REVIEW ARTICLE

Social robots in pediatric oncology: characteristics of interventions, feasibility, and emotional, social, and behavioral outcomes. A scoping review

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ABSTRACT

Objective: To synthesize the available evidence on social robot interventions, emotional, social, and behavioral outcomes, and feasibility indicators associated with their use in children and adolescents with cancer receiving care in clinical settings.
Methods: Primary studies with experimental, quasi-experimental, observational, and mixed-methods designs that evaluated interventions using social robots in children and adolescents with cancer were included. The search was conducted up to January 20, 2026, in PubMed, Scopus, PsycINFO, Cochrane Library, and Google Scholar. Emotional, social, behavioral, and cognitive outcomes were collected, as well as feasibility indicators, including safety, technical performance, recruitment, completeness and retention, acceptability, and logistics and implementation barriers.
Results: A total of 307 records were identified, and six studies were included. Findings were heterogeneous in terms of design, sample size, robot type, and outcomes. Favorable results were observed in emotional and social outcomes, whereas no consistent evidence of pain reduction during invasive procedures was documented, although more adaptive behaviors were reported during critical stages of the procedure. Overall, high acceptability was observed among children, parents, and healthcare personnel, but feasibility was influenced by technical, logistical, and staffing barriers.
Conclusions: The available evidence suggests that social robots are potentially feasible and promising interventions to support emotional and social outcomes in pediatric oncology. However, findings are derived from small, heterogeneous, and exploratory studies, highlighting the need for future research with more robust methodological designs, standardized measures, and systematic feasibility assessments.

Keywords: Robotics; Social Robots; Medical Oncology; Psycho-Oncology; Child; Adolescent; Psychosocial Impact (Source: MeSH)

Robots sociales en oncología pediátrica: características de las intervenciones, factibilidad y desenlaces emocionales, sociales y conductuales. Una revisión de alcance

RESUMEN

Objetivo: Sintetizar la evidencia disponible sobre las intervenciones con robots sociales, los desenlaces emocionales, sociales, conductuales y los indicadores de factibilidad asociados a su uso en niños y adolescentes con cáncer atendidos en entornos clínicos.
Métodos: Se incluyeron estudios primarios de diseño experimental, cuasiexperimental, observacional y de métodos mixtos que evaluaron intervenciones con robots sociales en niños y adolescentes con cáncer. La búsqueda se efectuó hasta el 20 de enero de 2026 en PubMed, Scopus, PsycINFO, Cochrane Library y Google Scholar. Se recopilaron los desenlaces emocionales, sociales, conductuales, cognitivos, así como los indicadores de factibilidad, que incluyeron seguridad, funcionamiento técnico, reclutamiento,

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completitud y retención, aceptabilidad, y logística y barreras de implementación.

Resultados: Se identificaron 307 registros y se incluyeron seis estudios. Los hallazgos fueron heterogéneos según diseño, tamaño muestral, tipo de robot y desenlaces. Se evidenciaron resultados favorables en desenlaces emocionales y sociales, mientras que en procedimientos invasivos no se documentó evidencia consistente de reducción del dolor, aunque se reportaron conductas más adaptativas en etapas críticas del procedimiento. En general, se observó una alta aceptabilidad entre niños, padres y personal de salud, pero la factibilidad estuvo condicionada por barreras técnicas, logísticas y de personal.

Conclusiones: La evidencia disponible sugiere que los robots sociales son intervenciones potencialmente factibles y prometedoras para apoyar los desenlaces emocionales y sociales en oncología pediátrica. No obstante, los hallazgos provienen de estudios pequeños, heterogéneos y de alcance exploratorio, lo que subraya la necesidad de investigaciones futuras con diseños metodológicos más robustos, medidas estandarizadas y evaluaciones sistemáticas de la factibilidad.

Palabras clave: Robótica; Robots Sociales; Oncología; Psicooncología, Niño; Adolescente; Impacto Psicosocial (Fuente: DeCS)

INTRODUCTION

Cancer treatment during childhood and adolescence involves prolonged hospitalizations, invasive procedures, and disruptive changes in daily life, increasing the risk of psychological distress and the need for emotional and family support throughout treatment (1). In response to this vulnerability profile, standards of care in pediatric oncology have been proposed that recognize the psychosocial component as an essential part of comprehensive cancer care, with emphasis on early assessment and continuous support for patients and caregivers (2,3).

In this context, social robots represent an emerging technological strategy to expand the psychosocial support available in clinical settings, particularly in pediatric care (4). In clinical applications, these interventions have shown potential to impact: (a) emotional outcomes, such as emotional well-being, anxiety, depression, and fear management; (b) social and communicative outcomes, including interaction and social expression; and (c) behavioral and cognitive outcomes, such as health habits, adherence, and selective attention (5).

However, the available evidence in pediatrics often groups different conditions and contexts, making it difficult to extrapolate findings to pediatric oncology settings. Pediatric cancer treatments typically involve prolonged and complex trajectories, with recurrent hospitalizations and repeated exposure to invasive procedures (e.g., needle-related procedures), which are associated with pain and procedure-related distress (6,7). The intensive and sustained nature of treatment may contribute to a greater emotional burden and challenges in psychological adaptation. Furthermore, psychosocial impact extends to caregivers and family dynamics, making early and continuous psychosocial assessment and support necessary (2,8).

Although previous review studies exist on social robots in general pediatrics and on digital interventions targeting specific symptoms in young populations with cancer (e.g., fatigue in adolescents and young adults), the evidence on social robots in pediatric oncology remains fragmented and has not been synthesized in a focused manner, including recent interventions (5,9–13). This gap limits the identification of which types of interventions have been implemented, which outcomes have been prioritized, and how feasible these interventions are in clinical settings with operational constraints and biosafety requirements.

Therefore, this scoping review aimed to synthesize the available evidence on intervention characteristics, feasibility indicators, and emotional, social/communicative, and behavioral/cognitive outcomes associated with the use of social robots in children and adolescents with cancer treated in clinical contexts, including inpatient and outpatient care. This synthesis describes the current state of knowledge and guides priorities for future research and clinical implementation.

METHODS

Protocol and registration

The scoping review was conducted in accordance with the Joanna Briggs Institute methodology (14). The protocol was registered in the Open Science Framework (OSF) on January 17, 2026 (https://osf.io/yjrx9).

Population, concept, and context

According to the PCC (Population, Concept, and Context) framework, the population of interest consisted of children and adolescents diagnosed with cancer. The concept included interventions using social robots, defined as systems in which social interaction constitutes a central component of human–robot interaction. These robots typically exhibit characteristics such as expressing and/or perceiving emotions; communicating through high-level dialogue; recognizing or modeling other agents; establishing and maintaining social relationships; using natural social cues (e.g., gaze, gestures); displaying distinctive personality traits; and developing or learning social competencies (15). The context corresponded to oncology clinical settings, including both inpatient and outpatient care.

Eligibility criteria

Inclusion criteria were: (a) primary studies with experimental (randomized controlled trials), quasi-experimental, observational (cohort or cross-sectional), and mixed-methods designs; (b) studies in which participants were children or adolescents under 18 years of age with a confirmed diagnosis of cancer (solid or hematological tumors); and (c) studies implementing interventions with social robots (including humanoid robots, robotic pets, or participatory robotics kits).

Exclusion criteria included: (a) studies focused on surgical robotics or exclusively physical motor rehabilitation robotics (e.g., exoskeletons for gait); (b) interventions based solely on virtual agents (screen-based avatars) lacking physical embodiment; and (c) studies with mixed populations (e.g., cancer combined with asthma or diabetes) in which no specific subgroup analysis was performed for pediatric oncology patients.

Search strategy and information sources

The search was conducted up to January 20, 2026, in four databases: PubMed, Scopus, PsycINFO, and Cochrane Central. Additionally, a search was performed in Google Scholar, reviewing the first 100 results ranked by relevance.

A manual search was also conducted by reviewing the reference lists of potentially eligible studies to identify additional publications not retrieved through electronic strategies. Forward citation tracking was not systematically performed, given the exploratory nature of the review and the breadth of the databases consulted.

The search strategies are presented in Supplementary Table 1.

Selection of sources of evidence

After completing the search, all identified citations were collected and uploaded into the Rayyan bibliographic software, where duplicates were removed. Titles and abstracts were screened to determine whether they met the inclusion criteria. Two reviewers (RG and SC) independently conducted the screening, and a third reviewer (AM) resolved discrepancies. Full texts of potentially eligible studies were retrieved and assessed, and reasons for excluding studies that did not meet the inclusion criteria were documented and explicitly reported.

Data extraction

Data extraction was organized into three main domains:

1. Characteristics of included studies: data were collected on first author, year of publication, country, study design, sample size, age range and mean or median age of participants, type of cancer, robot dose/frequency of use, clinical setting (inpatient or outpatient), robot name, role performed, personnel assisting the intervention, description of the intervention, duration, and number of sessions.

2. Effectiveness outcomes: reported outcomes were extracted, including:

a) Emotional outcomes: variables intended to assess emotional components in children associated with the social robot intervention, according to each study's operational definition (e.g., anxiety, depression, anger, or other reported emotional indicators).

b) Social and communicative outcomes: variables assessing the child's communicative performance within the intervention context, including pragmatic language skills and discourse organization evaluated during structured activities.

c) Behavioral and cognitive outcomes: variables assessing observable behavioral responses in clinical procedures or activities, as well as outcomes related to health habits and learning or knowledge acquisition associated with the social robot intervention.

Measurements were conducted according to the instruments and procedures described in each study, including both standardized scales and author-developed tools.

3. Feasibility indicators: feasibility indicators were recorded as measures related to the implementation viability of the intervention in the clinical context, including:

a) Safety: presence or absence of adverse events, as well as negative reactions or discomfort signals reported during the intervention.

b) Technical performance: operational performance of the robot during the intervention, including system stability, interruptions, technical failures, and support requirements to complete the session.

c) Recruitment: proportion of eligible participants who agreed to participate and reasons for non-inclusion when reported.

d) Completeness and retention: proportion of participants who completed the intervention and, when applicable, follow-up assessments.

e) Acceptability: perceptions and evaluations of robot use by children, caregivers, and/or healthcare staff, including satisfaction and favorable disposition toward the intervention.

f) Logistics and implementation barriers: conditions required for intervention delivery (personnel, time, space, hygiene protocols), as well as reported technical, organizational, or cultural adaptation barriers.

Data analysis

Given the heterogeneity of study designs, characteristics of social robot intervention characteristics, and evaluated outcomes, a descriptive synthesis of the evidence was conducted. Results were organized descriptively, grouping findings according to emotional, social/communicative, and behavioral/cognitive outcome domains, as well as feasibility indicators reported in the included studies.

In cases where studies did not report confidence intervals or p-values for comparisons, means, standard deviations, and sample sizes were used to perform secondary calculations, applying Welch's t-test to assess differences between groups. A p-value < 0.05 was considered statistically significant.

RESULTS

Search results

The study identification and selection process is presented in Figure 1. The literature search in PubMed, PsycINFO, Scopus, and Cochrane Library identified a total of 307 records. After removing 20 duplicate records, 287 studies were screened by title and abstract. As a result of this process, 275 records were excluded, and 12 studies were selected for eligibility assessment through full-text review. No documents were excluded due to unavailability of full text, and no additional studies were identified through other search methods. Finally, six studies met the inclusion criteria and were included in the scoping review. The reasons for exclusion of the remaining six studies are described in Supplementary Table 2.

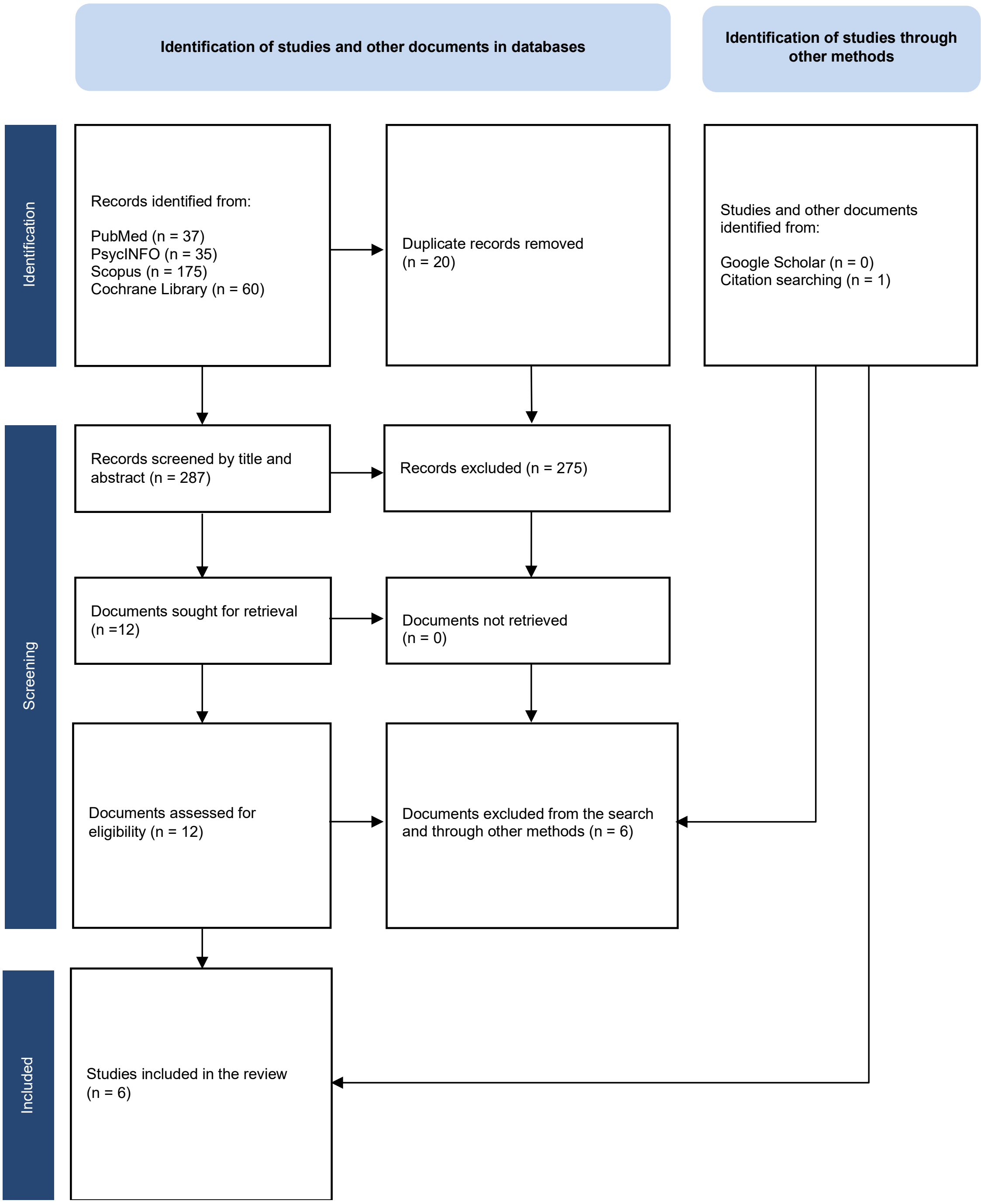

Figure 1. Flow diagram of the study identification and selection process

Characteristics of the included studies

The general characteristics of the studies are summarized in Table 1. A total of six studies published between 2015 and 2024 were included, conducted in Iran (n = 2), Colombia (n = 2), Canada (n = 1), and the Netherlands (n = 1).

Regarding methodological design, three studies used a comparative design with independent groups, in which the robotic intervention was compared with standard psychotherapy (human-only), active distraction (the same robot, only dancing and singing), or audiobook use. In contrast, three studies employed quasi-experimental designs based exclusively on pre–post evaluations within a single group, without external comparators.

Table 1. General characteristics of the included studies

First author and year	Country	Study design	n	Age (years)	Type of cancer	Clinical setting	Robot name	Role and description of the intervention	Duration/frequency of the intervention
Alemi et al. (2015)	Iran	Experimental study (2 independent groups, social robot vs psychotherapy)	10	$\bar{X}$ = 9.5	Not specified*	Patients undergoing active treatment	Nima	Companionship and emotional regulation. Uses role-play to address fear and stress, understanding of treatment (procedures and chemotherapy), pain management and hygiene, nutrition during treatment, empathy, the child's active participation, and strengthening hope.	8 sessions over 1 month
Colina-Matiz et al. (2024)	Colombia	Quasi-experimental study (1 group, pre-post)	13	Me = 15	Solid tumors and hematological cancers	Inpatient	LEGO Mindstorms EV3 kit	Communicative and motor stimulation through play to promote social interaction, improve communicative intention, and stimulate physical/ motor activity	1–2 sessions
Jibb et al. (2018)	Canada	Experimental study (2 independent groups, robot with cognitive–behavioral strategies vs robot that dances and sings)	40	$\bar{X}$ = 6.2	Acute lymphoblastic leukemia, lymphoma, brain tumor, and others	Patients undergoing active treatment	MEDiPORT	Cognitive–behavioral strategies (breathing, positive reinforcement) and active distraction for pain management and reduction of distress during invasive medical procedures (needle insertions)	1 session
Lozano-Mosos et al. (2023)	Colombia	Quasi-experimental study (1 group, pre-post)	14	$\bar{X}$ = 14.2	Not specified*	Inpatient (during consolidation phase)	NAO V6	Interactive educational session to increase knowledge about proper nutrition and self-care of the central venous catheter during the consolidation phase of treatment	1 session
Meghdari et al. (2018)	Iran	Quasi-experimental study (1 group, robot vs audiobook)	14	Not reported*	Not specified*	Inpatient	Arash	Social companionship and storytelling for entertainment, reduction of loneliness, and relief of emotional distress in the hospital setting	1 session
van Bindsbergen et al. (2022)	Netherlands	Quasi-experimental study (1 group, pre-post)	28	$\bar{X}$ = 9.4	Solid tumors, brain tumors, hematological cancers	Outpatient (pediatric oncology outpatient clinic)	NAO6	Gamified health education (interactive quiz) to teach healthy habits and improve sleep hygiene in outpatients	1 session

*Meets the eligibility criteria for pediatric cancer. $\bar{X}$ = mean; SD = standard deviation.

Sample sizes ranged from 10 to 40 participants. The study population consisted of children and adolescents diagnosed with cancer, with reported ages, expressed as mean or median, ranging from 6.2 to 15 years. In some studies, the mean or median age and the specific type of cancer were not detailed; however, the inclusion criteria were consistent with those of this scoping review.

Regarding the clinical setting, interventions were primarily conducted in inpatient settings or during active cancer treatment, although one study was conducted in an outpatient pediatric oncology setting. Different humanoid social robots were used, including Nima, MEDiPORT, Arash, NAO, and LEGO Mindstorms-based robotic platforms, fulfilling various roles such as social companionship, emotional regulation, health education, communicative stimulation, and support during medical procedures.

Interventions varied in duration and frequency, ranging from single or dual sessions, described in five of the six studies, to structured multi-session programs implemented over one month, reflecting heterogeneity in the application of social robots.

Effectiveness outcomes

Table 2 presents the effectiveness results of social robot use in the pediatric cancer population.

Table 2. Emotional, social, and behavioral outcomes and instruments used in the included studies

First author and year	Variables of interest and instruments	Intervention group (post-intervention)	Control group (post-intervention)	Mean difference between intervention group vs control group (95% CI)
Alemi et al. (2015)	Anxiety: MASC	$\bar{x}$ = 1.89 (SD = 0.203)	$\bar{x}$ = 2.38 (SD = 0.425)	DM = −0.49; 95% CI: −1.02–0.04; p = 0.065*
	Depression: CDI	$\bar{x}$ = 1.00 (SD = 0.078)	$\bar{x}$ = 1.30 (SD = 0.180)	DM = −0.30; 95% CI: −0.52–−0.08; p = 0.018*
	Anger: CIA	$\bar{x}$ = 2.31 (SD = 0.313)	$\bar{x}$ = 2.82 (SD = 0.161)	DM = −0.51; 95% CI: −0.86–−0.16; p = 0.010*
Colina-Matiz et al. (2024)	Self-care: Self-care activity index	Me = 0	NA	NA
	Communicative intention: Observational rubric	Me = 2	NA	NA
	Narrative: Observational rubric	Me = 1	NA	NA
	Topic management: Observational rubric	Me = 2	NA	NA
	Mobility: Mobility activity index	Me = 0	NA	NA
Jibb et al. (2018)	Post-needle insertion pain: FPS-R	$\bar{x}$ = 1.0 (SD = 2.3)	$\bar{x}$ = 1.4 (SD = 3.0)	DM = −0.40; p = 0.68
Lozano-Mosos et al. (2023)	Total knowledge: ad hoc questionnaire	Me = 19.69	NA	NA
Meghdari et al. (2018)	Cognition: TS–SF	$\bar{x}$ = 3.63	NA	NA
	Emotion: TS–SF	$\bar{x}$ = 2.52	NA	NA
	Imagination: TS–SF	$\bar{x}$ = 4.30	NA	NA
van Bindsbergen et al. (2022)	Sleep hygiene: CSHS	$\bar{x}$ = 5.26	NA	NA

*Calculated by the authors of this article using a two-tailed Welch's t-test. $\bar{x}$ = mean; SD = standard deviation; Me = median; NA = not applicable; DM = mean difference; MASC = Multidimensional Anxiety Scale for Children; CDI = Children's Depression Inventory; CIA = Children's Inventory of Anger; FPS-R = Faces Pain Scale–Revised; TS–SF = Transportation Scale–Short Form; CSHS = Children's Sleep Hygiene Scale.

1. Emotional outcomes

Alemi et al. (16) evaluated differences in mean anxiety, depression, and anger when comparing a social robot intervention with a psychotherapy-based comparator (n = 10). For anxiety (Multidimensional Anxiety Scale for Children [MASC]), the post-intervention comparison favored the social robot intervention but did not reach statistical significance (DM = −0.49; 95% CI: −1.02–0.04; p = 0.065). For depression (Children's Depression Inventory [CDI]), a significant difference was reported in favor of the robot at post-test (DM = −0.30; 95% CI: −0.52–−0.08; p = 0.018), compared with the control group. Similarly, for anger (Children's Inventory of Anger [CIA]), significant between-group differences were observed (DM = −0.51; 95% CI: −0.86–−0.16; p = 0.010), although the control group presented significantly lower baseline values, which complicates between-group interpretation.

Subsequently, the consistency of between-group comparisons and within-group pre–post changes was assessed. The intervention group showed a significant reduction in mean anxiety ($\bar{x}$ pre = 2.23 ± 0.227 vs $\bar{x}$ post = 1.89 ± 0.203; DM = −0.34; 95% CI: −0.47–−0.20; p = 0.002), whereas the psychotherapy comparator showed no change ($\bar{x}$ pre = 2.36 ± 0.440 vs $\bar{x}$ post = 2.38 ± 0.425; DM = 0.01; 95% CI: −0.11–0.15; p > 0.05). In depression, the intervention group also showed a significant decrease ($\bar{x}$ pre = 1.35 ± 0.093 vs $\bar{x}$ post = 1.00 ± 0.078; DM = −0.16; 95% CI: −0.24–−0.07; p = 0.019), with no relevant changes in the psychotherapy group ($\bar{x}$ pre = 1.31 ± 0.195 vs $\bar{x}$ post = 1.30 ± 0.180; DM = −0.01; 95% CI: −0.09–0.07; p > 0.05). For anger, the intervention group showed a significant reduction ($\bar{x}$ pre = 2.73 ± 0.546 vs $\bar{x}$ post = 2.31 ± 0.313; DM = −0.40; 95% CI: −0.71–−0.08; p = 0.012). This pattern suggests that improvements can be observed within the robot-exposed group, but they do not always translate into statistically significant differences compared with the comparator, particularly with small sample sizes.

Similarly, Meghdari et al. (17) evaluated a storytelling intervention using a social robot during hospitalization (n = 14) using the Transportation Scale–Short Form (TS–SF), comparing it with an audiobook-based intervention. The emotional dimension showed a significant decrease in the intervention group compared with the control group ($\bar{x}$ = 3.48 ± 0.94 vs $\bar{x}$ = 2.52 ± 1.00; p = 0.033), whereas no changes were observed in cognition ($\bar{x}$= 3.36 ± 0.80 vs $\bar{x}$ = 3.63 ± 0.83; p = 0.455) or imagination ($\bar{x}$ = 4.27 ± 0.67 vs $\bar{x}$ = 4.30 ± 0.82; p = 0.91). No studies were identified that directly evaluated global emotional well-being or fear management using measures comparable across studies.

2. Social and communicative outcomes

Regarding communicative outcomes, Colina-Matiz et al. (18) evaluated a play-based approach with robotic components during hospitalization (n = 13). Significant improvements were observed in communicative intention (Me pre = 1 vs Me post = 2; p = 0.034) and topic management (Me pre = 1 vs Me post = 2; p = 0.011). For narrative skills, a trend was reported (Me pre = 0 vs Me post = 1; p = 0.059). In contrast, no changes were observed in self-care (Me pre = 1 vs Me post = 0; p = 0.157) or mobility (Me pre = 0 vs Me post = 0; p = 0.157), suggesting that the effect was concentrated on communicative components rather than on functional dimensions assessed in parallel.

3. Behavioral and cognitive outcomes

In the context of needle procedures, Jibb et al. (19) compared two robot-based modalities: a robot applying cognitive–behavioral strategies versus a comparator robot providing active distraction through dancing and singing (n = 40). For post-insertion pain measured with the Faces Pain Scale–Revised (FPS-R), no differences were observed between conditions (DM = −0.40; p = 0.68). However, for approach–avoidance behaviors, significant differences were observed at critical stages of the procedure, such as nurse movement toward the child (DM = −1.00; p = 0.012), palpation (DM = −0.80; p = 0.006), and needle insertion (DM = −0.90; p = 0.020). No differences were observed during sterilization (p = 0.11), and sterile dressing showed a near-threshold result (p = 0.072). In the outpatient context, van Bindsbergen et al. (20) evaluated a gamified robot-based intervention targeting habits and sleep (n = 28). Sleep hygiene increased significantly ($\bar{x}$ pre = 5.11 ± 0.27 vs $\bar{x}$ post = 5.26 ± 0.25; DM = 0.10; p = 0.047).

Regarding cognitive outcomes related to health learning, Lozano-Mosos et al. (21) evaluated an educational session with a social robot focused on nutrition and central venous catheter care during hospitalization (n = 14). A significant increase in total knowledge was reported (Me pre = 15.53 vs Me post = 19.69; p < 0.001), with increases in subcomponents such as "care while eating" ($\bar{x}$ pre = 5.62 vs $\bar{x}$ post = 7.08; p = 0.009), "catheter care" ($\bar{x}$ pre = 4.57 vs $\bar{x}$ post = 5.29; p = 0.008), and "what to eat" ($\bar{x}$ pre = 5.36 vs $\bar{x}$ post = 7.29; p < 0.001). Among the included studies, no comparable direct measures of selective attention as a primary outcome were identified, and thus, this component could not be quantitatively synthesized.

Feasibility indicators

The included studies did not systematically report all feasibility indicators; therefore, the synthesis is based on the components reported in each publication: safety, technical performance, recruitment, completeness and retention, acceptability, and logistical aspects and implementation barriers. Table 3 presents the feasibility results for the use of social robots in the pediatric cancer population.

1. Safety

Safety indicators were mainly reported as the absence of adverse events or through subjective perceptions of safety. Colina-Matiz et al. (18) reported no adverse events during the intervention with LEGO Mindstorms EV3. Consistently, in interventions using NAO, van Bindsbergen et al. (20) reported that no child rated the robot as frightening, and Lozano-Mosos et al. (21) did not observe negative emotional reactions such as anger, fear, or sadness during interaction. Meghdari et al. (17) reported a high perceived safety of the Arash robot (4.51/5). In contrast, Alemi et al. (16) did not report specific safety indicators for the intervention using the Nima robot.

2. Technical performance

Technical performance was described in greater detail in studies conducted during clinical procedures or structured sessions. Jibb et al. (19) documented technical and operational failures in 35.0% of procedures using MEDiPORT. Failures

Table 3. Feasibility indicators reported in the included studies

First author and year	Safety	Technical performance	Recruitment	Completeness and retention	Acceptability	Logistics and implementation barriers
Alemi et al. (2015)	NR	NR	NR	High retention in a longitudinal study: the experimental group decreased from 6 to 5 participants (16.7% attrition) due to parents' reluctance to return to the hospital.	Parents and staff reported being "extremely happy" with the progress and interaction.	Operational dependence: requires a robot operator and a facilitating psychologist. Difficulty coordinating schedules outside treatment periods.
Colina-Matiz et al. (2024)	Absence of adverse events: no falls, hemodynamic instability, or infections were recorded during play.	NR	Acceptance rate: 65.0% (13/20). The main reason for non-eligibility was admission to the ICU (medical criterion).	Completeness: 100% (13/13) of participants completed the 2-day workshop.	NR	Hygiene protocols: strict disinfection protocols were implemented for LEGO pieces and tablets due to COVID-19 and immunosuppression.
Jibb et al. (2018)	NR	Logistical failures in 35.0% of procedures (14/40). Of these failures, 64% negatively affected clinical workflow (delays).	High acceptance rate: 85.1% (40/47). Refusals were due to a dislike of the robot or the video.	Retention: 100% (0 dropouts once randomized). Data completeness: >96% of items answered.	Children enjoyed the robot but reported less pain relief than expected. Nurses reported minimal impact on workflow.	Procedure duration: 7–10 minutes, considered acceptable by nurses.
Lozano-Mosos et al. (2023)	No negative emotions: fear, anger, and sadness were not observed during the interaction.	NR	NR	Completeness: 92.9% (13/14). One dropout due to transfer to the ICU because of clinical instability unrelated to the robot.	NR	Duration: the educational session lasts approximately 45 min; requires physical space and patient time.
Meghdari et al. (2018)	High perceived safety: mean score of 4.51/5. Validated design with no sharp edges or physical threats.	NR	NR	NR	Likability: mean score of 4.9/5. Preference: 85.7% preferred the robot over the audiobook.	Robot cost: USD 6,000. Requires a human operator due to the lack of autonomous Persian-language software.
van Bindsbergen et al. (2022)	No fear: no child rated the robot as frightening.	Stable: 89% of cases were problem-free. Failures were resolved by rebooting or a "backup mechanism" (tablet use if voice failed).	Acceptance rate: 58% (28/48). The main reason for refusal was that the child was not in the mood or "it was a bad moment" (42%).	Completeness: 100% during the session. Retention: 86% completed the 2-week follow-up.	Mean interaction score according to children: 8.6/10. Mean interaction score according to parents: 8.0/10. 55% of children reported no dislike for any aspect of the robot. 96% of parents agreed with its educational use. 93% of children participated in the social robot intervention from beginning to end. 83% of children stated that they wanted to repeat the experience.	Dependence on the researcher: 50–72% of children required researcher assistance to interact with the robot.

ICU = Intensive Care Unit; NR = not reported.

included loss of internet connection, requiring robot reboot and causing delays in needle insertion, as well as minor errors such as phrase repetition. Most of these incidents occurred in the cognitive–behavioral arm, attributed to the greater complexity and novelty of its programming compared with the more standardized active distraction software. In van Bindsbergen et al. (20), NAO performed adequately in 89% of sessions, and failures were resolved by rebooting or using a tablet as an alternative. Meghdari et al. (17) reported limited software autonomy as a constraint, requiring a human operator. Alemi et al. (16) did not report technical performance indicators for the Nima robot.

3. Recruitment

Recruitment was reported as initial acceptance and was influenced by the child's clinical status or the child's and family's willingness. Colina-Matiz et al. (18) reported an acceptance rate of 65.0% (13/20), with non-inclusion mainly due to admission to the intensive care unit. Jibb et al. (19) reported an initial acceptance of 85.1% (40/47), with refusals related to children's dislike of the robot or the comparator material. In the outpatient setting, van Bindsbergen et al. (20) reported an acceptance rate of 58% (28/48), suggesting moderate participation when attendance outside the immediate hospital environment is required. Alemi et al. (16) did not report specific recruitment metrics.

4. Completeness and retention

Completeness tended to be high when interventions were conducted within a hospital session or a defined procedure, whereas retention was more variable when return visits or follow-up assessments were required. Colina-Matiz et al. (18) reported a completeness rate of 100%, with all included participants completing the intervention. In Jibb et al. (19), no dropouts were reported after randomization, and data completeness exceeded 96%. According to van Bindsbergen et al. (20), session completeness was 100%, and retention at two-week follow-up reached 86%. In Lozano-Mosos et al. (21), completeness was 92.9% (13/14), with one dropout due to clinical instability unrelated to the intervention. In contrast, Alemi et al. (16) reported a retention rate of 83.3% in the experimental group, with a reduction from 6 to 5 participants (16.7% attrition), mainly attributed to parents' reluctance to return to the hospital outside routine care periods.

5. Acceptability

Acceptability was consistently reported as favorable, although measured using different and sometimes non-standardized instruments. Alemi et al. (16) described high acceptability of the Nima robot, noting that parents and hospital staff were "extremely happy" with the observed progress and interaction. At the same time, children reported feeling emotionally supported and more willing to share emotions and future expectations. In Jibb et al. (19), acceptability was assessed using author-designed questionnaires (Likert-type items) administered to children, parents, and nursing staff. No statistically significant differences were observed between groups for most items; however, parental satisfaction regarding the time required to complete the procedure was significantly higher in the cognitive–behavioral arm than in the active distraction arm. Nursing staff also reported minimal impact of robot use on clinical workflow. In van Bindsbergen et al. (20), acceptability was high among both children and parents: 55% of children reported no dislike for any aspect of the robot, 96% of parents agreed with its educational use, and high engagement was observed during the intervention (93%). Additionally, 83% of children expressed willingness to repeat the experience (20). Both children and parents provided high mean interaction scores (8.6/10 and 8.0/10, respectively) (20). Meghdari et al. (17) also reported high acceptability of the Arash robot, reflected by a mean likability score of 4.9/5 and an 85.7% preference for the robot over the audiobook, along with positive perceptions of animation, friendliness, and intelligence.

The feasibility of the interaction depended significantly on the robot's cultural adaptation. In studies conducted in Iran, the robot's identity was modified to ensure local acceptance. For example, Alemi et al. (16) renamed the commercial NAO robot as Nima and programmed it in Persian to be perceived as a friendly peer. Similarly, Meghdari et al. (17) designed the Arash robot with a name and appearance selected to culturally resonate with Iranian children and to reduce perceptions of the robot as a foreign object.

6. Logistics and implementation barriers

Regarding integration within the healthcare team, the evidence emphasizes that the technology should be positioned as a complementary tool rather than a replacement. Alemi et al. (16) formally defined the intervention as "social robot-assisted therapy," emphasizing the "irreplaceable role of the psychologist." In this model, the robot acts as an assistant or emotional catalyst facilitating children's expression of feelings, while the clinical professional directs therapy and manages psychological interpretation, thereby strengthening rather than replacing mental health protocols. Other studies expand this perspective by positioning the robot as a "therapeutic adjunct" to improve communication and physical activity (18), a procedural distraction tool to support nursing care (19), or an educational facilitator to extend the reach of the medical team without replacing supervision (20,21).

Implementation barriers included dependence on personnel, time and space requirements, and technical limitations. Alemi et al. (16) identified dependence on both a robot operator and a facilitating psychologist, as well as scheduling difficulties, which were consistent with observed attrition. Colina-Matiz et al. (18) highlighted the implementation of strict hygiene and disinfection protocols for robot components and tablets due to the COVID-19 pandemic and patient immunosuppression. In Jibb et al. (19), although nursing staff reported minimal disruption to workflow, technical and operational failures led to interruptions and delays, particularly in the cognitive–behavioral arm due to software complexity. Van Bindsbergen et al. (20) reported that some participants relied on the researcher to facilitate interaction, despite overall good technical performance. Lozano-Mosos et al. (21) indicated that the educational session lasted approximately 45 minutes, which implies the need for time and physical space in the hospital setting. Finally, Meghdari et al. (17) reported barriers including robot cost (approximately USD 6,000), the need for a human operator due to limited software autonomy, and design aspects related to stability and physical safety for hospital use.

DISCUSSION

Main findings

This scoping review identified six studies evaluating social robots in pediatric oncology, predominantly using humanoid robots. These robots were primarily used to provide emotional support during hospitalization, facilitate distraction or coping during invasive procedures, and support emotional, social, and health education–oriented interventions.

Regarding effectiveness, the included studies reported favorable results for specific outcomes; however, these findings were heterogeneous across study design, sample size, and measurement instruments, limiting comparability and the accumulation of evidence. In the emotional domain, changes were observed in specific emotional outcomes and components (e.g., emotional engagement in storytelling), while in social and communicative outcomes, improvements were observed in skills such as communicative intention and topic management. In the behavioral and cognitive domain, increases in health-related knowledge and modest improvements in sleep hygiene were reported. In contrast, effects on pain did not show consistent differences between conditions, although specific behavioral changes were observed during critical stages of procedures (e.g., palpation and insertion).

Regarding feasibility, studies reported favorable levels of acceptability and completeness once interventions were initiated. However, evidence on safety and technical performance was heterogeneous and, in some cases, incomplete. In several studies, safety was inferred from the absence of reported adverse events, which does not necessarily reflect a systematic safety assessment. Additionally, relevant operational barriers were identified, including technical failures, dependence on human operators, clinical coordination challenges, and logistical requirements, suggesting that observed feasibility remains preliminary and context-dependent.

Implications for public health

Current literature suggests a favorable scenario for the use of social robots in pediatric populations, particularly for interventions targeting emotional, communicative, and behavioral components. The need for psychosocial support is especially relevant in pediatric oncology, where children and their families require such support as part of the standard of care due to the emotional burden associated with cancer diagnosis and treatment (2,22). In hospital settings, particularly in contexts with limited human resources, continuous provision of specialized psycho-oncological interventions may be constrained by staff availability and workload, especially in prolonged treatments with recurrent hospitalizations. In this scenario, supportive technological tools could play a complementary role within the healthcare team, facilitating emotional coping strategies, procedural distraction, or health education, provided that their effectiveness and feasibility are demonstrated through methodologically robust studies.

However, the available evidence still presents important limitations that affect interpretation and potential integration into clinical practice. First, the evidence is methodologically limited, with few comparative studies, substantial variation in designs and comparators, and heterogeneous instruments and measurement timings. This combination reduces the consistency of results, hinders quantitative synthesis through meta-analysis, and limits the ability to support clinical or programmatic decisions based on robust evidence, ideally from randomized trials with adequate blinding and statistical power. Second, most interventions evaluated short-term effects, with insufficient information on sustained outcomes over time, which is particularly relevant in oncology care. Third, interventions were predominantly single-session or targeted specific situations (e.g., needle procedures or isolated educational sessions), whereas few studies evaluated structured multi-session protocols, limiting the analysis of dose, duration, and continuity. Fourth, the evaluation of clinically relevant outcomes remains incomplete, as variables such as global emotional well-being, quality of life, sustained coping, treatment adherence, and family impact have not been systematically examined.

Although studies report high feasibility in terms of acceptability and do not document major adverse events, few have incorporated robots into structured intervention protocols, with use largely limited to adjunctive and specific functions, such as procedural distraction. Additionally, few studies have explored sociocultural adaptation of robots (language, interaction styles, cultural relevance), often limited to simple renaming in the local language. Moreover, evidence on economic investment and required human resources is scarce. These limitations generate uncertainty regarding the sustainability and scalability of such interventions across clinical contexts.

Challenges for implementing social robots in clinical routine

Consistent with the findings of this review, a published review on the implementation of social robots in other clinical contexts, such as older adults and individuals with dementia, has described recurrent structural barriers even when commercial robots are used (23). Key challenges include technical complexity, difficulties integrating robots into existing organizational workflows, and dependence on trained personnel for operation and supervision, all of which align with challenges identified in pediatric oncology studies.

In addition, economic constraints represent a relevant barrier to large-scale adoption. It has been reported that humanoid robots may cost up to approximately USD 35,000, whereas pet-type robots cost around USD 3,000, limiting their implementation in resource-constrained settings (24). These findings suggest that the challenges observed in pediatric oncology are not exclusive to this population but reflect broader patterns in the adoption of social robots in clinical environments.

Although several of these aspects were repeatedly reported in the included studies, the literature has also highlighted additional relevant implementation elements that were not systematically evaluated in this review. In particular, economic feasibility emerges as a critical factor for sustained integration into clinical practice. However, the included studies did not report formal economic evaluations (e.g., cost-effectiveness or cost–benefit analyses) (25), creating a gap in decision-making and limiting recommendations for large-scale adoption, especially in health systems with limited resources.

From an operational and clinical safety perspective, and considering that these interventions are applied in an immunocompromised population, their incorporation into routine clinical practice requires strict cleaning and disinfection protocols for robots and associated devices. This aspect has been described by Colina-Matiz et al. (18) and should be considered an operational requirement to ensure patient safety and sustainability in hospital environments.

Finally, from an ethical and regulatory perspective, the literature has indicated that the incorporation of social robots in clinical settings poses challenges related to privacy, informed consent, and the management of data generated during human–robot interaction, particularly when audio or video sensors are used, which requires clear ethical frameworks and institutional protocols (26).

Taken together, these challenges should be considered in future research during the design, development, and validation of social robot–assisted interventions in clinical settings, particularly when targeting vulnerable populations such as pediatric cancer patients.

Comparison with previous reviews

Unlike recent reviews by Triantafyllidis et al. (5), Hsu et al. (9), and Wu et al. (10), which analyze the use of robots in general pediatric populations by combining disparate clinical conditions (autism, cerebral palsy, surgery), this review isolates the specific needs of pediatric oncology patients. Additionally, it differs from the approach of Jiang et al. (11), which, although addressing cancer, focuses on adolescents and young adults and on fatigue management through physical technologies (exoskeletons) or applications, excluding social interaction in early childhood. Regarding the reviews by Cheng et al. (12) and Lopez-Rodriguez et al. (13), both focus on pediatric cancer but classify robots within a broader category of "new technologies" or "digital health" (including virtual reality and mobile applications), preventing evaluation of the specific effects of human–robot interaction.

Limitations and strengths

As a scoping review, the primary objective was to map and synthesize the literature; therefore, no quantitative synthesis or formal comparative analysis of effect sizes was conducted, partly due to heterogeneity in study designs, sample sizes, outcomes, and instruments. The review depended on the information reported in the included articles, which affected the availability of detailed data across all feasibility and effectiveness indicators.

Additionally, the search strategy focused on biomedical (PubMed, Cochrane Central), psychological (PsycINFO), and multidisciplinary (Scopus) databases and did not systematically include gray literature, conference proceedings, or preprint servers. Given that social robotics is a rapidly evolving technological field, some emerging evidence may exist in these formats, potentially limiting the identification of recent or ongoing studies. However, peer-reviewed literature was prioritized to ensure a minimum standard of methodological quality and clinical relevance.

This review did not allow differentiation of specific interaction mechanisms associated with robot use, nor determination of whether effects such as novelty or mere presence of the robot influenced observed outcomes, as this information was not consistently reported. Only one study explicitly described the use of an "active distraction" mechanism as a comparator condition, defined as the robot performing explicit behavioral activities (e.g., dancing or singing).

As a strength, the search was comprehensive and included both biomedical and behavioral science databases. Additionally, data extraction enabled organization of findings by effectiveness domains (emotional, social/communicative, and behavioral/cognitive) and feasibility indicators (safety, technical performance, recruitment, completeness/retention, acceptability, and logistical and implementation barriers), facilitating interpretation not only of clinical outcomes but also of implementation conditions, addressing a knowledge gap left by previous systematic reviews.

Conclusion

This scoping review updates the evidence by extending beyond traditional outcomes such as depression, pain, and anxiety to include functional domains in pediatric oncology, specifically sleep hygiene, communicative stimulation, and health education. Furthermore, it provides added value through a multidimensional analysis of feasibility; unlike reviews limited to user acceptability, this study systematizes critical barriers related to technical performance, costs, cultural adaptation, operational logistics, and biosafety protocols for immunocompromised patients, offering a realistic implementation framework previously omitted from the general literature.

Current evidence on the use of social robots in children with cancer suggests favorable effects on emotional outcomes, particularly depression, as well as on communicative and cognitive outcomes such as social/communicative interaction and health knowledge. In contrast, results related to clinical procedures, such as pain, show less consistent patterns. In terms of feasibility, studies report high acceptability and potential for implementation in clinical settings, although uncertainty remains regarding operational and economic sustainability.

Future research should progress from pilot studies toward more robust comparative designs, including randomized controlled trials with adequate statistical power. These studies should incorporate post-intervention assessments and follow-up evaluations to estimate the duration of effects. Additionally, implementation analyses focused on sustainability and scalability should be integrated, including costs, operational burden, staffing requirements, and compatibility with clinical workflow. Finally, sociocultural adaptation of robots and their interaction (including language) should be considered to ensure contextual relevance.

Author contributions

RGA: Conceptualization, Investigation, Methodology, Formal analysis, Writing – original draft.

SCB: Investigation, Writing – review and editing.

AMR: Investigation, Writing – review and editing.

MJM: Investigation, Writing – review and editing.

RAH: Investigation, Writing – review and editing.

OPR: Investigation, Writing – review and editing.

Conflicts of interest

The authors declare no relevant financial or non-financial conflicts of interest.

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Data availability

The extracted data and the tables prepared for this review are available upon request from the corresponding author.

Ethical aspects

This scoping review was based exclusively on the analysis of previously published studies and did not involve the collection of primary data or direct interaction with human participants. Therefore, approval by an Institutional Research Ethics Committee was not required.

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