Mobile health interventions for cancer care and support: The next level of digitalization in healthcare?

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Abstract

Academic research has brought attention to the utility of mobile health (mHealth) interventions for assisting cancer patients and survivors in managing their medication, symptoms, and well-being. This is a vital research area, as cancer is the second main cause of death for the global populace. However, the knowledge on mHealth interventions for cancer is distinctly fragmented and there is a lack of clarity on its boundaries, which hinders identification of existing gaps and valuable areas in which to advance future research. Our study addresses this gap and provides a comprehensive review of extant literature to determine the core areas of discourse. This systematic literature review (SLR) amalgamates the extant findings related to users' (cancer patients, cancer survivors, healthcare providers, and clients) experiences of mHealth interventions. Following rigorous protocols, we reviewed pertinent literature from Scopus and Web of Science databases to curate 78 studies. Grounded theory was adopted as an analytical framework and content analysis was used to explicate state-of-the-art insights. To our knowledge, this is the most comprehensive SLR on this topic. The findings revealed four themes and incumbent gaps: (i) intervention targets and affordances, (ii) individual outcomes, (iii) methodological approaches, and (iv) intervention resistance or adoption. Our findings contribute to theory by proposing key areas for meaningful future research. Additionally, our findings provide crucial inputs to practitioners, such as app developers and healthcare personnel, to improve user engagement with mHealth interventions.

Keywords: Cancer, mHealth, interventions, systematic literature review (SLR), patients, healthcare providers

1. Introduction

The integration of mobile technologies into healthcare has promulgated a transformative era of healthcare initiatives based on human-technology interactions. According to the World Health Organization (WHO)[1], mobile devices and wireless technologies are increasingly used to support medical and public health practices across the globe. These technologies have led to the development of a specific subset of mobile technology-based healthcare, known as mHealth. mHealth applications have the potential to offer several benefits to stakeholders, including patients and health care providers, such as access to clinical information [2, 3], opportunities for real-time collaboration with care teams [4], ease of communication [5], and real-time [6] and remote monitoring of patients [7]. Due to these advantages and the increased integration of mobile technologies into modern life, the mHealth market has grown significantly over the past five years. The global revenue of the mHealth market was estimated to be about USD 28 million in 2018, and this sector is predicted to be worth approximately USD 247 billion by the end of 2025 [8].

These statistics suggest that mHealth interventions are finding increased applications for patients' care, and prognosis management. Prior research suggests these interventions have targeted multiple healthcare concerns, and these include managing chronic conditions like diabetes [9] and promoting healthy habits, such as smoking cessation [10]. However, recent research has particularly emphasized their potential for managing cancer, which is the second-highest chronic cause of global deaths after cardiovascular diseases [11]. About 19 million new cancer case incidents were reported in 2020, and the predictive prevalence is estimated at 30.2 million by 2040 [12], suggesting that cancer and its management is a critically contemporaneous issue in healthcare [13]. Consequently, academic research on the efficacy and efficiency of mHealth interventions for cancer management has gained momentum. Such applications have focused on providing information and support to patients, survivors, and their caregivers through various methods, such as mobile apps [7, 14, 15] and SMS-based interventions [16–18]. For example, a recent study developed and tested the TouchStream app's feasibility for delivering geriatric assessment (GA)-driven interventions to older individuals with cancer [19]. In contrast, other studies compared the efficacy and feasibility of commercially available meditation apps in reducing the adverse effects on the quality of life (QoL) of patients undergoing treatment for myeloproliferative neoplasm in terms of experienced anxiety, stress, and sleep disturbances, to name a few [20, 21]. These mobile apps are only two examples from a multitude of studies on the influence of mHealth interventions on cancer patients, survivors, and healthcare clients [22, 23]. Such interventions are concerned with encouraging positive and preventive behavior, such as cancer screening [22], oral medication adherence [24], pain or stress management [25, 26], and symptom management [27].

However, prior studies investigating cancer-related mHealth interventions have offered inconsistent findings [25, 28]. For instance, Kim et al. [29] found an insignificant improvement for QoL indicators except for pain, while Kubo et al. [30] reported an improvement for QoL. This can be attributed to several reasons, like varying sociodemographic characteristics of the incumbent individuals [31], the complexity of managing the disease as well as its treatment [32, 33], and the limitations of existing healthcare systems [34]. Moreover, prior research has suggested a degree of fragmentation in prior research designs and methodologies. For example, some studies have focused on understanding cancer management in specific demographic profile cohorts, such as elderly or older [35–37] or adolescent [34, 38, 39] populations, while others have focused on elucidating mHealth interventions for patients afflicted with a specific form of cancer, such as colorectal cancer [40] or breast cancer [41]. This widespread fragmentation indicates the need to amalgamate the prior research to identify the limitations in the present knowledge, incumbent gaps, and scope for future research through the use of systematic literature reviews (SLRs).

Scholars have previously recognized this need and conducted several SLRs on this subject. For example, recent SLRs have discussed the implications of mHealth, such as in the context of a specific economy [42], improving clinical outcomes [43] and QoL among breast cancer patients [9, 44, 45], and preventive screening for skin cancer [46], among others. Furthermore, prior SLRs have focused on the impact of different types of mHealth interventions, such as text messages [47] or mobile phone applications ("apps" hereafter) [48], on various stakeholders, including survivors [49] and caregivers [50]. However, these SLRs are constrained by a narrow focus on (i) the type of stakeholder [49], (ii) the specific form of cancer [9, 44], (iii) the specific outcomes [43], or (iv) a particular form of intervention [48]. Such constraints limit the degree of synthesis of existing knowledge and the depth and generalizability of these SLRs' findings.

We found one SLR that adopted a general perspective toward studying mHealth interventions for cancer [51], but it only considered articles published until August 2019 and thus does not account for recent knowledge developments. We argue that new findings continuously supplement existing knowledge due to the rapid advancement of mHealth interventions and their associated research, which also limits the knowledge contribution and utility of insights offered by these SLRs. The present SLR encompasses a more comprehensive and state-of-the-art scope, and contributes to the literature beyond the prior SLRs in three key ways: (i) by adopting a holistic overview of mHealth interventions for multiple forms of cancer, (ii) by adopting a more rigorous study protocol to identify the thematic foci of the prior research, and (iii) by examining more recent studies in this domain published until May 2022. Our findings offer significant implications that can thus be utilized to further develop mHealth interventions for managing cancer. The remaining manuscript details the adopted methodology in Section 2 and discusses the main results in Section 3. Lastly, Section 4 presents the concluding remarks along with the implications and limitations of this study.

2. Methods

The SLR protocol has been developed considering the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [52, 53] to offer a current, synthesized, and holistic view of the knowledge boundaries for research on mHealth interventions. The methodology follows prior SLRs published on technology for healthcare [54, 55] and comprises three sequential phases: planning, executing, and reporting [55, 56].

These phases were based on the grounded theory approach [57], which we adopted as an analytical framework [58]. Grounded theory is a well-regarded qualitative research design used to execute a theoretical and exhaustive topic analysis through an iterative and inductive process [59, 60]. It enables researchers to develop a concept-centric idea about a topic by focusing on its existing categories, propositions, consequences, and conditions as discussed in the literature [58]. Wolfswinkel et al. [60] suggested a five-step approach to conducting grounded theory-based SLRs for analyzing research content and knowledge in information systems. We followed these steps in our study (see Sections 2.2 & 2.3), which pertain to (i) defining the scope of research (sources, search terms, criteria for inclusion or exclusion), (ii) running the search, (iii) selecting the sample, (iv) analyzing (open and axial coding), and (v) presenting the content.

2.1 Study scope and research questions

We consider mHealth interventions as involving the use of mobile devices (e.g., smartphones, tablets) [61], smart-devices (e.g., Fitbit) [62], wireless technology (e.g., Bluetooth), and communication technologies (such as Short Messaging Service (SMS) texts) to deliver healthcare services targeted at the prevention, support, and self-management of chronic diseases for improved health outcomes [1, 20, 63, 64]. Furthermore, we consider that such mHealth interventions can use apps in conjunction with social media, the Internet, telephone or voice calls, chatbots, or emails to monitor the healthcare of patients [65, 66] and lend support to caregivers [30] and healthcare providers (HCP hereafter) [3].

We go beyond merely reporting the existing findings and address the limitations of prior SLRs through the following research questions (**RQs**). **RQ1.** What is the present status of research in the field? **RQ2.** What are the primary areas or themes on which prior scholars have focused? **RQ3.** What gaps and limitations challenge the utility of the existing knowledge? **RQ4.** What are the avenues and methods through which this knowledge can be advanced?

We answer **RQ1** by developing a contemporary research profile that discusses the annual publication trends, geographic scope of the prior research, attributes of the investigated samples, and methodological approaches adopted. In response to **RQ2**, we employ a content analysis to examine the major thematic areas that prior scholars have explored, through which we identify existing knowledge gaps and consequential avenues for future research in response to **RQ3** and **RQ4**, respectively.

2.2 Review planning

A comprehensive search was performed on two databases for identifying appropriate literature—Web of Science (WoS) and Scopus. These databases were chosen for their extensive coverage of peer-review literature from multiple disciplines [67–70], including health informatics [54]. A preliminary search on Google Scholar was conducted with the keywords "mHealth," "intervention," and "cancer" to ascertain the relevance of search results and determine possible alternative or synonymous keywords for mining the databases. The first 100 articles from this search that were directly relevant to the study RQs were reviewed and led us to identify "m-Health," "m health," and "mobile health," as additional keywords. Thus, the database search was executed using the keywords of "mHealth," OR "m-Health," OR "m health," OR "mobile health," AND "intervention," AND "cancer". The Boolean operators of "OR" and "AND" were used to develop complex search strings for both databases (see Appendix 1 note for search string sample).

Once the search was complete, we applied specific pre-determined article selection criteria (i.e., inclusion and exclusion) to curate the relevant studies from the search results. The inclusion criteria included: (i) the article addressing mHealth interventions for cancer (for healthcare clients, cancer patients and survivors, caregivers, and HCPs); (ii) the use of empirical research methodology; (iii) the availability of the full text of an article; and (iv) publication in a peer-reviewed journal in the English language only. The exclusion criteria, meanwhile, were: (i) the absence of keywords—mHealth, interventions, and cancer—in the reviewed titles, abstracts, and keywords; (ii) publication in conference proceedings, book chapters, monographs, theses, and trade publications; (iii) duplicated results; (iv) protocol and trial registrations without empirical results; and (v) failure to meet the threshold of the quality evaluation (QE) criteria. The QE criteria were based on prior SLRs [54, 71] and included: (i) a focus on the specific form of a mHealth intervention; (ii) a detailed description of the methodology; (iii) the type of research approach (qualitative, quantitative, mixed methods); (iv) a detailed presentation of the results;

and (v) the pertinence of the discussion on the intervention's effect in the context of cancer. Each reviewed article was evaluated according to these criteria, and those that did not meet the threshold of 2.5 (out of 5 marks) were excluded from the dataset. Citation chaining (forward and backward citation search) was also performed to reduce the possibility of excluding relevant literature.

2.3 Review execution

The original review was systematically conducted on Scopus and WoS databases in January 2021 in three phases. We limited the search to articles published from 2014 onward to focus on the field's latest research developments. Our initial search led to the identification of 339 results from WoS and 253 from Scopus. Studies obtained from both datasets were compared, and duplicate search results were removed. In the first phase, three authors independently reviewed the titles, abstracts, and keywords to check for the absence of predetermined keywords (mHealth, intervention, and cancer) and full-text availability. The authors removed 81 studies at this stage for not meeting these article selection criteria.

In the second phase, three authors reviewed the remaining 192 articles' full texts and determined each paper's eligibility against QE criteria. 131 studies were excluded from further consideration, resulting in 61 viable studies. Lastly, backward and forward citations were conducted for these studies, which yielded six additional articles that met the QE criteria. Thus, the dataset developed from the original search included 67 studies. However, we re-ran the search on the databases between May 22 and 27, 2022, using the same search strings to update the dataset. In this search phase, we found 345 studies in both databases, 39 of which were removed for duplication, 261 for failing to meet article selection criteria and 34 for failing to meet QE criteria. The remaining 11 articles were subjected to citation chaining, which produced no relevant new studies. Thus, 11 more articles were added to the database, bringing the total number of included studies to 78. The SLR protocols depicted in Figure 1 reflect the collective data from both search processes in the dataset selection segment.

Insert Figure 1

In the third phase, three authors independently reviewed the articles' content in the final dataset to derive emergent research themes [57]. In alignment with the grounded theory approach [58, 60], the content analysis commenced with assigning open codes to each article based on their primary findings. Upon completing the independent open code assignment, the authors held a discussion to agree on a common set of open codes that best reflected the articles' content. Next, based on the commonalities among the content and open codes, the authors independently assigned axial codes, which were subsequently reviewed by other coders and mutually agreed upon. The coding process thus created a hierarchical structure wherein the dimensions, associations, and contexts discussed in all reviewed articles were grouped into inclusive themes representing the core ideas currently discoursed in the literature. We found that our open codes (e.g., the method used, type of cancer, respondent type, intervention type, and design) translated into six axial codes (affected respondents; methodological approach; adoption and resistance to intervention; intervention affordances; intervention target and types; and well-being outcomes). These axial codes were further structured into four themes discussed in Section 3: (i) intervention design and schematics, (ii) individual outcomes, (iii) methodological approaches, and (iv) intervention adoption and resistance.

Lastly, an expert panel was invited to review the coding process without incentives and ensure these codes' appropriateness. The panel comprised three academicians with publications in healthcare, information science, and human-computer interactions in ABS-ranked journals (3 and above). The panel suggested minor modifications in the description of two codes, which were then incorporated. The 11 newly added articles were also similarly subjected to the coding process, and our review found them to be integrated well into the developed themes. The themes discussed in Section 3 reflect the final categorization of the axial codes approved by this panel.

2.4 Analysis and reporting

This stage involved reporting the profile of articles included in the dataset and the explicated themes. We conducted a grounded theory-driven content analysis to analyze the 78 selected studies' findings (see Appendix 1) and derive the focal themes and incumbent gaps in the reviewed research. Subsequently, the authors developed a narrative synthesis of the findings and identified future research directions from each thematic gap, as reported in Section 3.

2.4.1 Research status and profile

The annual publication trend indicates a steady increase in research publications investigating mHealth interventions for cancer (Figure 2). Most studies have been conducted in the context of breast, prostate, and colorectal cancers and leukemia (Figure 3). Most of the reviewed studies developed and tested interventions for older segments of the population (n = 45) along with cancer patients (n = 44) (Figure 4). The investigated samples also suggest a significant bias toward female (n = 48) and Caucasian (n = 25) respondents (Figure 4), which indicates that the findings of these studies may present a skewed perspective. The geographic distribution of studies further indicates an overwhelming focus on the USA (n = 37) and other developing countries, such as Sweden (n = 5) and the Republic of Korea (n = 5) (Figure 5). This indicates a clear gap in studies oriented towards the development of mHealth interventions in the context of developing nations such as India, which should be addressed in future research. Lastly, most of the studies utilized randomized control trials (RCTs, n = 16) and interviews (n = 14) as a methodology (Figure 6), which suggests the need to adopt other methods in future studies, for example, mixed-method studies, for validating the existing knowledge.

Insert Figures 2–6

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3. Discussion: Focal themes of extant research

We identified four focal themes from the content analysis, which represent the current knowledge boundaries and central ideas investigated by prior scholars (see Figure 7). We also discuss theme-specific gaps and potential avenues for future research for each theme.

Insert Figure 7

3.1 Theme 1: Intervention design and schematics

3.1.1 Intervention types and targets

The majority of the extant research has focused on developing behavioral [18, 25, 27, 41, 63], and cognitive [72, 73] interventions and testing their feasibility [19, 21, 30, 62, 64, 74]. A few studies have also examined the utility of such interventions for educating clients, patients, survivors, and their caregivers [75–77]. However, most studies have focused on specific forms of cancer, such as breast [15, 78–80], colorectal [81, 82], and prostate cancer [2, 6, 37], while testing the efficacy of the designed interventions (see Appendix 1). These studies suggest that mHealth interventions can provide incremental learning to stakeholders and reduce their stress [75] while managing their diagnosis or treatment protocols.

Examining the interventions' delivery forms has also been subject to extensive research. For example, mHealth interventions for cancer have predominantly focused on the use of SMS text messages [16, 23, 74], wearable devices [29, 83], and mobile apps [14, 27, 41, 84, 85], as forms of delivery. Recent studies have also begun to integrate mHealth interventions with gamification [72, 86] and other smartphone features like location sensing [87], thereby providing deeper insights into how these interventions influence participants. For example, Krebs et al. [88] studied the feasibility of delivering a smoking cessation intervention for lung cancer patients through an app designed as a game. Recent studies have also examined the efficacy of using chatbots as a delivery form [64] and the viability of combining mHealth applications with personalized supervision [89]. However, studies have also indicated that respondents were skeptical about the absence of personal contact with HCPs and the subsequent lack of perceived guidance in managing symptoms or medications [41], [90] due to the design of the mHealth interventions.

3.1.2 Respondents affected

Furthermore, prior studies have primarily examined the efficacy of mHealth interventions from the perspective of cancer patients and survivors [25, 28, 91]. Few studies, conversely, have included HCPs [28, 90, 92] or informal caregivers [61], such as family members and parents [4, 93], as respondents, which has slightly limited the nature and depth of derived insights in terms of intervention content, design, and delivery. For instance, some scholars [94, 95] suggest that a mHealth intervention can act as a facilitatory mechanism for data/information sharing, providing support and training for clinicians and participants to use the intervention (app) features. Wittenberg et al. [61] further suggest that these interventions can also facilitate information exchange and communication among caregivers, which could address their concerns and lend emotional and practical support to these lesser-investigated stakeholders.

3.1.3 Intervention affordances

Affordances (design, features, and content) are critical drivers for the adoption and usage of mHealth interventions. Prior studies have indicated the positive influence of audiovisual features, such as a presentation mode [96], for example, larger vs. smaller screens [97], on the adoption and usage of an intervention. For example, the design of an intervention interface [20, 88, 98], the availability of a feedback platform [91], and the use of a graphical display to facilitate the understanding of prior reported symptoms [2] have been found to have a positive influence on respondents' experience of the intervention. For example, the content, features, and design of mHealth apps have been linked to better intervention outcomes [31], such as higher adherence [31], compliance [62], and personalization of suggested activities [99], for example, according to reported symptom patterns [95].

The findings also suggest that content design significantly determines users' experience and acceptance of an intervention. For example, using easily understandable and non-technical language predicted respondents' interest in using an intervention [25, 74]. At the same time, the type of content, such as reminders [74], prompts [22], and interrogative text [16], was also found to be a significant factor in determining an intervention's efficacy. Studies have further indicated that users of interventions, such as apps, desire higher levels of structure and personalization [41, 99]. However, while such personalization and its effects may be studied for apps developed especially for academic investigations [41, 98], it may present a challenge in the use or study of commercially available apps [20, 21].

3.1.4 Gaps and future scope

Despite the extensive study of intervention targets and affordances, the review indicates specific knowledge gaps and challenges regarding this theme. First, limited studies have explicitly focused on examining the appeal of different features [82], the temporal aspect of intervention schematics and design [31], as well as the efficiency of interactive audiovisual content vis-a-vis text-based content [26]. Future studies may conduct comparative and ranking studies to elicit users' preference for specific features to design more appealing interventions. For instance, the review suggests that a more robust focus on social-communication factors, human characteristics, and modality interactivity is required when considering the design of intervention affordances [97]. Scholars may also focus on the linguistics of information developed for different forms of content, that is, reminders, prompts, and interrogative content.

Second, scholars need to examine the degree of personalization and standardization in intervention design along with the pros and cons of such trade-offs [41]. Such personalization, for example, could explore the closer integration of family group members and caregivers along with HCPs to facilitate better communication and support for the target users [61, 62, 73, 77].

Third, the prior studies have been remarkably divergent in examining the types and stages of cancer, thus limiting the generalizability of the derived findings. Scholars need to focus on developing and testing interventions for advanced versus less advanced stages of cancer. Further studies should also be conducted to test mHealth interventions for other types of cancers, for example, non-metastatic, neurological, and pulmonary.

Lastly, very few studies have examined commercially available mHealth apps on iOS or the Google Play Store. Moreover, apps developed explicitly for academic investigations are constrained in terms of platform (iOS or Android) applicability [61]. Future scholars can address these limitations by focusing on developed apps' scalability and the usability of commercially available apps in managing cancer-related issues.

3.2 Theme 2: Individual outcomes

The review indicates that most research in the field has examined mHealth interventions' health-related outcomes. We classify these outcomes into two broad categories: (a) individual well-being and (b) clinical objectives.

In terms of individual well-being, prior studies have investigated the positive influence of mHealth interventions on individuals' QoL [100], as well as on their physiological [29, 83, 89] and psychological health [100, 101]. Extant studies have indicated that interventions promulgated improvement in respondents' experience of negative indicators of psychological well-being, such as anxiety [28, 93], and depression [20, 21]. For instance, contingent on the degree of use (moderate to high), mHealth apps can improve chronic fatigue and the overall QoL of cancer patients [102, 103]. The research has also suggested that mHealth interventions can lead to reduced fear [5, 82] and uncertainties [92, 93] surrounding treatment protocols and prognoses, which can lessen users' stress [25, 104] and provide them with a greater sense of security [2]. Although few studies in the dataset explicitly studied the effect of mHealth interventions on physiological well-being, such interventions have been effective in facilitating increased physical activity [29, 80], increased exercise [105], improved sleep [4, 104], increased monitoring of one's nutrition [106], and decreased fatigue [21, 25].

The majority of the prior research has also directed attention to examining mHealth interventions in terms of diverse clinical objectives, including the management of pain [27] or symptoms [4, 65], adherence to medication [107], and screening rates [108–110]. The review indicates that mHealth interventions can help HCPs, cancer patients, and survivors successfully meet these objectives and facilitate preventive behavior, such as screening for cancer markers, among regular clients (individuals) of healthcare systems. For example, studies have observed improved post-intervention screening rates and medication adherence [16, 27]. Thus, our findings indicate that mHealth interventions have definitive positive connotations for improving health-related outcomes associated with the pre-specified clinical objectives.

3.2.1 Gaps and future scope

The review indicates a gap in scholars' consideration of the affective dimensions of well-being, such as moods, emotions, and constructive social interactions. Furthermore, there is limited information on how mHealth interventions affect users' daily lives, for example, completing daily errands and routine activities, such as household chores or grocery shopping. The findings also suggest a limited focus on understanding the holistic influence of mHealth interventions on an individual's overall QoL across various aspects, particularly completing daily routines and psychological and physiological health. In terms of achieving clinical objectives, few studies have focused on examining the success of mHealth interventions in respondents' management of adverse drug reactions [27], potential biochemical complications [29], personal weight [104], and body mass index (BMI) [111].

Consequently, we suggest that future studies consider a more comprehensive and holistic outlook on measuring QoL in the three aforementioned aspects. Studies should also focus on elucidating the potential impact of mHealth interventions on a user's affective state, that is, their moods and emotions. Scholars should especially focus on understanding how mHealth interventions interact with and affect individuals' lives to facilitate or inhibit their engagement with routine activities. This would help scholars uncover methods through which these interventions can be converted into habitual behaviors [16], thus leading to their higher success rate.

3.3 Theme 3: Methodological approach

The review indicates relatively narrow research approaches among the extant literature. Notably, only a few studies had intervention designs that were theoretically grounded. Of these articles, scholars utilized the Social Cognitive Theory [86], Self-Determination Theory [76, 86], Narrative Transportation Theory [86], the Player Experience of Need Satisfaction Model [76], Technology Acceptance Model [33], and the Unified Theory of Acceptance and Use of Technology [61]. Moreover, the findings show a significant focus on specific methodologies, such as randomized control trials (RCTs) [40, 112, 113], focus group discussions (FGDs), [90, 114] and interviews [41, 98, 115]. However, recent studies have also begun to adopt mixed-method research designs [5, 19, 38, 74, 78, 116] to garner deeper insights into the effect of mHealth interventions on respondents' well-being [117] and clinical outcomes.

The review also indicates a significant bias in terms of the sample and respondents (see Appendix 1, Figure 4). Prior studies seemed to have majorly focused on females [36, 78, 98, 114] and respondents of Caucasian ethnicity [21, 84, 91]. Few studies have studied the effects of mHealth interventions on vulnerable sections of the population, such as immigrants [79], or ethnic groups such as Koreans [114] or Chinese Americans [107]. The findings also suggest a differential examination of age cohorts' influence on users' responses to mHealth interventions. Most studies have reported results for respondents from specific age groups, such as adolescents and young adults [5, 16, 39] and older individuals [19, 37]. Yet, few scholars have reported comparative responses of intervention users from different age groups [7, 14, 15, 78, 90].

3.3.1 Gaps and future scope

We argue that current knowledge is constrained due to this domain's use of techniques such as RCTs. While RCTs are one of the most popular methodologies in this area, they are limited by the applicability of their derived findings to real-life scenarios [64]. Moreover, extant studies have reported small effect sizes [28] and biased or small samples [24, 91] as limitations. Based on these findings, we posit that most studies in this domain offer insights based on a short-term outlook that may not be sustainable in the long run. Thus, we emphasize the need to adopt more longitudinal studies to generate knowledge on the temporal stability of mHealth interventions and users' continuance intentions [19].

Furthermore, it may be beneficial to conduct more cross-sectional studies with larger and more diverse samples [29] to increase the reproducibility [109] and generalizability of the findings [5, 91]. For example, future studies may examine cultural and ethnic factors, such as communication norms in a particular ethnic or cultural group, that may influence the success of a mHealth intervention [5]. Lastly, to improve the generalizability and accuracy of the findings, future studies should incorporate more objective measurements of responses [32, 91], such as through log data, which can counteract some of the previously noted limitations, such as social desirability bias [26, 84].

Future scholars should also consider examining more vulnerable populations, such as pediatric and geriatric patients and clients belonging to high-risk groups. Studies should also focus more on including multiple stakeholders, particularly HCPs such as doctors, nurses, and caregivers, along with parents and other familial/peer support group members. These stakeholders can offer more diverse and nuanced insights about an individual's interaction with an intervention.

Lastly, the SLR revealed the minimal use of theoretically grounded models and frameworks in this domain [32]. It would thus be beneficial for scholars to use seminal theories from fields such as biology, medicine, information systems science, and psychology to examine the factors associated with mHealth interventions' successes and failures. For example, scholars could explore the influence of individual characteristics [6, 91, 114], such as sociodemographic factors (e.g., educational background, occupation) and personality traits on the adoption and use of mHealth interventions. Scholars can thus utilize theories like the Technology Acceptance Model [33], Biopsychosocial Model [83], and Behavioral Reasoning Theory (BRT) [118] toward this end.

3.4 Theme 4: Intervention adoption and resistance

The least explored theme in the prior literature pertains to specific factors that may encourage or inhibit a respondent's use and recommendation of an intervention [20]. Such factors can be classified across two dimensions: social context and perceived facilitators or barriers. In terms of social context, factors such as perceived support [81], familial encouragement [81], and integration with current HCPs' guidance significantly influenced users' perception of an intervention.

Scholars have proposed that factors that might positively facilitate the use of an app include perceived convenience [33] and concern for personal health [3, 30, 73]. Moreover, psychological motivators and their motivational value [62], such as perceived control [99], may also act as facilitators of an intervention's adoption or use. Multiple studies have also indicated that despite offering perceived benefits [114], interventions may be met with resistance due to certain barriers that have been investigated more when compared to benefits [119]. For example, scholars have observed that mHealth interventions caused significant concerns among respondents regarding the costs associated with intervention use [23, 63, 91], as well as data transmission [79], confidentiality, security [63], and privacy concerns [73, 82, 92]. Furthermore, older respondents indicated a lack of technological know-how [91] and the learning curve needed to enable them to practice using the intervention and become comfortable with its interface [78].

3.4.1 Gaps and future scope

We urge scholars to utilize seminal consumer behavior theories to study attitude, reasons for adoption, and intention to continue or use, such as the BRT [118], the Theory of Planned Behavior (TPB) [120], and the Theory of Reasoned Action [121]. Such theoretically grounded frameworks can help scholars develop a more nuanced understanding of respondents' behavior toward m-health interventions. In turn, this understanding can enable scholars to elucidate appropriate ways to educate consumers about these interventions' usage [98], enhance their adoption, and reduce perceived barriers. We also recommend that scholars investigate the motivations and purpose of use, which could act as facilitators of these interventions. Scholars should also focus more on investigating the socioenvironmental [83] and human aspects that affect an intervention's targeted users [97].

Furthermore, given the complexities of managing a chronic disease like cancer through technological interventions, we posit the need to adopt a multidisciplinary approach by incorporating knowledge from multiple disciplines, such as information systems, human-computer interactions, medicine, and management. Lastly, we emphasize the importance of considering the financial, technical, and economic implications of using a mHealth intervention [63, 91]. Although these concerns can negatively affect users' experience, few studies in the extant literature have investigated their effect [90].

4. Conclusion

The present SLR provided a comprehensive outlook of the state-of-the-art knowledge on mHealth interventions for cancer. The study raised and addressed four RQs to present a detailed discussion on the current research profile (**RQ1**), thematic focal research areas (**RQ2**), gaps in existing knowledge (**RQ3**), and potential avenues to further advance this field of study (**RQ4**). We instituted a rigorous protocol to address these **RQs**, curating a dataset of 78 studies, which were reviewed and analyzed through content analysis and narrative synthesis to derive pertinent insights.

Our findings indicate that mHealth interventions provide significant support to cancer patients and survivors, as well as to their caregivers, including HCPs and family members. Four main thematic areas were identified as the focal aspects of extant investigations: intervention design and schematics, individual well-being and related outcomes, methodological approaches, and factors associated with intervention adoption and resistance. Furthermore, we presented existing gaps in the academic knowledge that future scholars can address to expand the current intellectual boundaries of this area. Our findings thus raise important implications for theory and practice.

4.1 Implications for theory

Our study offers five critical implications for theoretical advancement in the area. First, our findings imply the need to explore other potential platforms for delivering mHealth interventions, for example, social media apps like WhatsApp. These platforms can be used to provide cancer patients, survivors, and their caregivers with prompt support while addressing evident concerns about personal contact or guidance from HCPs. A comparative assessment of existing app-based platforms may be made with these potential new ones to understand their efficacy and the possibility of creating hybrid interventions that combine the best of conventional and emerging platforms.

Second, the SLR reveals the need to conduct more longitudinal and mixed-method studies using objective data. Such methodological advancements can facilitate scholars' understanding of the long-term effects of mHealth interventions among different, especially vulnerable, sections of the population.

Third, our study underscores the need to focus more on understanding the behavioral perspectives of multiple stakeholders. These groups, such as HCPs, caregivers, and family members, often provide moral, emotional, and physical support to cancer patients and survivors. Integrating these stakeholders' experiences and perspectives would generate a more holistic and comprehensive outlook on the efficacy of mHealth interventions.

Fourth, the findings indicate the need to incorporate seminal consumer behavior theories, for example, TPB [122] and BRT [118], in future studies to configure details about stakeholders' attitudes and intentions towards mHealth interventions. Scholars may also employ theories of communication and linguistics to study more effective forms of content generation and delivery to educate consumers about the benefits and proper use of mHealth interventions.

Lastly, the review implies the need to utilize more multimedia tools to increase user engagement with different delivery forms of mHealth interventions. For example, scholars may focus on studying the use of more audiovisual and interactive forms of content (e.g., through gamification) to induce users to use the intervention continually.

4.2 Implications for practice

We offer four key implications for practitioners, such as app developers, healthcare personnel, and medical practitioners. First, the findings indicate the need to develop and adapt new and existing mHealth interventions in deep collaboration with HCPs and frontline caregivers, such as nurses. Such individuals may provide more in-depth and nuanced insights into the engagement and utilization of mHealth interventions by cancer patients and survivors. The collaborative development and adaptation of interventions with these HCPs can thus yield beneficial results.

Second, we highlight the need to consider existing healthcare infrastructure while developing mHealth interventions to ensure their scalability and widespread execution. This would require practitioners to consider the limitations of legacy healthcare systems, which could serve as the database and point of communication for multiple stakeholders, including patients and HCPs.

Third, intervention (mobile app) developers should consider the possibility of integrating multi-method communication platforms within the intervention design. Developers should also create more interactive features, such as mutual feedback platforms and graphical illustrations of patients' prior reports, to facilitate the interventions' ease of use and users' understanding of the data. However, developers should also concurrently consider the financial costs of interventions and try to reduce the economic and monetary burden for the users.

Lastly, there is a need to consider the data security and privacy protection concerns while developing mHealth interventions. Intervention developers should keep in mind the legal policies surrounding the use and protection of medical data, such as HIPPAA, to ensure that their interventions meet the highest ethical and legal compliance standards.

4.3 Limitations and future scope

Although our study followed a robust protocol, it is constrained by certain limitations. First, our study considered only two databases (WoS and Scopus). While we consider these databases to have provided significant coverage of existing literature, future scholars may consider other databases, such as ACM for more technically-oriented studies and MedLine and PubMed for gathering more insights from the medical domain. Second, our sample was restricted to journal articles based on the criteria chosen for selection (inclusion and exclusion). These limitations may have thus led to the exclusion of some relevant literature. Future SLRs may consider other article selection criteria and publication sources, such as conference proceedings, book chapters, theses, trade publications, and monographs, to expand on our study's findings.

Third, our sample considered studies published up until May 2022. Future scholars may, therefore, consider analyzing and including studies published after our study's conclusion. Fourth, our search strategy considered mHealth (and mobile health) interventions as an umbrella term and did not consider other keywords, such as SMS text-based interventions, wireless technology, and telemedicine. Future studies may consider such keywords to derive broader insights into the application of mHealth interventions for managing cancer. Lastly, despite the rigorous protocols followed by the authors for the dataset curation and content analysis of the selected studies, the process was privy to subjective evaluation and incumbent bias. Future scholars may conduct meta analyses to garner more objective knowledge about more effective forms and features of such mHealth interventions.

Despite these limitations, our study offers vital insights into the application of mHealth for managing cancer treatment, medication adherence, and prognosis management from a multi-stakeholder perspective, including patients, survivors, caregivers, and healthcare providers. Future scholars may further expand the academic knowledge in this domain by addressing the above limitations to derive more valuable implications for integrating mHealth interventions for the relevant stakeholders.

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Figure 1. SLR protocols and process

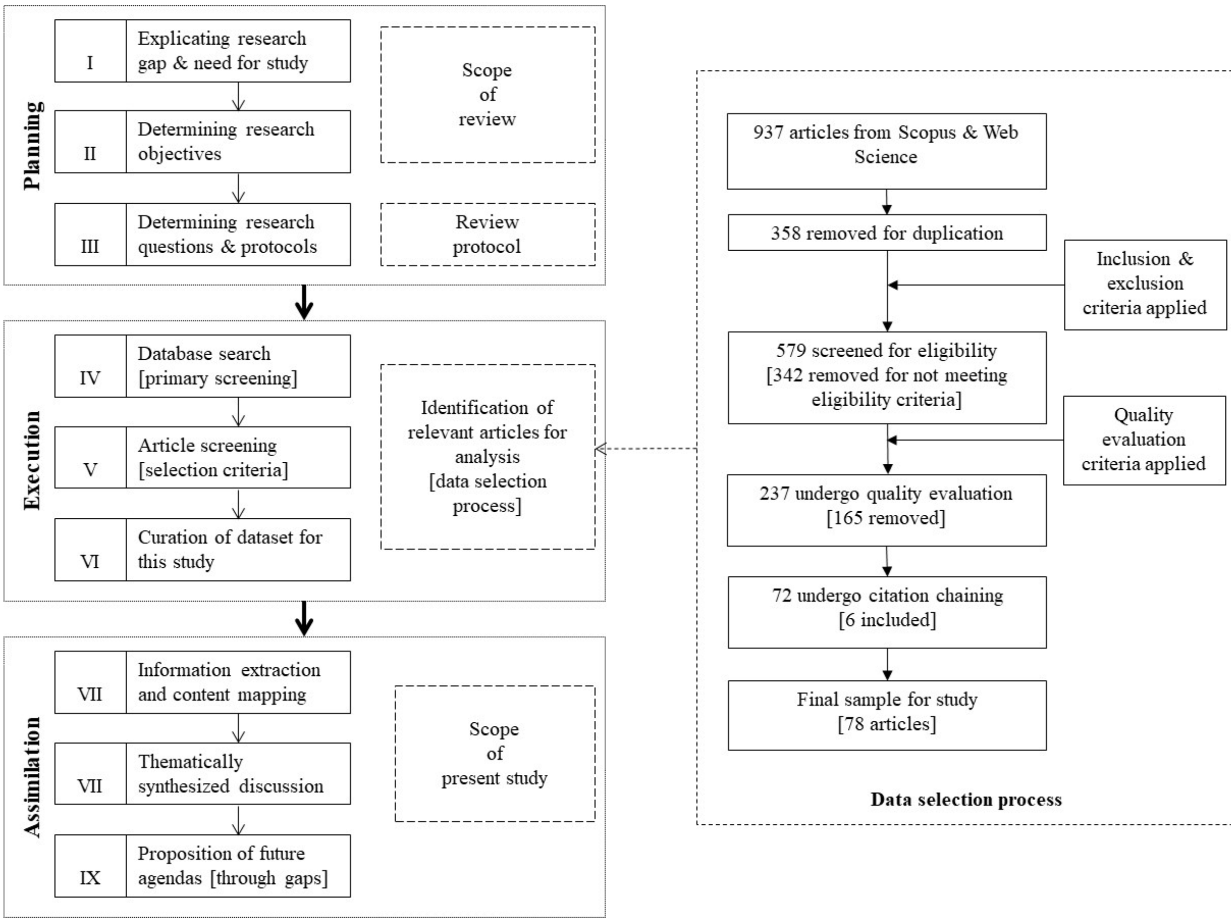


Figure 2. Annual scientific production of research studies

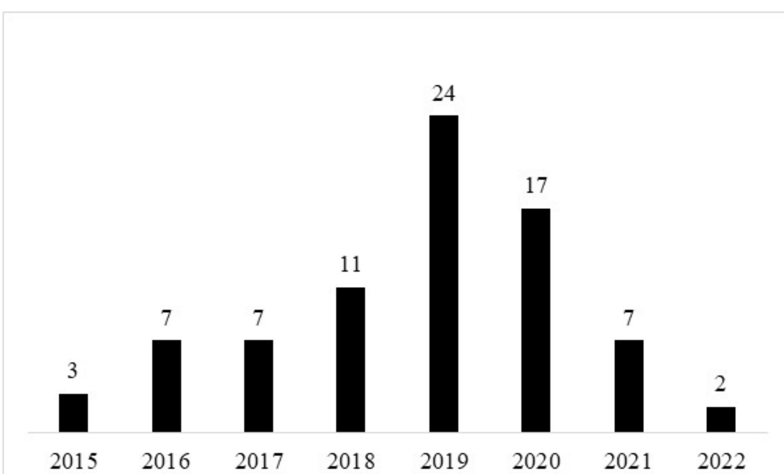
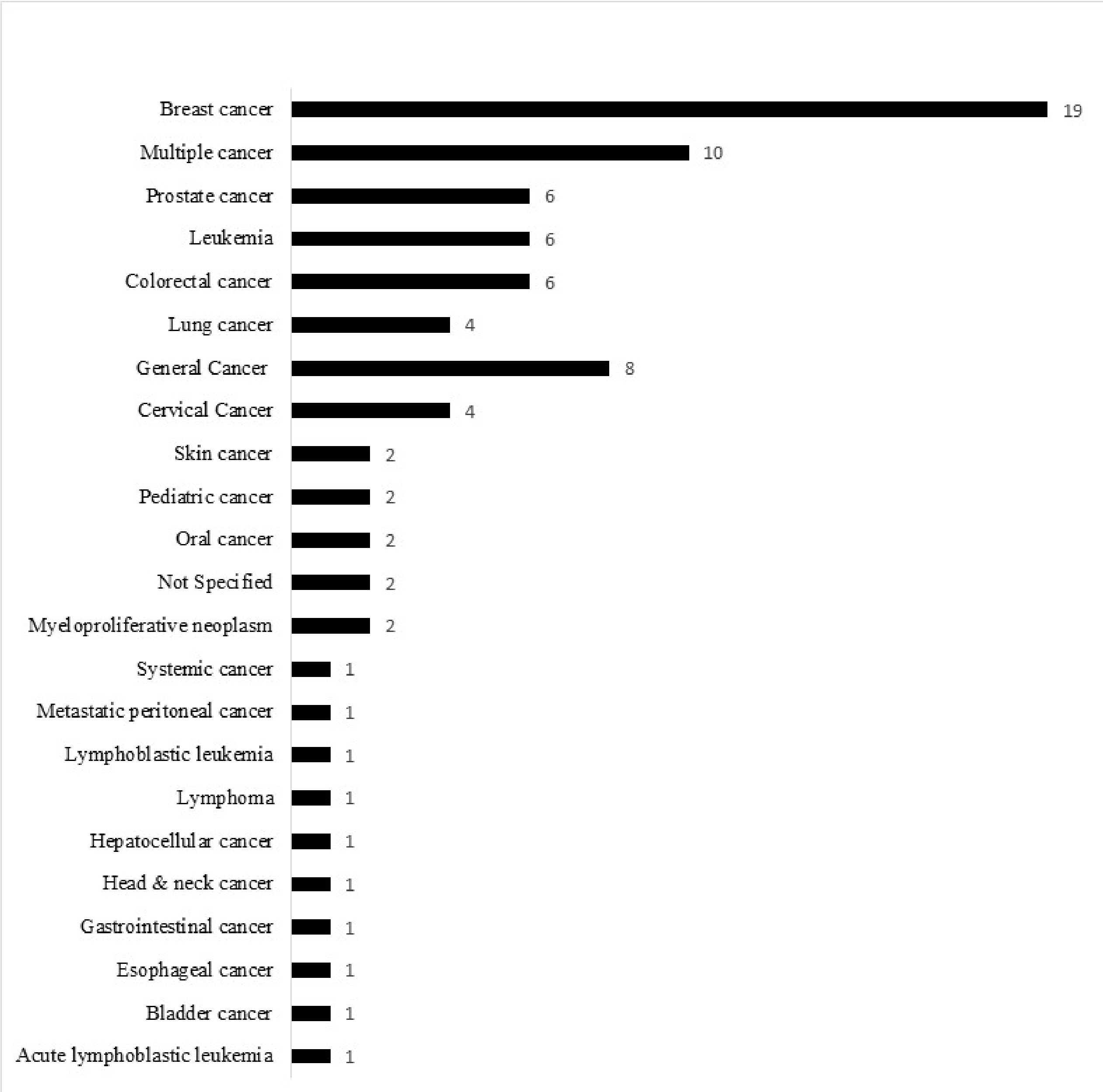
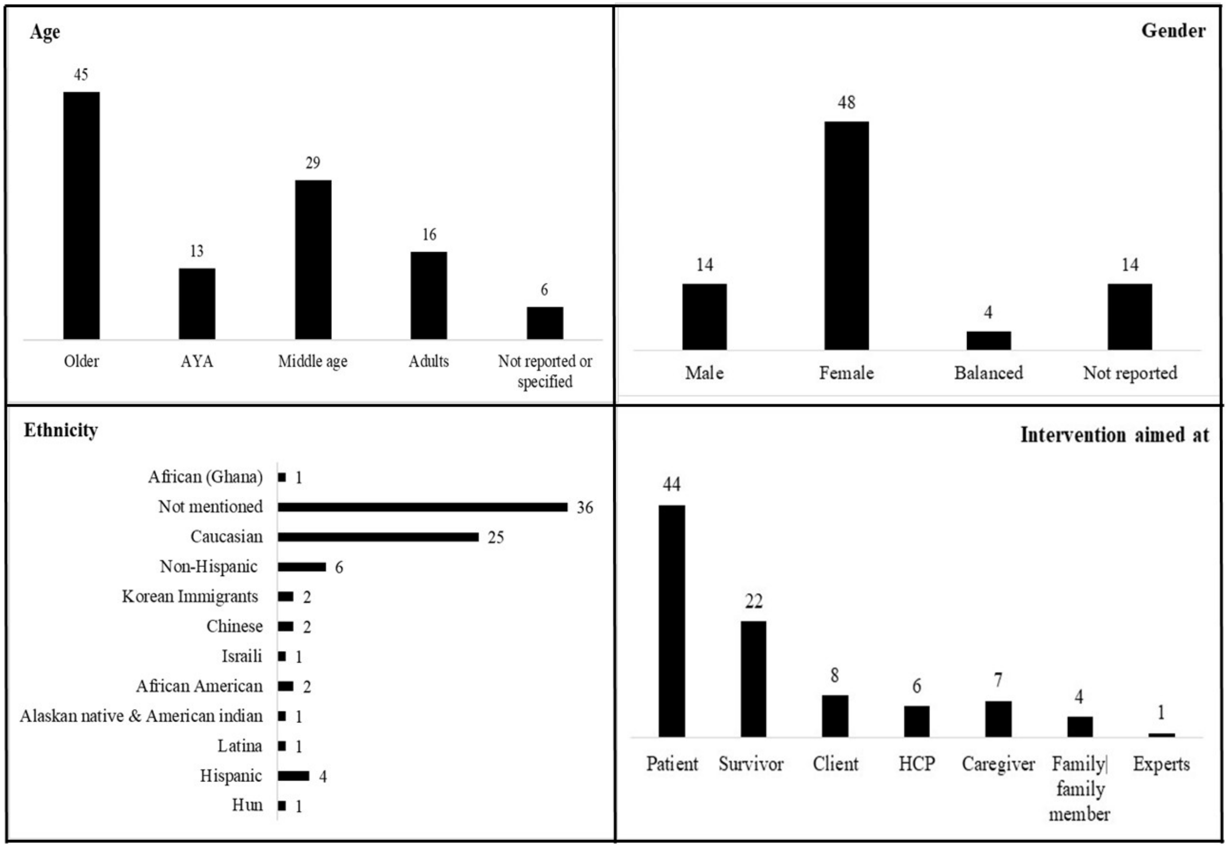


Figure 3. Type of cancer examined for intervention



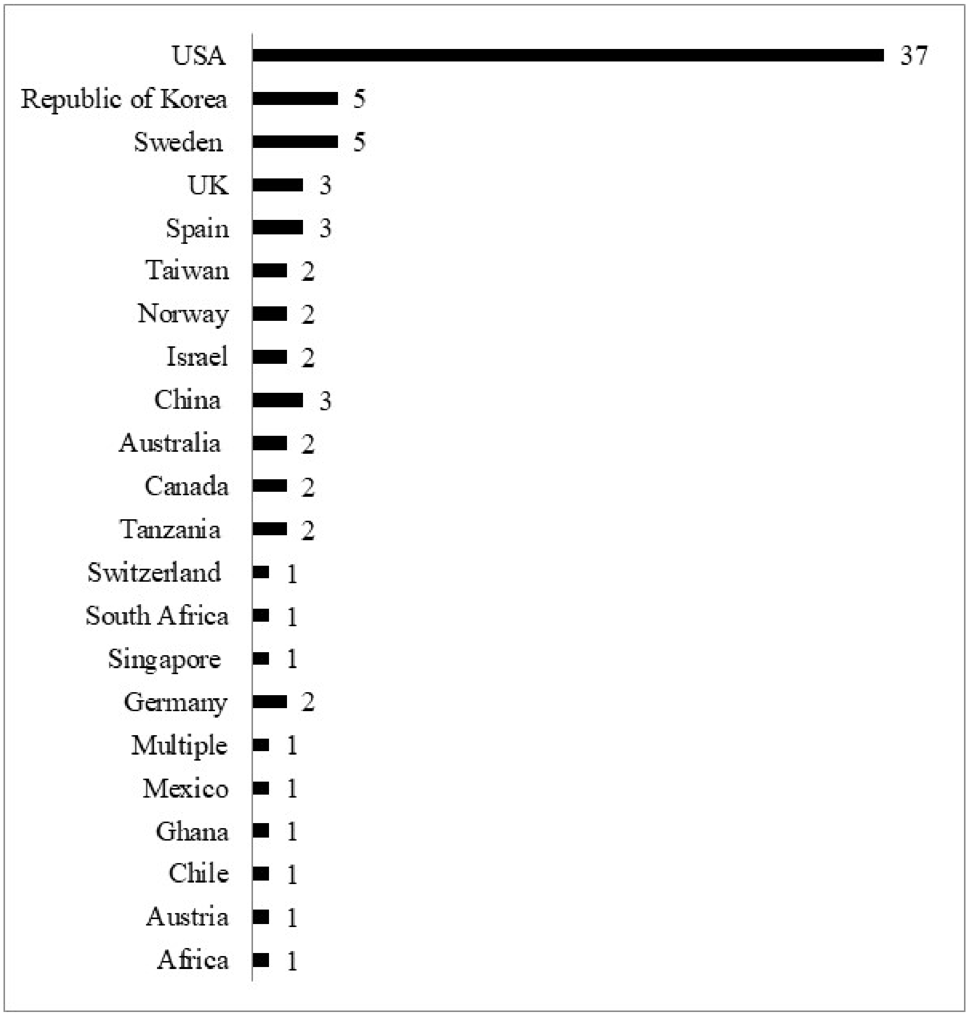
Note: Types include the predominant form of cancer reported by reviewed articles. Four articles in databases included interventions targeted at HCP for general cancer patient management and these have been included in the category of general cancer in this figure.

Figure 4. Sample distribution and attributes



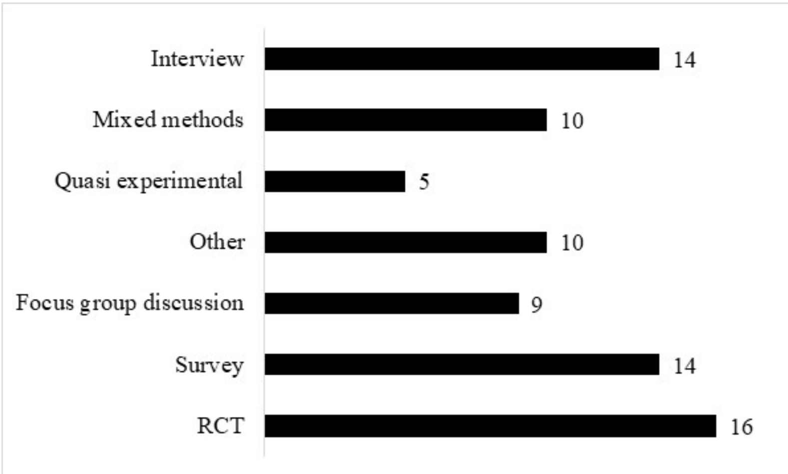
Note: AYA = adolescent and young adults, <= 24 years; HCP = healthcare provider; adults: 25–40 years; Middle age: 41–55 years; Older: >= 55 years; Client: individuals under healthcare system who should be screened. Some studies have included participants from multiple sample groups with varying ages and different gender weightages, multiple cohorts (patients, survivors, HCP, and clients), and ethnicities, due to which the absolute count exceeds the total number of studies.

Figure 5. Geographic scope of studies



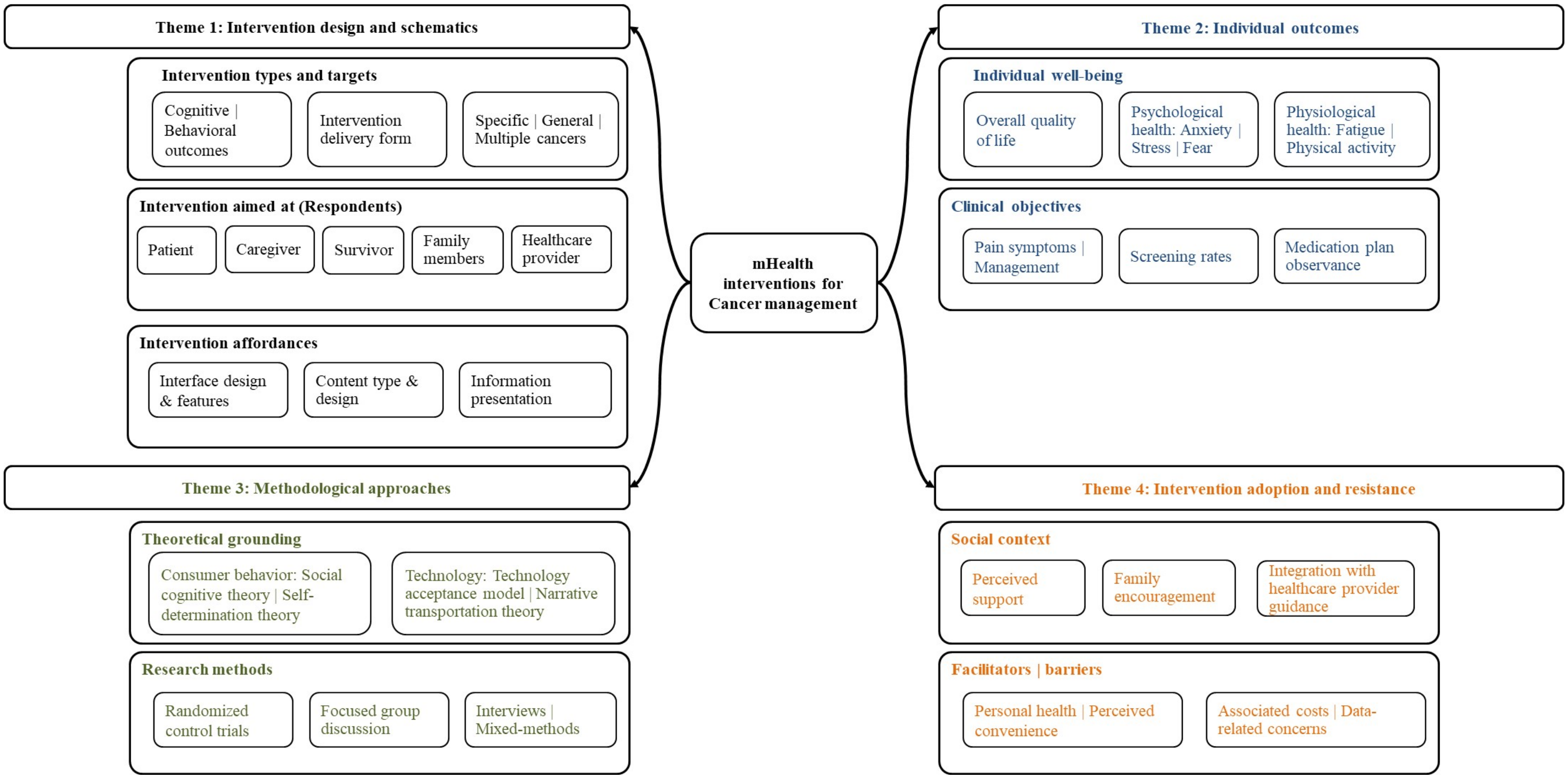
Note: Some studies have considered respondents from multiple countries, with one study considering 21 countries from the African region. This study's geography has simply been noted as Africa for better text presentation.

Figure 6. Prevalent methodologies



Note: RCT = randomized control trials, Other = data reported as obtained through nested qualitative study and journey mapping. See Appendix 1 for more details.

Figure 7. Graphical representation of themes and incumbent issues



Appendix 1. Description of studies in the dataset

Author (year) country	Sample	Gender	Focus	Ethnicity	Method	Aimed at (the type of cancer)	Aspects studied
Bonful et al. (2022) Ghana	N = 130 M_{age} = 28.5 Communities M_{age} = 28.2 Banks M_{age} = 28.8	Female	Young	African (Ghana: Akan, Ga/Dangme, Ewe, Dagbani, Dagaari, Kasem)	Focus group discussions and Chi-square tests	Patient (cervical cancer)	Behavioral (preferences of women regarding the modalities, willingness to receive health)
Spahrkäs et al. (2022) Multiple	N = 335 M_{age} = 57.4	Female	Adult, middle age, older	n.s.	Longitudinal multi-categorical multiple mediation analysis using PROCESS	General cancer patients and survivors	Behavioral (change in fatigue severity, interference)
Azizoddin et al. (2021) USA	N = 14 N.	n.s.	n.s.	n.s.	Interview	General cancer patients	Behavioral (acceptability)
Bade et al. (2021) USA	N = 40 M_{age} = 64.88	Female	Older	Non- Hispanic	T-Test and Chi-Square	Lung cancer patients (adenocarcinoma, squamous cell carcinoma, other or mixed histology)	Participation, satisfaction
Blair et al. (2021) Mexico	N = 54 M_{age} = 69.6	Female	Older	Hispanic, Non-Hispanic	Descriptive statistics, Linear mixed methods	Survivors (breast, prostrate, and others)	Feasibility, acceptability, and efficacy, behavioral (physical activity, physical performance, QOL)
King-Dowling et al. (2021) USA	N = 224 (App Group = 110, SCP = 114) App M_{age} = 20.5 SCP M_{age} = 20.2	App = Male Female SCP = balanced	AYA	Hispanic, Non-Hispanic (White)	Quantitative (Spearman's nonparametric rank correlation), interviews	Cancer survivors (leukemia /lymphoma, solid tumor, brain tumor)	Acceptability and feasibility, engagement
Mikolasek et al. (2021) Germany	N = 100 M_{age} = 53.2	Female	Adult, middle age, older	n.s.	Descriptive statistics and interviews	Patients (breast cancer, colon cancer, ovarian or	Behavioral (feasibility effectiveness, adoption, implementation, and

					mixed methods	cervical cancer, lung cancer)	maintenance
Psihogios et al. (2021) USA	N = 110 M_{age} = 20.51 Age at cancer diagnosis M_{age} = 9.75	Male	AYA	Hispanic and Non- Hispanic	Linear regressions, qualitative (interviews)	Survivors (leukemia/lymphoma, solid tumor, brain tumor, had relapse or second cancer)	Behavioral (engagement)
Schroeder et al. (2021) Tanzania	N = 40 n.s.	n.s.	AYA	n.s.	Descriptive statistics using mean and SD value	Pediatric patients and caregiver	Behavioral (acceptability), patterns and use of mobile phone
Beer et al. (2020) USA	N = 19, M_{age} (survivor) = 64.6, M_{age} (family) = 58.6	Female	Older	African American	Focus group discussion, Chi-square	Survivor (lung cancer), family members	Behavioral (intent to adopt), cognitive (attitude and acceptance)
Børøsund et al. (2020) Norway	N = 25, M_{age} = 48	Female	Middle-aged	Caucasian	Interview, statistical analysis (correlation, t-test)	Survivor (breast cancer)	Feasibility, behavioral (stress management)
Cai et al. (2020) USA	N = 7, M_{age} = 60	Female	Middle-aged	Caucasian	Daily survey (correlation)	Patient (breast cancer)	Behavioral (semantic location), cognition (mental health)
Cheng et al. (2020) China	N = 20 M_{age} = 62.20	Male	Adult, middle age, older	n.s.	Paired t-tests, chi-square tests, descriptive analyses	Patients (esophageal cancer)	Feasibility, safety, and efficacy, use of mobile application
Crafoord et al. (2020) Sweden	N = 149, median age (breast cancer) = 47; median age (prostate cancer) = 72	n.s.	Middle-aged, older	n.s.	Mixed method	Patient (breast and prostate cancer)	Behavioral (symptom management and self-care)
Fjell et al. (2020) Sweden	N = 149 (74 intervention, 75 control), M_{age} (intervention) = 48 (SD 10.6); M_{age} (control) = 50 (11.6)	Female	Middle-aged	n.s.	RCT	Patient (breast cancer)	Cognition (health-related QOL, symptom burden)
Fuemmeler et al. (2020) USA	N = 15, M_{age} = 14.8 (SD = 1.97)	Male	AYA	Caucasian	Quasi-experimental single-group pretest/posttest design	Survivors (general), parents (family)	Behavioral (physical activity, healthy diet)
Hohl et al. (2020)	N = 13, M_{age} = 47	Female	Middle-aged,	Caucasian	Focus group	Survivors	Behavioral (post-surgery

USA			older			(colorectal cancer)	screening)
Hou et al. (2020) Taiwan	N = 112, 45.5% aged 50–64 years	Female	Middle-aged, older	n.s.	RCT	Patients (breast cancer)	Behavioral (QOL management)
Kim et al. (2020) Republic of Korea	N = 31, M_{age} = 56.7 (SD 7.7)	Male	Older	n.s.	Survey (usability study)	Patients (hepatocellular cancer)	Behavioral (physical exercise promotion)
Low et al. (2020) USA	N = 15, M_{age} = 49.7	Female	Middle-aged	Caucasian	Daily experience reporting (single-arm pilot)	Patients (metastatic peritoneal cancer)	Feasibility, usability, behavioral (sedentary activities)
Lozano-Lozano et al. (2020) Spain	N = 80, M_{age} (mHealth only) = 49.76 (SD 8.42), M_{age} (mHealth and rehabilitation) = 53.40 (SD 8.66)	Female	Middle-aged,	n.s.	RCT	Survivors (breast cancer)	Behavioral (QOL and functional outcomes management)
Monteiro-Guerra et al. (2020) Spain	N = 14, M_{age} = 52.8 (SD 8.8)	Female	Middle-aged, older	Caucasian	Interview	Survivors (breast cancer)	Behavioral (physical activity)
Nielsen et al. (2020) USA	N = 30, M_{age} = 45.5 (SD 9.6)	Female	Middle-aged, older	Caucasian	Interview	Survivors (breast cancer)	Behavioral (physical activity), cognition (preference of features)
Rozwadowski et al. (2020) USA	N = 166 (family as unit)	n.s.	AYA, middle-aged	n.s.	Interviews	Patients and caregivers (general)	Behavioral (effectiveness)
Spahrkäs et al. (2020) Australia, Canada, UK, USA	N = 799, M_{age} = 55.5 (SD 9.79)	Female	Older	n.s.	Waiting list, RCT	Patients (multiple, majorly breast cancer)	Behavioral (chronic fatigue and QOL management)
Wang et al. (2020) Taiwan	N = 100, M_{age} = 57.01 (SD 8.87)	Male	Older	n.s.	Quasi-experimental, Survey	Patients (Oral cancer)	Behavioral (care needs and QOL improvement)
Allsop et al. (2019) Africa (21 countries)	N = 51, n.s	n.s.	n.s.	n.s.	Survey	HCP	Behavioral (palliative care provision)
Erwin et al. (2019) Tanzania	N = 866, M_{age} = 34 (SD 7.2)	Female	Adults	n.s.	RCT	Clients (cervical cancer)	Behavioral (screening rates)
Greer et al. (2019) USA	N = 145, M_{age} = 56.45 (SD 11.3)	Female	Older	Caucasian	RCT	Patients (multiple types of incurable	Cognitive, behavioral (Managing anxiety,

						cancer)	depression, QOL)
Hagoel et al. (2019) Israel	N = 1621 48.79% > 60 years	Female	Older	n.r.	Prospective cohort intervention	Clients (colorectal cancer)	Behavioral (screening rate)
Henshall and Davey (2019) UK	N (focus group) = 21, N (usability) = 6, 52.4% aged 40- 79 years	Female	Middle-aged, older	Caucasian	Focus group, development, and usability	Patients and survivors (lung cancer), HCP, family members	Behavioral (symptom management, exercise)
Huberty et al. (2019a) USA	N = 128 (94 completed), M_{age} = 58 (SD 12)	Female	Older	Caucasian	Survey	Patients (myeloproliferative neoplasm)	Feasibility, behavioral intervention (meditation)
Huberty et al. (2019b) USA	N = 128, M_{age} = 59 (SD 10)	Female	Older	Caucasian	Interview	Patients (myeloproliferative neoplasm)	Feasibility, behavioral (meditation)
Ji et al. (2019) Korea	N = 64, M_{age} (Group 1) = 57.97 (SD 9.868) & M_{age} (Group 2) = 60.50 (SD 10.198)	Male	Adults, middle-aged, older	n.r.	Prospective clinical trial	Patients (non-small cell lung cancer)	Behavioral (pulmonary rehabilitation)
Krebs et al. (2019) USA	N = 38, 40% in R_{age} 50 – 59 years	Female	Older	Caucasian	RCT	Patient (lung cancer)	Behavioral (smoking cessation)
Kubo et al. (2019) USA	N = 128, median age (patient) = 59, median age (caregiver) = 63	Female	Older	Caucasian	RCT	Patient (multiple types—majorly breast and hematologic cancer), informal caregivers	Feasibility, cognitive (mindfulness)
B.J. Lee et al. (2019) Republic of Korea	N = 96, M_{age} (smartphone) = 69.06 (SD 7.21), M_{age} (pedometer) = 69.82 (SD 7.73)	n.s.	Older	n.s.	Prospective randomized, open-label trial	Patients (prostate cancer)	Behavioral (comparative physical activity promotion)
Lozano-Lozano et al. (2019) Spain	N = 73, M_{age} = 51.35 (SD 8.58)	Female	Middle-aged	n.s.	Prospective quasi-experimental pre-post study	Survivors (breast cancer)	Feasibility (monitoring energy balance, inflammation markers)
Moodley et al. (2019) South Africa	N = 364, Median age = 29	Female	Adults	n.r.	Mixed method	Clients with precursors (cervical cancer)	Feasibility, behavioral (follow up, management of abnormal results)
Niu et al. (2019)	N = 134, M_{age} = 19.94	Female	AYA	Caucasian	Experiment	Clients (skin	Behavioral (prevention)

USA	(SD 2.22)				(ANCOVA, t-test)	cancer)	
Piau et al. (2019) USA	N = 9 (52 evaluations), M_{age} = 83.4 (SD 2.1)	Male	Older	n.r.	Survey	Patients (lymphoma, myelodysplasia, & myeloid leukaemia)	Feasibility, behavioral (symptom reporting & adherence)
Phillips et al. (2019) USA	N = 96, M_{age} = 55.8 (SD 10.2)	Female	Middle-aged, older	Caucasian	Mixed method	Survivors (breast cancer)	Cognition (education, information), behavioral (physical activity)
Psihogios et al. (2019a) USA	N = 29	n.r.	AYA, adults	Non-Hispanic	Focus group discussion, directed content analysis	Survivors and parents (family) (leukemia/ lymphoma)	Cognitive, experience
Psihogios et al. (2019b) USA	N = 26 M_{age} = 16.42 (SD 2.87)	Female	AYA	Caucasian	Statistical (longitudinal piecewise linear regression)	Cancer survivors (lymphoma/ leukemia)	Cognition (education/ information) & behavioral (engagement)
Roberts et al. (2019) UK	N = 32, M_{age} = 60 (SD 11)	Male	Older	Caucasian	Interview	Survivor (prostate cancer)	Experience, behavioral (physical activity)
Russell et al. (2019) Australia	N = 18, n.r.	n.r.	n.r.	n.r.	RCT	Patients (oral cancer)	Behavioral (medication adherence)
Smith et al. (2019) USA	N = 45, M_{age} (patients) = 67, M_{age} (caregiver) = 55	Female	Older	Caucasian	Interview (thematic analysis)	Patient, HCP, caregiver (bladder cancer)	Cognitive (educational)
Tark et al. (2019) Estonia	N = 9, M_{age} = 9.1 (SD 1.5)	Male	AYA	n.s.	Interview and in-game qualitative data analysis	Patient (pediatric cancer)	Cognitive (educational, psychological support), behavioral
Wittenberg et al. (2019)	N1 = 5, N2 = 26, N3 = 6, n.r.	n.r.	n.r.	n.r.	Survey	Caregivers (type n.s)	Acceptability, feasibility
Yang et al. (2019) China	N = 58, M_{age} (control group) = 53.96 (SD 8.58), M_{age} (Pain Guard App) = 51.10 (SD 8.98)	Male	Adults, middle-aged, older	Chinese	RCT	Patients discharged from hospital treatment (type n.s.)	Behavioral (pain management)
Ainsworth et al. (2018) USA	N = 40, M_{age} = 55 (SD 8)	Female	Older	Caucasian	Mixed methods	Survivor (breast cancer)	Acceptability, behavioral (time use)
Ali et al. (2018) Singapore	N = 409, 43.5% aged 21-54 years	Female	Adult, middle-aged	Chinese	Survey	Patients (breast cancer)	Cognitive (educational), behavioral (medication adherence)

Børøsund et al. (2018) Norway	N = 48, R_{age} = 31–81 years	n.r.	n.r.	n.r.	Journey map (design, development, usability testing)	Survivors, HCP, e-health experts, stress management experts	Behavioral (stress management)
Cowie et al. (2018) USA	n.s.	n.s.	n.s.	n.s.	Focus group discussion, interviews (usability testing)	Patient (head & neck cancer)	Feasibility, behavioral (swallowing exercise)
Jibb et al. (2018) Canada	N = 20, M_{age} = 14.4	Balance	AYA	n.r.	Nested qualitative study	Patients (acute lymphoblastic leukemia)	Feasibility, behavioral (pain management)
Lee et al. (2018) South Korea	N = 88, M_{age} = 47.3 (SD 7.7)	Female	Middle-aged	n.r.	Statistical (mean, standard deviation)	Patients (breast cancer)	Behavioral (exercise)
H.Y Lee et al. (2018) USA	N = 14, M_{age} = 50.57 (SD 6.64)	Female	Adult, middle-aged	Korean (immigrants)	Focus group discussion	Client (breast cancer)	Behavioral (screening rates)
Loh et al. (2018) USA	Patients N = 18, M_{age} = 76.8, Caregivers N = 13; M_{age} = 69.8	Male patients & female caregivers	Older	Caucasian	Mixed method	Patients (systemic cancer)	Feasibility & satisfaction (geriatric assessment for morbidity & mortality)
Raghunathan et al. (2018) USA	N = 631, M_{age} = 60.3	Female	Older	Caucasian	Survey	Survivor (breast cancer)	Cognitive (interest evaluation)
Soto et al. (2018) Chile	N = 27, R_{age} = 25 –64 years	Female	Adult, middle-aged, older	Latina (low socioeconomic)	Focus group discussion	Patients (cervical cancer) & HCP (midwives & paramedics)	Behavioral (screening rates)
Wang et al. (2018) China	N = 92	Female	Adult, middle-aged	Hun	Quasi-experiment (pre & post design)	Parents (family) of patients (acute lymphoblastic leukemia)	Cognitive (education), affective (support)
Uhm et al. (2017) Korea	N = 365, M_{age} = 50.3 (SD 9.5)	n.r.	Middle-aged, older	n.r.	Quasi-randomized multicenter trial, statistical (t- and paired t-tests, ancova, chi-square/Fisher's test)	Patients (post-treatment, breast cancer)	Behavioral (physical fitness & QoL)
Lee et al. (2017) USA	N = 120, M_{age} = 51.60 (SD 9.55)	Female	Middle-aged, adult, older	Korean immigrants	RCT	Client (breast cancer)	Cognitive (knowledge, attitudes, & beliefs about

							breast cancer screening), behavioral (readiness and receipt)
Languis-Eklof et al. (2017) Sweden	N = 66, M_{age} = 69 (SD 5.8)	n.r.	Older	n.r.	Descriptive (interview & log data)	Patient (prostate)	Behavioral (reporting), experience
Nyman et al. (2017) Sweden	N = 28, M_{age} = 70	n.r.	Older	n.r.	Interview	Patients (prostate cancer)	Behavioral (self-care, reporting) & cognitive (positive image of healthcare organization)
Casillas et al. (2017) USA	N = 23, R_{age} = 15–39 years	Female	AYA	n.r.	Focus group discussion, interview, trial	Survivor (lymphoma, leukemia)	Behavioral (acceptability, feasibility, usability)
Markun et al. (2017) Switzerland	N = 188, M_{age} = 40.4 (SD 17.25)	Female	Adult	n.r.	Performance test & statistical analyses	Client (skin cancer)	Prospective diagnostics, behavioral (screening)
Quintiliani et al. (2016) USA	N = 10, M_{age} = 59 (SD 6)	Female	Older	Non- Hispanic	One-group pre-post evaluation & technology-assisted phone counselling	Survivor (breast cancer)	Behavioral (weight management, diet, and physical activity)
Fortier et al. (2016) USA	N = 12, M_{age} = 12.33 (SD 3.42)	Male	AYA	Hispanic, white	Daily diary (10 days), descriptive statistics, one-sample Wilcoxon signed-rank tests	Patient (leukemia)	Cognitive (skills training) and behavioral (managing pain & symptom)
Drott et al. (2016) Sweden	N = 11, R_{age} = 44 – 68 years (median = 65)	Female	Older	n.r.	Interview	Patients (colorectal cancer)	Experience
Hagoel et al. (2016) Israel	N = 48,091, M_{age} = 60.44 (SD 6.04)	Balance	Older	Israel	RCT	Client (colorectal cancer)	Behavioral (screening)
Muller et al. (2017) USA	N = 2,386, R_{age} = 40–75 years	Female	Middle-aged, older	Alaskan Native & American Indian	RCT	Client (colorectal cancer)	Behavioral trait (screening)
Spoelstra et al. (2016) USA	N = 161, M_{age} = 58 [specialty pharmacy = 60.25 (SD 10.68), cancer clinic = 57.85 (SD 10.44)]	Female	Older	Caucasian	Secondary data from RCTs, statistical analysis (Chi-square, Fisher's exact, t-	Patients (multiple cancers)	Acceptability & behavioral (medication adherence, symptom management)

					tests, generalized linear modeling)		
Kessel et al. (2016) Germany	N = 108, 53.7% in R_{age} = 20 – 39 years	Male	Adult	n.r.	Survey	HCP	Cognitive (attitude)
Somers et al. (2016) USA	N = 30, M_{age} 60 (SD 11)	Female	Older	Caucasian	RCT	Patient (prostate)	Feasibility, behavioral (pain management)
Spoelstra et al. (2015) USA	N = 80, M_{age} = 58.5 (SD 10.7)	Female	Older	Caucasian	RCT	Patient (breast cancer)	Cognitive (self-efficacy) & behavioral (medication adherence)
Weaver et al. (2015) USA	N = 26, R_{age} 50–75 years	Female	Older	African American	Focus group discussion	Client (colorectal cancer)	Cognitive (attitude, appeal of messages) & behavioral (screening)
de Bruin et al. (2015) Austria	N = 25, R_{age} 37 – 77 years	Balance	Adult, middle-aged, older	n.r.	Clinical trial	Patient (gastrointestinal cancer)	Cognitive (opinions), behavioral (monitoring malnutrition)

Note: AYA = adolescents and young adults; SCP = Survivor care plans; APP = mobile application; HCP = healthcare practitioner; n.r. = not reported for the entire dataset; M_{age} = mean age in years; R_{age} = age range; n.s. = not specified; Ref. = Reference number; Age group: AYA: <= 24 years; Adults: 25–40 years; Middle-aged: 41–54 years; Older: >= 55 years. The predominant characteristic of the sample has been reported for gender (reported as “balance” if distribution 48–52%), focus, ethnicity, and type of cancer

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