Do Socially Assistive Robots Help in Caring for Elderly Patients with Frailty or Mild Cognitive Impairment?

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ABSTRACT

The burgeoning elderly population, set to double by 2050 worldwide, will place immense demand on provision of elderly care. The mismatch in supply and demand of social care, made worse by the recent Covid-19 pandemic, has heightened the search for viable adjuncts to social care. The purpose of this project is to explore the possible role of socially assistive robots (SAR) in care of elderly patients with frailty or mild cognitive impairment. In the past decade, SAR has emerged as a possible contender for assisted care. Through interviews with frontline NHS clinical stakeholders and review of research articles, this project has identified the barriers, limitations to SARs and ethical challenges that needs addressing before the mainstream implementation of SARs to assist in care of the elderly. It is imperative to establish SARs' safety profile and effectiveness through end-user inclusive, robustly designed, randomized clinical trials addressing the contextual factors of SAR implementation. Particular care and attention should be devoted to ensuring that future studies are enrolled with adequate numbers of participants to achieve statistically significant outcomes of SAR safety and acceptability. With paucity of social care workers and an ever-increasing population of older age adults, SARs will have a potential role to play in supporting the independence and dignity of elderly people in their own environment. SARs offer hope amidst the current social care despair, and further research is key to their eventual success in aged care, which may be years away from reality.
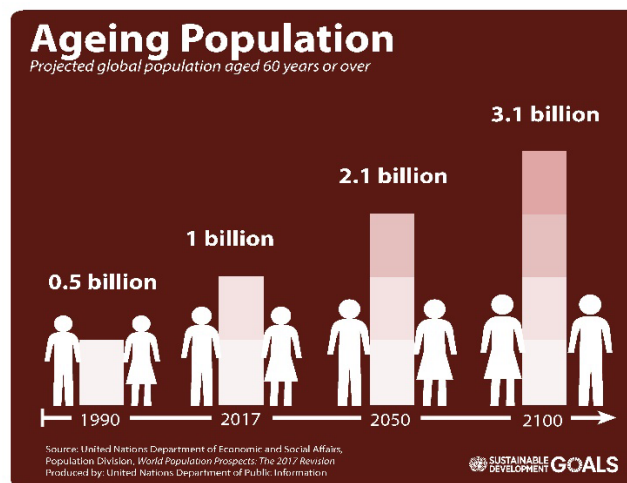
Introduction

Figure 1. Global burden of ageing population (adapted from www.un.org)

The population is undergoing a demographic shift worldwide. The adult population aged 60 years and above is expected to rise from 21% in 2015 to 33% by 2030 (United Nations, 2017). In terms of numbers, the population of this age group will accelerate from 900 million in 2015 to 2.1 billion by 2050 (United Nations, 2015).

Contrasting these figures with the number of health and social care providers shouldering the burden of looking after this aging population, the ratio of social workers to elderly adult is projected to decrease from 7:1 in 2015 to 4.9:1 by 2030 (United Nations, 2015). This mismatch between care givers and care needers will place enormous burden on all aspects of health and social care. In addition to the impact of paucity of carers for help with physical needs, the effect on loneliness remains significant. Over half of people above the age of 75 live alone (Thomas, 2015) and around 17% of them see family, friends, or neighbours less than once a week (Victor et al, 2000). A meta-analysis (Holt-Lunstad et al, 2010) showed that the impact of loneliness and isolation carries the same mortality risk as smoking 15 cigarettes a day (Abdi et al, 2017). It is worth remembering at this juncture, that social care is a labour-intensive industry with a globally shrinking workforce. This fact coupled with an increasingly aging population is fraught with familial, societal, and economic burden due to burgeoning numbers of adults with frailty and mild cognitive impairment (MCI) (Beuscher et al, 2017).
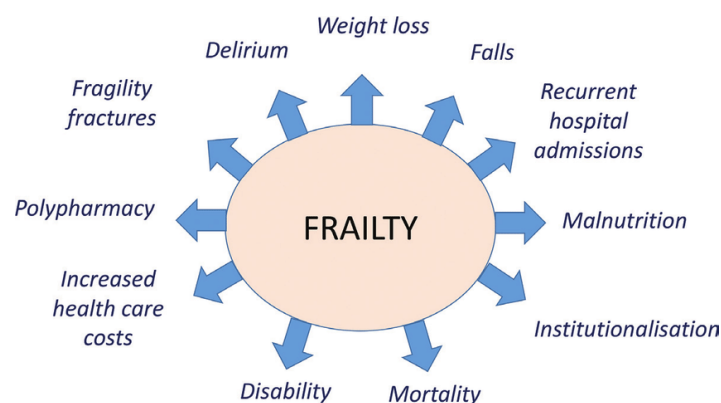
Frailty and its consequences

Figure 2. Frailty and its consequences (adapted from Patel et.al, 2017)

Frailty is a situation in which an elderly person is seen to be at increased risk of poor clinical outcomes, such as development of disability, dementia, falls, hospitalization, institutionalization, or increased mortality (European Innovation Partnership, 2012). In the identification of frailty, which is composed of many dimensions such as the decline of physical/cognitive condition or malnutrition, the elderly person does not have the luxury to notice the development of an unhealthy situation. Hence, it is extremely crucial to prevent the negative consequences of frailty. Since its initial discovery, frailty has become a highly prevalent phenomenon and the percentage of community-dwelling adults exhibiting early features of frailty range from 30.4% to 44.9% across ten European countries (Santos-Eggimann et al., 2009).

Frail elderly patients with multiple morbidities exhibit a clear and present danger to the healthcare system due to their need for recurrent hospitalisations (Patel et al, 2017). Unfortunately, in most cases, inpatient admissions prove detrimental to their physical and mental wellbeing. Being removed from their own comfort zone, these older persons not only become delirious but also at high risk of acquiring hospital-borne infections and falls (Patel et al, 2017). This event initiates a vicious cycle of further deconditioning, worsening frailty, rapid cognitive decline, which leads to increasing mortality. The Hippocratic Oath, 'primum non nocere' or 'First, do no harm' is put to the ultimate test.
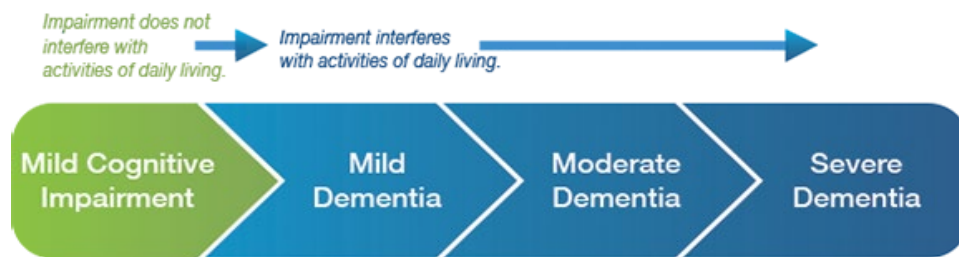
Dementia and MCI

Figure 3. Spectrum of memory impairment (adapted from www.mccare.com)

Dementia, on the other hand, refers to an umbrella term for conditions that are often characterized by a subsequent decline in many domains of cognitive function that affects a person's ability to perform activities of daily living (ADL). It varies from mild cognitive impairment (MCI) which refers to a compendium of clinical syndromes that reflect a worsening cognitive performance and neuropsychological assessment, to Alzheimer's disease the most common type of dementia (Bosmans et al., 2020). Though MCI does not significantly impact ADLs, it is considered to be a risk factor for worsening cognitive and functional decline leading to 5-15% annual risk of dementia (Alzheimer's Association, 2020). It is worth mentioning that about 50% of people suffering from MCI remain stable for up to 5 years and in some cases even improve over time (Dunne et al., 2021). This fact provides a golden opportunity to maintain the status quo by caring for and / or assisting these patients in their own familiar environment. Unfortunately, this possibility is increasingly made harder by the challenges encountered with dearth of social care infrastructure and care personnel in the community. The most vulnerable elderly citizens are left to fend for themselves with the only option to turn up to the emergency department at every opportunity during times of need and help (Morato et al., 2021).

Globally, healthcare is in crossroads. In several countries, years of underinvestment, creaking infrastructure, shortage of personnel coupled with inflation and cost of living crisis threatens the very foundation of healthcare being offered free at the point of use. Nevertheless, in every adversity lies opportunity. The lack of adequate carers in the community coupled with the dire need for home help leads to a sense of urgency for exploring the use of intelligent robotic systems that can enable older people to remain safe, maintain dignity and prolong their independence in their own familiar environment (Heerink et al., 2010). In addition, these technologies should improve older adults' physical and mental wellbeing and promote social inclusion whilst facilitating a meaningful contribution to the community (Broadbent et al., 2009).

Socially assistive robots (SARs)

SARs are an emerging form of assistive technology encompassing all robotic systems capable of aiding the user in social interaction (Pino et al, 2015). This technology is continuously evolving and has become increasingly promising in the last decade. SARs have been shown to assist physical care delivery for older adults thereby demonstrating the potential to reduce the burden on formal and informal caregivers (Macis et al, 2022). Prominent amongst these SARs are social companion robots, which are designed to forge a close interaction with humans in order to reduce loneliness and thus mental stress. When customised to the requirements of older people with MCI or frailty, SARs may allow elderly people to maintain functionality and live at home for longer. (Lukasik et al, 2021)

Putting people before process and technology is an essential element of ensuring the success of digital transformation in healthcare. However, ensuring the safety of the older patients in their own homes is of paramount importance. Taken from Asimov's novel, I, Robot, the first law of robotics states that 'a robot may not injure a human or, through inaction, allow a human being to come to harm'. (Asimov, 2018). Hence, soliciting the views of principal stakeholders (patients, carers, families, and healthcare workers) on SARs are fundamental to conceive an acceptable and useful purpose in frail elderly patients and those with MCI. This project will explore

in-depth the potential use of SARs as an adjunct to standard care for elderly patients with frailty or MCI. The objective will be realised through first-person accounts from stakeholder interviews namely the frailty and dementia specialist nurses, patients, carers, and families' attitudes and experiences through research article reviews.

Types of SARs

Socially Assistive Robots are adept at completing a complex series of physical tasks with the addition of a social interface capable of convincing a user that the robot is a social interaction partner. SARs have been categorised into two operational groups: 1) service robots and 2) companion robots. Service robots are tasked with aiding activities of daily living (Care-O-Bot4, Pepper) (Abdi et al, 2018). Companion robots, by contrast, are more generally associated with improving the psychological status and overall wellbeing of its users (Paro) (Abdi et al, 2018).

The quest to answer the research question began with interviewing two key stakeholders who have more than two decades of frontline NHS experience in caring for elderly patients with frailty and mild cognitive impairment. A Dementia Clinical Nurse Specialist and Clinical Frailty lead in a busy acute District general hospital in an outer London suburb. A virtual interview was held with those two frontline stakeholders to discuss the impact on the elderly adults' morbidity and mortality due to change from a home environment. The clinical stakeholders reminisced from their experience that the hospital environment is unsafe and increases the incidence of delirium, infection, and falls. It is a well-known fact that frail elderly patients perform poorly when hospitalised. For example, individuals with frailty who are discharged after short ambulatory stay have increased mortality and community resource use (Keeble et al., 2019) FIG. The strategy shifted to discharging patients early from the hospital, but it led to a vicious cycle of readmission, functional decline, institutionalisation, and death (Krumholz, 2013). There is little doubt that the best-case scenario for frail elderly patients is to remain safe and active in their own familiar environment with appropriate care support (Keeble et al, 2019). Unfortunately, this outcome is difficult to achieve due to the unavailability of carers and this adversity opens up an opportunity to explore if socially assistive robots could assist caring for these vulnerable patients. It is noteworthy, SARs research is still evolving, and the success will depend on the acceptance of SARs and awareness of barriers, limitations, and ethical challenges of SARs.

SAR Research: Past and Present

So far, the primary domains where SARs are researched belong to healthcare (Leite, 2013) and mostly in supports tasks aimed at helping vulnerable people in processes of restoration or maintenance of health. (Mataric, 2017). Although SAR's widespread implementation is still far from being a reality, significant European research initiatives (Rabbitt et al, 2015) and pilot projects already being launched evince institutional prospects to incorporate these technologies in (healthcare) assistive concepts.

The Accompany Project (Accompany, 2011) looked at using a robotic companion as a part of an intelligent environment for frail elderly patients to live independently at home by providing physical, cognitive, and social assistance in activities of daily living. It is a multinational study (UK, the Netherlands, and France) which explored Care-O-Bot 3 service robot platform designed to look at user acceptance and user requirements and the learning from this project is fed back to make SARs better suited to user demands and preferences. The assistance to the user was provided through socially interactive, acceptable, and empathic interaction building on computational models of social cognition and interaction. It is obvious that for SARs to be acceptable, a multidisciplinary approach with incorporation of end user's requirements is key to successful acceptance and implementation.

The CARESSES Randomised Controlled Trial (exploring the health-related impact of culturally competent artificial intelligence embedded into socially assistive robots and tested in older adult care home) was designed to explore the value of culturally competent socially assistive robots in improving the psychological wellbeing of older adults residing in care settings (Papadopoulos et al, 2022). Until recently, the evidence in favour of SARs in improving loneliness, companionship, and help with cognitive training though promising was insignificant due to small nature of the studies and use of a pet robot. It is noteworthy that the CARESSESS trial is the first study to use a cross-national trial design incorporating the cultural differences and explored the impact on

enhancing the health and wellbeing of older adults. The patients were randomised into the Experimental Group or Control Group 1 who received a Pepper robot for up to 18 hours across two weeks. Two versions of the CARESSES artificial intelligence were tested: a fully culturally competent system (experimental group), and a more limited version (Control Group 1). Control Group 2 (Care As Usual) participants did not receive a robot. Three six residents completed the Quantitative outcomes of interest which included: health-related quality of life (SF-36), loneliness scale (ULS-8), and perceptions of robotic cultural competence (CCATool-Robotics). Though this study did not show statistically significant changes in health-related quality of life, there were large and significant positive score changes in emotional wellbeing subscale in Experimental and Any Robot Group compared to Care As Usual Group even after an 18 hour/ day, 2-week period with Pepper Robot. The confounding variables were not explored, and this can impact the validity of this RCT. Nevertheless, this CARESSES Trial represents one of the largest attempts to explore the impact of autonomous social robots on the health and wellbeing of older adults in social care settings, and the first to assess the role of culturally competent systems.

The Emergence Network, led by a consortium of robotic scientists in the University of Nottingham, Sheffield, Hertfordshire, and Heriot-Watt provides a world class multidisciplinary platform for researchers, health and social care professions, service users, regulators, and policy makers to explore how SARs could be used to support people to better manage age related ailments like frailty and help healthcare practitioners to develop timely interventions from the data and information obtained (Emergence, 2015).The Emergence network is a comprehensive program that allows elderly people to self-manage their frailty by supporting behaviour change and help with activities of daily living and social isolation. Emergence Network is an ongoing project which focuses on identifying the needs of older adults, which could be assisted by SARs.

Acceptance of SARs by Older Adults: Qualitative and Quantitative Reviews

An increasing number of studies have focused on technology acceptance of SARs (Flanorder et al, 2012 & Broadbent et al, 2010) because it has been widely agreed that the significance of SARs can only be realised if people accept, embrace, and use this technology (He at al, 2022). A systematic review involving 23 articles of quantitative evidence of older adults' experience with and perceptions of the use of socially assistive robots in aged care by Vandemeulebroucke et al. looked at six themes which included, intention to use SARs, general attitude toward SARs, feelings about SARs, perceived usefulness and ease of use of SARs, tasks of SARs and their appearances. The results revealed that older adults are relatively open minded about SARs, generally feeling comfortable with at least some aspects of them and intend to use SARs in the future especially for physically assistive functions. The review also noted that older adults preferred SARs to carry out dull and heavy tasks such as fetching objects and working in house with physical embodiment perceived as an important aspect of their possible use. The main drawback of this quantitative review with impact on its reliability is the manner in which the study's design precludes the discussion of ethics and social dimensions of SAR in aged care. In addition, there were important limitations to note, the primary one being the limited number of subjects in the study, short duration of exposure to SARs and gender imbalance in favour of female subjects, which can influence older adults' reactions to robots. (Forlizzi, 2007; Mutlu, Osman, Forlizzi, Hodgins, & Kiesler, 2006).

Vandemeulebroucke and colleagues also looked at a systematic review of qualitative evidence of older adults' experience and perception of socially assistive robots in aged care settings through a literature search involving 23 studies (Vandemeulebroucke, 2019). Five themes emerged in relation to use of SARs. These included: role of SARs, interaction between older adults and the SAR's, technical and human aspect of interaction, appearance of SAR and normative/ethical issues regarding use of SARs. Similar to the quantitative studies the participants in qualitative studies also viewed SARs capable of physical tasks, assist in cognitive tasks like reminding appointments, medications and where certain objects were placed, entertainment function and companionship. There were several limitations of this review impacting its credibility. There were fewer participants due to qualitative design. Almost all of the studies were carried out in a western country preventing generalisation of using SARs across the different cultures and communities. It is noteworthy, several challenges came to the fore even before the implementation stage of SARs in a research setting.

Barriers to SAR implementation

A significant proportion of elderly patients with frailty and MCI are fiercely independent and live alone. As a result, psychosocial issues such as social isolation and loneliness continue to pose risk to their overall mental and physical health and safety. SARs seem to be an appropriate option to consider in these circumstances, but it is worth considering the barriers and limitations which was raised during the interview with frailty and dementia clinical specialists. A review of 53 studies were conducted in patient's home and care facilities to explore the barriers and facilitators to the implementation of SARs in elderly patients and those with cognitive impairment (Koh et al, 2021). Socially assistive robotics being a transdisciplinary study and in the absence of clear definition of implementation, Koh, and colleagues mapped the barriers onto the domain "intervention characteristics" to reflect the characteristics of social robots such as complexity (related to their functionality), physical accessibility, technical failures, and cost. SARs with more functionality led to proportional increase in technical issues, which resulted in negative perceptions by multi-level key stakeholders, including older people and people with dementia, family members and care professionals (Bemelmans et al, 2010). Other factors that influenced the acceptance of SARs are the degree of cognitive impairment and technology literacy.

Facilitators of SAR implementation

The facilitators correspond to the barriers and characteristics like physical accessibility, ease of use, cost and technical robustness were identified as implementation facilitators. The enablers included compatibility between SAR' functions and users' needs, and their congeniality with work processes in care organisations. (Koh et al, 2021) It has also been observed that despite initial ambivalence or scepticism, elderly patients and patients with cognitive impairment developed positive perception after using SAR that matched their needs and expectations. Correspondingly, when family members and care professionals experienced the positive impacts of the technology and developed a renewed understanding that their roles are not under threat, positive attitudes were reported. This fact confirms well held belief that direct experiences with a technology can elicit attitude change when the interactions evoke cognitive-affective discrepancies from baseline beliefs. (Koh et al, 2021) An equally important observation is impact of positive attitude of care professionals and families on the enthusiastic support and facilitation of patient- robot interactions. It leads to an important conclusion that careful analysis of interplay of multi-level contextual factors rather than evaluating the determinants of barriers and facilitators in silos is key to the winning strategy with SAR design and development before implementation.

SARs: User Requirements vs Functionality

One of the biggest obstacles is the mismatch between social robots' function and user's needs. This fact is more pronounced between people with frailty who are cognitively intact and those with MCI / dementia. This chasm is also wider between frail elderly patients who live in their own home versus dwelling in residential care home facilities. A recent scoping review by Abdi and colleagues found that the needs of these individuals ranged from mobility and interpersonal needs at one end of the spectrum to self-management needs at the other end (Abdi et al, 2018) As expected, the expectations of frail elderly patients in SARs involved more functionalities related to their activities of daily living. On the other hand, patients with cognitive impairment required stimulating day time activities and companionship in an SAR. One could now realise the importance of aligning the expectations of the patients with the functionalities of the SARs to ensure it is not set up to fail. It is worth noting the lack of studies, which investigated how social robots can be successfully integrated into care organisation (Koh et al, 2021). The barriers were disproportionately high ranging from incompatibility of intervention to institutional regulations or work processes and the lack of time, dedicated manpower and training to support implementation. (Koh et al, 2021) Another area lacking research is the investigation into the perspectives of other stakeholders such as management staff and policy makers, external policies, and interventions. It is quite obvious that there are a lot of unknown, unknowns in SAR research which needs careful exploration to be incorporated in the design of an SAR.

SARs: Ethical Challenges

The ethical challenges of SAR's have been raised by both frontline NHS specialists as an existential threat to SAR use in care of vulnerable elderly patients. Boada et al. have identified, quantitatively analysed and categorised ethical issues into three main thematic groups according to the ethical dimension of human life to which these are linked:

1. Wellbeing: Privacy and Data Control is a major concern in SAR literature due to their ability to collect store and process an individual's personal data. Safety concern is related to the possible threat to physical and psychological integrity due to risk of accidents posed by cohabitation by humans and robots. Human autonomy is a basic right challenged by robots and the effect on dignity, which could both be enhanced and negatively affected by SAR, is a major concern (Boada et al, 2021).

2. Care: The implications of SAR as to the quality of practices that they are meant to support are an important focus of ethical concern. Human substitution by robots could not only impact the quality but also the meaning of care. Human beings are there to care for people, across all cultural beliefs. Delegating this core human attribute to a machine may disrupt human moral practices and this role disruption could also threaten the essential element of trust that is constitutive of the relationship between caregivers and care recipients.

3. Justice: SAR, depending on how it is developed and implemented may either contribute to increase or lessen the equality of care both in terms of access and quality of treatment. Most of the SARs are trained using databases and thereby the social divide in terms of access is a big exclusion problem leading to inequality in healthcare (Vallverdu, 2015). As a technology to be introduced in daily life to autonomously carry out certain tasks in assistive practices, SAR's behaviour and decision-making capacity has decisive consequences for individuals, which raises the key concern: Who is held responsible if the robot makes an erroneous decision and places an individual in harm?

SARs: The Impact of Human - Robot Interaction

Humanity is innately primed to be empathetic, compassionate and support their loved ones in times of need. This attribute can give rise to potential conflicts and concerns when something very personal as caring for someone is shared with others - in this case, robots. The comfort feeling for an individual provided by establishing an emotional bond between them and their family could never be expected from an SAR. In the case of patients with MCI and related conditions, they could develop a one-sided emotional attachment with SARs, which in being unable to reciprocate this attribute, can raise an issue of deception. While this issue could be interpreted as a positive functionality of a robot, it could be misconstrued as a violation of human dignity because it involves instrumentalizing humans for the sake of achieving a goal. This issue could be hurtful and concerning to the family of the individual and be considered morally wrong. Emotional attachment with robots can also harm the therapeutic benefit of a SAR when it undergoes malfunction or does not fulfil expectations. This imbalance of human robot relationship can also foster human over trust and over delegation of tasks to robot, leading to counterproductive results. These issues have been found to be more plausible in humanoid robots and hence careful attention to robotic design is a decisive element in preventing this emotional pitfall.

Discussion

"It is more important to know what sort of person has a disease than to know what sort of disease a person has."
- Hippocrates, 460 BC

The crisis in social care is evident. There is a paradigm shift in the population demographics toward a burgeoning aging population, placing huge demands on the healthcare system. Cognitive impairment, at varying ends of spectrum from MCI to dementia, is causing the frail elderly population (also at varying levels of functional capacity) to often seek acute, in-hospital care. Following hospitalisation, due to a significant aberration of their familiar environment and deconditioning, there is a significant shift in their baseline functional status. To keep the older population safe and secure in their own environment, a need to augment the dwindling social care support is more acute than ever before (Lette et al, 2020). Several decades ago, automation of mundane physical tasks gave birth to an industrial revolution. Turning back once again to the machines, but now in the healthcare arena, might sound like a logical approach; but the similarities abruptly cease at this point. The research interest in the role of SAR to augment social care support is burgeoning and it's a race against time to determine whether it is a hope or hype.

On the surface, the key question of whether SARs can help care for elderly patients with frailty or mild cognitive impairment might seem an easy one to answer. As elucidated in the earlier sections, caring for people doesn't involve physical support alone. Humanity as a whole is very complex and inherently different from one another. Caring for such a diverse and unique species involves several stakeholders, both internal and external, with the patient in the core of everything being done. Brainstorming sessions with two NHS specialist frontline stakeholders in this domain provided an insight into the scale of the challenge. It was abundantly clear right from the start: machines can never replace humans in caring for the needy, unlike in the dawn of the industrial revolution. The key focus of the research to investigate the extent to which SARs can augment the humane care uncovered several pitfalls and challenges. The scale of the social care problem to be addressed is behemoth.

The key to the success of any technology is acceptance by end users and SARs are no different. However, with SARs, due to multiple stakeholder involvement in different settings and different end users with varied requirements, it becomes even more complex. In addition, the few research studies on this characteristic make it cumbersome to make meaningful conclusions. However, certain themes emerge from these studies. Overall, though older adults are generally receptive to SARs they are quite particular about their appearance and the tasks, SARs could perform. A recent review identified five supportive roles of SAR in elderly care: affective therapy, cognitive training, social facilitation, companionship, and physiological therapy (Abdi et al, 2018). Social isolation and loneliness are experienced by older independent adults. So, in addition to support for physical tasks, companionship is another attribute preferred in SARs. It can be safely inferred that there is no one-size-fits-all SAR, and it should be customised to meet the requirements of the end users. Furthermore, the needs of older adults vary depending on their dwelling (own home versus residential care home) and this factor should also be borne in mind while considering the use of SARs. A comprehensive, statistically significant clinical research study to prove the safety and efficacy of SAR is still illusory.

Some older adults are technology naïve and in the presence of physical and cognitive impairment, complex functionality would be a barrier to the acceptance and usefulness of SARs. To gain acceptance by end user, SARs should be supportive enough to ensure the safety of the end user whilst taking care not to hinder the independence of the older adults to perform the activities of daily living. This very fine balance should be preserved as much as possible to prevent deconditioning in elderly adults. More importantly, maintaining one's dignity by having unfettered access to a basic set of capabilities is vital to live a worthy human life. (Boada et al, 2021). To achieve this, studious first baseline assessment and regular monitoring of the end user's functionality is essential to ensure SARs acceptance and relevance in assisting care needers. The acceptance of SARs also depends on the cultural background of the stakeholders, both end-users and carers (Papadopoulos et al, 2023). In certain cultures, technology goes against the values of empathy and compassion, which creates a barrier to SARs acceptance. Hence, without careful initial planning involving a multidisciplinary approach including all the stakeholders, the success of SAR will be hard to encompass.

The Hippocratic oath, 'Do no harm', is worth mentioning at this juncture. In medicine, any intervention - diagnostic, therapeutic or supportive, would have to cross the threshold of a safety profile through independently validated clinical trials, if it is to achieve mainstream acceptance. The first important concern that was paramount in the hearts and minds of the two frontline NHS specialists was the role of SARs in ensuring the safety of the older adults. By choosing SARs to assist caring for the vulnerable adults, it is fair to inquire their role not only in helping the end user, but also ensuring their safety whilst co-habiting in a residence. In frail elderly patients with cognitive impairment in whom consent has been provided by their next of kin, the expectation is for the SAR to

ensure the safe wellbeing of their loved one, whom it supports. SARs have been proven to perform their set tasks in several studies. With regard to the safety profile, large scale trials to address this domain is still wanting. Even though SARs are not replacing but augmenting carers, there will be periods when the older adult will be alone with SAR, in their immediate environment. It is naïve to expect technology to be eternally robust with a zero chance of failure. The concern would be a scenario where the SAR has been implemented to assist with timely reminder of intake of medications. What if the SAR encounters a technical malfunction and fails to remind the care-needer to take the medication? What if the older adult falls ill and life is put at risk? What monitoring system is in place to alert the manufacturer to this unfortunate incident and what contingency measure is in place to alert the main carer / next of kin? These situations should be carefully thought through before the implementation of SAR. In medicine, there is a responsible care provider who owns ultimate responsibility in any unfortunate event. In the case of misfortune involving SARs, who will be held responsible? It is a valid question raised by the specialist NHS stakeholders, which still warrants a definitive answer.

The NHS specialist stakeholders in acute district general hospital were also concerned about the invasion of privacy (UNGA, 1948 & EU, 2012) - a right against arbitrary interference with one's private life, implying a user's right to be in control of personal information. (Boada et al, 2021) Privacy also relates to the feeling that users may have of being observed, of not being alone. Some older adults are fiercely independent and people with cognitive impairment prefer to be in their own space and left undisturbed. In this instance, SARs provide a potential opportunity to bridge the gap in between carer visits. SARs by virtue of their monitoring capacity can collect, store, process and access personal data thereby raising privacy concerns but could also aid in developing safety alerts in the future. With appropriate checks and balance to the real time access of these data, SARs potential could be further enhanced for the benefit of the patients. The issue of privacy is controversial and needs to be viewed through the prism of being done in the best interests of everyone's safety. Transparency about the dos and don'ts of SARs and obtaining proper consent before the implementation of SAR from individuals, or from next of kin with lasting power of attorney in older adults who lack capacity will help to narrow this chasm between privacy and intrusion. Unless careful thought is given to assess and balance the risks to privacy, and the overarching benefits of this promising robotic technology, SARs' role as potential caregiver risks being swung between being a bane or a boon.

Conclusion

The provision of social care is finite and diminishing. At present, an aging population is burgeoning with an inverse trend in increasing quantity rather than quality of life. The social care sector is in dire need for a viable adjunct and SARs, despite being present for a few decades, could not have come into prominence at a better time. The studies involving human-robot interaction are in silos, involving only relatively small numbers of the western population. It is vital to design clinical trials with sufficient numbers of diverse individuals across different cultures in order to facilitate widespread acceptance of this technology. It is paramount that forthcoming studies involving SARs are sufficiently powered, more conscious of a defined outcome measure, of adequate duration, and possess a clear translation into social care practice for the vulnerable older adult population. The safety profile of any SAR should first be established before any benefits can be proven. Larger randomised control trials using valid comparators are essential to comprehensively demonstrate the limits and usefulness of SARs in the elderly population. Therefore, new, and forthcoming research should shed more light on the precise role any robotic intervention intends to serve, the ethical challenges it addresses, and use validated measures to assess their differences.

SARs have unequivocally exhibited potential in elderly care. In light of burgeoning demographic shifts, SARs demonstrate promise to reform the provision of social care in the elderly population. Although, the key studies have methodological issues, the quality, design, and size of the studies are progressing. This project, by exploring the role of SARs in assisting care of older patients with age related ailments, has laid bare the barriers, limitations, ethical challenges, and opportunities to achieve a rightful place for this promising technology. In establishing these facts, this project does not intend to restrict ambition but to provide a discussion platform for effective use of SARs and design of future studies. It is imperative that new studies should have a multidisciplinary

coordinated SAR design that will address the needs of the end user (Koutentakis et al, 2020). Most importantly, studies should define the precise role any SAR intervention intends to achieve in the society. Future study design should be robust enough to demonstrate how SAR can solve real problems in order to shift from novelty to actuality in elderly care.

The research into SARs in care of the elderly is still evolving and mainly in experimental settings but has made promising strides so far. Once the limitations in the current studies are addressed and an ideal study is designed with a multidisciplinary input and the end user at the core, the stage will be set for a grand entry of SARs to start transforming the lives of the older adults. The use of SARs as a potential tool to enable personalised, proactive, and preventative healthcare is an area that lies beyond the domain of this project and is worth exploring in future studies. A word of caution; SAR is not a panacea for all social care ills. On the surface, the use of SARs holds significant promise. However, beneath the surface it is entrenched in a number of caveats. SARs are here to stay, however, with clear boundaries with humans. In the future, the role for SARs in caring for our society is propitious. It's time, though not right now, will eventually arrive.

Acknowledgements

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