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Robotics in Nursing: A Scoping Review

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Abstract

Purpose: Driven by the shortage in qualified nurses and the high percentage of aging populations, the past decade has witnessed a significant growth in the use of robots in nursing, especially in countries like Japan. This article is a scoping review of the different tracks in which robots are used in nursing. Whereas assistive robots are used for physical care, including service and monitoring tasks, social assistive robots focus on the cognitive and emotional well-being of patients in need of companionship.
Methods: A total of six electronic databases were used in the search for journal papers and conference proceedings. The key words used in searching the databases were nursing OR nurses, AND robots OR robotics. Topics covering surgical robotics, nursing education robotics, and clinical procedures were excluded.
Findings: A total of 1,758 articles were retrieved, from which 69 articles were included in the final review. The analysis of the chosen papers led to the categorization of robots into two main categories: assistive robots and social assistive robots.
Conclusions: After a detailed review of the state of the art in assistive robots and social assistive robots, an insight into the future of robotics in this field is provided. The recommendations include the need to intensify research on human robot interaction, greater focus on monitoring robots, and analysis of the psychological barriers that need to be surmounted to achieve more tolerance and higher acceptance of robots.
Clinical Relevance: For researchers and developers to provide suitable technological solutions, a full understanding of robotics in nursing is needed. An overview of the most recent applications and their proper categorization is key to finding areas for contribution.

The origin of the word robot comes from the Czech word *robota* meaning forced labor (Murphy, 2000). The *Merriam-Webster Dictionary* defines the word robot as "a person who resembles a machine in seeming to function automatically or in lacking normal feelings or emotions" (Merriam-Webster, 2018). This definition often creates a preconceived idea that the sole purpose of robots is to replace humans by performing the same tasks in a more systematic but insensitive manner. The lack of caring and sensitivity in robots has led professionals and patients to question the inclusion of robotic systems in nursing and health care. In fact, it was not until 1985 (Elgazzar, 1985) that the first robot was used in health care as an aid in neurosurgical biopsies. This came nearly 45 years after Asimov's three laws of robotics (Asimov, Silverberg, & Timmerman, 1978), which prevent robots from harming humans, either through action or inaction, and 30 years after the introduction of the first commercial robot in the industry (Ayres & Miller, 1982).

People's attitudes towards robotic assistance in health care, and especially in nursing, have evolved little over the past four decades. The lag in development can be attributed both to technical challenges and limited social acceptance. In 1986, a study on 57 adults over the age of forty showed clear preference towards having a medical student, rather than a robot, to measure their blood pressure (Engelhardt, 1986). Nearly 40 years later, a study by Simou, Alexiou, and Tiligadis (2015) highlighted the necessity of applying artificial intelligence to humanoids, allowing them to be socially ″well behaved″ and ready to use past experiences and interact emotionally with patients. Simou et al. concluded that people still needed to be trained to accept relationships with nonhuman beings (i.e., robots). The case of Japan, in which people are often in direct contact with robots, is a valid proof that the acceptance rate of robots in nursing can be improved in different societies. The U.S. and European populations might need more time to adapt to the new concepts but could eventually accept the inclusion of robotics in nursing.

Whether robots could prove to become reliable in nursing practices is still an unanswered question (Maalouf et al., 2016; Metzler, Lewis, & Pope, 2016). While ethical and social concerns remain, the increase in reliance on robotics in nursing is primarily a result of the ever-aging population (Pollock et al., 2014). This is reflected in Japan, where around 30% of the population is over the age of 65 years (Charova, Schaeffer, & Garron, 2010). It is no coincidence that the service robot industry, mainly directed to nursing and elderly care, is expected to reach 5 trillion yen (around US$45 billion) by the year 2035 (Nitto, Taniyama, & Inagaki, 2017). The aging population dilemma is also affecting the US, where the Department of Health and Human Services Administration on Aging estimated that by 2030, the 65 and older population will rise by 25.8 million as compared to 2014 (Buerhaus & Staiger, 1999). It is interesting to note that Japan and the US are the two countries with the most robotic devices in use (Freeman, 1995).

The shortage in qualified nurses is another major factor favoring the increased use of robotic systems in nursing. The Bureau of Labor Statistics stated that ″there will be over one million unfilled nursing jobs″ by the year 2022 (Buerhaus & Staiger, 1999). The main advantages of using robots in nursing are their continuous availability during day and night and consistent quality of service (Bendel, 2015). In 1992, Peck predicted a future where nurses are completely replaced by robots, and where there is no patient–nurse relationship. A less dramatic outlook views robots being used to aid human caregivers rather than replacing them (Moon, Danielson, & Van der Loos, 2012). The increase of robotics in nursing has led to several survey papers covering applied robotic systems in different areas of nursing, such as assistive robots used in physical care (Mitzner, Chen, Kemp, & Rogers, 2014; Wang et al., 2011; Zhang, 2012) and social assistive robots used in psychological care (Pfadenhauer & Dukat, 2015). While each survey paper provided valuable information on the role of robotics in a specific area, to the best of the authors' knowledge, a review in which research contributions of robotics in nursing in general are covered has yet to be found. The study is guided by the following research questions: What are the most commonly used robots in the field of nursing, and by which taxonomy can these robots be categorized?

Methodology

The methodology followed in this review is based on the framework developed in 2005 by Arksey and O'Malley. A scoping review aims at clarifying a research question through a broad analysis of available material (Arksey & O'Malley, 2005). This type of review consists of five main steps and one additional optional step depending on availability (Arksey & O'Malley, 2005; Levac, Colquhoun, & O'Brien, 2010). The five main steps include identifying the research question, identifying relevant studies, study selection, charting the data, and collating-summarizing-reporting the results. The optional step, which is not considered in this review, involves consulting stakeholders for more insight (Arksey & O'Malley, 2005).

Search Strategies

Robotics in nursing is a diverse field, comprising different robot types and applications. A proper classification of robotic use in nursing is integral to identifying the strengths and weaknesses of the field; towards this end, a scoping review is presented in this document, which will identify the many different applications of robotics in nursing. The sources used in this review include PubMed, ScienceDirect, Springer, Google Scholar, and IEEE Xplore. Journal papers and conference proceedings were searched using the key words ″robot″ OR ″robotics″ OR ″technology″ OR ″robotic systems″ OR ″smart systems″ AND ″nursing″, ″nurses″, ″caregivers″ AND each of the category-based search terms below:

- Assistive, social assistive, assistive living, care center
- Elderly, pediatric, disabled, dementia, autism, ADS, Alzheimer's disease
- Mobility, autonomy, feeding, carrier, monitoring, upper limb function
- Pet, companion, humanoid, emotional, cognitive

A total of 1,758 papers were screened (based on titles and abstracts) to determine their relevance to the research topic. One hundred ten papers were evaluated, out of which 69 papers, 4 web pages, and 1 governmental document were selected. The chosen papers cover studies with direct relation to robotics in assistive and social assistive care, excluding topics covering surgical robotics, nursing education robotics, and clinical procedures.

Charting the Data

After selecting the final set of studies, two authors extracted the relevant data that addressed the research question. The data charting strategy followed is shown in the flow chart of Figure S1. The extracted data, including robot name, source, target group, clinical condition, country, testing procedure or sample size, commercial status, and a brief description, are summarized in Tables S1 and S2.

Findings

In this article, the following taxonomy is adopted: robotics in nursing falls under the category of either assistive or social assistive; while the former category includes the fields of service and monitoring in nursing, the latter includes the fields of emotional and cognitive services. All these terms will be explained in the following sections. The scoping review highlights the need for advancement in monitoring robots, especially when dealing with elderly or children. The privacy policies for this robot category need continuous research to clear up any existing ambiguities. This increases patient acceptance to the inclusion of robots in the nursing field. The review also shows a need to improve the collaboration between nurses and robots instead of focusing on replacing nurses with robotic caregivers.

Assistive Robots

According to the World Bank Group (Kraus, 2017), people with disabilities formed 15% of the world's population in 2013. Disabled individuals need special care and support services to maintain a normal life; by relying on assistive technologies, this need is considerably reduced (Agree & Freedman, 2003). The U.S. Congress has defined assistive technology as ″any item, piece of equipment, or product, whether it is acquired commercially, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of individuals with disabilities″ (Public Law 108-364, 2004). The combination between robotics engineering and assistive technology forms what is known as assistive robotics; based on their specific task, assistive robots are further categorized as service or monitoring robots.

Service robots

The purpose of service robots is to aid the elderly and disabled in their daily lives. They are used more in private homes than in care centers, a fact that favorably complies with the elderly's preference of an assisted life in their home rather than in a paid accommodation (Alaiad & Zhou, 2014; Mitzner et al., 2014). Service robots are usually used for either mobility assistance or for monitoring.

Mobility aid robots

Mobility aid robots are intended to help people navigate from one spot to another. The visually impaired could particularly benefit from such systems; in 2015, around 7,297,100 persons were reported to have visual disability in the US (National Federation of The Blind, 2017). As an example of an assistive device, the Personal Adaptive Mobility Aid (PAM-AID) helps in achieving independent movement of a visually impaired person, while avoiding obstacles (Lacey & Dawson-Howe, 1998). Another example includes the SmartCane and SmartWalker, which can detect obstacles and build a map of their surroundings in order to localize the users inside the map, and subsequently guide them to different waypoints (Spenko, Yu, & Dubowsky, 2006). Other assistive devices include adaptive body support systems to help subjects (e.g., elderly) in standing and walking (Chugo, Matsuoka, Jia, Takase, & Asama, 2008). Finally, for people with severely impaired motion abilities, the MAid (Mobility Aid for Elderly and Disabled People) is a robotic wheelchair that can assure safe maneuvers in crowded spaces, such as malls and airports (Prassler, Scholz, Strobel, & Fiorini, 1999).

Serving and feeding assistance

Since caregivers and nurses in care centers or hospitals are usually overloaded during mealtimes, a variety of meal service robots are designed to increase serving efficiency (Osada & Yano, 2009). Matsukuma and Yamazaki (of Matsukuma, Yamazaki, Kanda, & Maruyama, 2000) developed a food-carrying robot for Japanese hospitals that can navigate, distribute food trays, and collect them in an autonomous manner. While nurses need help in serving food, there are cases in which assistance is also required to support upper extremity motion, such as for the case of the elderly and disabled. ″Handy 1″ (Topping & Smith, 1998) is the first low-cost commercial rehabilitation robot used for multitasks including feeding assistance. Another example is a 4DoF robotic manipulator (Lu et al., 2009) designed to assist the elderly with simple services such as pouring and serving a cup of water.

Carrier robots

Back pain is a common problem among caregivers due to the fact that one has to transfer patients from beds to wheelchairs, typically for an average of 40 times a day (Mukai et al., 2010). The Robot for Interactive Body Assistance (RIBA; Figure S2) is the first assistive robot to carry patients weighing up to 60 kg from bed to wheelchair and back. Commands are given to RIBA by the caregiver through tactile guidance, instead of the traditional joystick controller (Chen & Kemp, 2010). The relatively low weight-carrying ability of RIBA relates to the fact that it is developed in Japan, where the patient's average weight is lower than in other countries. In the US, the Robotic Nursing Assistant (RoNA; Ding et al., 2014) was proposed in 2014, designed for patients who weigh up to 226 kg. In yet another example, rather than designing a carrier robot, Li et al. (2013) proposed a multifunctional nursing bed that accommodates many positions, such as sitting and lying on one side. The bed can also support patients in standing position and could be easily transformed to a wheelchair by a simple push of a button. This system is still a concept and has not yet been developed into a product. A temporary solution to the bed-moving problem could be the use of powered robotic bed movers, which could enhance maneuverability in hospital environments. The powered mover reduces by half the manpower required to push the hospital bed, thus relieving nurses from the physiological strain (Guo, Yee, Mun, & Yu, 2017). Tests done in a lab environment on 14 subjects revealed easier maneuverability, higher accuracy, and less strain when the powered bed mover was used (Guo et al., 2017).

Monitoring robots

Another service that robots can offer is monitoring subjects, a service that is especially useful for patients with dementia (Bäck, Kallio, Perälä, & Mäkelä, 2012), who require special care and monitoring. Telepresence robots could help caregivers in this task by providing audio and visual feedback to the caregiver (Vaughn, Shaw, & Molloy, 2015). Humanoids are also capable of successfully performing this job; they can receive alarms, navigate to desired rooms in nursing homes, and send images and voice messages (Görer, Salah, & AkLn, 2017). In fact, studies by Petelin, Nelson, and Goodman (2007) showed faster response rates when using a robot than when using a human caregiver. Monitoring robotic systems can provide intelligent reminders for daily activities in addition to data collection and surveillance (Jia, Lin, Wang, & Takase, 2006). Monitoring robots can also be used to relieve nurses from having to continuously check on patients and record their vital signs. A urine output monitoring system is used to monitor the patient's urine output, generate warnings in case of emergencies, and autonomously empty the samples (Otero, Apalkov, Fernández, & Armada, 2014). Monitoring robots can be used as home service robots; one example is the Home Nursing Robot (HNR), which detects and processes six physiological parameters (electrocardiograph, saturation, blood pressure, pulse, respiration, and body temperature; Wang et al., 2011).

Other assistive robots

In addition to the robots listed above, there are several other types of assistive robots that provide different services. For physically impaired individuals, the RobotBathtub (Beedholm, Frederiksen, Frederiksen, & Lomborg, 2015) can be used to bathe a person while they lie down in a horizontal position inside the robot. The nurse helps the patient undress and lie on a wheeled carrier, which in turn is pushed inside the bathtub. The RobotBathtub autonomously washes the patient from neck to feet. Another example is the Quirubot (Pérez-Vidal et al., 2012), which is an assistive robotic scrub nurse; it includes a camera that recognizes up to 27 surgical instruments, and speech recognition for providing up to 82 verbal instructions. Finally, the Nao humanoid robot has served as an exercise tutor for the elderly, imitated predefined human tutor motions, observed the exercising person, and provided feedback (Görer et al., 2017). People were satisfied with the experience and kept engaged with the robot over several sessions. The main assistive robots covered in this survey are listed in Table S1.

Social Assistive Robots

Psychological comfort and emotional well-being are of the same importance as physical well-being. As a result, engineers also developed robots capable of providing emotional support for patients in need, in addition to engaging them with mental activities.

Emotional care

Children are in continuous need of emotional support and attention. For this purpose, PARO (Figure S3), a robotic baby seal, has been used to accompany children in hospitals, especially during times when their mothers were absent (Shibata et al., 2001). Children's interaction with the seal robot resulted in a state of relaxation and happiness that indirectly improved the patients' vital signs (Shibata et al., 2001). Jeong et al. (2015) introduced a huggable robot that provides socio-emotional support for children in hospitals. Like the seal robot, the huggable robot's smooth motions kept the children relaxed.

Robots that provide emotional support are also popular in elderly care, especially when older subjects are in nursing homes living far from their families and loved ones (Salichs, Encinar, Salichs, Castro-González, & Malfaz, 2016; Shibata & Wada, 2011; Tao, Wei, Wang, & Chen, 2008; Whelan et al., 2017). The use of PARO for the emotional support of the elderly in nursing homes showed similar results in socio-emotional needs between children and the elderly (Šabanović & Chang, 2016). CuDDler is another example of a companion robot for elderly care developed in Singapore and used for patients with dementia and visual impairment (Moyle et al., 2016). CuDDler gained positive reactions and acceptance from the elderly (Tan et al., 2013). Interestingly, Sharkey and Sharkey (2012) discovered that patients might confuse robotic systems with actual living things. An important factor in enhancing the elderly's emotional state is keeping them engaged in their favorite activities. That is the main purpose of MARIO (Kouroupetroglou et al., 2017), a companion robot for people with dementia, which provides patients with applications tailored according to their social interests, such as music, games, and movies. MARIO keeps the patients socially active and helps in reducing loneliness. While both children and elderly need emotional support, the elderly tend to be more affected by the robots' resemblance to humans or pets. This requires more studies and broader evaluation when testing robots for accompanying the elderly (Šabanović & Chang, 2016). However, to date none of the robotic pets proposed have rendered human care completely indispensable (Klein & Cook, 2012).

One of the main reasons for developing socially assistive pet robots is the fact that actual pets are usually not allowed in hospitals and some nursing homes (Shibata et al., 2001). AIBO, a dog-type robot, is one example used in Japan to improve the quality of life among the elderly while abiding by nursing home regulations (Kanamori et al., 2003). The use of a robotic pet instead of an actual one also decreases the level of attachment felt by the elderly while maintaining an acceptable level of emotional support. This is validated by a study done on AIBO in long-term care facilities, which showed that the robotic dog had the same effect of treating loneliness as a real dog, while imposing a weaker feeling of attachment from the elderly (Banks, Willoughby, & Banks, 2008). Another advantage favoring the use of a robotic pet in elderly care is the ability to give the patient a degree of control over the pet, which gives a feeling of authority and improves self-confidence (Naganuma, Ohkubo, & Kato, 2014). Interestingly, an autonomous version of AIBO was less accepted by patients, as compared to a remote-controlled version (Naganuma et al., 2014).

Socially assistive robots not only acted on the patients' emotional level, but also indirectly improved their vital signs; this was demonstrated in a study conducted by Robinson, MacDonald, and Broadbent (2015), where the use of a companion robot with the elderly helped regulate their blood pressure and heart rate. In light of the current robotic development in health care, and to reach a "healthier" robot–patient relationship, two factors still need to be improved: the robot's memory and ability to express emotions. The robot's artificial intelligence should enable it to "activate memories and emotions" (Simou et al., 2015, p. 19), and it should be accompanied by training programs that help people accept relationships with nonhuman beings (Simou et al., 2015). Shaping the human–robot relationship in nursing and health care reduces the risk for emotional attachment, especially in cases where the robot has a high resemblance to a human.

Cognitive care

During healing and rehabilitation, the focus is directed towards the patients' physical well-being, and their cognitive development is often overlooked. To address this shortcoming, several robots have been developed that can mentally stimulate patients who lack social interaction. Matilda (Khosla et al., 2012), for example, is a social robot used to engage the elderly with advanced social activities, by breaking down the barrier with technology. Quan, Niwa, Ishikawa, Kobayashi, and Kuno (2011) added a new dimension to social interaction and cognitive engagement by introducing a robot that interacts with multiple persons, thereby enhancing patient-to-patient interaction, in addition to the robot–patient relationship.

Keeping patients mentally active requires time and effort from nursing companions. With the shortage in the availability of qualified nurses, technological interventions are bound to be sought (Buerhaus & Staiger, 1999). Robotic intervention is highly needed in patients with dementia, where significant effort is needed to keep patients active on the cognitive level, or at least limit the deterioration of their mental abilities. Robotic assistance for patients with dementia range from humanoids to pet robots, to simple applications to keep the mind active (Soler et al., 2015). The use of humanoid robots such as Nao, Asimo, and HOAP has shown neuropsychiatric and cognitive improvements in patients with dementia (Martín, Agüero, Cañas, Valenti, & Martínez-Martín, 2013); in places where humanoids are unavailable, the use of nonverbal communication with pet robots also has positive effects on the mental condition of these patients (Nihei, Sakuma, Yabe, Kamata, & Inoue, 2017). As an example, PARO, the robotic seal, helped patients engage more with their environment while providing the needed emotional support (Sabanovic, Bennett, Chang, & Huber, 2013). Even with all the available robotic systems targeted at keeping dementia patients engaged in mental activities, there remain several areas for improvement on the patient–robot level and nurse–robot level (Cooper, Procter, & Penders, 2016; Montanini et al., 2016).

Children with autism spectrum disorders (ASD) experience impairments in communication and building relationships (Coeckelbergh et al., 2016). They usually have a triad of impairments in social communication, social interactions, and imagination (Cabibihan, Javed, Ang, & Aljunied, 2013). The social-assistive robots used in therapy for children with ASD include three main categories. First, there are the anthropomorphic robots, which are designed to greatly resemble humans (Cabibihan et al., 2013) and are made to replace the human caregivers during their absence. The second type of robots are the nonanthropomorphic type, in which robots are designed to resemble animals. These robots help build a sense of responsibility in children by considering the robot as both a friend and pet (Cabibihan et al., 2013). The third type is nonbiomimetic, in which the robots are designed in a way not to resemble any biological creature. This type helps in enriching children's imagination (Cabibihan et al., 2013). Studies have shown that nonbiomimetic and nonanthropomorphic robots tend to gain larger acceptance by children with ASD (Cabibihan et al., 2013; Feil-Seifer & Matarić, 2009); this is driven by the fact that children with ASD have difficulties in interactions with other people. As a result, humanoid robots are mostly used with children without ASD, such as in vaccination facilities (Beran, Ramirez-Serrano, Vanderkooi, & Kuhn, 2015). The use of humanoids distracts the children while taking their vaccines and relieves stress from their parents (Beran et al., 2015). The main social assistive robots covered in this survey are listed in Table S2.

The robot categorization is driven by the tasks required from each type of nursing robots. This approach portrays the technical importance of the assistance, being physical or social, provided by the robotic systems.

Analysis and Discussion

The scoping review conducted in this article answers the proposed research question by categorizing robotics in nursing into two main categories (assistive and social assistive) that branch into subcategories. The most commonly used robots in each category are highlighted along with their main functions and modes of operation. However, it is important to note that the review does not cover robots used for surgical or diagnostic medical procedures.

The noted rise in the number of publications during the past 5 years clearly suggests the increase in research and interest in the field of robotics in nursing (Figure S4). The distribution of the papers in this survey is almost evenly distributed between assistive (36%) and social assistive (38%). Among the assistive robots, only 19% of the papers covered monitoring robots, while 81% covered service robots. As for the social assistive robots, the papers were evenly balanced between emotional and cognitive care robots.

Service robots constitute a significant part of the assistive robots category (around 40%) since they are used for elderly and disabled individuals in private homes and nursing centers. Service robots can therefore be subcategorized into mobility aid (28%), carrier (43%), and serving or feeding assistance robots (29%). The presented statistical data show the high interest in service robots, especially for the elderly and disabled individuals. However, more research is needed on monitoring robots because it is not as well developed as other fields. The acceptance of monitoring robots by the public is highly affected by privacy concerns that appear when using robots for monitoring, and the question of who is authorized to provide consent for using such robots is debatable.

It is important to note that during the search and categorization performed in this paper, a significant number of papers were found related to the attitude of the nursing staff and that of the patients toward the inclusion of robots in nursing (Rincon et al., 2012). A study conducted by Broadbent et al. (2016) showed that nurses and healthcare centers reacted more positively to healthcare robots than did the elderly, thereby reinforcing the observation that the elderly still prefer human caregivers over robotic ones. Some studies suggest that the elderly tend to be more accepting of in-home caring robots when living alone (Rantanen, Parkkari, Leikola, Airaksinen, & Lyles, 2017). Some analysts often go far in portraying a dark future where nurses are entirely replaced by autonomous robots (Sparrow, 2016); such studies dampen the enthusiasm towards the use of robotics, especially for elderly care (Sparrow, 2016).

One of the main factors affecting a patient's attitude towards a robotic caregiver is his or her perceived, versus actual, intention of a robot. In a study conducted on 56 patients, a robot placed on the bedside was programmed to gently wipe the patient's forearm (Chen, King, Thomaz, & Kemp, 2014). While the action was identical with all patients, it elicited different attitudes from different patients: those who thought the robot's intention was to clean their forearm had positive attitudes, while those who thought the action was to comfort them did not perceive it in the same manner.

Robots used for elderly care provide many advantages from which the elderly and their loved ones can benefit (Martin, 2016; Salvini, 2015): (a) autonomy where elderly people feel independent of other humans and can take care of themselves, (b) delayed move from private home to nursing home, (c) more free time and less stress for human caregivers, and (d) easy monitoring solution for the family and loved ones. The aforementioned advantages are faced with several disadvantages, which cannot be overlooked (Sparrow, 2016). The main challenges are social isolation, less freedom, too much dependence on the robotic helpers, emotional attachment to nonhuman caregivers, and decrease in the number of caregiver jobs.

More ethical and legal issues come to mind when dealing with elderly having dementia, since in such cases the patients are often not fit to make their own decisions. This requires special care over who can provide consent to enroll patients with dementia in robotic-related research studies (Ienca, Jotterand, Vică, & Elger, 2016). The data collected by the robot, whether medical or just video recordings, also raises both ethical and legal concerns regarding patients' privacy (Ienca et al., 2016; Sparrow, 2016).

Future development of robotics in nursing depends on a series of improvements in theory, and in applications. Nurses and medical staff need more training to better cooperate with robots, thus perceiving robots as helpers and not competitors. Patients' positive attitudes towards robotic caregivers is also a topic that needs extensive efforts. Familiarizing people with robots and robotic applications at an early age helps create a well-defined robot–human relationship. This helps people to view robots as helpers and prevents emotional attachment or a feeling of antipathy. The relationship should be guided by a clearly defined set of social, ethical, and legal boundaries. This would form a strong foundation for the development of robots with full decision-making capabilities. From the application perspective, some assistive robots tend to be too specialized in the services they provide. One way to overcome this limitation is to introduce more multipurpose robots capable of helping in different tasks. An example that seems executable in the near future is adding telepresence to carrier robots. RIBA could then offer medical feedback to patients when it is not needed to transfer them.

Tables S1 and S2 show a shortage in commercially available assistive robots as compared to social assistive robots. The simplest reason behind the focus on social assistive robots is the low cost of development. Companion robots can be easily integrated into nursing homes and hospitals, whereas assistive robots, especially the ones used in hospitals, require special design considerations, and wider hallways and doors. Patients also find it harder to trust robots in physical assistance tasks, which delays the integration of assistive robots into the market. There is noticeable room for research and improvement in social assistive robotics for children and for disabilities other than dementia since the focus is currently on elderly with partial or total memory loss.

Conclusions

The field of robotics in nursing is evolving fast to cope with the need for help in caregiving, especially for the elderly and individuals with disabilities. This survey categorized robotic applications in nursing into assistive and social assistive robots, while focusing on the needs and weaknesses of robotics in each track. The survey highlights the importance of setting clear social and legal boundaries for robot–human relationships in order to help maintain the safety and privacy of the caregivers and patients. Future developments should include more multipurpose robots ready to help caregivers in varying situations. This requires more concentrated cooperation between developers and caregivers, which so far has not been significant.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web site:

Figure S1. Strategy used for article selection.
Figure S2. RIBA lifting a patient.
Figure S3. PARO the seal robot.
Figure S4. Publication distribution per year showing the increase in interest in the field of nursing robotics.
Table S1. List of Main Assistive Robots Covered in This Review
Table S2. List of Main Social Assistive Robots Covered in This Review