



Child-Robot Interaction in Healthcare: Opportunities, challenges, and resolutions

Robots are increasingly permeating the healthcare system, but limited studies exist in the field of child-robot interaction in healthcare.

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Individual well-being is universally accepted as a major indicator of sustainable development. Well-being on a societal level fosters economic opportunities and positively impacts the stability of a nation economically, socially, and politically. Hence, a healthy nation is always said to be wealthy. The healthcare system is a major sector in every country that effectively promotes, restores, and maintains the health of its citizens. Healthcare systems service patients through preventative, rehabilitative, curative, and palliative care. These services are usually focused on promoting the physical, mental, and social well-being of every member of society. Therefore, the universal goal is to improve access to healthcare, increase the quality of healthcare delivered to the entire populace, and

reduce medical cost and errors. Notably, this is in line with the United Nations Sustainable Development Goal 3 (SDG 3) to “ensure healthy lives and promote well-being for all at all ages [1].”

Nonetheless, healthcare systems across the globe face numerous challenges, including inaccessibility to quality healthcare, insufficient healthcare personnel, high cost of healthcare, and an exponential increase in medical errors [2]. The recent global coronavi-

rus (COVID-19) pandemic also revealed fragilities and vulnerabilities in the healthcare system. Including lack of investment in public health infrastructure as well as ill-prepared healthcare systems that could not effectively respond to the emerging needs of people globally. Consequently, the healthcare system is fraught with increased mortality and morbidity rates, limited patient care, and physically and emotionally exhausted healthcare providers.

In several parts of the world, including China, Italy, Great Britain, and Rwanda, and others, introducing robots to the healthcare system has gained popularity to ameliorate the aforementioned concerns. One of the ways in which robots are increasingly revolutionizing healthcare is by limiting person-to-person contact and reducing healthcare workers' exposure to pathogens. Robots are useful for lifting patients, beds, and other heavy objects



at point-of-care settings minimizing the physical strain on healthcare workers. Furthermore, robots have demonstrated their utility in assisting surgeons to perform complex surgical procedures with more precision and accuracy. Additionally, they also help to sanitize hospital wards and environments. Robots have also been used to address the challenge of staff shortages by assisting healthcare workers to dispense drugs; perform triage during emergencies; col-

lect patients' vital signs, mouth swabs, and blood samples; and reduce anxiety before vaccination. In the healthcare domain, robots serve as social counterparts to healthcare practitioners. Notably, these forms of interactive robots are typically referred to as social robots, and the study of people's behaviors and attitudes toward social robots in respect to their physical, technological, and interactive features is referred to as human-robot interaction (HRI).

HRI is an amalgamation of several disciplines, including robotics, artificial intelligence, cognitive science, developmental psychology, and human-computer interaction. The general goal of HRI is to develop robots that are acceptable to people, user-friendly, and meet the social and emotional needs of its users. Nevertheless, the primary focus of HRI in healthcare is to assist patients to enhance, support, and monitor their

health. Numerous studies have been conducted to explore the applications of HRI amongst the elderly in healthcare [2, 3]. However, there exists a wide bibliographic gap in studying the interaction between children and robots in healthcare [3]. Hence, our study provides a holistic and comprehensive study of the benefits and challenges of child-robot interaction in healthcare.

CHILD-ROBOT INTERACTION IN HEALTHCARE

Child-robot interaction is an emerging research direction in HRI whose focus is on how children perceive, interact, and collaborate with robots in a social and intuitive manner. Within the context of HRI, the interaction between robots and children varies from the interaction between robots and adults. This is because the behavioral patterns of children differ from those of adults. Notably, children are known to treat robots as social agents rather than machines, and this has made it easier for a social relationship to be established and maintained between robots and children in a natural way.

Daily interaction amongst human beings is usually carried out using multimodal forms that involve both verbal and non-verbal forms of communication, such as physical gestures, facial expressions, body posture, and gazes. In the same vein, humans interact with robots through verbal and non-verbal means. Spoken or written words are used to convey information, intentions, and emotions between humans and robots in verbal communication. In contrast, in non-verbal communication, information is conveyed between robots and humans through the use of locomotor interfaces and tactile, visual, and haptic sensors. Nonetheless, studies have shown children tend to be more sensitive to verbal and non-verbal cues during HRI [4]. Due to this tendency, children interact with robots in a more human-like manner. Thus, children develop a greater sense of trust and social bond with robots when compared to adults. Considering this, Woods emphasized children are more likely to derive benefits from robotic devices [5]. Hence, there has been an

exponential increase in the number of robots designed for child development in healthcare.

Child-robot interaction in healthcare is primarily concerned with monitoring and promoting children's health as well as improving the accessibility of children to healthcare services, which in turn increases their health outcomes. Social robots used for child development and care include behavioral therapy robots, educational robots, companion robots, and medication delivery robots. The relevance of child-robot interaction in healthcare includes providing companionship and comfort to children, reducing negative emotions experienced by children with chronic diseases, and providing entertainment, education, and encouragement. The deployment of social robots in healthcare has resulted in social and ethical debates relating to their desirability and vulnerabilities when used with children. Consequently, the opportunities and challenges of this field are briefly discussed in the subsequent sections.

IMPORTANCE OF CHILD-ROBOT INTERACTION IN HEALTHCARE

Children are our future leaders and decision makers. The right to survival of a child involves the right to a healthy life. Technological advances have enabled social robots to present a plethora of benefits for the well-being of children. The opportunities offered by child-robot interaction in healthcare are hereby highlighted.

Companionship/friendship. It is a general fact that many children feel stressed, lonely, nervous, and unsafe when they are hospitalized. This was heightened during the COVID-19 pandemic when visits to healthcare facilities were limited. The use of companion robots, therefore, became rampant in developed countries to promote the health and psychological well-being of hospitalized children by providing companionship and comfort. Companion robots can also serve as toys and pets that children can use during playtime for increasing their recovery rate. For example, the Pepper robot, dubbed "the world's first emotional robot," reflects values of companionship by modifying its behavior

in response to children's emotions, facilitating a natural interaction.

Therapeutic services. Social robots are also used to treat children's medical conditions through verbal communication and non-verbal interaction. This form of treatment helps children to recover rapidly from the effects of diseases and injury. For instance, children with autism spectrum disorders (ASD) who usually find it difficult to interact with their peers and adults because of the complexity associated with human verbal and non-verbal cues are usually drawn to social robots. The NAO6 robot, a humanoid robot with speech recognition abilities in 20 languages, is an excellent example of a social robot that provides therapeutic services to children. It has assisted children who have ASD to interact better with humans by engaging them in social and motor skills including playing games, hand-flapping, toe-walking, dancing, etc.

Management of childhood diseases. Children, especially those under the age of five, are vulnerable to conditions such as malaria, pneumonia, tuberculosis, and diarrhea. These diseases cause pain, distress, dysfunction, social problems, and even death. Globally, the rate of mortality of children under five is put at 38 deaths per 1000 live births [6]. One of the factors responsible for this unfortunate situation is the shortage of medical staff. Robots have, however, been deployed to reduce the mortality rate among children through the management of pediatric diseases. Robots can encourage children to learn more about their illnesses, how to manage them, and prevent a re-occurrence. Furthermore, robots can also help in reducing vaccination hesitancy amongst children against fatal medical conditions as well as minimize anxiety before vaccination. For instance, the Pepper robot has been used to boost vaccination rates in different parts of the world such as Germany and New Zealand.

Assistive aids for children with developmental disorders. Robotic platforms have been deployed within the context of healthcare to assist children with developmental disorders. For instance, the BlindPilot robot can

be used by visually impaired children to easily identify landmark objects toward their destination and with less effort. In addition, numerous robotic devices have been designed to assist children with mobility challenges. Examples of these devices include robotic wheelchairs and walkers.

Entertainment. Being admitted to the hospital can be a very lonely experience for children because they are disconnected from their loved ones and the outside world. Robots can alleviate this experience by providing activities that lessen feelings of isolation, relieve children from pain and stress, and improve their overall health outcomes. Typical examples of entertainment activities provided by robotic platforms include games, acrobatic stunts, and conversations with patients. Robin the Robot, an autonomous care assistant, is an example of a social robot that provides entertainment to children while they are admitted to the hospital.

SETBACKS OF CHILD-ROBOT INTERACTION IN HEALTHCARE

There are numerous challenges associated with child-robot interaction in healthcare, some of which are discussed.

Emotional attachment. According to Shellenbarger, children become emotionally attached to robots that serve as friends and companions to them, especially when they attach gender to robots [7]. Thus, a loss or irreparable damage to the robot can affect the health outcomes of the child.

High cost of robots. Robotic-assisted therapies are quite expensive and thus not readily available to children. This hinders child-robot interaction in healthcare.

Security concerns. The healthcare system is an information-intensive system and contains highly sensitive information that should be kept private and confidential. While robots can be used to collect information in healthcare through the use of surveillance cameras and sensors, they can certainly fall short of adequate security measures. This could include the possibility of hackers taking control of a robot's activity such as unauthorized access to and modification of patients'

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information. Such malicious activities can result in a lack of confidence, transparency, and trust in robotic systems, which in turn affects the seamless interaction between children and robots.

Reduces human-human relationship. Constant interaction between children and robots may reduce children's contact with other children and adults. This can interfere with their cognitive and linguistic development.

WAYS FORWARD

The achievement of effective child-robot interaction in healthcare is a daunting task that is characterized by numerous barriers. However, the following can be adapted to resolve the challenges associated with the field, in general.

► Children's care should be the responsibility of healthcare providers; robots should only be used to provide complementary care. This will prevent children from becoming emotionally attached to social robots and this will also mitigate the effects of limited human contact associated with such an interaction.

► Robots developed for pediatric care should be fault tolerant and designed to degrade gracefully. This is because the frequent malfunctioning of social robots for children's care can affect their health outcomes.

► Adequate security measures should be put in place for healthcare robots that collect children's information. The data collected by the robots should also be guarded against data loss, unauthorized access, destruction, and modification.

► Finally, healthcare providers, especially in developing countries, should be educated about the impor-

tance of social robots in children's care. They should be informed that the use of robots for children's care is for their professional convenience.

CONCLUSION

Social robots have been used to ameliorate several challenges relating to pediatric healthcare. Some of these challenges include a shortage of healthcare personnel to attend to the needs of children, fear and anxiety associated with hospitalization, and inadequate company for children within the healthcare facility. In spite of these benefits, a greater number of studies have been conducted on the interaction between adults in healthcare when compared with the interactions between children and social robots. As a consequence, this work explores the opportunities and challenges of child-robot interaction in healthcare and suggests potential solutions that can enhance it.

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Biography

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