Social Robots for People with Aging and Dementia: A Systematic Review of Literature

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Abstract

Background: *Social robots are currently a form of assistive technology for the elderly, healthy, or with cognitive impairment, helping to maintain their independence and improve their well-being.*

Objective: *The main aim of this article is to present a review of the existing research in the literature, referring to the use of social robots for people with dementia and/or aging.*

Methods: *Academic databases that were used to perform the searches are IEEE Xplore, PubMed, Science Direct, and Google Scholar, taking into account as date of publication the last 10 years, from 2007 to the present. Several search criteria were established such as "robot" AND "dementia," "robot" AND "cognitive impairment," "robot" AND "social" AND "aging," and so on., selecting the articles of greatest interest regarding the use of social robots in elderly people with or without dementia.*

Results: *This search found a total of 96 articles on social robots in healthy people and with dementia, of which 38 have been identified as relevant work. Many of the articles show the acceptance of older people toward social robots.*

Conclusion: *From the review of the research articles analyzed, it can be said that use of social robots in elderly people without cognitive impairment and with dementia, help in a positive way to work independently in basic activities and mobility, provide security, and reduce stress.*

Keywords: *telemedicine, e-health, rehabilitation, home health monitoring, social robot*

Introduction

Dementia is a disease that affects the cognitive part of a person, usually this type of disease occurs in older adults due to the loss of neurons and neuronal connections in the brain.[1] It is mainly due to lack of physical and mental exercises that an older adult has, although other things such as poor diet or even drugs that the person has consumed throughout his life influence.[2] The population is aging and as a result there are ~35.6 million older people globally who have dementia,[3] it is estimated that the number will increase to 82 million by 2040.[4] The treatment of the disease is symptomatic and involves a significant level of support and assistance. The level of care required increases with the progression of the disease and it is estimated that the cost of managing dementia amounts to 1% of the world gross domestic product (GDP).[5]

Dementia is characterized by a progressive impairment of an individual's functioning and includes a decline in cognitive functioning, altered communication, and depressed mood, which can often cause people with dementia (PwD) to feel socially isolated and lonely.[3,6] One of the most important aspects of dementia care is the maintenance of communication among PwD, family, and staff so that care provision can be appropriately individualized.[7]

Nonpharmacological treatments focus on physical, emotional, and mental activity. Engagement in activities is one of the key elements of good dementia care. Other cognitive rehabilitation therapies and protocols focus on recovering and/or maintaining cognitive abilities such as memory, orientation, and communication skills.[8]

With the advance of the disease, the isolation process is accentuated due to the growing loss of autonomy and the appearance of more severe behavioral symptoms. Also, the greater the severity of the behavioral disorders, the greater the need for professional care.[9] Moving to a long-term care institution causes patients to lose their orientation and break up their social networks: subjects lose their family spaces, habits, properties, and they are expelled from their community. All these factors concur to cause depression, apathy, loneliness, and an increasing loss of social and communication skills.

Hence, with the emergence of socially assistive robotics (SAR),[10–12] a new research field that has been increasing in

recent years that is dedicated to the design of social robots to interact with people for a well-defined care purpose, we can deal with this type of cognitive impairment[13] as with dementia. Studies presented in Ref.[14] show that by using a biomimetic robotic system some patients improve their cognitive attention, their cortical neurons activity, their feelings, and their ability to overcome stress. In addition, patients need less supervision while interacting with the robot and, consequently, their caregivers reduce their stress levels.

Robotics[15] is getting greater attention nowadays as a promising field to support older adults with a range of different activities and to address the challenges associated with aging, enabling them to live independently in their homes. Patients with dementia generally prefer small robots with human/animal traits, but also express some rejections toward a robot conceived as a substitute for human care provided.

Currently, researchers have focused on developing SAR[16] more skilled and versatile that increase commitment during therapeutic activities.[17] With respect to cognitive training, there has been a considerable amount of literature[18] documenting the positive effects of these types of interventions on the cognitive functioning of older adults.

Research[19] has shown that robots can successfully be included in therapeutic regimens for the elderly. Their effects can include positive health impacts, decreased stress and improved mood, decreased loneliness, and better communication with others.

There are similar reviews that base their study on the assistive social robots in older people[20] and the use of social commitment robots in the care of elderly PwD.[21] Therefore, the objective of this study is to present a review of the state-of-the-art of social robots in elderly people, either healthy or with dementia, taking into account the last 10 years, from 2007 to the present.

Methodology

The scientific databases were used for the review: Google Scholar, Science Direct, IEEE Xplore, and PubMed. The key terms introduced in the search engines of these databases are: "robot" AND "social" AND ("dementia" OR "ageing" OR "elderly" OR "old"), both in Spanish and English. These terms are searched in Abstract/Title/Keywords, from 2007 to the present. *Table 1* shows the search strategy used in this research.

The selection process of the articles was done by reading the titles and abstracts of the results obtained; the articles were classified by reading their abstracts as well as the whole article when required.

The selection criteria to take into account to classify the articles were the following: (1) Clinical studies of application to elderly people with or without cognitive impairment. (2) Studies where the goal of the robot is the improvement of support or social assistance. (3) Those studies aimed at a specific training, either physical or cognitive, are eliminated. Those about psychosocial support are chosen in a nonspecific manner. (4) Studies aimed at the general population, which are not specific for the elderly population, are eliminated.

All articles repeated in more than one database will be deleted. The diagram used in the search can be seen in *Figure 1*.

Of the 96 publications found, 29 were duplicated or with an irrelevant title for this research, the remaining 65 were read and analyzed to see their abstracts, which were of interest, resulting in 38 documents, which gave rise to relevant contributions. Then, in the following section, the most relevant works found are shown.

Results

Assistive robots[22] for older people offer important contributions to promote aging,[23] since they provide help to users through social and physical interaction. The idea is that

Table 1. Search Criteria in Different Databases

KEYWORDS/DATABASE	SCIENCE DIRECT	GOOGLE SCHOLAR	PUBMED	IEEE XPLORE
Robot AND cognitive impairment	"abstract, title, keywords"	"abstract, title, keywords"	"title/abstract"	"abstract"
Robot AND Dementia	"abstract, title, keywords"	"abstract, title, keywords"	"title/abstract"	"abstract"
Robot AND social Support AND old	"abstract, title, keywords"	"abstract, title, keywords"	"title/abstract"	"title/abstract"
Robot AND social AND dementia	"abstract, title, keywords"	"abstract, title, keywords"	"title/abstract"	"abstract"
Robot AND social AND aging	"abstract, title, keywords"	"abstract, title, keywords"	"title/abstract"	"abstract"
Robot AND dementia care	"abstract, title, keywords"	"abstract, title, keywords"	"title/abstract"	"abstract"
Robot AND dementia AND aging	"abstract, title, keywords"	"abstract, title, keywords"	"title/abstract"	"abstract"
Robot AND dementia AND elderly	"abstract, title, keywords"	"abstract, title, keywords"	"title/abstract"	"abstract"

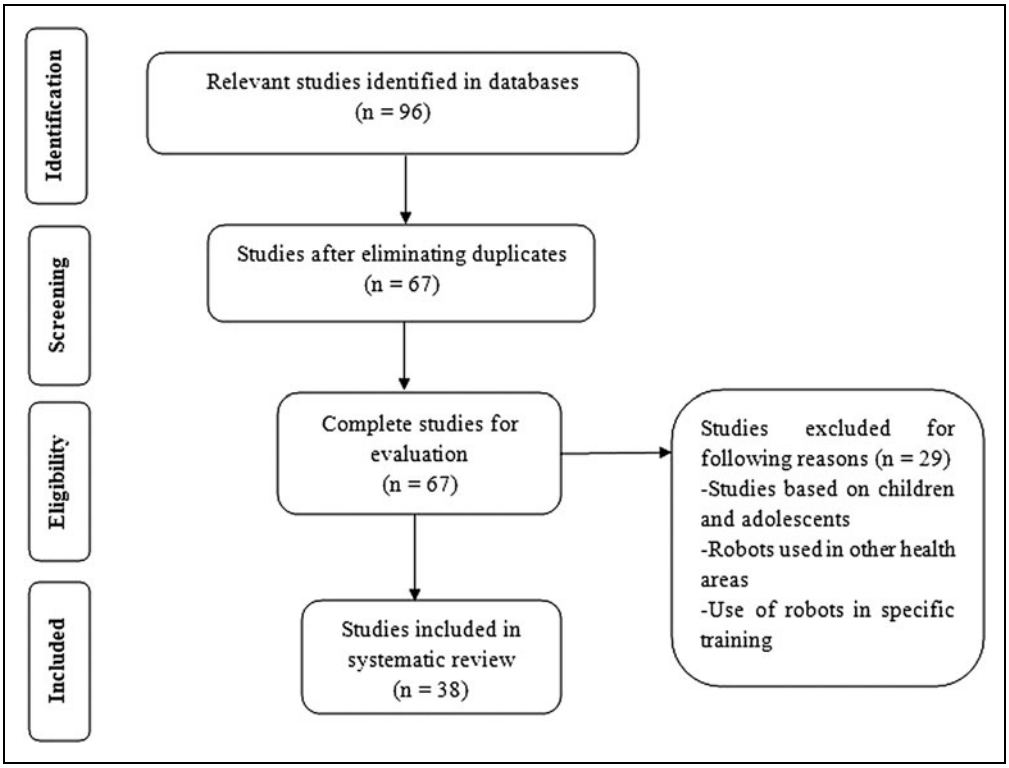

Fig. 1. Flow diagram used in literature review.

service robots can be perceived by the user as social entities with communication capabilities designed to facilitate daily activities and, therefore, support independent life.[24]

In the last years, many projects[25] have addressed the use of robots to support the aging of older people. Research in the technical community has begun to identify specific needs and values that future robotic technologies could support the elderly population.[26] Some of these include support in home management; maintain personal and domestic supply; monitor and provide ambulatory support; and provide communication and social interaction. Studies on social robots[27] in medical care focus on care robots that help older people work independently in basic activities and have mobility, such as household maintenance, and provide security by decreasing stress for the family or caregivers. Social robots[28] such as PARO,[29] Hobbit, and PaPeRo (see *Fig. 2*) are used in care centers for elderly to evaluate the social effects among the elderly and improve their quality of life in terms of loneliness, isolation, and depression.

There are other social robots such as NAO, KASPAR, AIBO, and iCat (see *Fig. 3*) that provide social support, commitment, and independence to people with special needs. Therefore, people with cognitive impairment constitute a group, which can benefit particularly from healthcare robots.[30] Currently, these robots are being designed to achieve a psychological and physiological improvement of the cognitive impairment in the elderly and allow them to become more independent.

LITERATURE REVIEW

In the review of literature,[7,26,30–33] we find studies that base their research on social assistance robots for elderly people with or without dementia. *Figure 4* shows the relevant article statistics found in the last 10 years.

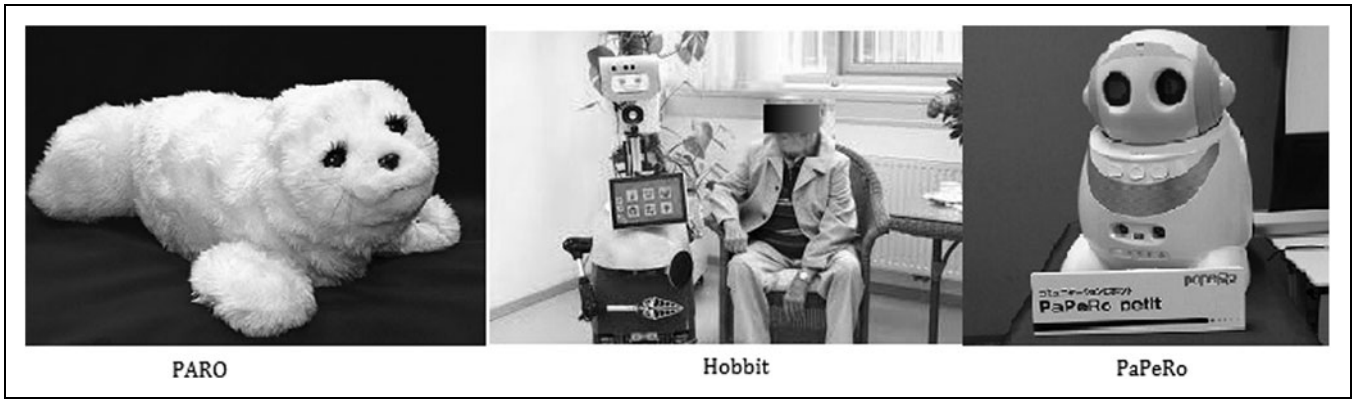

Fig. 2. Social robots: PARO, Hobbit, and PaPeRo.

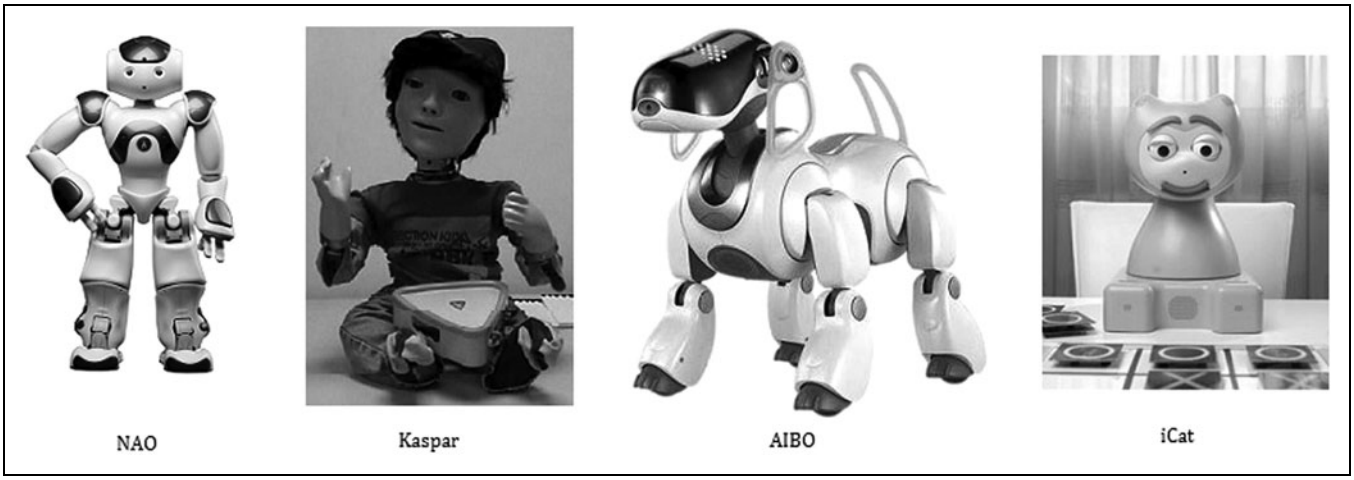

Fig. 3. Social robots: NAO, Kaspar, AIBO, and iCat.

Out of a total of 42 articles found, 22 belong to journals, while 20 are conference articles. The most important articles provided to us are from the years 2012 and 2013, the graph shows us an increase over the years, and then from 2013, there is a slight decline in the relevant publications of the articles, which amounts to years 2016 and 2017.

In Ref.,[31] the study offers an overview of the progress in developing a socially assistive home robot companion for elderly people with mild cognitive impairment (MCI) living alone at home. The spectrum of required assistive functionalities of such a robot companion is broad and reaches from reminding functions (e.g., taking medication) and cognitive stimulation exercises via mobile videophony with relatives or caregivers, up to the detection and evaluation of critical situations such as falls.

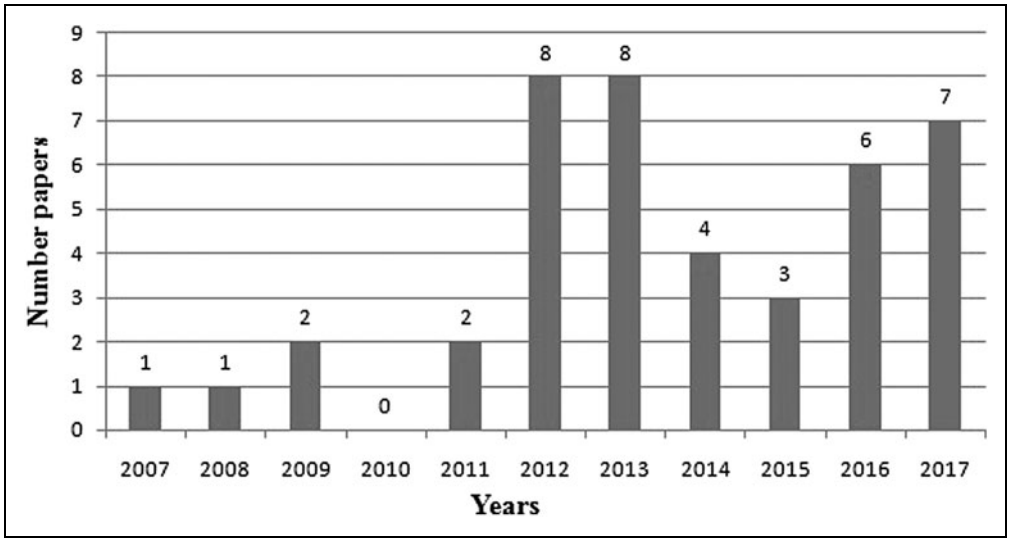

Fig. 4. Relevant articles' statistics found in the last 10 years.

The study in Ref.[32] proposed the use of a communication robot for 8 weeks in elderly women living alone. During the time of connivance with the robot, the saliva cortisol level was decreased, nocturnal sleeping hours tended to increase, and the difficulty in maintaining sleep tended to decrease. In conclusion, it was shown that living with the communication robot was effective for the improvement of cognitive function, particularly executive and memory functions, in elderly women living alone. This is the first study that demonstrates favorable cognitive results using a communication robot in the elderly.

In the study in Ref,[33] we describe on the feasibility and usability of a mobile robot to help older adults with dementia (OAwD) in activities of daily living (ADL). In this case, the teleoperated assistive robot helps a group of OAwD to prepare a cup of tea in the kitchen. The preliminary result of the research shows that the robot has an enormous potential to help OAwD in ADL.

In the study in Ref,[34] we describe the deployment of a socially-assistive robot (Matilda)-based multilayer service architecture to support PwD in home-based care. The results show that by combining generalized computer architecture with emotion measurement techniques, positive emotion engagement, and service personalization in its design. Matilda robot has successfully eliminated the barriers to the use of technology by elderly and, more importantly, had a positive impact on emotional well-being of the elderly,

augmenting their good memories, which finally contribute to enhance their quality of life.

Opportunities to connect families and PwD living in long-term care may now be made possible through new technologies, such as telepresence robots, and Giraff[7] is an example of this. It is a remotely controlled, mobile, human-height, telepresence robot. It is currently manufactured in Europe and is equipped with a videoconferencing system that includes a video camera, LCD screen, speaker, and microphone.

In Ref.,[7] it is seen that the Giraff, a telepresence robot, was used to connect a family member and a person with dementia as a means to improve communication between these two parties. With this videoconference, families can "virtually" visit PwD, participating in two-way conversations, with their faces appearing on "life size" video screen. There are many potential situations, in which telepresence robots could be used to support older people and promote social interaction.

In Ref.,[35] the study describes an improved telepresence robot named ROBIN as part of a telecare system derived from the GIRAFFPLUS project with the aim of supporting and monitoring older adults in homes who live alone. As result of the research, ROBIN robot was accepted in a general way, the interaction with it resulted pleasant, and the required workload was limited, supporting the idea of using it as a central component for remote assistance and social participation. They also conclude that the role of the personality appeared to be relevant for the interaction, underscoring a clear role of the service personalization.

In Ref.,[27] the study presents the main factors of social vulnerability among older people and improvements in social

Table 2. Studies of the Literature Review Related to Acceptance of Social Robots by Older People With or Without Dementia

AUTHORS	YEAR OF PUBLICATION	ROBOTS	RESULTS
Tiberio et al.[24]	2012	Telepresence robots in the interaction with elderly people affected by MCI.	Positive attitude and favorable view of the robot that could be an indication of perceived usefulness of robotic assistance.
Wu et al.[25]	2012	Humanoid robots.	Reticence toward some humanoid robots that have nonauthentic expressions.
Yamazaki et al.[38]	2012	Telenoid, teleoperated android in a residential care center for elderly with dementia	It provoked positive images and interactive reactions of the elderly with mild dementia, even from those with severe cognitive impairment.
Seelye et al.[39]	2012	Remote controlled robot with video communication capability for older adults without cognitive impairment.	Positive attitude in general toward the robot to improve their physical health and well-being, the social connection and the ability to live independently in the home
Moyle et al.[3]	2013	PARO Robot in eldercare with dementia.	Improvement in mood and social interaction.
Šabanovic et al.[19]	2013	PARO Robot in eldercare with cognitive impairment.	Provides benefits through particular modalities that vary between primary and nonprimary interaction.
			Interpretative flexibility of the robot, adaptation to individuals with different needs and levels of cognitive impairment.
Wu et al.[40]	2013	Robots to help patients with *MCI* in *ADL*	Difficult acceptance of the participants in how these highly innovative technologies could satisfy their needs related to cognitive difficulties or loneliness.
Wu et al.[41]	2015	Kompaï Robot in the care of older people healthy and with MCI.	It can recognize and synthesize voices, and navigate in unknown environments. It also remembers appointments, manages shopping lists, plays music and can be used as a video conference system.
			The participants as a whole rated this positive experience.
Jøranson et al.[42]	2016	PARO Robot effectiveness in the quality of life in older PwD.	Tactile stimulation through caresses and sample of affection for PARO. Stimulates communication with the robot and other participants.
Korchut et al.[6]	2017	General study of social robots in PwD.	Positive attitude toward the socioemotional interaction between the elderly and robots.
McGlynn et al.[43]	2017	PARO Robot in the eldercare without cognitive impairment.	Individual differences in the mode people responded to robot, both positive and negative.
			Potential to meet need for socioemotional support.

ADL, activities of daily living; MCI, mild cognitive impairment; PwD, people with dementia.

life after engaging with social robots. The results of this article indicated that social robot services can lead to the provision of service innovation in aged care and promotion of the quality of life, for older people to live socially and independently through reduction of social vulnerability. Knowing the factors of social vulnerability, social robotics experts are able to design and operate appropriate social robots for older people rather than technology push.

We found two studies[35,36] that established comparisons between robots; one of them compared the robot PARO and a toy to know which has greater acceptance among the elderly with dementia.

In Ref.,[36] they investigate the acceptance of a new robot Guide for the care of elderly PwD, in comparison with PARO that has already been successfully used previously. Guide robot is 1.6 m high, manufactured by ED Robotics Company in Seoul, Korea. It can be programmed with software applications, which currently include the ability to take vital signs (such as blood pressure) and store them in a database, entertainment (music videos, appointments, photographs), telephone calling to phone numbers using Skype, and brain fitness games. The main results of this study are the following: the residents looked, smiled, and talked to PARO more than Guide. Relatives and staff thought that PARO was more appropriate in a situation of dementia and that Guide needed to be simpler and more practical for this type of person. This confirms the need for Guide applications to be adapted for dementia care, rather than the current design, which is intended for older people without cognitive impairment.[36]

In Ref.,[37] a study is presented where they make a comparison between the robot PARO and a toy, looking for which has greater acceptance in elderly people with mild/moderate and severe dementia. The results show that the robot PARO had greater acceptance even among people who did not like animals, and their attraction was such that they embraced spontaneously. Moreover, PARO might be able to address the unmet needs of elderly people with severe dementia. The subjects in both groups showed positive emotional expressions and a tendency to laugh more in their interaction with PARO than with the toy, improving their moods. Therefore, intervention with PARO has potential to increase willingness of staff members to communicate and work with elderly PwD, especially those with mild/moderate dementia, who express their demand of communication more than those with severe dementia.

Other studies found in the review of literature, regarding the acceptance of social robots by older people with or without cognitive impairments, are shown in *Table 2*.

In Ref.,[25] the study indicated that although participants were reluctant to some humanoid robots, they did show very positive attitude toward some creative small robot with human traits. Whether a robot has a high degree of human likeness did not matter to them, instead, they seemed to be attracted by the kind of humanoid robots that somehow look different from the human being and that are creative.

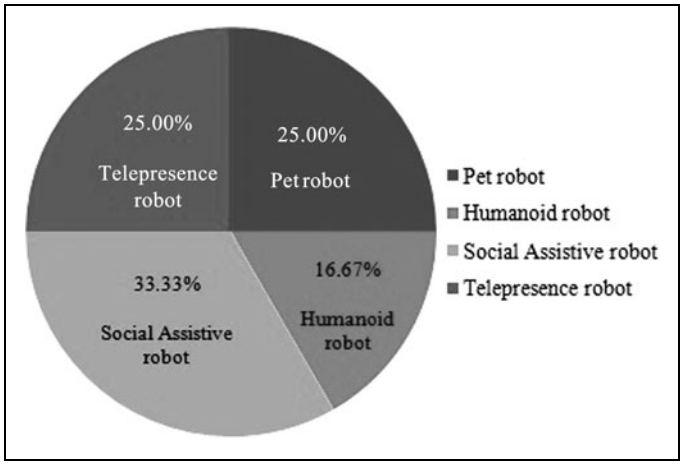

Fig. 5. Percentages of social robots classification found the publications.

In the study[19] 10 elderly people living in residences with different levels of dementia participated. It was shown that the PARO robot has direct (interacting with PARO) and indirect (engagement with other people and the environment) effects on the activity levels of the elderly with cognitive impairment.

The results obtained in the review of the literature have been presented, and *Figure 5* shows a percentage of social robots classification found in the relevant publications, taking into account those referring to the use of social robots in healthy people or in people with dementia.

For the classification of social robots found in the relevant articles, we took into account those that have the pet aspect, humanoid aspect, those that function as telepresence and social assistance robots. *Table 3* shows the classification for each type of robot.

All these social robots for the elderly PwD, healthy or with other characteristics, provide social support, assistance, and independence.

Table 3. Classification of the Social Robots Found in the Revision

CLASSIFICATION OF SOCIAL ROBOTS	ROBOT TYPE
Pet robot	AIBO, iCAT, PARO
Humanoid robot	Kaspar, NAO
Social assistive robot	Matilda, Kompaï, Hobbit, PaPeRo
Telepresence robot	Giraff, Telenoid

Discussion

One of biggest problems of the aging society is the increase in number of elderly people living alone; this causes limitations in many of ADL, which can lead to cognitive impairment and a high dementia risk. Healthcare robots in general have the potential to help meet the needs identified by staff and relatives for PwD in terms of entertainment, stimulation, and calm, improving lives of staff and residents.

In a majority projects, destined for robot design, although the explicit objective is not to replace human aid with robotic aid, there is little consideration of the social environment, in which the development of the robot takes place. Although they live alone, most of the elderly are not completely deprived of human presence. Family members, friends, neighbors, professional caregivers, and so on can be present in one's daily life. For example, in a study,[41] the high satisfaction levels with the robot contrast strongly with the low intention to use it, none of the participants without cognitive impairment expressed the intention to use an assistance robot because they did not consider themselves in the situation of needing it. Therefore, this leads us to identify barriers for the acceptance of robots in people who do not present any indication of dementia and consider adapting the robotic system to the elderly characteristics.

As for older PwD or some cognitive impairment, the acceptance level of robots is more positive, willing to use, and test robotic technologies. Pleasant and attractive activities with the use of these robots can improve the people's quality of life. Furthermore, telepresence robots can become a beneficial tool in homecare and rehabilitation services, helping older people stay in their homes for longer. They can represent an additional means to facilitate social interaction by creating a support network through a collaborative nursing staff or a relative.

Therefore, as a recommendation, it is necessary to state that to optimize the use of new robots, developers must work with social scientists, health professionals, and people user to meet the anticipated needs and help adopt better technologies.

In the literature review, where the existing publications were analyzed in the last 10 years, taking account of the studies referring to social robots use in improvement of support or social help to older people, with or without cognitive impairment, and in the exposed results, we propose as a future line and continuation of this research design, a social robot for PwD in the Zamora hospital and evaluate existing robots.

Acknowledgments

This research has been partially supported by the European Commission and the Ministry of Industry, Energy, and Tourism under the project AAL-20125036 named "WetakeCare: ICT-based Solution for (Self-) Management of Daily Living."

Disclosure Statement

No competing financial interests exist.

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Received: February 27, 2018
Revised: May 8, 2018
Accepted: May 8, 2018
Online Publication Date: August 23, 2018