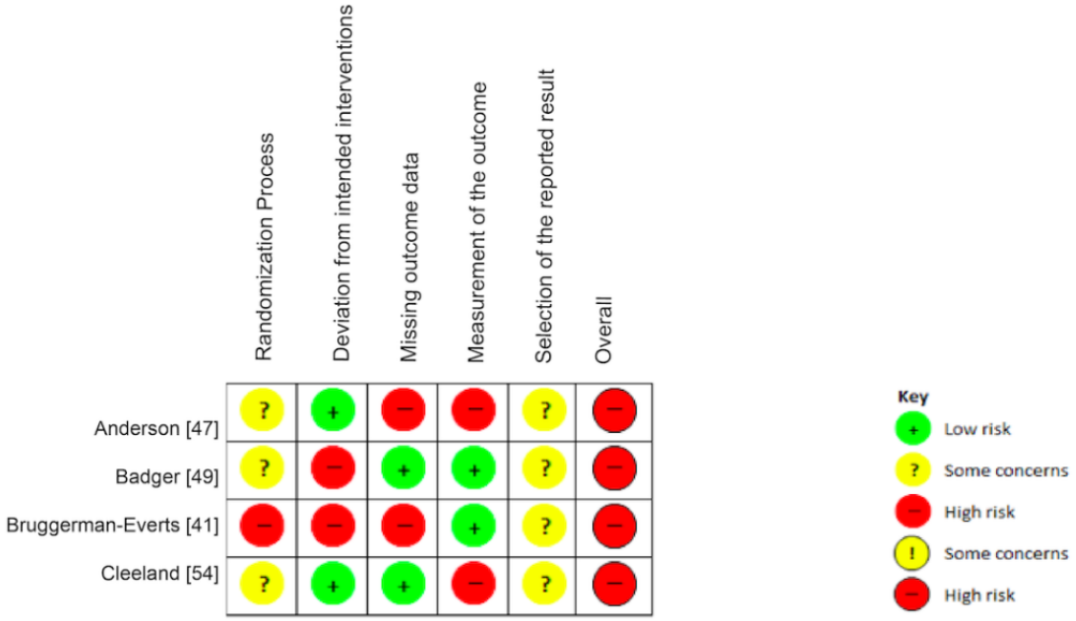


Figure 3. Risk of bias in studies with per-protocol analysis.



Intervention Outcomes

Overview

Interventions were analyzed according to the before-after test design, with most of the interventions including repeated measurement points. Although 20 studies were included, the interventions and outcomes were heterogeneous and did not enable meta-analyses. Outcomes were synthetized using a model for quality of life among cancer survivors developed by Ferrell and Dow [61,62]. The model encompasses dimensions of physical, psychological, social, and spiritual well-being, specifying the content for each dimension in the context of cancer survivors. Details of the intervention outcomes and statistically significant results are presented in Table 1.

Table 1. Intervention outcomes.

Author	Primary and secondary outcomes (grouped)	Measures	Results
Anderson et al [47]	• Pain • Sleep • Fatigue	• MDASI[a]	• Decreased pain severity from baseline to time point 1 (0.6 vs 2.3; *P*=.03; 95% CI 0.13 to 3.3) and from baseline to time point 2 (1.2 vs 3.5; *P*=.02; 95% CI 0.47 to 4.2) in the intervention group. • Improved reported sleep.
Badger et al [49]	• Depression • Symptom distress • Social well-being; spiritual well-being	• CES-D[b]; GSDS[c]; Social and spiritual; Well-being scales	• Depression, symptoms, and spiritual well-being improved in intervention groups (*P*=.01). No between-group differences. Social well-being improved for tele and video groups.
Børøsund et al [46]	• Symptom distress • Anxiety • Depression • Self-efficacy	• MSAS[d] • HADS[e] • CBI[f]	• WebChoice lower symptom distress (−0.16, 95% CI −.25 to −0.06; *P*=.001), anxiety (−0.79, 95% CI −1.49 to −0.09; *P*=.03), and depression (−0.79, 95% CI 1.18 to −0.05; *P*=.03) compared with control. • Internet-based communication group lower depression (−0.69, 95% CI −1.32 to −0.05; *P*=.03) compared with usual care. No change in symptom distress or anxiety.
Bruggeman-Everts et al [41]	• Fatigue severity • Mental health • Distress	• CIS-FS[g] • The positive and negative affect schedule • HADS	• Clinically changes in fatigue severity in 66% (41/62) of patients in home-based physiotherapist guided protocol (AAF[h]), 49% (27/55) of patients in web-based psychologist-guided intervention (eMBCT[i]), and 12% (6/50) of patients in psycho-education e-mails only.
Cheville et al [58]	• Functional capacity • Pain • HRQoL[j]	• AM-PAC[k] • BPI[l] • 5-item EQ-5D-3L	• Telerehabilitation by physical therapist-physician team (intervention group 1) improved function (difference, 1.3; 95% CI 0.08 to 2.35; *P*=.03) and quality of life (difference, 0.04; 95% CI 0.004 to 0.071; *P*=.01) compared with control. • Intervention groups 1 and 2 showed reduced pain interference and average intensity (intervention group 1, −0.4; 95% CI −0.78 to −0.07; *P*=.02; and intervention group 2, −0.5; 95% CI −0.84 to −0.11; *P*=.006).
Cleeland et al [54]	• Symptom threshold events • Cumulative distribution of symptom threshold events • Symptom severity	• MDASI	• Both groups had decreased symptom threshold events, control group reported more events at the end of the study period. For both groups together, the effect size of reduction in symptom severity was 0.72, effect size of 0.68 in the control group and 0.75 in the intervention group.

Author	Primary and secondary outcomes (grouped)	Measures	Results
Dong et al [51]	• HRQoL • Muscle strength • Cardiorespiratory capacity	• SF-36[m] • Stand-up or sit-down chair test and arm lifting test (30 seconds) • Modified Bruce treadmill protocol	• CEIBISMS[n] intervention showed improvements after 12 weeks in role-physical (P=.009), general health (P=.02), mental health (P=.01), vitality (P=.01) and health transition (P=.007). • In comparison with control group, differences in vitality (P=.009), mental health (P=.001), and health transition (P=.048).
Freeman et al [50]	• HRQoL • Functional capacity • Fatigue, sleep • Spiritual well-being	• SF-36 • FACT-B[o] • FACIT-F[p] and cog • FACT-Sp[q]	• Less fatigue (P=.002), cognitive dysfunction (P=.001), and sleep disturbance (P<.001) for both intervention groups compared with control. • No differences between live delivery and telemedicine delivery of therapy. • No group effect on overall quality of life; however, there was a time effect.
Galiano-Castillo et al [43]	• Functional capacity • Cognitive function	• 6-minute walk test • Trail making test • ACT[r]	• After intervention, the telerehabilitation group had significantly improved distances as well as percentage of predicted 6-minute walk test compared with the control group (P<.001).
Gustafson et al [55]	• Caregiver surveys reporting patient symptom distress	• Modified ESAS[s]	• Caregivers in the CHESS[t] arm consistently reported lower patient physical symptom distress than caregivers in the internet arm at 4 months (P=.03); and at 6 months (P=.004)
Kearney et al [44]	• 6 chemotherapy-related symptoms	• Common toxicity criteria adverse events chemotherapy symptom assessment scale	• Difference between groups in fatigue, higher in the control group (OR[u] 2.29, 95% CI 1.04 to 5.05; P=.04) and in hand-foot syndrome lower in control group (OR control or intervention 0.39, 95% CI 0.17 to 0.92; P=.03)
Kroenke et al [56]	• Depression • Pain severity	• HSCL-20[v] • BPI	• Improvements for the intervention group: >30% decrease in pain index (P<.001) and >50% decrease in the depression scale (P<.001). Effect size between-group differences at 3 months was 0.67 (95% CI 0.33 to 1.02) for pain and 0.42 (95% CI 0.16 to 0.69) for depression. • Intervention group had better outcomes for several HrQoL domains, including mental health, vitality, anxiety, and physical symptom burden.
Lynch [52][w]	• Vigorous physical activity (MVPA[x])	• Actigraph and activPAL accelerometers	• Between-group difference in MVPA at T2 (69 min/week; 95% CI 22 to 116); decreased total time of sitting 37 min/day (95% CI −72 to −2) and prolonged bouts of sitting 42 min/day (95% CI −83 to −2), favoring the intervention group
Vallance [53][w]			

Author	Primary and secondary outcomes (grouped)	Measures	Results
	• HRQoL • Fatigue	• FACT-B • FACIT-F	• Intervention group improvement in fatigue at T2 4.6 (95% CI 1.3 to 7.8). Within groups: intervention group, increase in fatigue at T2 5.1 (95% CI 2.0 to 8.2) and at T-3 3.3 (95% CI 0.1 to 6.41). No effects on HRQoL.
Mooney et al [59]	• Symptom severity • Distress	• Single item scale	• No significant difference between symptom severity or distress scores between groups.
Ruland et al [45]	• Symptom distress • Depression • Self-efficacy • HRQoL	• MSAS-SF[y] • Centre for Epidemiological Cancer Behavior Inventory Studies-Depression Scale 15 d	• Decreased distress on one subscale of MSAS. • Group differences on symptom distress were significant for the MSAS-SF (slope estimate, −0.052, 95% CI −0.101 to −0.004; t244=4.42; *P*=.04). There were no significant within- or between-group differences on the other MSAS-SF subscales.
Sikorskii et al [60]	• Symptom severity	• MDASI	• Decreased symptom severity across both intervention groups after 10 weeks. No between-group differences. Effect sizes were similar for NASM[z] (0.56) and ATSM[aa] (0.59)
Steel et al [57]	• Depression • Pain • Serum cytokine levels natural killer cell numbers	• CES-D • BPI • Functional assessment of cancer therapy–anemia, and hepatobiliary	• Reductions in pain (Cohen d=0.62), fatigue (Cohen d=0.26), depression (Cohen d=0.71), and significant changes in HRQoL with an effect size of Cohen d=0.99 at 6 months follow-up (*P*=.05) when compared with those in the enhanced usual care arm at 6 months.
Wheelock et al [48]	• Time between symptoms • Health care use	• Clinic visits • Health service use	• Did not meet primary objective, no difference in health service use
Zernicke et al [42]	• Feasibility • Mood • Stress • Posttraumatic growth inventory	• Monitoring interest, eligibility, and participation • Profile of mood states • CSOSI[ab]	• Significant improvements and moderate effect sizes in the web-based MBCR[ac] group relative to controls for mood disturbance (Cohen d=0.44; *P*=.049), stress (Cohen d=0.49; *P*=.02), spirituality (Cohen d=0.37; *P*=.04), and mindfully acting with awareness (Cohen d=0.50; *P*=.03).

[a]MDASI: MD Anderson symptom inventory.

[b]CES-D: Center for Epidemiological Studies-Depression.

[c]GSDS: General Sleep Disturbance Scale.

[d]MSAS: Memorial Symptom Assessment Scale.

[e]HADS: Hospital Anxiety And Depression Scale.

[f]CBI: Cancer Behavioral Inventory.

[g]CIS-FS: Checklist Individual Strength-Fatigue Severity.

[h]AAF: Ambulant Activity Feedback

[i]eMBCT: Web-based Mindfulness-Based Cognitive Therapy.

[j]HRQoL: health-related quality of life.

[k]AM-PAC: Activity Measure for Postacute Care.

[l]BPI: Brief Pain Inventory.

[m]SF-36: 36-item Short Form Health Survey.

[n]CEIBISMS: combined exercise intervention based on internet and social media software.

[o]FACT-B: Functional Assessment of Cancer Therapy–Breast.

[p]FACIT-F: Functional Assessment of Chronic Illness Therapy–Fatigue.

[q]FACT-Sp: Functional Assessment of Chronic Illness Therapy-Spiritual Well-Being.

[r]ACT: acceptance and commitment therapy.

[s]ESAS: Edmonton Symptom Assessment Score.

[t]CHESS: Comprehensive Health Enhancement Support System.

[u]OR: odds ratio.

[v]HSCL-20: Hopkins Symptom Checklist Depression Scale.

[w]Lynch [52] and Vallance [53] are 2 publications with different outcomes of the same randomized controlled trial.

[x]MVPA: moderate-to-vigorous intensity physical activity.

[y]MSAS-SF: Memorial Symptom Assessment Scale – Short Form

[z]NASM: nurse-assisted symptom management

[aa]ATSM: automated telephone symptom management

[ab]CSOSI: Calgary Symptoms of Stress Inventory.

[ac]MBCR: mindfulness-based cancer recovery.

Physical Well-being

Despite measuring similar outcomes, heterogeneous self-reported instruments were used across the studies. Control or reduction of symptoms and maintenance of function and independence comprise this domain. A total of 16 studies reported statistically significant changes in outcomes within the physical well-being domain [41,43-47,49,50,52-58,60]. Furthermore, 4 studies showed a significant reduction in pain [47,56-58], of which 3 used the Brief Pain Inventory [56-58]. Decreased fatigue was reported in 4 studies, favoring the intervention groups [41,44,50,53]. The most common outcome measure reported was clustered symptom changes, as referenced in 6 studies [45,46,49,54,55,60]. Finally, functional capacity-related outcomes were significant in 3 studies [43,52,58].

Health-Related Quality of Life

Health-related quality of life was the second most common domain, with significant improvements for the intervention group referenced in 4 studies [51,56-58].

Psychological Well-being

The most common outcome in this domain reporting significant improvements in the 4 interventions was depression [46,49,56,57]. Anxiety was reduced compared with the control group in one study [46], and significant improvements in mood disturbance were observed in one study [42].

Social and Spiritual Well-being

A single study reported a significant improvement in social well-being in the intervention group [49]. Badger et al [49] was also the only study that evaluated spiritual well-being changes, resulting in statistically significant improvements for the intervention group but no between-group differences.

Discussion

Principal Findings

Overview

In the studies integrated in this review, the interventions included digital health education, psychotherapy, nursing support, remote exercise, rehabilitation program delivery, and digital mindfulness interventions. All interventions satisfied the domains *health in our hands* and *interacting for health* of the digital health model by Shaw et al [13]. Digital supportive care interventions have been shown to improve cancer-related symptoms [45,46,49,54,55,60], pain [47,56-58], fatigue [41,44,50,53], health-related quality of life [51,56-58], functional capacity [43,52,58], and depression [46,49,56,57]. Only 2 RCTs included in this review did not report significant changes in one or more outcomes [48,59].

Digital Supportive Cancer Care Interventions

The digital interventions reviewed have been shown to be beneficial and independent of disease and demographic factors. This is similar to findings reported in other reviews [20,31,32,35,47,63] and meta-analyses [34]. In addition, the use of technology for cancer follow-up appears to be acceptable to patients, is clinically safe [31], and improves health knowledge and self-management practices [64]. However, such interventions vary in design and features, most lack or fail to report theoretical frameworks, and they use outcome measures making pooling or comparison between studies difficult. Another issue when comparing digital supportive care interventions is that it may be possible that interventions vary in their efficacy across different populations and technologies used for delivery. Furthermore, past studies have reported potential challenges impacting the implementation of digital health care, such as technical problems, lack of technology knowledge, and data security [65], which need to be considered when planning future studies. Recent systematic reviews concluded that a range of strategies should be implemented in digital supportive care [20,35,63] and general digital health interventions [66]. The study by O'Connor et al [66] recommends increasing public awareness of different

technologies and understanding of how they work, personalization of care, clinical accreditation of interventions, improving focus on health literacy, and safeguarding privacy of personal information as key areas for investigation. Key areas for digital supportive care design and implementation noted in previous cancer-related reviews that should be further explored are mechanisms for participant feedback to drive the co-design of digital interventions [20,67], the efficiency of delivering relevant and tailored health care information [65], and ways to integrate supportive care services at all stages of the cancer treatment pathway [35].

A supportive digital care intervention model should be underpinned by a theoretical framework that anticipates not only the outcomes and the tools to measure these, but also the process of achieving the outcomes from a particular intervention [20,63,68]. However, many studies do not address the validity of patient-reported health outcomes, and most of them use self-reported measures in pre-post test design, which leaves them at a RoB. This might be in part because one of the main challenges in the development of an evidence-based digital supportive cancer care intervention is the velocity of technology development in comparison with the often-long process of conducting and evaluating clinical trials.

Digital Health for Chronic Disease Care

Evidence from the research and implementation of digital health interventions across other disease groups may facilitate the transferability of digitally enabled supportive cancer care. Cancer is a chronic disease for many people [69]. Applications of research findings in other chronic diseases, such as cardiovascular disease [70], hypertension [12], and diabetes [71], which have a larger evidence base in digital health–enabled interventions with positive effects, should be used where possible. A recent systematic review [72] focused on the broader application of these symptom-reporting systems within multiple patient groups and concluded that although further research needs to be completed, most studies reported positive health outcomes. For example, in the case of diabetes, Greenwood et al [71] found that the most effective digital interventions incorporated all components of a technology-assisted self-management feedback loop, connected people with diabetes and their health care team using two-way communication, analyzed patient-generated health data, tailored education programs, and individualized feedback. A 2018 systematic review focused on using remote monitoring in people with a history of type 2 diabetes [73] significantly improved glycated hemoglobin and self-management. Evidence from diabetes research seems more cohesive, in part, because the outcomes of lowering glucose levels and glycated hemoglobin allow homogeneous measurement across studies.

Several successful digital health interventions focus on both behavior change and increasing patient engagement [74,75]. Barello [75] concluded that most studies failed to account for the complexity of patient engagement and that a more holistic approach might help maximize the potential of digital health technology [75]. Another recent review focused on mobile health apps for chronic disease management and found that regular symptom assessments, automated reminders, and feedback loops were common features, with most studies reporting significant improvement in health outcomes [73].

Current Challenges and Need for Quality Information

This review compiles evidence regarding the potential of digital health interventions for supportive cancer care in different settings, including remote areas and emergency situations [33]. However, the challenges facing public health systems worldwide in terms of emergencies, such as the COVID-19 pandemic, have rapidly increased the use of digital health interventions [29]. Health care systems, including cancer care, are adapting in response to the need for social distancing, lockdowns, and other public health initiatives. Cancer clinics have reduced clinical appointments, administration encounters, and postponed elective cancer surgeries [28], which has increased the need for follow-up and management without visiting hospitals [76]. This situation has advanced the use of digital health and telehealth apps and programs worldwide [30]. Digital supportive cancer care has been implemented out of necessity and is becoming a common delivery model [77]. Two of the suggested strategies to enable supportive cancer care during COVID-19 are (1) empowering patients and caregivers through the use of digital communication and (2) increasing the use of existing digital health platforms [28].

There is an urgent need to agree on relevant outcomes, methods of assessment, and there is a need for improved quality of primary studies and RCTs, as shown by our quality assessment. The lack of high-quality randomized trials identified in this review reflects the ongoing problem of low-quality research. Moreover, only 2 of the included publications referenced the CONSORT Digital Health Checklist, which was published in 2011. Only 3 included studies were published before 2011, making it disappointing that most later publications failed to reference this standard. Comments of Dickinson in BMC Cancer [31] remain relevant in 2020:

> *Nevertheless, there are surprisingly few randomized trials given the explosion in technological innovation in recent years. It could be that technology is evolving so fast that potential innovative technological interventions become outdated before they can mature sufficiently to be subjected to randomized trials.*

This insight has been recurrent in different systematic reviews [32,74].

Strengths and Limitations

Although the review was a rigorous evaluation of RCTs, there were a small number of included studies that indicated there may be significant literature in the phase I or II feasibility spectrum. Although 20 studies were included, the interventions and outcomes were heterogeneous and did not enable meta-analyses. Owing to the nature of this review, there was also a heterogeneous population, variable outcome measures, variable study quality, and methodological limitations. These characteristics have been found to contribute to a lack of evidence regarding the benefits of digital health [19]. It is difficult to draw conclusions and synthesize studies with inconsistent outcome measures, and a systematic approach to using standardized measures is required. The CONSORT Digital

Health Checklist should be used routinely. The review was limited to studies written in English. Therefore, it is possible that research papers published in other parts of the world were missed. As with many studies in oncology, this review found that breast cancer survivorship dominated. Thus, the development of supportive care interventions across other tumor streams is required. As most of the included studies were conducted in the United States and Europe, it is unclear whether the findings from these studies can be generalized to other countries and populations, particularly in developing nations.

Future Directions

Living well with cancer has gained greater relevance as the survival rates of many cancer types are increasing. The future of digital health in oncology supportive care brings a range of new and exciting possibilities. There is a need to evaluate the efficacy and efficiency of digital interventions in real-world conditions and standardize a core set of outcomes included in all studies to facilitate comparisons between interventions and digital technologies.

Conclusions

Digital health–enabled supportive cancer care is capable of improving health-related quality of life, symptom burden including self-report of pain and fatigue, depression, and, to a lesser extent, functional capacity. Supportive digital interventions in the field of cancer are being used and have been reported to be helpful for patients, independent of other factors. However, there is a need for higher quality research and clearer reporting than is evident in the current RCTs. Future research should focus on using valid, standardized outcome measures, increasing the methodological rigor of studies undertaken, and the development and evaluation of strategies to improve both patient and health professional engagement in the design and delivery of supportive digital health interventions.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Search strategy.
[DOCX File , 52 KB-Multimedia Appendix 1]

Multimedia Appendix 2

Population and intervention characteristics.
[DOCX File , 35 KB-Multimedia Appendix 2]

Multimedia Appendix 3

Summary of risk of bias assessment.
[DOCX File , 96 KB-Multimedia Appendix 3]

References

1. Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin 2018 Nov;68(6):394-424 [FREE Full text] [doi: 10.3322/caac.21492] [Medline: 30207593]
2. Bluethmann SM, Mariotto AB, Rowland JH. Anticipating the "Silver Tsunami": prevalence trajectories and comorbidity burden among older cancer survivors in the United States. Cancer Epidemiol Biomarkers Prev 2016 Jul;25(7):1029-1036 [FREE Full text] [doi: 10.1158/1055-9965.EPI-16-0133] [Medline: 27371756]
3. Hui D, De La Cruz M, Mori M, Parsons HA, Kwon JH, Torres-Vigil I, et al. Concepts and definitions for "supportive care," "best supportive care," "palliative care," and "hospice care" in the published literature, dictionaries, and textbooks. Support Care Cancer 2013 Mar;21(3):659-685 [FREE Full text] [doi: 10.1007/s00520-012-1564-y] [Medline: 22936493]
4. Basch E, Deal AM, Dueck AC, Scher HI, Kris MG, Hudis C, et al. Overall survival results of a trial assessing patient-reported outcomes for symptom monitoring during routine cancer treatment. J Am Med Assoc 2017 Jul 11;318(2):197-198 [FREE Full text] [doi: 10.1001/jama.2017.7156] [Medline: 28586821]
5. Olver IN. The importance of supportive care for patients with cancer. Med J Aust 2016 Jun 20;204(11):401-402. [doi: 10.5694/mja16.00279] [Medline: 27318394]
6. Rubin G, Berendsen A, Crawford SM, Dommett R, Earle C, Emery J, et al. The expanding role of primary care in cancer control. Lancet Oncol 2015 Sep;16(12):1231-1272. [doi: 10.1016/S1470-2045(15)00205-3] [Medline: 26431866]
7. Lisy K, Kent J, Piper A, Jefford M. Facilitators and barriers to shared primary and specialist cancer care: a systematic review. Support Care Cancer 2021 Jan;29(1):85-96. [doi: 10.1007/s00520-020-05624-5] [Medline: 32803729]
8. Nasi G, Cucciniello M, Guerrazzi C. The performance of mHealth in cancer supportive care: a research agenda. J Med Internet Res 2015 Feb 13;17(1):e9 [FREE Full text] [doi: 10.2196/jmir.3764] [Medline: 25720295]
9. Rooij TV, Marsh S. eHealth: past and future perspectives. Per Med 2016 Jan;13(1):57-70. [doi: 10.2217/pme.15.40] [Medline: 29749870]

10. Eysenbach G. What is e-health? J Med Internet Res 2001;3(2):E20 [FREE Full text] [doi: 10.2196/jmir.3.2.e20] [Medline: 11720962]
11. Elbert NJ, van Os-Medendorp H, van Renselaar W, Ekeland AG, van Roijen LH, Raat H, et al. Effectiveness and cost-effectiveness of ehealth interventions in somatic diseases: a systematic review of systematic reviews and meta-analyses. J Med Internet Res 2014 Apr 16;16(4):e110 [FREE Full text] [doi: 10.2196/jmir.2790] [Medline: 24739471]
12. McLean G, Band R, Saunderson K, Hanlon P, Murray E, Little P, DIPSS co-investigators. Digital interventions to promote self-management in adults with hypertension systematic review and meta-analysis. J Hypertens 2016 Apr;34(4):600-612 [FREE Full text] [doi: 10.1097/HJH.0000000000000859] [Medline: 26845284]
13. Shaw T, McGregor D, Brunner M, Keep M, Janssen A, Barnet S. What is eHealth (6)? Development of a conceptual model for eHealth: qualitative study with key informants. J Med Internet Res 2017 Oct 24;19(10):e324 [FREE Full text] [doi: 10.2196/jmir.8106] [Medline: 29066429]
14. Ekeland AG, Bowes A, Flottorp S. Effectiveness of telemedicine: a systematic review of reviews. Int J Med Inform 2010 Nov;79(11):736-771. [doi: 10.1016/j.ijmedinf.2010.08.006] [Medline: 20884286]
15. Zanaboni P, Ngangue P, Mbemba GI, Schopf TR, Bergmo TS, Gagnon M. Methods to evaluate the effects of internet-based digital health interventions for citizens: systematic review of reviews. J Med Internet Res 2018 Jun 07;20(6):e10202 [FREE Full text] [doi: 10.2196/10202] [Medline: 29880470]
16. Eland-de Kok P, van Os-Medendorp H, Vergouwe-Meijer A, Bruijnzeel-Koomen C, Ros W. A systematic review of the effects of e-health on chronically ill patients. J Clin Nurs 2011 Nov;20(21-22):2997-3010. [doi: 10.1111/j.1365-2702.2011.03743.x] [Medline: 21707807]
17. Kuijpers W, Groen WG, Aaronson NK, van Harten WH. A systematic review of web-based interventions for patient empowerment and physical activity in chronic diseases: relevance for cancer survivors. J Med Internet Res 2013 Feb 20;15(2):e37 [FREE Full text] [doi: 10.2196/jmir.2281] [Medline: 23425685]
18. Seiler A, Klaas V, Tröster G, Fagundes CP. eHealth and mHealth interventions in the treatment of fatigued cancer survivors: a systematic review and meta-analysis. Psychooncology 2017 Sep;26(9):1239-1253. [doi: 10.1002/pon.4489] [Medline: 28665554]
19. Roberts AL, Fisher A, Smith L, Heinrich M, Potts HW. Digital health behaviour change interventions targeting physical activity and diet in cancer survivors: a systematic review and meta-analysis. J Cancer Surviv 2017 Dec;11(6):704-719 [FREE Full text] [doi: 10.1007/s11764-017-0632-1] [Medline: 28779220]
20. Ventura F, Ohlén J, Koinberg I. An integrative review of supportive e-health programs in cancer care. Eur J Oncol Nurs 2013 Aug;17(4):498-507. [doi: 10.1016/j.ejon.2012.10.007] [Medline: 23158437]
21. Jansen F, van Uden-Kraan CF, van Zwieten V, Witte BI, Verdonck-de Leeuw IM. Cancer survivors' perceived need for supportive care and their attitude towards self-management and eHealth. Support Care Cancer 2015 Jun;23(6):1679-1688. [doi: 10.1007/s00520-014-2514-7] [Medline: 25424520]
22. Butow PN, Phillips F, Schweder J, White K, Underhill C, Goldstein D, Clinical Oncological Society of Australia. Psychosocial well-being and supportive care needs of cancer patients living in urban and rural/regional areas: a systematic review. Support Care Cancer 2012 Jan;20(1):1-22. [doi: 10.1007/s00520-011-1270-1] [Medline: 21956760]
23. Bender JL, Wiljer D, To MJ, Bedard PL, Chung P, Jewett MA, et al. Testicular cancer survivors' supportive care needs and use of online support: a cross-sectional survey. Support Care Cancer 2012 Nov;20(11):2737-2746. [doi: 10.1007/s00520-012-1395-x] [Medline: 22382589]
24. Aaronson NK, Mattioli V, Minton O, Weis J, Johansen C, Dalton SO, et al. Beyond treatment - psychosocial and behavioural issues in cancer survivorship research and practice. EJC Suppl 2014 Jun;12(1):54-64 [FREE Full text] [doi: 10.1016/j.ejcsup.2014.03.005] [Medline: 26217166]
25. Mehnert A. Employment and work-related issues in cancer survivors. Crit Rev Oncol Hematol 2011 Feb;77(2):109-130. [doi: 10.1016/j.critrevonc.2010.01.004] [Medline: 20117019]
26. Lubberding S, van Uden-Kraan CF, Te Velde EA, Cuijpers P, Leemans CR, Verdonck-de Leeuw IM. Improving access to supportive cancer care through an eHealth application: a qualitative needs assessment among cancer survivors. J Clin Nurs 2015 May;24(9-10):1367-1379. [doi: 10.1111/jocn.12753] [Medline: 25677218]
27. Fagherazzi G, Goetzinger C, Rashid MA, Aguayo GA, Huiart L. Digital health strategies to fight COVID-19 worldwide: challenges, recommendations, and a call for papers. J Med Internet Res 2020 Jun 16;22(6):e19284 [FREE Full text] [doi: 10.2196/19284] [Medline: 32501804]
28. Salako O, Okunade K, Allsop M, Habeebu M, Toye M, Oluyede G, et al. Upheaval in cancer care during the COVID-19 outbreak. Ecancermedicalscience 2020 Apr 1;14:ed97 [FREE Full text] [doi: 10.3332/ecancer.2020.ed97] [Medline: 32269597]
29. Spicer J, Chamberlain C, Papa S. Provision of cancer care during the COVID-19 pandemic. Nat Rev Clin Oncol 2020 Jun;17(6):329-331 [FREE Full text] [doi: 10.1038/s41571-020-0370-6] [Medline: 32296166]
30. Young AM, Ashbury FD, Schapira L, Scotté F, Ripamonti CI, Olver IN. Uncertainty upon uncertainty: supportive Care for Cancer and COVID-19. Support Care Cancer 2020 Sep;28(9):4001-4004 [FREE Full text] [doi: 10.1007/s00520-020-05604-9] [Medline: 32613372]

31. Dickinson R, Hall S, Sinclair JE, Bond C, Murchie P. Using technology to deliver cancer follow-up: a systematic review. BMC Cancer 2014 May 03;14:311 [FREE Full text] [doi: 10.1186/1471-2407-14-311] [Medline: 24885758]
32. Agboola SO, Ju W, Elfiky A, Kvedar JC, Jethwani K. The effect of technology-based interventions on pain, depression, and quality of life in patients with cancer: a systematic review of randomized controlled trials. J Med Internet Res 2015 Mar 13;17(3):e65 [FREE Full text] [doi: 10.2196/jmir.4009] [Medline: 25793945]
33. Srivastava S, Pant M, Abraham A, Agrawal N. The technological growth in eHealth services. Comput Math Methods Med 2015;2015:894171 [FREE Full text] [doi: 10.1155/2015/894171] [Medline: 26146515]
34. Larson JL, Rosen AB, Wilson FA. The effect of telehealth interventions on quality of life of cancer patients: a systematic review and meta-analysis. Telemed J E Health 2018 Jun;24(6):397-405. [doi: 10.1089/tmj.2017.0112] [Medline: 29112484]
35. Aapro M, Bossi P, Dasari A, Fallowfield L, Gascón P, Geller M, et al. Digital health for optimal supportive care in oncology: benefits, limits, and future perspectives. Support Care Cancer 2020 Oct;28(10):4589-4612 [FREE Full text] [doi: 10.1007/s00520-020-05539-1] [Medline: 32533435]
36. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med 2009 Jul 21;6(7):e1000097 [FREE Full text] [doi: 10.1371/journal.pmed.1000097] [Medline: 19621072]
37. EndNote homepage. EndNote. URL: https://endnote.com/ [accessed 2021-10-05]
38. Better systematic review management. Covidence. URL: https://www.covidence.org/ [accessed 2021-10-05]
39. Sterne JA, Savović J, Page MJ, Elbers RG, Blencowe NS, Boutron I, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. Br Med J 2019 Aug 28;366:l4898. [doi: 10.1136/bmj.l4898] [Medline: 31462531]
40. Eysenbach G, CONSORT-EHEALTH Group. CONSORT-EHEALTH: improving and standardizing evaluation reports of web-based and mobile health interventions. J Med Internet Res 2011 Dec 31;13(4):e126 [FREE Full text] [doi: 10.2196/jmir.1923] [Medline: 22209829]
41. Bruggeman-Everts FZ, Wolvers MD, van de Schoot R, Vollenbroek-Hutten MM, Van der Lee ML. Effectiveness of two web-based interventions for chronic cancer-related fatigue compared to an active control condition: results of the "Fitter na kanker" randomized controlled trial. J Med Internet Res 2017 Oct 19;19(10):e336 [FREE Full text] [doi: 10.2196/jmir.7180] [Medline: 29051138]
42. Zernicke KA, Campbell TS, Speca M, McCabe-Ruff K, Flowers S, Carlson LE. A randomized wait-list controlled trial of feasibility and efficacy of an online mindfulness-based cancer recovery program: the eTherapy for cancer applying mindfulness trial. Psychosom Med 2014 May;76(4):257-267. [doi: 10.1097/PSY.0000000000000053] [Medline: 24804884]
43. Galiano-Castillo N, Arroyo-Morales M, Lozano-Lozano M, Fernández-Lao C, Martín-Martín L, Del-Moral-Ávila R, et al. Effect of an internet-based telehealth system on functional capacity and cognition in breast cancer survivors: a secondary analysis of a randomized controlled trial. Support Care Cancer 2017 Nov;25(11):3551-3559. [doi: 10.1007/s00520-017-3782-9] [Medline: 28639097]
44. Kearney N, McCann L, Norrie J, Taylor L, Gray P, McGee-Lennon M, et al. Evaluation of a mobile phone-based, advanced symptom management system (ASyMS) in the management of chemotherapy-related toxicity. Support Care Cancer 2009 Apr;17(4):437-444. [doi: 10.1007/s00520-008-0515-0] [Medline: 18953579]
45. Ruland CM, Andersen T, Jeneson A, Moore S, Grimsbø GH, Børøsund E, et al. Effects of an internet support system to assist cancer patients in reducing symptom distress: a randomized controlled trial. Cancer Nurs 2013;36(1):6-17. [doi: 10.1097/NCC.0b013e31824d90d4] [Medline: 22495503]
46. Børøsund E, Cvancarova M, Moore SM, Ekstedt M, Ruland CM. Comparing effects in regular practice of e-communication and web-based self-management support among breast cancer patients: preliminary results from a randomized controlled trial. J Med Internet Res 2014 Dec 18;16(12):e295 [FREE Full text] [doi: 10.2196/jmir.3348] [Medline: 25525672]
47. Anderson KO, Palos GR, Mendoza TR, Cleeland CS, Liao K, Fisch MJ, et al. Automated pain intervention for underserved minority women with breast cancer. Cancer 2015 Jun 01;121(11):1882-1890 [FREE Full text] [doi: 10.1002/cncr.29204] [Medline: 25711974]
48. Wheelock AE, Bock MA, Martin EL, Hwang J, Ernest ML, Rugo HS, et al. SIS.NET: a randomized controlled trial evaluating a web-based system for symptom management after treatment of breast cancer. Cancer 2015 Mar 15;121(6):893-899 [FREE Full text] [doi: 10.1002/cncr.29088] [Medline: 25469673]
49. Badger T, Segrin C, Pasvogel A, Lopez AM. The effect of psychosocial interventions delivered by telephone and videophone on quality of life in early-stage breast cancer survivors and their supportive partners. J Telemed Telecare 2013 Jul;19(5):260-265. [doi: 10.1177/1357633X13492289] [Medline: 24163235]
50. Freeman LW, White R, Ratcliff CG, Sutton S, Stewart M, Palmer JL, et al. A randomized trial comparing live and telemedicine deliveries of an imagery-based behavioral intervention for breast cancer survivors: reducing symptoms and barriers to care. Psychooncology 2015 Aug;24(8):910-918 [FREE Full text] [doi: 10.1002/pon.3656] [Medline: 25146413]
51. Dong X, Yi X, Gao D, Gao Z, Huang S, Chao M, et al. The effects of the combined exercise intervention based on internet and social media software (CEIBISMS) on quality of life, muscle strength and cardiorespiratory capacity in Chinese postoperative breast cancer patients:a randomized controlled trial. Health Qual Life Outcomes 2019 Jun 26;17(1):109 [FREE Full text] [doi: 10.1186/s12955-019-1183-0] [Medline: 31242926]

52. Lynch BM, Nguyen NH, Moore MM, Reeves MM, Rosenberg DE, Boyle T, et al. A randomized controlled trial of a wearable technology-based intervention for increasing moderate to vigorous physical activity and reducing sedentary behavior in breast cancer survivors: the ACTIVATE Trial. Cancer 2019 Aug 15;125(16):2846-2855 [FREE Full text] [doi: 10.1002/cncr.32143] [Medline: 31012970]
53. Vallance JK, Nguyen NH, Moore MM, Reeves MM, Rosenberg DE, Boyle T, et al. Effects of the ACTIVity And TEchnology (ACTIVATE) intervention on health-related quality of life and fatigue outcomes in breast cancer survivors. Psychooncology 2020 Jan;29(1):204-211. [doi: 10.1002/pon.5298] [Medline: 31763746]
54. Cleeland CS, Wang XS, Shi Q, Mendoza TR, Wright SL, Berry MD, et al. Automated symptom alerts reduce postoperative symptom severity after cancer surgery: a randomized controlled clinical trial. J Clin Oncol 2011 Mar 10;29(8):994-1000 [FREE Full text] [doi: 10.1200/JCO.2010.29.8315] [Medline: 21282546]
55. Gustafson DH, DuBenske LL, Namkoong K, Hawkins R, Chih M, Atwood AK, et al. An eHealth system supporting palliative care for patients with non-small cell lung cancer: a randomized trial. Cancer 2013 May 01;119(9):1744-1751 [FREE Full text] [doi: 10.1002/cncr.27939] [Medline: 23355273]
56. Kroenke K, Theobald D, Wu J, Norton K, Morrison G, Carpenter J, et al. Effect of telecare management on pain and depression in patients with cancer: a randomized trial. J Am Med Assoc 2010 Jul 14;304(2):163-171 [FREE Full text] [doi: 10.1001/jama.2010.944] [Medline: 20628129]
57. Steel JL, Geller DA, Kim KH, Butterfield LH, Spring M, Grady J, et al. Web-based collaborative care intervention to manage cancer-related symptoms in the palliative care setting. Cancer 2016 Apr 15;122(8):1270-1282 [FREE Full text] [doi: 10.1002/cncr.29906] [Medline: 26970434]
58. Cheville AL, Moynihan T, Herrin J, Loprinzi C, Kroenke K. Effect of collaborative telerehabilitation on functional impairment and pain among patients with advanced-stage cancer: a randomized clinical trial. JAMA Oncol 2019 May 01;5(5):644-652 [FREE Full text] [doi: 10.1001/jamaoncol.2019.0011] [Medline: 30946436]
59. Mooney KH, Beck SL, Friedman RH, Farzanfar R, Wong B. Automated monitoring of symptoms during ambulatory chemotherapy and oncology providers' use of the information: a randomized controlled clinical trial. Support Care Cancer 2014 Sep;22(9):2343-2350 [FREE Full text] [doi: 10.1007/s00520-014-2216-1] [Medline: 24687538]
60. Sikorskii A, Given CW, Given B, Jeon S, Decker V, Decker D, et al. Symptom management for cancer patients: a trial comparing two multimodal interventions. J Pain Symptom Manage 2007 Sep;34(3):253-264 [FREE Full text] [doi: 10.1016/j.jpainsymman.2006.11.018] [Medline: 17618080]
61. Ferrell BR, Dow KH, Grant M. Measurement of the quality of life in cancer survivors. Qual Life Res 1995 Dec;4(6):523-531. [doi: 10.1007/BF00634747] [Medline: 8556012]
62. Ferrell BR, Dow KH. Quality of life among long-term cancer survivors. Oncology (Williston Park) 1997 Apr;11(4):565-8, 571; discussion 572, 575. [Medline: 9130276]
63. Laakso E, Tandy J. Use of technology as an adjunct to improve health outcomes for survivors of cancer. Physical Ther Rev 2011;16(1):39-45. [doi: 10.1179/1743288x10y.0000000017]
64. Hamine S, Gerth-Guyette E, Faulx D, Green BB, Ginsburg AS. Impact of mHealth chronic disease management on treatment adherence and patient outcomes: a systematic review. J Med Internet Res 2015 Feb 24;17(2):e52 [FREE Full text] [doi: 10.2196/jmir.3951] [Medline: 25803266]
65. Alberts NM, Hadjistavropoulos HD, Dear BF, Titov N. Internet-delivered cognitive-behaviour therapy for recent cancer survivors: a feasibility trial. Psychooncology 2017 Jan;26(1):137-139. [doi: 10.1002/pon.4032] [Medline: 26555347]
66. O'Connor S, Hanlon P, O'Donnell CA, Garcia S, Glanville J, Mair FS. Understanding factors affecting patient and public engagement and recruitment to digital health interventions: a systematic review of qualitative studies. BMC Med Inform Decis Mak 2016 Sep 15;16(1):120 [FREE Full text] [doi: 10.1186/s12911-016-0359-3] [Medline: 27630020]
67. Leykin Y, Thekdi SM, Shumay DM, Muñoz RF, Riba M, Dunn LB. Internet interventions for improving psychological well-being in psycho-oncology: review and recommendations. Psychooncology 2012 Sep;21(9):1016-1025 [FREE Full text] [doi: 10.1002/pon.1993] [Medline: 21608075]
68. Pingree S, Hawkins R, Baker T, duBenske L, Roberts LJ, Gustafson DH. The value of theory for enhancing and understanding e-health interventions. Am J Prev Med 2010 Jan;38(1):103-109 [FREE Full text] [doi: 10.1016/j.amepre.2009.09.035] [Medline: 20117565]
69. Phillips JL, Currow DC. Cancer as a chronic disease. Collegian 2010;17(2):47-50. [doi: 10.1016/j.colegn.2010.04.007] [Medline: 20738055]
70. Dale L, Dobson R, Whittaker R, Maddison R. The effectiveness of mobile-health behaviour change interventions for cardiovascular disease self-management: a systematic review. Eur J Prev Cardiol 2016 May;23(8):801-817. [doi: 10.1177/2047487315613462] [Medline: 26490093]
71. Greenwood DA, Gee PM, Fatkin KJ, Peeples M. A systematic review of reviews evaluating technology-enabled diabetes self-management education and support. J Diabetes Sci Technol 2017 Sep;11(5):1015-1027 [FREE Full text] [doi: 10.1177/1932296817713506] [Medline: 28560898]
72. Lee PA, Greenfield G, Pappas Y. The impact of telehealth remote patient monitoring on glycemic control in type 2 diabetes: a systematic review and meta-analysis of systematic reviews of randomised controlled trials. BMC Health Serv Res 2018 Jun 26;18(1):495 [FREE Full text] [doi: 10.1186/s12913-018-3274-8] [Medline: 29940936]

73. Lee J, Choi M, Lee SA, Jiang N. Effective behavioral intervention strategies using mobile health applications for chronic disease management: a systematic review. BMC Med Inform Decis Mak 2018 Feb 20;18(1):12 [FREE Full text] [doi: 10.1186/s12911-018-0591-0] [Medline: 29458358]
74. Brigden A, Anderson E, Linney C, Morris R, Parslow R, Serafimova T, et al. Digital behavior change interventions for younger children with chronic health conditions: systematic review. J Med Internet Res 2020 Jul 31;22(7):e16924 [FREE Full text] [doi: 10.2196/16924] [Medline: 32735227]
75. Barello S, Triberti S, Graffigna G, Libreri C, Serino S, Hibbard J, et al. eHealth for patient engagement: a systematic review. Front Psychol 2016 Jan 8;6:2013 [FREE Full text] [doi: 10.3389/fpsyg.2015.02013] [Medline: 26779108]
76. Hanna TP, Evans GA, Booth CM. Cancer, COVID-19 and the precautionary principle: prioritizing treatment during a global pandemic. Nat Rev Clin Oncol 2020 May;17(5):268-270 [FREE Full text] [doi: 10.1038/s41571-020-0362-6] [Medline: 32242095]
77. Chan A, Ashbury F, Fitch MI, Koczwara B, Chan RJ, MASCC Survivorship Study Group. Cancer survivorship care during COVID-19-perspectives and recommendations from the MASCC survivorship study group. Support Care Cancer 2020 Aug;28(8):3485-3488 [FREE Full text] [doi: 10.1007/s00520-020-05544-4] [Medline: 32451702]

Abbreviations

CONSORT: Consolidated Standards of Reporting Trials
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PROSPERO: International Prospective Register of Systematic Reviews
RCT: randomized controlled trial
RoB: risk of bias

Edited by R Kukafka, G Eysenbach; submitted 02.10.20; peer-reviewed by N Wreglesworth; comments to author 30.10.20; revised version received 01.11.20; accepted 20.09.21; published 29.10.21

Please cite as:
Marthick M, McGregor D, Alison J, Cheema B, Dhillon H, Shaw T
Supportive Care Interventions for People With Cancer Assisted by Digital Technology: Systematic Review
J Med Internet Res 2021;23(10):e24722
URL: https://www.jmir.org/2021/10/e24722
doi: 10.2196/24722
PMID: