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Article

eHealth Interventions for Children and Adolescents with Cancer: Scoping Review

Maryam Homayounpour[1], Fariba Zarani[2], and Mohammad Ali Mazaheri Tehrani[3]

[1]PhD Candidate in Health Psychology, Faculty of Education and Psychology, Shahid Beheshti University, Tehran, Iran; [2]Associate Professor of Psychology, Department of Psychology, Shahid Beheshti University, Tehran, Iran; [3] Professor of Clinical Psychology, Department of Psychology, Shahid Beheshti University, Tehran, Iran.
fzarani@yahoo.com

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Abstract

Children and adolescents with cancer face complex medical and psychological challenges that are increasingly addressed through digital and game-based eHealth interventions. This scoping review systematically mapped 46 unique tools developed between 2010 and 2023, aiming to identify their features, reported outcomes, limitations, and research gaps. A systematic search of five databases (Google Scholar, PubMed, Science Direct, Web of Science, Scopus) covering 2000–2025 was conducted following PRISMA-ScR guidelines. Interventions primarily targeted symptom monitoring (54.3%), psychological support (30.4%), health education (10.9%), and social interaction (4.3%), mostly via mobile/tablet platforms (59.1%). Positive outcomes included improved illness knowledge, reduced anxiety and pain, and enhanced treatment adherence. However, 84% of tools lacked explicit theoretical grounding, engagement often declined over time, advanced hardware was frequently required, and personalization was limited. This review provides the most comprehensive and up-to-date mapping of pediatric oncology eHealth tools to date, with a focus on design narratives and gamification strategies—dimensions underexplored in prior reviews. Findings highlight the need for user-centered, culturally adapted, and theory-informed designs, interdisciplinary collaboration, and rigorous longitudinal evaluation to ensure effective, sustainable digital health solutions for children and adolescents with cancer.

1. Introduction

Cancer remains one of the leading causes of disease-related mortality in children. The prognosis for pediatric and adolescent cancer patients has improved significantly over the past half-century, with survival rates exceeding 80 percent in high-income countries but declining to approximately 50 percent in middle-income and below 30 percent in low-income settings [1]. Effective control and management of childhood cancer—similar to other malignancies—require robust public health programs, timely referrals, and high-quality, multidisciplinary clinical services [2]. Although

survival rates are high, patients experience multiple treatment-related complications that can disrupt therapy, which may be mitigated through appropriate daily care [3]. Pediatric cancer patients and their families, regardless of geographic region, experience short- and long-term psychosocial, emotional, social, and economic burdens arising from the disease and its treatment [2]. The diagnosis profoundly affects family dynamics, while treatment often involves painful procedures, repeated hospitalizations, and frequent physician visits. Moreover, patients encounter psychological challenges—such as anxiety or depression—that necessitate timely intervention [4]. Adolescents, in particular, are vulnerable due to disruptions in autonomy and independence, which can result in sustained psychological impact; thus, specialized psychosocial support and continuous follow-up are critical. Health systems must respond by delivering coordinated services and implementing information systems that identify challenges at each stage. Consequently, comprehensive care should commence at diagnosis and encompass interventions targeting both symptom management and health-related quality of life [2].

In this context, health-focused games have emerged as promising tools to engage patients while imparting cancer-related information [4]. Empirical evidence suggests that play therapy can promote relaxation, distraction, improved social functioning, expression of positive emotions, enhanced treatment adherence, and reduced anxiety in children with cancer [5],[6],[7]. Innovative game-based interventions leverage widespread technology adoption among younger cohorts and heightened immersion levels. Such approaches can alleviate side effects (e.g., nausea), support physical rehabilitation, and facilitate adaptation to illness [5], [7], [8]. Digital health interventions—including websites, mobile applications, and serious games—are well received by youth. Serious games, defined as games developed or utilized for health-related objectives, have demonstrated efficacy in improving young patients' disease-related knowledge and self-management [3], [9], [10]. Furthermore, these games provide an opportunity to raise awareness on challenging topics such as treatment and disease prevention [4], [11].

Numerous eHealth tools have been designed and implemented to manage disease and symptoms in pediatric and adolescent oncology. Despite this promising potential, a systematic and contemporary mapping of the current landscape is critically needed. Prior reviews have often focused narrowly on specific modalities (e.g., only serious games) or lacked a comprehensive, up-to-date scope, failing to critically evaluate the theoretical foundations guiding these designs. The absence of explicit psychological or behavioral theories in tool development constitutes a crucial gap, hindering robust evaluation and scale-up. To address this critical gap, and thereby advance the state of the art by providing a broader, more up-to-date synthesis and a critical appraisal of theoretical underpinnings, this scoping review aims to synthesize the current evidence base by answering the following specific research questions:

- What are the characteristics (year, country, and platform) and primary objectives of digital interventions developed for children and adolescents with cancer?
- How are these tools categorized based on their functional purpose (i.e., Health Education, Symptom Monitoring, Psychological Support, and Social Interaction)?
- Which theoretical frameworks (e.g., self-efficacy, health belief model) are explicitly mentioned as grounding the design and implementation of these interventions?

2. Methods and Material

The present study employed a scoping review design following the five-stage framework proposed by Arksey & O'Malley [12]. Scoping reviews aim to identify and map key concepts, the breadth of evidence, and gaps in a given research area. To achieve this, systematic searches were conducted across Google Scholar, PubMed, Science Direct, Web of Science, and Scopus for studies published between 2000 and 2025. The search strategy combined terms related to pediatric oncology and digital interventions, including "children with cancer," "childhood cancer," "mobile games," "serious games," "application," "virtual reality," "mobile app," "eHealth," and "digital health."

2.1. Inclusion and Exclusion Criteria

Inclusion Criteria: Studies were eligible if they:

1. Were published in English.
2. Evaluated a digital tool specifically designed for children or adolescents (0–18 years) diagnosed with cancer.
3. Were primary studies, pilot studies, experimental studies, app/digital tool evaluations, or systematic/scoping reviews.
4. Included interventions aimed at education, psychological support, symptom management, treatment adherence, or improving the child's experience with the illness.

Exclusion Criteria: Studies were excluded if they:

1. Targeted children or adolescents of parents with cancer, healthcare professionals, or adult patients.
2. Were conference proceedings, abstracts without full text, or duplicate reports.
3. Included tools not directly related to children with cancer (e.g., general educational or entertainment apps).
4. Had very low reporting of essential study data (e.g., population size, intervention details, or outcomes) or did not report outcomes necessary for the data extraction template.

2.2. Screening and Selection Process

The review protocol and reporting strictly adhered to the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews) guidelines [13]. The initial search retrieved 49,524 records from the databases. After removal of 49,032 duplicates, irrelevant titles, and inaccessible texts, 492 records remained for screening. Two independent reviewers screened the titles and abstracts of the remaining 492 records. Full-text articles of potentially eligible studies were then assessed against the inclusion and exclusion criteria. Any disagreements during the screening process were resolved through discussion between the two reviewers, and if necessary, by consulting a third reviewer. After excluding 446 studies that did not meet the criteria, 46 digital tools were ultimately selected for comprehensive analysis. The selection process is visually summarized in the PRISMA-ScR flow diagram (Figure 1), which is presented here to enhance readability and transparency.

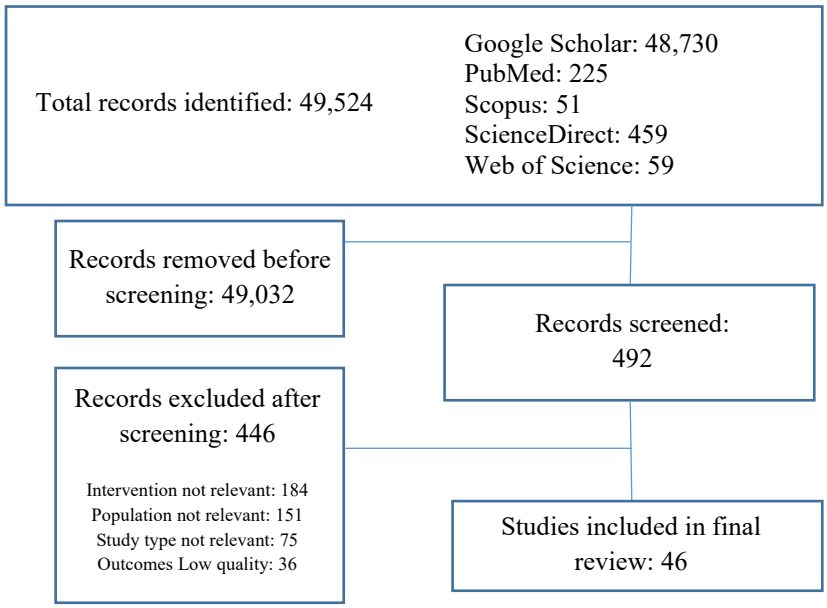

Figure 1. PRISMA-ScR flow diagram detailing the study selection process

2.3. Data Extraction and Synthesis

Data extraction was performed independently by two reviewers using a standardized data extraction form developed by the research team. From each included study, we extracted information on publication year, country, digital tool type, target population, intervention objectives, reported outcomes, delivery platform, and references. For synthesis and analysis, we specifically extracted and evaluated the following:

- **Intervention Objectives:** Categorized into four key areas (Health Education, Symptom Monitoring, Psychological Support, and Social Interaction) to allow for clear comparison and quantitative mapping of the field.
- **Reported Outcomes:** Quantified based on specific findings (e.g., studies showing reduced anxiety, improved adherence).
- **Theoretical Grounding:** Assessed the explicit mention and application of psychological or behavioral theories in the tool's design to address a key research gap.
- **Design Features and Engagement:** Focused on the use of gamification, storytelling, and interactive elements.

Extracted data were organized and reported according to tool type, purpose, and target age group. Data were synthesized narratively to identify similarities, differences, and emerging patterns across the 46 tools, highlighting strengths, limitations, and key design features in the current evidence base.

3. Results

Findings derived from the scoping review of 46 digital interventions for children and adolescents with cancer are summarized below. The structure of the results is guided by three separate tables designed for efficient data presentation: Table 1 provides a descriptive overview of the included tools, Table 2 offers a qualitative synthesis of design features, theoretical grounding, and key outcomes, and Table 3 outlines the quantitative distribution trends.

Table 1. Basic Information on the Development of the Tools

Number	Name of the tool	Year of Development	Country	Target Group	Setting
1	HabitApp [5]	2020	Spain	Children and adolescents aged 1 to 16 years, and their parents	Android (Tablet)
2	Triumf [14]	2019	Russia Estonia	Children/ adolescents (7–14 years)	Android and iOS
3	iManageCancer [15], [16]	2017	England Germany	Children and adolescents under 18 years, and adults	Platform including several applications
4	EmpowerStar [17]	2018	America	Children and adolescents aged 7 to 14 years	Mobile phone
5	3D GIT [7]	2014	Pakistan	Children/ adolescents (10–14 years)	Desktop
6	INTERACCT [18]	2020	Australia	Adolescents aged 12 to 19 years post-transplant	Android and iOS
7	Presence App [19], [20]	2014	Australia	Children (7–12 years)	Tablet
8	Adventures in Sophoria [4], [19]	2011	Germany	Children and adolescents (7–19 years)	Web Game
9	Health Voyager [19], [21]	2019	America	Under 18 years	Tablet and Smartphone
10	Proton U [19], [22]	2018	America	Children (4–10 years)	Tablet and Smartphone
11	The City of Dreams [19], [23]	2017	Iran	Children and adolescents (8–12 years)	Mobile phone
12	Cytarius [4], [19]	2011	Germany	Children and adolescents (7–18 years)	Console
13	Farmooo [19], [24]	2018	Canada	Under 18 years	Virtual Reality Glasses

14	Re-Mission [25]	2006	America	Adolescents and youth (13–29 years)	Minicomputer & Console
15	Pets vs Onco: a virtual pet serious game [3], [26]	2021	_	Children and adolescents (6–17 years)	Android
16	ASyMS-YG [27]	2005	England	Adolescents (13–18 years)	_
17	Mobile Oncology Symptom Tracker (mOST) [28], [29]	2012	America	Adolescents and youth (13–21 years)	iOS
18	Cherry [28]	2013	Norway/ Sweden	Children and Parents	Android
19	Eating After Transplant (EAT!) [28], [30]	2010	America	Adolescents (11–18 years)	_
20	Pain Squad [28], [31]	2013	Canada	Children and adolescents (9–18 years)	iOS
21	Children's International Mucositis Evaluation Scale (ChIMES) [28], [32]	2013	Canada	Children and adolescents (8–18 years)	Android and iOS
22	Painometer [28], [33]	2014	Spain	Children, adolescents, and young adults	Android and iOS
23	Computerized Symptom Capture Tool (C-SCAT) [28], [34]	2014	America	Adolescents and youth (13–29 years)	iOS
24	iCan Cope with Pain [28], [35]	2014	Canada	Adolescents (14–18 years)	Website/ iOS
25	Late effects surveillance system (LESS) [28], [36]	2015	Germany	Children	Android
26	SyMon-SAYS [28], [37]	2015	America	Children, parents, and healthcare providers	_
27	Symptom screening in pediatrics SSPedi [28], [38]	2016	Canada	Children, and adolescents	iOS
28	PainBuddy [28], [39]	2016	America	Children and adolescents (8–18 years)	iOS
29	Sisom-2 [28], [40]	2016	Norway/ Sweden	Children and adolescents (6–12 years)	iOS
30	Pediatric PROMIS [28], [41]	2017	China	Children aged 8 to 17 years and their parents	_
31	Fit bit [28], [42]	2017	America	Recovered adolescents aged 14 to 18 years	iOS
32	Pain Squad+ [28], [43]	2018	Canada	Adolescents (12–18 years)	iOS
33	Dosecast9 [28], [44]	2018	America	Adolescents and youth (15–29 years)	Android and iOS
34	CanSelfMan [45], [46]	2022	Iran	Children and adolescents aged over 7 years	Mobile phone
35	Ben's Game [47], [48]	2004	America	Children and adolescents	Computer
36	Kimotopia [49], [50], [51]	2018	Brazil	Children and adolescents (8–13 years)	Android
37	Arash [52]	2018	Iran	Children and adolescents (5–12 years)	Robot
38	AquaScouts [53]	2021	Germany Greece Czech	Children and adolescents (6–17 years)	Android and iOS
39	KLIK Pain Monitor [54]	2021	Netherlands	Children and adolescents (8–18 years)	Android and iOS

40	Therapeutic Video Game (TVG) [55]	2020	Taiwan	Preschool children	-
41	Color Me Healthy [56]	2021	America	Children and adolescents (6–12 years)	-
42	virtual reality game to support the radiation therapy [67]	2023	Germany	Children and adolescents (7–16 years)	Android and iOS
43	Goo [50]	2023	Brazil	Children and adolescents	Android and iOS
44	Serious Game About Radiotherapy [58]	2022	Sweden	Children and adolescents (5–14 years)	-
45	FORTEe – Get Strong App [59]	2024	Europe (Lead: Germany)	Children and adolescents (6–18 years)	Mobile phone / Tablet
46	Extended Reality (XR) Gaming for Exercise & Mindfulness [60]	2024	America	Adolescents and young adults (13–24 years)	Virtual Reality (VR) System

As detailed in Table 1, the 46 reviewed tools exhibit substantial diversity in terms of country of origin, target age groups, and technical platforms. Most tools were developed between 2010 and 2023, with a notable acceleration in development post-2015, underscoring the growing global interest in leveraging digital technologies in pediatric oncology. The majority of interventions targeted children and adolescents aged 6 to 18 years, though the scope occasionally extended to preschoolers (e.g., Proton U) or young adults up to 29 years (Re-Mission).

Table 2. Overview of Digital Tools Along with Their Strengths and Limitations

No.	Primary Objective Category (POC)	Theoretical Grounding Cited (TGC)	Key Design Features (KDF)	Key Strength Focus (KSF)	Primary Design Limitation (PDL)
1	Psychological Support (PS)	Emotional Contagion Theory	Storytelling, Remote Nature Access	Increased Positive Affect & Strengthened Caregiver Relationship	Limited Effect with Anxious Parents / Lack of Gamification
2	Health Education (HE)	Self-Determination Theory (SDT) & PENS Model	Serious Game (SG), Gamification	Improved General Well-being / Mental Health Screening	Low Long-term Engagement / No significant psychological change
3	Symptom Monitoring (SM)	None Explicitly Cited	Platform/App Integration	Focus on enhancing Quality of Life (QoL)	Limited specific findings reported
4	PS	Behavioral Health & Game Interaction Theories	Gamification, Mini-games	High User Satisfaction / Favorite Component: Collecting Rewards	Least Favorite Component: Travel / Lack of content diversity
5	PS	Cognitive-Behavioral Principles	3D Psychotherapy Game	Improved Self-Image, Reduced Anxiety/Aggression	Focus limited to Brain Tumor Patients / Desktop Platform
6	SM	None Explicitly Cited	E-Diary, Gamification	Superior Data Quality (vs. Paper) / High Satisfaction	Adherence Declined Over Time / Extensive Data Recording
7	Social Interaction (SI)	None Explicitly Cited	Social Communication Feature	Mediating Social Communication among Hospitalized Children	Focus limited to social mediation
8	PS	None Explicitly Cited	Web Game, Fantasy Content	More positive rating for non-illness related content	Less effective than games with illness-related content

9	HE	None Explicitly Cited	Mobile App, Visualization	Improved Anatomy Understanding / High Satisfaction and Reuse	Need for greater visualization to sustain adherence
10	HE	Kolb's Experiential Learning Theory	Story-driven, Tablet/Smartphone	Improved Patient Education & Greater Procedure Understanding	Limited age group focus (4-10 years)
11	PS	None Explicitly Cited	Computer Game	Effectively influenced health behaviors & Improved QoL	Limited detailed reporting of findings
12	PS	None Explicitly Cited	Console Game	Positive emotional responses during gameplay	Older Platform (Console)
13	PS	None Explicitly Cited	Virtual Reality (VR) Glasses	Effective in providing Distraction during Chemotherapy	Hardware Dependency (VR)
14	HE	None Explicitly Cited	Serious Game, Console	Improved Treatment Adherence and Self-Efficacy/Knowledge	Lacks Social Interaction Features / Older Platform
15	HE	Social Learning & Protection Motivation Theories	SG, Virtual Pet, Gamification	Increased Intention for Treatment/Self-Care / Enhanced Knowledge	Tutorials are text-based / Inferior Graphics Quality
16	SM	None Explicitly Cited	Mobile Monitoring System	Promoted Self-Care / Enhanced Communication Quality	Limited specific findings reported
17	SM	None Explicitly Cited	Symptom Tracker (iOS)	Increased overall adherence to daily symptom reporting	Limited specific findings reported
18	SM	None Explicitly Cited	Mobile App	Increased patient engagement	Limited specific findings reported
19	HE	None Explicitly Cited	Mobile App	Increased patient knowledge of symptom management	Program Use Declined Over Time (Content Familiarity)
20	SM	None Explicitly Cited	Gamified E-Diary (Agent/Rewards)	High Satisfaction / Accurate Pain Self-Reporting	Reward System May Fade / Repetitive Questions
21	SM	None Explicitly Cited	Symptom Tracker (ChIMES)	Assistance with mucositis assessment	Limited specific findings reported
22	SM	None Explicitly Cited	Pain Assessment App	Improved pain assessment	Limited specific findings reported
23	SM	None Explicitly Cited	Symptom Capture Tool	Improved symptom management and patient experience	Limited specific findings reported
24	SM	None Explicitly Cited	Website/iOS	Improved pain management and functioning across life domains	Limited specific findings reported
25	SM	None Explicitly Cited	Mobile App	Significant potential for Patient Empowerment	Limited specific findings reported

26	SM	None Explicitly Cited	Assessment System	81% willingness to use for managing fatigue and symptoms	Limited specific findings reported
27	SM	None Explicitly Cited	Symptom Screening App	Increased communication / Facilitated self-reporting	Limited educational content
28	SM	None Explicitly Cited	Comprehensive Digital Tool, Gamification	Improved home-based pain and symptom management	Primarily focuses on pain / Requires Wi-Fi
29	SM	None Explicitly Cited	Interactive Computer Tool	Improved design over prior version (color, layout, content)	Focuses solely on evaluation / Lacks education or management
30	SM	None Explicitly Cited	Child-friendly Cartoon Style	Child-friendly and easy to use	Lack of reward system reduces motivation
31	SM	None Explicitly Cited	Activity Tracker (Fitbit)	Improved Physical Activity levels	Focus is limited to Physical Symptoms
32	SM	None Explicitly Cited	Real-time Assessment App	Improved pain-related outcomes / Tailored recommendations	Limited assessment questions / Lacks integration of serious games
33	SM	None Explicitly Cited	Visual/Auditory Reminders	Improved Medication Adherence and compliance	Limited scope (Only Adherence) / Lacks Emotional Support Tools
34	HE	None Explicitly Cited	Mobile App, 5 Modules	Access to appropriate patient information / Facilitates communication	Text-oriented format may lead to fatigue and boredom
35	PS	None Explicitly Cited	Action-packed Shooting Game	Empowerment to fight cancer actively / Indirect education	Limited to computer platforms / Lacks personalization
36	HE	None Explicitly Cited	Runner Game Style, Virtual Reality	Enhanced understanding of illness/treatment during invasive procedures	Continuous use may cause fatigue/headaches / Lacks personalization
37	SI	None Explicitly Cited	Social Robot, Storytelling	Enhanced Social Interaction & Emotional Support	High Cost / Pre-recorded Speech (Limited Communication)
38	SM	None Explicitly Cited	Skill-based Game, Immersive Environment	Reduced Psychological Burden / Increased Healthcare Awareness	Limitations in Depth of Information / Incomplete Disease Coverage
39	SM	None Explicitly Cited	Pain Monitor App (Parent/Child)	Real-time Pain Monitoring / Enhanced Communication	Not all children could use independently / Limited to Pain Intensity
40	PS	MDA Framework	Therapeutic Video Game, Cartoon companions	Anxiety reduction during invasive treatments / Increased familiarity	Limited to Acute Lymphoblastic Leukemia / Repetitive content
41	SM	None Explicitly Cited	Game-based Symptom Assessment	Enhances communication of symptoms / Flexible pain reporting	Focuses primarily on pain / Neglects other aspects of disease

42	PS	None Explicitly Cited	Virtual Reality (VR), Simulation	Anxiety Reduction / Preparation for Radiotherapy	Hardware Dependence / Narrow Focus (Only RT) / Repetitiveness
43	PS	None Explicitly Cited	Virtual Pet, Gamification	Aids psychologists in identifying emotional issues & therapy design	Addresses only limited aspects of disease / Target age unspecified
44	PS	None Explicitly Cited	Serious Game, Dollhouse-style VR	Introduces children to the radiotherapy environment	Focuses primarily on radiotherapy / Insufficiently addresses negative emotions
45	Physical Activity (PA) / (SM)	Behavioral Theory (Social Cognitive Theory, Self-Determination Theory)	Gamification, Personalized Exercise Training, Augmented Reality (AR) Features	Enhanced Physical Fitness & Reduced Symptom Burden / Multicenter Pan-European RCT Design	High Variability in Intervention Delivery Across Multiple Centers / Primarily Focused on Physical Goals, Lacks Dedicated Psychosocial Support
46	(PS) / (PA)	Self-Determination Theory (SDT) / Dual Process Model of Behavior Change	Extended Reality (XR) Gaming, Active Video Gaming, Integrated Mindfulness Modules	Novel Combination of Exercise and Mindfulness in Immersive Environment / High Potential for Engagement	Hardware Dependency (VR System) / Narrow Age Focus for Trial (Adolescents/Young Adults)

The synthesis of findings detailed in Table 2 revealed key patterns in design, a significant gap in theoretical grounding, and common outcomes and challenges, which are thematically grouped below.

Thematic Design Strategies: Many tools employed metaphorical narratives to convey complex medical concepts, effectively externalizing the illness and fostering a sense of control. For instance, Re-Mission and Cytarius utilized science fiction narratives centered around nanobots battling cancer cells, enhancing users' understanding of disease and treatment.

Approximately 38% of tools integrated gamification elements (e.g., points, rewards, leaderboards) to increase intrinsic motivation, as seen in Pain Squad and Triumf. Furthermore, some interventions, such as Proton U and the VR application Farmooo, utilized immersive and multisensory learning through VR, sound, and interactive storytelling to accommodate diverse learning styles (visual, auditory, kinesthetic), which was particularly effective for younger children.

Theoretical Grounding and Gap: A critical finding from Table 2 is the significant absence of explicit theoretical grounding in the design and evaluation of these interventions. The majority of the reviewed tools (84%) were categorized as "None Explicitly Cited" in the Theoretical Grounding Cited (TGC) column.

Only a small fraction of studies explicitly utilized established models, such as the Self-Determination Theory (SDT) (Triumf) or the Emotional Contagion Theory (HabitApp). Crucially, the most recently designed interventions (FORTEe and XR Gaming) show a promising shift, explicitly integrating SDT, Social Cognitive Theory, and the Dual Process Model, indicating a growing recognition of the need for theory-driven eHealth design. The reliance on implicit or undefined mechanisms of change represents a major theoretical gap in the field, which may limit the generalizability and replicability of findings.

Key Outcomes and Design Limitations: The Key Strength Focus (KSF) column reveals that the digital tools successfully contributed to enhanced awareness of illness and treatment, reduced anxiety and pain (e.g., Adventures in Sophoria, Presence App), improved treatment adherence (Dosecast9), and strengthened communication between children, caregivers, and healthcare teams.

However, the Primary Design Limitation (PDL) column highlighted recurring challenges:

- Usage Decline over Time: Several high-quality tools, including Triumf and Eating After Transplant, experienced a decline in usage, despite positive initial feedback. This

suggests that sustained user engagement remains a major design challenge, often linked to repetitive content or the fading novelty of reward systems (Pain Squad).

- Hardware Dependency: Tools relying on specialized hardware, such as VR headsets (Farmooo, virtual reality game for RT), faced limitations in accessibility due to cost and technical requirements.
- Narrow Scope: Many monitoring tools focused primarily on a single symptom (e.g., pain or fatigue) or a specific phase of treatment (e.g., radiotherapy preparation), limiting their utility for the comprehensive management of pediatric cancer.

Table 3. Quantitative Distribution & Key Trends of Included Digital Tools by Country, Platform, and Primary Objective Category

Criterion	Count (N=46)	Percentage (%)
Country Distribution		
United States (America)	14	30.4
Canada	5	10.9
Germany	5	10.9
Australia	3	6.5
Iran	3	6.5
Platform Distribution		
Mobile Phone/Tablet (Android/iOS)	27	58.7
Desktop/Web/Console	10	21.7
Virtual Reality (VR)/Robot/Glasses	4	8.7
Not specified/Other	5	10.9
Primary Objective Category (POC)		
Symptom Monitoring (SM)	25	54.3
Psychological Support (PS)	14	30.4
Health Education (HE)	5	10.9
Social Interaction (SI)	2	4.3

Geographically, Table 3 highlights a significant concentration of development in high-income Western countries: the United States (30.4%) and Canada (10.9%) accounted for the largest share. However, regional development, such as the three localized tools identified in Iran (The City of Dreams, Arash, and CanSelfMan), demonstrates increasing domestic attention to this field outside the Western context.

The Mobile Phone/Tablet platform was the most dominant setting, accounting for nearly 59% (58.7%) of the tools, reflecting its widespread accessibility and user-friendliness for pediatric applications. In contrast, emerging technologies like Virtual Reality and Robots remain a small minority (8.7%).

In terms of the Primary Objective Category (POC), the majority of interventions focused on Symptom Monitoring (54.3%), utilizing tools like e-diaries and pain trackers to record symptoms (e.g., *Pain Squad*, *mOST*). Psychological Support (30.4%) was the second most common focus, followed by Health Education (10.9%). Interventions focused primarily on Social Interaction (4.3%) were the least represented group.

4. Discussion

The present study aimed to review the digital tools developed within the field of eHealth for children and adolescents with cancer. It presented key findings regarding the design, functionality, and effectiveness of these tools, while striving to identify existing gaps and opportunities for improvement, thus contributing to a better understanding of the needs of this specific patient population.

This scoping review advances the state of the art by providing the most comprehensive and up-to-date mapping of the field to date, specifically by: 1) incorporating recent studies up to 2025; 2) quantifying the landscape across four key functional categories (SM 54.3% vs. SI 4.3%), thereby identifying areas of over- and under-development; and most critically, 3) analytically identifying and quantifying the major theoretical gap across all reviewed tools. While previous reviews noted the need for theory, our finding that 84% of tools lack explicit grounding provides a concrete call to action for the design community.

As previously discussed, the existing tools—despite notable advantages and strengths—face several limitations. Most of the reviewed eHealth tools were focused on one or a few specific aspects of cancer or its treatment, which limits their generalizability and applicability to other cancer types and dimensions of the illness [7], [19], [21], [22], [23]. Some tools have demonstrated strong performance in symptom management (e.g., pain), psychosocial support, and educational purposes for children and their families [28], [31], [43], but few have managed to provide a comprehensive approach that encompasses the psychological, physical, and social dimensions of cancer care.

Moreover, many tools lack personalization features, limiting their adaptability to changes in treatment plans or the patient's condition [4], [7], [19]. This underscores the need for more flexible tools that can modify their content and functionality based on changing circumstances. Findings indicate that many tools included educational modules about the illness through games or psychological training in the form of text or videos. Additionally, modules for monitoring physical and psychological symptoms and for reminding patients of treatment-related tasks such as medication intake were frequently incorporated.

Attractive and interactive designs—such as gamification, cartoon characters, and emerging technologies like virtual reality—played a significant role in attracting attention and increasing engagement among children [5], [15], [16], [19]. Tools with higher levels of interactivity tended to perform better, as such features enabled children to engage more deeply with their treatment processes. However, the complexity or time-consuming nature of some tools could discourage usage by children and parents. In some cases, text-heavy tools were less suitable for younger children, resulting in fatigue and reduced engagement. Therefore, a simple, engaging, and developmentally appropriate design must be prioritized [28], [34], [37].

Many tools showed a positive impact on reducing anxiety, improving treatment adherence, and enhancing the overall treatment experience for children and families [25], [28]. However, the lack of robust evidence regarding their real-world effectiveness has limited the use and recommendation of some tools. Comprehensive studies are needed to evaluate the long-term effects of these tools, especially in terms of improving children's quality of life.

The absence of diverse, reward-based games was another limitation that could reduce children's and adolescents' motivation to engage with the tools [28], [31], [41]. In some cases, the lack of a mobile version significantly limited access in environments such as hospitals [47], [48]. Technical challenges—such as access to advanced technologies and high costs—also emerged as major barriers to widespread use [52]. Furthermore, inadequate collaboration among multidisciplinary teams (e.g., physicians, psychologists, and technology designers) may compromise the quality of developed tools. For instance, some design and evaluation teams did not clearly report the involvement of psychologists [28], [33], [43], [52], [53].

Importantly, the most valuable design references come from individuals directly affected by the phenomenon—in this case, children with cancer and their caregivers. Their lived experiences can guide the identification of essential needs and features. Accordingly, needs assessments involving patients or their parents were part of the design process for tools such as C-SCAT, iCan

Cope, AquaScouts, and the Presence App [19], [20], [28], [34], [35], [53]. However, for some tools such as Painometer, LESS, SSPedi, and Proton U, there was no clear mention of direct input from children or their families [19], [22], [28], [33], [36], [38].

The most striking finding of this scoping review is the pronounced absence of explicit psychological or behavioral theoretical grounding in 84% of the digital tools. While many interventions utilized design elements such as gamification that align with principles of behavioral change (e.g., positive reinforcement), the failure to explicitly cite and operationalize an established theory—such as the Self-Determination Theory (SDT) or the Health Belief Model (HBM)—poses a significant challenge to the field. The theoretical vacuum compromises the longevity and replicability of the interventions. Theory provides a roadmap for why an intervention works; without it, positive initial outcomes may be merely attributed to the novelty effect, leading to the observed declining long-term engagement (as seen in Triumf and EAT!). This lack of explicit theory limits our ability to predict effectiveness, scale successful tools, or even accurately measure the mechanisms of change. A clear theoretical foundation enhances scientific credibility. Even when children and caregivers are not the primary source of design, grounding the tool in a relevant theoretical framework increases its value. This is evident in tools like *City of Dreams* (based on cognitive-behavioral theory), *Triumf* (self-determination theory), and *Pets vs Onco* (social learning and protection motivation theories) [3], [14], [19], [23], [26]. Notably, although many tools may have been influenced by theoretical principles, explicit reference to these theories was often lacking in the studies.

Additionally, tools designed exclusively for one cancer type or a specific treatment phase limit generalizability [47], [48], [55]. With advancements in technologies such as virtual reality, artificial intelligence, and data analytics, it is now possible to create tools that offer greater personalization and adaptability. These tools can help children understand treatment stages, alleviate fears, and actively manage their illness.

In conclusion, based on the current analysis of digital tools, future development and improvement efforts should consider the following points:

- Tools should tailor content based on age and type of cancer, covering common pediatric cancers, treatments, and associated side effects.
- Educational modules on illness and treatment management should be integrated into games and videos.
- Symptom monitoring (both physical and psychological) and reminder systems for medication and hygiene practices should be incorporated.
- Game-based environments should include high variety, appropriate use of colors, sounds, and visuals to ensure usability and attractiveness across developmental stages.
- Reward systems should be included to enhance engagement.

Despite the effort to provide a comprehensive overview of digital tools designed to support children with cancer, this study faced several limitations that should be considered when interpreting the findings. For some tools, complete information on design, implementation, or scientific evaluation was not available, limiting deeper analysis of functionality and quality. The included studies used diverse methods and instruments to assess effectiveness (e.g., self-reporting, psychometric tests, and qualitative evaluations), which hinders precise comparisons and prevents definitive conclusions about the most effective tools. Additionally, since the goal of this study was to review tools from the perspective of design, target group, platform, and initial outcomes, long-term clinical outcomes, impacts on quality of life, and deeper psychological outcomes were beyond its scope.

To address the identified gaps, it is essential to develop comprehensive, flexible, and evidence-based tools. These tools should be created through interdisciplinary collaboration and focus on the psychological, social, educational, and physical needs of children with cancer. Moreover, they should deliver an enjoyable, engaging, and supportive experience that accompanies children and their families throughout the treatment journey.

5. Conclusions

This scoping review synthesized and analyzed digital health tools developed to support children and adolescents with cancer, revealing increasing global interest in eHealth interventions for pediatric oncology. The findings underscore the promising potential of these tools in enhancing patient engagement, improving treatment adherence, and fostering communication. However, the review also highlights persistent challenges, notably the prevalence of narrowly-scoped interventions and a significant theoretical vacuum in tool design (84% lacking explicit theoretical grounding).

Moving forward, the design of eHealth tools must be evidence-based, developmentally appropriate, and fundamentally grounded in psychological and behavioral theories to ensure sustainable efficacy and scientific credibility. User-centered design, driven by interdisciplinary collaboration, is paramount for creating comprehensive, flexible, and meaningful digital interventions.

Unlike previous reviews that often focused on individual interventions or specific platforms, this scoping review provides a comprehensive mapping of 46 eHealth tools across multiple platforms, functionalities, and target outcomes, offering a broader and more up-to-date overview of digital interventions in pediatric oncology.

Ultimately, these findings underscore the urgent need for the field to mature beyond preliminary testing. Although many tools show promise in pilot or short-term studies, there remains a lack of rigorous, longitudinal evidence demonstrating sustained impact on patient engagement, treatment adherence, and quality of life, highlighting the critical need for future studies with large, diverse populations and standardized outcome measures. Future research should prioritize longitudinal studies with diverse populations and standardized outcomes to confirm the long-term, real-world impact of digital health solutions.

This review advances the current state of pediatric oncology eHealth research by providing the most comprehensive, up-to-date mapping of digital interventions, quantifying functional gaps, and highlighting the critical absence of explicit theoretical grounding, thereby offering concrete guidance for future tool development and research.

Conflicts of interest

The authors declare that there are no conflicts of interest related to this work.

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