Is there an app for that?: A Systematic Search and Analysis of mHealth apps in the digital marketplace for pediatric cancer patients

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Abstract

Background: The significant increase in smart phone ownership has led to a rise in mobile health (mHealth) app use. This type of app aims to improve patient outcomes by reducing barriers to recovery through various features. Developing tailored features through mHealth apps creates a pathway to address healthcare needs of pediatric cancer patients and their families who have complex care needs. However, few apps are designed specifically to integrate with pediatric cancer care.

Objective: This study reports a systematic search and analysis findings of mHealth apps available on the Apple App and Google Play Store, designed for managing pediatric cancer through a list of features that serve patients, caregivers, or both audiences.

Methods: Following the PRISMA guidelines, we reviewed apps for pediatric cancer patients and caregivers that were available as of January 2024. We searched the Apple App and Google Play Stores with a list of keyword combinations focusing on pediatric cancer care. Inclusion criteria were (a) specifically targeted apps on pediatric oncology patients, their families, or both; (b) available in either app store, and (c) available in English (not exclusively). Once identified, apps were assessed by reviewing their features, user ratings, and app store information with descriptive analysis.

Results: In total, 22 apps were identified, and 17 of those apps were available on both platforms. The most popular features (n=12) amongst the selection in order were resource sharing, symptom tracking, reminders, care team connections, journaling, community support, medication tracking, data visualizations, appointment tracking, health activity data, data sharing, and integration with other health apps. These platforms designed their features and interface for caregivers (n=9) more frequently than the patients (n=7) while a subset of apps created options for both users (n=6). Out of 18 apps with publicly available reviews, 16 of them were rated highly (M=4.4, Min=3.1, Max=5.0, SD=0.59). A small subset (n=3) achieved over 5000 downloads while the remaining 19 apps had fewer than 500. Despite the growing inclusivity of multilingual platforms, more than half of the apps (n=12) were not publicly available in languages other than English. Apps that required extra hardware or software requested access to a range of device functionalities (M=2.72, Min=0, Max=10, SD=3.13).

Conclusions: Our review highlights the promising yet underdeveloped potential of mHealth apps in pediatric oncology care, underscoring the urgent need for more inclusive, comprehensive, and integrative digital health solutions. Future developments should actively involve key stakeholders from the pediatric oncology community, including patients, families, and healthcare professionals, to ensure the apps meet specific needs while addressing linguistic and cultural barriers. Our findings could guide developers, patients and caregivers, and healthcare providers towards understanding the state of pediatric oncology mHealth and approaches to enhancing existing platforms.

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Abstract

Background: The significant increase in smart phone ownership has led to a rise in mobile health (mHealth) app use. This type of app aims to improve patient outcomes by reducing barriers to recovery through various features. Developing tailored features through mHealth apps creates a pathway to address healthcare needs of pediatric cancer patients and their families who have complex care needs. However, few apps are designed specifically to integrate with pediatric cancer care.

Objective: This study reports a systematic search and analysis findings of mHealth apps available on the Apple App (iOS) and Google Play Store (Android), designed for managing pediatric cancer through a list of features that serve (1) patients, (2) caregivers, or (3) both audiences.

Methods: Following PRISMA guidelines, we reviewed apps for pediatric cancer patients and caregivers that were available as of January 30th, 2024. We searched the Apple App and Google Play Stores with a list of keyword combinations focusing on pediatric cancer care. Inclusion criteria were (a) specifically targeted apps on pediatric oncology patients, their families, or both; (b) available in either app store, and (c) available in English (not exclusively). Once identified, apps were assessed by reviewing their features, user ratings, and app store information. In addition, available apps were assessed using the Mobile App Rating Scale (MARS) and descriptively reported. The MARS is a quality assessment for mHealth apps, including components of engagement, functionality, aesthetics, and informational quality (5-point Likert scale items- 1: low and 5: high quality in corresponding components).

Results: In total, 22 apps were identified, and 17 of those apps were available on both platforms. The most popular features (n=12) amongst the selection in order were resource sharing, symptom tracking, reminders, care team connections, journaling, community support, medication tracking, data visualizations, appointment tracking, health activity data, data sharing, and integration with other health apps. These platforms designed their features and interface for caregivers (n=9) more frequently than the patients (n=7) while a subset of apps created options for both users (n=6). Out of 18 apps with publicly available reviews, 16 of them were rated highly (M=4.4, Min=3.1, Max=5.0, SD=0.59). A small subset (n=3) achieved over 5000 downloads while the remaining 15 apps had

fewer than 500. More than half of the apps (n=12) were not publicly available in languages other than English. Apps requested access to a range of device functionalities to operate (M=2.72, Min=0, Max=10, SD=3.13). Out of 22, 17 apps were publicly accessible. They were downloaded and assessed with MARS. The mean MARS scores for the apps ranged from M=1.71 (SD=0.75) to M=4.33 (SD=0.82). Overall, apps scored high on functionality (M=3.72, SD=0.54) whereas low on engagement (M=3.02, SD=0.93).

Conclusion: Our review highlights the promising yet underdeveloped potential of mHealth apps in pediatric oncology care, underscoring the need for more inclusive, comprehensive, and integrative digital health solutions. Future developments should actively involve key stakeholders from the pediatric oncology community, including patients, families, and healthcare professionals, to ensure the apps meet specific needs while addressing linguistic and cultural barriers. Our findings could guide developers, patients and caregivers, and healthcare providers towards understanding the state of pediatric oncology mHealth and approaches to enhancing adoption of digital health interventions.
Keywords: mHealth, mobile app, pediatric cancer, systematic analysis, oncology

Introduction

Approximately 400,000 children are diagnosed with cancer each year internationally, and the incidence continues to rise annually [1]. Fortunately, treatment advances have also resulted in significant improvements in survival rates [2,3]. Despite these significant advances, pediatric cancer remains a leading cause of death among children [4]. The management of pediatric cancer is complex and requires multidisciplinary care that involves ongoing monitoring, management of physical/psychological symptoms, and social supports for families. This includes community resources, symptom management, rehabilitation, and access to educational content for patients and their families. Digital interventions, such as mobile health apps, have the potential to meet these needs in real-time while eliminating barriers like the distance from a medical center, lifestyle demands (e.g. work, school), and mental health stigma [5].

Mobile health apps, also known as mHealth apps, are software applications designed to run on mobile devices, such as smartphones and tablets [6]. The significant increase in mobile or smartphone ownership has simultaneously led to a rise in the use of mHealth apps. Furthermore, the global proliferation of mobile devices among the younger demographic underscores the feasibility of mHealth apps for pediatric cancer patients. Recent statistics indicate that technological access is substantial among the adolescent cohort [7]. Approximately 95% of adolescents possess or at least have access to smartphones, and 90% have access to a desktop or laptop computer in the U.S. Notably, almost half of this demographic (46%) reported to be online almost constantly [7].mHealth apps offer a range of health-related services and resources, such as tracking symptoms, providing medication reminders, and connecting patients with healthcare professionals [5,8]. The use of mHealth apps in the context of pediatric cancer is an emerging field that holds great potential for improving the management and outcomes of this disease [5,9]. mHealth can provide valuable support for families dealing with pediatric cancer, including access to emergency contact information, educational resources, and social support networks [10]. Some apps also provide pediatric cancer families with tools to improve psychosocial well-being and health outcomes [11]. Additionally, these apps can help healthcare professionals to monitor and track patient progress more efficiently while providing more personalized care [12].

Despite the increasing numbers of mHealth apps developed for cancer patients, there is a lack of literature in pediatric cancer regarding the mHealth apps available on the market. To our knowledge, a limited literature has focused on mHealth apps for caregivers of pediatric cancer patients [5,9]. One of the early investigations highlighted cancer apps for adolescent and young adult cancer patients with their functionalities for symptom tracking, pain management, monitoring, and medication management [13]. Looking at the broader literature, the studies mostly reported findings on a specific mHealth app, which might be focusing on electronic medical diaries for mood, symptom and treatment tracking [14], care after cancer treatment [15], pre-rehabilitation support [16], and post-treatment medical adherence [17]. In addition, newer mHealth technologies have leveraged wearable technologies for tracking physical activity [18,19] social media behaviors [19,20], web-text messaging for weight management [21], and gamification of monitoring symptoms to address cancer-associated pain through self-guidance [22,23].

mHealth apps for pediatric patients require further investigation to explore the potential benefits collectively. Therefore, a broader perspective (beyond the apps available in current literature) is required to understand the current state of the mHealth apps. In line with that, evaluation of those apps further contributes to the current state of the app market in pediatric oncology care. The aim of this systematic search is (a) to investigate currently available mHealth apps designed specifically for pediatric oncology in mobile app repositories (Google Play Store, Apple App Store), (b) analyze the features and cost of services provided, (c) to conduct a descriptive analysis to inform developers, designers, and clinician scientists. Our study aims to evaluate pediatric cancer-specific mHealth apps that ultimately improve psychosocial and health outcomes in vulnerable populations.

Methods

We performed an observational, cross-sectional, descriptive study of all smartphone apps associated with pediatric cancer available on the iOS (Apple App Store) and Android (Google Play Store) platforms. We only evaluated apps available on these 2 online stores.

Mobile app search

The methodology used was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) system (see Figure 1, and Appendix 1 for PRISMA checklist) [24]. The search was conducted on January 2024 by a researcher (DIJ), accessing app stores via mobile devices (Apple iPhone SE and Google Pixel 4a). The review used a series of keyword combinations (n=116) through the Apple App Store and Google Play Store. The search terms included: “pediatric”, “kid”, “teen”, “youth”, “adolescent”, “child”, “infant”, “little”, “minor”, “onco- “, “teenager”, “young”, “blood”, “bone”, “leukemia”, “lymphoma”, “oncology”, “tumor”, and “cancer”.

Inclusion criteria

Co-authors (MSF, MS, ES, DIJ) reviewed apps for eligibility. For inclusion in the review, apps met the following criteria: (a) specifically related to supporting pediatric cancer patients/families, (b) available in the Apple App Store or Google Play Store (Android) as of January 30th, 2024, and (c) available in English (not exclusively). Free apps (no cost), apps for a fee and free trial apps (freemium), and subscription service apps were included. Apps that functioned as multi-institutional patient portals were excluded for being too broad to be considered a service for pediatric oncology care. A total of 196 apps were identified in both app stores. At the screening round, 159 apps were

excluded due to not meeting our inclusion criteria based on store descriptions. Then, the eligible apps (n=37) were assessed for full inclusion (downloading and reviewing the apps). At this stage, we excluded 15 additional apps as they were identified as not being specific to the target population (n=7), not having an English interface (n=1), or were no longer available in either app store by the time the researchers initiated the analysis (n=7) . Figure 1 illustrates the PRISMA flow diagram of the review.

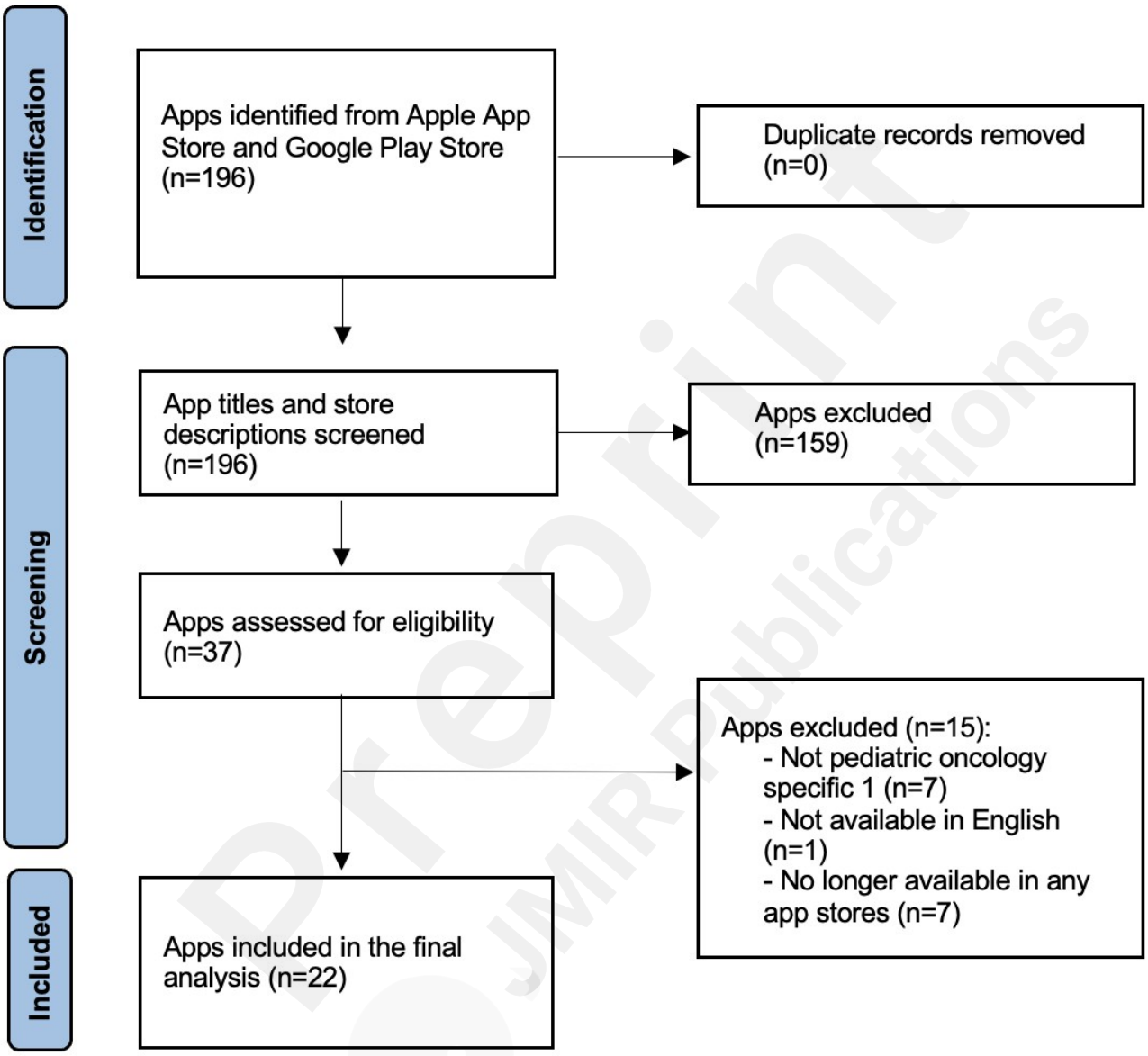

Figure 1: PRISMA Flow Diagram

Data collection and analysis

Data was collected on the following variables from the app stores: descriptions, app rating (out of 5), number of reviews, total cost of services, intended user demographic, file size, supported languages, app privacy and data access requests, latest update, and the app features. App features were determined through reading the app description, reviewing snapshot images provided in the store, downloading the apps from each store on one of the mobile devices (Apple iPhone SE or Google Pixel 4a), and reviewing the original publisher's website post or press release. Each app was categorized by the level of access required before using the app (no account required, login via account, closed signups, shutdown). A secure set of credentials were used for "login via account"

apps. Data were recorded on a Microsoft Excel sheet for analysis (See Appendix 2).

App Quality Assessment

We used The Mobile App Rating Scale (MARS), which is a 23-question assessment of mHealth interventions to measure apps in 5 domains including Engagement, Functionality, Aesthetics, and Information (see Table 1) [25]. We utilized information from the store page and in-app information to evaluate the population of eligible apps. We included 17 apps for MARS evaluation. Apps unavailable for download or having special access requirements (not publicly available) (n=5) were not evaluated. To measure Credibility (the legitimacy of the app publisher) and Evidence (scientific reports on the test or trial of the app) subcategories in the MARS, apps were cross verified with external sources from the store page and in-app info, such as the developer's company page or ClinicalTrials.gov (as suggested by MARS guidelines). Two researchers evaluated the apps using MARS instrument and resolved any disagreements via discussion and consensus. Finally, we reported the descriptive results. All included apps were available in Apple App Store but not in Google Play store (n=5). For those available in both stores, we observed no difference in user interface, therefore, apps were downloaded and tested on an iPhone SE for quality assessment. Please see Appendix 3 for the MARS scoring for each app.

Table 1: Mobile App Rating Scale (MARS) Domains

Domain	Description
Engagement	This domain measures how appealing, flexible, and well-targeted an apps for the target audience. This may include techniques for entertainment (i.e., gamification), app features (i.e., sound, content, notifications), and applicability between caregiver and pediatric patient age groups.
Functionality	This measures basic app functions, ease of use, navigational difficulty, and gestural components. This may include how quickly buttons and menus react to user inputs. Additionally, this measures how logically consistent device-specific interactions are, such as taps, swipes.
Aesthetics	This assesses the layout, graphical design, and visual appeal of the app. This may include quality of graphics or size of the visuals.
Information	This domain evaluates the quality, quantity, and credibility of information within the app. This includes understanding the source of the content such as the developer and sponsor from their linked store page as well as scientific literature.

Results

In total, 22 apps were included in this review of pediatric cancer apps within the digital marketplace. Most applications were available in both the Google Play (Android) and Apple App Stores while sharing the same features for both Android and iOS users (See Appendix 2). Therefore, our report is based on consolidated data (Google Play/Android and Apple App Store) for each app. More specifically out of 22 apps, 17 of them were available on both marketplaces. The remaining 5 apps were exclusively present on the Apple App Store either because the Google Play Store (Android) version was taken down or was never created. No apps were exclusively available on the Google Play Store.

App Features

We grouped and summarized the features of the apps by frequency (see Table 2). The Resource and Information feature was the most frequent property (77%, n=17). This feature allows users to access guidebooks and video course material related to pediatric cancer. Following that, the Symptom Tracking feature (55%, n=12) allowed users to log journal entries or short reports on their immediate symptoms. Reminders (45%, n=10) let users customize push notifications for important treatment-related events. Connections to Care Teams, Journaling, and Community Support (41%, n=9) provided speed-dial options to oncological healthcare, a logging feature for clinical guidance, and a social component to connect with other pediatric oncology patients or caregivers directly. Medication Tracking and Data Visualization/Graphs (36%, n=8) saved or described dosage instructions and created pictures to describe variables over time such as medication adherence. The Ability to Share Data, Appointment Tracking, and Health Activity Data (27%, n=6) present a repository for users to save important documents to send pictures to a healthcare team, schedule upcoming medical appointments on the app calendar, and record basic aerobics, mindfulness activities, and nutritional habits. Integration with Other Health Apps (9%, n=2) allowed the platform to access other downloaded health and fitness data tracking apps in the patient or caregiver's phone, such as Apple Health or the Fitbit App.

Table 2: Apps and feature distribution

App names	App features												
	Symptom Tracking	Medication Tracking	Appointment Tracking	Information / resources	Push notification reminders	Data visualization / graphs	Ability to share data	Journaling	Connection to care team	Health activity data tracking	Integration with other health apps	Community support	Multiple Language Support
COG KidsCare	✓	✓	✓	✓	✓		✓	✓	✓				✓
Cancer.Net Mobile	✓	✓		✓		✓			✓				
My Cancer Tracker	✓	✓	✓			✓	✓	✓					
CancerAid	✓	✓	✓	✓				✓	✓			✓	
NET Cancer Health Storylines	✓	✓		✓	✓	✓		✓		✓	✓		
Pain Squad*	✓				✓								
iThrive Beyond Peds Cancer*	✓			✓	✓								
HomeTown Cancer Predisposition	✓		✓	✓	✓	✓				✓			
Heroes Circle*												✓	
The Breath Brake App*												✓	
Kids' Guide to Cancer				✓								✓	✓
The Lounge at MSK				✓			✓		✓			✓	✓
BELONG beating Cancer Together				✓	✓		✓		✓			✓	✓
Tracker, Reminder - CareClinic	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		
Outcomes4Me Cancer Care	✓	✓	✓	✓	✓	✓			✓			✓	
iaya				✓				✓				✓	
I'll explain it to you*				✓									✓
FORTEe Get Strong				✓						✓			
AYABytes	✓			✓	✓	✓		✓		✓			
Our Journey with Cancer				✓				✓	✓				
LLS Coloring with Kids				✓									
OncoPower	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	
Frequency n (%)	12 (55%)	8 (36%)	6 (27%)	17 (77%)	10 (45%)	8 (36%)	6 (27%)	9 (41%)	9 (41%)	6 (27%)	2 (9%)	9 (41%)	5 (23%)

*All apps available in both Apple App stores and Google Play store except * (only in Apple App stores)

Most apps (n=16) were free-to-use and publicly available. "Tracker, Reminder - CareClinic" had additional in-app purchases (up to $60 total) that expanded on the existing features of the software.

App quality assessment

For each app, we calculated mean values and standard deviation of MARS scores under 4 categories (Table 3). In addition, we report "objective score", which represents the mean value of 4 categories. Functionality (M=3.66, SD=1.05) scored the highest among the 17 apps following Aesthetics (M=3.51, SD=1.02), Information (M=3.49, SD=0.80), and Engagement (M=3.02, SD=1.05). See Appendix 3 for detailed scoring in each category.

Table 3: App evaluations with the Mobile App Rating Scale. Objective score reflects average of 1 through 4 for each app.

App names	Mean score (Standard Deviation)				
	1. Engagement	2. Functionality	3. Aesthetics	4. Information	Objective score
COG KidsCare	3.80 (0.98)	4.50 (0.50)	4.33 (0.47)	4.67 (0.75)	4.33 (0.82)
My Cancer Tracker	3.00 (1.10)	4.25 (0.43)	4.00 (0.82)	3.17 (0.69)	3.50 (0.96)
CancerAid	2.60 (1.36)	4.25 (0.83)	3.67 (0.94)	4.17 (1.07)	3.67 (1.29)
Net Cancer Health Storylines	4.00 (1.10)	4.50 (0.87)	4.00 (0.00)	4.20 (0.75)	4.18 (0.86)
Pain Squad	4.00 (0.63)	4.75 (0.43)	4.00 (0.82)	4.14 (0.99)	4.21 (0.83)
HomeTown Cancer Predisposition	1.60 (0.80)	4.00 (0.71)	3.00 (0.82)	4.00 (1.22)	3.06 (1.39)
Heroes Circle	1.80 (0.75)	1.50 (0.50)	2.33 (0.47)	2.25 (0.43)	1.94 (0.66)
The Breath Brake App	1.80 (0.75)	1.75 (0.83)	1.67 (0.47)	1.60 (0.80)	1.71 (0.75)
Kid's Guide to Cancer	2.80 (1.33)	3.75 (1.30)	5.00 (0.00)	4.00 (0.89)	3.76 (1.31)
BELONG Beating Cancer Together	4.40 (0.80)	5.00 (0.00)	4.33 (0.94)	3.40 (1.02)	4.24 (1.00)
Tracker, Reminder – CareClinic	4.60 (0.49)	2.50 (0.50)	4.67 (0.47)	3.00 (1.41)	3.65 (1.28)
Outcomes4ME Cancer Care	3.00 (0.89)	4.75 (0.43)	4.00 (0.82)	4.33 (1.11)	4.00 (1.11)
I'll explain it to you	1.80 (0.98)	4.75 (0.43)	2.33 (0.47)	4.00 (1.26)	3.24 (1.52)
FORTEe Get Strong	3.20 (1.17)	2.25 (0.43)	2.67 (0.47)	2.67 (0.75)	2.72 (0.87)
Our Journey with Cancer	1.40 (0.80)	3.00 (0.00)	2.00 (0.00)	3.40 (0.49)	2.47 (0.98)
LLS Coloring for Kids	4.60 (0.49)	4.25 (0.43)	3.67 (0.94)	3.67 (0.75)	4.06 (0.78)
OncoPower	3.00 (1.41)	3.50 (0.50)	3.00 (0.82)	2.80 (1.60)	3.06 (1.26)
Average score	**3.02**	**3.72**	**3.45**	**3.50**	**3.40**

Audience categories

Apps were split into 3 groups based on their intended audience. In the first group, apps that focused on a pediatric population, between the ages of 0 to 17 years-old (n=7), used activities designed to

interest the younger demographic to convey valuable information or make certain features more accessible from a medical literacy perspective. In the second group, apps that focused on caregivers, 18 years and older (n=9), were more likely to create direct connections to healthcare and generate data visualizations to translate numbers into meaningful interpretations. In the last group, the rest of the apps targeted both pediatric patients and caregivers (n=6). These apps proposed separate user accounts to differentiate parent and child as well as the targeted features.

User ratings and reviews

The majority of apps (n=18) had user ratings publicly available for review and analysis. Four apps did not receive any user reviews or ratings (Hometown Cancer Predisposition, Kid's Cancer Guide, AYABytes, and FORTEe Get Strong). These apps had between 1 and 100 posted reviews per app, whereas there were apps that received a high number of user ratings, such as "Tracker, Reminder - CareClinic" (n=3100) and "BELONG Beating Cancer Together" (n=5770). 16 apps received high ratings (M=4.4, Min=3.1, Max=5.0, SD=0.59).

Downloads and storage

CancerAid, Cancer.Net Mobile, BELONG Beating Cancer Together, and My Cancer Tracker were downloaded by more than 5000 users. The rest of the apps were downloaded by less than 500 users. Apps required between 1.7 to 235.3 megabytes of storage for saving health-related information and app functionality (M=67.03 MB, SD= 58.38).

Language availability

To be included, apps were required to have an English option. The majority of the apps provided English exclusively (n=12). However, 10 apps provided multi-language options including Spanish (n=4), French (n=4), Arabic (n=2), German (n=2), Chinese (n=2), Hebrew (n=1), Dutch (n=1), Italian (n=2), Hindi (n=1), Romanian (n=1), and Portuguese (n=1).

Data and Health Information Privacy

Apps typically request access to key hardware or software features built into the device to exercise the full length of capabilities designed into the mHealth app. These requests appear as pop-up notifications the require an input before continuing using the app (M=2.72, Min=0, Max=10, SD=3.13). The types of requests across both app stores included approved access to calendar, files, camera, microphone, location, user ID, device ID, Wi-Fi networks, contacts, and phone status. Based on our observation, none of the apps mentioned any type of encryption on the app store or in-app. Similarly, none of the apps provided 2-step verification options or similar security measures after account creation.

Discussion

Principal findings

The principal findings of our systematic search and analysis study reveal a noticeable scarcity of pediatric oncology-specific mHealth apps in the digital marketplace, highlighting a critical gap in resources aimed at supporting pediatric cancer patients and their families. Despite the growing prevalence of mHealth solutions in the broader healthcare landscape [26], our analysis underscores the underrepresentation of pediatric cancer patients in this technological advancement [27].

Similarly Jupp et al.'s earlier review identified only 1 out of 28 qualifying oncology apps that specifically served pediatric patients [28].

The existing apps predominantly focus on educational resources, symptom tracking, and medication reminders. We observed that the adoption of these apps may rely on how well an app can both target specific diagnoses and remain applicable for the wider oncology audience. Therefore, high functionality may have come at the cost of aesthetics and engagement quality of the apps and lacking concise and quality information. While these features align with general needs within chronic illness management, they often lack the specificity and depth required for the complex care trajectories typical in pediatric oncology. This includes focusing on cancers more common in children than adults, implementing risk-based medical follow-ups, a systematic plan for lifelong surveillance, managing symptoms, addressing developmental delays or educational disruption, and mitigating long term effects of treatment [29,30].

Quality assessment

Of the objective domains, functionality scored the highest while engagement scored lowest on average. The prioritization of equipping patients and their caregivers with accessible tools is a strong theme among newer mHealth apps, especially in pediatric oncology. These health management apps can create the structure needed for caregivers and patients to monitor progress, which lead to better accountability and overall better patient outcomes [31]. However, design of these apps often does not incorporate tactics to maintain attention or consistent usage, such as gamification, in the long-term. This in combination with the lower information scores create an obstacle to sustained adoption. An app may be highly functional and aesthetically professional but lacks the specific flexibility and informative quality for caregivers, patients, or both.

Lower scores for engagement are consistent with other studies in the literature that used MARS for oncology app interventions [32]. Additionally, the developers tendency to focus on implementation rather than building evidence-based features highlights a trend of understudied interventions on the market today [33]. Many of the apps included in this study either were minimally tested in a usability trial or were not rigorously tested at all. New users of these apps may find oncology mHealth apps helpful for minor tracking purposes like notifications but might find them problematic with evolving treatment plans, expanding diagnostic information, and available support groups in the area.

Target population

Of the few apps currently available for pediatric cancer, apps were designed to target children and adolescent patients, caregivers, or both user populations. Apps designed for adolescents and young adults (AYA) with cancer are of interest since nearly two-thirds of AYAs within in the US report using an app for health behaviors, including medication reminders [34]. Several studies have reported the informational needs of AYAs in a cancer care app by highlighting features such as free-text diaries. The overarching goal of a cancer care app is expected to help monitor the impact of the disease and treatment in their day-to-day life and emotions [14]. Additionally, there is a need for personalized data to be adapted to a patient's specific condition, considering factors such as the type, history, and severity of cancer,[35] as well as age-appropriate content that addresses topics like diagnosis, treatment options, sustaining social ties, and strategies to manage the illness [36]. These abilities help AYAs to be more independent with self-care, thus easing the transition to adulthood and long-term survivorship [37]. Additionally, more recent pediatric oncology literature has called out the gap in the child's voice, particularly in symptom assessment [38–40]. mHealth apps designed specifically

for children could provide that opportunity to improve reporting standards.

Value of apps in patient care

In our study, the majority of the apps focused on educational (information) resources for different user audiences. This aligns with Vaffis et al.'s [30] finding as mHealth apps focusing on cancer as an important component of patient disease management. Moreover, this an expected finding as pediatric cancer treatment requires complex treatment regimens, daily medications, intensive side effects, and symptom burden [41]. In addition, medication tracking, symptom tracking and notifications for reminders are other majority of the features. This matched with the need and also the major challenge to the oncological treatment plans, which is managing medication non-adherence/non-compliance. Missed treatments during home care are major causes of increased adverse outcomes including infection, relapse, and death in this vulnerable population [42]. Therefore, the apps have been aiming to address this vital issue via those critical features, aligning with earlier applications [43]. In addition, literature presents evidence to support the efficacy of digital interventions in improving medication adherence, psychosocial well-being, and health outcomes in children and adolescents with chronic health conditions [5]. This indicates that mHealth apps aim to improve adherence, self-management and alleviating symptom burden could be essential to improving utility of the apps, and health outcomes.

Inclusivity

Furthermore, our findings highlight a significant language barrier, with more than half of the reviewed apps available exclusively in English. The accessibility of these digital interventions in alternative languages is a step towards closing the gap in care [44,45]. However, this has been an improvement as a review in 2017 cited only 20% of all medication apps were offered alternative languages [37]. In addition, the digital divide between socioeconomic and ethnic groups reduces the availability of such resources to underserved populations including Limited English Proficiency (LEP) patients and families [46,47]. New approaches via mobile apps should be considered, as these platforms can help with medical literacy and build self-care routines among patients and families [48,49]. In addition, developers and decision makers should consider the device compatibility and dependency on cellular connectivity to reduce problems due to inconsistent service, limited storage, data plan requirements, or budget-friendly smartphones that are outside of the regularly maintained cycle of software updates [14,20,37]. Such an approach may support scalable, accessible, and affordable use.

Privacy and security

Finally, data security and privacy are important as patients and families are storing and sharing personal identifiable information and confidential health information via apps. Healthcare institutions create guidelines for handling sensitive data; however, the privacy and security of personal health apps remains the responsibility of end-users. Unfortunately, the Health Insurance Portability and Accountability Act (HIPAA) does not regulate 3rd party apps or their services [50]. Other regulations such as the Children's Online Privacy Protection Act (COPPA) has been a major piece of legislation for protecting child information from 3rd party organizations, yet it has limited protections with regard to healthcare information [51–53]. To ensure adequate protection, app stores hosting mHealth tools should have additional protocols to require justification for the necessity of accessing requested phone sensors and other sensitive health informatics (e.g., camera, location, microphone) [50].

Limitations

This review provided an overview of pediatric cancer specific apps limited to the currently available apps in the Google Play and Apple App Store. We included these two common app stores because they are available in two major smartphone operating systems (iOS and Android) and are accessible by majority of end users [54]. We have not included other stores, such as the Galaxy Store or Amazon Appstore, due their limited user base and specific to requirements for service (i.e., the Amazon Appstore requires additional app installations) which may not be applicable for broader audience of pediatric oncology patients and caregivers. We focused on the US market for available apps as both app stores are regionally locked due to our physical location. In addition, we focused on apps available in the English language with additional language options. That limited our access to other apps that do not include English language as an option, or alternative apps for different regions or languages. We were not able to use content or sentiment analysis with all user comments because not all apps had a sufficient volume of comments to be analyzed. In addition, we have not received feedback from developers, patients, and clinicians about the apps during the study. This may have limited the study's objectivity by not including their insights about the apps. Finally, the apps have a lifecycle and are subject to change depending on developer updates and business or are not accessible and have restricted access. Some apps could be also removed from these stores for any reason, which may reduce the ability to evaluate these apps continuously and replicate this review with the same set of apps.

Future works

Further research is suggested to investigate how developers create mHealth interventions through theory-based frameworks and collaborations (i.e. co-design). Based on the MARS, we recommend future interventions to balance focus between extensive customizability and reliable intractability. Additionally, future development efforts must prioritize the involvement of pediatric oncology stakeholders, including patients, families, and healthcare professionals, to ensure that the apps are not only technically sound but also deeply aligned with the specific needs, reducing linguistic and cultural barriers. We suggest a focus on evidence-based implementations and rigorous testing approaches for intervention, validation, adoption, and effectiveness. Going beyond, future research may expand how these apps are created from the developer's perspective and ways to enable cross-disciplinary collaborations including patient and clinician stakeholders as well. Other avenues of research may also incorporate recent innovations in VR, XR, and AI to create more effective mobile and web applications.

Conclusions

Our study examined the landscape of mHealth apps for pediatric cancer. While mHealth apps hold promise for enhancing care and support for pediatric cancer treatment, our findings underscore the need for more inclusive, comprehensive, and integrated digital health solutions. The complexity of pediatric cancer is a multifaceted challenge, and mHealth apps can bridge the gaps to become a fundamental source of support for patients and caregivers from diagnosis to survivorship.

Conflict of interest

ES is editorial board member of JMIR as an associate editor.

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References

1. Childhood cancer. Available from: https://www.who.int/news-room/fact-sheets/detail/cancer-in-children [accessed Apr 11, 2023]

2. Ward ZJ, Yeh JM, Bhakta N, Frazier AL, Girardi F, Atun R. Global childhood cancer survival estimates and priority-setting: a simulation-based analysis. Lancet Oncol Elsevier BV; 2019 Jul;20(7):972–983. PMID:31129029

3. Erdmann F, Frederiksen LE, Bonaventure A, Mader L, Hasle H, Robison LL, Winther JF. Childhood cancer: Survival, treatment modalities, late effects and improvements over time. Cancer Epidemiol Elsevier BV; 2021 Apr;71(Pt B):101733. PMID:32461035

4. Bhakta N, Force LM, Allemani C, Atun R, Bray F, Coleman MP, Steliarova-Foucher E, Frazier AL, Robison LL, Rodriguez-Galindo C, Fitzmaurice C. Childhood cancer burden: a review of global estimates. Lancet Oncol Elsevier BV; 2019 Jan;20(1):e42–e53. PMID:30614477

5. Ramsey WA, Heidelberg RE, Gilbert AM, Heneghan MB, Badawy SM, Alberts NM. eHealth and mHealth interventions in pediatric cancer: A systematic review of interventions across the cancer continuum. Psychooncology Wiley; 2020 Jan;29(1):17–37. PMID:31692183

6. Mahmood A, Kedia S, Wyant DK, Ahn S, Bhuyan SS. Use of mobile health applications for health-promoting behavior among individuals with chronic medical conditions. Digit Health SAGE Publications; 2019 Jan;5:2055207619882181. PMID:31656632

7. Vogels EA. Teens, social media and technology 2022. Pew Research Center: Internet, Science & Tech. 2022. Available from: https://www.pewresearch.org/internet/2022/08/10/teens-social-media-and-technology-2022/ [accessed Oct 24, 2023]

8. Marcolino MS, Oliveira JAQ, D'Agostino M, Ribeiro AL, Alkmim MBM, Novillo-Ortiz D. The impact of mHealth interventions: Systematic review of systematic reviews. JMIR MHealth UHealth JMIR Publications Inc.; 2018 Jan 17;6(1):e23.

9. Mueller EL, Cochrane AR, Moore CM, Jenkins KB, Bauer NS, Wiehe SE. Assessing needs and experiences of preparing for medical emergencies among children with cancer and their caregivers. J Pediatr Hematol Oncol Ovid Technologies (Wolters Kluwer Health); 2020 Nov;42(8):e723–e729. PMID:32427703

10. Slater PJ, Fielden PE, Bradford NK. The Oncology Family App: Providing information and support for families caring for their child with cancer. J Pediatr Oncol Nurs SAGE Publications; 2018;35(2):94–102. PMID:29161974

11. Lau N, Parsa AG, Walsh C, Yi-Frazier JP, Weiner BJ, Curtis JR, McCauley E, Rosenberg AR, Barton K. Facilitators and barriers to utilization of psychosocial care in adolescents and young adults with advanced cancer: Integrating mobile health perspectives. J Adolesc Young Adult Oncol Mary Ann Liebert Inc; 2021 Aug;10(4):476–482. PMID:32985937

12. Lawitschka A, Buehrer S, Bauer D, Peters K, Silbernagl M, Zubarovskaya N, Brunmair B, Kayali F, Hlavacs H, Mateus-Berr R, Riedl D, Rumpold G, Peters C. A web-based mobile app (INTERACCT app) for adolescents undergoing cancer and hematopoietic stem cell transplantation aftercare to improve the quality of medical information for clinicians: Observational study. JMIR MHealth UHealth JMIR Publications Inc.; 2020 Jun 30;8(6):e18781. PMID:32602847

13. Wesley KM, Fizur PJ. A review of mobile applications to help adolescent and young adult cancer patients. Adolesc Health Med Ther Dove Medical Press Ltd.; 2015 Aug 18;6:141–148. PMID:26316835

14. Elsbernd A, Hjerming M, Visler C, Hjalgrim LL, Niemann CU, Boisen K, Pappot H. Cocreated smartphone app to improve the quality of life of adolescents and young adults with cancer (kræftværket): Protocol for a quantitative and qualitative evaluation. JMIR Res Protoc JMIR Publications Inc.; 2018 May 10;7(5):e10098. PMID:29748162

15. Hanghøj S, Boisen KA, Hjerming M, Pappot H. Adolescents' and young adults' experiences of a prototype cancer smartphone app. Digit Health SAGE Publications; 2021 Jan;7:205520762199725.

16. McCann L, Hewitt C, McMillan KA. Developing an e-prehabilitation system of care for young adults diagnosed with cancer: User-centered design study. JMIR Cancer JMIR Publications Inc.; 2023 Mar 30;9(1):e41441.

17. Ralph JE, Sezgin E, Stanek CJ, Landier W, Pai ALH, Gerhardt CA, Skeens MA. Improving medication adherence monitoring and clinical outcomes through mHealth: A randomized controlled trial protocol in pediatric stem cell transplant. PLoS One Public Library of Science (PLoS); 2023 Aug 17;18(8):e0289987.

18. Hooke MC, Gilchrist L, Tanner L, Hart N, Withycombe JS. Use of a fitness tracker to promote physical activity in children with acute lymphoblastic leukemia. Pediatr Blood Cancer Wiley; 2016 Apr;63(4):684–689. PMID:26756736

19. Mendoza JA, Baker KS, Moreno MA, Whitlock K, Abbey-Lambertz M, Waite A, Colburn T, Chow EJ. A Fitbit and Facebook mHealth intervention for promoting physical activity among adolescent and young adult childhood cancer survivors: A pilot study. Pediatr Blood Cancer Wiley; 2017 Dec;64(12):e26660. PMID:28618158

20. Park BK, Kim JY, Rogers VE. Development and usability evaluation of a Facebook-based intervention program for childhood cancer patients: Mixed methods study. J Med Internet Res JMIR Publications Inc.; 2020 Jul 28;22(7):e18779. PMID:32720897

21. Huang JS, Dillon L, Terrones L, Schubert L, Roberts W, Finklestein J, Swartz MC, Norman GJ, Patrick K. Fit4Life: A weight loss intervention for children who have survived childhood leukemia. Pediatr Blood Cancer Wiley; 2014 May;61(5):894–900. PMID:24436138

22. Jibb LA, Stevens BJ, Nathan PC, Seto E, Cafazzo JA, Johnston DL, Hum V, Stinson JN. Implementation and preliminary effectiveness of a real-time pain management smartphone app for adolescents with cancer: A multicenter pilot clinical study. Pediatr Blood Cancer Wiley; 2017 Oct;64(10). doi: 10.1002/pbc.26554

23. Bruggers CS, Baranowski S, Beseris M, Leonard R, Long D, Schulte E, Shorter A, Stigner R, Mason CC, Bedrov A, Pascual I, Bulaj G. A prototype exercise–empowerment mobile video game for children with cancer, and its usability assessment: Developing digital empowerment interventions for pediatric diseases. Front Pediatr Frontiers Media SA; 2018 Apr 9;6. doi: 10.3389/fped.2018.00069

24. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, Chou R, Glanville J, Grimshaw JM, Hróbjartsson A, Lalu MM, Li T, Loder EW, Mayo-Wilson E, McDonald S, McGuinness LA, Stewart LA, Thomas J, Tricco AC, Welch VA, Whiting P, Moher D. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. Syst Rev Springer Science and Business Media LLC; 2021 Mar 29;10(1):89. PMID:33781348

25. Stoyanov SR, Hides L, Kavanagh DJ, Zelenko O, Tjondronegoro D, Mani M. Mobile app rating scale: a new tool for assessing the quality of health mobile apps. JMIR Mhealth Uhealth 2015 Mar 11;3(1):e27. PMID:25760773

26. Upadhyay VA, Landman AB, Hassett MJ. Landscape analysis of oncology mobile health applications. JCO Clin Cancer Inform American Society of Clinical Oncology (ASCO); 2021 Dec; (5):579–587.

27. Mehdizadeh H, Asadi F, Mehrvar A, Nazemi E, Emami H. Smartphone apps to help children and adolescents with cancer and their families: a scoping review. Acta Oncol Informa UK Limited; 2019 Jul;58(7):1003–1014. PMID:30915872

28. Jupp JCY, Sultani H, Cooper CA, Peterson KA, Truong TH. Evaluation of mobile phone applications to support medication adherence and symptom management in oncology patients. Pediatr Blood Cancer Wiley; 2018 Nov;65(11):e27278.

29. Diller L, Chow EJ, Gurney JG, Hudson MM, Kadan-Lottick NS, Kawashima TI, Leisenring WM, Meacham LR, Mertens AC, Mulrooney DA, Oeffinger KC, Packer RJ, Robison LL, Sklar CA. Chronic disease in the childhood cancer survivor study cohort: A review of published findings. J Clin Oncol American Society of Clinical Oncology (ASCO); 2009 May 10;27(14):2339–2355. PMID:19364955

30. Vaffis S, Whaley S, Axon DR, Hall-Lipsy E, Hincapie A, Slack M, Warholak T. Features of cancer mHealth apps and evidence for patient preferences: Scoping literature review. JMIR Cancer JMIR Publications Inc.; 2023 Apr 28;9:e37330. PMID:37115587

31. Vo V, Auroy L, Sarradon-Eck A. Patients' perceptions of mHealth apps: Meta-ethnographic review of qualitative studies. JMIR MHealth UHealth JMIR Publications Inc.; 2019 Jul 10;7(7):e13817.

32. Wasserman S, Ould Brahim L, Attiya A, Belzile E, Lambert SD. An evaluation of interactive mHealth applications for adults living with cancer. Curr Oncol MDPI AG; 2023 Jul 25;30(8):7151–7166.

33. Jakob R, Harperink S, Rudolf AM, Fleisch E, Haug S, Mair JL, Salamanca-Sanabria A, Kowatsch T. Factors influencing adherence to mHealth apps for prevention or management of

noncommunicable diseases: Systematic review. J Med Internet Res JMIR Publications Inc.; 2022 May 25;24(5):e35371.

34. Psihogios AM, Stiles-Shields C, Neary M. The needle in the haystack: Identifying credible mobile health apps for pediatric populations during a pandemic and beyond. J Pediatr Psychol Oxford University Press (OUP); 2020 Nov 1;45(10):1106–1113. PMID:33068424

35. Mehdizadeh H, Asadi F, Mehrvar A, Nazemi E, Emami H. Smartphone apps to help children and adolescents with cancer and their families: a scoping review. Acta Oncol Informa UK Limited; 2019 Jul 3;58(7):1003–1014.

36. Schwartz-Attias I, Raz H, Natanzon-Bracha T, Finkelstein A, Kreitler S. Adolescents with cancer need trustworthy information and prefer to receive it from a human source rather than from the internet: A qualitative study. Front Psychol Frontiers Media SA; 2021 Nov 22;12. doi: 10.3389/fpsyg.2021.746810

37. Dayer LE, Shilling R, Van Valkenburg M, Martin BC, Gubbins PO, Hadden K, Heldenbrand S. Assessing the medication adherence app marketplace from the health professional and consumer vantage points. JMIR MHealth UHealth 2017 Apr 19;5(4):e45. PMID:28428169

38. Maurer SH, Hinds PS, Reeve BB, Mack JW, McFatrich M, Lin L, Withycombe JS, Jacobs SS, Baker JN, Castellino SM, Freyer DR. Patients, caregivers, and clinicians differ in performance status ratings: Implications for pediatric cancer clinical trials. Cancer Wiley; 2021 Oct 1;127(19):3664–3670. PMID:34196962

39. Pinheiro LC, McFatrich M, Lucas N, Walker JS, Withycombe JS, Hinds PS, Sung L, Tomlinson D, Freyer DR, Mack JW, Baker JN, Reeve BB. Child and adolescent self-report symptom measurement in pediatric oncology research: a systematic literature review. Qual Life Res Springer Science and Business Media LLC; 2018 Feb;27(2):291–319.

40. Freyer DR, Lin L, Mack JW, Maurer SH, McFatrich M, Baker JN, Jacobs SS, Lucas N, Withycombe JS, Tomlinson D, Villabroza KR, Waldron MK, Hinds PS, Reeve BB. Lack of concordance in symptomatic adverse event reporting by children, clinicians, and caregivers: Implications for cancer clinical trials. J Clin Oncol American Society of Clinical Oncology (ASCO); 2022 May 20;40(15):1623–1634. PMID:35294262

41. Hooke MC, Linder LA. Symptoms in children receiving treatment for cancer—Part I: Fatigue, sleep disturbance, and nausea/vomiting. J Pediatr Oncol Nurs SAGE Publications; 2019 Jul;36(4):244–261. PMID:31307321

42. McGrady ME, Pai ALH. A systematic review of rates, outcomes, and predictors of medication non-adherence among adolescents and young adults with cancer. J Adolesc Young Adult Oncol Mary Ann Liebert Inc; 2019 Oct;8(5):485–494. PMID:31038372

43. Wesley K, Fizur P. A review of mobile applications to help adolescent and young adult cancer patients. Adolesc Health Med Ther Informa UK Limited; 2015 Aug;6:141. PMID:26316835

44. Saeed SA, Masters RM. Disparities in health care and the digital divide. Curr Psychiatry Rep Springer Science and Business Media LLC; 2021 Sep;23(9). doi: 10.1007/s11920-021-01274-4

45. Hamilton EC, Saiyed F, Miller CC III, Eguia A, Fonseca AC, Baum GP, Tsao K, Austin MT. The digital divide in adoption and use of mobile health technology among caregivers of pediatric surgery patients. J Pediatr Surg Elsevier BV; 2018 Aug;53(8):1478–1493.

46. Shi L, Lebrun LA, Tsai J. The influence of English proficiency on access to care. Ethn Health Informa UK Limited; 2009 Dec;14(6):625–642. PMID:19953393

47. Diamond LC, Schenker Y, Curry L, Bradley EH, Fernandez A. Getting by: underuse of interpreters by resident physicians. J Gen Intern Med Springer Science and Business Media LLC; 2009 Feb;24(2):256–262. PMID:19089503

48. Sezgin E, Noritz G, Hoffman J, Huang Y. A medical translation assistant for non-English-speaking caregivers of children with special health care needs: Proposal for a scalable and interoperable mobile app. JMIR Res Protoc JMIR Publications Inc.; 2020 Oct 14;9(10):e21038. PMID:33051177

49. Chang DTS, Thyer IA, Hayne D, Katz DJ. Using mobile technology to overcome language barriers in medicine. Ann R Coll Surg Engl Royal College of Surgeons of England; 2014 Sep;96(6):e23-5. PMID:25198966

50. McKeon J. The Quest to Improve Security, Privacy of Third-Party Health Apps. Heath IT Security. Available from: https://healthitsecurity.com/features/the-quest-to-improve-security-privacy-of-third-party-health-apps [accessed Apr 12, 2023]

51. Children's online privacy protection rule ("COPPA"). Federal Trade Commission. 2013. Available from: https://www.ftc.gov/legal-library/browse/rules/childrens-online-privacy-protection-rule-coppa [accessed Apr 12, 2023]

52. Jargon J. How 13 became the internet's age of adulthood. Wall St J (East Ed) The Wall Street Journal; 2019 Jun 18; Available from: https://www.wsj.com/articles/how-13-became-the-internets-age-of-adulthood-11560850201 [accessed Apr 12, 2023]

53. Schwartz GN. Leaning into CHAOS (child's Health and Online Safety Act): Revision to FTC's enforcement of COPPA & new model rule for child advertising. University of Maine School of Law; 2022. Available from: https://digitalcommons.mainelaw.maine.edu/privacy-certificate-student-publications/3/ [accessed Apr 12, 2023]

54. Biggest app stores in the world 2022. Statista. Available from: https://www.statista.com/statistics/276623/number-of-apps-available-in-leading-app-stores/ [accessed Oct 24, 2023]

Supplementary Files

Multimedia Appendixes

PRISMA Checklist.
URL: http://asset.jmir.pub/assets/c3dfbdd434b91e4255a35a2a581ac6b9.docx

mHealth app list.
URL: http://asset.jmir.pub/assets/7b60b3c0fad52b8d9e67fc2f5667857c.xlsx

MARS scores.
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