Chapter 22

Robotic Nursing in Elderly Care: AI-Supported Systems, Theoretical Frameworks, and Clinical Applications

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Abstract

Global population ageing is increasing demand for long-term care and placing growing pressure on nursing services worldwide. Projections from the United Nations and the World Health Organization indicate that the proportion of older adults will continue to rise, with care needs expanding faster than the healthcare workforce. Accordingly, gerontechnology, robotics, and artificial intelligence (AI)–supported solutions have become increasingly prominent as approaches to supporting care delivery, alleviating nursing workload, and improving the quality and safety of care. Robotic nursing is informed by person-centered and relationship-based frameworks for technology-mediated care, namely Nursing as Caring, Technological Competency as Caring in Nursing, and the Transactive Relationship Theory. Current applications indicate that robotic and AI-supported systems are being implemented across a broad range of domains, including surgical support, direct care, monitoring, logistics, and clinical decision-making. Technologies such as the Da Vinci surgical system, Robear/RIBA, Cody, Veebot, robotic medication dispensing and transport systems, Telenoid, and Atacan exemplify the diverse ways in which these systems are applied in clinical and care settings. Socially assistive robots—both humanoid and animal-like—have also been explored for their potential to reduce loneliness and social isolation among older adults. Nevertheless, privacy and ethical concerns, user acceptance, technical limitations, and potential reductions in

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https://doi.org/10.58830/ozgur.pub1126.c4598

human interaction remain key challenges. Overall, robotic and AI-supported systems should be conceptualized not as replacements for nursing care, but as complementary tools that strengthen person-centered nursing practice.

1. Introduction

According to the population projections of the United Nations (UN), the global population reached approximately 8.2 billion in 2024, with an estimated 833 million people aged 65 years and older. Accordingly, older adults constitute about 10.2% of the world's total population. The countries with the highest proportions of older adults are Monaco (36.2%), Japan (29.8%), and Italy (24.6), respectively. Türkiye ranks 75th among 194 countries, with an older population proportion of 10.2% (Republic of Türkiye Ministry of Family and Social Services, 2023; TURKSTAT, 2025).

In Türkiye, life expectancy at birth for the period 2021–2023 was calculated as 77.3 years, with 74.7 years for men and 80.0 years for women (TURKSTAT, 2025). According to UN population projections, the global average life expectancy at birth for the period 2020–2025 is 73.2 years (UN, 2022). The World Health Organization projects that the proportion of individuals aged 60 years and older will nearly double, increasing from 12% to approximately 22% between 2015 and 2050 (WHO, 2025). This demographic transition results in the care-dependent older population growing more rapidly than the healthcare workforce, thereby exerting substantial pressure on health systems (Bemelmans et al., 2012).

The increasing older population necessitates the restructuring of healthcare services and the organization of elderly care, requiring nursing practice to adapt to changing care needs. Ageing is associated with multidimensional challenges at both individual and societal levels. Older adults face social challenges (neglect, isolation, loneliness), financial difficulties (low income, inadequate insurance coverage), psychological problems (depression, dementia, insomnia), and physiological impairments (muscle weakness, bone fragility, gait disorders) (Christoforou et al., 2020).

Access to timely, high-quality, and safe healthcare services for older adults is recognized as a fundamental human right (Bayer et al., 2019). The growing burden of chronic diseases and functional decline increases the demand for long-term care, prompting health systems to seek innovative, technology-based solutions (Annear et al., 2016). Contemporary approaches to elderly care, aligned with models that support ageing in place, aim to provide both physical and emotional support through robotic systems and modern technologies (Christoforou et al., 2020). The use of technology and artificial intelligence (AI) in diagnostic, therapeutic, and care processes has gained increasing importance due to its potential to reduce workload and support care delivery (Tüfekçi et al., 2017).

Rapid advances in robotic systems offer significant opportunities to maintain and enhance the quality of elderly care in the context of limited institutional and workforce capacity. The term "robot" originates from the Czech word *robota*, meaning forced labor, and is defined by Merriam-Webster as a machine capable of carrying out complex actions automatically (Murphy, 2019; Merriam-Webster, 2023). The first use of robots in healthcare dates back to 1985, when they were employed to assist with biopsy procedures in neurosurgery, accelerating ethical and technological debates surrounding robotics in medicine (Elgazzar, 1985; Asimov et al., 1978; Ayres & Miller, 1982; Maalouf et al., 2018).

Today, robotic systems are applied across a wide range of domains in elderly care, including surgery, monitoring, rehabilitation, activities of daily living, and social support. Robots are reported to contribute to increased service capacity, improved care quality, cost-effectiveness, and enhanced care experiences (Bemelmans et al., 2012). Developments in robotic nursing enable nurses to devote more time to direct patient care, while telemedicine, robot-assisted surgery, and remote monitoring have become increasingly visible in elderly care settings (Christoforou et al., 2020; Khan et al., 2020; Zhao et al., 2022a; Şendir et al., 2019).

Robotic systems used in elderly care support older adults in maintaining independence and autonomy, allowing them to live longer in their own homes, while also reducing caregiver workload and enabling remote monitoring by family members (Salvini, 2015). Nevertheless, the literature highlights potential risks, including increased social isolation, reduced human-centered care interactions, and excessive dependence on robotic technologies (Maalouf et al., 2018).

2. Theories of Robotic Nursing in Elderly Care

With the increasing use of technology in elderly health and nursing care, the number of robotic systems and AI-supported devices has grown, and humanoid robots have assumed a more visible role in care processes. In response, theoretical approaches have been developed within nursing and related health disciplines (Soriano et al., 2022). In this chapter, care robots, healthcare robots, and humanoid robots used in nursing care are addressed under a unified conceptual framework. Nursing as Caring (Boykin & Schoenhofer), Technological Competency as Caring in Nursing (Locsin), and the Transactive Relationship Theory (Tanioka) constitute the primary theoretical frameworks that conceptualize technology-supported care from a human-centered perspective (Boykin & Schoenhofer, 2015; Pepito & Locsin, 2019; Locsin & Ito, 2018; Şendir et al., 2019).

These theoretical frameworks guide the understanding of the roles of technology, AI, and healthcare robots in the delivery of nursing care to older adults (Salvini, 2015). Based on the International Organization for Standardization's ISO 8373 robotic terminology, robots and robotic systems used in nursing can be defined as systems composed of mechanical, electrical, and control components, operated by trained professionals in healthcare settings, and interacting directly with patients, nurses, physicians, and other health professionals (ISO, 2021). Christoforou et al. (2020) suggest that care robots may function as "additional healthcare workers" in hospitals, long-term care facilities, and home settings by undertaking physically demanding and logistical tasks, addressing issues such as loneliness and inactivity, and performing routine activities including vital sign monitoring.

Evidence indicates that AI applications in nursing support the secure recording and management of health data and that delegating certain routine nursing tasks to robotic systems allows nurses to focus more effectively on complex care processes (Locsin & Ito, 2018; Şendir et al., 2019). Such applications are emphasized as enhancing care quality by increasing the time nurses can dedicate to older adults, individuals with disabilities, and those requiring specialized care.

Tanioka et al. (2017) introduced the concepts of healthcare robots, humanoid nursing robots, and humanoid care robots, and evaluated the potential roles of humanoid nursing robot systems (HNRS) (Tanioka et al., 2017; Tanioka, 2019). The Transactive Relationship Theory in Nursing (TRETON) has been applied to explain interactions between humanoid robots and older adults, particularly those with cognitive impairments such as dementia and Alzheimer's disease (Tanioka, 2017). Studies report that effective human–robot interaction can be achieved with HNRS and that these systems have the potential to collaborate with humans in nursing care. Randomized controlled trials further indicate that older adults with preserved physical and cognitive function can perform upper extremity exercises guided by robots, resulting in improvements in quality of life (Tanioka, 2017; Tanioka, 2019). These theoretical approaches provide a conceptual foundation for integrating robotic nursing into care processes, while the technologies used in practice represent the operational manifestation of this framework.

3. Robotic Systems Developed with Artificial Intelligence

In elderly health services and nursing care, robotic systems and AI-supported technologies are increasingly utilized. These systems, employed in surgical, caregiving, logistical, monitoring, and decision-support processes, aim to enhance the effectiveness of nursing care and reduce care burden. Examples include the Da Vinci Surgical System, Robear, RIBA, Cody, Veebot, robotic medication dispensing systems, TUG, Swisslog RoboCourier, Google DeepMind Health, CareSkore, Sentrian, Telenoid, and Atacan (Pepito & Locsin, 2019; Gümüş & Uysal Kasap, 2021; Zhao et al., 2022b; Şendir et al., 2019; Wiederhold, 2017; Alvarez et al., 2018; Jeelani et al., 2015; Kohn et al., 2017).

The Da Vinci Surgical System (2000) supports precision in surgical procedures while indirectly influencing nursing workflows in operating rooms. Care-oriented robots such as Robear (2015) and RIBA (2009) assist with physically demanding tasks, including patient lifting and mobilization. Cody (2010) was developed for personal care activities such as bed bathing. Veebot (2010) supports venous access procedures and has demonstrated a certain level of accuracy in technology assessment studies. Robotic medication dispensing systems (2006) promote safe medication administration by supporting the principles of the right patient, right time, right medication, and right dose (Gümüş & Uysal Kasap, 2021). TUG robots (2015) and Swisslog RoboCourier (2013) contribute to logistical processes by transporting medical supplies and medications (Pepito & Locsin, 2019; Şendir et al., 2019).

Google DeepMind Health (2018) represents AI systems designed to monitor patient status, evaluate care processes, and identify gaps in hospital care. CareSkore (2017) integrates clinical and sociodemographic data to support preventive care decisions, while Sentrian (2012) focuses on early detection and remote monitoring through biosensor data (Gümüş & Uysal Kasap, 2021; Pepito & Locsin, 2019; Şendir et al., 2019). Telenoid (2010) is equipped with AI for remote communication with individuals with dementia and Alzheimer's disease (Kuwamura et al., 2016). In Türkiye, the nursing robot Atacan (2020) contributed to nursing care by performing tasks such as food and medication delivery, vital sign measurement, and educational support during the COVID-19 pandemic, reducing staff exposure and infection risk (Pepito & Locsin, 2019; Şendir et al., 2019; Zhao et al., 2022b). Beyond clinical and logistical applications, social interaction and communication constitute a critical dimension of elderly care.

4. Assistive Robots Used for Social Adaptation and Communication

The potential of robots to communicate with humans and facilitate social interaction has been demonstrated through various approaches. Zhakypov et al. (2019), inspired by ant behavior and communication models, developed small-scale robots and showed that specific patterns of social behavior could potentially be encoded into robots for future care processes. Similarly, Nishio et al. (2021) reported that "twin robots" enabled long-term (Zhakypov et al., 2019), conversation-based interactions with older adults and could provide a form of social support (Nishio et al., 2021).

In addition to clinically and logistically oriented robotic applications, the social and communicative dimensions of elderly care have become increasingly prominent. Particularly among older adults at risk of dementia, Alzheimer's disease, and social isolation, interaction-based robotic systems are emphasized as potentially supportive of psychosocial well-being. Social robots developed for this purpose aim not only to assist with physical care, but also to support emotional needs and sustain care processes in a human-centered manner.

Telenoid is a representative example of a socially interactive robot, designed with a minimal humanoid appearance and remote communication capabilities to engage older adults. Studies indicate that robots such as Telenoid may facilitate communication in older adults experiencing cognitive decline, elicit emotional responses, and function as a supportive tool enhancing the caregiver–care recipient relationship (Kuwamura et al., 2016). Likewise, the nursing robot Atacan, developed in Türkiye, reduced nursing workload through basic care and logistical support functions and contributed to infection prevention during the COVID-19 period by limiting patient–healthcare worker contact (Şendir et al., 2019; Zhao et al., 2022b).

Animal-like robots designed to support socialization and communication also occupy an important place in the literature. Robots such as Mero, Paro, AIBO, Furby, and NeCoRo are reported to reduce loneliness and stress by fostering social bonding among older adults (Bradwell et al., 2019; Chang et al., 2013; Kim et al., 2015; Šabanović & Chang, 2016; Shishehgar et al., 2018; Wada & Shibata, 2006; Zhang et al., 2024). However, some robots, such as Pleo, have been reported to have limitations in meeting all care needs in long-term care contexts; therefore, their use should be evaluated carefully with respect to setting and intended outcomes (Tulsulkar et al., 2021; Gümüş & Uysal Kasap, 2021).

Overall, these findings suggest that socially interactive robots are not intended to replace nursing care, but rather to support human–human interaction and serve as complementary tools within care processes. Utilizing robotic systems within this supportive framework is critical for the sustainable and human-centered integration of robotic nursing in elderly care.

5. Humanoid Robots Used in Healthcare Delivery and Elderly Care

Humanoid robots have been developed with diverse functions to support physical well-being, monitor vital signs, enhance independence, and strengthen social interaction in older adults (Tulsulkar et al., 2021; Gümüş & Uysal Kasap, 2021; Christoforou et al., 2020; Zhao et al., 2022a; Şendir et al., 2019). These robots can be broadly categorized into three functional domains: (1) support for activities of daily living and safety, (2) physical activity guidance and health monitoring, and (3) social interaction and psychosocial support.

5.1. Support for Activities of Daily Living, Safety, and Care

Humanoid robots such as Pearl, Silbot, Hobbit, Lio, Kompaï, TIAGo, and Matilda are designed to support safe and independent living within older adults' living environments. Their functions include assisting with daily routines, reducing fall risk, environmental monitoring, and supporting basic care needs (Fischinger et al., 2016; Khosla & Chu, 2013; Mišeikis et al., 2020; Coşar et al., 2020; Martinez-Martin et al., 2020; Pu et al., 2019).

5.2. Physical Activity, Exercise, and Health Monitoring

Robots such as Nao, Zora, and Kompaï accompany older adults during physical activity and provide exercise guidance. Studies involving the Nao robot report increased participation in physical exercise and improvements in certain vital parameters (Shen & Wu, 2016; Cespedes et al., 2020). The Zora robot has been positively received by both care staff and older adults in physical activity interventions and demonstrates potential for social use as well (Huisman & Kort, 2019; Melkas et al., 2020). In addition to providing physical support, robots in this category may also reduce caregiver workload.

5.3. Social Interaction and Psychosocial Support

Humanoid robots such as Pepper, Buddy, CommU, Robovie, and Nadine are designed to engage older adults to promote social participation and psychosocial well-being. Pepper has been reported to encourage socialization among individuals requiring psychosocial support, including those with dementia and schizophrenia, and to distinguish interactive communication (Miyagawa et al., 2019; Betriana et al., 2022). Studies using CommU indicate that conversation-based interaction may support mental health (Tulsulkar et al., 2021). AI-enabled Robovie has been reported to increase perceived social support in elderly care settings, although no clear improvements in cognitive functioning were observed (Sabelli et al., 2011; Karunarathne et al., 2019). Nadine, through facial expression recognition and speech synthesis, has been reported to support positive affect and contribute to reduced workload among care home staff (Tulsulkar et al., 2021).

In general, humanoid robots in elderly care function as complementary tools rather than replacements for nursing care, providing physical, social, and psychosocial support. Nevertheless, broader implementation requires careful consideration of ethical issues, technical constraints, and user acceptance.

6. Challenges and Unresolved Issues

Despite technological advances, the use of humanoid and assistive robots in nursing care for ageing populations involves substantial challenges. Chief among these is the level of acceptance by older adults. Evidence suggests that older adults' attitudes and perceptions directly influence the success of integrating robots into care processes (Sifeng et al., 2016; Nishio et al., 2021; Soriano et al., 2022).

Robots' capacity to learn, store, and process personal data raises concerns regarding privacy protection and potential ethical violations. In particular, the use of robotic systems in older adults' homes or long-term care facilities may generate a feeling of constant surveillance, negatively affecting psychological well-being and engagement in care processes (Christoforou et al., 2020; Mudd et al., 2020).

Another major challenge limiting widespread implementation is the ability of robotic systems and AI-supported systems to operate effectively in crowded and dynamic care environments. Robots used in hospitals, nursing homes, and home settings may not consistently meet technical requirements such as spatial perception, localization, and safe navigation (Ramdani et al., 2019). Moreover, robots' physical and social design may lead older adults to form unrealistic expectations regarding robot capabilities, increasing the risk of disappointment and distrust (Feil-Seifer & Matarić, 2011; Christoforou et al., 2020; Tulsulkar et al., 2021).

To fulfill their assigned roles, robots may require a certain degree of autonomy; however, this can also imply that control is not always fully in the hands of older adults. Therefore, obtaining informed consent, ensuring transparency of control mechanisms, and carefully evaluating ethical frameworks are essential (Brożek & Jakubiec, 2017; Abbott et al., 2019).

Human–robot interaction is a key determinant of the success of robotic nursing applications. Three main barriers have been identified: physical limitations restricting mobility, communication difficulties that impede information exchange, and cognitive decline that negatively affects information processing (Abbott et al., 2019). When effective and safe interaction cannot be established, the expected contribution of robots to care is likely to remain limited.

A further challenge concerns nurses' acceptance and adoption of these technologies. Some nurses may view the incorporation of robots into care processes as potentially weakening the humanistic dimension of care. Debates about whether robots can replace human nurses persist, partly due to limited high-level evidence regarding clinical outcomes (Mudd et al., 2020; Soriano et al., 2022).

In this context, further scientific evidence is needed regarding how nurses can guide the selection and use of robotic systems for vulnerable populations, and under what conditions—and to what extent—robotic applications affect nursing care and patient outcomes (Locsin et al., 2018). Addressing these challenges in an integrated manner, encompassing ethical, technical, and human factors, is essential for ensuring that robotic nursing applications in elderly care are safe, acceptable, and sustainable.

7. Conclusion

The continued growth of the older population necessitates a reassessment of the scope of healthcare services, models of elderly care, nursing practice, and health policy. This demographic transformation strengthens the need for innovative, technology-based solutions to sustainably improve the quality of elderly care. Robotics and modern technologies support active ageing by enabling both physical and emotional support for older adults and may contribute to reducing care dependency.

AI and robotic nursing applications are gaining increasing importance in healthcare services to enhance the effectiveness of diagnostic, therapeutic, and care processes, reduce workforce burden, and support care safety. Effective and safe implementation requires strong collaboration between engineering disciplines and health professionals. The active involvement of nurses and physicians in the design, implementation, and evaluation of robotic systems will facilitate the development of solutions that are aligned with clinical needs and feasible in practice.

In the broader adoption of robotic nursing, ethical, legal, and human dimensions must not be overlooked. Nurse researchers have a responsibility to evaluate the effects of robotic systems on care processes in accordance with ethical principles and, when necessary, to guide, restrict, or redesign the use of these technologies. Future studies should examine the safety, functionality, and user acceptance of robots in elderly care in greater depth, and such systems should be developed using interdisciplinary approaches.

Overall, the integration of robotic and AI-supported systems into elderly care should be conceptualized not as a replacement for nursing care, but as a complementary approach that strengthens and supports nursing practice. Structuring human–robot–health professional interaction in an ethical, safe, and human-centered manner remains a fundamental requirement for the sustainable and effective implementation of robotic nursing.

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