Sys Rev Pharm 2020;11(9):725-744
A multifaceted review journal in the field of pharmacy

mHealth Interventions for Cancer Care and Support A Systematic Literature Review

Samar Zuhair Alshawwa*[1], Rasha Assad Assiri[2]
[1]Department of Pharmaceutical Sciences, College of Pharmacy, Princess Nourah bint Abdulrahman University, Alriyadh, Saudi Arabia samarzuhair@yahoo.com
[2]Department of Basic Science, College of Medicine, Princess Nourah bint Abdulrahman University, Saudi Arabia, Riyadh raassiri@pnu.edu.sa

Corresponding Author: Samar Zuhair Alshawwa
Email: samarzuhair@yahoo.com

ABSTRACT

Background: Mobile health (mHealth) interventions for improving quality of life (QoL) are rising, particularly those related to promoting prevention, improving screening, managing care and supporting cancer patients and survivors. Though there is a clear surge in the mHealth interventions for cancer patients, yet the related research findings are fragmented. There is an urgent need to amalgamate the extant learnings, particularly those related to the review the effect of the mHealth interventions on awareness and screening of cancer.

Objective: The purpose of this study is to systematically review the available literature on mHealth interventions for different types of cancer patients and survivors with a view to synthesize the outcomes and impact for these interventions on the cancer disease management, right from awareness till survival.

Methods: The study followed systematic literature review (SLR) methodology wherein the peer-reviewed literature from Scopus and Web of Science databases were identified and analyzed. The SLR that involved study selection, data extraction, and data synthesis comprised of two stages, first, identifying the relevant mHealth interventions in context to cancer patients, and second, summarizing the outcomes and themes of the SLR followed a robust search protocol with clear inclusion and exclusion criteria, along with forward and backward searching of relevant records.

Results: A total of 57 publications (number of participants, n=112196) describing mHealth interventions for different types of cancer were identified. Of the 57 included studies, 23 (40%) were randomized controlled trials (RCTs), 21 (37%) were qualitative experimental, 5 (9%) pilot feasibility studies, 3 (5%) cross sectional surveys, 3 (5%) quasi-experimental and 2 (4%) sequential-mixed methods.

Most studies found that mHealth interventions have positive impact on cancer survivors and caregiver teams, as well as family members. Additionally, several RCTs suggest that mHealth provides person-centered care in clinical management settings for different types of cancer and improved survivorship care.

Conclusion: This SLR confirms the efficacy of mHealth interventions in cancer care and highlights the growth in number of studies exploring the implementation of mHealth interventions for cancer treatment and prevention. However, less conclusive data examining the impact of mHealth interventions on various psychological dimensions is available. The SLR findings suggest that mHealth interventions should be developed based on a theoretical approach and defined framework design. It would be useful if future studies carefully describe key elements of mHealth intervention used by cancer patients.

Keywords: Cancer care, cancer survivors, cancer management, mHealth interventions, patient's systematic literature review

Correspondence:
Samar Zuhair Alshawwa
Department of Pharmaceutical Sciences, College of Pharmacy, Princess Nourah bint Abdulrahman University, Alriyadh, Saudi Arabia
Email: samarzuhair@yahoo.com

INTRODUCTION

According to World Health Organization (WHO) [1], mobile devices are useful tools as they can support the practices related to medical and public health. In fact, mobile health (mHealth) intervention is one of the biggest technological breakthroughs, which is rapidly transforming the healthcare sector today. mHealth is defined as the use of mobile technology such as smartphone, tablets, and other handheld devices to deliver health care and preventive health services [1,2]. The mHealth apps involve the use of short message service (SMS), voice calls, social media, Internet and emails for health care interventions [2]. It offers various benefits such as access to clinical information, opportunities to collaborate with care teams, ease of communication with patients, real-time monitoring of patients, reduction in the cost of health, and remote healthcare services (referred to as telemedicine) [3,4]. Prior literature on mHealth suggests that it can be used for managing various diseases such as asthma, diabetes, HIV, various chronic disease, and even eating disorders [5].

In the recent past, it has been realized that diseases like cancer can also be managed through mHealth

interventions. Substantial progress made in the diagnosis and treatment of cancer has made it possible to apply care methods as other chronic diseases. Towards this end, scholars argue that self-management interventions can help patients and their families to manage care themselves [6]. With the result, during the past decade, mHealth apps have been utilized to support cancer patients and cancer survivors [7].

The key factor in implementing cancer screening using mHealth intervention is accuracy with complete recording and sharing of data on uptake and outcome of screening and treatment [8]. mHealth interventions are promising for improving education in cancer prevention and treatment. Example, Lung Cancer App (LuCApp) allows mobile phone-based remote monitoring system to know patients' symptoms and patient-reported outcome measures, and to share it with healthcare professionals during pharmacological therapies for lung cancer [9]. It is available on Play-store (Android online store) and iTunes (Apple online store) since April 2018 [6]. LuCApp has been pilot-tested with a number of oncologists, healthcare professionals and specialists [9]. Other examples are: (a) Optimal-Lymph-Flow mHealth intervention to manage chronic pain for breast cancer treated women [10]. In this app, the patients learn about self-care strategies and track their symptoms; (b) medication adherence apps based interventions that provide patients with information on the oral anti-cancer agents medication adherence [11].

With their proliferation, the literature on the use of mHealth in improving (QoL) in cancer patients is also growing [8]. A quick examination of this available literature suggests varied results, underscoring the need for systematic evaluation to present clear and actionable outcome for future research and practice. Thus, there is a need to undertake systematic review of literature (SLR) related to use of mHealth interventions for cancer disease management. Our comprehensive investigation further revealed that many SLRs have already been undertaken in the domain. For instance, there are five SLRs which have focused on mHealth interventions for supporting breast cancer patients only. One of these SLRs reviewed research on the use of eHealth for improving QoL in breast cancer patients, where it listed guidelines for future eHealth research and development [12]. Another SLR examined research that tested mobile apps for breast cancer care, and defined different mHealth apps focusing on survivorship with positive effects on weight loss, improving QoL and decreasing stress [13]. Other SLRs assessed mobile phone apps for QoL and well-being in breast and prostate cancer patients [14] and health care stakeholders [2].

In the context of other types of cancers, one SLR on skin cancer research shows how mHealth has established itself as a prominent part of dermatology for cancer screening [15]. Yet another SLR has assessed the research on the feasibility, usability and acceptability of technology-based interventions among care givers of people living with cancer [16]. Other SLRs in the domain include one on fatigued cancer survivors and the effect of mHealth intervention [17] and text messaging intervention on cancer[18].

The existing SLRs are a proof of the importance of mHealth intervention in cancer disease management. Given the importance, there is a need to address two gaps which still exist in the literature, first, the changes in technology are occurring at fast pace due to which prior literature reviews might not include the latest technological trends, and second, almost all the prior reviews spanning the years 2016 to 2019 have focused on specific type of cancer individually. In contrast, no attempts have been made to present a collective review of findings related to mHealth interventions for different types of cancer in one place. The current study proposes to address these two gaps in the literature by conducting a systematic review of the latest articles on mHealth interventions for all kinds of cancers.

The key objectives of this review are to: (i) identify the key components of existing mHealth interventions designed to support cancer patients and survivors, (ii) develop an understanding of which components are most valued by cancer patients and survivors, and (iii) consider evidence for effectiveness of mHealth interventions used to support different cancer patients and survivors. The findings of the SLR are expected to be useful for health care professionals, policy makers, patients and their families.

METHODS

The study was conducted in accordance with the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) which is a guideline to help authors prepare protocols for planned systematic reviews [19]. In addition to this, the methodological considerations suggested by the prior SLRs were also followed [18]. The SLR methodology spanned three sequential stages, namely, planning, executing and reporting the review.

PLANNING THE REVIEW

Setting the objectives

The key objective of this SLR is to systematically review the available literature on mHealth interventions for different types of cancer patients and survivors with a view to synthesize the outcomes and impact for these interventions on the cancer disease management, right from awareness till screening, prevention, as well as improving QoL in different types of cancer patients and survivors. The impact of mHealth interventions on different cancer types is proposed to be assessed by evaluating the primary outcomes in terms of cancer awareness, screening and prevention; impact on QoL, physical activity support, oral cancer therapy adherence, pain management and others in context to cancer patients and survivors [20]–[24].

Specifying the search procedure

The relevant studies were proposed to be searched in Scopus and Web of Science by utilizing a comprehensive search strategy to find the suitable studies and at the same time, reduce the possible bias. The search strategy was based on searching the title, abstract and keywords

using different combination of keywords such as "mHealth intervention " and "cancer", "m-Health intervention " and "cancer" and "mobile health intervention " and "cancer". The citation chaining comprising forward and backward citations of the selected studies was also proposed to be performed using Google Scholar. Relevant studies were proposed to be selected from all downloaded studies by applying a set of inclusion and exclusion criteria.

Inclusion and exclusion criteria

The inclusion criteria used are: first, include studies addressing mHealth interventions with focus on cancer patients and survivors, second, include studies based on empirical methodologies like randomized control trials (RCTs), quasi-experimental designs (pre-post studies), qualitative and quantitative studies, and third, include only full text articles published in peer reviewed international journals in English language.

The exclusion criteria are: first, exclude studies on mHealth interventions related to behavioral change, second, exclude systematic reviews, protocols, books, protocol sand conference articles, and third, exclude duplicate articles.

Executing the review

Scopus and Web of Science databases were systematically searched in August 2019 and the search was limited to publications after 2014, since the review specifically wanted to incorporate the latest developments instead of repeating the findings of the prior reviews in the domain. The search results from the databases were combined in single library and duplicate records were removed. The published studies on the mHealth intervention for different types of cancer were included in the first stage. The initial screening was based on titles and abstract and three researchers independently evaluated these abstracts. The publications were retrieved for full-text evaluation if the abstract did not provide the complete information. Subsequently, three investigators independently evaluated full-text articles and determined the eligibility of every manuscript. The authorship, journal, or years were not blinded. The Mendeley reference management software was utilized for managing the referencing of the selected studies. An overview of articles selection process is outlined in Figure 1.

A PRISMA flow diagram of literature search and articles selection process is shown in Figure 1. The database search identified 244 records. After excluding duplicates, 220 articles were screened. 101 Full text articles assisting for eligibility were reviewed. Out of these 44 studies were excluded for different reasons [12]–[14], [25]–[31]. The 57 remaining studies were considered in this systematic review.

Thereafter, three researchers conducted data extraction following the standardized criteria where they all used independent coding. The results were then reviewed by the team together. The following data were extracted: journal, publication year, databases searched, setting, theme, objective, intervention type, number of studies, total number and countries of patients, study design, whether a review of systematic reviews or meta-analysis was performed, outcomes, key findings, lessons and barriers for implementation, and main limitations.

Reporting the review

This stage involved reporting the profile of the studies selected for the review. Additionally, the findings of the studies were examined and presented in the form of broad themes. Finally, the review was used to provide recommendations for future research possibilities based on the open gaps in the extant literature.

Synthesis of Results

Due to substantial differences among studies; researchers performed narrative synthesis of findings, where data were managed using Microsoft excel. Information from multiple publications was pooled and most recent descriptions were used. Thematic analysis was used to categorize and group the studies. Researchers collected information for trial studies on mHealth interventions used in cancer, outcomes and results were recorded.

Research profiling

Of the 57 included studies, 3 studies (5%) were published in 2015, 12 studies (21%) were published in 2016, 10 studies (18%) were published in 2017, 13 studies (23%) were published in 2018 and 19 studies (33%) were published in 2019 (Figure 2). The included studies were conducted in 19 different countries, with 45% in the United States, 7% in Sweden, 5% in China and 3.6% studies in each of; Africa, Israel, Australia, Chile, Germany, Korea, Norway and Tanzania, and 1.8% studies in each of; Canada, Denmark, Edinburgh, Italy, Singapore, Spain, Switzerland and United Kingdom (Figure 3). Figure 4 illustrates the number of research studies published by various countries. Presentation of studies characteristics in terms of most productive authors is illustrated in Figure 5. Figures 6 and 7 represent the word cloud based on the keywords and titles of selected studies respectively.

The SLR included 57 articles, addressing 7 different cancer disease types interventions. Table 1 provides a detailed overview of mHealth interventions in each study. The researchers reported that, of the 57 included studies, 5 studies (9%) were about cervical cancer awareness, screening and management. A total of 17 (30%) mHealth interventions evaluated breast cancer awareness, prevention, early detection and care management. 5 studies (9%) addressed colorectal cancer screening, one study (2%) discussed dermatological cancer screening, 2 interventions (3%) focused on lung cancer health promotion, 4 studies (7%) each focused on pain management for children undergoing cancer treatment. 4 studies (7%) dealt with oral anti-cancer medication adherence and 19 studies (33%) studies focused on the impact of mHealth interventions on self-regulation for QoL for cancer patients and survivors.

Table 1 summarizes that 23 studies (40%) were randomized controlled trials (RCTs), 21 (37%) were qualitative experimental, 5 (9%) pilot feasibility studies, 3 (5%) cross sectional surveys, 3 (5%) quasi-experimental and 2 (4%) sequential-mixed methods.

Furthermore, sample sizes ranged from 6 to 50000, with many studies being RCTs. A problem with possible

selection, performance, or attrition bias was identified in many of the studies. Many studies had small sample size. Moreover, in some studies data collection was done by non-blinded members of the study team.

Control group was not clear in some studies [22], [23], but others were very specific, as the case in the study carried by Rosemary *et al* (2017) where participants in intervention group received The-Optimal_Lymph_Flow Web- and mobile based intervention; while participants in control group received the Web- and mobile-based Arm Precaution program [10].

Results: Thematic analysis

Theme 1: Type of Intervention

mHealth interventions were categorized by platform used to deliver the intervention. Of these 57 platforms, 30 (52%) were mobile apps, 20 (35%) were text messages interventions, 5 (10%) were phone interviews, 2 (3%) were multimedia messaging.

Some of the common mobile applications utilized for mHealth interventions are Breast Cancer e-Support Program (BCS) [31], Energy Balance on Cancer (BENECA) mHealth system [32], IntelliCare app [33] and Care Assistant application [34].

The most frequent intervention was use of mobile apps for screening, education, prevention and motivation. Other forms of mHealth interventions were transcribed phone interviews, SMS reminders, counseling phone calls, multimedia messaging intervention, improved medication adherence and promoted clinical management [3], [20], [35]. All interventions aimed to address the impact of implementing mHealth interventions to promote and treat different types of cancer diseases and improve QoL and health self-efficacy for cancer patients and survivors.

[3], [20], [35] studies concluded that mHealth intervention using text messaging are feasible in cancer patients prescribed oral anticancer agents to improve their medication adherence and promote self-management. Multiple interventions were used in a duration of follow-up period that varied from some days to few months.

One intervention provided support to meet parents social, emotional and care needs caring for their children with Acute lymphoblastic leukemia [36]. Four mHealth interventions inform about the implementation of best supportive care practice to enhance medication adherence in adult patients prescribed oral anti-cancer agent [11], [20], [35], [37]. Other two studies enhance pain management and improve QoL for adolescents and young adults (AYAs) who recently completed treatment for cancer [22], [38].

Theme 2: Effectiveness of interventions

Current evidences show benefits of mHealth interventions in management of cancer diseases, improving symptoms and QoL and wellbeing, improve attendance rate and enhance cancer therapy adherence [28]. Most popular mHealth intervention was behavior change using mobile app and next SMS text messaging to improve QoL. Lee et. al (2018) demonstrated the use of novel wearable technology "pedometer" which changes breast cancer patient exercise self-report to direct measurement using new technology [39]. Many studies addressing mHealth interventions tested the effectiveness of intervention to improve health self-efficacy of women suffering from breast cancer women's health self-efficacy [10], [32]–[34], [39]–[51]. Additionally, six more interventions were found to improve screening and management of clients with cervical cancer [8], [24], [52]–[55].

Theme 3: Outcome measures

Different outcome measures were utilized in the studies. For example, usability of the interventions, emphasizing self-regulation for QoL, improving healthy lifestyles, cancer screening, enhancing pain management, symptom relief, and improving oral cancer therapy adherence. Qualitative results mainly focused on usability of interventions, such as mobile text messages, platform and apps [8], [10], [24], [32]–[34], [39]–[55], cross-sectional surveys[11], [56], [57], phone interviews [48]–[49][58]–[59], and focus groups[60].

Theme 4: Outcomes

The primary outcomes assessed were behavioral or lifestyle changes (eg, physical activity promotion, mood, promote QoL, social and emotional support, weight management), clinical outcomes (e.g., cancer management, screening, body mass index [BMI], pain reduction, symptom relief), and process of care (e.g., cancer therapy adherence, counselling, attendance rate follow-up, person-centered care, survivorship care). Secondary outcomes were cost-effectiveness and patient satisfaction.

<u>Cervical Cancer outcomes</u>

The use of SMS mHealth intervention had improved the follow-up of clients with abnormal Pab smears[52]. Attendance at cervical cancer screening within 60 days of randomization was more likely with SMS intervention group participants than control group participants [24]. Use of cell phones and text messaging had improved cervical cancer screening [53]–[55].

<u>Breast Cancer outcomes</u>

Semi-structured phone interview interventions showed improvement in physical activities and QoL in breast cancer survivors [45], [48], [49]. Singleton et. al (2019) [47] assessed the cost-effective text messaging intervention in promoting health self-efficacy for women suffering from breast cancer . Breast, prostate and colorectal cancer survivors' recommended that physical activity (PA) apps should be integrated into cancer care [41], [42], [50]. Breast cancer survivors were very satisfied with mHealth app for exercise intervention where overall satisfaction score increased with age [39]. A lot of studies discussed how mHealth apps had supported breast cancer patients and survivors and their loved ones, and improved their QoL [32]–[34], [40], [46], [51]. Optimal-Lymph-Flow web mobile-based intervention had managed chronic pain for breast cancer treated women [10]. Hee *et al*. had promoted breast cancer screening by adopting a culturally tailored mobile app [43]–[44].

Lung Cancer outcomes

Lung Cancer App (LuCApp) developed by Ciani *et al*. (2019) demonstrated clinical support and cost-effectiveness for patients with metastatic lung cancer versus standard of care [6]. Furthermore, patients with non-small cell lung cancer used the newly developed mHealth pulmonary rehabilitation app which significantly improved their QoL[9], [61].

Skin Cancer outcomes

Mobile teledermatology for skin cancer screening resulted in higher specificity, accompanied by reduction of unnecessary further testing for skin cancer lesions [62].

Colorectal Cancer outcomes

Hagoel *et al* (2016) and Weaver *et al* (2015) had demonstrated that text-message reminders appear to be modestly effective in colorectal cancer screening with significant health promotion change [60][63]–[64] A self-reported mobile phone-based systems reinforced patients with colorectal cancer [58].

Theme 5 : Other Issues in Cancer Disease

Ali *et al*. [11] had conducted a study to evaluate patient's perception in using an app for oral anti-cancer medication adherence where majority of participants were interested in using that app. mHealth supportive care intervention "Android smartphone app "Care Assistant"" had met parents' social, emotional and care needs who are caring for their children with acute lymphoblastic leukemia [36]. Animated avatar-based tablet app, Pain buddy, developed using state-of-the-art software enhanced pain management and improve QoL for children who are cancer patients [23]. 26 adolescents and young adults (AYAs) recently completed cancer treatment, they applied Short Message Service (SMS) intervention which improved AYAs survivors of childhood cancer and decreased AYA survivors responsivity to text messages, higher engagement with prompt and personal messages was achieved [22], [38].

DISCUSSION

Our review provides up-to-date summary of the evidence of mHealth interventions targeting cancer disease management with comprehensive systematic search. This SLR provides evidence indicating that different types of mHealth interventions showed positive impact on cancer patients' disease management compared to traditional health interventions. Moreover, this is the first SLR that investigates mHealth interventions with regards to all kinds of cancers without referring to any specific type of cancer. Findings of studies in our included in our review highlight the fact the mHealth interventions play relevant role in the care of cancer patients and survivors. Overall, general perceptions of mHealth interventions discussed in this review were positive, having encouraged promising outcomes regarding improved clinical aspects for cancer patients and survivors. In developing mHealth interventions for cancer patients, several points need to be addressed. For example, issues related to privacy and security were highlighted. Another issue that needs addressing is the complexity, since some patients found functions such as private messaging, decision aids, and login screens complex to use. Furthermore, cancer survivors and parents were more likely and motivated to use an intervention which is applicable to their circumstances[27].

Open gaps

The current study addresses the gaps in the literature by conducting a systematic review of the latest articles on mHealth interventions for all kinds of cancers. Changes in latest technological trends that have not been covered in prior literature reviews had been discussed in this SLR study. A collective review of findings related to mHealth interventions for different types of cancer are presented here in one article, while almost all the prior reviews spanning the years 2016 to 2019 have focused on specific type of cancer individually.

Our review of prior related studies on mHealth interventions with cancer survivors suggests various limitations of the available literature. First, in addition to patient dependence on professional supervision and fear of technology failure, issues related to privacy and security are less focused upon highlighted. Second, there is general failure of studies to include economic analysis, despite the fact that costs are dependent on the nature and sample size of the interventions. Only one study[54] reported cost effectiveness for education text messages and SMS reminders for cervical cancer screening. Third, even though it was found that patients felt functions such as private messaging, decision aids, and login screens were complex to use, very few studies discussed the satisfaction level of cancer patients with regard to the usability aspects of mHealth interventions. Fourth, many of studies had small sample sizes, which severely restricted their ability to provide robust information or to detect an effect. Only some scholars have undertaken complex and varied interventions, with wide-range study designs and findings. Other limitations of the reviewed studies were: (a) dropouts was a major issue in selected studies and only some components of mHealth interventions were utilized.; (b) effectiveness of individual components of the interventions was not much explored in the selected studies; and (c) Some of the selected studies have only briefly described the usability of the intervention design and layout.

Gaps and limitations

The insights from the present SLR resulted in the identification of different research gaps and limitations in the prior literature, as described below.

Platform-specific studies

Recent studies associated with colorectal cancer screening addressed limitations including First, the there is no evidence that participants read the message. Second, message with organizational signature is less effective than if personally signed. Third, these studies did not address mechanisms underlying Question-Behavior Effect (QBH), which is the goal of future work. Additionally, there is a lack of data on digital literacy and health status necessary confounders [63]–[65]. Future studies should test the routine use of SMS reminders for cancer patients and their medication adherence and appointment attendance. Text message platform with

Adolescent and Young Adult (AYA) cancer survivors was not able to measure whether participant read the message [23], [38]. Furthermore, responsivity to text messages was heterogeneous between participants. Use of open-ended questions for mobile app (Life in a Day) for breast cancer survivors may limit qualitative data obtained from the study [51].

Methodological challenges

Prior literature suffers from different methodological challenges.

a) *Focus on self-reports*: Patients with colorectal cancer self-reported their neurotoxic side effects lost nonverbal information by adopting shorter telephone interviews instead of longer face-to-face interviews. Beside the possibility of incorporating only patients with positive attitude due to these interviews [58].

b) *Small effect size*: The small effect sizes in the studied associations of mHealth interventions for cancer care and support were also a limitation with some of the studies [33], [34], [36], [37], [43], [49], [51], [58], [61]. The small effect size limits the degree of interpretation of results drawn from the studies. However, small sample size is relevant in qualitative studies. Future research should consider appropriate sample size for cancer screening studies and recruiting care givers including parents and other people.

c) *Data collection and participants*: Prior literature has reported various methodological challenges related to the data collection and recruitment of participants. Among these, contamination between control and intervention groups could not be assessed, if the control participants behavior was influenced by the intervention participants outcomes after sharing their text messages reminders for colorectal cancer screening [64]. This contamination would bias the results. Uptake of cervical cancer screening using SMS intervention resulted in contamination between participants groups [24].

d) *Measurement*: reproducibility of results was uncertain for skin cancer screening study using mobile teledermatology platform, since only one teledermatologist was involved in the study [62]. Lack of practical reliable measures of medication adherence whether in patient self-report or medical records results in limited ability to measure medication adherence with texting intervention for adult patients prescribed oral anti-cancer agents [20], [35].

e) *Generalizability of settings*: text message reminders for colorectal cancer screening study was restricted to patients within single health care center who had text-enabled mobiles. This ends up with non-generalizability of study results to other settings [64]. App-based education enhancing oral anticancer medication adherence included only English-speaking participants, affecting generalizability of study to non-English-speaking patients [11], [44]. This study was also based on patients from single center. Using mobile phone interviews to manage cervical cancer patients was conducted only in health facilities resulting in bias affecting the care received [52]. All participants in mHealth PA intervention study during chemotherapy for breast cancer received care at National Cancer Institute. More diverse cancer centers should be included in future studies [34], [45], [49].

f) Duration of study: mHealth platform-based pulmonary rehabilitation (PR) study for patients with lung cancer did not assess long-term effects [61]. Effect of cancer application (CA app) for parents of children with acute lymphoblastic leukemia was conducted over short 3 months course [36]. Another limitation is the short recruitment for patients prescribed oral anticancer agents to promote self-management with text messaging intervention [20]. Furthermore, short recruitment for cervical cancer screening patients with SMS intervention [24]. Future studies are needed to examine long-term benefit of PR platforms for patients and health care professionals, as well as CA app. More real-life app duration should be engaged for breast, prostate and colorectal cancer survivors using mobile app to promote their PA [50], [51].

g) Technology limitations: many participants (mainly elderly) may have difficulty with handling the technology or even did not own the appropriate device for the study due to budgetary limitations [24], [34], [36], [61]. Further research is needed to provide effective technology service using smart mobiles for older patients. Some apps run only on limited smartphone type and not on other types [36], [51]; an example is CA app for parents of children with acute lymphoblastic leukemia [36], which runs only on Android smartphone. In future, CA app running on IOS is to be developed. Pain Buddy game platform in children cancer pain management involves internet connection access through Wi-Fi, which may limit the access to Pain Buddy for some population [23]. Future studies should consider implementations of mobile internet access, or even select devices that do not depend on Wi-Fi connectivity [46].

RECOMMENDATIONS FOR THE FUTURE

1. It is recommended that there should be good-quality clinical studies to guide future implementations.
2. Bigger sample sizes and framework-based designs are needed to obtain stronger research conclusions.
3. Stronger efforts should be made to consolidate evidence base, effectiveness, privacy, security and safety of cancer-focused apps.
4. Furthermore, mHealth interventions should be extensively research tested in terms of complexity before making them available to the public. Moreover, these interventions should be acceptable and usable to stakeholders before doing experimental research phases.
5. There is a need to develop mHealth interventions based on a theoretical approach and defined framework design. It would be useful if future studies carefully describe key elements of mHealth intervention used by cancer patients.
6. Before recommending implementation of mHealth interventions for cancer disease management, information on cost-effectiveness should be made available.

7. We recommend also that future interventions should focus on better understanding and exploring the effectiveness of different components of mHealth intervention in aiding the healthcare of cancer patients and survivors.

CONCLUSION

A strength of this review is its novelty as it is the first systematic review study addressing current state of mHealth interventions impact on different types of cancer patients' disease management. This study reviewed previous literature and identified the core components of mHealth interventions for cancer patients, survivors and their care giving team whom will benefit and improve their QoL and wellbeing. Best practice methods for systematic reviews were applied to minimize errors and bias in the review process. Complex and varied interventions were used with wide-range study designs and findings. Moreover, three independent reviewers were involved in all review process stages. This SLR will help in the further enhancement and development of future mHealth interventions for treatment and management of cancer diseases, as well as cancer patients and survivors clinical, physical and psychological concerns. The study utilized comprehensive inclusion criteria, which provided larger evidences base, covering the use of mHealth interventions for different types of cancer diseases to manage cancer patients and survivors. In comparison, prior SLRs on this subject focused on specific types of cancer diseases, hence their contributions were limited to individual type of cancer. Consequently, one of the main strengths of this SLR is that it provides critical synthesis of evidences on the use of mHealth interventions for improving QoL and wellbeing of different types of cancer diseases. This review recognizes that for cancer patients and survivors, face-to-face interventions may be preferred, but our findings highlighted the promising potential of mHealth interventions to support cancer patients and survivors, which warrants extensive future development work and testing. Most commonly useful mHealth interventions were mobile apps and SMS text messaging. Enhanced cancer screening by the use of mHealth interventions has undoubted potential to reduce cancer-specific morbidity and mortality.

Results showed that the use of mHealth intervention is effective in promoting proper management of cancer patients and survivors. Strong and collective efforts should be made to determine cancer-focused apps that provide reliable tools for cancer patients' and survivors' disease management. The review findings highlight the promising potential of mHealth interventions to support cancer patients' and survivor's disease management, which warrants further development and testing. There is a need for evidence—base guidance for developing and evaluating mHealth interventions for cancer patients and survivors as it is becoming more promising.

Limitations of our SLR

Despite following a robust search and analysis method, the current SLR suffers from certain limitations. First, the language of the search was limited to English, so it failed to identify all relevant studies (e.g., non-English language articles), second, although two databases can be considered enough for systematic review, more sources could have allowed more comprehensive future review efforts, third, the review considered only assessment of two main psychological measures, namely, QoL and wellbeing. Additional studies should consider other psychological measures such as fatigue or secondary symptoms of cancer treatment. Fourth, the search was last updated on August 2019. Due to fast-moving nature of this field of research, it is likely that additional publications will be available by the time this SLR is published. This is common limitation of systemic reviews. The current SLR also has some limitations that should be considered in future studies. The selection of the relevant studies was limited by including only the full text articles published in the peer reviewed journals. There is always a possibility that a lot of mHealth interventions were successfully carried out but might not have published in the academic literature. Despite this limitation, the search strategy utilized in this SLR was thorough, rigorous and consistent with the previous articles published in JIMR.

ACKNOWLEDGEMENT

This research was funded by the Deanship of Scientific Research at Princess Nourah bint Abdulrahman University through the Fast-track Research Funding Program.

The authors wish to thank Dr. Amandeep Dhir for continuous support through research work.

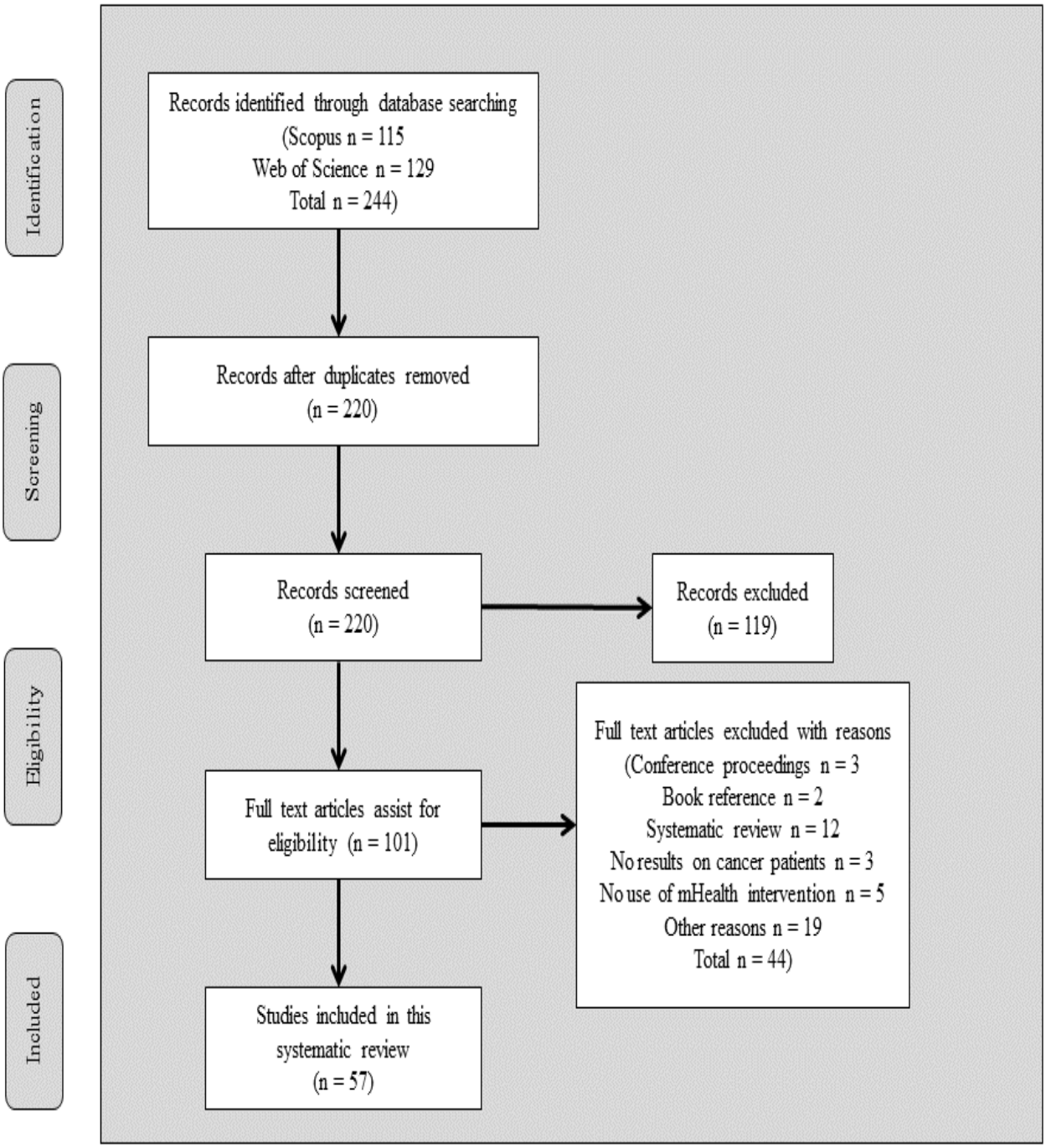

Figure 1: Articles selection process

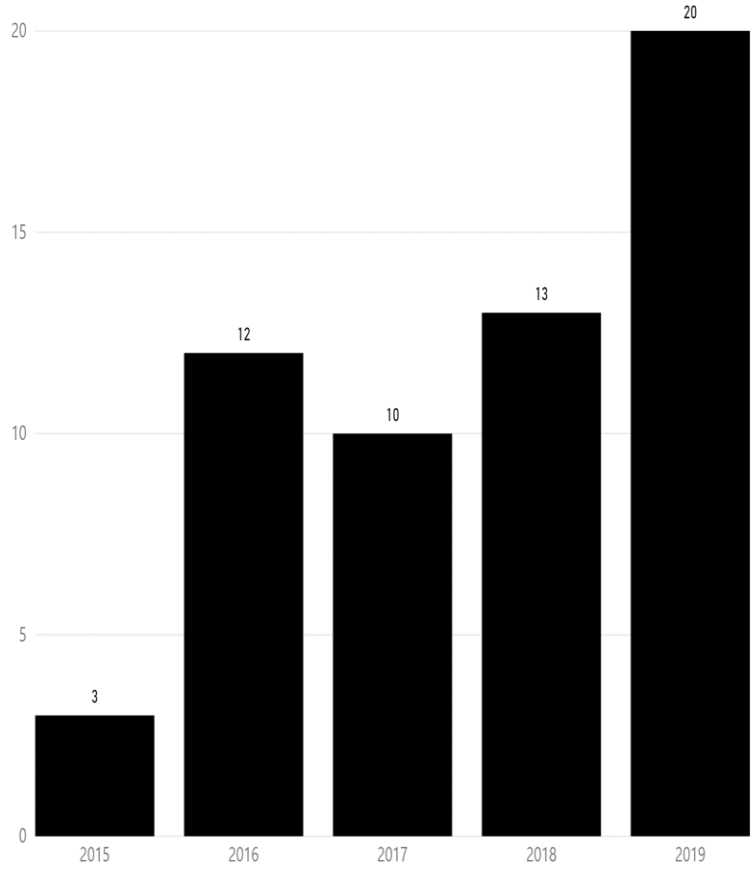

Figure 2: Annual scientific production of research studies

Figure 3: Country-wise presentation of research studies

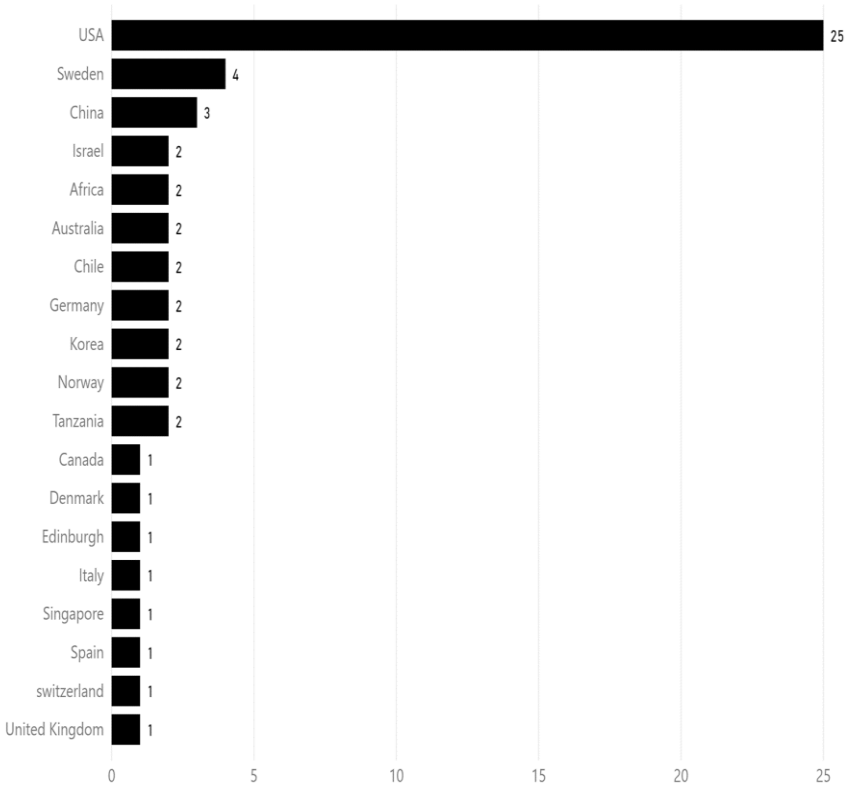

Figure 4: number of research studies published by various countries

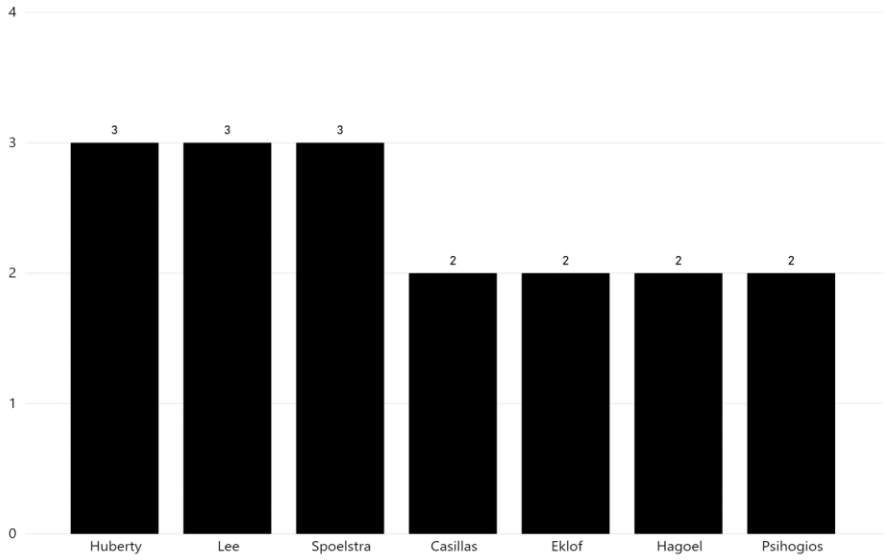

Figure 5: Most productive authors

Figure 6: Keyword cloud based on keywords of selected studies

Figure 7: Keyword cloud based on titles of selected studies

Table 1. Characteristics, mHealth interventions for cancer diseases, study design, outcomes and key findings

Author (Year) Country	Sample	Study Focus	Study Design	Outcomes	Key Findings
Moodley *et al*. (2019) South Africa	N 364 R_{age} 18-30 (100% Female)	Survey, Pap smear, SMS-text messages	Sequential mixed method, cross-sectional survey	Management of cervical cancer clients	mHealth interventions, specially the use of SMS text-based messaging, are perceived positively by majority of women interviewed
Erwin *et al*. (2019) Tanzania	N 866 Rage 25-49 (100% Female)	SMS and eVoucher for	RCT (double-blind)	Cervical Cancer Screening	Intervention group participants were more likely to attend than control group participants
Phillips *et al*. (2019) USA	N 96 Mage = 55.8 (SD = 10.2)	Transcribed phone interviews. Online questionnaires	Mixed methods study	PA promotion for breast cancer survivors	Breast cancer survivors are interested in mHealth PA promotion interventions
Nielsen *et al*. (2019) USA	N 30 M_{age} = 45.5 (100% Female)	Transcribed phone interviews.	Cross-sectional qualitative evaluation	PA education during chemotherapy	Breast cancer survivors are interested in mHealth PA promotion interventions during chemotherapy
Roberts *et al*. (2019) United Kingdom	N 32 age > 18 50% prostate cancer, 25% breast cancer, 25% colorectal cancer	Mobile apps	Qualitative evaluation	Implementation of using apps to support PA	An app-based PA intervention promotes health management and quality of life in breast, prostate, and colorectal cancer survivors
Singleton *et al*. (2019) Australia	N 160 age > 18 (100% Female)	Text message	RCT (Single-blind)	Self-efficacy for managing chronic disease; Clinical outcomes (body mass index), lifestyle and mood	Study will test support of text message program to women's physical and mental health
Chow *et al*. (2019) USA	N 50 (25 breast cancer patients and 25 caregivers) age ≥ 18	IntelliCare mobile app-based mental health intervention, self-report surveys	RCT (pre-post)	Mental health outcomes	How scalable mobile phone-delivered programs can support cancer patients and their loved ones
Russell *et al*. (2019) Australia	N 18	Daily medication-reminder text messages	RCT (Pilot)	Oral cancer therapy adherence	Implementation of best supportive care practice
Psihogios *et al*. (2019) USA	N 26 AYAs M_{age} 16 (62% Female)	Text messaging intervention for AYAs survivors of cancer	Qualitative, 2-way text messaging study	Text message responsivity	AYA survivor's responsivity to text messages decreased and higher engagement with prompt and personal

					messages was achieved
Lee *et al*. (2018) South Korea	N 88 M_{age} 47.3 ± 7.7 years (100% Female)	Smartphone application with pedometer, satisfaction questionnaire	Qualitative evaluation	5-point Likert scale for patient satisfaction	Patients were satisfied with telephone counselling
Ainsworth *et al*. (2018) USA	N 40 M_{age} 55 (SD 8) years (100% Female)	Life in a Day mobile phone app measuring time use in breast cancer survivors, satisfaction survey	Qualitative evaluation	Self-administered participant satisfaction	Mobile phone app is an acceptable time-use measurement modality
Soto *et al*. (2018) Chile	N 27 R_{age} 25-64 (100% Female)	Use of cell phones and text messaging to improve cervical cancer screening	Qualitative Study	Perceptions of SMS	Use of cell phones and text messaging to improve cervical cancer screening was positive
Lee *et al*. (2018) USA	N 14 M_{age} 50.57 (SD 6.64) years (100% Female)	Multimedia messaging intervention (mMammogram) to promote breast cancer screening	Qualitative method	Understand breast cancer and Mammgraphy, awareness and screening methods	Better understanding of breast cancer and screening through mMammogram
Wang *et al*. (2018) China	N 101 Parents	mHealth supportive care intervention "Android smartphone app "Care Assisstant""to meet parents social, emotional and care needs caring for their children with ALL	Quasi-Experimental Pre- and Post-design study	Measure parents QoL, anxiety, depressive orders and social support	Effectiveness of mHealth intervention in supporting parents of children with ALL
Ali *et al*. (2018) Singapore	N 409 Surveys Age > 21 (71.1% Female)	App-based educational and behavioural for OAs medication adherence	Cross-sectional survey	Adherence-enhancing strategies	Patients valued the inclusion of interventions in adherence apps
Momany *et al*. (2017) Chile	N 400 R_{age} 25-64 (100% Female)	Text and voice messages to improve cervical cancer screening	RCT (study protocol)	Completion of Pap test assessment, evaluation of text message intervention implementation	The mobile technology raise cervical cancer screening adherence
Linde *et al*. (2017) Tanzania	N 700 Rage 25-60 (100% Female)	Education text messages and SMS reminders for cervical cancer screening	RCT (mixed-methods subpopulation study)	Attendance rate follow-up, cost-effectiveness	Potential effects of SMS for increased risk women in developing cervical cancer
Eklof *et al*. (2017) Sweden	N 150 Breast cancer, N 150 Prostate cancer Age ≥ 18	Platform use to improve clinical management for prostate and breast cancer survivors	RCT (Prospective, repeated measurements)	Symptom burden, QoL, progress and health care costs	Provide knowledge for the effects for using app to monitor and manage prostate and breast cancer treatment
Uhm *et al*. (2017) Korea	N 365 R_{age} 20-70	Smart phone application to monitor exercise to improve QoL	RCT (Prospective, quasi)	General QoL, user satisfaction survey	Superiority of mHealth over conventional "exercise brochure" program was not definitely evident

Zhu *et al*. (2017) China	6 Age ≥ 50	Mobile app (BCS) to offer social and emotional support	RCT	Women's self-efficacy and social support	Test effectiveness of BCS program
Lozano *et al*. (2016) Spain	N 80 R_{age} 25-75 (100% Female)	Use of mobile application (BENECA APP)	RCT (Two-arm, assessor blinded parallel design)	QoL, body composition	Support healthy lifestyles in breast cancer survivors
Lee *et al*. (2017) USA	N 120 Rage 40-77 (100% Female)	Mobile phone messaging intervention (mMammogram) to promote breast cancer screening; control group received printed brochure	RCT (Pilot two-arm)	Knowledge and attitudes about breast cancer screening for mammography	Intervention group showed significant greater change on scores of knowledge of breast cancer and screening guidelines
Casillas *et al*. (2017) USA	N 23 AYAs cancer survivors, R_{age} 15-39	Text messaging, or SMS intervention for improving AYAs survivors of childhood cancer	Qualitative	Usability of SMS service	Improved receipt survivorship care
Lyons *et al*. (2016) USA	N 20 R_{age} 45-75 (100% Female)	Game-Oriented mobile app, counseling phone calls	RCT	PA at six months, fitness and physical function	Emphasize self-regulation for QoL
Mckenzie *et al*. (2016) Africa	N 800 Age ≥ 18 (100% Female)	Use of mHealth tool telephone call for study management	Prospective hospital-based	Survival and impact on QoL for African women with breast cancer	Provide updated information on QoL
Fu *et al*. (2016) USA	N 120	Optimal-Lymph-Flow web- and mobile-based intervention to manage chronic pain for breast cancer treated women	RCT (Parallel, control experimental, pre- and post-test, repeated measures)	Pain reduction, symptom relief, optimal body mass index (BMI) and QoL	Patients learn self-care strategies from a Web- and mobile-based program and track their symptoms
Quintiliani *et al*. (2016) USA	N 10 M_{age} 59 (SD 6) (100% Female)	Mobile health (daily text messages) supported behavioral counselling intervention for weight management	One-group trial with a pre-post evaluation	Physiological (weight), behavioral (diet and physical activity)	Findings support the conduct of mHealth intervention
Fortier *et al*. (2016) USA	N 12 R_{age} 8-18	Animated avatar-based tablet application, Pain Buddy, developed using state-of-the-art software	RCT	Enhance pain management and improve QoL	Pain Buddy is effective in in improving pain and manage symptoms in children under cancer treatment
Spoelstra *et al*. (2015) USA	N 75 Age ≥ 21	Text message intervention	RCT (Two-group, repeated measures)	Medication adherence in adult patients OAs	Text messages have high generalizability to transform care
Spoelstra *et al*. (2015) USA	N 80 M_{age} 58.5 (SD 10.7) (60% Female)	Text message intervention	RCT (Longitudinal)	Medication adherence and symptom severity	Promote self-management for patients prescribed OAs
Markun *et al*. (2017) switzerland	N 188 M_{age} 40.4 (60% Female)	Teledermatolgist image	Qualitative evaluation	Detection of skin cancer further study needed	Evaluate most convenient mobile teledermatology intervention in skin cancer patients

Ji *et al*. (2019) Korea	N 64 R_{age} 20-40	Pulmonary rehabilitation app	Qualitative evaluation	Mobile health-based pulmonary rehabilitation app for recording and monitoring real time health	This was the first m health Pulmonary rehabilitation in korea
Drott *et al*. (2016) Sweden	N 11 M_{age} 44-68	Telephone interview	Qualitative evaluation	This mobile phone-based system reinforced the patients feeling of involvement in their own care	The increased number of mobile phone user creates new possibilities for intervention with mobile
Muller *et al*.(2016) USA	N 2386 M_{age} 40-75	Text messages	RCT	A simple text messaging intervention was found to increase CRC screening rates	Further studies needed
Weaver *et al*.(2015) USA	N 26 R_{age} 50-75 (62% Female)	Text messages	Qualitative evaluation	Sharing sample messages wiith patients may increase acceptance of this tool in the clinic setting	The development of text messages that acceptable and useful to an older population
Hagoel *et al*.(2019) Israel	N 50,000	Text -message reminder	Pilot feasibility study	Enhance screening	This novel application resulted in population level enhanced screening
Hagoel *et al*.(2016) Israel	N 50 000 M_{age} 50-74	Text -message reminder	RCT	Performance of fecal occult blood test was higher in the interrogative reminder groups than in other 3 groups	Colorectal cancer screening
Ciani *et al*. (2019) Italy	N 120 M_{age} 18	Daily monitoring and grading of list of symptoms app	RCT Prototype	Follow lung cancer patient with LuCAPP	Timely contribution to test a mobile application designed to improve the quality
Spoelstra *et al*. (2016) USA	N 169	Text messaging	RCT	Text message interview trial	Adult cancer patients were likely to participate in TM intervention trial
Jibb *et al*. (2018) Canda	N 20 M_{age} 12-18	Interviews transcribed and independently coded	Qualitative evaluation	The effect of the study on cancer patient	Assessing the effectiveness of pain squad on adolescents with cancer health outcomes
Schera *et al*. (2018) Germany	-	intelligent personal health record application	Qualitative evaluation	The effect of the study on cancer patient	H2020 manager Cancer project
Borosund *et al* (2018) Norway	N 48 M_{age} 31-81	Stress management app	Qualitative evaluation	The ultimate goal was to have an end product useful for cancer patients	To develop a stress management intervention
Elsbernd *et al*. (2018) Denmark	R_{age} 15-29	App user after treatment group study	Qualitative evaluation	More studies needed	App development can be utilized for creation of other m health intervention

Huberty *et al*. (2019) USA	N 128	4 groups using2 consumer apps (happier and calm)	Pilot feasibility study	Delivering meditation via the calm app is feasible and scored higher in terms of feasibility when compared with 10%happier app	The calm app will be used in further RCT studies
Psihogios *et al*. (2019) USA	N 26 M_{age} 16-62 (62% Female)	2-way text messages about survivorship health topics	Pilot feasibility study	evaluating text message responsivity revealed important patterns in 2-way text message intervention for AYA cancer survivors	Understanding responsivity to different types of text messages
Huberty *et al*. (2019) USA	N 48	4 groups using2 consumer apps (happier and calm)	Qualitative evaluation	Delivering meditation via the calm app is feasible and scored higher in terms of feasibility when compared with 10%happier app	The calm app will be used in further RCT studies
Raghunathan *et al*t. (2018)	N 631 (65.8% Female)	Survey among cancer patient from one urban academic hospital and 11 community hospital	Cross sectional survey	Further study needed	Many patients expressed interest in smartphone application-based information about supportive care services
Borosund *et al*. (2019) Norway	N 25 R_{age} 18	One face to face introduction session,10 app-based modules with stress management educational material and exercises	Pilot feasibility study	App-based stress management intervention such as stress can provide appreciated support for cancer survivors should be easy to use can provide significant stress reduction and improve emotional well-being	Benefit of app-based stress management intervention for cancer survivors
Yang *et al*. (2019) CHINA	N 58	Pain Guard app	RCT descriptive	At the end of study, the rate of pain remission in trial group was significantly higher than that in the control group	Motivated by the need for better pain management in discharge patients
Eklof *et al*. (2017) SWEDEN	N 66	Adherence to daily reporting of symptom app	Qualitative evaluation	Use of interaktor increased patients sense of security and their reflections on their own well-being and thereby served a supportive tool for the self-management symptoms	Some further development of the apps content might be beneficial for future use
Nyman *et al*. (2017) Sweden	N 28 R_{age} 57-77	Interactive smartphone app enable participation in care	Qualitative evaluation	Using innovative ways to communicate with patient such as interactive app for symptom management with contact with health	The need to evaluate whether an interactive smartphone app could enable participation in care

				care in real time can successfully help achieve increased patient participation in care	
Kessel *et al*. (2016) Germany	N 108	Online survey 24 questions evaluating general attitude toward telemedicine	Cross sectional survey	A majority of HCPS are in favor of telemedicine and the use of oncological apps patients	A mobile app would enhance the patient's relationship to their treating department because they are in permanent contact
Somers *et al*. (2016) USA	N 30	Randomly assigned participants (n=30) post intervention assessment included measure of pain	RCT Prospective	All participants had a clinical pain score of 3 or greater	To gain information about the accessibility and efficacy of mobile pain coping skills training (Mpcst)intervention delivered to cancer patients
Piau *et al*. (2019) USA	N 52 M_{age} 83.4	9 unselected patients from the chatbot with a total of 52 completed remote evaluation	Qualitative evaluation	Rely on end-user's current knowledge of technologies	Text messaging
Huberty *et al*. (2019) USA	N 128	2 consumer-based apps	Qualitative evaluation	Qualitative calm app as more appealing	further studies needed
Loh *et al*. (2018) USA	N 18 M_{age} 76.8	Touch Stream consists of mobile app and a Web portal	Pilot feasibility study	Touch Stream and usable for older patients on cancer treatment and their caregivers	Further studies needed
Muller *et al*. (2016) USA	N 2386 R_{age} 40-75	Screening by text messaging	RCT	Text message maybe cost effective	A simple text messaging intervention was found to increase CRC screening rates

R_{age} = Range of age
RCT = Randomized controlled Trial
M_{age} = Mean age
PA = Physical Activity
AYAs = Adolescents and young adults
OAs = Oral anti-cancer agents
ALL = Acute lymphoblastic leukemia
SMS = Short Message Service
BSC = Breast Cancer e-Support Program
App = Application
P = prospective clinical trial
QL = qualitative study
RCT P = randomized control trial protocol
CRC = colorectal cancer
Pr = prototype development study
F = feasibility study
PI = Pilot intervention
CS = cross sectional survey
PT = Pilot testing
RCT D = randomized control trial double arm study
D = descriptive study
S = survey
PF = pilot feasibility study
3 A RCT = 3-armed randomized control trial one control group and the other two intervention group

REFERENCES

1. G. Observatory, "New horizons for health through mobile technologies," vol. 3.
2. T. O. Tokosi, J. Fortuin, and T. S. Douglas, "The Impact of mHealth Interventions on Breast Cancer Awareness and Screening: Systematic Review Protocol," *JMIR Res. Protoc.*, vol. 6, no. 12, p. e246, 2017.
3. S. L. Spoelstra *et al.*, "Adult cancer patient recruitment and enrollment into cell phone text message trials," *Telemed. e-Health*, vol. 22, no. 10, pp. 836–842, 2016.
4. S. L. Spoelstra and A. Sikorskii, "Adult Cancer Patient Recruitment and Enrollment into Cell Phone Text Message Trials 1," pp. 836–843, 2015.
5. S. W. Davis and I. Oakley-Girvan, "mHealth Education Applications Along the Cancer Continuum," *J. Cancer Educ.*, vol. 30, no. 2, pp. 388–394, 2015.
6. O. Ciani *et al.*, "Lung Cancer App (LuCApp) study protocol: A randomised controlled trial to evaluate a mobile supportive care app for patients with metastatic lung cancer," *BMJ Open*, vol. 9, no. 2, pp. 1–10, 2019.
7. E. H. Silva, "The effectiveness of mHealth for self-management in improving pain , psychological distress , fatigue , and sleep in cancer survivors : a systematic review," pp. 97–107, 2019.
8. S. Bhatt *et al.*, "Mobile technology and cancer screening: Lessons from rural India," *J. Glob. Health*, vol. 8, no. 2, p. 020421, 2018.
9. L. Hagoel, E. Neter, N. Stein, and G. Rennert, "Mobile Health Management Platform–Based Pulmonary Rehabilitation for Patients With Non–Small Cell Lung Cancer: Prospective Clinical Trial," *Am. J. Public Health*, vol. 106, no. 11, pp. 1998–2004, 2016.
10. M. R. Fu *et al.*, "A Web- and Mobile-Based Intervention for Women Treated for Breast Cancer to Manage Chronic Pain and Symptoms Related to Lymphedema: Randomized Clinical Trial Rationale and Protocol," *JMIR Res. Protoc.*, vol. 5, no. 1, p. e7, 2016.
11. E. E. Ali, J. L. Leow, L. Chew, and K. Y. L. Yap, "Patients' Perception of App-based Educational and Behavioural Interventions for Enhancing Oral Anticancer Medication Adherence," *J. Cancer Educ.*, vol. 33, no. 6, pp. 1306–1313, 2018.
12. S. Triberti, L. Savioni, V. Sebri, and G. Pravettoni, "eHealth for improving quality of life in breast cancer patients: A systematic review," *Cancer Treat. Rev.*, vol. 74, no. January, pp. 1–14, 2019.
13. C. Jongerius, S. Russo, K. Mazzocco, and G. Pravettoni, "Research-tested mobile apps for breast cancer care: Systematic review," *J. Med. Internet Res.*, vol. 21, no. 2, pp. 1–15, 2019.
14. E. Rincon, F. Monteiro-Guerra, O. Rivera-Romero, E. Dorronzoro-Zubiete, C. L. Sanchez-Bocanegra, and E. Gabarron, "Mobile Phone Apps for Quality of Life and Well-Being Assessment in Breast and Prostate Cancer Patients: Systematic Review," *JMIR mHealth uHealth*, vol. 5, no. 12, p. e187, 2017.
15. J. Choi, Y. Cho, and H. Woo, "mHealth Approaches in Managing Skin Cancer : Systematic Review of Evidence-Based Research Using Integrative Mapping Corresponding Author :," vol. 6, pp. 1–10, 2018.
16. N. Heynsbergh, L. Heckel, M. Botti, and P. M. Livingston, "Feasibility , useability and acceptability of technology-based interventions for informal cancer carers : a systematic review," pp. 1–11, 2018.
17. A. Seiler, V. Klaas, G. Tröster, and C. P. Fagundes, "eHealth and mHealth interventions in the treatment of fatigued cancer survivors : A systematic review and meta - analysis," no. June, pp. 1239–1253, 2017.
18. S. Darlow and K. Wen, "Development testing of mobile health interventions for cancer patient self-management : A review," 2016.
19. [D. Moher *et al.*, "Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement," pp. 1–9, 2015.
20. [S. L. Spoelstra *et al.*, "Feasibility of a Text Messaging Intervention to Promote Self-Management for Patients Prescribed Oral Anticancer Agents," *Oncol. Nurs. Forum*, vol. 42, no. 6, pp. 647–657, 2015.
21. S. Rajan and M. Sathiyanarayanan, "Breast cancer awareness through smart mobile healthcare applications from Indian doctors' perspective," *Proc. 2017 Int. Conf. Smart Technol. Smart Nation, SmartTechCon 2017*, no. April 2019, pp. 607–612, 2018.
22. J. Casillas *et al.*, "Development of a text messaging system to improve receipt of survivorship care in adolescent and young adult survivors of childhood cancer," *J. Cancer Surviv.*, vol. 11, no. 4, pp. 505–516, 2017.
23. M. A. Fortier, W. W. Chung, A. Martinez, S. Gago-Masague, and L. Sender, "Pain buddy: A novel use of m-health in the management of children's cancer pain," *Comput. Biol. Med.*, vol. 76, pp. 202–214, 2016.
24. E. Erwin *et al.*, "SMS behaviour change communication and eVoucher interventions to increase uptake of cervical cancer screening in the Kilimanjaro and Arusha regions of Tanzania: A randomised, double-blind, controlled trial of effectiveness," *BMJ Innov.*, pp. 1–7, 2019.
25. G. Ferreira, A. C. Traeger, G. MacHado, M. O'Keeffe, and C. G. Maher, "Credibility, accuracy, and comprehensiveness of internet-based information about low back pain: A systematic review," *J. Med. Internet Res.*, vol. 21, no. 5, pp. 1–9, 2019.
26. S. V. Gentry *et al.*, "Serious gaming and gamification education in health professions: systematic review," *J. Med. Internet Res.*, vol. 21, no. 3, 2019.
27. J. Hopwood *et al.*, "Internet-based interventions aimed at supporting family caregivers of people with dementia: Systematic review," *J. Med. Internet Res.*, vol. 20, no. 6, 2018.
28. M. S. Marcolino, J. A. Q. Oliveira, M. D'Agostino, A. L. Ribeiro, M. B. M. Alkmim, and D. Novillo-Ortiz, "The impact of mHealth interventions: Systematic review

of systematic reviews," *JMIR mHealth uHealth*, vol. 6, no. 1, 2018.
29. A. T. Ramsey, J. M. Satterfield, D. R. Gerke, and E. K. Proctor, "Technology-based alcohol interventions in primary care: Systematic review," *J. Med. Internet Res.*, vol. 21, no. 4, pp. 1–12, 2019.
30. M. Semwal, P. Whiting, R. Bajpai, S. Bajpai, B. M. Kyaw, and L. T. Car, "Digital education for health professions on smoking cessation management: systematic review by the digital health education collaboration," *J. Med. Internet Res.*, vol. 21, no. 3, 2019.
31. L. Warrington *et al.*, "Electronic Systems for Patients to Report and Manage Side Effects of Cancer Treatment: Systematic Review," *J. Med. Internet Res.*, vol. 21, no. 1, p. e10875, 2019.
32. J. Zhu, L. Ebert, Z. Xue, Q. Shen, and S. W. C. Chan, "Development of a mobile application of Breast Cancer e-Support program for women with breast cancer undergoing chemotherapy," *Technol. Heal. Care*, vol. 25, no. 2, pp. 377–382, 2017.
33. M. Lozano-Lozano *et al.*, "Integral strategy to supportive care in breast cancer survivors through occupational therapy and a m-health system: design of a randomized clinical trial," *BMC Med. Inform. Decis. Mak.*, vol. 16, no. 1, pp. 1–10, 2016.
34. P. I. Chow *et al.*, "Use of mental health apps by breast cancer patients and their caregivers in the United States: Protocol for a pilot pre-post study," *J. Med. Internet Res.*, vol. 21, no. 1, 2019.
35. S. L. Spoelstra *et al.*, "A randomized controlled trial of the feasibility and preliminary efficacy of a texting intervention on medication adherence in adults prescribed oral anti-cancer agents: Study protocol," *J. Adv. Nurs.*, vol. 71, no. 12, pp. 2965–2976, 2015.
36. J. Wang *et al.*, "Mhealth supportive care intervention for parents of children with acute lymphoblastic leukemia: Quasi-experimental pre- and postdesign study," *JMIR mHealth uHealth*, vol. 6, no. 11, 2018.
37. L. Russell *et al.*, "The trials and tribulations of conducting an m-health pilot randomized controlled trial to improve oral cancer therapy adherence: Recommendations for future multisite, non-drug clinical trials," *BMC Res. Notes*, vol. 12, no. 1, pp. 1–6, 2019.
38. A. M. Psihogios *et al.*, "Text message responsivity in a 2-way short message service pilot intervention with adolescent and young adult survivors of cancer," *J. Med. Internet Res.*, vol. 21, no. 4, 2019.
39. H. Lee *et al.*, "Patient Satisfaction with Mobile Health (mHealth) Application for Exercise Intervention in Breast Cancer Survivors," *J. Med. Syst.*, vol. 42, no. 12, 2018.
40. A. Langius-Eklöf, M. T. Crafoord, M. Christiansen, M. Fjell, and K. Sundberg, "Effects of an interactive mHealth innovation for early detection of patient-reported symptom distress with focus on participatory care: Protocol for a study based on prospective, randomised, controlled trials in patients with prostate and breast cancer," *BMC Cancer*, vol. 17, no. 1, pp. 1–11, 2017.
41. K. E. Uhm *et al.*, "Effects of exercise intervention in breast cancer patients: is mobile health (mHealth) with pedometer more effective than conventional program using brochure?," *Breast Cancer Res. Treat.*, vol. 161, no. 3, pp. 443–452, 2017.
42. E. J. Lyons *et al.*, "Testing the effects of narrative and play on physical activity among breast cancer survivors using mobile apps: Study protocol for a randomized controlled trial," *BMC Cancer*, vol. 16, no. 1, pp. 1–18, 2016.
43. H. Lee, M. Lee, Z. Gao, and K. Sadak, "Development and Evaluation of Culturally and Linguistically Tailored Mobile App to Promote Breast Cancer Screening," *J. Clin. Med.*, vol. 7, no. 8, p. 181, 2018.
44. H. Lee, R. Ghebre, C. Le, Y. J. Jang, M. Sharratt, and D. Yee, "Mobile Phone Multilevel and Multimedia Messaging Intervention for Breast Cancer Screening: Pilot Randomized Controlled Trial," *JMIR mHealth uHealth*, vol. 5, no. 11, p. e154, 2017.
45. F. McKenzie *et al.*, "African Breast Cancer - Disparities in Outcomes (ABC-DO): Protocol of a multicountry mobile health prospective study of breast cancer survival in sub-Saharan Africa," *BMJ Open*, vol. 6, no. 8, 2016.
46. L. M Quintiliani, D. M. Mann, M. Puputti, E. Quinn, and D. J. Bowen, "Pilot and Feasibility Test of a Mobile Health-Supported Behavioral Counseling Intervention for Weight Management Among Breast Cancer Survivors," *JMIR Cancer*, vol. 2, no. 1, p. e4, 2016.
47. A. Singleton *et al.*, "A text message intervention to support women's physical and mental health after breast cancer treatments (EMPOWER-SMS): A randomised controlled trial protocol," *BMC Cancer*, vol. 19, no. 1, pp. 1–9, 2019.
48. S. M. Phillips *et al.*, "Breast cancer survivors' preferences for mHealth physical activity interventions: findings from a mixed methods study," *J. Cancer Surviv.*, vol. 13, no. 2, pp. 292–305, 2019.
49. A. M. Nielsen *et al.*, "Preferences for mHealth physical activity interventions during chemotherapy for breast cancer: a qualitative evaluation," *Support. Care Cancer*, 2019.
50. A. L. Roberts, H. W. W. Potts, D. A. Koutoukidis, L. Smith, and A. Fisher, "Breast, prostate, and colorectal cancer survivors' experiences of using publicly available physical activity mobile apps: Qualitative study," *J. Med. Internet Res.*, vol. 21, no. 1, pp. 1–17, 2019.
51. M. C. Ainsworth *et al.*, "Acceptability of a mobile phone app for measuring time use in breast cancer survivors (life in a day): Mixed-methods study," *J. Med. Internet Res.*, vol. 20, no. 5, pp. 1–12, 2018.
52. J. Moodley, D. Constant, M. H. Botha, F. H. van der Merwe, A. Edwards, and M. Momberg, "Exploring the feasibility of using mobile phones to improve the management of clients with cervical cancer precursor lesions," *BMC Womens. Health*, vol. 19, no. 1, pp. 1–10, 2019.
53. M. Soto *et al.*, "Preferences of underserved chilean

women on a mobile technology intervention for cervical cancer screening: Qualitative study," *JMIR mHealth uHealth*, vol. 6, no. 11, pp. 1–9, 2018.
54. D. S. Linde, M. S. Andersen, J. D. Mwaiselage, R. Manongi, S. K. Kjaer, and V. Rasch, "Text messages to increase attendance to follow-up cervical cancer screening appointments among HPV-positive Tanzanian women (Connected2Care): Study protocol for a randomised controlled trial," *Trials*, vol. 18, no. 1, pp. 1–11, 2017.
55. M. K. C. Momany *et al.*, "Development of mobile technologies for the prevention of cervical cancer in Santiago, Chile study protocol: A randomized controlled trial," *BMC Cancer*, vol. 17, no. 1, pp. 1–6, 2017.
56. K. A. Kessel, M. M. Vogel, F. Schmidt-Graf, and S. E. Combs, "Mobile Apps in Oncology: A Survey on Health Care Professionals' Attitude Toward Telemedicine, mHealth, and Oncological Apps," *J. Med. Internet Res.*, vol. 18, no. 11, p. e312, 2016.
57. N. J. Raghunathan, D. Korenstein, Q. S. Li, E. S. Tonorezos, and J. J. Mao, "Determinants of mobile technology use and smartphone application interest in cancer patients," *Cancer Med.*, vol. 7, no. 11, pp. 5812–5819, 2018.
58. J. Drott, M. Vilhelmsson, K. Kjellgren, and C. Berterö, "Experiences With a Self-Reported Mobile Phone-Based System Among Patients With Colorectal Cancer: A Qualitative Study," *JMIR mHealth uHealth*, vol. 4, no. 2, p. e66, 2016.
59. K. Sundberg, Y. Wengström, K. Blomberg, M. Hälleberg-Nyman, C. Frank, and A. Langius-Eklöf, "Early detection and management of symptoms using an interactive smartphone application (Interaktor) during radiotherapy for prostate cancer," *Support. Care Cancer*, vol. 25, no. 7, pp. 2195–2204, 2017.
60. K. E. Weaver, S. D. Ellis, N. Denizard-Thompson, D. Kronner, and D. P. Miller, "Crafting Appealing Text Messages to Encourage Colorectal Cancer Screening Test Completion: A Qualitative Study," *JMIR mHealth uHealth*, vol. 3, no. 4, p. e100, 2015.
61. W. Ji *et al.*, "Mobile Health Management Platform–Based Pulmonary Rehabilitation for Patients With Non–Small Cell Lung Cancer: Prospective Clinical Trial," *JMIR mHealth uHealth*, vol. 7, no. 6, p. e12645, 2019.
62. S. Markun, N. Scherz, T. Rosemann, and R. Tandjung, "Mobile teledermatology for skin cancer screening."
63. L. Hagoel, E. Neter, N. Stein, and G. Rennert, "Harnessing the Question – Behavior Effect to Enhance Colorectal Cancer Screening in an mHealth Experiment," vol. 106, no. 11, pp. 1998–2005, 2016.
64. C. J. Muller, R. F. Robinson, J. J. Smith, and M. A. Jernigan, "Text Message Reminders Increased Colorectal Cancer Screening in a Randomized Trial With Alaska Native and American Indian People," 2017.
65. L. Hagoel, N. Stein, G. Rennert, and E. Neter, "Better Ask Than Tell: Responses to mHealth Interrogative Reminders and Associations With Colorectal Cancer Screening Subsequent Uptake in a Prospective Cohort Intervention," *JMIR mHealth uHealth*, vol. 7, no. 1, p. e9351, 2019.