Storytelling in Digital Health Technologies for Promoting Health Literacy: An Integrative Review

ABSTRACT

Background and Objectives: Digital health technology should be an educational tool for child care and empowerment when applied to children's health literacy. This study aimed to analyze digital health technologies that utilize storytelling resources to promote children's health literacy.

Materials and Methods: This integrative review was conducted in six distinct stages across major healthcare databases (MEDLINE/PubMed, CINAHL, Web of Science, and Scopus), selecting studies published between January and February 2023, guided by the research question. The search and selection process for articles was adapted from the Preferred Reporting for Systematic Reviews and Meta-Analyses guidelines. Selected articles were assessed for methodological rigor using a tool adapted from the Critical Appraisal Skills Programme, and Rayaan software was used for data screening. Two independent reviewers were involved in article selection, extraction, and analysis.

Results: Of the 13,049 articles identified, 15 studies were selected, focusing on self-care in health management, children's feelings, and learning through storytelling. Digital health technologies included mobile applications, educational software, virtual reality, videos, and images, which used resources such as storytelling, animation, gamification, comics, storyboards, poetry, music, and interactive narration. Seven studies were identified regarding self-care and health management.

Conclusion: Digital health technologies with storytelling, when based on learning and promoting health literacy, can be important tools for expanding children's experiences of self-care in health management, both inside and outside hospital settings. Therefore, further studies on this topic are needed, encompassing children, parents, teachers, healthcare professionals, institutions, and public policies from the perspective of child health literacy.

Paper Type: Research Article

Keywords: Health Education, Health Literacy, Storytelling, Digital Health, Digital Technology.

Adélia Karla Falcão Soares
* Universidade Federal de Pernambuco, Graduate Program in Nursing, Recife, Pernambuco, Brazil.
(Corresponding Author):
adelia.falcao@ufpe.br

Rute Costa Regis de Sousa
Universidade Federal de Pernambuco, Graduate Program in Nursing, Recife, Pernambuco, Brazil.

Weslla Karla Albuquerque Silva de Paula
Universidade Federal de Pernambuco, Graduate Program in Nursing, Recife, Pernambuco, Brazil.

Ana Paula Esmeraldo Lima
Universidade Federal de Pernambuco, Graduate Program in Nursing, Recife, Pernambuco, Brazil.

Juliana Bastoni da Silva
Universidade Federal de Tocantins, Graduate Program in Nursing, Palmas, Tocantins, Brazil.

Mirela Dantas Ricarte
Universidade Federal de Pernambuco, Graduate Program in Psychology, Recife, Pernambuco, Brazil.

Maria Wanderleya Lavor Coriolano-Marinus
Universidade Federal de Pernambuco, Graduate Program in Nursing, Recife, Pernambuco, Brazil.

Introduction

Situations involving illness or healthcare can generate feelings of fear and anxiety, restricting children's daily activities (such as interacting with and exploring the various spaces around them). This makes care provided by healthcare professionals challenging, and can pose a temporary or lasting threat to pediatric patients' physical and emotional well-being, especially when their needs are not understood and specific strategies for comprehensive care are not implemented (1,2).

Communication established through playful strategies that connect children's physical, cognitive, and emotional care can foster the sharing of health information and increase the understanding that children need to participate in decision-making (3). Parents, caregivers, and healthcare professionals need strategies to connect with children's emotional issues in situations of illness and care to establish bonds of trust that facilitate this interaction (2,3).

In this context, storytelling, or the art of storytelling, emerges as a powerful communication tool capable of translating complex health information into understandable and engaging narratives, promoting the active participation of children in decisions about their own health (3).

Strengthening this participation is a central pillar of children's health literacy (HL). Defined as the ability to access, understand, assess, and apply information to make health decisions (4,5), HL in the pediatric age group has specific characteristics, which were highlighted by Bröder et al. (2019) in the 6D Model: 1) Differential epidemiology and health perspectives; 2) Demographic patterns and inequalities; 3) Developmental change and socialization process; 4) Dependency within power structures and generational relationships; 5) Democratic citizenship and active participation; 6) Digitalization/growing up in digital worlds. Among these definitions, "Digitalization/growing up in digital worlds" is a critical dimension that shapes new generations' health experience, alongside factors such as psychosocial development and dependency on power structures (6,7). Therefore, when combined with HL, digital technologies can transcend mere distraction to become an important educational tool for child care and empowerment, aligning with the Sustainable Development Goals by promoting health and well-being (8,9).

Health applications have offered attractive communication and comfort strategies for children by offering solutions and content with playful elements in the form of stories and interactive games that can be integrated and accessed quickly and appropriately by children and families inside or outside hospital settings (10).

The literature recognizes the potential of digital technologies for temporary pain and stress relief during pediatric procedures. However, the use of digital storytelling (DST) offers an additional, more profound benefit: a creative process that fuses traditional storytelling with the interactivity of technology, transforming children from a passive recipient into a main player of their care journey (11).

Despite the widespread use of digital health technologies, contributions to children's HL during stressful and threatening events are still limited. While studies assess the impact of digital tools on specific clinical

outcomes, there is a lack of synthesis on how storytelling elements are specifically employed to develop children's HL skills and broaden their experience of self-care in health management in a participatory manner. It is unclear which narrative resources (e.g., gamification, characters, and interactive storylines) are most effective and how they are applied in different healthcare contexts.

Given the above, this integrative review aimed to analyze digital health technologies that use storytelling resources to promote children's HL.

Materials and Methods

1. Framing the study question

This is an integrative review, structured in six distinct stages: 1) Topic identification and research question selection; 2) Database and inclusion and exclusion criteria definition; 3) Definition of the information to be extracted from selected studies; 4) Assessment of studies included in the review; 5) Analysis and interpretation of results; 6) Presentation of review/synthesis of knowledge (12). To this end, the research question was structured based on the Population, Interest, Context (PICo) strategy, as recommended by Sousa et al. (2023), presented below: P (Population) — Hospitalized preschool and school children; I (Interest) — Digital health technologies that use storytelling resources; Co (Context) — Learning and active participation of children from the perspective of HL. The research question was: What is the evidence of digital health technologies that use storytelling resources for learning and active participation of children from the perspective of child HL?

2. Search strategy

The bibliographic survey was conducted in January and February 2023 through virtual access to Medical Literature Analysis and Retrieval System Online (MEDLINE), accessed through the PubMed portal, Cumulative Index to Nursing and Allied Health Literature (CINAHL), accessed via Core Collection (Thomson Reuters), Scopus (Elsevier), and Web of Science. For the database search, we selected descriptors indexed in the Medical Subject Headings and CINAHL Titles, as well as uncontrolled descriptors, established according to synonyms of controlled descriptors, through prior reading on the topic of interest.

To systematize data collection, an advanced search form was used, respecting the peculiarities and distinct characteristics of each database. The search descriptors and keywords were "Child", "Child Preschool", "Child Hospitalized", "Education Technology", "Mobile Applications" (keyword), "m-health" (keyword), "Storyteller" (keyword), "Health Literacy", "Health Education", "Child Development", "Child Health", and "Learning". The descriptors and keywords were combined with the Boolean OR within each set of PICo strategy terms, then crossed with the Boolean AND. The Boolean combinations used were "Child" OR "Child, Preschool" OR "Child, Hospitalized" AND "Education Technology" OR "Mobile Applications" OR "m-health" AND "Storyteller" OR "Health Literacy" OR "Health Education" AND "Child Development" OR "Child Health" OR "Learning" to meet the research question and criteria of interest.

The search was conducted by two researchers, who standardized the sequence of descriptors and cross-referencing in each database. To ensure a comprehensive search, the studies were accessed in their entirety through the Coordination for the Improvement of Higher Education Personnel— Brazil — journal portal.

3. Selection criteria

Original articles published in the last ten years were included in the sample, as they are believed to reflect the most recent recommendations on storytelling-based digital health technologies for children's HL. Articles available in full, written in English, Portuguese, or Spanish, that answered the guiding question, meeting one or more of the following criteria of interest, such as learning and active participation of children in health settings, were excluded. Review or reflective articles, letters to the editor, historical articles, reviews, final papers, theses, dissertations, and articles whose methodological rigor resulted in a score lower than six were excluded.

4. Study selection process

To optimize the database search and selection process, the retrieved studies were imported into Rayyan. Rayyan is a program designed specifically to streamline the screening of duplicate articles and the reading of abstracts and titles using a semi-automated process (13). The articles selected for full-text reading were then exported to Mendeley, a bibliographic reference management software available in Scopus, to organize the retrieved studies. The articles were exported to nursing-specific databases (CINAHL) and health databases (MEDLINE/PubMed), followed by nonspecific databases (Web of Science, Scopus).

The titles, abstracts, and descriptors of the articles were read once they were identified, and those that met the eligibility criteria were selected for full-text reading. After a comparative assessment between the two researchers, a third researcher was requested to assess any discrepancies to minimize bias. The search and selection process was adapted from Preferred Reporting for Systematic Reviews and Meta-Analyses recommendations (14) (Figure 1). To systematically assess the methodological rigor of the selected articles, an adapted Critical Appraisal Skills Programme (15) tool was used. This tool has ten criteria, and only articles that obtained a score of six or higher were included in this review. The level of scientific evidence was also measured and classified into seven levels: level I - systematic reviews or meta-analysis of relevant clinical trials; level II - well-designed randomized controlled clinical trial; level III - well-designed clinical trials without randomization; level IV - well-designed cohort and case-control studies; level V - systematic review of descriptive and qualitative studies; level VI - evidence derived from a single descriptive or qualitative study; level VII - opinion of authorities or report of expert committees (16).

5. Findings synopsis

The articles selected for the review were compiled into a spreadsheet containing items relating to the author, year of publication, country, and types of technologies, theoretical framework, target audience, setting, and storytelling resources (Table 1).

Critical analysis of digital health technologies considered the 6D model (six dimensions) of children's HL, considering that the appropriation of knowledge about children's physical, cognitive, and socioemotional aspects and interactions with their social environment (caregivers, friends, teachers, and healthcare professionals) can improve self-care management and child leading role (6,8). The attributes of children's learning to access/apply (behavioral/operational), understand/assess (cognitive), and motivate (affective/conative), which, according to Piaget and Vygotsky's theories, indicate that cognitive processes—assimilation, accommodation, and adaptation—are relevant to children's understanding of HL (5, 6), as shown in Table 2.

For better understanding, this integrative review was divided into three topics: self-care in health management; children's feelings; and learning with storytelling resources.

Results

A total of 13,049 articles were initially obtained based on the search strategy and selection process. After assessing the studies' eligibility, 15 articles were included in the final sample. Figure 1 represents the study selection process.

Of the articles identified in the databases, 10 (66.7%) were found in Scopus, one (6.7%) in MEDLINE/PubMed, and four (26.6%) in Web of Science. None were found in CINAHL. Of the countries where the studies were conducted, two articles were from Iran and two were from the United States (USA). The other countries presented only one article each. A higher frequency of publications occurred in 2022, 2021, and 2016.

Of the primary studies included, six based the construction/development of digital health technology on different theoretical frameworks: Participatory Design Theory; Growth Mindset Theory; Social Cognitive Theory; Behavioral and Empowerment/Engagement Theories; Norma Engaging Multimedia Design (NEMD); Biobehavioral Family Model (BBFM); and DST. In terms of study design, four were user-centered methodological studies (S8, S12, S13, and S15), consisting of technology development and usability assessments. In terms of level of evidence, S5, S6, S7, S9, and S14 were classified as level II, S1 and S2 were classified as level IV, and S3, S4, S8, S10, S11, S12, S13, and S15 were classified as level VI (16).

The digital health technologies for child learning identified in the studies were mobile applications (S1, S4, S10, and S12), applications (S5, S13, S14, and S15) on different types of devices (cell phone and tablet), educational software (S2, S3, S8, and S15), virtual reality (VR) software (S6 and S7), videos, and images (S1, S3, S9, and S11) that used some storytelling resource (e.g., DST (S11); videos with animations (S2 and S3); gamification (S2, S3, S12, and S13); comics (manga) (S10); anecdotes and stories (S14); animations, stories and poetry (S5); narrated stories and music (S4); characters and cartoons (S1, S8, S9, S12, and S13); interactive narration (S8, S12, S13, and S15); storyboard and sharing of stories (S13 and S15)), as shown in Table 1. These studies targeted children and adolescents between the ages of 2 and 17 in various care settings, including hospitals, schools, and homes.
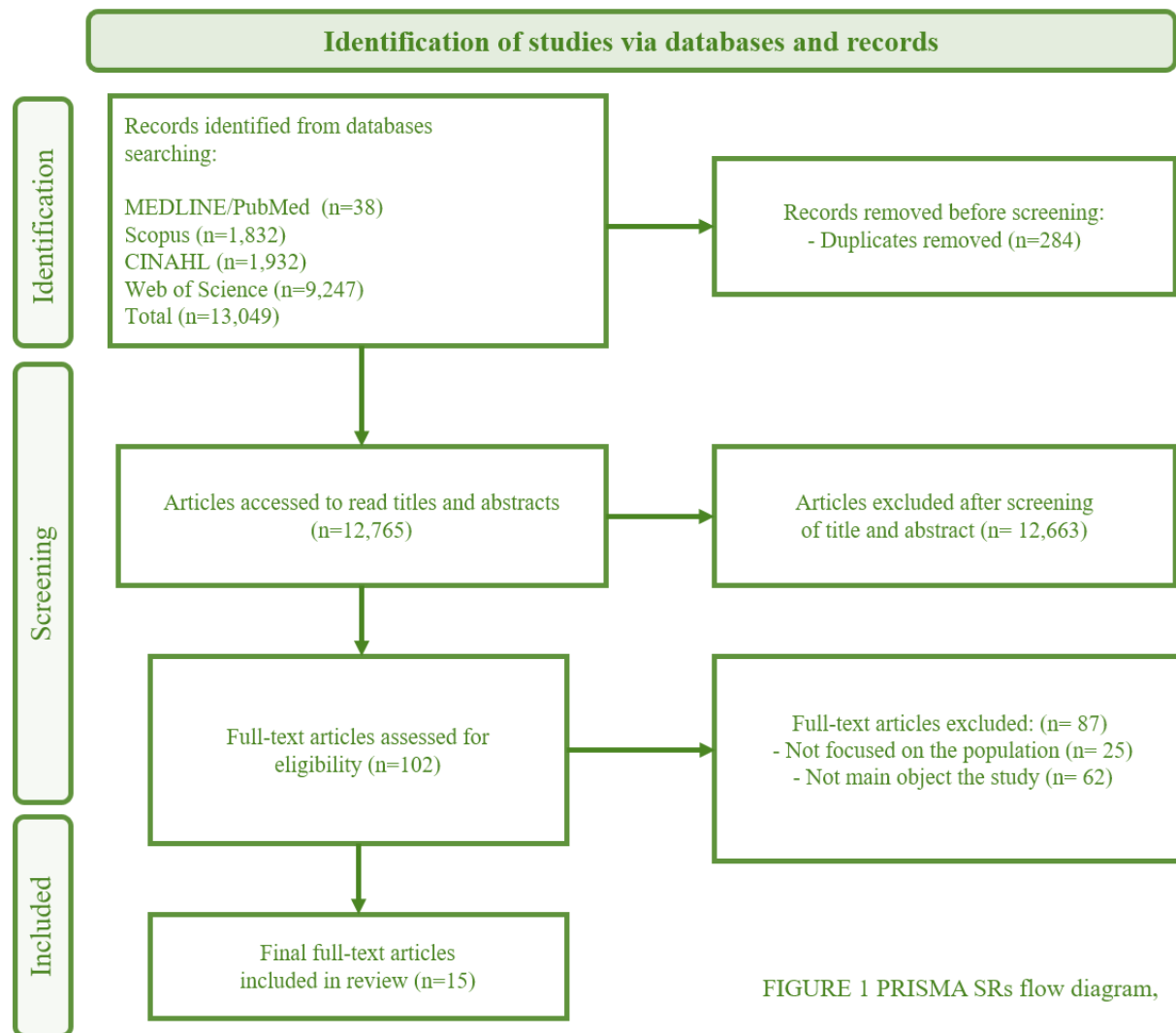
Identification of studies via databases and records

Records identified from databases searching:

MEDLINE/PubMed (n=38)
Scopus (n=1,832)
CINAHL (n=1,932)
Web of Science (n=9,247)
Total (n=13,049)

Records removed before screening:
- Duplicates removed (n=284)

Articles accessed to read titles and abstracts (n=12,765)

Articles excluded after screening of title and abstract (n= 12,663)

Full-text articles assessed for eligibility (n=102)

Full-text articles excluded: (n= 87)
- Not focused on the population (n= 25)
- Not main object the study (n= 62)

Final full-text articles included in review (n=15)

FIGURE 1 PRISMA SRs flow diagram,

Figure 1. Preferred Reporting for Systematic Reviews and Meta-Analyses flow diagram showing the study identification and selection process (14)

The topics of digital health technology covered in the studies varied significantly. S1, S2, S6, S7, S9, and S14 focused on minimizing anxiety, pain, and fear in children during clinical situations related to preoperative surgery, hospitalization, and immunization procedures in primary care. Regarding self-care in health management, S8, S10, S12, and S15 focused on self-care for chronic or acute diseases such as asthma and cancer. Other studies (S3 and S5) addressed oral hygiene, while S13 addressed guidance on outpatient procedures and pediatrician appointments and S4 addressed sleep hygiene (Table 2).

Legend: *Behavioral/operational: skills for searching for and accessing health information, using the information obtained, communication, interpersonal interaction; **Cognitive: actions related to thoughts, learning, and information processing; ***Affective/conative: self-control, self-regulation, self-management, interest, and motivation (5, 6).

Table 1. Identification of studies and extracted data on the types of digital health technologies with storytelling resources

S – study Author/year/country	Technologies	Target audience Setting	Storytelling resources
S1- Dreuning et al. (2023)3 Netherlands	Mobile application + informative videos Theoretical framework: None	4 to 12 years and their parents Home	Interactive drawings based on a thematic guide. Informative videos of the pre- and post-operative period of a child undergoing inguinal hernia surgery.
S2 - Zamani et al. (2022)17 Iran	Educational software Theoretical framework: None	9 to 12 years Hospital	Animated videos showcasing the hospital environment and routine.
S3 - Ram Surath Kumar et al. (2022)18 India	Animated video and interactive game Theoretical framework: None	12 to 15 years School	An animated video presents oral health and its importance, brushing techniques, and the five golden rules for maintaining effective oral health.
S4 - Chung et al. (2022)19 USA	Mobile application Theoretical framework: None	3 to 8 years Home	A mobile application with audio stories and music designed to help children with sleep difficulties.
S5 - Rahaei et al. (2022)20 Iran	Educational application Theoretical framework: None	10 to 12 years School	Educational animations, poetry, and audio stories with Iranian characters about toothache and its treatment.
S6 - Chang et al. (2022)21 Singapore	Virtual reality software Theoretical framework: None	4 to 10 years Immunization room	A 3D story centered on the mascot "Burp's" magic tower, which contains a cozy room with books and magical items.
S7 - Ryu et al. (2022)1 South Korea	Virtual reality software Theoretical framework: None	4 to 10 years Hospital	A story centered on the characters from the animated series "Pororo, o Pequeno Pinguim".
S8 - Sarasmita et al. (2021)22 Indonesia	Educational software Theoretical framework: Growth Mindset Theory Norma Engaging Multimedia Design	6 to 12 years School	Drawings and plots with playful interactive narrations featuring situations for managing and treating asthma.
S9 - Härter et al. (2021)23 Germany	Educational video Theoretical framework: None	6 to 17 years Hospital	Animations on a portable tablet. These images change as the story unfolds.

S – study Author/year/country	Technologies	Target audience Setting	Storytelling resources
S10 - Lio et al. (2020)24 Japan	mHealth mobile application Theoretical framework: Social Cognitive Theory	2 to 12 years old and their parents Outpatient	Comics (manga).
S11 - Lang et al. (2019)25 Canada	Videos and images Theoretical framework: Digital storytelling	Not specified Hospital	Storytelling with digital resources.
S12 - Bruggers et al. (2018)26 United Kingdom	Mobile application Theoretical framework: Behavioral, Empowerment, and Engagement Theories Participatory Design Theory (children, parents, and healthcare professionals)	7 to 14 years Home	Interactive narration and animated characters.
S13 - Stålberg et al. (2016)27 Sweden	Application Theoretical framework: Participatory Design Theory (children)	2 to 5 years Outpatient	Interactive narration and cartoons with a storyboard and the child's creation of an avatar.
S14 - Liguori et al. (2016)28 Italy	Application Theoretical framework: None	6 to 7 years Hospital	Use of anecdotes and playful stories, with clown characters.
S15 - Wyatt et al. (2013)29 USA	Software/application Theoretical framework: Biobehavioral Family Model Norma Engaging Multimedia Design	8 to 11 years School	Two interactive narrations: a snowboarding story and a school playground story.

Table 2. Topics of digital health technologies that use storytelling resources from the perspective of children's health literacy

Topics	Access/application (behavioral/operational) *	Understanding/assessment (cognitive)**	Motivation to apply health information (affective/conative) ***
S1- Decreasing anxiety	Mobile application/informative videos	Interactive drawings	Self-control/self-regulation
S2- Decreasing anxiety	Educational software	Animated videos	Self-control/self-regulation
S3-Oral hygiene practices	Animated video and interactive game	Animated videos	Self-care in health management
S4- Sleep hygiene	Mobile application	Narrated stories and music	Self-care in health management
S5-Oral hygiene practices	Educational application	Animations, poetry and stories	Self-care in health management
S6-Decreasing anxiety	Virtual reality software	3D story	Self-control/self-regulation
S7-Decreasing anxiety	Virtual reality software	3D story	Self-control/self-regulation
S8-Asthma self-management	Educational software	Drawings and interactive narration	Self-care in health management
S9-Decreasing anxiety	Educational video	Animations	Self-control/self-regulation
S10-Asthma self-management	Mobile application	Comics (manga)	Self-care in health management
S11-Express feelings	Videos and images	Digital storytelling	Self-control/self-regulation
S12-Practice physical exercise	Mobile application	Interactive narration and cartoons	Self-care in health management
S13-Teach care situations	Application	Interactive narration and cartoons	Self-control/self-regulation
S14-Decreasing anxiety	Application	Anecdotes and stories	Self-control/self-regulation
S15-Asthma self-management	Software/application	Interactive narrations	Self-care in health management

Discussion

The digital health technologies, mediated by storytelling highlighted in this research, explored a variety of topics. For child health management, studies focused on chronic/acute diseases such as asthma and cancer (S8, S10, S12, and S15), and oral health and sleep hygiene (S3, S5, and S4). These technologies were primarily software and mobile applications aimed at guiding and teaching children and adolescents how to develop their autonomy.

S10 carried out in Japan demonstrated positive aspects of mHealth application. In addition to providing educational health information in simple and easily accessible language, S10 allowed children to play and have fun with comic books (manga), promoting interest and learning about asthma (24).

For parents and/or caregivers, S10 app allows them to share content in easy-to-understand language, especially for monitoring asthma symptoms with their pediatrician during outpatient visits. This app feature has facilitated communication and management of their children's health with healthcare professionals (24). Studies show that careful and deliberate shared responsibility between parents and children improves asthma symptom assessment, medication adherence, and overall asthma management (30).

As in S12, a mobile application (video game) was developed and validated for its usability by children, parents, oncologists, nurses, and software engineers to construct stories and plots about the challenges faced by pediatric cancer patients. The application contributed information on empowerment and self-management for children undergoing chemotherapy who require care after hospital discharge (26). This study highlights the need for future studies that require more time to assess the effect of this technology on the health of children with other chronic diseases.

S8, an Indonesian study, developed a digital educational program for managing asthma symptoms in children aged 6 to 12. The technology includes an interactive narrative, games, and an asthma education plan. The application development was conducted in two phases: the first involved developing the software elements and content; and the second involved creating an interactive narrative (serious game), developed and validated by experts, a pediatrician, and two pharmacists (22). This technology did not involve children's co-design.

S15 developed a software/application that included content and interactive narratives about asthma management for children aged 8 to 11. The study was conducted through six focus groups held in US schools to assess usability based on feedback from the children themselves. The application was developed for use in school clinics, but it has the potential to be adapted to other settings such as pediatric waiting rooms, hospitals, and even homes (29).

S3 and S5 digital health technologies, aimed at promoting oral health, with animated videos, interactive games, animations, poems, and narrated stories, allowed school children aged 10 to 15 to understand the importance of brushing techniques, the five golden rules for oral

healthcare and treatment for toothache (18, 20).

S4, aimed at children aged 3 to 8 years, featured a mobile application with narrated stories, audio music, and accessibility features (screens, light and dark modes) to help children with sleep difficulties (19). These communication features can facilitate interpersonal interaction and information gathering for children and caregivers (31).

The presence of smartphones has led to an explosion of self-management health (mHealth) applications (9). The use of digital applications is increasing, and patients are becoming more engaged in obtaining health information outside of hospitals. These findings directly reflect better health outcomes (32).

However, studies show that although mobile technology has become an instrument in the daily lives of young children in industrialized nations around the world, the use of applications related to children's health needs is still limited when compared to the adult population (11).

Children and families need to be able to manage and make appropriate health decisions. People with inadequate HL utilize more healthcare resources, have higher treatment costs, visit emergency rooms more frequently, and have worse health outcomes (7,8).

To encourage acceptance and use, applications must meet users' needs and daily routines, be useful, and user-friendly. Involving children and caregivers from the beginning of design and development is crucial to ensuring that the application is focused on this target audience and adapts to

children's daily lives and world of experience (18, 27).

Thus, it is observed that some studies used theoretical frameworks in the development of digital technologies. Among these frameworks is NEMD, which employs five factors— simulation interactivity, construct interactivity, immediacy, feedback, and goals—to promote user engagement and learning, as identified in S8 and S15 (22,29).

The Participatory Design Theory mentioned in S12 and S13 addresses children's participation during the development of technologies, indicating that their contributions and involvement as co-designers assist in construction and assessment processes in terms of usability and graphic design, enabling the identification of needs and ensuring product suitability (26, 27).

Lambert's DST method, described in S11, guides participants in creating short films about their experiences, using videos and images, with potential educational application and improvement of healthcare for hospitalized patients (25).

The BBFM used in S15 seeks to promote self-management skills with the support of family members, colleagues, the community, and healthcare professionals, covering socioemotional aspects related to asthma acceptance (29). The difficulty of addressing and facilitating shared responsibility is highlighted as a gap in existing digital interventions for asthma management (30).

The Growth Mindset Theory was incorporated into S8 during the development of the game's interactive narrative, aiming to help children overcome obstacles and manage asthma symptoms (22). In S10, social

cognitive and adaptive theories were used in an mHealth application aimed at increasing the self-efficacy of children and caregivers in asthma management, in addition to fostering knowledge and self-management of symptoms (24). Most studies point to a lack of technologies based on scientific evidence, information from professionals, and end users.

From this perspective, digital tools based on scientific evidence can support digital health (eHealth) and mobile health (mHealth) by developing effective technologies to promote child empowerment, improving the understanding of health, disease and treatment options for users who use such technologies (9,23).

In relation to children's feelings, most of the identified digital health technologies focused on distraction and self-control stimuli to minimize pain, fear, and anxiety. Furthermore, children's ability to apply health information was limited in the technologies (S6 and S7) that used VR.

These studies consider VR's potential as a resource for pain and anxiety relief. Children who participated in S6 and used VR in the immunization room experienced pain relief during vaccination. In an inpatient setting, S7's VR, used by children before anesthesia in a surgical center, significantly reduced preoperative anxiety (1, 21).

Similarly, a study using VR to treat acute pain during daily dressing changes in burn patients demonstrated a significant reduction in pain by between two and four points on the scale used in pediatric patients (33).

S1, S2, S3, S9, S13, and S14 not only minimized pain, fear, and anxiety but also provided educational information to help children understand the procedures to be performed by healthcare professionals during hospitalization or outpatient follow-up. Complementing children's developmental needs and psychosocial aspects with educational information has proven effective in preparing children for surgery. Therefore, children who participate in educational programs have a greater ability to manage anxiety and, therefore, experience lower levels of preoperative anxiety (3, 18).

From a learning perspective, storytelling is an engaging and creative way to teach and guide children and parents about healthcare (10, 11). Since ancient times, there has been a human tradition of transmitting wisdom through storytelling. Even before the printed word, oral traditions carried people's stories—preserved to educate, empower, teach, warn, or connect (30,34).

Digital literature plays an increasingly important role in children's daily lives, opening new avenues for family literacy and early childhood education. From an early age, children begin to explore and intuitively use digital media (9, 35).

Interactive health-promoting technologies show significant potential to effect behavioral change and promote disease self-management through education and active patient engagement aimed at understanding health, disease, and treatment (26).

From this perspective, the international market is responding to these possibilities with applications aimed at children (11). In addition to gaming and entertainment applications, there is a growing number of educational applications, storybook applications, and e-books that promote

language and literacy development in preschoolers (31, 34).

As a result, digital technologies are expanding children's access to written language, establishing modified modes of communication in various literacy environments. For child HL, DST proves to be a promising strategy for empowering and learning children and their caregivers (8, 9, 11).

From this perspective, gamification (the application of game design elements) is increasingly used in health applications for rehabilitation and self-care routines to increase adherence and engagement. Serious games are resources designed to benefit players by training them to improve specific outcome measures (changes in cognitive, physical, and educational variables) relative to predefined goals (22, 35).

Such games serve two purposes. They can be used as experimental tools to collect data on patients' learning and behavioral adaptations. They can also be used as intervention methods if the data suggest efficacy (26). Immersive VR is a promising, engaging, playful strategy that can minimize pain and anxiety in children undergoing painful procedures and experiencing acute pain (1, 19). Furthermore, it can provide distraction and pleasure in unstable psychological and physiological environments, facilitating the rehabilitation of pediatric patients with chronic pain (20, 33).

Research suggests that digital technologies can be used to create and disseminate content, such as writing poems and stories, making music, recording sound, and creating images, drawings, and videos. These technologies, offered in healthcare and promotion settings, can promote children's comfort, learning, and active participation. Therefore, when shared, stories emerge from these encounters and can provide language for exploring the ways in which individuals make sense of experiences that challenge or exceed their usual sensory or cognitive norms (25, 34).

Thus, it is noteworthy that digital devices with storytelling for children also have benefits for literacy development. Research shows that balanced and collaborative parenting practices in digital use are beneficial, such as promoting family and social interactions based on children's interests and stimulating learning, problem-solving, and attention skills (11,31).

Digital texts have the potential for many more features and functionalities than print texts and can vary greatly from one text to another, making it challenging to develop clear guidelines for parents, compared with parental recommendations developed for print texts. However, research on how specific digital reading conditions impact children's understanding of stories and how shared reading interactions and adults' responsive strategies are affected by devices is still lacking (36).

This integrative review suggests that storytelling-based digital health technologies should be created using scientific evidence that prioritizes children's physical, cognitive, and socioemotional development, as well as their daily social experiences. The goal is to empower children, help them learn, and encourage self-care. The limitations of this study were the limited timeframe in identifying studies. Furthermore, the focus on

nursing and health databases may have overlooked additional studies in education focused on digital HL.

Conclusion

The results of this integrative review highlight the diverse uses of digital health technologies with storytelling capabilities in health promotion. These include adapted physical activities for children with cancer, asthma symptom management, oral healthcare, and sleep hygiene. These applications are not only promising but also enable children to better cope with and understand different situations, such as hospitalizations, readmissions, and withdrawal from daily activities.

Digital health technologies can incorporate playful and gamified elements to engage and motivate children to use the health information they need for self-care. Thus, digital resources with storytelling can facilitate children's ability to access, understand, assess, and apply health information to promote good health and well-being for themselves and those around them.

However, there is a shortage of digital health technologies that use storytelling to encourage children to learn and participate actively. Clearly, digital health technologies that address emotional aspects, such as fear, pain, and anxiety in caregiving and hospitalization situations, are more prevalent than those focused on self-care and child health management.

However, most of these digital health technologies are concentrated in countries with privileged educational development indices. In countries like Brazil, where a large proportion of hospitalizations are due to acute and chronic childhood illnesses, providing digital health technologies in a storytelling format to promote HL in social settings, such as homes, schools, and hospitals, can encourage communication and provide comfort. This can also facilitate access to appropriate health information, enabling children and families to take action regarding their healthcare.

Finally, further studies on this topic are needed that encompass children, parents, teachers, healthcare professionals, institutions, and public policies from the perspective of children's HL. When guided by learning and promoting health literacy, digital health technologies with storytelling can be important tools for expanding children's experiences with self-care in health management, both inside and outside hospital settings.

Availability of Data and Materials: The data supporting the study's findings are available from the corresponding author upon reasonable request.

Conflicts of interest: The authors declare that they have no conflict of interest.

Consent for publication: Not applicable.

Ethical Approval and consent to participate: Because this study is a integrative review, its primary objective is the synthesis and critical analysis of the existing literature. As the research does not involve

the collection of primary data or the direct involvement of humans in the study, formal approval by an ethics committee or obtaining informed consent from participants is considered unnecessary. It should be noted that this approach aligns with the principles outlined in the Declaration of Helsinki, ensuring ethical standards are upheld even in literature-based reviews.

Author Contributions: This study is the result of a collaboration between AKFS, RCRDS, WKASDP, APEL, JBDS, MDR and MWLCM. All authors contributed, reviewed and improved the manuscript equally. All authors reviewed the final manuscript. All authors read and accepted the published version of the manuscript.

References

1. Ryu JH, Ko D, Han JW, Park JW, Shin A, Han SH, Kim HY. The proper timing of virtual reality experience for reducing preoperative anxiety of pediatric patients: A randomized clinical trial. Front. Pediatr.2022; 10:899152. https://doi.org/10.3389/fped.2022.899152 PMid: 36177450 PMCid: PMC9514542.

2. Barroso MC, Santos RS, Santos AE, Nunes MDR, Lucas EA. Children's perception of venipuncture through therapeutic toy. Acta Paul Enferm. 2020; 33: e-APE20180296. https://doi.org/10.37689/acta-ape/2020AO0296.

3. Dreuning KM, Haverman L, Bosschieter PF, Van Looij MA, Van Heurn LE, Derikx JP. Age-specific and family-centered information modalities to prepare children at home for day-care surgery. Journal of Pediatric Surgery.2023; 58 (3), 510-517. https://doi.org/10.1016/j.jpedsurg.2022.08.023 PMid: 36184312.

4. Jones K, & Scholz B.Perceptions of children's participation as patients in health interactions. Children & Society.2025; 39, 193-207. https://doi.org/10.1111/chso.12907.

5. Ortiz La Banca R, Nascimento LC. Placing the child into the center of self-care: reflections about cognitive development and health literacy in childhood [editorial]. Rev Esc Enferm USP. 2019; 53:e03533. https://doi.org/10.1590/s1980-220x2019ed0303533 PMid: 31800824.

6. Bröder, J et al. Child and youth health literacy: A conceptual analysis and proposed target-group-centred definition. Int J Environ Res Public Health. 2019; v.16, n.18, p.3417. sep.2019. https://doi.org/10.3390/ijerph16183417 PMid: 31540040 PMCid: PMC6765952.

7. Shahid R, Shoker M, Chu LM, Frehlick R, Ward H, Pahwa P. Impact of low health literacy on patients' health outcomes: a multicenter cohort study. BMC Health Serv Res. 2022; 12; 22(1):1148. https://doi.org/10.1186/s12913-022-08527-9 PMid: 36096793 PMCid: PMC9465902.

8. Schulenkorf T, Sørensen K, Okan O. International Understandings of Health Literacy in Childhood and Adolescence-A Qualitative-Explorative Analysis of Global Expert Interviews. Int. J. Environ. Res. Public Health. 2022; 2, 19, 1591 https://doi.org/10.3390/ijerph19031591 PMid: 35162618 PMCid: PMC8834706.

9. Chidambaram, S et al. An introduction to digital determinants of health. PLOS Digit Health.2024; 3(1):e0000346. https://doi.org/10.1371/journal.pdig.0000346 PMid: 38175828 PMCid: PMC10766177.

10. Poot CC, Meijer E, Bruil A, Venema M, Vegt NJH, Donkel N, Van Noort V, Chavannes NH, Roest AAW. How to use participatory design to develop an eHealth intervention to reduce preprocedural stress and anxiety among children visiting the hospital: The Hospital Hero app multi-study and pilot report. Front Pediatr. 2023; 14:11:1132639. https://doi.org/10.3389/fped.2023.1132639 PMid: 36865696 PMCid: PMC9971988.

11. Lohr AM et al.The use of digital stories as a health promotion intervention: a scoping review. BMC Public Health. 2022; 22, 22:1180. https://doi.org/10.1186/s12889-022-13595-x PMid: 35698097 PMCid: PMC9192132.

12. Sousa MNA, Bezerra ALD, Egypto, IAS. Trilhando o caminho do conhecimento: o método de revisão integrativa para análise e síntese da literatura científica. Observatório de la economía latino-americana. 2023; 21(10), 18448-18483. https://doi.org/10.55905/oelv21n10-212.

13. Fei Y, Chuanrui L, Selina,S. Performance, Usability, and User Experience of Rayyan for Systematic Reviews.Proceed. Ass. Inform. Sci.Technol.2022; 59 (1), 843-844. https://doi.org/10.1002/pra2.745.

14. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L et al. The PRISMA (2021) statement: An updated guideline for reporting systematic reviews. BMJ. 2021; 372:n71. https://doi.org/10.1136/bmj.n71 PMid: 33782057 PMCid: PMC8005924.

15. CASP. Critical Appraisal Skills Programme [2018]. CASP checklist. Oxford, UK: 1993[cited 2025 Aug. 11].

Available from:https://casp-uk.net/casp-tools-checklists.

16. Stillwell SB, Fineout-Overholt E, Melnyk BM, Williamson KM. Evi-dence-based practice, step by step: searching for the evidence. Am J Nurs. 2010[citado em 2021 mar. 20]; 110(5):41-7. https://doi.org/10.1097/01.NAJ.0000372071.24134.7e.

17. Zamani M, Sigaroudi AE, Pouralizadeh M, Kazemnejad-Leili, E. Effect of the Digital Education Package (DEP) on prevention of anxiety in hospitalized children: a quasi-experimental study. BMC Nurs. 2022; 2 25; 21(1):324. https://doi.org/10.1186/s12912-022-01113-8 PMid: 36434594 PMCid: PMC9700912.

18. Ram Surath Kumar K et al. Effectiveness of a Visual Interactive Game on Oral Hygiene Knowledge, Practices, and Clinical Parameters among Adolescents: A Randomized Controlled Trial. Children. 2022; 9, (12). https://doi.org/10.3390/children9121828 PMid: 36553272 PMCid: PMC9776468.

19. Chung A, Jin P, Kamboukos D, Robbins R, Blanc J, Jean-Louis G, Seixas A. Out Like a Light: Feasibility and Acceptability Study of an Audio-Based Sleep Aide for Improving Parent-Child Sleep Health. Int J Environ Res Public Health. 2022; 1; 19(15):9416. Available from: https://doi.org/10.3390/ijerph19159416 PMid: 35954773 PMCid:PMC9368592

20. Rahaei Z, Moradian E, Falahati-Marvast F. Improving dental-oral health learning in students using a mobile application ("My tooth"): A controlled before and after study. Int J Dent Hyg. 2022; 20(3):512-518. https://doi.org/10.1111/idh.12504 PMid: 33829640.

21. Chang ZY, Kang GCY, Koh EYL, Fong, RJK, Tang J, Goh CK,Tan NC. Mmersive Virtual Reality in Alleviating Pain and Anxiety in Children During Immunization in Primary Care: A Pilot Randomized Controlled Trial.Frontiers in Pediatrics. Front Pediatr. 2022; 25:10:847257. https://doi.org/10.3389/fped.2022.847257 PMid: 35402359 PMCid: PMC8990251.

22. Sarasmita MA, Larasanty LPF, Kuo LN, Cheng KJ, Chen HYA.computer-based interactive narrative and a serious game for children with asthma: development and content validity analysis. J Med Internet Res. 2021; 13; 23(9):e28796. https://doi.org/10.2196/28796 PMid: 34515641 PMCid: PMC8477291.

23. Härter V, Barkmann C, Wiessner C, Rupprecht M, Reinshagen K, Trah J.Effects of Educational Video on Pre-operative Anxiety in Children - A Randomized Controlled Trial. Front Pediatr. 2021; 12:9:640236. https://doi.org/10.3389/fped.2021.640236 PMid: 34055683 PMCid: PMC8149614.

24. Iio M, Miyaji Y, Yamamoto-Hanada K, Narita M, Nagata M, Ohya Y. Beneficial features of a mHealth asthma app for children and caregivers: Qualitative study. JMIR MHealth and UHealth.2020; 8(8):e18506. https://doi.org/10.2196/18506 PMid: 32831181 PMCid: PMC7477670.

25. Lang M, Laing C, Moules N, Estefan A.Words, Camera, Music, Action: A Methodology of Digital Storytelling in a Health Care Setting. International Journal of Qualitative Methods. 2019; 18, 160940691986324. https://doi.org/10.1177/1609406919863241.

26. Bruggers CS, Baranowski S, Beseris M, Leonard R, Long D, Schulte E et al. A prototype exercise-empowerment mobile video game for children with cancer, and its usability assessment: Developing digital empowerment interventions for pediatric diseases. Front Pediatr. 2018; 9:6:69 https://doi.org/10.3389/fped.2018.00069 PMid: 29686977 PMCid: PMC 5900044.

27. Stålberg A, Sandberg A, Söderbäck M, Larsson T. The child's perspective as a guiding principle: Young children as co-designers in the design of an interactive application meant to facilitate participation in healthcare situations. J Biomed Inform. 2016; 61:149-58. Available https://doi.org/10.1016/j.jbi.2016.03.024 PMid: 27050824.

28. Liguori S, Stacchini M, Ciofi D, Olivini N, Bisogni S, Festini F. Effectiveness of an app for reducing preoperative anxiety in children: A randomized clinical trial. JAMA Pediatrics.2016; 170,(8). https://doi.org/10.1001/jamapediatrics.2016.0533 PMid: 27294708.

29. Wyatt TH, Li X, Huang Y, Farmer R, Reed D, Burkhart PV. Developing an Interactive Story for Children with Asthma. In Nursing Clinics of North América.2013; 48(2): 271-285. https://doi.org/10.1016/j.cnur.2013.01.006 PMid: 23659813 PMCid: PMC5389666.

30. Sonney J, Cho EE, Zheng Q, Kientz JA.Refinement of a Parent-Child Shared Asthma Management Mobile Health App: Human-Centered Design Study. JMIR Pediatrics and Parenting. JMIR Pediatr Parent.2022; 17; 5(1):e34117. https://doi.org/10.2196/34117 PMid: 35175214 PMCid: PMC8895285.

31. Cho YS, Hong J, Lee W. Understanding children's use of a mobile digital storytelling app, Digital Creativity. 2024; 35:2, 91-106. https://doi.org/10.1080/14626268.2024.2334026.

32. Carlsson IM, Arvidsson S, Svedberg P, Nygren JM, Viklund Å, Birkeland AL, & Larsson I. Creating a communication space in the healthcare context: children's perspective of using the ehealth service, sisom. Child Health Care. 2020; 1-13. https://doi.org/10.1177/1367493520904804 PMid: 32048874 PMCid: PMC7897780.

33. Saleh SES, Abozed HW. Technology and Children's health: Effect of virtual reality on pain and clinical outcomes during hydrotherapy for children with burns. Journal of Pediatric Nursing. 2024; 78, e155-e166. https://doi.org/10.1016/j.pedn.2024.06.031 PMid: 38971634.

34. Zhang A, Huang G, Ying F. Babbling: A Digital Book Application to Improve Preschool Children's Social Communication Ability. Frontiers in Artificial Intelligence and Applications. 2023; 365, 379-389. https://doi.org/10.3233/FAIA220731.

35. Vidal E, Castro-Gutierrez E, Arisaca R, Paz-Valderrama A, Albiol-Pér ez S. Serious Game for Fine Motor Control Rehabilitation for Children With Epileptic Encephalopathy: Development and Usability Study. JMIR Form Res. 2023; 7:e50492. Available from:

https://doi.org/10.2196/50492 PMid: 37788071 PMCid: PMC 10582812.

36. Nicholas M, Paatsch L. The shared reading of digital storybooks with young children: Parents' perspectives. Research Papers in Education.2024; 39(4), 650-667. https://doi.org/10.1080/02671522.2023.2205411.