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Advancing capability-actualization through human–robot collaboration: A strengths-based approach☆

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ABSTRACT

Healthcare is facing intensifying demands for more holistic, equitable, and efficient care. In response, this study adopted a strengths-based approach to explore the enabling conditions individuals can leverage toward human flourishing. It introduces the concept of capability-actualization as the realization of human capabilities, understood as the process through which individuals actualize their potential, enabled by the necessary resources and the conversion factors that shape these resources into prospective enactments of a capability. This study utilizes Nussbaum's Central Human Capabilities framework to qualitatively analyze observations and interviews showing how hospitalized individuals collaborate with a robot for capability-actualization. Specifically, it identified how the robot could be leveraged for cognitive stimulation, affective catalyzation, social connection, and creative engagement. This paper articulates these mechanisms in a conceptual model that presents capability-actualization as a strengths-based response to vulnerability. The findings advocate a shift toward a strengths-based perspective in research and practice.

1. Introduction

Providing care in hospitals has become increasingly challenging in recent years because of the mounting pressure on global healthcare systems. The World Health Organization (WHO, 2024) highlighted a significant shortage of qualified medical personnel, projecting that by 2030, an additional 10.6 million workers will be needed worldwide (Parzonka et al., 2023; Tamata & Mohammadnezhad, 2023). At the same time, efforts to achieve the UN Sustainable Development Goals—particularly those related to equality, health, and well-being—require a transformative shift in how healthcare is delivered (Liu & Eggleston, 2022). This shift must extend beyond traditional medical treatment to include a holistic approach that prioritizes patients' overall well-being while fostering resilience and personal growth. (Gottlieb & Gottlieb, 2017; WHO, 2022).

Within this context, strengths-based approaches (SBAs) offer promising responses to systemic pressures. The person-centered and collaborative approach of SBAs focuses on strengths rather than deficits, thereby promoting well-being and empowering individuals to engage actively in their care and recovery (Fletcher-Brown et al., 2021; Gottlieb & Gottlieb, 2017). Research shows that individuals who are supported to thrive during hospitalization, rather than merely endure it, often recover more quickly and require fewer resources (Feng et al., 2020). This holistic approach is especially crucial for populations experiencing vulnerabilities, as these tend to need healthcare services more frequently than the general population. (Sudbury-Riley et al., 2024).

Enabling individuals to build on their strengths can positively impact broader societal challenges, such as access, equity, and resource allocation. However, as healthcare environments evolve, especially through digitalization, there is a need for additional solutions that can implement and enhance the SBA. One such solution lies in socially assistive robots (SARs), defined as robots "designed to address social needs" (Piezzo & Suzuki, 2017, p. 2), which play a growing role in responding to healthcare pressures (Hurmuz et al., 2023). SARs used in human-robot collaboration (HRC) can support nursing staff and enhances the well-being of individuals (Henkel et al., 2020; Mele and Russo-Spena,

Abbreviations: CHC, Central Human Capabilities; HRC, Human-Robot Collaboration; SBA, Strengths-based approach; SAR, Socially Assistive Robot.

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2025).

Therefore, this current study examined how HRC, guided by SBAs, can enable individuals to actualize capabilities for human flourishing. The study conceptually extends SBAs by introducing the concept of *capability-actualization*. This concept captures the extent to which service environments, such as those augmented by SARs, enable individuals to express, expand, and transform their strengths into meaningful actions.

Capability-actualization differs fundamentally from other capability concepts, such as capability-development (i.e., how abilities evolve; Hansen and Alewell, 2013), capability-utilization (i.e., the degree to which abilities contribute to performance; Schweiger and Sandberg, 1989), or capability-deployment (i.e., the modification of capabilities to match objectives; Biesenthal et al., 2019. Instead, capability-actualization focuses on the enabling role of an environment in allowing latent strengths to be translated into human potential. We advance the following working definition of *capability-actualization* as the realization of human capabilities, understood as the process through which individuals actualize their potential, enabled by the necessary resources and the conversion factors that shape these resources into prospective enactments of a capability.

Grounded in the human capabilities approach (e.g., Sen, 1980), this definition of capability-actualization explains that people thrive when they have both external resources and personal qualities that give them freedom to act. (e.g., tools and skills) *and* an external environment's ability to support the realization of opportunities to make use of such freedom. For example, even with strengths such as social skills, resilience, or curiosity, individuals need a care environment that channels strengths into the potential for action. Capability-actualization is, therefore, the process that endows individuals with the circumstances in which self-determined decision-making can happen.

This explorative study employed content analysis (Fazeli et al., 2023) on video observations and interviews. The data include 44 hospitalized persons, their families, and staff interacting with Pepper, a humanoid SAR, at a hospital ward. Our study contributes in the following key ways: First, it advances strengths-based service research by introducing capability-actualization, showing how technological and environmental factors enable latent human capacities. It also addresses the need for strengths-based research to move beyond identifying individual assets by showing how supportive systems can promote flourishing (Fenton et al., 2015). The focus on capability-actualization supports understanding vulnerability as an experience (Raciti et al., 2022; Russell-Bennett et al., 2024) of customers navigating complex, dynamic realities often overlooked (Rancati & Maggioni, 2023). Second, it brings the classification of Central Human Capabilities (CHC) into service research, expanding our understanding of vulnerabilities and human flourishing beyond conventional commercial metrics and well-being results. Third, it offers empirical evidence that HRC can function as a situational enabler of strengths—including creativity, emotional openness, and social connection—especially in restrictive environments.

Overall, by offering five propositions, our reframing can shift the dominant narrative away from focusing on deficiencies and the presumption of helplessness and contribute to a more empowering perspective in service research. This study also deepens business research by emphasizing the quality of opportunities available to service users, particularly in the context of customer vulnerability. Following, we present the theoretical background relevant to exploring capability-actualization via HRC in healthcare settings.

2. Theoretical background

2.1. Human capabilities approach and central human capabilities

Unlike other capability approaches, such as dynamic capabilities (e.g., Teece et al., 1997) or operational capabilities (e.g., Helfat & Winter, 2011), this study adopted the *human capabilities* approach. It drew on an Aristotelian-informed viewpoint, arguing for the moral importance of all business activities that contribute to human flourishing (Bhogal-Nair et al., 2024; Giovanola, 2009). This approach provides an interdisciplinary lens well-suited for service research beyond conventional economic or monetary interpretations (Del Giudice et al., 2023). Originally developed to improve welfare economics, it emphasizes life's complexity and argues that human capabilities (i.e., "what humans can do and be;" Nussbaum, 2011, p. 18) are key to flourishing (Robeyns, 2003).

At its core, the capabilities approach links well-being to the freedom to live the life one values (Del Giudice et al., 2023). Therefore, this approach transcends resource availability and emphasizes access to substantial opportunities defined by context (Fisk et al., 2020; Saigaran et al., 2015). It distinguishes means from conversion factors (i.e., any factor that influences how effectively a person can convert a resource into a meaningful outcome or activity; Bhogal-Nair et al., 2024). For example, means (e.g., a book) can be converted (e.g., by literacy) into capabilities (e.g., the freedom to read) that can be turned into functioning (e.g., reading the book). Consequently, resources are objects with intrinsic characteristics that can expand human capabilities, while conversion factors afford the freedom to turn a resource into functioning (Haenssgen & Ariana, 2018).

Following this, we argue that reducing the ambiguity inherent in the term conversion factor is necessary. Conceptually, conversion factors describe any general aspect that equips individuals with the freedom to turn means into capabilities, yet they do not differentiate among specific types of factors. For example, an individual can own a wheelchair (mean) and possess the capacity to maneuver (conversion factor) a wheelchair. However, the extent to which the wheelchair supports day-to-day goal attainment (functioning) remains subject to additional conversion factors that cannot be internalized (i.e., situational enablers; Kuppelwieser & Klaus, 2020; Nussbaum, 2006). Thus, the concept of capability-actualization is introduced to bridge the situational process in which capabilities are actualized based on the interplay of means, conversion factors, and situational enablers. It remains that such processes are tied to attaining actual and not nominal freedom of making self-determined decisions and performing actions of turning capabilities into functioning (Pearson & Borenstein, 2013).

In this sense, capability-actualization directly counters vulnerability, which reflects the "absence of, or diminished capacity for agency" (Sudbury-Riley et al., 2024, p. 1,045), i.e., the lack of freedom to purposefully direct events and be in control. When individuals are given the means and opportunities to act on their capabilities, they regain agency, which is essential for recovery and flourishing. Thus, capability-actualization is particularly critical in care contexts, where individual capacities may be latent or constrained by situational factors. Unlike traditional service metrics that measure satisfaction or efficiency, capability-actualization focuses on the specific conditions that enable people to transform their potential into actual abilities and achievements.

Additionally, even after differentiating conversion factors, it remains unclear which capabilities can lead to flourishing. Therefore, this study adopted a list of CHC (see Appendix A) that overcome cultural relativism in determining a good life (Saigaran et al., 2015; Nussbaum, 2000, 2011). This contrasts with the typical use of human-capability approaches in service research (see Table 1). The list of CHC describes capabilities irrespective of cultural norms, such as good health or long age, that are cornerstones of happiness, prosperity, and flourishing (Ryan & Deci, 2001). It is arguably one of the most useful normative tools to determine the basis from which human flourishing becomes attainable (Pearson & Borenstein, 2013). Its normative clarity of which capabilities link to human flourishing and the thereof deriving practical utility in evaluating healthcare environments provides a structured and comprehensive lens through which the dynamics of HRC can be examined.

Table 1
A selection of empirical research referring to a human capabilities approach.

Source	Area	Capability lens	How is a human capabilities approach used?
Davey et al., 2021	Service	Human Capabilities Approach	Individuals possess the abilities and agency to realize human capabilities despite adversity.
Davey et al., 2023	Service	Human Capabilities Approach	"Combining human capabilities approach with service inclusion principles to understand how service provider practices align with the strengths of consumers experiencing marketplace vulnerability" (p. 830).
(Field et al., 2021)	Service	Human Capabilities Approach	Capabilities approach to argue for a humans-first approach in service research that emphasizes the opportunity for well-being.
Del Giudice et al., 2023	Service	Human Capabilities Approach	To explore why functioning is achieved in informal, rather than formal, settings.
Fisk et al., 2023	Service	Human Capabilities Approach	The human capabilities approach offers a lens for a strengths-based examination of how service inclusion can facilitate opportunities for meaningful outcomes.
Current Research	*Service*	*List of Central Human Capabilities*	*Extending strengths-based business research by the concept of capability-actualization and introducing central human capabilities as a normative tool to service research*

2.2. Linking human capabilities and strengths-based approaches

Both strengths-based and human-capability approaches address ambitions that individuals and groups value and have a reason to pursue. While neither approach is intended to directly elucidate well-being, both have been linked to understanding well-being as a composition of eudemonia and hedonism (Bhogal-Nair et al., 2024; Ryan & Deci, 2001). Each supports individuals in overcoming adversities and empowering them to live freely within their understanding of well-being (Del Giudice et al., 2023; Rapp et al., 2006). They mutually consider context-specificness and individual agency, aiming to reduce the gap between capabilities and functioning and stress equity over equality (Nussbaum, 2011). Both approaches avoid labeling individuals based on their impairment and seek to adequately individualize the provision of service (Bhogal-Nair et al., 2024).

Like SBAs, the human capabilities approach focuses on creating "pockets of hope rather than reinforcing deficit approaches" (Price, 2015, p. 20), acknowledging individual agency and uniqueness by placing freedom, empowerment, and autonomy at the forefront. Both are guided by social equity through inclusion and mutual respect (Fujimoto & Uddin, 2022). Specifically, the list of CHC focuses on capabilities that inspire humans to hope in challenging and fulfilling ways, while SBA leverages innate strengths that drive humans to thrive and succeed (Nussbaum, 2016; Zhao et al., 2025). Both approaches seek to empower each individual to achieve their preferences (Nussbaum, 2006; Pulla, 2017).

The demonstrated commonalities between strengths-based and human capabilities approaches highlight their suitability in conceptually complementing each other to investigate how individuals collaborate with robots for capability-actualization. Following this, we present the current understanding of human collaboration with robotic applications and highlight how these three distinct areas contribute to this study.

2.3. Human–robot collaboration

Traditionally regarded as extensions of human ability, computer technologies have permeated diverse domains, showcasing the dynamic interplay between humans and machines. With the advent of robots, this evolution has progressed beyond engineering and algorithms to encompass human–robot interaction (Song & Kim, 2022). In service research, human–robot interaction focuses on the design and evaluation of communicative and behavioral exchanges between humans and robots. In contrast, HRC emphasizes the coordinated execution of interdependent tasks toward shared goals in service contexts (Mele et al., 2024). This collaborative facet requires integrating social cues, linguistic comprehension, and nonverbal communication, often supported by a robot's physical embodiment (Blut et al., 2021; van Doorn et al., 2017).

Rather than acting autonomously, robots in HRC operate in tandem with humans, complementing their efforts within structured service activities (Paluch et al., 2022). Roles can vary from enablers and facilitators to social companions, depending on the context (Lu et al., 2020). Key factors influencing robot acceptance include trust, perceived utility, and ease of use (Mende et al., 2019), which affect customer experiences (Becker et al., 2023; Henkel et al., 2020). Emotional responses to robots (e.g., joy, interest, or surprise) are shaped by expressive features and movement (Chuah & Yu, 2021). SARs are particularly relevant because they emphasize meaningful interactions (Odekerken-Schröder et al., 2020). Their shift from functional tools to socially engaging companions has significant implications for service research on human emotions and well-being (see Table 2 for an overview).

SARs in healthcare are a growing field of innovation that enhances the quality of care for individuals with diverse needs (Čaić et al., 2019; Mele and Russo-Spena, 2025). Research often centers on assistive roles for actors experiencing vulnerability, primarily older adults, with a limited focus on children (Robinson et al., 2014). Companion robots can alleviate loneliness and promote emotional engagement (Odekerken-Schröder et al., 2020) . They support independence, improve mental resilience, and foster calmness through mindfulness guidance (Khaksar et al., 2016; Baisch et al., 2017). SARs assume multiple roles (such as assistants, peers, and companions), addressing functional and emotional needs (Blaurock et al., 2022). Value propositions from SARs leverage cognitive and affective resources in elderly care networks (Čaić et al., 2018,2019). Research highlights empathy, connection, and ethical sensitivity as crucial for care value.

Our review of the literature found empirical studies to predominantly focus on human responses or robot features (e.g., Hudson et al., 2017; Pozharliev et al., 2021), leading to two distinct streams: social expectation (Odekerken-Schröder et al., 2020) and performance capability (Phillips et al., 2023). In contrast, few studies have investigated HRC from a phenomenological or customer ecosystem perspective, leaving the investigation of the human role in HRC relatively open (Lu et al., 2020). This gap stems from a technocentric bias that marginalizes users' experiential and relational roles. Consequently, emotional, social, and moral dimensions remain under–theorized, which is especially critical in contexts such as HRC in pediatric care. Children are often seen as passive in HRC, overlooking their agency, improvisation, and affective contributions. Given children's structural social exclusion and limited representation in institutional decision-making processes (Duchak, 2014), such oversight risks perpetuating a deficit-oriented view that underestimates their intrinsic resources and capacities.

2.4. A strengths-based investigation of capability-actualization via HRC

In this study, we applied a SBA to frame SARs as tools for self-determined engagement, not as tools that respond to deficits. This is unlike, for example, a television, which can provide temporary relief for boredom but fails to leverage its potential for creating meaningful, long-term engagement. In contrast, when individuals use SARs interactively, the focus shifts from the robot as a provider to an individual's capacity to create, connect, and find joy, positioning the robot as a facilitator of a multitude of different self-determined activities. As the SBA emphasizes

Table 2
A selection of empirical research contributions referring to socially assistive robots.

Source	Area	Focus	Findings
Khaksar et al., 2016	Management	The main factors of social vulnerability among older people and the improvements in social life after engagement	Aged care service innovation plays a mediating role between social robot services and the reduction of social vulnerability.
Baisch et al., 2017	Social Robotics	The relevance of psychosocial functioning for robot acceptance on the basis of the user–technology fit.	The importance of psychosocial variables for the acceptance of social robots by older people and the relevance of the fit between user and technology
Čaić et al., 2018	Service	Socially assistive robots, value co-creation / destruction in elderly care networks	Six roles of SAR in an older adult's value network (enabler, intruder, ally, replacement, extended self, and deactivator)
Cifuentes et al., 2020	Robotics	Social robots in therapy and care	Social robots can develop several roles in healthcare and well-being (e.g., companion, partner, coach/instructor, and assistive tool).
(Odekerken-Schröder et al., 2020)	Service	Companion robots and loneliness as an indicator of well-being	Companion robots can mitigate feelings of loneliness (i.e., indicators of well-being).
Ge & Schleimer, 2023	Service	Service robots to improve the well-being of older adults from culturally and linguistically diverse backgrounds.	Service robots can increase older people's well-being by enhancing their sense of belonging, independence, and quality of life while living at home.
Shanks et al., 2024	Marketing	Cobotic service teams, employees, and robots collaborate to serve customers.	Consumers ascribe less power to robot (vs. human) team leaders, which increases consumer anxiety and drives downstream responses through serial mediation
Current research	*Service*	*Strengths-based approach in a hospital setting where* individuals *collaborate with socially assistive robots*	Individuals *use SARs to actualize their capabilities—Senses, Imagination & Thought, Emotions, Affiliation, and Play —for flourishing.*

what can be done than what cannot be done, it is the lens of choice for developing empowering research and practice, such as the study of capability-actualization through HRC (Kao et al., 2016; Russell-Bennett et al., 2023.

We thus explored capability-actualization to HRC from a customer-centric perspective that went beyond the downstream implementation of robots (Mele et al., 2024; Mickelsson et al., 2022) and, thereby, added to the current discourse by emphasizing humanity in HRC (Mele et al., 2021; Ostrom et al., 2021). Capability-actualization connects human-related components in healthcare to an approach that addresses vulnerability by building on people's existing strengths. We gained normative clarity regarding which capabilities are most relevant to human flourishing by adopting Nussbaum's list of CHC (2008). CHC align with strengths-based frameworks to help individuals navigate challenges and pursue well-being on their own terms (Del Giudice et al., 2023; Rapp et al., 2006).

Pursuing the freedom to function in hospital healthcare is inherently strengths-based. Enabling the conditions where individuals can pursue their ultimate ends is as much about improving the external environment and helping individuals leverage readily available strengths (Bhogal-Nair et al., 2024; Caiels et al., 2021). Adopting CHC versus the broader human capabilities approach provides direction and enables the analysis of capabilities relevant to human flourishing. In summary, SBA enriches the understanding of how individuals can leverage HRC with SARs to attain enabling conditions in which potential can be converted into action.

3. Methodology

This empirical investigation examined how capability-actualization unfolds through the hospitalized individuals' (hereafter referred to as patients) collaboration with the humanoid robot Pepper in a hospital environment. Given the exploratory focus, this study adopted a qualitative methodology. This approach is well-suited to capturing complex, context-dependent dynamics that often elude quantitative measurement (Kalu & Bwalya, 2017). It has been effective in prior research on HRC and is especially relevant for exploring collaboration in sensitive environments (Leone et al., 2021). In this study, the software used to control Pepper was Robomate, which was previously used in healthcare settings (Russo et al., 2023). While Pepper has been used to support adults with dementia (e.g., Ikeuchi et al., 2018), recent studies have highlighted its potential for engaging other age groups (Tuomi et al., 2021; De Gauquier et al., 2023).

The patients met Pepper for approximately 30 min at a time. Each session unfolded through a set of activities atypical of the hospital routine, such as math exercises, charades, singing, and dancing, that were not part of any medical procedure and did not interfere with them. The interactions were not confined to structured activities, as patients could also decide whether to engage in a responsive conversation by exchanging a few words or simply experiencing its presence quietly. Similarly, support persons, nurses, and doctors were encouraged to observe and, when appropriate, join in. While their involvement was never imposed but left entirely to the patients' choice, the encounter unfolded entirely according to the patients' preferences. Framed as options rather than prescriptions, patients were able to actively influence the character and atmosphere of the encounter, moving seamlessly between specified tasks and casual exchanges, individual conversations, and collective participation.

Given the empirical context, this research adhered strictly to ethical principles. Pepper's introduction to the ward was not a clinical trial or intervention, and no health data or personal identifiers were collected. Additionally, the data collection was conducted with special care. For example, the hospital approved the observational study design, the use of Pepper, and the data collection process before fieldwork. All robot-related activities were non-invasive and supervised by hospital staff. Participation was entirely voluntary, with written informed consent obtained from all participants prior to Pepper's visit to the ward. The data collection was limited to video recordings and interview materials, which were fully anonymized before analysis. All data were securely stored in encrypted formats and handled exclusively by the research team to ensure confidentiality. More details about the research process are outlined in Web Appendix A.

3.1. Data collection

Collected data include video recordings and field notes of inpatient interactions (i.e., speech, movement, and social behavior) with Pepper, semi-structured interviews with hospital staff, and unstructured interviews with support persons. From December 2023 to August 2024, video recordings were made of 44 patients and their environments (e.g., physical space, including staff and support persons) in a hospital ward where Pepper was present.

While the presence of a camera naturally influences the observed environment and participants, the advantages of this approach outweigh its drawbacks (Mondada, 2012). Video recordings capture the complexities of human interactions (Ciesielska et al., 2018). Their permanence over time enables an in-depth exploration of real-time HRC, including nonverbal communication and behavioral dynamics (Luff & Heath, 2012). Revisiting these recordings reduced the influence of initial impressions because repeated engagement with the material could

identify additional details (Erickson, 1982; LeBaron et al., 2018). Data triangulation strengthens validity (Fielding, 2012). Interviews with families provided further context for the participants' experiences, while interviews with hospital staff situated HRC within broader hospital practices and care routines. Together, the interviews captured subjective experiences, contextual insights, and professional reflections, complementing observational data. More details about the data collection are outlined in Web Appendix A.

3.2. Data analysis

In the first analysis round, we examined the data for human CHC-based functioning to approximate capability-actualization. We found that not all CHC are equally relevant to this study. For example, certain capabilities – such as longevity, nourishment, and shelter, reflection on life planning, caring for animals, and political and material participation – extend beyond Pepper's direct functional scope. In contrast, Pepper is designed to promote playful, recreational, and socially engaging activities that stimulate cognition and emotion (i.e., observable behaviors). Therefore, in the second analysis round, we focused on four specific CHC (senses, imagination, and thought; emotions, affiliation, and play) and excluded six others (life, bodily health, bodily integrity, practical reasoning, other species, and control over one's environment).

Following this central choice, the anonymized data were analyzed until codes and themes emerged (see Web Appendix B; Braun & Clarke, 2012). The analysis of video recordings in natural settings was guided by Knoblauch (2012), with particular attention to event sequences, physical movements, and expressions, capturing behaviors that might go unnoticed without visual data (Fele, 2012). In contrast, observation notes and interview transcripts were thematically coded using a hybrid approach (Fereday & Muir-Cochrane, 2006), using themes from the observations as a starting point. The final analytical product was collectively reviewed to ensure consistency and rigor in the findings. Table 3 presents key excerpts and their analyses.

4. Results

The results of our study shed light on the complex dynamics between HRC and the actualization of CHC in pediatric care. Grounded in a strengths-based perspective, our findings highlight how patients actively engage with Pepper to co-create enabling environments. Rather than being passive recipients of care, patients leverage interactions with Pepper through tailored activities that stimulate imagination, communication, emotion, and play. These activities offer meaningful opportunities for the contextually situated actualization of CHC. By shifting the analytical focus from patients' predefined roles to their enacted practices—what they *do* and who they *are,* rather than what they are assigned to be—we emphasize their capacity to thrive within the constraints of a hospital setting.

4.1. Senses, imagination, and thought

Senses, imagination, and thought embody the human capability to meaningfully engage with a surrounding environment—exercising sensory perception, creativity, reason, and personal choice (Nussbaum, 2008). This capability can be significantly hindered within hospital settings, where routines are often rigid, and patients' autonomy may be compromised. Our findings suggest that SARs, when tailored to patients' interests and needs, serve as catalysts for activating and sustaining this capability. By facilitating personalized, interactive experiences, Pepper creates spaces where imagination, cognitive stimulation, and voluntary exploration can thrive, even amid the emotional and physical constraints of hospitalization.

Our video observations revealed the compelling role SARs play in disrupting the typical static rhythms of hospital life. Patients often

Table 3
Capability-actualization of central human capabilities via HRC.

Emerging themes	Excerpt from observations used in the analyses	Interview quotes from support persons, doctors, and nurses used for triangulation
Senses, Imagination, and Thought: • Sensory engagement with the surrounding environment • Imaginative alteration of reality (e.g., roles and actors) • Deep immersion in collaboration and the related experience	• The patient brings his toy alive by having it converse with Pepper. The exchange involves creative imagination as the inpatient voices the toy's "thoughts" or "questions," to which Pepper responds, encouraging a lively collaboration. (Video 11) • The patient asks Pepper to take a selfie to share with her friends, imagining the robot as a social entity. (Video 35) • The patient imagines the robot inpatient who needs to be operated on. He offers a stuffed animal, placing it directly into the robot's hand as a good luck charm for the robot's upcoming surgery. (Video 41)	• "It was amazing to see that the children interacted with the robot almost as if it were a person; it's a wonderful initiative." (Support Person 4) • "What I liked about Pepper was that it engaged my daughter so much that, for a moment, she almost forgot she was in a hospital." (Support Person 15) • "It makes our routine easier. I showed the children how I took Pepper's temperature, and afterwards, they didn't cry when I measured them." (Nurse 1) • "It was clear that Pepper left a lasting impression on the children's minds. They kept talking about Pepper, even when it wasn't there." (Doctor 3)
Emotions: • Expression of emotions • Expression of feelings toward others and objects	• The patient cries and runs toward their mother, wrapping her arms in a tight embrace; she seems frightened by the robot. (Video 31) • The patient jumps and claps, a wide smile spreading across their faces, radiating a sense of accomplishment and happiness as Pepper congratulates them for answering their questions correctly. (Video 32) • The patient runs with arms outstretched toward Pepper, hugs it, kisses it, and greets it with "goodbye, see you soon." (Video 36)	• "I could not help but film what was happening; we were in the hospital, and it seemed unreal to see my child so happy." (Support Person 17) • "My daughter was so excited and happy. It was the first time I saw her smile since she was in the hospital." (Support Person 20) • "My daughter wouldn't give me a kiss, even if I paid her, and then she hugged and kissed Pepper. I am happy that, even though she was about to have surgery, I could see her a little happy." (Support Person 42) • "We rarely walk through the ward and see children smile like that." (Nurse 5)
Affiliation: • Activities increasing companionship and social bonds • Performance of activities relating to group dynamics and nested social interactions	• While playing with the robot in the ward, the patient seems to adopt a nurse role and take care of others. They guide the robot, illustrating how to create space for a passing patient in the stroller with his mother. (Video 26) • The older patient understands the younger patient's difficulties and assists her in choosing the	• "My son is so shy that he didn't want to play with anyone until today, but I saw him getting help from another child to answer the questions. I can't believe it." (Support Person 43) • "The children seemed incredibly attached to Pepper; it was as if they saw it as part of the team. It would be

(*continued on next page*)

Table 3 (*continued*)

Emerging themes	Excerpt from observations used in the analyses	Interview quotes from support persons, doctors, and nurses used for triangulation
	right answer to Pepper's question. (Video 33) • The patient introduces their new friend, Pepper, to the nurse who has just entered the room to ask how they are feeling; the nurse plays along and seems to facilitate a social connection with the hospitalized person. (Video 44)	wonderful to dress Pepper in a lab coat, making it look like one of us and further strengthening its connection with our environment." (Nurse 5) • "I entered the room, and the child was talking to Pepper. He turned around and introduced me to it." (Doctor 1)
Play: • Involvement in recreational activities • Redirect focus away from routine interactions	• The patient doesn't appear to be involved with Pepper's games. When the robot asks them to play, they decline, saying that their Barbie dolls are prettier than Pepper; then, they continue playing with dolls, ignoring the robot. (Video 8) • When Pepper plays music, the patients respond immediately by dancing, displaying a shift to joyful, playful engagement through music and movement. (Video 18) • The patient becomes deeply absorbed in Pepper's music. Inspired by its songs, the patient starts playing a tune on a portable keyboard. (Video 25) • The patient actively enjoys geometry puzzles. (Video 39)	• "My son was so absorbed in playing with Pepper that I could talk to the other mom without interruptions." (Support Person 9) • "My son wasn't embarrassed to imitate an airplane in front of other people to mimic Pepper; I can say that he is usually much shyer." (Support Person 12) • "It was fun to see my daughter dance and distract herself from her pain. I even had to dance with her." (Support Person 28) • "We already have some toys in the ward, but I have never seen the children as engaged [in playing] as they were with Pepper." (Nurse 2) • "As the children played with Pepper, it was easier to ask them questions. It was enough to say that if they did not answer, Pepper would get upset and no longer want to play with them." (Doctor 4)

responded to Pepper's entrance with curiosity, abandoning current activities (Videos 1, 10, and 23) to engage, touch, and inspect the robot (Videos 13 and 29). Some initiated social interactions, for example, by starting a conversation about its name (Videos 15 and 22). While adapting interactions according to the patients' interests, Pepper responded with behaviors that conveyed attentiveness and personalization (Videos 5, 7, and 25). For instance, Pepper talked about its favorite movies because a patient had been specifically asking (Video 39). To other patients who mentioned a fondness for mathematics, it proposed math and geometry games (Video 13). These personalized moments exemplify SARs' potential to accommodate individual differences and situational contexts.

This adaptability stands in stark contrast to the standardized, impersonal nature of typical hospital settings. Pepper's presence introduces an alternative rhythm—one that is responsive, imaginative, and user-directed—where patients are not merely passive recipients of care but active agents capable of reimagining their surroundings. This dynamic was vividly illustrated in instances where patients animated their own toys to converse with Pepper (e.g., Video 11) or symbolically entrusted the robot with cherished objects (e.g., a lucky charm; Video 41). These interactions transcended mere entertainment; they constituted acts of imaginative synthesis in which patients reconstructed their environment to include new, meaningful relationships.

Ultimately, these interactions signify more than momentary diversions. They represent the activation of the freedom to think, imagine, and make sense of one's world in personally resonant ways. Within the constraints of hospitalization, these autonomy, creativity, and relational engagement exercises preserve and potentially restore patients' sense of dignity. By enabling these experiences, SARs like Pepper reveal how technology can be designed not just to assist but also to affirm the holistic human experience of care.

Data from support persons, nurses, and doctors supplemented these observations. For example, one support person, noting the patients cognitive process, shared: "It was amazing to see that the children interacted with the robot almost as if it were a person." (Support Person 4). Another expressed joy in seeing her daughter become so engrossed with Pepper and her imagination that "for a moment, she almost forgot she was in a hospital" (Support Person 15).

However, reactions varied between individuals; one support person remarked that Pepper's engagement was limited, perhaps because the patient was "too big or asked too difficult questions" (Support Person 22). In the same way, healthcare staff also observed Pepper's impact, noting its role in enhancing the patient's senses, imagination, and thought. Nurses described Pepper as a comforting figure (e.g., Nurse 3) who helped them to level with the patient's cognition to exercise medical procedures (Nurse 1). For example, the data show at least two instances (Videos 29 and 44) in which nurses took the robot's temperature before applying a thermometer to a patient's forehead. Furthermore, doctors observed that patients continued to talk about their experiences with Pepper long after their encounter (Doctor 3).

The first proposition highlights how HRC can act as a cognitive stimulator to facilitate capability-actualization:

Proposition 1. Individuals can enhance their senses, imagination, and thought-actualization via HRC, which offers open-ended and personalized engagement to support autonomous interpretation and creative reimagining of the surrounding environment.

4.2. Emotions

Emotions encompass the human capability to form bonds with others and experience a broad spectrum of affective states, including joy, fear, affection, and vulnerability (Nussbaum, 2008). SARs can offer meaningful opportunities for patients to engage effectively with their surroundings. Our data illustrate that patients interacting with Pepper exhibited a broad range of emotional responses—from excitement and curiosity to cautiousness and affection—demonstrating diverse forms of emotion-actualization.

Video analyses revealed that emotional expressions were predominantly positive. Smiles (Video 7), waves (Video 29), laughter, and spontaneous exclamations (Video 18) suggest genuine joy and engagement. Expressions varied dynamically over the course of the interaction. For example, one patient initially exhibited surprise and took a step back (Video 16), but later transitioned to a different affective state, displaying excitement through jumping, clapping, and a broad smile during the interaction (Video 32).

While observing varying emotional intensities in patients' reactions, some joyful encounters were not limited to one-time experiences but can be interpreted as profound manifestations of deeper connections. Patients who embraced and kissed Pepper (Videos 11, 17, and 36) or said good-bye by saying "See you soon" (Videos 3 and 36) reflect an established attachment to the robot that goes beyond fleeting curiosity, suggesting that patients may form emotional bonds. One patient who came to offer his favorite toy to the robot, an object likely to hold substantial sentimental value, reinforced this notion. These bonds enable patients to express trust, attachment, and individuality, reinforcing a

sense of dignity.

Feedback from support persons, nurses, and doctors corroborates these findings. The joy of seeing the patient "so happy" in a hospital setting, often characterized by stress and fear (Support Person 17) or even just expressing a smile "for the first time since being in the hospital" (Support Person 20), provides compelling evidence of the emotional relief and positive engagement enabled by HRC. Comments by the hospital staff reinforce how the robot-infused environment fostered the freedom to actualize emotions. For example, one nurse observed that patients rarely smiled as much on the ward (Nurse 5).

However, not all emotional responses were positive, reflecting variability in the affective reactions elicited by HRC. One patient instinctively sought comfort from their support person (Video 31), prompting the support person's surprise, given their usual confidence with technology (Support Person 31). However, such reactions also represent the freedom to express complex, context-dependent emotional states. These diverse expressions—whether affectionate or apprehensive—demonstrate the breadth of emotion-actualization that HRC can support.

We present a second proposition illustrating how HRC can act as an effective catalyst to facilitate capability actualization.

Proposition 2. Individuals can advance their emotion-actualization through HRC, which fosters emotionally rich experiences and provides opportunities to cultivate and express a full spectrum of affective states in a supportive, nonjudgmental environment.

4.3. Affiliation

The capability of affiliation refers to the ability to establish relationships, foster empathy, and engage in meaningful social interactions (Nussbaum, 2008). In healthcare settings where isolation may arise from medical, behavioral, or contextual constraints, HRC can offer alternative channels for social connections.

Observational data indicate that patients often perceive Pepper as a social companion, treating it as a peer with whom to interact respectfully. For example, patients refrain from excessive touch, demonstrating awareness of boundaries (Videos 5, 10, and 26). These interactions often encourage the development of social behaviors, such as empathy, cooperation, and shared responsibility, illustrated when patients adjust their behavior to accommodate Pepper or assist others in engaging with it (Video 26).

Beyond dyadic interactions, Pepper functions as a social facilitator. Patients hesitant to engage individually often seek cues from others or participate jointly in activities such as games and quizzes (Videos 1, 23, and 42). Some wait and observe others' encounters to understand how to approach this new character (Video 19), while others engage together by playing games or answering Pepper's questions, creating a supportive environment that fosters signs of trust and camaraderie (Video 33). Meanwhile, the robot-infused environment also enhances connections with adults—support people, nurses, and doctors—in the hospital. For instance, some Patients discuss possible answers to Pepper's questions with family members (Video 24). In contrast, others incorporated Pepper into their communication by taking and sharing selfies (Video 35) or even streaming their encounters through Video-calling outside the hospital (Video 21). Through activities like these, Pepper metaphorically becomes a bridge, facilitating connections between peers and strengthening social bonds beyond the observed hospital setting.

Support persons highlight Pepper's impact on fostering connections. They expressed surprise to "see [them] accepting help from [others]" (Support Person 33) or "dance with their roommate in front of [unknown peers]" (Support Person 29), thus describing interactions that may not have occurred otherwise. Similarly, healthcare staff members made similar observations. The nurses noted that "the children gathered around Pepper were laughing together and socializing" (Nurse 6, adding that, for an atypical moment, the ward felt like a "lively social space" (Nurse 2). Patients became so engaged that they would introduce everyone entering their rooms to "their new friend, Pepper" (Doctor 1), thus showing their eagerness to integrate Pepper into their affiliation processes. While the structural opportunity for affiliation may be nominally present, Pepper provides substantial opportunities, particularly for those facing barriers to spontaneous social engagement.

We present a third proposition illustrating how HRC can act as a social connector to facilitate capability-actualization:

Proposition 3. Individuals can cultivate affiliation-actualization through HRC, which facilitates socially meaningful engagement and strengthens empathy, interpersonal connections, and a sense of belonging.

4.4. Play

Play refers to the human capability to engage in recreational, joyful, and imaginative activities (Nussbaum, 2008). Such opportunities can be limited in hospital settings, which are often characterized by physical discomfort, emotional stress, and restricted mobility. Our findings highlight how SARs can enhance the hospital environment by facilitating play-based interactions that offer moments of levity and pleasure.

Video observations show how Pepper supports this capability through music, games, and expressive engagements. When Pepper plays music, Patients often respond with spontaneous enthusiasm, dancing, and moving joyfully (Videos 18 and 25). Similarly, in charade-style games, patients display focused participation and amusement, eagerly guessing characters and interacting with Pepper (Video 30). These examples demonstrate how SARs create engaging moments of entertainment and spark imaginative, playful behavior.

Not all patients engaged with Pepper in the same way. Some expressed preferences for traditional toys, such as dolls (Video 8) or toy cars (Video 40), emphasizing their autonomy in choosing how and with whom to play. This variation underscores that SARs can serve as an additional, rather than exclusive, means of play—respecting each patient's individual preferences and agency.

Data from support persons and hospital staff support this observation, highlighting Pepper's remarkable impact on patients combined capability to engage in play. Support persons report patients to be "so absorbed in playing" (Support Person 9), overcoming personal inhibitions such as pretending to be "an airplane in front of other people" (Support Person 12). This suggests that Pepper also supports the confidence to play according to one's own ambition. Furthermore, a nurse mentioned that although the ward also offers other toys, "I have never seen the children as engaged as they were with Pepper" (Nurse 2), pointing to the unique allure of robot-facilitated play. Crucially, the actualization of this capability does not require engagement in play but rather the genuine freedom to play. Whether patients decided to interact with Pepper, preferred other toys, or remained observant, the robot's presence enriched the environment and expanded the spectrum of recreational possibilities available.

We present a fourth proposition illustrating how HRC can act as a creative engager to facilitate capability-actualization:

Proposition 4. Individuals can enact play-actualization through HRC, which offers imaginative and joyful social play to enhance emotional resilience and active participation.

4.5. Capability-actualization with socially assistive robots

Within this context, HRC plays a facilitating role in the patient's capability-actualization. Subsequently, we introduce a model that illustrates SAR's role in supporting this dynamic within the patients' environment (Fig. 1). In the model, activities that stimulate *senses, imagination, and thought* foster cognitive engagement by encouraging patients to think critically, solve problems, and engage in creative imagination. Similarly, opportunities for *emotions* help patients freely

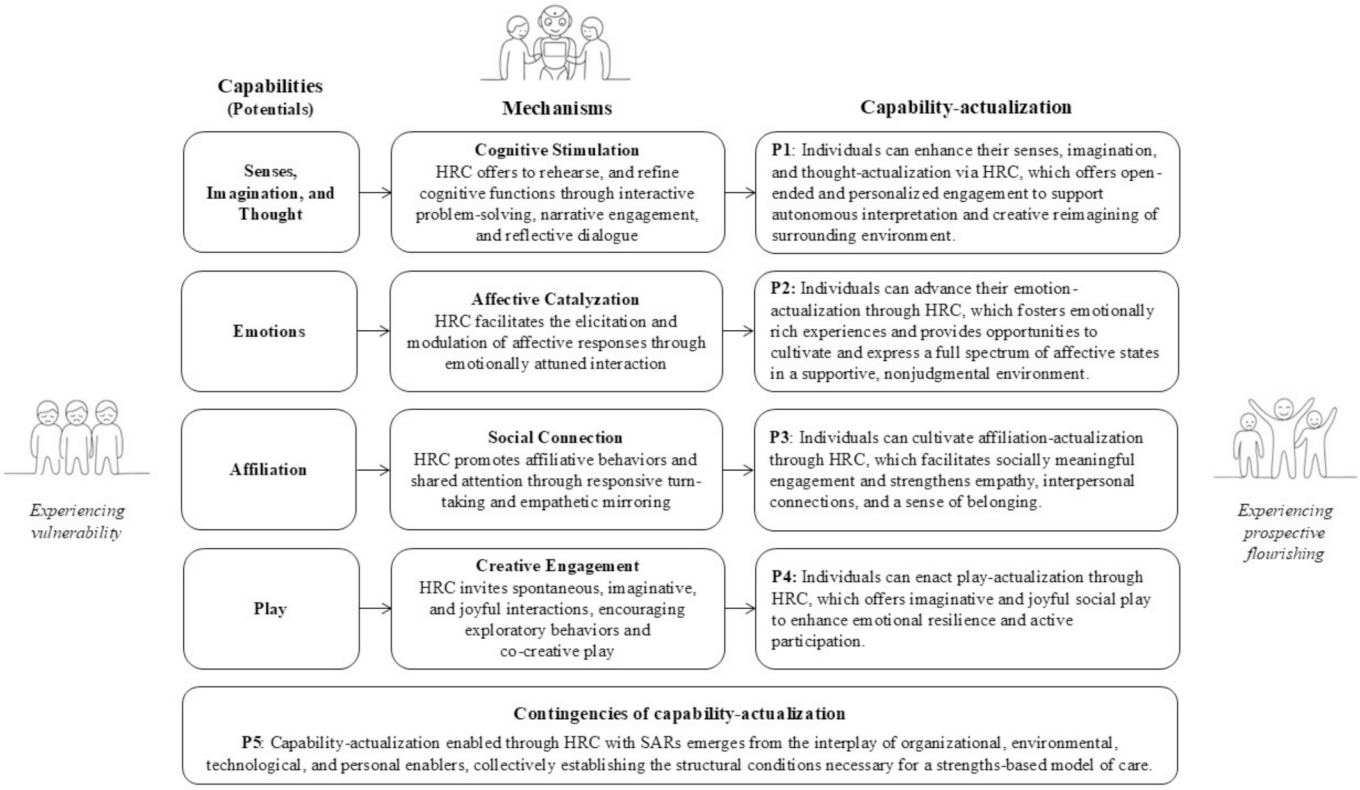

Fig. 1. HRC as leverage for capability-actualization.

regulate their feelings, offering moments to form attachments, validation, encouragement, and emotional development. *Affiliation* in terms of social bonds is strengthened by promoting human-to-human interaction and empathy, enabling patients to connect meaningfully with peers through shared experiences. Finally, Pepper invites patients to *play* freely, eliciting joy and relaxation through music, dance, and imaginative games. In this study, Pepper acts as a catalyst for capability-actualization through these mechanisms, enriching the hospital environment by aligning with patients' intrinsic strengths and internal capabilities. It creates relational and affective spaces where combined capabilities can be actively nurtured and expressed.

Our findings further indicate that capability-actualization in SAR-mediated care is not a uniform or isolated process. Instead, it is contingent upon the convergence of systemic, environmental, technological, and personal enablers. Organizational factors, such as institutional openness to innovation, flexible care protocols, and a commitment to patient-centered SBAs, created the foundational conditions for using a robot toward capability-actualization.

At the environmental level, many patients experienced constraints related to hospitalization, including boredom, emotional withdrawal, and limited peer interaction. Pepper's mediating presence disrupts typical constraints by fostering playful moments, affective engagement, and interpersonal connections. Pepper's appearance, for example, its humanoid form, gestural language, and voice-based interaction, enhanced its capacity to create a social presence that patients could relate to emotionally and imaginatively. Its predictable and nonjudgmental routines, such as storytelling and games, provided a safe and inviting space for interaction.

On a personal level, the patient's developmental stage, emotional readiness, and willingness to engage played a critical role in shaping the quality and depth of their interactions. Pepper afforded inpatient-led interaction, allowing patients to initiate and terminate engagement on their terms. These findings highlight that capability-actualization is not a direct consequence of individual traits or technological affordances alone but rather the emergent outcome of a sociomaterial system composed of interdependent enablers that support human flourishing in context-sensitive ways.

Proposition 5. Capability-actualization enabled through HRC with SARs emerges from the interplay of organizational, environmental, technological, and personal enablers, which collectively establish the structural conditions necessary for a strengths-based model of care.

5. Discussion

This empirical study contextualizes the concept of capability-actualization by investigating how patients collaborate with robots in a hospital setting. The results highlight the robot's significant role in supporting a positive environment that provides substantial opportunities for activities linked to human flourishing. In the following section, we discuss the implications of these findings for scholars and practitioners in the field.

5.1. Theoretical implications

This study advances understanding of how sociomaterial systems can support human flourishing by integrating HRC with a strengths-based approach. Specifically, the findings show that robotic technologies can be designed and deployed to amplify human strengths in service contexts, rather than substitute for or constrain human agency. These contributions refine existing theoretical models and open new avenues for reimagining technology's role in enabling individual and collective well-being (Haenssgen & Ariana, 2018; Odekerken-Schröder et al., 2020).

We introduce a conceptual framework that combines the human capabilities approach with empirical insights from care environments involving SARs. Central to this framework is the concept of capability-actualization, which describes the process that endows individuals with the circumstances in which self-determined decision-making can

take place within the existing human capabilities. This addition deepens SBA by moving beyond identifying individual strengths to demonstrate how they can be actualized in practice. By linking strengths-based and human capability approaches, the framework provides a relational, contextual, and normative lens for understanding service experience.

Moreover, this study introduces the list of CHC into service research, offering a normative basis for reconceptualizing service outcomes. Grounded in Nussbaum's (2008) capabilities approach, we show how individuals interact with SARs to receive care and actively co-create sociomaterial environments that support their *doing* and *being*. For instance, collaborative engagement with the robot enabled individuals to reinterpret past experiences, engage in social play, or form new affiliative bonds—latent capabilities that could be turned into functioning. Importantly, individuals exercised agency by selectively engaging with or dismissing the robot based on personal assessments of relevance and value, thereby enacting personalized pathways to well-being.

This study reframes SARs as catalysts in creating conditions for human flourishing in vulnerability contexts. Our findings show that robots do not function merely as tools for operational efficiency or task automation, but as relational agents embedded within sociomaterial networks that co-create new affordances for agency, empowerment, and well-being (Mele et al., 2024; Mele and Russo-Spena, 2025). When integrated into care environments, robots such as Pepper enable individuals to activate and expand internal capabilities—including imagination, emotional expression, social affiliation, and play—thereby transforming SARs into enablers of agency and dignity in service (Kabadayi et al., 2023).

Furthermore, the study empirically validates that HRC can serve as a structural enabler of individual strengths in resource-constrained settings. SARs provided relational and technological affordances that supported emotional openness, social connection, and creative expression, even without prior positive attitudes toward robots (Lu et al., 2020). Notably, by offering a nonjudgmental environment for expressing positive and negative emotions, SARs promoted emotion-actualization (Proposition 2) and highlighted the distinction between affective engagement and emotional flourishing. Moreover, capability-actualization emerged from the interplay of organizational, environmental, technological, and personal enablers—thus aligning with Proposition 5 and situating the structural enablers for capability-actualization within a model of strengths-based care (Pulla, 2017).

These contributions reorient theoretical understandings of HRC by emphasizing its role in enabling human flourishing. This paradigmatic shift encourages future research to develop inclusive, context-sensitive models that recognize individuals—especially children—not as passive recipients of care but as co-constructors of their care environments and trajectories of flourishing.

5.2. Practical implications

This study offers substantial managerial implications that span multiple levels and domains, from clinical practice to hospital management and technological innovation. More specifically, we address the need to build human-centric HRC processes tailored to future realities in care. We have illustrated how capability-actualization has benefited from Pepper. The findings reveal how such technologies can redirect individuals' attention to discovering their freedom to engage in self-determined play and social activities. This shift can enhance patient well-being and help healthcare professionals address health issues beyond routine treatments. Moreover, Pepper improved inpatient cooperation during nursing work, such as checking body temperatures and easing workloads. Therefore, SARs can be a resource to facilitate human-centric care by complementing and enriching traditional practices rather than replacing human interaction.

This research shows that individuals can actively shape their experiences. Therefore, traditional perceptions of patients as passive care recipients must evolve to recognize them as active and capable participants. In this sense, the findings encourage hospitals to foster environments that are conducive to inpatient empowerment by allowing individuals the freedom to choose how they interact with robots. Overcoming the perception of passive, vulnerable inpatients by granting autonomy in interactions enables them to leverage their strengths and actualize their capabilities, reinforcing a sense of agency and dignity. Each CHC is essential for human flourishing and is thus fundamental for guiding future developments in HRC. This perspective aligns with broader healthcare industry goals and challenges, such as addressing workforce shortages in healthcare, enhancing service delivery, and increasing operational efficiency. By creating a positive and strengths-enabling environment, hospitals can transform the care experience into one that fixes what is broken *and* promotes flourishing, fundamentally reshaping the patient–hospital dynamic.

Finally, this study presents a critical directive for technology providers: the design of robots must reject the human-as-a-resource perspective (Kabadayi et al., 2023) and move beyond addressing immediate operational needs to align with the principles of human flourishing and capability-actualization (Kamishima et al., 2018). SARs should not be used as stopgap solutions for deficiencies in the healthcare system but as meaningful and empowering tools for individuals. This requires avoidance of the potential "dark side" of technology, where automation could inadvertently dehumanize care or exacerbate social isolation. Instead, robots should be developed to serve as process-oriented instruments that support users in realizing their full potential. This humanistic approach to technology enhances the effectiveness of robots in healthcare, ensuring their role in creating environments that value and amplify human strengths. By embracing this perspective, technological providers can play a pivotal role in shaping the future of care, ensuring that robotic innovations promote dignity, engagement, and well-being.

6. Limitations and further research

This study's limitations offer valuable directions for future research, particularly in advancing the understanding of how SARs contribute to capability-actualization in healthcare settings. First, the empirical investigation was conducted within a single pediatric hospital ward and focused on a specific robotic platform (Pepper). This context-specific focus limits the generalizability of the findings across other healthcare environments and robotic technologies. As such, there is a need for future research to engage in multisite studies that encompass a variety of healthcare infrastructures and robotic embodiments. Such investigations would help clarify how different robot functionalities and morphologies influence the actualization of human capabilities in diverse care contexts. In other words, what robots are most effective in facilitating capability-actualization in diverse healthcare environments?

Second, this study focused on a subset of Nussbaum's (2008) CHC framework, excluding others deemed less applicable to this study. While this selection enabled a focused analytical approach, it limited the broader applicability of the findings. Therefore, future research should consider how other capabilities can be supported via HRC. Can SARs be designed to support more abstract or context-dependent capabilities and contribute to a fuller spectrum of human flourishing enablers?

Also, although the CHC framework aspires to universality, cultural factors remain a significant yet underexplored dimension. Variations in societal norms, value systems, and expectations may shape how individuals perceive, interpret, and engage with robotic technologies. Expanding this research to include diverse cultural and geographical contexts would be instrumental in uncovering how culture mediates HRC and influences the realization of capabilities. In what ways do cultural variables mediate the relationship between HRC and capability-actualization?

Furthermore, each proposition highlights a specific dimension of capability-actualization that merits deeper exploration (see Table 4).

Table 4
Research questions to further explore SARs' role in capability-actualization.

Theme/focus area	Description	Research questions
Proposition 1: Senses, Imagination, and Thought	How SARs activate sensory, cognitive, and imaginative engagement in individuals.	1. How do different sensory and symbolic inputs from SARs influence imaginative and critical thought? 2. How does HRC support an individual's autonomy in interpreting and reimagining his or her environment? 3. How do variations in robot expressiveness affect cognitive stimulation and reflective thinking in individuals?
Proposition 2: Emotions	Role of SARs in enabling emotional expression and development.	1. How does emotional reciprocity between individuals and SARs influence emotional development and well-being? 2. How does HRC contribute to emotional regulation and resilience in pediatric inpatients? 3. What role do SARs play in helping individuals externalize, process, and normalize complex emotional states?
Proposition 3: Affiliation	SARs as mediators of social interaction and inclusion.	1. How do SARs facilitate or hinder social bonding and inclusion in pediatric healthcare settings? 2. What types of HRC foster a sense of belonging and empathy among children? 3. How do SARs influence the formation and quality of peer relationships and caregiver–patient dynamics?
Proposition 4: Play	Contribution of SARs to playful, creative, and therapeutic activities.	1. How does robot-facilitated play compare to traditional or digital play in supporting psychosocial development? 2. In what ways does HRC promote meaningful and autonomous engagement in playful activities? 3. How can SARs be adapted to different play styles and developmental needs across pediatric populations?
Proposition 5: Systemic Enablers	Interaction of organizational, technological, and personal enablers in HRC.	1. What are the key enablers and inhibitors of capability-actualization in HRC across systems? 2. How can system-level HRC design foster equitable access to patient-led, strength-based care? 3. How do institutional and environmental conditions shape the effectiveness of SAR interventions?
Capability-Actualization – Concept and Measurement	Further development of mechanisms and metrics for assessing actualization.	1. How can actual versus nominal capability-actualization be robustly measured in pediatric HRC? 2. What mechanisms underlie the activation of capabilities in HRC? 3. How can researchers capture the relational and developmental nature of capability expression over time?

HRC allows individuals to interpret and reimagine their environments autonomously (Proposition 1). Future research could investigate the specific cognitive and perceptual mechanisms activated via interactions with SARs. Studies might, for instance, explore how different forms of sensory and symbolic input from robots affect the individuals' ability to generate imaginative or critical thoughts and how such effects vary across developmental stages and care contexts.

SARs provide a nonjudgmental environment conducive to emotional expression and recognition (Proposition 2). While affective computing continues to evolve, a limited understanding remains of how emotionally responsive robots influence the depth, authenticity, and regulation of the emotional experiences of vulnerable populations. Further research should examine how emotional reciprocity between individuals and robots shapes momentary affect and longer-term emotional development and well-being.

HRC enables socially meaningful, self-directed interactions that foster empathy and connection (Proposition 3). This opens pathways for investigating how SARs mediate social inclusion, particularly in clinical environments in which isolation or anxiety are prevalent. Future studies could analyze how robots act as social catalysts and whether they facilitate, hinder, or transform peer-to-peer or patient–caregiver relationships.

Given the centrality of play in pediatric psychosocial development, more research is needed to assess how SARs contribute to joyful, creative activities and whether robotic play differs from traditional or digital play in its impacts (Proposition 4). Furthermore, questions remain about the balance between autonomy and guidance in robot-facilitated play and how this affects therapeutic outcomes.

A more systemic perspective argues that capability-actualization in HRC settings arises from the interplay of organizational, environmental, technological, and personal enablers (Proposition 5). This multidimensional view invites further investigation into the antecedents and contextual conditions that foster or inhibit the realization of capabilities. Future research should adopt a configurational or systems-oriented approach to map how these enablers interact and to identify leverage points for designing strengths-based, patient-led care pathways.

These propositions highlight the richness of the capabilities approach as a conceptual framework for analyzing HRC. They also indicate a range of empirical questions concerning the design, implementation, and evaluation of socially assistive robotics in healthcare. Importantly, capability-actualization itself warrants further conceptual and methodological development. Despite its theoretical promise, the mechanisms via which capabilities are activated, sustained, or inhibited in HRC contexts remain insufficiently understood. Future studies should investigate the dynamic processes underpinning capability-actualization and develop robust instruments to distinguish between nominal freedoms and genuinely experienced capabilities. This includes advancing measurement frameworks that account for the situated, relational, and developmental nature of capability expression in pediatric care.

CRediT authorship contribution statement

Stefan Burggraf: Writing – review & editing, Writing – original draft, Conceptualization. **Angelo Ranieri:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation. **Cristina Mele:** Writing – review & editing, Writing – original draft, Supervision, Conceptualization. **Kristina Heinonen:** Writing – review & editing, Supervision, Conceptualization.

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Appendix A. The central human capabilities adapted from Nussbaum (2008)

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Central human capability	Description
1. Life	Being able to live to the end of a human life of normal length; not dying prematurely, or before one's life is so reduced as to be not worth living.
2. Bodily Health	Being able to have good health, including reproductive health; to be adequately nourished; to have adequate shelter
3. Bodily Integrity	Being able to move freely from place to place, to be secure against violent assault, including sexual assault and domestic violence; having opportunities for sexual satisfaction and for choice in matters of reproduction
4. Senses, Imagination, and Thought	Being able to use the senses to imagine, think, and reason—and to do these things in a "truly human" way, a way informed and cultivated by an adequate education, including, but by no means limited to, literacy and basic mathematical and scientific training. Being able to use imagination and thought in connection with experiencing and producing works and events of one's own choice, religious, literary, musical, and so forth. Being able to use one's mind in ways protected by guarantees of freedom of expression concerning both political and artistic speech and freedom of religious exercise. Being able to have pleasurable experiences and to avoid nonbeneficial pain.
5. Emotions	Being able to have attachments to things and people outside ourselves; to love those who love and care for us, to grieve in their absence; in general, to love, to grieve, to experience longing, gratitude, and justified anger. Not having one's emotional development blighted by fear and anxiety. (Supporting this capability means supporting forms of human association that can be shown to be crucial in their development.)
6. Practical Reason	Being able to form a conception of the good and engage in critical reflection about planning one's life. (This entails protection for the liberty of conscience and religious observance)
7. Affiliation	A. Being able to live with and toward others, recognise and show concern for other human beings, engage in various forms of social interaction, and imagine the situation of another. (Protecting this capability means protecting institutions that constitute and nourish such forms of affiliation and the freedom of assembly and political speech.)B. Having the social bases of self-respect and non-humiliation means being able to be treated as a dignified being whose worth is equal to that of others. This entails provisions of nondiscrimination based on race, sex, sexual orientation, ethnicity, caste, religion, and national origin.
8. Other Species	Being able to live with concern for and about animals, plants, and the world of nature.
9. Play	Being able to laugh, to play, to enjoy recreational activities
10. Control over One's Environment	A. Political. Being able to participate effectively in political choices that govern one's life, having the right to political participation, and protecting free speech and association.B. Material. Being able to hold property (both land and movable goods), having property rights on an equal basis with others, having the right to seek employment on an equal basis with others, and having the freedom from unwarranted search and seizure. In work, as a human being, exercise practical reason, and enter meaningful relationships of mutual recognition with other workers.

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jbusres.2026.115998.

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