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REVIEW

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Smartphone apps to help children and adolescents with cancer and their families: a scoping review

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ABSTRACT

Introduction: Considering the importance of empowering patients and their families by providing appropriate information and education, it seems smartphone apps provide a good opportunity for this group. The purpose of this review was to identify studies which used smartphone apps to help children and adolescents with cancer and their families.

Method: Arksey and O'Malley's framework was employed in this review. To examine the evidence on the design and use of smartphone apps for the target group, PubMed, Embase, Scopus and Web of Science databases were searched from 2007 to November 2018.

Results: Twenty-four articles met the inclusion criteria, with 33% being conducted in the USA and 21% in Canada. Moreover, in 20 studies (83%), app was specifically designed for children and adolescents, with only three studies (13%) for parents and one study (4%) for both. The main modules of smartphone apps in these studies included symptom assessment (90%), provision of information and education (74%), communication with caregivers (57%), social support (30%) and calendar and reminder (21%).

Conclusions: Due to the easy access to smartphones without a costly infrastructure compared to landline phones, the use of mobile health (m-Health) has become a suitable method of providing healthcare services, especially for cancer. Use of smartphone apps, increases patient and families' access to reliable and suitable education and information regarding the disease. Thus, healthcare policy-makers in developing or underdeveloped countries can exploit the health-related potentials of m-Health following the experience of developed countries.

Introduction

According to GLOBOCAN (Global Cancer Observatory) reports, the incidence rate of new cancer cases will be about 20 million worldwide in 2025, of which the highest incidence rate will belong to low-income countries [1]. Approximately, 1% of all new cases of cancer occur in children [2]; according to the latest report of the American Cancer Society, the incidence rate of new pediatric cancer has risen to 198,700 in 2018, of which more than 80% occur in underdeveloped and developing countries [3]. The common treatment for cancer is chemotherapy, especially for children [4]. The main disadvantage of this method is severe and debilitative complications which, if left controlled, decrease children's quality of life (QOL) and may lead to treatment cessation [5]. This is especially challenging for patients and parents who lack sufficient medical knowledge with regard to the nature of the disease, treatment, complications and control [6]. Thus, most parents desire to have detailed and precise information about disease, potential complications and the effects of treatment on their children's life [7].

Studies show that the provision of information and education for patients and their parents improves the disease experience and clinical outcomes. For example, the results of studies conducted by Kuhrik et al. [8] and Şahin and Erguney [9], on the effect of education and information provision on patients showed that enhancing knowledge reduces patient and family anxiety, improves the control of complications and, as a result, decreases the severity of complications. Mostert et al. also reported that increasing the knowledge of parents enhances the adherence of patients to treatment [10]. The results of the study by Novrianda and Khairina, also proved that parental education reduces complications and anxiety and improves adherence to treatment, thereby enhancing the QOL of patients and families. In fact, increasing knowledge improves parents' ability to provide high-quality care for their children [11].

In the clinical environment, empowerment is a process accelerating mental and physical recovery in patients [12]. Currently, empowerment interventions provided by healthcare professionals and through educational pamphlets, audio tapes, videos and group sessions [13]. The results of a

systematic review by Ankem to identify information resources used by patients with cancer showed that educational pamphlets and oral information provided by healthcare professionals are the most important information resources for patients [14]. The results of another systematic review conducted by Mcpherson et al. similarly revealed that the common way to provide information for patients in healthcare centers is through educational pamphlets. The results also showed that, while this method increases patients' knowledge, it also causes confusion due to the large amount of information [15]. In addition, educational pamphlets are not suitable for all patients due to differences in the level of knowledge and information needs among them [16]. Therefore, the fixed level of information as well as lack of human interaction make this method inefficient [17].

Oral presentation is another common method of providing information for patients and their families, employed during face-to-face meetings with the physician. This method relies on the individual's ability to remember and recall information and, consequently, has a low efficiency [18]. Most patients are dissatisfied with the difficulty of remembering and recalling information provided in this way [19]. Studies show that about 40–80% of oral information is immediately forgotten, and half of the information is misremembered by patients [17,20]. Thus, it seems that providing information to patients and their families is not efficient using the current methods.

Moreover, effective management and control of symptoms in cancer treatment require communication between patients and providers and a desirable assessment of patients condition [21]. Indeed, oncologist can provide appropriate care for children with cancer only when they acquire information regarding their symptoms and problems through direct communication [22].

On the other hand, effective communication between physicians, patients, and parents enhances patient satisfaction, adherence to treatment and clinical outcomes [23]. In fact, poor communication between physicians, patients and parents is the most important reason for non-adherence to treatment in young patients [24]. Currently, the different communication style and limited verbal skills of children as well as lack of systematic approaches to the evaluation of symptoms pose obstacles to the communication between children and the treatment team [25]. On the other hand, in most cases, the symptoms that experienced by patients, underestimated by the clinical staff responsible for recording and reporting these symptoms in terms of frequency and severity [26]. For example, the results of Williams study show that the number of registered symptoms by physician in medical records, is much lower than symptoms recorded by the patient in the self-reported questionnaires [27]. As a result, the majority of symptoms and problems remain unidentified, therefore, are not properly treated [22]. Accordingly, new approaches and tools are required for these purposes.

One such tool is smartphones, powerful computing devices that have special capabilities, including Internet connection and running various apps [28]. These features along with the increase in the number of people owning smartphones have led to the emergence of new health-related interventions known as mobile health (m-Health) [29]. The World Health Organization (WHO) defines m-Health as 'A domain of electronic health aiming to provide health-related data and services using mobile communication and portable devices such as cell phones, patient monitoring devices, personal digital assistants, and other wireless devices' [30]. The unique capabilities of smartphones and their prevalence have motivated the development of m-Health for use in self-management of chronic diseases, including cancer [31].

For example, Lapid et al. reported that 93% of the parents (who had a child with cancer) tended to use new technologies, such as smartphones since they believed that these devices improve their roles as caregivers, assisting them in the provision of effective care to their children [32]. Studies report that children and adolescent are more willing to use ICT devices compared to paper-and-pencil and traditional forms, and have a strong learning potential for using these devices [33]. In fact, their comfort and confidence in using electronic devices is an advantage, increasing the sharing of information [34]. Moreover, the relative unimportance of age limits for the use of these tools encourages and facilitates the use of smartphone apps for this purpose. For instance, children as young as five years old can provide meaningful reports on symptoms, such as pain intensity and fill in QOL questionnaires in a reliable and valid manner if they access tools and education appropriate for their [35]. For younger children or those with cognitive problems who have lower levels of understanding with regard to disease and symptoms, as well as children under five years who cannot self-report due to the stage of their disease, parents' reports can serve as a suitable source for symptom assessment [21].

Currently, the use of smartphones is becoming prevalent as an acceptable and easy method for the provision of information, symptom assessment and communication with care provider [36]. Thus, it seems, the use of this method helping the provision of information and increasing the access of users in different regions is a necessity in developing and underdeveloped countries [37]. Therefore, the use of smartphone apps provides a golden opportunity for the large population of patients with cancer and their families to receive education regarding the management and control of cancer [38]. Although numerous studies have been conducted on the use of smartphone apps by children with cancer, no comprehensive study has focused on the utilization of these apps to support these patients and their families. For instance, Wesley and Fizur examined smartphone apps for assisting adolescent with cancer, only focusing on apps designed for adolescents and thus excluding studies on children and families. In this study, results indicated that the use of these apps generally leads to better condition management during and after cancer treatment; improves patient knowledge, self-management, communication, medication management and receiving social support from patients in the same situation [39].

Therefore, considering the importance of promoting participation and empowering patients and their families, this

study aimed to identify studies that use smartphone apps for helping children and adolescents (0–19 years) with cancer or their families and also identifying primary components of these apps. The questions examined in this study were: What studies used smartphone apps for helping children and adolescents with cancer and their families? What are primary components of these apps? To have a more comprehensive understanding of the topic, other questions were posed to present a deep analysis of the literature: What are the characteristics of relevant studies? what operation system (OS) do these apps work? What is the gap in these studies?

The questions examined in this review study were: What apps are available for assisting children and adolescents with cancer and their families? What modules exist in these apps? On what OS do these apps work? To have a more comprehensive understanding of the topic, other questions were posed to present a deep analysis of the literature: What are the characteristics of relevant studies? What is the gap in these studies?

This study used Arksey and O'Malley's framework to conduct a scoping review [40]. According to this framework, a scoping study has five main stages and one selective stage, including:

1. Identification of the research question;
2. Identification of relevant studies;
3. Selection of studies;
4. Charting the data;
5. Collating, summarizing and reporting the results;
6. Consultation exercise. The sixth stage was not included in this review.

Search strategy and data sources

In order to investigate the evidence regarding the use of smartphones for children and adolescents with cancer and their families, relevant peer-reviewed journal articles published between 2007 and November 2018 were searched from the PubMed, Embase, Scopus and Web of Science. The year 2007 was selected because the first smartphone was presented by Apple Company in June 2007. A combination of MESH terms and free text terms was utilized to search electronic databases. Key search terms and word combinations included: *((Telemedicine(Mesh) OR eHealth(Text Word) OR mHealth(Text Word) OR mobile application(Text Word) OR mobile applications (Text Word) OR smartphone(Text Word) OR cell phones(Text Word) OR mobile(Text Word) OR mobile phone(Text Word) OR mobile health app(Text Word) OR mobile health application(Text Word) OR mobile game(Text Word) (AND(Caregivers(Mesh) OR Parents (Mesh) OR Family (Mesh)) OR (Child(Mesh) OR child(Text Word) OR children(Text Word) OR pediatric(Text Word) OR pediatric(Text Word))AND (Neoplasms(Mesh) OR Cancer (Text Word)))*. The search strategy was changed across databases. In addition to electronic databases, the associated m-Health journals, including JMIR m-Health and u-Health, were also searched.

Eligibility criteria, screening and selection of studies

The inclusion criteria were articles being written in English, published in original peer-reviewed journals, and focusing on the use, design or assessment of smartphone apps; and the population sample including children, adolescents and parents. Editorials, discussion points or personal opinion pieces were excluded.

Systematic selection process of articles

The electronic search of the four noted databases yielded 760 studies. The selected studies were entered in Mendeley software and duplications were eliminated. Then, two authors separately reviewed the titles and abstracts of articles in terms of their relevance to research questions. In cases, where the relevance of a study could not be identified based on its abstract, the full text of studies was examined. Disagreements were resolved through reaching consensus or by consulting a third reviewer. In the next step, the full texts of the qualified studies (68), were retrieved and reviewed to comply with inclusion and exclusion criteria and make the final decision. Eventually, 24 articles were included. The process of selecting the studies is illustrated in Figure 1.

Charting the data or data extraction

Data were extracted from the selected papers using a data extraction form developed for the study. Two reviewers independently checked the full text of the selected study and extracted the data items. The results were then compared, and disagreements were resolved by discussion, after which the form was revised where necessary. The findings are presented in Table 1 based on the Preferred Reporting Items for Systematic Review and Meta-Analyses for Scoping Reviews (PRISMA-ScR) checklist [41]. Also, another Table 2 is created to determine the most repeated modules of each app. The characteristics of each study, including the name of the app, participants, key findings and app modules were extracted by the first author and confirmed by the second author. The findings are reported below in a narrative format.

Results

In general, 24 studies included in this review were conducted from 2010 to 2018 in 11 countries, mostly developed. The majority of studies were performed in USA (33%) and Canada (21%). Examination of the type of OSs, showed that in 12 study (50%), app was designed only for IOS, four study (17%) only for Android and three studies (12%) for both OS. In five study (21%) OS was not mentioned. The target group of 20 studies (83%) comprised children and adolescents, that the lowest age range was five years old. For children five to seven, the apps were used with the help of parents to measure and report symptoms. Only in three studies (12%), apps were specifically designed for support the families. Table 1 gives the characteristics of the included studies.
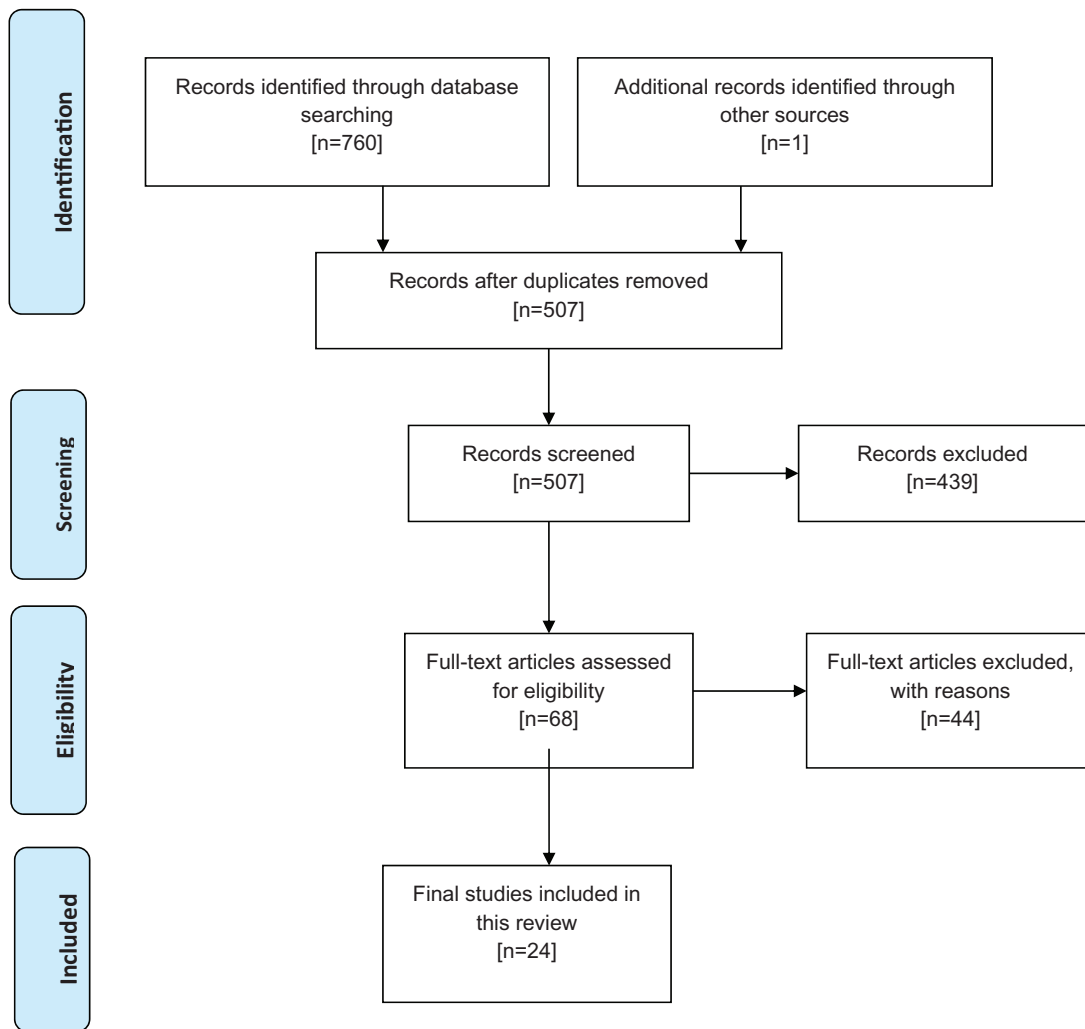
Figure 1. PRISMA flow diagram of scoping literature search and selection.

All studies examined in this review have developed smartphone apps for general support and better cancer management for children and adolescents with cancer and their families. Only five studies (21%) were specifically designed and implemented to manage specific symptoms such as pain in the target group. The apps used in these studies include Painometer, iCan Cope with Pain, PainBuddy, Pain Squad and Pain Squad+.

There is no information on the implementation of these apps out of the research setting. After searching the App Store and Google Play Store, the research team found a number of apps available for download and use. However, it is impossible to use features such as communication module or asking questions. For example, you can easily download Pain Squad, Fitbit, Dosecast and Oncology Family App from the App Store and use most of the features in these apps, but to use I Can Cope with Pain, one must have a special code that belongs to the participants in the research.

App modules

To answer the second research question, i.e., 'What are primary components of these apps?', since there are no

guidelines or standards for grouping app components, the research team categorized these components based on the results of studies conducted by Barlow et al. [42] and Lalloo et al. [43] who systematically categorized repetitive modules in smartphone apps developed for supporting patients with chronic diseases such as cancer. The definition of each module is presented below.

Information and education module

This module includes classified information and education about the disease, treatment, symptoms and symptom management. It is similar across apps and provides the ability to read, search and bookmark the existing content.

Symptoms tracking module

In most cases, it includes the electronic version of symptom assessment questionnaires. Through this module, information about the incidence and severity of symptoms is recorded by patients. It provides the ability to report symptoms to healthcare providers in the form of graphs.

Table 1. Details of primary studies identified and reviewed.

References	Country	App name	OS	Participate age range	Aim of study	Key findings
Aldiss et al 2010 [48]	UK	ASyMS-YG	Not report	Children with cancer aged 13–18 years	Home monitoring and report chemotherapy-related symptoms	Promote self-care Enhance communication between young people and health professionals
Baggott et al/2012 [44]	USA	Mobile Oncology Symptom Tracker (mOST)	IOS	Children with cancer aged 13–21	Test the utility of app for record and report medical symptoms	Increase overall adherence rates to daily symptom reports
Berntsen & Babic/2013 [54]	Norway-Swede	Cherry	Android	Children with cancer and their parent	Provide information	Increase patients engagement simple and gesture-based interface
Rodgers et al/2013 [51]	USA	Eating After Transplant (EAT!)	Not report	Children with cancer aged 11–18	Increase self-management skill in patients during stem cell transplantation	Increase patient knowledge about symptom management
Jibb et al/2013 [60]	Canada	Pain Squad	IOS	Children with cancer aged 9–18 years	Develop pain assessment tool for adolescents with cancer	Increase compliance rates and satisfaction
Tomlinson et al/2014 [45]	Canada	Children's International Mucositis Evaluation Scale (ChIMES)	IOS	Children with cancer aged 8–18 years	Measure of oral mucositis in cancer patients	Suitable for monitoring and measuring symptom
de la Vega et al/2014 [46]	Spain	Painometer	IOS/Android	Children, adolescent and young adult with cancer	Develop mobile app for assessing pain intensity	Improve the accuracy of pain assessment
Macpherson et al/2014 [72]	USA	Computerized Symptom Capture Tool (C-SCAT)	IOS	Children with cancer aged 13–29 years	Evaluate the feasibility and acceptability of app	Empowering communicate about symptom experience. improve symptom management
Stinson et al/2014 [73]	Canada	iCan Cope with Pain	IOS	Children with cancer aged 14–18 years	Address the self-management needs of adolescents with chronic pain	Improve pain management and functioning (sleep, mood, physical and social activities)
Kock et al/2015 [4]	Germany	Late effects surveillance system (LESS)	Android	Children with cancer	Provide follow up information	Increase the awareness of childhood cancer survivors for taking their follow-up visits seriously
Duregger et al/2015 [74]	Australia	Not report	Android	Children with cancer and parent	Monitoring pediatric patients at home to increase the quality of life	Use point-of-care measurement devices and a smart-poster for symptom assessment
Lai et al/ 2015 [57]	USA	SyMon-SAYS	Not report	Children, with cancer parents and provider	Symptom Monitoring & Systematic Assessment	The app was feasible and acceptable to patients and parents
Wang et al/2016 [6,53]	China	Care assistant	Android	Parents and family with cancer	Provide information for parents and family caregivers of children with ALL	Improving knowledge, confidence and social support in caregiving. Reduced stress
O'Sullivan et al/2016 [58]	Canada	Symptom screening in pediatrics SSPedi	IOS	Children and adolescent with cancer	Evaluate and refine the mobile app for symptoms screening	Facilitate symptoms screening and self-report. Increase communication with care provider

Table 1. Continued.

References	Country	App name	OS	Participate age range	Aim of study	Key findings
Fortier et al/2016 [75]	USA	PainBuddy	IOS	Children and adolescent with cancer	Development an app for enhancing pain management	Improve pain and symptom management
Morrison et al/2016 [7]	USA	Not report	Not report	Families of patient	Develop app for providing information and reduce stress and uncertainty	Not report
Arvidsson et al/2016 [56]	Swede	Sisom	IOS	Children with cancer	Redesign tools for assessment and communication in pediatric cancer	Children, parents and pediatric nurses contribute in improve terms of content, esthetics and usability of Sisom
Wang et al / 2017 [47]	China	Pediatric PROMIS	Not report	Children with cancer/parent/nurse	Development app to monitor pediatric symptom	The app was easy to use and the interfaces were friendly to children
Mendoza et al/2017 [76]	USA	Fit bit	IOS	Children with cancer	Use smartphone app to promote physical activity among	Promote Physical activity among childhood cancer survivors
Jibb et al/2018 [59]	Canada	Pain Squad+	IOS	Children with cancer	Smartphone app for provides support for pain management	Improve pain-related outcomes for adolescents with cancer
Bruggers et al/2018 [77]	UK/Netherland	Empower Stars!	IOS	Children with cancer/parents and healthcare	Develop video game for physical exercise	Supported the self-care of pain and improve patient-provider communication
Wu et al/2018 [61]	USA	Dosecast9	IOS/Android	Adolescent and young adult with cancer	reminder app to promote adherence to oral medications	Useful for prompting medication taking, Improve Medication adherence
Elsbernd et al/2018 [50]	Denmark	Kraeftvaeket	IOS	Adolescent and young adult with cancer	Evaluation of app designed to improve health-related quality of life	Not report
Slater et al /2018 [52]	Australia	Oncology Family App	IOS/Android	Parents and family of children with cancer	Provide access to information for family and caregiver	Efficient and convenient way to provide needed information

Communication module

This module commonly provides the ability for patients to communicate with the healthcare team members, including the physician and nurse. Patients can ask questions about their disease and treatment. In this way, they are able to send symptom assessment results to physicians and receive their recommendations.

Social support module

This module is similar to online discussion forums where patients and parents are able to share their experience of the illness and treatment and help other patients or families, or use the experience of others with the same problem and receive emotional support.

Calendar and reminder module

This module is similar to a calendar, reminding future appointments with the physician as well as the time to take medications or attend healthcare centers for periodic tests, thus preventing parents and patients from forgetting these appointments.

According to the definitions given above, the five main modules in these apps include: symptom assessment (21 studies), patient education and information provision (17 studies), communication with provider (13 studies), social support

Table 2. Details of app modules.

Main module	App	Frequent	%
Education and information (self-management skill)	ASyMS-YG, Cherry, EAT! (SyMon-SAYS), PainBuddy, SISOM, Care Assistant, Morrison, iCanCope with Pain, LESS, Morrison et al. (C-SCAT), Pediatric PROMIS, Pain Squad+, Empower Stars! Kraeftvaerket, Onco Family App	17	71
Symptom assessment	ASyMS-YG, mOST, Cherry, SISOM, Care Assistant, PainBuddy, Morrison et al., Pain Squad, Painometer, ChIMES, iCanCope with Pain, LESS, SyMon-SAYS, SSPedi (C-SCAT), Duregger, Pediatric PROMIS, Fitbit, Pain Squad+, Kraeftvaerket, Onco Family App	21	87.5
Communication with provider	ASyMS-YG, Cherry, SISOMCare Assistant, PainBuddy, Morrison et al., Painometer, SyMon-SAYS, Pediatric PROMIS, Fitbit, Empower Stars!, Pain Squad+, Onco Family App	13	54
Social support (peer support)	Cherry, Care Assistant, iCanCope with Pain, Pediatric PROMIS, Fitbit, Empower Stars!, Kraeftvaerket	7	29
Calendar & reminder	Onco Family App, Pain Squad, LESS, Pain Squad+, Dosecast	5	21

(seven studies) and calendar or reminder (five studies). Table 2 shows the frequency of these modules.

Measuring and reporting symptoms to clinicians

An important and frequently used module in these studies was symptom assessment that repeated in 21 studies (87.5%(. This module facilitates the measurement and recording of symptoms by patients. In this way, patients can measure and record their symptoms as they occur and present this information to clinicians upon in-person visits or online [5]. Recording symptoms when they occur, enhanced the precision of symptom measurement [39]. Examination of relevant studies indicated that the majority of apps incorporate the electronic version of standard patient-reported outcome (PRO (forms for collecting the data reported by patients [44–47]. For instance, Baggott et al. developed smartphone app that utilizes the electronic version of the pediatric nausea assessment tool (PNAT) for measuring the symptoms of children and adolescents with cancer. MOST app serves as an electronic dairy and increases the target groups' adherence to the daily measurement and reporting of their symptoms by 91% compared to paper-and-pencil tools [44]. Moreover, in other study, Tomlinson et al. developed smartphone app named eChIMES, that used Children's International Mucositis Evaluation Scale for measuring chemotherapy symptoms in children and adolescent with cancer. This app effectively increased patients participation in reporting symptoms to clinicians, by self-report [45]. De La Vega et al. for evaluating pain intensity in children, adolescents and young adults with cancer, developed smartphone app. This app (Painometer (offering four standard measures appropriate for each age group. This app markedly enhanced the precision of pain measurement in patients. Ninety four percentage of specialist, who received patient pain reports by Painometer, interested in use this app as a pain reporting tool for patient with cancer [46].

Furthermore, some apps offer feedback to users on symptom management and control in addition to symptom collection and recording. For example, Aldiss et al. and Gibson et al. developed smartphone app to monitoring chemotherapy-related symptoms in children with cancer. ASyMS-YG collects symptoms reported by patients through questionnaires in real time. This app showed two types of alarm, red alarm (cases requiring immediate action (and yellow alarm (non-emergency clinical interventions (based on the severity of reported symptoms. Additionally, ASyMS-YG provided information and recommendations to help symptoms management in children and adolescents with cancer. Information that provided by this app, increase the chance of real-time interventions and give a sense of support to patients [48,49]. In another study, Elsbernd et al. developed smartphone app (Kraeftvaerket (for improving quality of life in adolescent and young adult with cancer. Kraeftvaerket used certain algorithms to determine the severity of symptoms reported by patients. Then in case of emergencies, alarm sent automatically and patient received recommendations for symptom management [50].

Provision of information and education

Provision of information and education was second frequent module primary module. In 17 studies (71%(, this module providing information and self-management skill to empower patients and their families and promote their participation in making informed decisions. For instance, Cherry, Care Assistant, Eating After Transplant (EAT!), iCan Cope with Pain, Kraeftvaerket and Oncology Family App were designed to assist patients in understanding various aspects of their disease. For example, Kraeftvaerket provides practical and clinical information in order to support and enhance the QOL of children and adolescents with cancer [50]. The target user of these studies divided into two groups; (1) patients with cancer (children and adolescents) (2) Parents, family members and caregivers. At first, we described studies that developed apps to support children and adolescents with cancer. Rodgers et al. developed smartphone app (EAT!) to increasing self-management skills in adolescents with cancer. This app (EAT!) provided information about diet, possible postoperative symptoms and strategies for preventing and controlling the complications [51]. In another study, Kock et al. developed late effects surveillance system (LESS) aims to

enhance autonomy in this group to face the complications of disease and treatment. This app provides personalized information tailored to the patients' status based on the data entered with regard to the type and grade of cancer. A considerable feature of this app was the one-week reminder for follow-up visits, periodic examinations, and tests based on the preliminary data entered by the patient [4].

Information and education for the families

Of the 24 studies reviewed, only in three studies (13%), apps were specifically designed for supporting parents and caregivers [6,7,52]. For instance, Slater et al. developed Oncology Family App to facilitate access to information by families, including information about treatment plans. This app provides the opportunity of 24-h emergency contact with healthcare providers and the feedback by users showed that it effectively met the families' need for information [52]. Moreover, Wang et al. specifically designed Care Assistant App to meet the needs of families for information [53]. Results showed that using this app for only two weeks, markedly increased parents' information with regard to the disease and enhanced their self-confidence is providing care for their children [6]. In addition, Berntsen and Babic designed smartphone app that called Cherry. This app provides information about cancer and treatment in forms interesting and understandable for children and their families [54].

Improving communication

Another feature of the examined apps was establishing communication between patients and healthcare professionals as the next frequent module. This module repeated in 13 studies (54%). Recording of symptoms by patients and reporting them provides communication and information flow between patients and the healthcare team [55]. This feature is of special importance for children due to the difficulty of communicating with them and lack of verbal cooperation on the symptoms they experience [56]. For instance, Sisom is a highly successful app that developed by Arvidsson et al. for improving communication between children with treatment team's, making it possible for children aged 6–12 years to directly report their symptoms in their own words. Sisom is among the best apps in terms of user interface design and content, as it was the result of comprehensive research to determine the content and find equivalents for symptoms using phrases understandable to children. Results revealed that this app increases children's cooperation and thus leads to a more effective collection of symptoms [56]. SyMon-SAYS is another app that developed by Lai et al. to resolve children and treatment team's communication problems. This app includes a patient-centered evaluation and information system in which patients record symptoms and, in case of any risk, a warning is sent to the physician or nurse to provide care as soon as possible. Thus, the care provided is actively focused on the main problems of the patients, forming the basis for upcoming follow-up visits. Results of app

usage indicated that 93% of patients and 78% of parents considered it is very easy to work with and 81% were willing to use it again for the management of other cancer symptoms [57]. Furthermore, O'sullivan et al. developed and refined SSPedi (Symptom Screening in Pediatrics) to facilitate symptom screening and self-report by children and adolescents with cancer. This app improving the communication between patients-oncologist and raising their awareness of the symptoms experienced by patients. Based on the results of app usage by the target group, 95% of participants believed that SSPedi had improved their interaction with oncologist and treatment team [58].

Social support and communication with other patients

Studies show that social support for children and adolescents with cancer by their family, friends or others can enhance their quality of life [58]. Therefore, some apps provide the possibility of communicating with other patients and sharing experiences on the disease and provision of care. In this review, this module repeated in seven studies (29%). For example, Cherry offers the possibility of recording the experiences with the disease and sharing them with others, including friends, parents and the treatment team [54]. Moreover, Wang et al. developed Care Assistant app, to provide social support for parent and family members. This app allows users to share their experiences with the disease and users can ask others questions. Care Assistant introduces ways to contact resources and centers active in cancer and supportive care. As a result of this support, the stress and burden experienced by parents, significantly decreases [6]. Furthermore, Elsbernd et al. developed Kraeftvaerket app that emphasized the role of social supports in improving quality of life in patients and families, thus establishing a communication and support network among users. This network includes all users who can send and share ideas and pictures about their disease or treatment [50]. Furthermore, studies on the role of smartphone apps for provide social support, show that they offer the chance of receiving support from other users through sharing experiences related to the disease and care for the child with cancer, while also decreasing financial and social burdens and stress by linking families to organizations and resources offering support and social services [6,50].

Calendar and reminders

This module existed in only five studies [21%]. Calendar and reminder module in general used to manage time and prevent forgetting doing things. Stinson et al. develop smartphone app for increasing compliance rate in children and adolescents with cancer. They develop Pain Squad app as a pain assessment tool. This app included reminder module to alarm patient to use information and enter daily status in the form of a patient's diary. By providing direct reminders to children and adolescents, therefore, this responsibility is taken out of the parents' hand [59,60]. Moreover, Wu et al. developed Dosecast app to improve medication adherence

in adolescent with cancer. This app includes a reminder for medications which, according to results, Dosecast significantly increased the adherence of the target group to drug regimens prescribed by physicians [61]. Slater et al. in their study developed Onco Family App that had a reminder module for medications as well as visits to the physician, thereby helping patients and their families [52]. In another study, Kock et al. for providing follow up information in children with cancer, developed LESS with a calendar and reminder module. The reminder module in this app automatically informs the user of the following events by showing colored dots on the calendar based on settings. For instance, informs the user, three weeks in advance of the appointment and periodic tests [4].

Discussion

The studies examined here were conducted from 2010 to 2018 in 11 developed countries, with 54% in USA and Canada alone (13 out of 24 studies). These results demonstrate the further willingness of developed countries for employing modern technologies in healthcare and helping patients with cancer. In this review, most studies (50%), developed apps that worked on IOS, and the rest on Android, which is justifiable considering the prevalence and high number of smartphones using these two OS. Of course, the majority of users uses Android-based devices; based on 2017 statistics, 86% of all smartphones sold worldwide use Android OS [62]. Therefore, it seems that, due to the different features, capabilities and limitations in the domain of programming and software development, there is no constraint as to the selection of the type of OS, and it is chosen based on user preferences, popularity and goals of the software development team and budget limitations [36]. Considering the frequency of Android and IOS, it seems that software developers should offer versions which can run on both OS or even on web browsers in order to increase the number of users, so that no limitation as to the type of OS would exist for users.

The target group of most studies (83%) comprises children and adolescents and few studies were conducted to resolve the needs of families and parents. One reason may be that children and adolescents are active users of smartphones as they are increasingly working with ICT devices [17,46]. It is estimated that 75% of those aged 12–17 years own smartphones and approximately 91% of them access the Internet *via* smartphones, tablets and other portable devices [39]. Moreover, most studies focused on children and adolescents above eight years old with cancer, with few studies targeting those below eight. One reason for this may be the uncertainty that children aged seven or below can understand the information on disease and symptom assessment. However, evidence suggests that most children as young as five can report their symptoms and fill in symptom assessment questionnaires [63]. From among only in 13% of the studies, smartphone app was designed to supporting parents and caregivers, while the desire of parents and caregivers for using healthcare apps is more than children and

adolescents [7]. In summaries, these results are somewhat consistent with those of Pelentsov et al. study on the care-related needs of parents. This study showed that, while the responsibility of caring for children with rare diseases, such as cancer, is borne by the parents, only a few number studies have been conducted to support them [64]. Further, parents as the sole source of information for their children must have enough information regarding the disease and treatment, to be able to answer children's questions about disease [65]. Increasing parent's information about disease and treatment effect management enhances their self-confidence and ability to provide high-quality care at home [53].

In this review, results showed that symptom assessment, provide information, communication with healthcare professionals, social supports and reminder were most frequent modules. These results were similar to those reported by Collado-Borrell et al. [66], Barlow et al. [42], and Lalloo et al. (2015) [43]. Collado-Borrell et al. reviewed the existing apps for cancer patients. The results showed that information on the disease, self-management skills, calendars, symptom evaluation and social support were the most frequent modules [66]. Moreover, Lalloo et al. examined 279 studies using smartphone apps to help self-management in chronic diseases, including cancer. The results showed that providing information and education, symptom measurement and social support were the most frequent modules [43]. Furthermore, Barlow et al. examined 145 studies to identify the main components of self-management programs in chronic diseases. The results indicated that the most important components were information, symptom management, drug management and mental health management [42]. Therefore, it is observed that, these component are similar across most studies aimed to support patients and parents, but can be different depending on the type of disease, target group and user preference.

Based on Pelentsov et al.'s study, the most frequently noted needs of parents and patients with cancer were in social support, information and emotional domains [64]. In another study, Kerr et al. investigated the needs of parents of children with cancer, reporting that request for information, emotional needs and social needs had the highest priority, respectively [67]. Also, Mueller et al. concluded that increasing the level of knowledge and measurement of symptoms were the most important modules requested by parents of patients with cancer [68]. Therefore, it can be seen that in most studies aimed to support patient and parents, these component are steady, but can be different depending on the type of disease, target group and users preference. In another word, it can be concluded that available apps are designed based on the actual needs of users. Consequently, the use of smartphones apps is an appropriate method for providing information, symptom assessment and complication management for children and adolescents [17,46]. In general, the use of m-Health in the domain of cancer plays a significant role in the management of patient condition by increases access to reliable sources of personalized information, symptoms tracking, improve

communication with healthcare professionals and facilitates social supports.

Finally, a limitation of this review was that only studies using smartphone apps for children and adolescents with cancer as well as their families were selected. For example, Slaughter et al. proposed the Information Architecture for a Pediatric Cancer Symptom Assessment Tool, aiming to help improve communication and reporting of symptoms by children to healthcare professionals. Although this study discusses a system called PedsCHOICE (symptom management system) for children with cancer [69], due to the lack of sufficient information about the system's features, design, and use, it was discarded from this review. In another study, Slagle et al. developed a medication management system (MyMediHealth) to improve children's medication use quality and safety. Although this smartphone app could be used for cancer patients, because the study population was not children with cancer, it was removed from the present review [70]. In addition, Casillas et al. developed a web-based system to improve the delivery of cancer services for adolescents with cancer through text messages. This study was also omitted from this review because it did not use a smartphone app [71].

Conclusion

In this review, the number of apps designed for children and adolescents was much higher than families and caregivers. This demonstrates the involvement of children and adolescents in the process of cancer treatment which was neglected before, while also indicating lack of attention to parents and family members. Nevertheless, cancer imposes considerable financial, social and psychological effects, not only on patients, but also on parents and family members. Thus, healthcare policy-makers and researchers must pay attention to this group. In general, the use of smartphone apps is expanding due to the provision of information, assessment of patients' status, improvement of communication between patients and the healthcare team, and receiving social support by patients and families. The large number of relevant studies in developed countries shows that healthcare policy-makers and researchers in these countries are well aware of the expansion and pivotal role of m-Health in healthcare and treatment services and are planning to exploit these capabilities. Consequently, healthcare policy-makers in developing or underdeveloped countries must also attend to the potentials of m-Health in general and smartphones in particular in the domain of pediatric cancer following the experience of developed countries.

Disclosure statement

All authors have no conflicts of interest to declare.

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