Insights on the acceptability of assistive technologies for ageing in place: towards the development of design criteria.

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Abstract. This research develops an understanding into how older adults, adults with disabilities, and health and care professionals use, understand, consider, implement, and accept in-home monitoring and assistive technologies as part of their ageing in place strategies. Alongside a literature review of 25 recent publication, 33 semi-structured interviews were performed with 17 older adults, 5 adults with disabilities, and 11 medical professionals or care providers to identify key themes around technology acceptability, factors to ageing in place, and the support required as people's capacities deteriorate over time. The results provide a series of overlapping themes that are analysed and highlight the nuanced relationship between ageing and autonomy, the barriers associated with administrative responsibilities, and the meta-analysis health and care professionals develop through their personal relationships with beneficiaries. The analysis is then distilled into nine criteria for technology acceptability – framed within the context of this research. It's proposed that a solution should be understandable, future-proof, easy to integrate, useful, customisable, desirable, manageable, reassuring, and financially conscious. Findings shed light on how technology can support healthier and more secure ageing in place strategies. The research provides an up-to-date understanding of the relationship between older adults and in-home monitoring technology, going beyond current concerns and transforming them into criteria with practical value for their design or implementation.

Keywords: Ageing in Place, Acceptability, Older Adults, Disability, Assistive Technology

1 Gaps within Ageing in Place and Assistive Technologies

Concerns around ageing and technology have become pressing current affairs: "Two key drivers that underlie societal change in the twenty-first century are demographic changes associated with ageing societies and significant changes in technology" [1]. Assistive Technologies are key to current European strategies for ageing in place (Horizon 2020, 2016), said to help older adults live at home longer, and improve their senses of capability, security, and safety [2]. Yet, uptake of assistive technologies is dependent

on whether those involved (older adults, adults with disabilities, carers, and care providers) accept them as part of their everyday [3] [4].

Whilst several reviews and original research studies explore assistive technologies, their acceptability, and their perceptions through different users and carers, few comparatively intersect the issues raised across different actors, and fewer report on data collected after 2022 - a post-pandemic society affected by increasing technological divides and subsequent social isolation [5] [6]. Uptake of ageing in place strategies are grimly justified when considered against disproportionally higher death rates and visiting restrictions in long-term care facilities during the pandemic [7]. These gaps in research lead to wonder:

- (RQ1) What are peoples current lived experiences of technology and ageing in place, and what are the subsequent key themes that emerge,
- (RQ2) how do these up-to-date perspectives (framed within the project) compare against literature about the acceptability of assistive technologies for older adults at home, and
- RQ3: how can these findings be actioned to directly support practitioners, care providers, and policy makers?

[redacted section on the context of the study – location, project, procedures, actors involved (approx. 120 words)]

2 Exploring Real-World Perspectives and Theory

2.1 Literature Review

A February 2024 literature review was performed using internal university library resources and google scholar, and a combination of keywords (and variants); *Assistive Technology, Acceptability, Criteria, Evaluate, Monitoring Technology, Perceptions, Older Adults, Disabilities*. A subsequent cascading process was done to manually search for other relevant publications within those initially discovered. 25 publications were retained and reviewed including:

- 16 pieces of original research published between 2011 and 2024 (case studies, interview studies, longitudinal qualitative inquiries). [1] [2] [3] [4] [5] [8] [9] [10] [11] [12] [13] [14] [15] [16] [17] [18] [19]
- 8 reviews published between 2017 and 2024 (scoping, literature, systematic literature, systematic integrated literature). [20] [21] [22] [23] [24] [25] [26] [27]
- 1 opinion paper / editorial published in 2024. [28]

Intent to provide up-to-date perspectives of current concerns, it is noted that the most recent reviews and original research were completed in 2022.

2.2 Interviews

34 hour-long semi-structured interviews were held between March and April 2023 with 18 older adults, 5 adults with varying disabilities that affect mobility and accessibility requirements, and 11 health care professionals connected to consortium partners and focused on ageing in place services. Purpose sampling provided mostly or relatively autonomous older adults with declining capabilities who could find value from in-home health monitoring and fall detection technologies. Testimonials report self-declared demographics, key factors to ageing in place, warning signs to health declines, relationships with technology, motivations to use technology, and technologies they may already use or appreciate. Interviewers recorded the proceedings and took notes, whilst follow-up researchers listened to the recordings to complete the entries.

2.3 Thematic Clustering

Interview entry coding produced 327 keywords, eventually reduced to 71 after processing duplicates and neighbouring concepts (see annex XXX for full list of keywords and groupings). Keywords were then analysed and thematically clustered during a group working session with seven research partners. Initial overarching themes were negotiated through use of the following statement:

> "*Given the concerns about [the following keywords and descriptions], a technological solution designed to support ageing in place should be [title of criteria and description]*."

For example,

> *"Given the concerns about [rehabilitation, capabilities, changes in behaviour or habits, and the use of staircases], a technological solution designed to support ageing in place should be [Evolving: Adapts and continues to meet the person's needs through the deterioration or adaptation of their health and habits.]*

Following the session, keywords were tagged with either 1 or 2 of the proposed themes to ensure saturation. Unable to tag a relevant theme, "N/D" was used to flag the entry and iteratively review or amend proposed themes until there were 0 undefined keywords. Similarly, each publication found through the literature review was read in full to identify any excerpts that mention or allude to *factors, concerns, criteria, conditions, etc…* about the acceptability of technologies, and were equally tagged with 1 or 2 of the thematic clusters. If unable to associate a theme, the excerpt was also tagged "N/D" for review. 23 entries were tagged N/D and categorised into sub-themes, presented below.

3 From Keywords, to Themes, to Criteria

Table 1. Distribution of tagged themes across testimonials and literature review

Theme	Tagged within *Testimonials*	Tagged within *Literature Review*
Understandable	8	22
Evolving	17	17
Easy to Integrate	15	34
Useful	18	38
Desirable and Customisable	14	38
Reassuring	*8*	23
Manageable	*13*	17
Financially Conscious	*4*	11
N/D	*0*	23
Other themes (tagged "N/D")		
User Attitudes	--	11
Participatory Approaches to designing	--	3
Care provider support (burnout)	--	3
Preferences for human / social contact	--	2
Beneficial	--	2
Testing before committing	--	1
Dealing with unconscious bias	--	1
Total number of tags	*97*	223
Total number of keywords & excerpts	*71 keywords*	*157 excerpts*
Total number of testimonials and publications	*33 interviews*	*25 publications*

Please note that the number of tags is not quantifiably representative of impact since repeated statements across testimonials, keyword processing, and the removal of duplicates is hidden behind each theme. Equally, the literature review was opportunistic; a search for themes, rather than counting the number of instances a theme was mentioned within a publication. Possible similarities in the proportions between testimonials and publications can only be, within this research, considered coincidental.

**An annex to the distribution of entries and tags across all publications and testimonials can be provided.* *

3.1 Criteria: a combination of theory and real-world experiences

Here, a brief definition of each theme, followed by observations from testimonials and literature are provided.

Understandable: *Easy and intuitive to use, capable of being explained effortlessly. Pay attention to the required level of technological proficiency, the means, and capabilities (physical, cognitive, cultural, linguistic, and literacy) by which the person can interact with the solution, and the allocated time and methods (brochure, website, video, training for care providers …) needed to explain its proper use.* Participants highlight access to easily digestible information, avoiding overload. Regardless of technological advancements, professionals and older adults insist that human interaction and connection is essential to delay or avoid institutionalisation. Simple terms that avoid jargon [8], a familiarity with technology [25], and training strategies that "cater for different learning needs" [22, p. 141] seem to catalyse understanding. Equally, intergenerational training seems effective [8], whereas weak care provider training and high staff turnover hinder [21].

Evolving: *Adapts and continues to meet the person's needs through changes (deterioration) to their health and habits, as well as advancements in necessary hardware and software.* Staircases are clear markers to a health decline according to older adults who associate them to a fear of falling that leads to reconfigure the ground floor of their homes, and as a threshold to their abilities and autonomy sometimes leading to install electric stair climbers. Care providers are more attuned to a nuanced decline through reduced capabilities, behavioral changes, and shifts in daily habits and routines, and quickly defer to technologies that support autonomy. Yet, once technologies fail to meet needs, they become quickly obsolete or unused. Older adults seem to acknowledge an inevitable decline in their abilities [10] and the value of combined technologies to address changes associated with ageing to adapt the social and physical environments [4]. Throughout one's evolution, it's reported that "technology was seen as a way to support the wish to age-in-place and, therefore, embraced, accepted or tolerated as a support tool" [2].

Easy to integrate: *Non-intrusive, non-destructive installation and setup that is compatible with the person's physical environment and considers their social network (interaction with family, loved ones, and caregivers). This also includes installation timelines, steps, required needs, and deinstallation for reuse or resale.* Concerns are raised by professionals and users who explain how the home environment is often habit driven and furniture can serve to navigate spaces. Users rely on specific spatial cues, or use chairs, tables, and other surfaces as support. A misplaced rug, or a shifted end table can cause undue falls. This complicates the installation of some technologies that require changes to allow the technology to function properly. Equally, older adults found that lengthy installation can overwhelm, administrative requirements are mentally draining, and a constant technological presence can compromise a sense of intimacy in their own home. Professionals also note that technologies often outlive their need within a single home and should be easily transferrable to other users without complicated refurbishment. The need for internet access can compromise the value of many new technologies

that rely on a constant connection and several power outlets [27]. Friends and family members may also show concerns when visiting the home – surprised or offput by the presence of monitoring technologies [3].

Useful: *Provides a sufficiently significant added value to justify its use. Suggests an ability to bridge the gap and meet basic needs to support autonomy. Ensures that the solution – in cases where it is needed – functions regardless of extenuating conditions or circumstances.* Participants readily insist on the value of technical aids to maintain their autonomy and allow for time and energy on social activities, particularly bathroom aids. Towards more technological solutions, the smartphone is central to many, provided the solution is accessible and easily useable. Those interviewed with declared disabilities were much younger than the older adults involved in the study and anticipate another 4 of 5 decades. They were much more enthusiastic to try solutions that provide any chance of improved autonomy or mobility. Some older adults were reluctant and described the purchase and process of learning how to use new technologies as "futile" if they expected to pass away soon (justified by their personal outlook rather than an underlying medical condition). Technologies should "fulfil a number of specifications in terms of the operation and the design in order to be useful" [2, p. 324]. For many, an interpretation of technology relates closely to communication with their social network [24] and 24-hour access to family or care services [10]. Otherwise, it seems that older adults particularly value the usefulness of technology (beyond assistive aids) for urgent care needs, rather than consistent support [13]. For those in cognitive decline, technology can enhance their independence whilst easing carer responsibilities to circumvent intermittent institutionalisation caused by carer burnout [24].

Desirable and Customisable*: Meets aesthetic criteria, semiotics, and the desires of the targeted individuals (visual language, materials, quality of finish, modes of communication, functionalities, etc.). Addresses issues related to the stigma of ageing and disability.* Professional carers reported on how older adults who experience a decline in capabilities but are not yet dependent of technologies are deterred by the aesthetic properties of most solutions. In their words, most ATs are designed for "old people" and - regardless of the age or condition - struggle to identify themselves within that group. Referring to tablets or phones, older adults found that solutions are easier to accept when they also provide entertainment. Gamification is said to promote positive interactions with technology [8] and a willingness to learn more [18]. Although older adults are a heterogenous group [4] where bespoke understandings of a target groups beyond "older adults" is highly beneficial to a design [19].

Reassuring: *Offers functionalities that appease concerns and ensure the safety of users and their formal and informal care providers. Addresses concerns related to (i) misuse, (ii) disruptions, (iii) fear of doing it wrong, (iv) personal safety, (v) use at crucial moments, and (vi) forgetting to use the solution at the right times. sufficient customer service.* Older adults and professionals often sense that technological gaps cause misuse. New technology appears more difficult to absorb into daily routines, and older adults fail to remember the technology is available to them during critical moments. There are mixed reviews about the level of "surveillance" a technology should provide. Whilst older adults report an invasion of privacy, they are encouraged by family members who seek reassurance. Those with advanced stages of health decline and higher

risks of accidents or issues shed their inhibitions more readily [3] [13]. More digitally adept users seem more placid towards the idea of surveillance [16], although this doesn't dismiss concerns about data privacy [10], nor does it diminish the risk of data overload, wherein users feel anxious or overwhelmed by the information some health related technologies provide – particularly when they cannot witness improvements in their health [25].

Manageable: *When applicable, enables easy navigation to control different accesses to information about the user (privacy and data security). Adjust to the person's habits and does not inconvenience them if they decide to change their schedule or (international trips, evenings out, birthday parties, sleepovers, etc.). Adapts to the changes and resumes "normal" functioning without fuss.* With dual definitions, testimonials report on how a technology should allow for easy navigation and clarity in data processing and security. Namely, who has access to data, how is it shared across health networks and how to avoid false reports (for example, did the user fall, or are their grandchildren at home for the weekend and jumping on the bed?). A combination of concerns related to reassurances, customizable functions and easy integration but distinct to understandings and interactions with the technology and how it handles data. The concept of control over data empowers the user and creates a distinction between personal habits (in the home) and data collected technologies that "watch over" [27].

Financially conscious: *The solution considers users' financial means and meets standards that allow to qualify for reimbursement or subsidies, applicable to all potential users or other stakeholders interacting with the proposed solution.* An ominous concern for older adults, particularly those who've experienced economic crashes or were raised by parents who experienced World War II (particularly "baby boomers"). Socio-economic context is key to understanding the user's willingness to adopt new technologies [10] [5]. Some may depend on family members when state services are unsupportive (particularly witnessed for internet services) [8], although this complicates how older adults perceive their own autonomy. Testimonials from those with lifelong disabilities show little concern for financial constraints since they feel well supported by state services.

3.2 Other themes

The literature review highlighted a few other themes that impact the acceptability of technology for ageing at home. Namely, many highlight how acceptability is affected by *the user's attitude* towards the integration of new technologies [4] [8] or their desire to learn and understand [27], although this intuitively relates more so to market segmenting than the design of a technology itself. Principles of participatory design in early design phases was equally reported [20] [28], early involvement can be central to many practices concerned with uptake within marginalised or misunderstood user groups [29]. Other themes, echoed throughout the present study address the importance of supporting care workers [25] [17], a preference for human contact over technological solutions [10], and the possibility of allowing users to test a product before committing [21].

4 Conclusion

The proposed themes are representative of testimonials from overlapping perspectives each concerned by the value of technology as part of ageing in place. Combined with recent publications about the intersection of technology, acceptability, and ageing, the proposed themes provide some form of overarching outlook on what matters to users and their network. These themes could serve as criteria for new technologies and adaptations, although should recognise the bespoke nature of their specific user groups and the capabilities proposed by the technology itself. Indeed, ongoing studies in this project contextualise the themes and suggest how some may be irrelevant or ignorant to some, or otherwise overshadow. For instance, imposed eligibility criteria have created a sample of users who are afraid to leave their homes and are focused solely of avoiding further decline rather than improving the personal health. They initially worry little about the visual appeal of a product, so long as it can support their needs. Yet, as the study progresses, they have begun to comment on how the product looks in their home. This suggests that the themes are weighted differently as time goes on. Some themes may be initially critical, whilst others become relevant later. Acceptability can benefit from studies that support product retention over time as well as studies about initial adoption.

By intersecting the views of different actors, concerns for one or the other emerged that were not initially reported by participants within the group itself. For instance, professionals reported significant concerns about modernised banking services and the issues around access by older adults to their own funds. Whilst these fears are shared by older adults and their carers to the professionals, they did not share these stories with the interviewers. Perhaps the existing relationship or proximity to the care professionals influences the conversations – particularly a comfort to discuss money that is unshared with interviewers.

Finally, the term “technology” is vast and different interpretations were sensed throughout the review of literature and the testimonials. Assistive technologies included chairs that assist in the bathroom, electric stair climbers, canes, and rails, as well as ambient home monitoring, automatic blinds, phones, and tablets. Curiously, left undefined, users expressed their opinions about these varied technologies without much confusion. At this stage, it doesn’t seem that categories of technology would have helped align conversations since each element of the study is equally vast; the particularities of older adults, the understanding of technology or the roles and responsibilities of different formal and informal carers. Further exploratory studies that test the criteria would better suit to defining their relevance within contexts rather than defining prescriptive understandings of each element in the study.

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