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Social and Assistive Robotics in Dementia Care: Ethical Recommendations for Research and Practice

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Abstract The steadily growing number of older adults with dementia worldwide poses a major challenge for global public health. The integration of robotics into both formal and informal dementia care opens up new possibilities for improving the life of patients and alleviating the burden on caregivers and the healthcare services. However, ethical, legal and social implications should be considered early in the development of assistive and social robots for dementia to prevent slow adoption, incorrect implementation and inappropriate use. This paper delineates the ethical landscape and provides recommendations for design and use aimed at protecting users and maximizing the benefit in assisting such vulnerable population.

Keywords Dementia · Alzheimer's disease · Robotics · Ethics · Informed consent · Recommendations

1 The Global Burden of Dementia and Ageing

According to current projections, there will be over 130 million people with dementia worldwide: 1 in 85 world inhabitants [1,2]. The increasing prevalence of dementia poses a major problem for public health and the healthcare services at various levels: financial management and caregiving burden. Alzheimer's disease (AD), the most common form of dementia, is among the most costly diseases for twentyfirst century societies, with a total estimated cost of US$818 billion globally [1,3]. Such dramatic costs are primarily associated to institutional and community-based long-term care at nursing homes and other healthcare facilities [4]. Besides public finances, the burden of dementia also affects the healthcare system, and, most importantly, the affected population and their families.

The patients' capability to live independently at home, interact with their social environment and perform activities of daily living (ADLs), is progressively undermined by the disabling condition of dementia. In most countries, the primary source of care, assistance and support for dementia patients is represented by informal caregivers, mostly family members such as spouses, children and siblings. This informal caregiving service is highly time-consuming and requires great effort from caregivers in terms of physical and mental energy. Care provision frequently involves high socioeconomic and psychophysical costs for caregivers [5]. Increasing evidence shows that informal caregivers of dementia patients may experience negative psychological consequences in the form of emotional and psychological stresses, mood disturbances such as anxiety and depression and other psychological conditions [5,6]. In spite of this multi-domain burden, informal care is, in most countries, neither accounted for nor reimbursed in the healthcare economy [7].

At the level of individual patients, the burden of dementia is reported to dramatically diminish the quality of life (QoL) of older adults, and result in comorbidities such as depression and other mood disturbances as well as in an increased risk of social isolation [8,9].

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2 Alzheimer's Disease and Other Dementias

Dementia is an umbrella term used to identify a syndrome "usually of a chronic or progressive nature, in which there is disturbance of multiple higher cortical functions, including memory, thinking, orientation, comprehension, calculation, learning capacity, language, and judgment" [10]. According to the International Classification of Diseases and Related Health Problems (ICD) of the World Health Organization, in order to be classified as dementia such condition of decline in mental ability should be sufficiently severe to interfere with a person's daily life [10].

Alzheimer's disease (AD) is the most common form of dementia as it accounts for 60–80 % of dementia cases worldwide [3]. AD is a progressive neurodegenerative disorder with distinct neuropathology characterized by the presence of plaques and tangles in the brain [11]. The prevalence of AD worldwide is rapidly increasing over time as a consequence of the demographic trend known as population ageing. The probability of developing AD, in fact, dramatically increases with age. A U.S. study found that dementia affects 5 % of people aged 71–79, rising to 37.4 % of people aged 90 and older. Among this population, AD was the cause of dementia for 46.7 % of people in their 70s and for 79.5 % of people in their 90s [12]. The neurodegenerative progression of AD is described in three macro-stages—mild (early-stage), moderate (middle-stage), and severe (late-stage). Mild Alzheimer's disease ($\leq$1 according to the Clinical Dementia Rating Scale) is the stage when the patient still largely retains independence in spite of frequent memory lapses. During moderate Alzheimer's disease (CDR-2), in contrast, the patient usually needs greater care to compensate for severe impairments in the short-term memory and other functions. Finally, during severe Alzheimer's disease (CDR-3) patients require full-time care as they experience severe cognitive deficits, reduced awareness and personality change [11,13].

These epidemiological and neuropathological facts are crucial to produce technology designs that better match the specific needs of people with dementia. In particular, knowledge of the specific cognitive deficits or emotional and behavioral disturbances caused by AD and other dementias is essential to produce robotic devices that can effectively alleviate or compensate for those deficits and disturbances. In addition, knowledge of the correlation between dementia and age is crucial to take into consideration not only the specific deficits of dementia but also the general motor and learning deficits that are typical of the old age [14]. Finally, knowledge of the progressive character of AD and other dementias is fundamental to recognize the importance of adaptive designs that can cope with the progressive intellectual and physical decline of users, as well as to identify the specific technological needs of users at each stage of the disease.

3 Robotics for an Ageing World: Social and Ethical Challenges

In view of the current limited possibilities for pharmacological treatment, a promising approach in response to the emerging global crisis of AD and other dementias is the design and development of Intelligent Assistive Technologies (IATs) that compensate for the specific physical, cognitive and behavioral deficits of people with dementia, and there by, also reduce caregiver burden related to long-term care and institutionalization [15]. In fact, the massive deployment of intelligent tools for cognitive, physical and behavioral assistance as well as for monitoring and facilitated care delivery could help dementia patients to continue living independently at home or maintain independence in healthcare facilities. This would provide a *triple-win effect* [16,17] on dementia care: (I) delaying or obviating the need for institutional care, hence reducing healthcare expenditures associated with long term care and institutionalization [18], (II) mitigating the caregiving burden on family members or other informal carers [19], and (III) improving the quality of life of patients by improving their independence, autonomy, social interaction and help fulfill their wish to *age in place* [20]. The potential of IAT for dementia care has been recognized also by the European Commission, whose Information Society Policy Link (ISPL) initiative emphasized that "[…] home-based care is much more cost-effective than care in a hospital or care home. As demand for these services increases, effective use of ICT technologies and services offers an attractive alternative to the costs and disruptions of early and unnecessary institutionalized care" [21].

Robotics constitutes a major component of the IAT spectrum. Research has shown extensive applicability and effectiveness of various robotherapy interventions targeted at older adults with dementia both in the in-home and the residential setting [22–24]. In particular, four categories of robots are increasingly being implemented into dementia care: rehabilitation robots, service robots, telepresence robots and companion robots. Rehabilitation robots such as the Cyberdyne's HAL system are mainly used in physical rehabilitation and can support or assist several physical or cognitive functions of the user, especially locomotion and motor control. Service robots are primarily used to deliver direct care to patients with dementia, hence replacing or integrating the care delivered by human caregivers. For example, Fraunhofer IPA's Care-o-bot (now at its 4th generation, Care-O-bot 4), has been successfully tested to assist the specific memory deficits of older adults with dementia and assist them in the completion of a number of activities of daily living. Telepresence robots, such as Giraff and VGo, have proven effective in providing remote monitoring of adults with dementia and enabling long-distance control or interaction between patients and caregivers, often in combination

with telephony and long-range remote control. Finally companion robots such as Paro (now at its 8th generation) provide a wide spectrum of psychosocial support including the elicitation of positive (e.g. calming) emotional responses.

While assistive robots open up promising possibilities for improving the quality of life of older adults with dementia and alleviating the multifaceted burden on the healthcare system, yet their adoption remains lower-than-expected [15]. One reason for that stems from a translational gap in the cross-section of technology and healthcare [25]. This gap does not arise exclusively from current strategies for the implementation of robots into neurogeriatric care but concerns three inherent dimensions of the relationship between technological products and end-users: the societal, the legal and the ethical dimension.

In the following sections we will delineate the major ethical, social and legal implications of robotics in dementia care. This analysis aims at proactively integrating ethical considerations into the design of robots for dementia care, hence maximizing the benefits of these technologies for dementia care, preventing unintended pitfalls, and favoring their acceptance and ethically appropriate use among target users. This ethical analysis does not pretend to be exhaustive but only to identify some core issues with the purpose of guiding individual use and healthcare practice. Further research is required to expand this analysis into a general framework.

4 The Societal Dimension and the Information Gap

The low distribution and uptake of social and assistive robotics for dementia care has been ascribed to an *information gap* in the cross-sections of technology design, healthcare and society [25,26]. As stated by Kramer, this *information gap* is a major cause of the lower-than-expected acceptance of robots and other IATs among older adults with cognitive disabilities [25]. Currently, limited information is available to designers and developers regarding the specific needs, wishes, and expectations of their end-user population. Reviews report that several devices are developed without or with limited involvement of people with dementia and their carers [15]. The reason for that is threefold. First, research on the use of assistive robots among elderly and cognitively disabled users is still in its infancy and current evidence is far from being extensive, cross-culturally generalizable and theoretically systematic. In addition, methodological quality of studies has been often reported to be low [27,28]. Second, research trials that directly involve older adults with dementia or other disabilities are time-consuming and must be supported by higher-than-average research ethics safeguards. Since direct information from target users is practically difficult to obtain, prototypes are often developed in absence of extensive assessments of the users' needs, hence without systematically incorporating the views of end-users into the product design. As unmet users' expectations are a major indicator of suboptimal adoption, the lack of user-oriented approaches in product design risks to generate a vicious circle where unmet user needs cause lower-than-expected uptake which, in turn, perpetuates unmet user needs.

Third the implementation of robots among target users is subject to several structural limitations. In fact, patients learning to work with new devices are hindered by several factors including (i) memory, learning and orientation problems, (ii) limited understanding of verbal instructions, (iii) problems with execution of purposeful activities, (iv) poor recognition of audio–visual prompts, and (v) other cognitive or physical limitations. As a response to this triple challenge we recommend the establishment of platforms for knowledge dissemination, the creation of incentives for user-driven research and the promotion of user-centered functional designs.

Knowledge dissemination is a key concept to favor interaction and information sharing among all relevant stakeholders involved in the care and management of robots for dementia care, in particular: designers, software developers, hardware engineers, manufacturing companies, geriatricians, neurologists and other healthcare professionals, healthcare institutions, regulatory agencies, informal caregivers, and, most importantly, patients. Healthcare institutions and individual professionals should increase their awareness about available technological opportunities that may be beneficial for the patient and favor their introduction into care. To achieve this goal, the organization of cross-disciplinary workshops and other shared activities should be encouraged. In addition, the exploratory introduction into residential care (e.g. geriatric hospitals) could increase the perception of robots as standard care practice; hence favor the introduction also in the in-home setting.

User-driven research is a framework or paradigm according to which research is driven by the needs and wishes of end users [29]. The shift to this research paradigm is crucial to favor the development of user-centered technology designs. By producing large-scale or personalized knowledge about the needs and wishes of end-users, researchers can create prototypes whose functional specifications better match these needs and wishes. User-driven research conducted to date has identified several functional requirements that are particularly needed among elders with dementia. These include (i) user-friendly, simple-to-use and intuitive interfaces, (ii) high degree of personalisability (according to the user's preferences), (iii) usefulness in daily life. More specific functional requirements can be identified by investigating the users' perceptions about their own needs in relation to available services. A large-scale interview-based study has investigated the needs of 231 community-dwelling persons with dementia and 321 caregivers and assessed them accord-

ing to the Camberwell Assessment of Need in the Elderly (CANE) [30]. Results show that the highest proportions of unmet needs reported by persons with dementia concern the support for memory problems, the availability of information about dementia, the access to care and treatment, and the compensation for isolation and psychological distress; in contrast, the highest proportion of unmet needs reported by informal carers concern issues of memory, daytime activities and company [30,31]. In accordance with Niemeijer et al. and Robinson et al., we call for a rapid transition to a user-centered model of technology design and development where the specific needs of persons with dementia and of their carers are carefully identified, considered, and integrated into the robots' functionality [31,32]. Such a user-centered and participatory approach should be implemented at the stage of technology assessment and evaluation. A good example in this direction is an exploratory study by Heerink et al. in which researchers interviewed professional caregivers of older adults with dementia to identify a list of functional requirement perceived by them as suitable for therapy and subsequently used such list to assess commercially available robotic pets [33].

5 Informed Consent

Before enrolling people with dementia as research subjects into user-driven research, researchers have an ethical and legal obligation to obtain informed consent. This obligation also partly applies to installing and utilizing a robot both in the in-home and residential setting with the purpose of interacting with an adult with dementia. The obligation to informed consent, postulated in numerous codes and declarations such as the Declaration of Helsinki (1964–2008) and the Additional Protocol on the Convention of Human Rights and Biomedicine concerning Biomedical Research (2005), is an essential mechanism for the protection of a person's wellbeing and self-determination [34]. In the context of AD and other dementias, the problem of obtaining informed consent is exacerbated by the increased difficulty to determine whether a person has the capacity to give informed consent as a consequence of the cognitive and emotional deficits caused by the disease. Competence, in fact, is to a great extent—but not exclusively—linked to cognitive capacity.

Informed consent can be obtained from or on behalf of people with dementia in three ways: (i) directly, (ii) proactively through advanced directives, (iii) or through proxy decision making. Direct consent can be obtained when the patient explicitly shows competence and cognitive capacity, usually at the early stage of AD or in the case of mild cognitive impairment. Advanced directives are (usually written) externalizations of a person's decisions and wishes regarding future medical courses of action. Through these directives, patients at early stage of AD or other dementias can spell out decisions about their future choices ahead of time, i.e. before the progression of the disease make them incapable to make autonomous and competent choices [35]. Proxy decision making occurs when the decision involves a person other than the patient (called proxy), usually the patient's legal representative according to the local law or a person who was previously appointed by the patient. Alzheimer Europe has produced several recommendations for the obtainment of informed consent from persons with dementia [35]. Although designed for guiding research, such recommendations are largely applicable to the implementation and use of robots too. Alzheimer Europe's recommendations are articulated into seven main tasks: capacity and willingness assessment, provision of information, ongoing consent and withdrawal, capacity loss, third-party involvement, advanced directives, further use of data.[1]

At the level of capacity assessment, it is important to know that required cognitive levels vary depending on the complexity of the decision to be made. In general, a diagnosis of dementia should be considered as reasonable grounds for doubt concerning a person's capacity to consent and to justify the assessment of their capacity; however, it should never be considered alone a sufficient justification. While a person with mild dementia might be competent for many medical decisions, the symptoms at this stage of the disease could already interfere with competency for very complex situations. For any type of more advanced dementia, physicians would need to argument actively why they evaluated a patient as competent for a given decision. Cognitive testing alone may be insufficient [36]. In the context of enrolling people with dementia for research, researchers must ensure that potential research subjects agreed to participate freely and willingly after having been extensively informed about the research process and demonstrated a clear understanding of such information without undue pressure from third parties and through satisfactory responses to possible questions.

Similar external pressures should also be prevented at the level of domestic or residential use of robots. In particular, scenarios where family members or other informal caregivers *force* a patient with capacity to consent to have a service robot in the house—e.g. because they want to reduce their time-investment and caregiving-workload should be prevented. We suggest that the combination of advanced directives, behavioral observation and confirmation by proxy may offer a triple protection. A scenario where (i) a patient

[1] Our recommendations on informed consent are largely based or further elaborated upon Alzheimer Europe's report "The Ethics of Dementia Research." [35].

at the early stage of the disease makes advanced directives to the use of the device while still mentally competent, (ii) shows enjoyment and no observable sign of distress during the continuative use of the device after the disease progresses, (iii) a proxy confirms the advanced directives based on behavioral observation, should be considered the optimal model.

When providing information for informed consent purposes, researchers or healthcare professionals should adapt their communication to the patient, respond to questions, use visual and other aids if necessary, and facilitate the communication of the decision by the patient. If consent is being sought for the purpose of enrollment in research, it should be ensured that potential participants with dementia understand the difference between treatment and research, emphasizing the fact that the direct objective of research is not to benefit the individual participant. If consent is being sought for the purpose of installing and using a robot in the patient's home, it must be ensured that the user understands the basic functionality of the robot and its potential usefulness for their daily life.

A crucial requirement of research involving dementia patients is that informed consent should be obtained in multiple occasions during the study. Due to the progressive and mood-changing character of the disease, patients may revoke their initial consent and must be free to withdraw at any time. In the research setting, researchers should monitor possible signs of distress resulting from participating in the study and if necessary ask the participants if they wish to withdraw from the study. In the implementation setting, caregivers should be attentive to signs of distress associated to the use of the robot or to its presence in the house.

If a research participant with dementia loses capacity during the study, and did not express prior to the study a wish to continue, should be withdrawn from the study. For this reason, clauses regarding the continuation of participation as well as regarding future use of data should be early included in the informed consent process when the person is still competent. In contrast, in the case of using a robot in the in-home or institutional setting, the use can continue after the patient loses capacity if the application provides a recognizable therapeutic or assistive benefit and no signs of distress are observable.

Ideally, third parties, especially spouses or partners, should be involved in the consent process. If the third party opposes the will of a person with dementia who has the capacity to consent, their opposition is not sufficient to override the will of that person. To prevent such conflicts and to avoid risks associated with sudden loss of capacity, the practice of writing advanced directives to externalize future preferences should be encouraged. While in the context of research enrollment such directives should state explicitly whether the person with dementia would or would not like to take part in research, in the context of technology use they could contain more specific preferences about everyday life and social activities: instead of either yes-robot or no-robot choices, users should be able to externalize what features, functionalities or activities of the robot they wish to continue or interrupt.

In the research context, consent forms should include explicit opt-out clauses about the re-use of their records for future studies. In the in-home and institutional setting, data should be only collected from users for the purposes that have been clearly explained to the user and to which the user has consented. Any additional use of the data should require additional consent. For example, monitoring data collected by telepresence robots for the purpose of increasing safety and conveying the presence of caregivers should not be used for additional (research, marketing etc.) purposes unless (i) the person with dementia has previously and explicitly consented to this further use, (ii) the reuse of that information can provide a recognizable therapeutic or assistive benefit for the patient.

It may be observed that, from the perspective of research, the promotion of user-driven studies and the strict criteria for consent in research delineated above pose an ethical dilemma. In fact, while large-scale enrollment of patients with dementia is highly desirable to maximize the benefits of robotics for people with dementia worldwide, strict procedures for informed consent limit and strictly regulate this enrollment process among individual participants. The major ethical challenge is to resolve this dilemma by promoting user-driven research in a context of rigorous application of ethical standards for informed consent.

6 Privacy and Data Security

Privacy is originally described as the right to be let alone [37]. Within the context of social robotics for dementia it is crucial to determine what specific components of the right to privacy are at stake. Niemeijer and Hertogh proposed to distinguish four types of privacy: (i) informational privacy, (ii) physical privacy, (iii) attentional privacy, (iv) and decisional privacy [38]. Informational privacy pertains to the capacity to seclude sensitive, confidential or private information. Physical privacy pertains to the capacity to demarcate one's personal physical space. Attentional privacy pertains to the capacity to retain one's attention from unsolicited prompts such as mail or telephone calls. Finally, decisional privacy pertains to the ability to choose a particular course of action without intrusion or interference from other agents. Informational privacy is particularly relevant in the context of telepresence robots. Robots such as Giraff and VGo may create a problem for informational privacy since they can be used as a 24-h videosurveillance and

recording system. Following the EU Data Protection Directive [39], we recommend that the collection and usage of visual information from elderly people with dementia meets the conditions of transparency, legitimate purpose and proportionality.

Transparency implies that the patient who is controlled is aware of being monitored and has given informed consent both to the installation of the robot and to the monitoring process. In addition, it also implies that the data collector and manager (e.g. the responsible informal or formal caregiver) has stated why data are being collected and processed. This procedure may be perceived as redundant from the perspective of family members whose goal is to increase safety, interaction, or conveying a sense of personal presence. However, it serves to prevent illegitimate third parties from managing those data. Exceptions should be allowed for monitoring interventions that prevent patients from being harmed (especially patients in the moderate to severe stages of the disease), following similar regulatory standards to those regulating monitoring technology for severely ill and incompetent patients in residential care (e.g. Intensive Care Units). In addition, data collectors should be reasonably informed about the potential risks associated with the illicit access to the data by malicious agents. Legitimate purpose is when the monitoring is performed for a specific purpose that is in the best interest of the patient and to which the patient or caregiver has previously consented. Legitimate purposes for videomonitoring include increasing safety, reducing risks and facilitating communication. Illegitimate purposes, in contrast, may include unauthorized surveillance or spying. Finally, the principle of proportionality requires that the videomonitoring is not disproportionate to the real therapeutic, assistive or emotional needs of the patient. For example, a non-stop video surveillance of an otherwise independent patient with mild to moderate dementia might not be proportionate to the needs of the patient and their condition.

Further ethical and legal investigation is needed within a twofold framework. In particular, in the context of criminal law, proactive and rigorous conditions should be established for determining legal responsibility and culpability in both patients and robots. In emerging scenarios where the person with dementia has lost the capacity to consent, neither the patient nor the robot can be considered fully competent agents, hence fully responsible and ultimately culpable for their actions. To face these scenarios, unequivocal standards are required. For example, in case the robot harms the user in a non-programmatic way or the user harms another agent through the robot, unequivocal standards of accountability, responsibility and liability for both the robot and the user will be needed. Interdisciplinary work at the intersection between roboethics, neuroethics, criminal law, and forensic psychology should be encouraged to produce those standards.

7 Safety, Beneficence, Non-Maleficence and Autonomy

Good system safety norms require that a robot used in health care or as a commercial application is safe and that its use does not cause any increased risk of harm for users. Safety should be achieved through scientific, technical, and ethical-social strategies of risk identification, risk analysis, and elimination, control, or ongoing management of risks throughout the life-cycle of the robot and its activities. In ethical language, safety largely translates into the concept of non-maleficence, i.e. the principle of avoiding (preventing and not-inflicting) harm. This ethical principle is usually paired with the principle of beneficence, i.e. the principle of promoting what is in the best interest of the user [40]. In the context of robocare, the principles of beneficence and non-maleficence require a careful assessment of the balance between therapeutic, assistive or psychosocial benefit, on the one hand, and potential risks or distress, on the other hand. The promotion of the best interest of the user would also require a careful and continuative evaluation of their positive and negative experiences, with the knowledge that the user's preferences and experiences may change over the progression of the disease and that their ability to communicate those preferences and experiences may decrease over time. In addition to safety, data security must be taken into account too. In fact, the more data the robot is capable to collect and process, the higher the risk that such data can be used for unintended purposes, including purposes that are malicious or detrimental for the user and/or third parties. Data security standards are particularly relevant for monitoring and tracking devices, as well as for devices that can access and process personally identifiable and medical information of the users.

Robotic interventions that are in the best interest of the patients are those that prevent the patient from being harmed, and protect or promote the patient physical, cognitive, emotional and social wellbeing. Preventing harm and protecting or promoting wellbeing must be the common goals of robotic applications in dementia care, in ways that are specific of and appropriate to each type of robot. For example, telepresence robots are mainly designed for preventing harm, rehabilitation robots for promoting physical and cognitive wellbeing, and social or companion robots for emotional and psychosocial wellbeing. As previously stated, under specific circumstances, the best interest of the patient may reasonably justify partial exceptions to competitive moral rights such as privacy or consent. For example, when a robotherapy intervention supports life-maintaining functions in a patient with advanced dementia, this intervention may be delivered also in absence of explicit consent from the patient or the proxy to pursue the best interest of the patient—unless previously rejected by the patient via advanced directives or assessed as futile by the local medical team and ethics committee.

Some authors have argued that the use of robots in dementia care, especially robotic pets and other companion robots, raises the moral and psychological risk of making patients more infantile and dehumanizing care by reducing human interaction [41,42]. These risks could be avoided by increasing the awareness and active decisional role of patients. The patient should not be overridden but constantly included in the decision making process about the use of a new robotic application. This will not only reduce the risk of infantilization but also—and most importantly, promote their perception of the robotic application as empowering, hence as a valuable instrument for the promotion of their autonomy and independence.

8 Justice, Equity and Fair Distribution

Until now, social justice and distributive justice have not been considered as primary concerns in the introduction of robotics into healthcare. Neither attaining fairness, nor applying substantive principles in allocating robotic applications are an easy task. A one-size-fits-all policy could be inadequate because of the specific functional characteristics of each application, and the fluctuation in the costs for their provision caused by the current level of maturity of their market. Moreover, the healthcare systems of different countries follow different principles of justice and answer to dissimilar needs surging from social structures and diverse cultures in each country. *Universal access by fair opportunity* to assistive technologies should be the target in the long run, but in the early stages their fair distribution has to be prioritized.

Distributive justice is not a matter of chance or plain equality. Its principles are guidelines for providing rightfulness, fairness, and redress in institutional settings. One option for healthcare institutions and robot manufacturers to attain these principles is to curb the costs by promoting the development of low-cost robots technologies. To this purpose, the dissemination of open-source initiatives for affordable devices such as the OpenBionics (http://www.openbionics.org/) should be encouraged.

From a regulatory perspective, robots for dementia are often in a gray zone between the regulation of medical applications and that of general ICT applications. A striking example is Paro, who is classified as Class 2 medical device by the U.S. FDA regulation but not in the EU. Therefore, a principle of justice in disseminating innovation should take into account the dual nature of these robot types as well as the differences in local regulations. Emphasizing each of these aspects—respectively the medical and the commercial—has both regulatory advantages and disadvantages. A privileged focus on the medical aspects would favor the application to care robots of standard medical practices, the implementation of safeguards that are specific for medical applications, and the development of more welfarist plans for technology access and distribution. As a downside, it could slow down the increase in performance (as implied by the Moore's law) as well as the price fall over time. In contrast, a privileged focus on the commercial aspects would accelerate the decrease in price and increase in computational power of future application. As a downside, however, it would decrease the level of safeguards; hence increase the vulnerability of future applications to technical, ethical, legal, and social risks.

When developing robotic applications for dementia it is fair *to recognize* the special needs of patients, their differences from healthy users, and the fact that they are not responsible for their health conditions. Some corrective measures could help reduce inequality and provide redress such as the promotion of experimental settings with assistive robots in state owned retirement houses, the establishment of State incentives for developing better technologies (when is the case, for example in the EU), and the promotion of user-centered research involving patients and caregivers. Patient well-being should not exclusively rely on their economic resources.

9 Conclusions

Assistive robotics opens up the prospects of a triple-win scenario for the global management of the public-health crisis posed by dementia and population ageing. However, the goals of robotics-assisted dementia care could remain unachieved if social, legal and ethical questions are not addressed. In this paper we delineated the ethical, legal and social landscape of robotics for dementia care. Further interdisciplinary research is required to extensively address each specific issue and develop a comprehensive framework to maximize the benefits of robotics-assisted care while minimizing the unintended consequence. In particular, further cross-cultural empirical research involving seniors with dementia and their caregivers is required to better inform technology producers about the specific needs of this vulnerable target population. In parallel, translational research at the intersection between robotics, geriatrics, gerontology and the nursing sciences should be conducted to increase the implementation and uptake of robotic applications in dementia care. Finally, further research in bio- and neuroethics is required to orient and promote the ethical development and responsible application of future applications.

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