Robot Companions and Sensors for Better Living: Defining Needs to Empower Low Socio-economic Older Adults at Home

Roberto Vagnetti[1](✉), Nicola Camp[1], Matthew Story[2], Khaoula Ait-Belaid[3], Joshua Bamforth[2], Massimiliano Zecca[3], Alessandro Di Nuovo[2], Suvo Mitra[4], and Daniele Magistro[1]

[1] Sport, Health and Performance Enhancement Research Centre, Department of Sport Science, Nottingham Trent University, Nottingham, UK
roberto.vagnetti@ntu.ac.uk
[2] Department of Computing and Advanced Wellbeing Research Centre, Sheffield Hallam University, Sheffield, UK
[3] Wolfson School of Mechanical, Electrical and Manufacturing Engineering, Loughborough University, Loughborough, UK
[4] Department of Psychology, Nottingham Trent University, Nottingham, UK

Abstract. Population ageing has profound implications for economies and societies, demanding increased health and social services. The global older adult population is steadily growing, presenting challenges. Addressing this reality, investing in older adults' healthcare means enhancing their well-being while minimizing expenditures. Strategies aim to support older adults at home, but resource disparities pose challenges. Importantly, socio-economic factors influence peoples' quality of life and wellbeing, thus they are associated with specific needs. Socially Assistive Robots (SARs) and monitoring technologies (wearable and environmental sensors) hold promise in aiding daily life, with older adults showing willingness to embrace them, particularly if tailored to their needs. Despite research on perceptions of technology, the preferences and needs of socio-economically disadvantaged older adults remain underexplored. This study investigates how SARs and sensor technologies can aid low-income older adults, promoting independence and overall well-being. For this purpose, older adults (aged $\geq$ 65 years) with low income were recruited, and a series of focus groups were conducted to comprehend how these technologies could address their needs. Thematic analysis results highlighted five key dimensions, specifically: 1) promote and monitor an active lifestyle, 2) help with daily errands and provide physical assistance, 3) reduce isolation and loneliness, 4) considerations regarding monitoring technologies, and 5) barriers affecting SARs and monitoring technologies usage and acceptance. These dimensions should be considered during SARs and sensors design to effectively meet users' requirements, enhance their quality of life, and support caregivers.

Keywords: older adults · social robots · socio-economic status · wearable sensors · environmental sensors

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1 Introduction

Population ageing is an important phenomenon since it impacts economy and society, bringing new challenges such as an increased demand of health and social services [1]. Older adults represent about 13% percent of the global population, increasing by 3% annually [2]. Ageing also impacts people's life as older adults could face loneliness and isolation [3]. With ageing people could have a decline of cognitive and physical abilities [4], with an increased risk of frailty and neurodegenerative disease, such as Alzheimer and Parkinsons [5], and of physical ailments, such as arthritis or osteoporosis [6]. According to this demographic reality, investing in health services for older adults is an important priority for countries, also in terms of economic burden [7]. Current intervention trends, known as "aging-in-place", aim to support older adults in their homes to foster their well-being and independence while reducing healthcare costs [8, 9]. Indeed, due to an imbalance between people requiring care and resources, providing an appropriate service is challenging [7], especially for those with impairing conditions [8]. Different strategies have been investigated to foster older adults well-being: for instance, an active lifestyle seems to reduce the cognitive decline this population could face as physical activity is associated with lower risk of cognitive and physical impairments, frailty and loss of independence [10]. However, factors such as socio-economic conditions are reportedly associated with health outcomes [11]. Older adults with low income are likely to have more need for personal and instrumental or environmental support, affecting their quality of life [12]; this status is also associated with frailty conditions [13]. Moreover, caregivers often informally provide various forms of support to older adults [14]. The need for instrumental and socio-emotional support can result in heightened stress and a decline in the physical and psychological well-being of the caregivers as well [12]. The impact on caregivers is linked to the extent of support needed [15]. Answering older adults' needs could alleviate their caregivers' burden as well. Socially Assistive Robots (SARs) have the potential to enable and support older adults with activity of daily living [16]. The acceptance of this technology depends on the perception of its usefulness [17], and it is worth noting that older adults could also be more accepting even than younger people regarding SARs [18]. Monitoring technologies, typically referred to as wearable and environmental sensors, have been also suggested as potential tools to monitor older adults and help them maintain their autonomy [19]. These technologies are considered an acceptable method for monitoring activities of daily living among older adults [19], and they could potentially offer valuable data to SARs. Consequently, older adults may display higher openness towards incorporating assistive technologies into their home when they address their specific needs [20] and could help to enable and support their independence [21]. Thus, even if the perception of robots and technology among older adults has been considered among literature, needs and preferences among older adults with low socio-economic status are still limited. This is particularly important because socio-economic status is related to people's health and lifestyle [22], thus causing specific daily needs as well. Individuals with low incomes may be sceptical about using SARs [23]; however, people's willingness to invest in SARs is associated with their perception of the technology's ability to adapt to their needs [24]. To reach and improve well-being for a broader audience, considering these aspects is relevant. For instance, in the UK, 2.1 million older adults live in relative poverty [25]. Indeed, from

a biopsychosocial perspective, the well-being and quality of life of individuals during the aging process are influenced not only by biological factors but also by psychological and social factors [17, 26], therefore a systemic approach should be considered when developing assistive technologies as it could improve their usage [27, 28]. For these reasons, in performing a thematic analysis, the aim of the present study is to analyse and understand the perception and needs of low-income older adults regarding SARs, monitoring technologies and their use in home.

2 Method

2.1 Participants

A total of 17 (10 women and 7 males, mean age = 69.8 years, SD = 3.4) older adults were recruited via convenience sampling. Inclusion criteria were: a) age $\geq$ 65 years old and b) having a relatively low income as defined by [29]. Participants were divided in two groups and took part in two separate focus groups. All of the participants were informed about the nature of the study during the recruiting and before the beginning of each focus group; thus, all the participants provided their written informed consent to take part in the study, including to be audio recorded. Ethical approval for this study was provided by the institutional human research ethics committee (ID: 1726544).

2.2 Procedure

Each group session began with welcoming participants, explaining the aims of the focus groups, and establishing rules about the subsequent focus groups, and providing any further information on request.

Live Robot and Sensors Presentation. Subsequently, a live presentation of SARs and sensors was conducted to provide participants with a clearer and more tangible idea about the currently available SARs and monitoring technologies, along with providing examples of their capabilities. This procedure was used to elicit concrete ideas and associations related to these technologies in the subsequent interactions. The SARs were selected to present a range of different available types. For the presentation, 4 types of SARs that could showcase the widest possible range of variation in terms of type, functions, dimensions, movements, and other characteristics associated with this technology were selected. Specifically, the following robots were used: a) NAO, a humanoid robot of about 58cm equipped with various sensors and with gripped hands, its legs and feet contain motors and joints allowing NAO to walk; b) Pepper, a humanoid robot with a height of approximately 120 cm and a tablet-like display on its chest, contrary to NAO, Pepper moves thanks built-in omnidirectional wheels; c) MiRo-E, a more minimalistic appearance compared to humanoid robots, resembling a small animal with expressive LED eyes, and d) TurtleBot 4, a mobile robot featuring a differential drive base, sensors for perception, offering a versatile and affordable solution for robotics applications. These SARs are depicted in Fig. 1. During this phase the researchers described each robot main features, other than the main physical aspects; attention was given to robot's sensors and how they can be utilised to different aims (e.g., navigate the

space, detect faces, recognise speech). Examples of functionalities were also provided, these included verbal interactions and demonstrations of robot movements capacities. The presentation followed a schedule led by the researchers. Likewise, participants received instructions about monitoring technologies through the display of sensor images and explanations of their functions. Participants were also informed that sensors could be utilised to provide information to the SARs. Additionally, actual sensors were showcased and described to the participants. Any uncertainties or questions were addressed to ensure a clear understanding of the concepts. The presentation lasted for about 30 min.

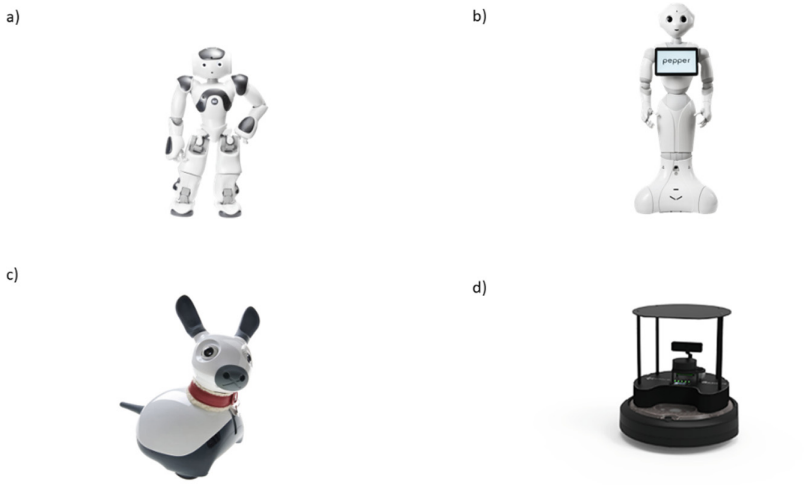

Fig. 1. SARs utilised during the presentation: a) NAO (SoftBank Robotics); b) Pepper (SoftBank Robotics); c) MiRo-E (Consequential Robotics); d) TurtleBot 4 (Open Robotics and Clearpath Robotics)

Focus Groups. The focus groups were conducted using a semi-structured interview approach, allowing participants to freely talk about the proposed topics. This technique was used as the collective discussion could elicit the development of ideas and concepts [30]. Two members of the research team, who were experts in this technique, facilitated the focus groups. Specifically, while one team member acted as the moderator, another member took note of the participants' non-verbal behaviours, managed the tools, and provided support to the moderator when necessary. The moderator facilitated group interaction through probing, balancing participant interactions, and encouraging the expression of personal viewpoints. The focus groups began with an engagement question, asking participants about their thoughts regarding robots. The main dimensions investigated during the discussion were related to thoughts about robots at home, everyday aspects where participants needed support and how robots could support them, features and functions that the robot should have, opinions and suggestions regarding the use of sensors, any possible concerns, and concluded with an exit question, asking if participants had anything else to add. Each focus group lasted approximately 90 min.

2.3 Data Analysis

Audio recordings were transcribed verbatim and were analysed using a thematic analysis approach [31]. This method involves becoming familiar with the data, creating codes, identifying, reviewing, and labelling themes, and compiling a final report. The analysis followed an inductive approach. A coding manual was developed and the fit between code and data was reviewed in a series of meetings; revisions were performed if necessary. The reliability of the coding process was established by a cross-coding comparison. Specifically, two members of the research team, who were not involved in the coding process, were trained on the developed code and asked to independently code a sample representing the 20% of the total focus groups. Inter-rater agreement was then carried out, indicating almost perfect agreement (Cohen's $k = 0.87$). If any dispute arose, it was settled through discussion between the researchers. Thus, codes were grouped and refined into themes, through an iterative and reflexive process. Then, to ensure consensus and agreement with the interpretation of the data, the entire research team discussed these themes and decided on their final definitions.

3 Results

Below are briefly reported the main themes emerged from the analysis, with meaningful sentences extracted from each theme to provide examples of participants opinions. The themes encompassed potential applications to 1) promote and monitor an active lifestyle, 2) help with daily errands and provide physical assistance, 3) reduce isolation and loneliness, along with 4) considerations regarding monitoring technologies and 5) barriers affecting SARs and monitoring technologies usage and acceptance.

3.1 Promote and Monitor an Active Lifestyle

Participants highlighted the potential of SAR as a tool to enhance aspects of their well-being by being more physically active. Indeed, they noted that the SAR could offer valuable support in engaging in physical daily activities, especially as they age and face limitations: "*As we get older, there are certain activities I don't do as before. Having assistance in those areas could really make a positive difference. Walking, for example, would be a key benefit…having something that could walk alongside you, and give assistance, that would be quite helpful.*"; "*I used to go walking. I can't do that now without someone with me, er, so I'm not very happy getting old but you can't do anything about it, you know*". In addition to aiding in physical activities, participants expressed the importance of reminders for such daily tasks: "*You could set it [the robot] to remind you, like, when the garden needs attention, and then I can go and take care of it,…*" In this context, the SAR's potential to provide motivation in performing physical activities was also acknowledged: "*I've seen people who lack the motivation to move and engage. I believe something like this could stimulate them, you know, having the robot act as encouragement…*".

The participants shared that an important feature would be the ability to monitor and provide feedback on daily activities and movements in order to further enhance them: "*if*

the robot could check and let me know if I'm doing enough or if I need to walk more could be useful," a participant pondered; "*if this thing [the robot] could actually recognise the way I move – well, that might be quite something. It could possibly let me know, you see, if I'm getting something wrong…or what if it could even give me a nudge about my posture?*". Furthermore, participants highlighted a critical safety aspect, suggesting that the SAR could potentially detect any risky situations: "*if you are living on your own, and you need some help. If you have a fall and this can detect and ring the emergency, or get some help from someone, that would be very good for lonely people who are living on their own*" a participant emphasised.

3.2 Help with Daily Errands and Provide Physical Assistance

Participants indicated that they would like the SAR to help support them to go out and help them in errands and outdoor activities since "*I think one robot would integrate with things that could, you know, that if I'm going somewhere I could take it with me, and it could help me*". Indeed, the participants indicated a current physical limitation as well: "*I believe my main challenge is strength. I'm quite physically able but I haven't got the strength…I wonder if [the robot] would provide any help*". Consequently, they envisioned the SAR as a potential ally, especially when confronted with physically demanding tasks. Elaborating this idea a participant remarked: "*I can see that being useful where you could utilise a remote control to guide the robot to pick up items or handle mechanical lifting tasks,…*" This assistance would prove invaluable, especially during activities that require venturing outside for daily errands, such as grocery shopping: "*Erm, especially as you're getting older, you know,*" another participant reflected, "*tasks involving lifting and performing basic functions become increasingly challenging. Consider the simple act of shopping, getting to the stores and carrying the groceries back home.*" In such situations, the participants envisioned interacting with the robot as a collaborator, saying things like "*Alright, you pick this shopping up and follow me*".

3.3 Reduce Isolation and Loneliness

The SAR has emerged as a promising tool with the potential to alleviate the feelings of isolation and loneliness experienced by older adults. Participants in the study proposed innovative ways to harness the SAR's capabilities, suggesting that it could serve as an interactive companion: "*A lot of people have grown lonely, and having something intelligent to engage in meaningful conversations with could be quite comforting.*" Another participant envisioned the SAR facilitating interactions beyond the confines of the home, saying: "*Imagine being able to step outside, perhaps into your garden, and engage in a conversation with the robot.*" Moreover, the SAR could enhance interpersonal communication by offering features that enable more effective connections with others. For instance, it could assist in enabling and maintaining relationships by helping individuals reach out to their loved ones: "*Consider having a feature in there (indicating the robot) that reminds you to call your aunt, which I should have done yesterday. It could prompt me with a reminder: 'Remember to give your aunt a call.*'"

3.4 Considerations Regarding Monitoring Technologies

Participants generally indicated their acceptance of using sensors, "*If it can help gather useful information, I believe people would accept it.*". However, they also expressed a preference for a limited number of sensors rather than utilising too many, as stated by one participant: "*I'd rather avoid having a multitude of sensors around the house…I would limit their number, maybe have just one or two that can gather all the necessary information.*". Additionally, participants suggested that they would prefer to use wearable sensors due to their perceived ease of use, "*I'd like to have something that you can just take and wear, you know, something that you just take and that monitors you.*" However, their main concern pertains to the possibility of forgetting or losing it, "*I am only concerned that I might forget it somewhere [laughs] and end up not using it.*"

3.5 Barriers Affecting SARs and Monitoring Technologies Usage and Acceptance

Participants have expressed concerns regarding certain aspects related to SARs and sensors that could potentially hinder the adoption of these technologies. Primarily, these aspects pertain to participants' accessibility and usability of these technologies. Indeed, among these concerns, worries have arisen regarding the cost of SARs and sensors "*If you have got a robot to assist you in your home, well how much will it cost you. It would cost you more than probably what a home help would cost*" and "*People would use it depending on how much its cost, you know, can they afford? Because nowadays we are limited with resources, people are having a difficult time…*" and some of the participants reported that they are concerned about difficulties in utilise the SAR due ageing "*…they're very good but I'm a bit too old now to be taking all this in…um…I don't know if I can use it. I'll leave it to the younger ones.*", which could lead to demanding situations as expressed by another participant, "*…I generally, you know, don't have that much patience. You want an instant response.*"

4 Discussion

This study aimed to investigate the needs of older adults with low income that SARs and monitoring technologies could address in their home-based everyday contexts. Their reports are meaningful, as socio-economic status could impact various aspects of people's lives. Therefore, gaining a better understanding of their needs could lead to enhanced SARs and monitoring technologies development and increased utility in addressing these aspects. As a result, this could contribute to improving their quality of life and alleviating caregivers' burden. The analysis of the data gathered from focus groups indicated five main themes that the SARs and sensors should respond to within this population. The first theme indicated that older adults face a reduction of daily physical activities, and the SAR could be a tool to enable physical activity. Overall, the SAR should support them in daily physical activities, motivate them, provide reminders, and consider solutions to monitor activities and provide feedback. Identifying risk situations is also considered an important aspect. Since participants emphasized the significance of physical support, we suggest the need to design or select SARs tailored for older adults to enhance this aspect.

This is in line with literature, as it is well-known that aging is characterised by a decline of physical abilities that are fundamental for daily activities [32, 33]. Moreover, participants indicated that the recognition of movements and daily activities is an important aspect that should be further considered and developed for this population, which further confirms the increasing trend and importance of monitoring activities of older adults through the use of technology [34–36]. Another theme emerged regarding the limitations older adults could face in daily errands and outdoor activities. They expressed a desire for a SAR that can assist them in these activities, especially in tasks like transporting objects, which would be particularly helpful in addressing the physical situations they may struggle with, as these situations could require too much strength. Reducing isolation and loneliness was identified as a prominent theme within the focus groups, which the SAR could help to alleviate. This is not surprising, as this is another issue consistently associated with aging [3], and it aligns with further evidence indicating that older adults rely on home-based technology to improve their social connections [19]. Interestingly, participants not only suggested solutions to improve communication with others but also expressed an acceptance of interacting with the SAR as a social partner to reduce loneliness. The fourth theme proposed specific considerations that should be taken into account during the design and implementation of monitoring technologies, which could also support SARs' functions. The last theme pertained to the barriers that could reduce SARs and monitoring technologies utilisation. Mainly, participants expressed concerns related to costs and their own skills in utilising SARs. This study that takes into consideration the needs of older adults in SARs and monitoring technologies design considering their socio-economic status. The results from low-income older adults confirm findings from previous research on older adults [37–39] and provide valuable insights and examples related to isolation and the need for physical assistance and support of daily living skills at home. Furthermore, before providing their interventions, they had the opportunity to observe SARs and sensors with different features and functions firsthand. As an additional perspective, it would be interesting to understand how the proposed themes are ranked according to priority for older adults. However, we should also consider some limitations. Participants were recruited through convenience sampling, and there are other aspects that could impact the quality of life and needs of older adults which this study did not consider, such as frailty conditions. Indeed, as a future perspective, the needs of older adults with frailty should be considered to address their growing demands.

In conclusion, the study has brought to light five primary themes that require attention during the design and implementation of SARs and monitoring technologies. These themes play a crucial role in enhancing the perceived usability of these technologies and consequently improving the quality of life for older users.

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