ISSN: 1676-4285

OBJN Online Brazilian Journal of Nursing
ENGLISH
Federal Fluminense University
AURORA DE AFONSO COSTA NURSING SCHOOL
uff
Original Articles

The use of robots in nursing care practices: an exploratory-descriptive study

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ABSTRACT

Aim: To investigate patents related to the invention of robots for use in nursing care. **Method**: An exploratory, descriptive study with a quantitative approach into the INPI, LATIPAT, Espacenet, USPTO, FPO, CIPO, JPO and WIPO databases, with no restrictions regarding the publication year of patents. **Results**: 35 patents were identified: 40% related to the creation of robots to aid in the mobility of patients; 28.5% regarding the development of robots to aid daily activities; 23% about robots created for physiological assessment and monitoring of patients; and 8.5% regarding those designed to participate in the process of patients' rehabilitation. **Conclusion**: the patents related to the invention of robots for use in nursing care are, mostly, suited to the needs of elderly or disabled people. Also, the world regions more focused on the development of robotics in the field of health care are Asia, Europe and North America.

Descriptors: Nursing; Robotics; Nursing Care.

Mesquita AC, Zamarioli CM, Carvalho EC. The use of robots in nursing care practices: an exploratory-descriptive study. Online braz j nurs [internet] 2016 Sept [cited year month day]; 15 (3):404-413. Available from: http://www.objnursing.uff.br/index.php/nursing/article/view/5395

INTRODUCTION

The focus of technological progress in the health sector is to improve the supply of health care services to patients[1]. In this context, technological advances in health care remain one of the fastest growing aspects of the modern world and, as such, are recommended to health organizations investing in the development, acquisition, implementation and evaluation of technology devices and products[1-3].

Nursing professionals are daily exposed to this new technology, whether in their personal or professional life, and the faster they can seize and master it, and put it at the service of human health care, greater is the progress they can achieve in their profession[4]. The United States of America (USA) Medical Institute, in its 2011 report entitled "The Future of Nursing: leading change, promoting health," recommends that health care organizations, and also private and public funders, collaborate to advance research on innovative solutions, including technology that will enable nurses to contribute to improvements in health care[2]. In this point of view is important that scientific and technological research is understood and consumed by nursing professionals in order to provide better quality of care[4]. Also, in addition to consuming new technologies, nurses must transform their daily practices, creating innovations that can be tested and systematized through scientific research[4].

Robotics, a multidisciplinary area that uses the knowledge of other sciences – such as mathematics, physics, mechanics, electronics, among others – to create robots[5] is an emerging and very promising field for the health sector[6]. A robot is a mobile manipulator, often similar to a human being in size and height, with the ability to feel and manipulate objects as well as to navigate in human environments[6]. For the area of personal health care, the field of robotics is currently seen as an area of research in development, to meet the needs of individuals with physical and cognitive limitations, particularly in the promotion of independent community life[7].

It is known that in China a team of roboticists developed a robot to serve as a companion for the elderly, capable of reading their signals to individually interact with them[8]. In Japan, to deal with the growing elderly population, the government has invested heavily in health care robotic products[9]. In Europe, an example of the development of robots in human care services can be seen in Germany, where a company developed a robot, the o-O-bot Care (Fraunhofer IPA, Stuttgart, Germany), which performs household tasks that elderly people are unable to do, such as washing clothes and preparing food, among other activities[10]. However, knowledge about the use of robotics for specific applications in the field of nursing care is still scarce.

According to a study that aimed to analyze the patents registered in the nursing field in the period 1990-2009, via a search performed in the patent record database from the National Institute of Industrial Property (INPI), no records could be found regarding the development of robotic products for nursing care in Brazil[4]. So the following questions arose: are there any patents regarding the development of robots for use in the practice of nursing care in Brazil or in other countries; and what problems do these inventions try to solve?

In this context, this study aimed to investigate patents related to the invention of robots for use in nursing care.

METHOD

This is an exploratory-descriptive research with a quantitative approach. The following question guided this study: "Which patents are related to the invention of robots for use in nursing care?"

Data collection was conducted in August 2015 in the following public patent registration databases: National Institute of Industrial Property (INPI), Latin American Patents (LATIPAT), European Patent Office (Espacenet), United States Patent and Trademark Office (USPTO), Free Patents Online (FPO), Canadian Intellectual Property Office (CIPO), Japan Patent Office (JPO) and World Intellectual Property Organization (WIPO). For the record search, we used keywords according to each specific base indexing (Chart 1).

Chart 1 - Search strategy according to the selected databases – Ribeirão Preto, Brazil, 2015.

Database	Search Strategy
INPI	Pesquisa Avançada: Título: 'ROBÔ' \ Resumo: 'ENFERMAGEM' \
Latipat	Advanced Search: robot en el título AND enfermería en el título ó resumen
Espacenet	Advanced Search: robot en el título AND nursing en el título ó resumen
USPTO	Quick Search: nursing AND robot
FPO	Quick Search: Title: Robot \ Abstract: Nursing
CIPO	Boolean Search: ((robot) <AND> (nursing))
JPO	Searching PAJ: Abstract: Nursing \ Title of invention: Robot
WIPO	Field Combination: EN_TI:robot AND EN_AB:nursing

Source: Author's Research

The inclusion criteria defined for the pre-selection of the patents were the following: records in English, Portuguese or Spanish containing abstracts, and presenting as invention robots designed for use in nursing care. No limit for the year of publication of patents was set. The selection process was carried out through a detailed inspection of the titles, so that the records that made the final selection met the inclusion criteria already mentioned. For the final selection, we conducted a thorough reading of abstracts, and only ones that primarily focused on the invention of robots for use in nursing care were kept.

For the data collection and analysis, we used a tool developed by the researchers, which contained the following topics of interest: database, name and country of the first inventor, title of the invention, year of publication of the patent, and core functionality of the invention.

RESULTS

The final sample consisted of 35 patents from international databases (Table 1). It is important to note that seven patent applications were found in more than one database (Chart 2).

Table 1 - Distribution of selection of patents according to the inclusion criteria. Ribeirão Preto, Brazil, 2015.

Database	Found	Pre-selected	Selected
INPI	0	-	-
Latipat	0	-	-
Espacenet	0	-	-
USPTO	454	18	5
FPO	7	6	2
CIPO	2	1	0
JPO	11	10	7
WIPO	40	35	21
Total	514	70	35

Source: Author's Research

Of the identified patents, the earliest one was published in 1998, the most recent in 2015. The highest concentration of records (34%) occurred in the years 2014 and 2015 (Chart 2). Of the selected patents, 43% (15) are from China; 23% (8) from Japan; 14% (5) from Korea; 8% (3) come from Taiwan; 6% (2) from the USA; 3% (1) from the United Kingdom; and 3% (1) from Spain.

Chart 2 summarizes the patents included in this study.

The inventions identified in this study were grouped according to their main function into 4 categories as follows: mobility, which relates to robots developed for the transfer, moving and transport of patients from one location to another; physiological monitoring/assessment, a category for inventions that had as a main objective to evaluate the physiological conditions of patients and monitor their health status remotely (remote communication with patients, online support for groups of patients, evaluations conducted via webcam, among others); assistance in daily activities, which refers to inventions developed for assistance in carrying out activities related to self-care; and rehabilitation, for inventions designed to assist the patient in the musculoskeletal pathologies rehabilitation process.

Most of the patents (40%) are related to the invention of robots designed to assist in the transportation of patients. We identified the main function of aid in daily activities in 28.5% of the patents included in this study. The main function of 23% of inventions registered in these patents is related to physiological monitoring/evaluation of patients, and 8.5% is dedicated to the development of robots for use in the rehabilitation process of patients (Chart 2).

DISCUSSION

Robotics, specifically the development of robots for personal health care, has advanced rapidly in Asia, Europe and North America[7], which corroborates the data found in this study. Regarding the number of patent registrations, the US technology market is the main private market in the world for technology licenses, with 54.2% of global market share of patents in USPTO; followed by Japan (21.4%) and the European Union (EU) (15.2%), while the share of Brazil reaches 0.1%[11]. With regard to the introduction of technology, the gap between Latin America, and more specifically Brazil, and Asia, Europe and North America, may exist due to certain factors, for example, the strong correlation between the level of economic development, investment in research and the number of scientists[12]. Asian economies have shown a rapid-growth trajectory of productivity and *per capita* income towards the technology frontier, while Latin American countries have shown a relative stagnation, with slow growth of productivity and *per capita* income[13].

North America, Europe and South Asia are leaders in investment in research and development, with 94% of world funding in this area, while Brazil has 2% of investment in this field[12]. Regarding the number of scientists, in 2007 there were 5,573 researchers per million of residents in Japan; 4,624.4 in North America; 2,936.4 in the EU; and 656.9 scientists per million inhabitants in Brazil[11]. China is about to overtake both the US and the EU in terms of number of researchers. Each of these countries represents around 20% of the global contingent of researchers. If we add the participation of Japan (10%) and Russia (7%), it is possible to realize the extreme concentration of researchers: these five countries account for

Chart 2 - Summary table of the features of patents included in the database, name and country of the first inventor, the patent certificate, year of publication and main function. Ribeirão Preto, SP, Brazil, 2015.

Id	Database	First Inventor	Country	Title	Year	Main function
1	FPO/ WIPO	X. A. Miro	Spain	Intelligent nurse robot	2005	Monitoring physiological conditions of patients and storing the data
2	FPO/ WIPO	T. Han	Taiwan	Nurse robot	2004	Transporting patients from bed to other locations
3	JPO	T. Hirobumi	Japan	Robot	2014	Transporting patients from bed to other locations
4	JPO	T. Hirobumi	Japan	Nursing Care Method And Nursing--Care Robot Used Therefor	2014	Transporting patients from bed to other locations
5	JPO/WIPO	S. Hirobumi	Japan	Trackless self-traveling type nursing--care robot device	2005	Transporting patients from bed to wheelchair
6	JPO/ WIPO	M. Takuhara	Japan	Robot for nursing care	2003	To gather information and develop a plan of care, and it is also programmed to assist the patients in situations where they might feel embarrassed to ask for help from a human caregiver, for example, as going to the bathroom during the night
7	JPO/WIPO	K. Hiroshi	Japan	Robot for nursing care support and nursing care support system	2002	Monitoring patients' condition and providing their remote communication with nurse/caregiver
8	JPO/WIPO	Y. Seishiro	Japan	Flexible robot arm	1999	A robotic arm that can be placed on a bed or a chair to help the patient to stand or sit
9	JPO/ WIPO	F. Toshio	Japan	Robot for nursing and nursing system	1998	Monitoring patients' condition and providing audio and video remote communication with nurse/caregiver
10	WIPO	Y. K. Kim	Korea	Nursing robot and nursing robot monitoring system	2004	Monitoring patients' condition and sending data to a control center
11	WIPO	V. Maria	United Kingdom	Robot Device	1999	Transporting patients unable to move by themselves
12	WIPO	W. Chao	China	Nursing robot with bathing and massaging functions	2014	Assisting in patients' bath, performing massage and move patients' body in bed
13	WIPO	Y. Junyou	China	Excretion aid robot	2015	Collecting excreta
14	WIPO	Z. Yuhong	China	Intelligent walk--assisting robot	2013	Assisting patients to walk
15	WIPO	D. Hua	China	Intelligent nurse robot	2005	Assisting in patients' rehabilitation
16	WIPO	H. Kuisheng	China	Remote monitoring robot	2012	Monitoring vital signs and patients through video

17	WIPO	L. Feng	China	Double joint nursing robot	2007	Moving patients who have lost the ability to walk
18	WIPO	H. S. Park	Korea	Transfer robot for nursing patients	2014	Transporting elderly patients in order to minimize physical stress to the caregivers
19	WIPO	Y. Yuntian	China	Medical robot electric nursing bed	2005	Performing massage, moving patient's body on nursing bed, changing bedpan
20	WIPO	S. Yang	China	Synchronous movement control system and method for wheelchair and nursing bed body of robot nursing bed	2015	Transporting patients from bed to wheelchair
21	WIPO	M. Jike	China	Hair-washing and massaging robot	2013	Performing massage and wash patients' hair
22	WIPO	Z. Xizheng	China	Robot for transferring and transporting patients	2010	Transferring and transporting patients
23	WIPO	---	Korea	Robot system for assisting nurses and a control method thereof, which transfers patients	2012	Transferring and transporting patients
24	WIPO	---	Korea	Nursing assist robot which measures and manages a vital signal and a vital signal measurement method	2010	Monitoring vital signs
25	WIPO	Z. Qiang	China	Method for folding wearable lower limb assisting robots	2015	Moving patients who have lost the ability to walk through assisting leg movement
26	WIPO	C. Diansheng	China	Bed-chair integrated robot with detachable side surface	2012	It turns from a bed into a chair
27	WIPO	Z. Weihu	China	Suspension-type active joint and passive joint mixed traditional Chinese medicine massage robot	2015	Performing massage
28	WIPO	C. Shu Park	Korea	Emergency situation processing system using a robot and a method thereof for directly confirming an emergency situation through image information	2013	Monitoring emergency situations by transmitting images to a control unit

29	WIPO	J. Hui-qing	China	Robot nursing bed, force sense rehabilitation system and master-slave control method of force sense rehabilitation system	2014	Robot-bed designed to assist in the rehabilitation of patients with sciatic nerve condition by performing exercises
30	WIPO	X. Shaojie	China	Upper limb recovery robot	2011	Assisting in the rehabilitation of patients with upper limbs paresis by performing exercises
31	USPTO	J. P. Dekar	USA	Self feeding device having a user prompt feature	2015	Assisting patients to feed
32	USPTO	L. F. Griswold	USA	Patient transfer system	2012	Tranferring patients from bed to chair and vice-versa
33	USPTO	C. Y. Tsai	Taiwan	Nursing system	2009	Monitoring of patients through video transmission to a control center
34	USPTO	T. Han	Taiwan	Nurse robot	2014	Assisting patients to move themselves to any desired place without the help of any other person
35	USPTO	O. Okamoto	Japan	Pressure-distribution sensor for controlling multi-jointed nursing robot	2002	Detect pressure points and move the body of bedridden patients

about 35% of the world population; however, they have three-quarters of all researchers. In contrast, a populous country like India still represents only 2.2% of the world total, while Latin America and Africa represent 3.5% and 2.2%, respectively[11].

Another point we take into account is the lack of national expertise in engineering and technology, which may explain the slow pace in Brazilian innovation process, when compared, for example, to the performance of China[11]. In health care, the collaboration with engineers in the development of technologies in personal care has the potential to contribute to the creation of products that better meet the needs of persons requiring care[7]. Engineers and end users would benefit from the perspective of nurses regarding robot production, with maximum benefit for the support to the population of elderly and disabled patients[7]. Still, there are other aspects that also hinder the introduction of new technologies in our environment, such as human resources training and upgrading for its proper use, the constant updating of instruments to regulate/certify new products, and the requirement for constant investment in appropriate physical infrastructure[4].

According to the categories identified in this study (mobility, physiological monitoring/assessment, aid in daily activities and rehabilitation), we can observe that inventions are adequate for the needs of elderly or disabled people, a pattern that has continued for a number of years. Worldwide, increased longevity, in combination with falling birth rates, indicates that the proportion of older people in society is increasing disproportionately compared to the active labor force that provides care for them[7]. Due to the severity of this problem, the United Nations and the World Health Organization called for govern-

ments and private companies to act urgently to address the needs of older people, with particular attention to their physical aspects, and to consider the potential of technology in meeting their necessities[7]. Technology has the potential to increase the capabilities of older people and improve their quality of life, especially the field of robotics, an emerging technology area that may be of particular promise for this population[6]. An European survey about the perception of people in relation to robots found that 62% of people aged over 55 reported a positive feeling regarding these machines[14].

Regarding the use of robotics in favor of patients with disabilities, robot-assisted therapy has emerged in recent years. With the use of robots, dull and repetitive exercises can turn into challenging and motivating tasks, like real games. Moreover, robots can provide a quantitative measure of rehabilitation progress[15]. People with cognitive and/or motor disabilities can benefit from the use of telepresence robots to engage in social activities[16]. An advantage of support robots is that patients with little or even zero movement capabilities can make use of them[17]. Other examples of robotic applications in development include monitoring patients at home, collecting data about medicine use, daily activities, biometrics and promoting social interaction, and others[7].

The use of robotics in other areas, such as medical and dentistry fields for example, is a consolidated reality that continues to evolve. Several types of robots help in different situations, such as performing diagnostic and therapeutic procedures, clinical simulation situations for the training of professionals, and others[18]. As for nursing, so far, the literature has not addressed how nurses will participate in the selection and use of robotic technology, or how robotics could influence the nursing care practice and patient outcomes[7]. In addition, some professionals resist the use of new technologies, often because they do not realize the relevance of its use, whether in prophylactic treatment or in aspects of rehabilitation[19]. Openness is necessary not only to accept the arrival of new technologies, but also to continue to learn about these, as well as the procedures and challenges involved in their use[20].

Technology that helps with home care for the elderly and patients with disabilities will probably be present in the case of intensive care conditions. In a world in which human financial resources may be small compared to the need for health services, a scenario that is expected for the next decade or more, it is necessary to think about how the nursing area can best use robotic devices to maximize their service range[7].

CONCLUSION

Based on these results, we conclude that patents related to the invention of robots for use in nursing care, according to the main function of the invention, are distributed in the following four distinct areas: mobility, physiological assessment/monitoring, assistance in daily activities and rehabilitation. Furthermore, the global regions that have seen the most development of robotics in the field of health care are Asia, Europe and North America. The study provides a direction for nurses to think about the development and the use of such technology in their clinical practice, since it presents itself as a trend for the future of this profession.

It is important to be aware of the need for monetary and intellectual investment in

this area, and also the need of cooperative work between nurses and professionals from other fields such as engineering, since multidisciplinary work is essential to achieve the best outcomes in the development of robots for health care services, and ultimately for the benefit of patients.

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All authors participated in the phases of this publication in one or more of the following steps, in According to the recommendations of the International Committee of Medical Journal Editors (ICMJE, 2013): (a) substantial involvement in the planning or preparation of the manuscript or in the collection, analysis or interpretation of data; (b) preparation of the manuscript or conducting critical revision of intellectual content; (c) approval of the versión submitted of this manuscript. All authors declare for the appropriate purposes that the responsibilities related to all aspects of the manuscript submitted to OBJN are yours. They ensure that issues related to the accuracy or integrity of any part of the article were properly investigated and resolved. Therefore, they exempt the OBJN of any participation whatsoever in any imbroglios concerning the content under consideration. All authors declare that they have no conflict of interest of financial or personal nature concerning this manuscript which may influence the writing and/or interpretation of the findings. This statement has been digitally signed by all authors as recommended by the ICMJE, whose model is available in http://www.objnursing.uff.br/normas/DUDE_eng_13-06-2013.pdf

Received: 11/11/2015
Revised: 07/13/2016
Approved: 07/14/2016