

Integrating Robotics into Patient-Centered Care Models

Nuwamara Samuel

Mechanical Engineering Kampala International University Uganda

Email: nuwamara@kiu.ac.ug

ABSTRACT

The integration of robotics into patient-centered care models represents a transformative shift in modern healthcare delivery. As healthcare systems worldwide grapple with increasing demand, aging populations, and workforce shortages, robotic technologies offer promising solutions to support patients, caregivers, and clinicians alike. This paper explores the intersection of robotics and patient-centered care, emphasizing the potential of robotics to enhance personalization, efficiency, and safety across various care settings. From surgical and rehabilitation robots to social companion devices, robotics is being designed not only to perform technical tasks but also to support patients emotionally and socially. The paper examines the types, roles, and applications of robotic systems in healthcare, alongside challenges in implementation such as ethical concerns, regulatory hurdles, and acceptance by users. Case studies demonstrate the benefits and limitations of deploying robots in clinical and home environments. Ultimately, integrating robotics within patient-centered frameworks can lead to more responsive, equitable, and sustainable healthcare delivery, provided that design and implementation prioritize human needs and values.

Keywords: Robotics in healthcare, patient-centered care, surgical robots, rehabilitation robotics, social companion robots, healthcare automation, smart home care, robotic assistive devices.

INTRODUCTION

Patient-centered care models focus on patients and their preferences to improve health outcomes. By fostering collaborative relationships between patients and providers and promoting shared decision-making, these models address care utilization and costs. They leverage technology to collect subjective patient-reported data, which enables a comprehensive understanding of patients. Integrating robotic solutions into existing healthcare infrastructure enhances processes, mitigates privacy risks, and builds trust while ensuring a patient-centered digital ecosystem that enhances personalization, safety, equity, and quality. Despite the healthcare industry's slow adoption of technologies, robots are increasingly integrated into clinical settings for surgery, rehabilitation, logistics, and assisting individuals with disabilities. The emerging field of personal robotics in healthcare is largely unexplored, yet the aging population and rising personal health care costs demand support for daily living activities. Ongoing investigations into the technical and infrastructural readiness for personal healthcare robotics are essential. An analysis of existing technologies and the roles of robots in healthcare reveals insights into patient needs and expectations. Key aspects of healthcare robot architecture, including functionalities, capabilities, and software/hardware integration, are outlined to provide a foundation for future developments. Additionally, emerging roles and communication capabilities of personal healthcare robots are discussed, emphasizing their expected acceptance and trust among users [1, 2].

Overview of Robotics in Healthcare

The demand for robotic systems in healthcare continues to grow in this rapidly evolving field and might soon change the focus of healthcare delivery. There may be a nurses' strike in Massachusetts hospitals, mirroring a trend that has been seen across the world. The 2.6 trillion dollar U.S. healthcare industry employs 20 million people, by far the largest segment of the workforce. These numbers are almost completely accounted for by the 20 million people, many of whom are healthcare providers, a category that includes nurses, who saw an increase in demand. The overall impetus for demand for robotic health care systems stems from increasing healthcare demands amid a shortage of healthcare workers, especially nurses. Much of the demand for robots in healthcare stems from their ability to perform tasks that human beings cannot do as efficiently. Robotic systems can endure long hours without fatigue, and they can work in more extreme environments than people can handle. Robotics expertise can also lead to enhanced remote oversight and training of providers as a method of deploying scarce skill sets. Furthermore, more fundamentally, robots can intervene in emergencies faster than people and pick up and move patients of various sizes and weights with ease. In summary, robotic health care systems take on many forms and can perform many tasks, from very simple to very complex acts. They are used to assist or augment health care providers as they work, train other health care providers, and support health care consumers in their duties or self-care. Robotic health care systems allow flexibility, adaptability, and customizability of design, programming, operation, and mission goals, and levels of automation available for operation [3, 4].

The Role of Robotics in Patient Engagement

In many healthcare roles, robots are being used increasingly. However, the word robotics is often misinterpreted. Initially, there was an enormous hype wave about the use of robotics in healthcare. The failure of clinical implementations in many healthcare organizations followed, resulting in a decline of interest from research, industry, and healthcare. This text tries to provide a summary of the current state of an exploration field, entailing the role of robots in healthcare. Healthcare is generally based on national and (regional) local regulations and funding schemes. Each healthcare organization is operating under unique national laws, reimbursement, and planning conditions. Robots are usually mild transforming agents that directly impact processes that are already established. Therefore, if they are to be adopted on a wider scale, discussions about the impact of robotics on healthcare organizations must be raised quickly. The advantage of robots is the increasing precision and safety of them. In areas such as surgery or medication dispensing, there are now well-established robotic systems. These robots are appreciated where they take care of repetitive and sometimes dangerous tasks. Nowadays, robots are also being developed to assist the elderly or disabled. They have the potential to enhance quality of life and take some of the burden of care off health care providers. Healthcare brings an enormous market for healthcare robots, and over the next decades, this market will expand enormously. Nevertheless, there are hurdles to be conquered before robots can be widely used in healthcare. Well-established robots must demonstrate their effectiveness (meaning a positive, clinically proven effect on patient outcomes) [5, 6].

Types of Robotics in Patient Care

Robotic systems can be used in multiple ways in patient care due to their advantages in being designed for autonomous execution of pre-established tasks and in reducing physical exertion. Robotic systems can be used inside the body, on the body, or outside the body. Those applied inside the body include microrobots, surgical robots, and interventional robots. Microrobots can be used for minimally invasive surgery, where traditional methods cannot be applied due to the delicate nature of the surgery or are technically complicated. Surgical robots can be used when conventional surgery requires additional maneuvers such as three-dimensional view, movement scaling, tremor filtering, six-degree-of-freedom motion, or access to a position that is hard to reach. Surgical robots can be used for heart surgery, prostatectomy, hysterectomy, and many other procedures. In general, this group of robots can assist in physical surgery, such as drilling through a blood clot or opening up obstructions in the urinary tract. Robotic systems worn on the body include robotic prostheses, orthoses, and exoskeletons. Robotic prostheses can take on diverse forms, including a prosthetic hand, prosthetic foot, upper limb prosthetic, and bionic prosthetic. For hands, the actuator can be categorized into motor-driven, pneumatic-driven, and based on muscle technology. Robotic orthoses can be used to assist rehabilitation and training for foot posture and exoskeletons. Exoskeletons can help workers with physically demanding tasks such as moving patients or assisting people with muscle weakness or movement disorders. Robotic systems applied outside the body can help avoid direct contact when treating patients with infectious diseases or help when the patient is uncontrollable. Robots can assist in surgery by supplying instruments or retracting the incision. Instead of conducting a surgery based on the guidance of pre-understood images,

surgical robotic systems can also assist in cases with complicated and irregular structures. Robots can assist providers when moving patients, thus both alleviating workloads and increasing patient safety. To increase computation efficiency and data elaboration speed, multiple patient monitoring devices can produce data input. Intelligent monitoring systems can help convert large, noisy data into meaningful patient information [7, 8].

Surgical Robots

Between 2001 and 2021, nine robotic surgical systems gained FDA clearance in the U.S. The da Vinci system was the first, approved in 2000, while the Precision and Hugo systems were the latest, receiving clearance in 2020 and 2021. Of these, one was cleared via the radiological devices pathway, and eight through the general surgery pathway. Key features included mechanical arms, vision, and automation. The da Vinci system was also the first to be cleared for minimally invasive urology. Since 2017, the Senhance system has been the only system approved for laparoscopic procedures in the U.S. Following the introduction of robotic-assisted systems, procedures such as robotic hysterectomies saw a marked increase in the U.S., with robot-assisted radical prostatectomy emerging as the most common RAS procedure. Academic institutions performed half of all hysterectomies and radical prostatectomies robotically. There is significant variation in the number of robotic surgeries performed. As RAS adoption rises, initiatives are being proposed to improve training and credentialing. Future Level 4 and 5 surgical robots might be classified as Class III devices, requiring Premarket Approval (PMA), which ensures thorough safety and effectiveness reviews. Concerns persist regarding software efficacy, robotic autonomy, socioeconomic disparities, and training effectiveness. Some next-generation robots for gynecological and thoracic procedures have faced rigorous post-market surveillance requirements, while notable recalls stemmed from severe complications during surgeries, such as unintended burns and tissue grasping issues. Stricter regulations and comprehensive clinical studies are suggested to enhance patient safety, with progress in regulatory coordination noted between the FDA, EU, and China [9, 10].

Rehabilitation Robots

In recent years, robotic technologies have been developed to assist clinical rehabilitation, focusing on active engagement for neural plasticity. The designs and functions of robotic devices vary significantly. The Lokomat exoskeleton, introduced in the 1990s, helped lower limb movement using a treadmill and motion-capturing technology. The MIT-MANUS, created in 1999, retrained mental representation and motor skills in impaired arms. Another development featured a compliant, bioinspired parallel robot that improved ankle function in post-stroke patients. The Hocoma Armeo Spring was introduced for upper-limb rehabilitation, aiding the movement of elbows and wrists. These systems have demonstrated efficacy in enhancing rehabilitation outcomes. Furthermore, various assistive control strategies are essential for maximizing patient engagement. To improve treatment effects, control strategies aim to identify engagement levels and enhance robotic guidance. Active engagement during therapy is crucial for fostering neural plasticity. Combining psychological approaches with robot-assisted physiotherapy may increase human-robot engagement and therapeutic benefits. Fostering patient trust in robotic systems is critical to encourage acceptance of robot-guided training. Research has identified that robot performance significantly influences trust in human-robot interaction. The use of robotics in elderly rehabilitation is on the rise, with diverse forms like robotic arms and multi-wheeled robots. They fulfill three primary roles: coach, observer, and feedback provider. As a coach, robots demonstrate rehabilitation task motions, ensuring correct starting positions. Acting as observers, they monitor patients performing tasks and ensure adherence to prescribed movements. Finally, they offer feedback after task completion, which may vary in complexity. For effective elderly rehabilitation, motion analysis capabilities are vital [11, 12].

Social Companion Robots

There is increasing evidence that social robots provide companionship and care in innovative ways, surpassing chatbots and video calls. These robots aim to meet social and well-being objectives alongside clinical tasks, addressing issues like loneliness and boredom. By being physically present, they can stimulate interaction and conversation, thus helping to meet the deeper psychological needs of patients. For instance, nursing home residents often experience loneliness, a critical aspect of their overall health. Unlike static voice boxes or text displays, an engaging robot with limbs and an animated face can encourage spontaneous affinity and conversation before any guided interaction occurs. Companion robots can support therapy informally, foster enjoyment through games, and connect to broader social networks using video calls or gamified clinical narratives. Patient-Centered Care (PCC) prioritizes respect and dignity in healthcare, emphasizing the role of technologies in enhancing this approach. Tools applied in consultations, telemedicine, and wellness systems can contribute to this goal, extending beyond just clinical functions. Moreover, these robots can nurture specific social interactions aimed at fostering

emotional well-being, providing a unique perspective on technology use. While they may not serve direct medical purposes, companion robots can effectively entertain and engage potential users, enriching their experiences [13, 14].

Benefits of Integrating Robotics

Robotics is one technology that has become increasingly commonplace in both consumer and healthcare products. Robotic telepresence systems that connect doctors with in-home patients have been adopted widely. Consumer service robots, such as the Roomba, have also entered homes. With the many robots available today, it must be determined which robots would best serve to improve activities of daily living (ADLs) for an older adult population. A clear definition of needs and an understanding of how robots can help are crucial steps to take before deployment. Robots are being used in home environments today, such as robotic vacuum cleaners and lawn mowers. Elderly patients are found in these environments on occasion, creating an opportunity to explore the implementation of these robots in a smart home care system. Previous research, as well as ongoing personal projects, has led to the identification of a need to identify health conditions in older adults as a means to increase independence. While humans are generally required for more sophisticated tasks, robotics has the potential to greatly improve the efficiency of the health care industry. Robotics can increase the quality of health care delivered and improve the lives of both patients and providers alike. Robotics can benefit the health care industry in numerous fields as it pertains to the diagnosis of conditions, surgery and treatment, therapy and rehabilitation, and home health care equipment that promotes health and independence. A problem area in the health care field that has been identified as one that would benefit from the implementation of robotics involves concept development of a set of requirements for an autonomous robot that would recognize and assist in the diagnosis of health conditions in older adults within a smart home context (e.g., ADLs) [15, 16].

Challenges in Implementation

To gather information on robotic systems in nursing care, we searched peer-reviewed articles in German or English published since 2010. We identified barriers and facilitators to the implementation of robotic devices, categorizing them based on the COMBIO framework, which includes intervention characteristics, individual barriers, facilitators for healthcare professionals and patients, implementation characteristics, and sociocultural factors. Implementation strategies were also categorized. This systematic review adhered to the Preferred Reporting Items for Systematic Review and Meta-analyses guidelines, aiming to classify the barriers, facilitators, and strategies related to robotic devices in nursing care. Robotic systems are being increasingly integrated into health and elder care to assist in sensitive environments. Healthcare organizations must adopt and sustain these technologies to ensure safe, ethical care. Although literature on technological innovations in health is expanding, knowledge of integrated robotic systems remains limited. This study synthesizes relevant research to provide insights into facilitators and barriers concerning the implementation of robotic systems in healthcare, focusing on peer-reviewed articles from the last decade that explore factors affecting these implementations within a specific research field [17, 18].

Case Studies of Robotics in Patient-Centered Care

Robotic systems encompass a wide range of technologies that can take on various roles in caregiving settings, and efforts have been made across many research communities to design and implement systems for assisting caregivers with such tasks. Some systems focus on teleoperation and telepresence, which enable a caregiver to communicate with a resident remotely. Limitations of these systems mainly stem from the involvement of a third party in resident interactions, creating a communication gap and inducing misunderstanding. Technical complications of vision systems constitute the biggest usability challenge. More recently, commercial application of care robots has gained support. Companies have been marketing robots geared toward general home assistance applications. However, there is little information about sensors and actuators used in these robots, obstacles to their autonomous operation, and protection of user privacy. Conversely, studies have tested the effectiveness of introduced robots in care task performance or care recipient perceptions. Considerable efforts have been made, for example, to develop robot-based assistance for older adults with cognitive impairments. The robot was deployed in a smart home environment to assist older adults with cognitive impairments with reminders. Results from a controlled study of the deployed system show that the robot is perceived as a useful tool for performing tasks and is found to be enjoyable. Family members also expressed the desire to set up and control the robot. These studies highlight the importance of considering caregivers as well as care recipients in the design of robot systems. Robotics is increasingly being explored for existing and looming long-term care needs: the need for extra hands to assist care recipients with care tasks and the need for improved quality

of care to ensure positive experiences for the resident. Care robots can address both these needs, focusing on providing effective assistance and creating a positive experience for care residents. However, results show that the needs of caregivers for robots to assist with care are not sufficiently considered. Therefore, care robot designs are unlikely to be readily adopted in today's care environments. A sizable number of studies have aimed to develop design requirements for autonomous and teleoperated robots intended for care settings. Most of these studies examined the caregiving tasks and needs of older adults and their caregivers via participatory design sessions, ethnographies, interviews, and focus groups, followed by the design of robot systems from the users' perspective. Care robots can assist older adults in retirement communities with care tasks. Attitudes toward care robots are explored through questionnaires and interviews with residents, family, and staff. How care robots can support informal caregivers managing care needs is investigated, including their own lives. These studies show how the different design approaches with various stakeholders in care robots can create a more complete understanding of robots in care contexts [19, 20].

Ethical Considerations

The integration of robots in healthcare should be carried out in line with established ethical frameworks and under strict regulations. By exploring scrupulous bioethical grounds before implementing robot technologies, regulatory authorities can ensure that the regulatory process keeps up with emerging technologies. Patients' consent to using robots for care delivery purposes and scope must be specified, and the explicit processing purpose must be strictly limited to the consented intentions; otherwise, patients must grant their consent again if such intention changes. Furthermore, standard guidelines must be developed on what happens with the information obtained by the robots and how their data is protected. Guidance must take the form of a step-by-step procedure for maintaining the level of privacy of the patients. Robots must comply with the established ethical criteria for healthcare interventions, taking into account the safety, security, and privacy. As ethical criteria are implemented at the level of the organizations, risk-preventive approaches towards robotic technologies must be implemented at the healthcare organization level. Based on the institutions' policies on robotic technologies, risk analysis must be performed for any robotic technology to be acquired, showing that it can be effectively and safely procured and operated at the proposed location. Implementing ethical guidelines will inevitably assign liability to organizations that will need to justify when and how they exercised such responsibility. Parallel to safeguard mechanisms, strategies for developing an overarching ethos for integrating robots into patient-centered care models, taking into consideration both their risks and advantages without overlooking the importance of developing care relationships with the patient and other care providers, must be minted. Based upon focus groups with patients, family members, and healthcare professionals, possibilities for safeguarding against the risks of robotic care should be examined, and strategies for leveraging robots' advantages considered. In such a workshop setting, practical actions should be envisioned to safeguard against the risks of technological care providers and beneath it the ideal 'ethos of patient-centered care', which will dictate the pros and cons of robot integration [21, 22].

Future Trends in Robotics and Patient Care

The U.S. healthcare sector will continue to be a fertile domain for robotics, dramatically altering the context of patient care delivery and introducing both opportunities and challenges for providers. There will be intense demand for robotic systems that are capable of efficiently and effectively executing a range of healthcare tasks traditionally performed by people either where such labor is in short supply or to augment existing capabilities. Increased demand is likely to stem from, at least, the convergence of four trends in society that will change the very fabric of patient care delivery – resource/environmental challenges, an ever-mounting cost crisis, inequitably distributed conflicts in human forces, and societal change. Fundamentally, the emergence of a cohort of older, frailer, and sicker patients, combined with their non-compliant behaviors that have proliferated with communications technology and improvements in prenatal care, will accelerate the demand for robotic systems that can augment and extend the reach of human caregivers. Likely, robots will ultimately act in support of family caregivers' intervention during mediated intervention. This creates a pressing need to ensure that such systems behave predictably and are safe and effective. A new set of design criteria will likely emerge for virtual caregivers, requiring a deeper understanding of "autonomous" machine behaviors that stand in for human agency. Such pervasive robotic systems will also significantly augment and change the information available to care planners and providers across spaces, communities, agencies, and scales of temporal aggregation. Data visualization and mining will deepen and change our ability to derive actionable information from such data. This will inject opportunities into, but also complicate, the planning and operational processes. Such developments will likely challenge the foundations of patient agency and the ethics of care. Deeply embedded robotic

and automated systems will raise important challenges to ethical, accountability, and control dilemmas [23-28].

CONCLUSION

The integration of robotics into patient-centered care models offers a compelling vision for the future of healthcare. As robotic technologies advance in precision, autonomy, and social interaction, their ability to support both the clinical and emotional needs of patients continues to grow. Robots can reduce the burden on healthcare workers, enhance safety and accuracy in medical procedures, assist in rehabilitation and daily living, and offer companionship to vulnerable populations. However, the promise of robotics in healthcare will only be fully realized if implementation efforts are grounded in the principles of patient-centered care, respect, empathy, collaboration, and personalization. Addressing barriers such as regulatory concerns, sociocultural acceptance, and ethical considerations is critical for achieving widespread adoption. With interdisciplinary collaboration and patient-inclusive design, robotics can be a powerful ally in transforming care delivery, improving outcomes, and promoting dignity and autonomy for all patients.

REFERENCES

1. Elendu C, Amaechi DC, Elendu TC, Jingwa KA, Okoye OK, Okah MJ, Ladele JA, Farah AH, Alimi HA. Ethical implications of AI and robotics in healthcare: A review. *Medicine*. 2023 Dec 15;102(50):e36671. [lww.com](#)
2. Singh M, Gupta S, Bhardwaj P, Tripathi R, Mishra J, Bhardwaj R. Integrating artificial intelligence and robotics for advancements in personalized medicine within life science. In *AIP Conference Proceedings 2025 Feb 5 (Vol. 3254, No. 1)*. AIP Publishing. [\[HTML\]](#)
3. Holland J, Kingston L, McCarthy C, Armstrong E, O'Dwyer P, Merz F, McConnell M. Service robots in the healthcare sector. *Robotics*. 2021 Mar 11;10(1):47. [mdpi.com](#)
4. Javaid M, Haleem A, Pratap Singh R, Rab S, Suman R, Kumar L. Utilization of robotics for healthcare: a scoping review. *Journal of Industrial Integration and Management*. 2025 Mar 13;10(01):43-65. [worldscientific.com](#)
5. Pfeifer-Chomiczewska K. Intelligent service robots for elderly or disabled people and human dignity: legal point of view. *AI & SOCIETY*. 2023 Apr;38(2):789-800.
6. Kyrarini M, Lygerakis F, Rajavenkatanarayanan A, Sevastopoulos C, Nambiappan HR, Chaitanya KK, Babu AR, Mathew J, Makedon F. A survey of robots in healthcare. *Technologies*. 2021 Jan 18;9(1):8. [mdpi.com](#)
7. Panahi, O. The Rising Tide: Artificial Intelligence Reshaping Healthcare Management. *SJ Public Health*. 2024;1(1):1-3.
8. Ugwu CN, Ugwu OP, Alum EU, Eze VH, Basajja M, Ugwu JN, Ogenyi FC, Ejemot-Nwadiaro RI, Okon MB, Egba SI, Uti DE. Medical preparedness for bioterrorism and chemical warfare: A public health integration review. *Medicine*. 2025 May 2;104(18):e42289.
9. Morgan AA, Abdi J, Syed MA, Kohen GE, Barlow P, Vizcaychipi MP. Robots in healthcare: a scoping review. *Current robotics reports*. 2022 Dec;3(4):271-80. [springer.com](#)
10. Bogue R. Surgical robots: history, applications and prospects. *Industrial Robot: the international journal of robotics research and application*. 2024 Dec 2;51(6):873-80. [\[HTML\]](#)
11. De Ravin E, Sell EA, Newman JG, Rajasekaran K. Medical malpractice in robotic surgery: a Westlaw database analysis. *Journal of Robotic Surgery*. 2023 Feb;17(1):191-6. [springer.com](#)
12. Zhong B, Niu W, Broadbent E, McDaid A et al. Bringing Psychological Strategies to Robot-Assisted Physiotherapy for Enhanced Treatment Efficacy. 2019. [ncbi.nlm.nih.gov](#)
13. Devanne M, Rémy-Néris O, Le Gals-Garnett B, Kermarrec G, Thepaut A. A co-design approach for a rehabilitation robot coach for physical rehabilitation based on the error classification of motion errors. In *2018 Second IEEE International Conference on Robotic Computing (IRC) 2018 Jan 31 (pp. 352-357)*. IEEE.
14. Ugwu CN, Ugwu OP, Alum EU, Eze VH, Basajja M, Ugwu JN, Ogenyi FC, Ejemot-Nwadiaro RI, Okon MB, Egba SI, Uti DE. Sustainable development goals (SDGs) and resilient healthcare systems: Addressing medicine and public health challenges in conflict zones. *Medicine*. 2025 Feb 14;104(7):e41535.
15. Soljacic F, Law T, Chita-Tegmark M, Scheutz M. Robots in healthcare as envisioned by care professionals. *Intelligent Service Robotics*. 2024 May;17(3):685-701. [\[PDF\]](#)
16. Ruggiero A, Mahr D, Odekerken-Schröder G, Spena TR, Mele C. Companion robots for well-being: a review and relational framework. *Research handbook on services management*. 2022 Aug 5:309-30. [\[HTML\]](#)

17. Haleem A, Javaid M, Singh RP, Suman R. Medical 4.0 technologies for healthcare: Features, capabilities, and applications. *Internet of Things and Cyber-Physical Systems*. 2022 Jan 1;2:12-30. [sciencedirect.com](https://doi.org/10.1016/j.iotcps.2022.12.001)
18. Habuza T, Navaz AN, Hashim F, Alnajjar F, Zaki N, Serhani MA, Statsenko Y. AI applications in robotics, diagnostic image analysis and precision medicine: Current limitations, future trends, guidelines on CAD systems for medicine. *Informatics in Medicine Unlocked*. 2021 Jan 1;24:100596. [sciencedirect.com](https://doi.org/10.1016/j.imu.2021.100596)
19. Edyedu I, Ugwu OP, Ugwu CN, Alum EU, Eze VH, Basajja M, Ugwu JN, Ogenyi FC, Ejemot-Nwadiaro RI, Okon MB, Egba SI. The role of pharmacological interventions in managing urological complications during pregnancy and childbirth: A review. *Medicine*. 2025 Feb 14;104(7):e41381.
20. Dino MJ, Davidson PM, Dion KW, Szanton SL, Ong IL. Nursing and human-computer interaction in healthcare robots for older people: An integrative review. *International Journal of Nursing Studies Advances*. 2022 Dec 1;4:100072. [sciencedirect.com](https://doi.org/10.1016/j.ijnsa.2022.100072)
21. Bardaro G, Antonini A, Motta E. Robots for elderly care in the home: A landscape analysis and co-design toolkit. *International Journal of Social Robotics*. 2022 Apr;14(3):657-81.
22. Zhao D, Sun X, Shan B, Yang Z, Yang J, Liu H, Jiang Y, Hiroshi Y. Research status of elderly-care robots and safe human-robot interaction methods. *Frontiers in Neuroscience*. 2023 Nov 30;17:1291682. [frontiersin.org](https://doi.org/10.3389/fnins.2023.1291682)
23. Temple A. MANAGING RECRUITMENT, RETENTION, AND TURNOVER IN LONG-TERM CARE FOR IMPROVED QUALITY AND SUSTAINABILITY. *Managing Quality and Safety in Long-Term Care*. 2024 Nov 23.
24. Soares A, Piçarra N, Giger JC, Oliveira R, Arriaga P. Ethics 4.0: Ethical dilemmas in healthcare mediated by social robots. *International Journal of Social Robotics*. 2023 May;15(5):807-23. [springer.com](https://doi.org/10.1007/s12351-023-00000-0)
25. Paul-Chima UO, Ugwu CN, Alum EU. Integrated approaches in nutraceutical delivery systems: optimizing ADME dynamics for enhanced therapeutic potency and clinical impact. *RPS Pharmacy and Pharmacology Reports*. 2024 Oct;3(4):rqae024.
26. Weng YH, Hirata Y. Design-Centered HRI Governance for Healthcare Robots. *Journal of Healthcare Engineering*. 2022;2022(1):3935316.
27. Miloski B. Opportunities for artificial intelligence in healthcare and in vitro fertilization. *Fertility and Sterility*. 2023 Jul 1;120(1):3-7.
28. Curchoe CL, Letterie GS, Quaas AM. Unlocking the potential of artificial intelligence (AI) in reproductive medicine: the JARG collection on assisted reproductive technology (ART) and machine learning. *Journal of Assisted Reproduction and Genetics*. 2023 Sep;40(9):2079-80.