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Empowering Nurses with Robotic Allies: A Review of Current Applications and Future Prospects

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Introduction:

The World Health Organization (2021) projects that the proportion of the world's population aged 60 and older will nearly double from 12% to 22% between 2015 and 2050. This indicates that the rate of growth of the elderly population is significantly faster than in previous eras. As a result, numerous nations encounter substantial challenges pertaining to the well-being of the elderly, necessitating the readiness of social and healthcare infrastructures to capitalize on this demographic transition. As a consequence, certain nations have undertaken the development of technological integrations that enable human interaction, including artificial intelligence (AI)-enabled machines (Oksanen et al., 2020). Hospitals, where the provision of healthcare services can oversaturate staff and lead to a paucity of personnel, find these technologies especially beneficial (Zhao et al. 2022).

When the system implementation involves advanced technologies such as robotics in nursing, Frazier et al. (2019) state that understaffing remains a pressing issue today, given that nurses comprise 45% of all healthcare professionals in practice. Therefore, the implementation and utilization of sophisticated technologies, including healthcare robotics, as systems of care, are gaining significance (Lee et al. 2018). The implementation of robotics in healthcare has the potential to improve patient outcomes, primarily as a result of technological advancements. Proficiency in technology is essential for achieving, preserving, and advancing human health and well-being in the face of an aging population (Anghel et al., 2020). Anticipated results encompass enhanced operational effectiveness and the provision of reinforcement and augmentation for personnel shortages (Frennert et al., 2021). As the integration of caring science into nursing practice facilitates the transition away from technological dependence (Locsin, 2017), healthcare professionals gain a heightened understanding of the potential consequences of technological dependence, which are further compounded by the advent of a pandemic (Aymerich-Franch & Ferrer, 2022).

Technological advancements have facilitated the creation of nursing robots that have the potential to supplement insufficient personnel and deliver effective healthcare to individuals with disabilities, the elderly, or those who are considered vulnerable (Christoforou et al. 2020). As a consequence of the assistance and support provided by technologies during procedures such as surgery, advancements have been made in their application and integration into various facets of healthcare, including rehabilitation and treatment. Potential applications of robots in nursing and other health care fields include enhancing the speed and accuracy of disease detection and facilitating end-of-life care by allowing patients to maintain their independence for extended durations.

The advancement of technology is often accompanied by the anticipation of novel manifestations of intricate processes. Particularly evident in the strategies employed when utilizing management systems, the administration of health care practices demonstrates the system's progressive complexity (Clancy, 2020).

The purpose of this article is to analyze pertinent ideas regarding robots and robotics in the field of nursing, distinguish between humans and healthcare robots as collaborators, and provide instances and obstacles in the development of robots.

What does Robotics mean as It Relates to Nursing:

The demand for care for elderly individuals has increased in tandem with the progressive increase in the world's aging population, which is estimated to be 703 million individuals aged 65 and older (United Nations, 2019; Tanioka et al., 2021). As a consequence, a prospect is emerging to create and advance healthcare robots in the field of nursing, which would be equipped with artificial superintelligence (ASI) and able to perform menial tasks and nursing interventions in hospital environments. In order to provide efficient and accurate care for patients, particularly elderly patients (Locsin & Ito, 2018), von Gerich et al. (2022) defined robots in nursing in accordance with the International Organization for

Standardization 8373 definition: "trained operators operate systems comprising electrical, mechanical, and control mechanisms within a professional healthcare environment to execute tasks in direct collaboration with patients, nurses, doctors, and other healthcare professionals."

In a similar vein, Christoforou et al. (2020) suggest that nursing robots have the potential to function as adjunctive healthcare personnel in residential settings, assisted living facilities, and hospitals. Routine nursing duties such as monitoring patients' vital signs or addressing loneliness and inactivity among the elderly can be accomplished with the assistance of robotic systems that perform laborious and logistical physical labor. Furthermore, robotic technologies can be integrated with additional hospital technologies, such as electronic health record systems (Locsin, 2017), which enable the documentation of a patient's healthcare history to ensure continuity of care. As care time may be prolonged by this assistive robotics technology, it may be possible to improve communication between the patient and the nurse (Christoforou et al., 2020).

In contrast, Frazier et al. (2019) assert that advanced sensors, transmitters, and receivers are frequently programmed into robots as fundamental components. Furthermore, display devices are integrated into robot computer systems to exhibit data sensing programs generated in response to the patient's condition. The operational mechanism of the robot is designed to transmit detected patient physiological conditions to the display device, where they are subsequently recorded in the patient database, upon recognition of such conditions in particular scenarios. Effectively providing nursing care services, this healthcare robot operates via an ASI comprised of numerous systems and sensors. The development of robots in the field of nursing has elevated the priority operational functions to those that are both efficient and accurate (Ito et al. 2021).

The Role of Robots and Robotics in the Field of Nursing:

Nursing robots find utility in both institutional settings and senior living facilities. By relieving nurses of burdensome duties, robots may enable them to focus on tasks that are directly related to their primary responsibilities. The utilization of robotic devices to assist in the distribution of food trays, medications, and laboratory specimens across a hospital has been contemplated. Additionally, logistics duties associated with medical equipment and supply storage may be automated by robots. In addition to these responsibilities, an enhanced function for robotics could involve collaborating with nurses to aid in their work and improve efficiency. Moreover, robot nurses can assist in reducing the amount of hazardous infections or substances that human nurses are exposed to on the job. By completing specialized training, nurses can assume the responsibility of supervising and coordinating the operations of an autonomous fleet within a hospital, thereby establishing an entirely new field of expertise. The implementation of specialized robotic systems that assist nurses with patient transfers, ambulation, and carrying could substantially alleviate their physical strain. It is not uncommon for individuals providing care to experience occupational illnesses and back discomfort. (Potito et al., 2020)

One application of specialized robotic equipment is the execution of arduous duties, including the transfer and relocation of patients (Tashiro et al. 2017). Additionally, this relates to the broader investigation of ubiquitous exoskeleton devices. Exoskeletons have the potential to augment an individual's physical capabilities by enabling the extension of weights (power extenders) and averting musculoskeletal disorders. Indeed, exoskeletons offer a viable substitute for fully automated autonomous systems, thereby effectively safeguarding the skills inherent in human labor. Additionally, nursing robots have the potential to offer telemedicine services (Ito et al., 2021).

By integrating telepresence platforms, robotic nurses can efficiently facilitate long-distance communication between physicians and patients. Common situations entail regular virtual examinations in which the robot uses the onboard display to navigate to hospital facilities and establish the necessary visual contact with the patients being examined. In this regard, the incorporation of autonomous navigation capabilities into robots is an especially appealing attribute, as it eliminates the need for personnel to manually guide the robots in order to locate a particular patient. Further, the robot has the capability to record the patient's vital signs at predetermined time intervals, as dictated by standard clinical protocols and diagnostic criteria. The latter scenario, in theory, pertains to the provision of specialized care to individuals residing in healthcare facilities situated in remote and isolated areas, including the patient's home environment. (2018, Maalouf et al.) In general, electromechanical caregivers possess distinct advantages in comparison to their human counterparts, one of which is the ability to operate nonstop for the duration of the day. Robots, due to their programmable nature, possess the capability to customize care and adjust to diverse requirements. Significantly, the integration of robotics with additional hospital technologies, including cloud-based electronic health record (EHR) systems, guarantees continuity of care by facilitating access to a patient's complete medical history.

Types of robots that assist nurses in their tasks:

A. <u>Socially-assistive robots</u>

Assistive robots include socially-assistive robots, which lend support to end-users via social interaction. The inclination of humans to ascribe human qualities and intentions to mobile physical entities renders robots more efficient than any mobile health application for a smartphone or computer program. The following are potential applications of socially-assistive robots as suggested in the literature: (i) companion robots; (ii) assistance for individuals with dementia; (iii) encouragement of physical activity;

and (iv) rehabilitation following a stroke. (Aymerich-Franch & Ferrer, 2

Companion robots have become a distinct

subset of assistive robotics. Their primary responsibility has been to facilitate connections between the elderly and their families and acquaintances, thereby enhancing their social lives. Socially assistive robots are equipped with the capability to oversee geriatric patients through video monitoring and relay notifications to caregivers regarding patient activity. Furthermore, robots have the potential to furnish elderly individuals with news and entertainment updates, serve as medication adherence reminders, and promote physical activity. (Papadopoulos et al., 2020),

Conversely, robotic companion animals have garnered significant interest as a potential remedy for depression and stress, while circumventing the labor and dangers associated with animal care. A second critical area of socially assistive robots is assisting those with dementia. Consistent engagement in physical activity is imperative for the elderly in order to preserve and enhance their health condition, promote overall mental and physical wellness, and mitigate the risk of developing depression. In order to motivate elderly individuals to participate in physical activity, robots have been engineered to facilitate training sessions, assess user performance, and deliver immediate feedback. (Robaczewski et al. 2021)

B. Physically-assistive robots

Nanavati et al., (2023) Identify two essential components of independent living that are positively correlated with the quality of life of patients and the elderly: (a) The ability to maintain mobility; and (b) The capability to manipulate objects. Loss of mobility is caused by an extensive array of medical conditions that affect the geriatric, including but not limited to neurodegenerative diseases, bone fractures, and a decline in muscular strength. In response to this circumstance, robotic interventions that offer the support necessary for standing, sitting, and walking have been suggested (Caleb-Solly et al. 2021).

Users benefit from increased mobility, safety, and autonomy with robotic wheelchairs (Badr & Dankar, 2022). By equipping the robotic wheelchair with a suitable mechanical framework, it is possible to surmount architectural obstacles such as curb ascent and descent (Candiotti et al. 2019). A robotic wheelchair can incorporate hierarchically the following control functions: (i) high-level functions (e.g., directing the wheelchair) and (ii) low-level functions (e.g., obstacle/collision avoidance, corridor centering). Motorly impaired individuals may benefit from assistive robotic manipulation systems that are designed appropriately. These systems can assist those who have limited hand and arm movements, severe spinal injuries, or tremors.

The following assistive device requirements have been identified through surveys of disabled individuals in this group (Hersh, 2015): feeding assistive devices for eating and drinking; personal care aids for shaving, washing, and applying cosmetics; aids for handling objects such as books and devices; aids for mobility and access (such as opening doors); and general reaching and moving tasks.

Wheelchair-mounted or fixed manipulation systems are viable options for addressing the aforementioned challenges (Ktistakis et al., 2015).

C. Tele-robotics

Tele-operated medical robotic systems have proven to be effective in the broader domain of healthcare, enabling the execution of procedures including diagnoses, treatments, and surgeries from a distance via wired and/or wireless communication networks. Panayides et al. (2020) state that recent advancements in tele-robotics and their enabling technologies—video streaming, robotic manipulation, and telecommunications—enhance the efficacy of nursing and assistive robots and expand their range of applications.

Telepresence is made more natural and efficient by robotics hardware, which enables remote manipulation tasks to be executed and facilitates mobility. Nursing-specific tele-robotics solutions could potentially facilitate the virtual visits of physicians. By employing an adjustable onboard camera, the user has the capability to operate the robot remotely in order to identify a patient within the clinic or to supply a predetermined list of destinations for the robot to independently traverse. By utilizing bidirectional video conferencing, the physician is subsequently able to interact with the patient via the robot's display in order to evaluate the patient's present clinical condition (telehealth).

By employing a robot-mounted device that is equipped with vital signs acquisition capabilities and EHR connectivity, real-time medical charts have the potential to augment and supplement this remote clinical assessment. An example of this concept is the ENDORSE, which was examined in the section titled "Robots in Healthcare Environments: Endorse Concept Case Study." Telepresence robots that provide assistance to geriatric individuals in their homes have the potential to foster social interaction, encourage the elderly to maintain social engagement, and enable family members to virtually visit and experience a sense of close proximity.

They also facilitate communication with physicians and caregivers in order to provide the necessary support and remotely monitor their health. In contrast to video conversations, the mobility of a telepresence robot contributes to a heightened sense of naturalness in interpersonal communication. The inherent compatibility of tele-robotic systems with information technology (IT) technologies, such as the internet of things (IoT), enables the development of enhanced functionalities. An illustration of this is the IoT-enabled tele-robotics application in home care, (Zhou et al. 2019). Reis et al. (2018) conducted a comprehensive evaluation of telepresence robotic systems, identifying three primary domains where tele-robotics find utility in the care of the elderly: telemedicine, telehealth monitoring, and remote interpersonal interactions.

The primary obstacles to effective nursing and assistive robotics implementation

User acceptability is a significant obstacle to the successful implementation of nursing and assistive robotics. The perspectives of both patients and elderly individuals, as well as nurses and attendants, are significant. The significance of geographical and cultural variations should not be underestimated, as illustrated by the case study of China in (Sifeng et al. 2016). A natural concern that arises on behalf of patients and the elderly is that the implementation of robots in their homes could potentially supplant human interaction and support, resulting in diminished companionship and heightened isolation. Additionally, robots are capable of learning and processing personally identifiable information, which constitutes a violation of privacy. The existence of autonomous systems within one's residence engenders a sense of perpetual surveillance. It is noteworthy that, when viewed from an alternative standpoint, autonomous technologies could potentially enhance privacy levels by eliminating the necessity for human intervention in activities that are considered private in nature. A significant non-physical risk from a psychological standpoint pertains to the development of an attachment to the automaton and the dissemination of false information regarding its capabilities. Numerous nurses are acclimated to the influence of emerging technologies on their daily tasks and work. Gradually, nursing curricula are incorporating pertinent robotics material (Mudd et al. 2020). Nevertheless, the implementation of nursing robotic solutions might be impeded by an inherent apprehension that such solutions will pose a risk to employees' employment stability. In addition to user acceptability, there are technological obstacles that are relevant to the robotics technology that need to be resolved. In crowded, dynamic environments (e.g., a residence or a hospital) (Ramdani et al., 2019), conventional sensing, localization, and navigation methods utilized in controlled settings (e.g., a manufacturing facility) are not easily applicable to mobile robots.

The well-established safety concepts that are also applicable to manipulation systems in industrial settings must be reconsidered. In this regard, the ENDORSE concept has been making contributions. In order to prevent the nursing robot from becoming a source of contamination, sterilizability should be incorporated into its specifications. This is especially crucial for robot deployments during outbreaks of contagious diseases. Concerning communications and cloud technology integration, the possibility of unauthorized access to healthcare databases and sensitive private information is a potential safety risk associated with robotic nursing; thus, data security technologies become pertinent. Human factors engineering is concerned with the secure and efficient interaction between humans and machines, which is vital for the success of nursing and geriatric care robots.

In the context of geriatric care, interfaces for human-robot interaction should be intuitive and visually appealing to older generations, taking into account their limited familiarity with contemporary ICT applications. This is one way in which personalization can be implemented, an inherent benefit of programmable robotics. An essential element of successful human factors design is a comprehensive comprehension of the user characteristics, which may include factors such as age, illness, birth defects, and incidents. Elderly populations are characterized by the presence of three primary categories of disabilities: (1) Physical limitations, such as motor impairments, impede an individual's capacity to manipulate controls and attain them. (2) Perceptual impairments, also known as sensory limitations, hinder an individual's capacity to receive feedback and information. (3) Cognitive impairments hinder the capacity of an individual to effectively comprehend information. User perception generally holds that the visual appeal and ornamental qualities of physically and socially assistive robots are significant. Software agents may assume various forms, such as humanoid, machinelike, or software-like entities adorned with human features.

It is widely acknowledged in the bibliography that social expectations are influenced by the physical appearance of a robot; conversely, unrealistic expectations that surpass the robot's actual capabilities may result from a human appearance (Sharkey & Sharkey, 2011). In regard to motion systems, wheeled mobile robots predominate due to the reduced mechanical and control complexity they entail. A primary benefit of legged/anthropomorphic robots, notwithstanding their complexity, is their capability to function in environments and utilize instruments that were initially intended for human use. Although both nursing and assistive robots necessitate a certain level of autonomy to carry out their functions, it is critical that the user retains ultimate control. The expansion of autonomous robotic technology applications will necessitate a legal and ethical framework that serves as a cornerstone for subsequent developments.

Conclusion:

AI and technology are practical and beneficial for patients. The interdisciplinary field of robotics in nursing investigates the methodologies, technologies, and ethical considerations associated with the creation of collaborative robots that assist physicians, nurses, and other healthcare professionals in their daily work. The objective of robotics in nursing is to acquire knowledge about robots in order to improve nursing care. In pursuit of this goal, robotics in nursing also proposes and develops the necessary robots in collaboration with engineers. Nonetheless, additional research is necessary to define robotics in nursing and to examine its applications in the field of nursing. Insufficient research has been conducted to determine whether their potential to replace human nurses in terms of the capacity to demonstrate compassion stems from their inherent humanness or their unpredictability. We believe that developing the Nursing Situation and Response Databases would be among the most crucial duties. The empathic capabilities that AI and robotics are capable of exhibiting toward humans can be realized via programmed actions. The resulting knowledge will provide insights into the interconnections between AI and empathy, aid in comprehending its practical applications, and influence theories of nursing and caregiving.

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