Development of a Playful Scale of Child Health Literacy Integrated into a Digital Game about Childhood Cancer

https://doi.org/10.32635/2176-9745.RBC.2025v71n4.5327EN

Desenvolvimento de uma Escala Lúdica de Letramento em Saúde Infantil Integrada a um Jogo Digital sobre Câncer Infantil

Desarrollo de una Escala lúdica de Alfabetización en Salud Infantil Integrada en un Juego Digital sobre Cáncer Infantil

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ABSTRACT

Introduction: Health literacy enables children to understand and use health-related information. Employing educational strategies tailored to them makes it easier to grasp complex health concepts and helps coping with the disease. **Objective:** Process of development of a playful pediatric health literacy scale integrated into a digital game designed for children diagnosed with cancer, focusing on acute lymphoid leukemia. **Method:** Methodological study conducted from November 2024 to May 2025, consisting of five main stages: defining the theoretical domains of the scale, adapting language for a young audience, integrating evaluative elements into the game's narrative, creating a question bank, and planning validation. The scale was embedded in a digital educational game structured in chapters and minigames, with playful questions at the end to assess health literacy domains. **Results:** Four main domains were established: (1) Knowledge about cancer; (2) Treatment and side effects; (3) Self-care and healthy habits; and (4) Emotions and support. Twelve objective questions were developed and integrated into the game "Star Pirates". Health literacy is assessed interactively through the game's story and the choices children make during their experience. **Conclusion:** Embedding the scale in a digital game offers an innovative strategy to promote and evaluate health literacy in children with cancer, contributing to more humane, understandable, and participatory care.
Key words: Health Literacy; Health Education; Educational Technology; Child; Precursor Cell Lymphoblastic Leukemia-Lymphoma.

RESUMO

Introdução: O letramento em saúde capacita as crianças a compreenderem e utilizarem informações sobre saúde. A utilização de estratégias educativas adaptadas facilita a compreensão de conteúdos complexos de saúde e contribui para o enfrentamento de doenças. **Objetivo:** Apresentar o processo de desenvolvimento de uma escala lúdica de letramento em saúde infantil, integrada a um jogo digital voltado para crianças com diagnóstico de câncer, com foco em leucemia linfoide aguda. **Método:** Estudo metodológico conduzido entre novembro de 2024 e maio de 2025, composto por cinco etapas principais: definição teórica dos domínios da escala, adaptação da linguagem para o público infantil, integração dos elementos avaliativos na estrutura narrativa do jogo, elaboração do banco de perguntas e planejamento da validação. A escala foi inserida em um jogo digital educativo, estruturado em capítulos e *minigames*, com perguntas lúdicas ao final para avaliação dos domínios do letramento em saúde. **Resultados:** A escala foi construída com base em quatro domínios principais: (1) Conhecimento sobre o câncer; (2) Tratamento e efeitos colaterais; (3) Autocuidado e hábitos saudáveis; e (4) Emoções e suporte. Foram desenvolvidas 12 perguntas objetivas integradas ao jogo *Piratas das Estrelas*. A avaliação do letramento ocorre de forma interativa por meio da narrativa do jogo e das escolhas feitas pela criança ao longo da experiência. **Conclusão:** A construção da escala integrada a um jogo digital representa uma estratégia inovadora para promover e avaliar o letramento em saúde de crianças com câncer. A proposta visa contribuir para o cuidado mais humanizado, compreensível e participativo.
Palavras-chave: Letramento em Saúde; Educação em Saúde; Tecnologia Educacional; Criança; Leucemia-Linfoma Linfoblástico de Células Precursoras.

RESUMEN

Introducción: La alfabetización en salud les permite a los niños comprender y utilizar información sanitaria. Emplear estrategias educativas adaptadas facilita la comprensión de contenidos complejos de salud y ayuda a enfrentar enfermedades. **Objetivo:** Presentar el desarrollo de una escala lúdica de alfabetización en salud infantil, integrada en un juego digital dirigido a niños con diagnóstico de cáncer, centrado en leucemia linfoide aguda. **Método:** Estudio metodológico realizado entre noviembre de 2024 y mayo de 2025, con cinco etapas principales: definición teórica de los dominios de la escala, adaptación del lenguaje para niños, integración de elementos evaluativos en la narrativa del juego, elaboración de un banco de preguntas y planificación de la validación. La escala se incorporó a un juego educativo digital, estructurado en capítulos y minijuegos, con preguntas lúdicas al final para evaluar los dominios de la alfabetización en salud. **Resultados:** Se construyó la escala con base en cuatro dominios principales: 1) Conocimiento sobre el cáncer; 2) Tratamiento y efectos secundarios; 3) Autocuidado y hábitos saludables; y 4) Emociones y apoyo. Se desarrollaron 12 preguntas objetivas integradas en el juego Piratas de las Estrellas. La evaluación de la alfabetización se realiza de forma interactiva mediante la narrativa del juego y las decisiones que toma el niño durante la experiencia. **Conclusión:** La creación de esta escala integrada en un juego digital representa una propuesta innovadora para promover y evaluar la alfabetización en salud de niños con cáncer, contribuyendo a un cuidado más humanizado, comprensible y participativo.
Palabras clave: Alfabetización en Salud; Educación en Salud; Tecnología Educacional; Niño; Leucemia-Linfoma Linfoblástico de Células Precursoras.

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INTRODUCTION

Health literacy in childhood is the child's ability to understand, process and utilize health-related information to take decisions of everyday life. This competence, in addition to favoring health behaviors, promotes childhood protagonism to cope with sickening situations, especially in hospital environments that can create fear and insecurity. The development of strategies to promote health literacy since early in life is an investment in autonomy, prevention and adherence to treatment during the life course[1].

Especially in cases of chronic diseases as cancer, childhood hospitalization is a potentially traumatic experience. Hospitalized children are exposed to unknown environments, painful procedures, complex and many times toxic treatments and separation from their families, which can trigger emotional distress and compromise biopsychosocial development. Appropriate caring spaces that favor a positive coping with hospitalization according to the literature are closely related to emotional support and understanding the child has about his/her condition[2].

Childhood cancer, although relatively rare compared to adult cancer, is one of the leading causes of pediatric morbimortality in the world. Leukemia accounts for nearly 30% of the cases of childhood cancer. Usually, prolonged and aggressive treatment imposes the child a life of invasive procedures and intense side effects as hair loss, fatigue and nausea directly affecting their body image and quality of life. Proper communication on what is going on is essential to diminish the suffering and increase the adherence to treatment[3].

Health literacy assumes a strategic role within this scenario, interventions promoting understanding of the disease, the treatment and required care help to cope and adjust to a new routine. Children and adolescents who understand their sickening process are more resilient, less anxious and trust the health team more often. However, scarce are the instruments validated and matched to the child language that allow to validate the health literacy grade in this specific group[3,4].

To make the information accessible and meaningful to children, educative strategies should be adapted to their forms of expression and understanding. The use of digital educative games appears as an innovative approach because they combine playful elements, interactivity and symbolic narratives that facilitate the understanding of complex health contents. Children exposed to games addressing health exhibit significant improvement of understanding of procedures and better adherence to therapeutic recommendations[5].

In addition, the utilization of educative materials allows to address the content in a non-threatening manner, favoring the emotional expression and identification with the characters[6,7]. If well structured, games are able to integrate cognitive, affectionate and behavioral aspects, encompassing multiple domains of health literacy. This approach is especially useful in pediatric oncologic contexts where the sensitive content needs to be worked carefully and with empathy.

The present study has the objective of presenting the development of a playful scale of health literacy embedded into an interactive digital game targeted to children with cancer, particularly leukemia.

METHOD

Methodological study based on structured approach to develop a playful scale of childhood health literacy embedded into an educative digital game targeted to children diagnosed with cancer, particularly acute lymphoid leukemia (ALL). One experienced nurse and one experienced physician in constructing games and literacy scales elaborated the material and conducted the study. To refine the game and the scale, other professionals joined in: a pedagogue responsible for analyzing the adequacy of health literacy based on his clinical practice and a game designer in charge of ensuring the coherence of health instructions and the principles of design and usability of the games.

All the stages have been conducted between November 2024 and May 2025 through Google Meet® virtual meetings. An active search of the health literature at databases/portals was conducted to construct the game and the literacy scale and list the main compromises found during the treatment of the child with ALL. The process was designed according to the following stages:

Initially, a literature review was performed to identify the main relevant domains of childhood health literacy in the oncologic context. Four main domains have been defined:

- **Knowledge about cancer**: Basic understanding of the disease, causes and effects on the body.
- **Treatment and side effects**: Information about therapeutic modalities as chemotherapy and possible adverse effects.
- **Selfcare and healthy habits**: Daily practice that help the recovery and maintenance of health during treatment.
- **Emotions and support**: Psychologic aspects and importance of emotional and social support.

Articles to support the theoretical content of the game were searched at the databases Virtual Health Library Regional Portal®, SciVerseScopus®, Embase® and Web of

Science® with the following key-words: "nausea", "vomit", "acute lymphoid leukemia", "anemia", "altered nutrition", "ulceration of the mucosa", "hemorrhagic cystitis", "alopecia", "risk of infection", "bone pain" combined through Boolean operators "AND" and "OR". Eventually, 86 results were found, 68 of which were excluded for not meeting the scope. In all, 18 articles were considered for full reading, of which eight formed the final sample to assist the elaboration of the theoretical content of the game. The contents were divided and grouped according to similarity to be discussed and debated in the same chapter of the game.

Given the target age-range (children from six to 12 years of age), the language was adapted to be accessible and engaging. A playful narrative was adopted with analogies and metaphors to facilitate the understanding of complex concepts. For instance, cancer cells were represented as little monsters that need to be fought.

The digital game was structured in chapters and minigames, each one corresponding to one of the domains of the scale. This integration allowed an easy and interactive evaluation of the literacy as the child advanced in the story and faced challenges related to his/her treatment.

Based on the experiences the game provided, the game was elaborated with objective questions associated with each domain. Whether the response was correct these questions were incorporated into the final minigame when the child showed his/her understanding about the themes addressed.

Chart 1 portrays the structuring to create this type of methodology of construction of a playful scale of health literacy focused to childhood cancer[3].

This research is a methodological study targeted to a playful scale of health literacy in childhood embedded into an educative digital game for children diagnosed with ALL. All the stages were developed with secondary data extracted from the scientific literature available at the main health databases and no primary data have been collected directly with human beings in this study stage. Thus, the analysis and review by an Ethical Committee was waived in compliance with Directive 510/2016[8] of the National Health Council (CNS). Ethical principles have been strictly complied with, ensuring the integrity, transparency and reproducibility of the procedures adopted. The theoretical contents to elaborate the scale and of the game were referenced according to the copyrights disposed in Laws 9,610/1998[9] and 12,853/2013[10], ensuring the recognition of the sources. In addition, there was no manipulation, omission or distortion of the data accessed. The development of the material followed clear methodological criteria based on scientific evidences, respecting the commitment with the reliability of the information presented and ethical accountability in producing knowledge for this population.

RESULTS

A specific plot was created to guide the construction of the story to structure the game and make adjustments to specific health themes. Figure 1 depicts this plot of the chapters.

The game, titled "Star Pirates", was developed with an engaging narrative where the child takes over the role of a young pirate who faces challenges similar to the oncologic treatment. Each chapter addressed a specific domain showing integration of the chapters of the game with the domains of the scale (Chart 2).

The construction of a plot and integration of the chapters of the game with the domains of the scale portrayed in Chart 2 were based on a search of specialized literature at the databases aforementioned. Emerging data included: (D1) recognition of signs and symptoms, basic understanding of cancer and its body impact; (D2) understanding of the purpose of the treatment and side effects (including the metaphor of "red pee") and associated conducts; (D3) selfcare practices (feeding, hydration, rest) and warning signs; (D4) emotions, self-image and mobilization of the support network. These findings were categorized according to content analysis guided by a hierarchical code book (domain and subcategories), applying independent coding by two evaluators (nurse and physician) and solution by consensus (other participants). The process of analysis comprehended: extraction of units of meaning of the narrative and gameplay, connection to drafts of items, experts judgment (pedagogue and game designer, and organization in an item-evidence matrix (item/domain/subcategory and chapter/minigame), followed by language and pedagogic refinement.

The mapping ensured the coverage of the content with no orphan items, explicit traceability, mechanic alignment/message (adjustments in "Stellar Monsters" and crossed reference of "Red Pee" between D2 and D3), and improvement of applicability (pictograms, simple punctuation marks and micro-tutorials with formative feedback), resulting in observable items and clear rules to interpret health childhood literacy throughout the playful experience.

12 questions distributed in four domains embedded in the final minigame "The Boarding" have been developed according to the distribution and integration of the content created in Chart 3. The questions were elaborated playfully utilizing the language and content of the game to facilitate the child's identification and response.

Chart 1. Stages of the construction of a playful scale of health literacy in childhood focused to childhood cancer

Stage	Description	Technical details/Strategies
1. Definition of the concept and domains	Theoretical structuring of the scale based on references of health literacy in childhood	• Bibliographic survey on health literacy and educative games • Target: children with leukemia • Definition of main domains
2. Adaptation of the language to the target public (children)	Creation of accessible and playful language	• Use of visual and textual analogies • Development of childhood characters that guide the narrative • Creation of plots and dialogues based on the daily life of the hospitalized child
3. Insertion of the scale into the design of the digital game	Integration of evaluative items to the game mechanics	• Minigames, narratives selection, interactive quizzes • Right responses earn rewards (points, positive speeches) • Wrong responses prompt an explanation as a scene or illustrative speech
4. Construction of responses and items of the scale	Formulation of the questions based on the domains defined	• Simple, visual and responsive language • Stimuli to emotional identification with the situations • Each question is embedded into a narrative context (for instance, a character with nausea asks what to do)

The scale is diegetic in the game itself: after living educative challenges with the protagonist, his/her progression depends on the response to the questions (point-and-click). Each hit is confirmed with an explanatory complement; an explanation is offered for each error (why) and guidance on how to correct, configuring informative feedback. The interactions are registered and form the final score which summarizes the performance of the domains evaluated (Chart 4).

DISCUSSION

The development of playful instruments to promote health childhood literacy is a relevant and innovative strategy, especially in pediatric cancer. The integration between health literacy and digital technology through the game "Star Pirates" meets a rising demand for approaches that respect the child's language, emotions and symbolic universe. In that line, educative games are effective to mediate health knowledge and humanization of the pediatric care, especially in situations of chronic disease as cancer[7].

The option of integrating the evaluation of literacy into narrative and interactive experiences of a digital game favors not only the child engagement but also the authenticity of the response since the content is grasped meaningfully. Children learn better if they are part of active and symbolic processes where they can try, err and correct safely[11]. Therefore, the game provides simultaneously a therapeutic and educative space, promoting not only the understanding of the process health-disease, but also the emotional coping with the condition lived. The incorporation of the scale into the regular flow of the game according to the psychometric analysis favors more ecologic responses and less reactive; when associated with pediatric cognitive interviews and interactive pre-tests, this strategy improves the understandability, reduces the bias of formulation and strengthens the validity of the instrument's content[12].

While addressing domains of self-care, side effects and emotional support, the scale constructed reinforces the importance of an ample perspective about health literacy, going beyond the simple transmission of medical information. Childhood health literacy should consider multiple domains – cognitive, emotional and social – for the child to understand, evaluate and apply the information autonomously and critically[13]. The organization of the items was guided by levels of functional, interactive and critical literacy proposed by specific contemporaneous models for childhood and adolescence that highlight the multidimensional nature of the construct. This theoretical base supports the definition of domains (access/understanding, communication/dialogue and decision-making) and the construction of items aligned with the actual experience of children in oncologic treatment[14].

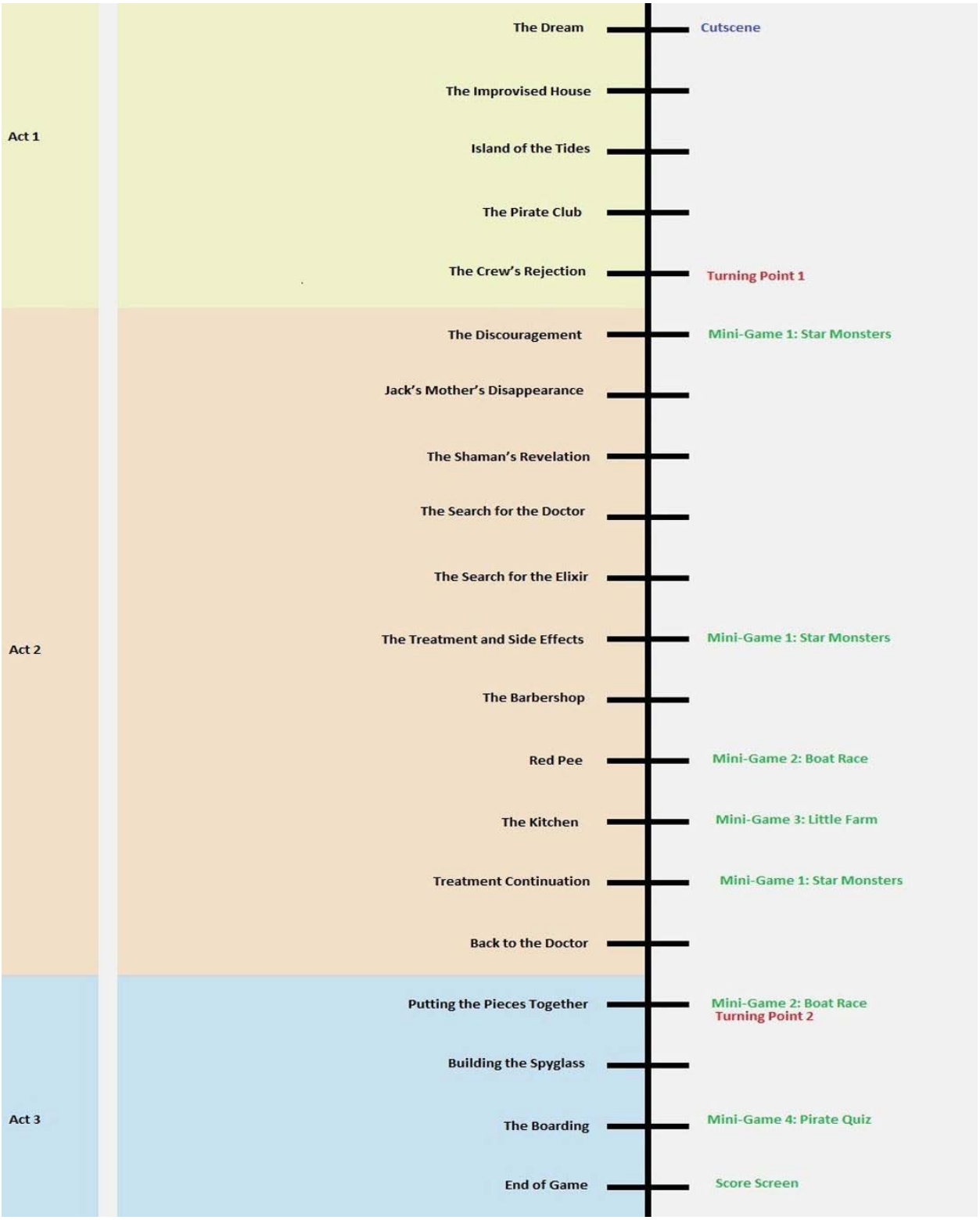

Figure 1. Plot of the game chapters

Another relevant aspect is the participation of the child as protagonist of his/her care. The utilization of digital games in hospital environments has been shown potential to strengthen the bond among the patient and the team, favor the communication of difficult themes and reduce the psychological suffering associated with hospitalization[15]. Specifically for cancer, where the control over the body and routine is lost, provide the child the possibility to "understand and act" in the game indicates that expanding the feeling of control and self-efficacy is

Chart 2. Integration of the game chapters with domains of the scale

Domains of the scale	Evaluative objective	Corresponding chapter/ minigames	Concept worked
Domain 1: Knowledge about the cancer	Evaluates whether the child understands what cancer is, its signals and impact on the body	• *The Revelation of the Shaman* • *Search for the Doctor* • *The Dream and the Assembly of the Spyglass*	Discovery of the disease, diagnosis and perception of physical symptoms
Domain 2: Treatment and side effects	Understand how the treatment works and which side effects may appear	• *The Search for the Elixir* • *The Treatment* • *Minigame: Stellar Monsters* • *Back to the Doctor* • *Red Pee*	Symbolic representation of chemotherapy and adverse symptoms
Domain 3: Selfcare and healthy habits	Stimulate selfcare practices and prevention during treatment	• *The Kitchen (Minigame 3)* • *Minigame: Boat Race* • *Red Pee*	Healthy feeding, adverse reactions and importance of hydration
Domain 4: Emotions and support	Explore the feelings, self-esteem and emotional support	• *Rejection of the Crew* • *The Discouragement* • *Barbershop*	Body image, acceptance, distress and importance of support

associated with better adherence and understanding of the therapeutic regimen – critical components for the performance of the literacy scale[15,16].

Although the scale proposed requires further validation, as evaluation by experts and tests with children in treatment, its playful character and adapted to the childhood language is a significant progress if compared to traditional tools. The paucity of specific instruments targeted to childhood literacy within the general pediatrics context, especially oncology, was highlighted in a study, revealing the urgency of proposals as the one developed herein[17]. The methodology adopted allows not only the evaluation of the literacy level, but also the direct intervention through the content presented.

The development of a playful scale was supported by a robust theoretical framework and interdisciplinary approach, involving health professionals, pedagogy and game design. This articulation is essential to ensure technical and pedagogical adequacy of the material as advocated by authors who discuss the construction of health educational technologies[18]. The present proposal reinforces the potential of digital games as caring and learning devices, applicable specifically to complex contexts as pediatric oncology related health literacy.

CONCLUSION

The present study presented the process of development of a playful scale of health literacy in childhood embedded into an educative digital game for children in oncologic treatment, especially leukemia. The innovative proposal combines technical-scientific knowledge, accessible language and playful elements to promote the meaningful and empathic understanding of the process health-disease.

The structuring of the scale in specific domains inserted interactively into the game narrative allows not only to evaluate the child's literacy grade but also to potentialize his/her engagement with the themes addressed. The interaction reinforces the child protagonism and contributes for an experience of more humanized care, strengthening the communication and adherence to treatment.

The scale will be validated in a subsequent study through content evaluation by experts and pilot-application with children in treatment. This is a critical stage to ensure reliability and applicability in clinical and educative contexts.

The game "Star Pirates" is offered cost-free for Android devices through Play Store, expanding its reach and facilitating the access of children, families and health professionals to an innovative educative technology. It is believed that the dissemination of this tool can contribute effectively to strengthen health literacy in childhood with positive impacts on pediatric oncologic care.

This study is an important step to construct interactive and validated strategies for health literacy of children with cancer, opening opportunities to new studies and future researches that prioritize the well-being and the autonomy of children in their process of treatment.

Chart 3. Model of questions bank of the scale in playful format

Domains	Question (related chapter)	Alternatives	Response
Knowledge about cancer	*The Revelation of the Shaman* "What did the Shaman say cancer is?"	(A) Treatable disease (B) Flu (C) Pirate curse	(A)
	The Search for the Doctor "Cancer passes from one pirate to the other?"	(A) Not communicable (B) Yes, airborne (C) Yes, by contact	(A)
	The Assembly of the Spyglass "Why changes in the body are worrying?"	(A) Disease effects (B) Faking (C) Not playing	(A)
Treatment and side effects	*The Search for the Elixir* "What is chemotherapy good for?"	(A) Fight sick cells (B) Grow hair (C) Become sleepy	(A)
	Back to the Doctor "What to do if fever or nausea happens?"	(A) Tell an adult (B) Hide (C) Eat something	(A)
	Red Pee "Why drink water?"	(A) Avoid problems while peeing (B) Swim better (C) Just because	(A)
Selfcare	*The kitchen* "What to eat to be strong?"	(A) Fruits and legumes (B) Candies and chips (C) Only soda	(A)
	Boats race "Why did you feel like vomiting?"	(A) Chemo effect (B) Boat broken (C) Ate too much	(A)
	Red pee "How to avoid red pee?"	(A) Drink water (B) Avoid sun (C) Cold shower	(A)
Emotions and support	*Rejection of the crew* "What to do if my appearance is poor?"	(A) Talk to someone (B) Hide (C) Be angry	(A)
	The discouragement "How to deal with sadness?"	(A) Talk to someone (B) Be alone (C) Yell	(A)
	Barbershop "Why change the look?"	(A) Accept the appearance (B) Imitation (C) Giving up	(A)

Chart 4. Environment of application of scale of literacy

Evaluative environment	Evaluating chapter	Strategy of evaluation
Application end of the scale	Minigame 4 – The Boarding	The child responds to playful questions integrated to the plot. The responses show understanding and allow the categorization of the literacy grade (beginner/apprentice of pirate/commander of the boat/master guardian)

CONTRIBUTIONS

Giovani Basso da Silva, Heloíse Benvenutti, Lucas Paulo de Souza, Simone Travi Canabarro, João Gabriel Toledo Medeiros and Lucia Campos Pellanda contributed substantially to the conception and design of the study, acquisition, analysis and interpretation of the data, writing and critical review. Guilherme Kayser Prates Basso da Silva contributed substantially to the writing and critical review. All the authors approved the final version for publication.

DECLARATION OF CONFLICT OF INTERESTS

There is no conflict of interests to declare.

DATA AVAILABILITY STATEMENT

Al content underlying the text is contained in the manuscript.

FUNDING SOURCES

None.

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Recebido em 18/6/2025
Aprovado em 18/8/2025

Associate editor: Mario Jorge Sobreira da Silva. Orcid iD: https://orcid.org/0000-0002-0477-8595
Scientific-editor: Anke Bergmann. Orcid iD: https://orcid.org/0000-0002-1972-8777