



UNIVERSITY of
STIRLING



AGEING WELL WITH ASSISTIVE TECHNOLOGY:

**Co-producing technology solutions
with older people**

A scoping review of the evidence

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Part of the INVITE project:

Promoting INclusive liVing vIa

Technology-Enabled support

In partnership with



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Executive summary

As cited in the recent report from the All-Party Parliamentary Group on Housing and Care for Older People, “Housing for people with dementia – are we ready?”, technology has enormous potential to support quality of life for older people, including those with age-related conditions such as dementia. Devices, apps and online systems may enable people to remain independent, stay in their own homes and keep connected to friends, family and the wider community. Delivering on this potential is important not just for older people, but also for the services that support them, including health, social care and housing. However, the research evidence to date has been somewhat underwhelming, showing limited impact on wellbeing, independence, or demand for health and social care services.

A central problem seems to be that technology is often introduced without fully involving older people or those around them in the process of choosing, installing and adapting it in use. This report provides some guidance to help improve this situation. We reviewed the literature to explore the range of technology available, identify the problems that arise in its implementation, and find out what works in terms of involving older people to make assistive technology fulfil its promise.

The evidence base related to involvement and co-production is relatively limited, and many studies go no further than the design stage for new pieces of technology (see section 3). Nevertheless, there are useful points of learning from research which examines how older people engage with and use different forms of technology in their homes. Recognising the ways in which technology has to be continually adapted to fit everyday life is crucial in order to understand how we can most effectively work with older people to explore new possibilities – from designing technology, to planning services and putting technology in place.

Drawing on academic and non-academic research, we highlight the growing range of assistive and everyday technology which aims to address a diversity of age-related issues (see section 4). Different devices, apps and online services are now available to support older people with aspects of social connectedness, autonomy and independence, mental health and wellbeing, physical health, and safety. However, the evidence about the real-world impacts of such technology, whilst promising, is still quite limited – many studies focus on prototypes in the lab, rather than the messy complexity of real life.

Alongside this, a significant number of studies attest to the difficulties that can arise in the processes of identifying, installing and using technology (see section 5). In particular, there are problems related to: perceptions of technology and assumptions about older people themselves; gaps in IT skills, knowledge and confidence amongst older people and those around them; organisational issues regarding funding, staff workload and strategic leadership; and limitations in the capacity and adaptability of the technology itself.

Whilst co-production cannot solve every difficulty with technology, engaging older people themselves, as well as family members, housing and care staff, can help to ensure that technology is appropriate, accessible, practically useful and therefore less likely to be abandoned. Thinking about the stages of introducing new technology, our recommendations (set out in more detail in section 6) can be summarised as follows:

Recommendations

Identifying the desires, needs and capacity of residents

At this stage...

- Focus on positive outcomes and capacity. Problems and age-related impairments are important, but they should not be the primary focus.
- Don't talk about technology too much – focusing on existing knowledge of technology may limit the discussion of actual needs and desires.
- Explore existing use of, and confidence with technology carefully to avoid reinforcing any fears of technology.

Identifying and introducing possible technology options

At this stage...

- Let people see and try out technology if possible.
- Recognise that people may have legitimate concerns that technology:
 - Could replace face-to-face contact
 - Might undermine their control or independence

- Comes with a stigma of ageing and infirmity
- Will be uncomfortable
- Will be too complicated for them
- Might do unwanted things with their data
- Could monitor them too much
- Keep focusing on wants and needs, not just what the technology can do.
- Talk about whether people will be able to use technology and what support they might need, being aware of physical and cognitive impairments.
- Think about resilience – don't set something up that is reliant on one staff member only.
- Consider costs and who has to pay them.

Using, adapting and continuing to use technology

At this stage...

- Think about how any piece of technology can be adapted in situ, to best meet the needs of each individual user.
- Aim to build skills and confidence of all those involved.
- Regularly review whether technology is really doing what people want it to do.
- Think about the impact on staff workloads and wider service delivery.
- Check the impact on family members and other caregivers.

Focusing on these learning points at each stage of the process should improve the chances of implementing the right technology, in the right way, to meet the desires and needs of older people, as well as delivering benefits for family members and other stakeholders.



1 Introduction

We reviewed the research literature as part of the INVITE project (promoting INclusive liVing vIa Technology-Enabled support), which aims to explore how assistive and everyday technologies could be used to enhance support for residents of retirement living schemes, and improve their wellbeing and social connectedness. The study is a partnership with Stonewater Housing Association and is funded by the Longleigh Foundation.

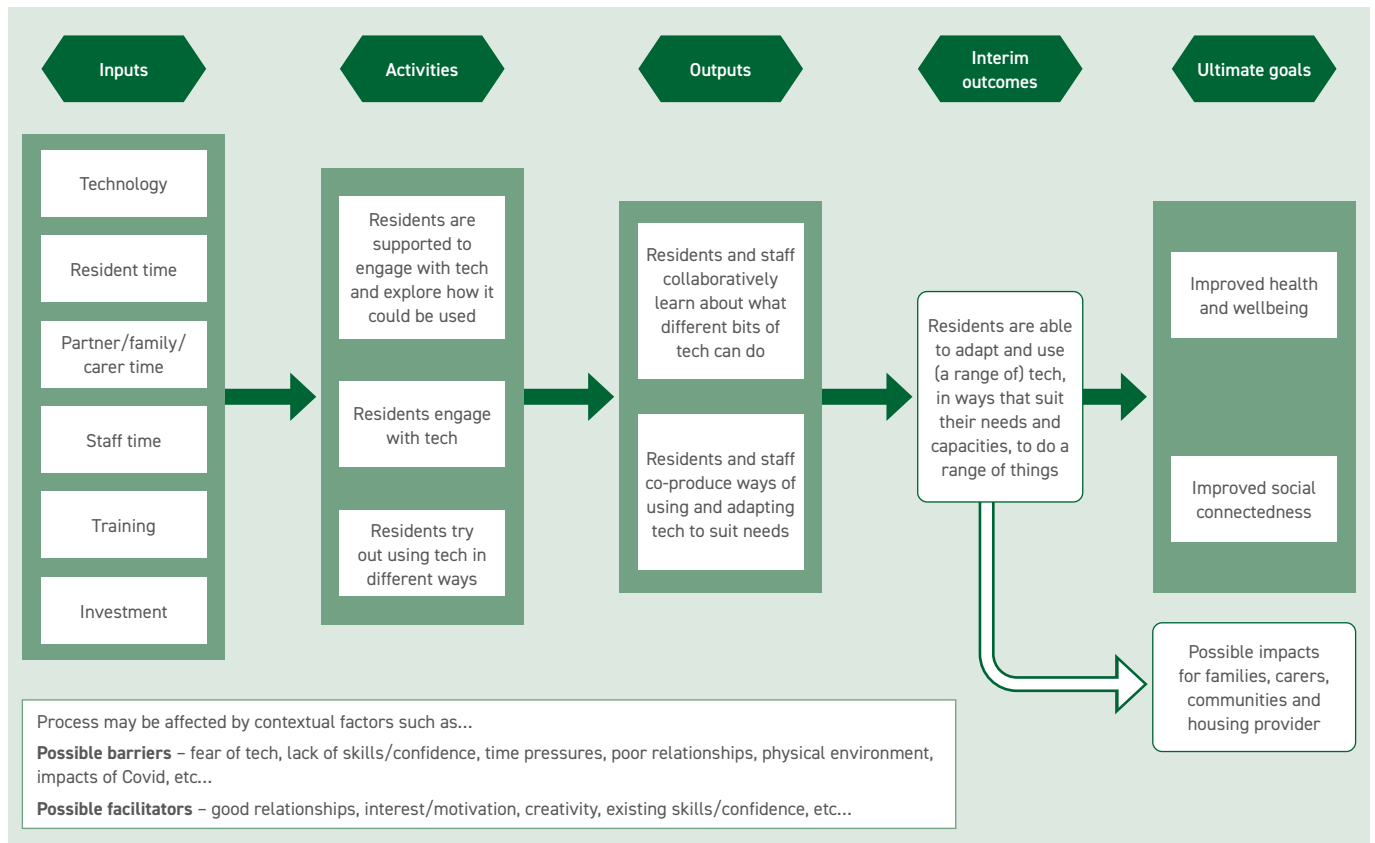
To provide a framework for thinking about the introduction and use of technology, we developed a Theory of Change (Figure 1). This model provides a simplified representation of the processes involved, showing what needs to happen for technology to deliver positive outcomes, as well as some of the barriers that may arise and facilitators that may help to overcome them.

In considering the ultimate outcomes in terms of the health, wellbeing and social connectedness of older people, it is important to think broadly to incorporate different aspects of wellbeing such as physical and mental health, opportunities for recreation, connections to the natural world, and personal autonomy. This is especially valuable in terms of co-production, in order to work with older people to identify the elements of their lives that they may wish to improve, rather than focusing on preconceived ideas of the possibilities offered by technology.

As the diagram suggests, use of technology may also have benefits for family members/carers (e.g. reassurance), the wider community (e.g. involvement of isolated older people in social groups) and the housing provider as an organisation (e.g. cost savings). Whilst our primary focus in this review is on the wellbeing and social connectedness outcomes for older people themselves, it is important not to lose sight of these wider potential impacts, since any new technology is more likely to be funded, implemented effectively and maintained if it is supported by these other stakeholders.

In order to develop guidance around the introduction and use of assistive and everyday technology for older people, this report reviews three areas of the existing research evidence. Firstly, we look at the evidence around co-production, to understand what works in terms of involving older people effectively. Secondly, we provide a broad overview of the types of technology available and explore what the current evidence base tells us about potential impacts on wellbeing and social connectedness. And lastly, we summarise the evidence regarding barriers and facilitators in relation to the use of technology by older people. Before summarising these findings, in the next section we set out the approach we took to the review.

Figure 1 - Theory of Change for assistive technology introduction and impact



2 Approach to the review

We began our review by searching the academic and non-academic research literature for three sets of evidence:

- Studies which provide an overview of the types of technology available to and used by older people, particularly in the context of retirement living.
- Studies which assess the impact of technology in terms of the health, wellbeing and social connectedness of older people.
- Studies which examine the role of co-production in relation to older people and technology.

For the academic literature, we searched databases of peer-reviewed research using combinations of search terms focused on these three elements. For the non-academic literature, we searched the websites of relevant organisations, based on the expert knowledge of the

research team. In both cases, we only included items published since 2010, on the basis that the field of assistive technology is developing so fast that earlier publications would likely be dated.

Having completed our search, we read the abstracts and/or executive summaries to filter out publications which did not provide useful evidence, such as papers focused on specific items of medical technology with only limited relevance to older people. Two of the team then extracted the key information from each publication, including evidence regarding the purpose of the technology being studied, how it was used, the impact for older people and the barriers or facilitators that affected its use and impact. Based on these summary points, we synthesised the key learning from all the reviewed studies to generate this report.



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3 Co-production

3.1 Rationale for using a co-production approach

The existing research literature includes multiple calls for greater co-production in relation to assistive technology, driven by two inter-related reasons related to human rights and practicalities.

Firstly, from a human rights perspective, there are concerns about the ethics of introducing technology without the full involvement of older people themselves¹⁻³, including concerns about data sharing and surveillance⁴⁻⁶. Whilst there is a recognition that there can be challenges in involving older people, especially where individuals have cognitive impairments³, the central premise from the disability rights movement that there should be 'nothing about us without us' carries significant political and ethical weight.

Secondly, from a practical perspective, there is a strong argument that technology will only deliver positive outcomes if older people themselves are involved in the processes of design and implementation⁷⁻⁹. Whereas the findings from large, randomised control studies such as the Whole Systems Demonstrator and the ATTILA study show minimal impact of assistive technology¹⁰⁻¹², the suggestion here is that these studies fail to consider the complex interactions between technology, older people, family members and professionals, treating technology as a simple 'plug and play' adaptation^{7,8}. For example, studies which examine the impact of installing a telecare alert system without considering whether the system is being used in different ways by different people will fail to understand the different impacts created by these different situations. Much the same argument has been made by studies that have reviewed specific forms of technology, such as fall detectors¹³ and smart home systems¹⁴, as well as from more general reviews of assistive technology for people with dementia¹⁵.

Given these concerns, we need to consider how technology can be co-produced with older people, from design through to implementation and use over time. In this section, we review the evidence from studies which have used and/or studied a co-production approach, in order to outline what works to effectively involve older people.

3.2 What we mean by co-production

Co-production is a complex and contested concept, used in different ways in different contexts. At its core, however, is the notion that people who are the users of services or products are involved in the processes of design and delivery. Thus, services or products are produced with users, rather than provided to or imposed upon them. Involving other stakeholders, such as staff or family members can also be an important element of co-production. To understand what works in terms of co-production in relation to assistive technology, it is important to consider three aspects.

Firstly, co-production can occur at different stages of the process of developing, introducing and using assistive technology¹⁶. For the purposes of this review, we can think of a five-stage process:

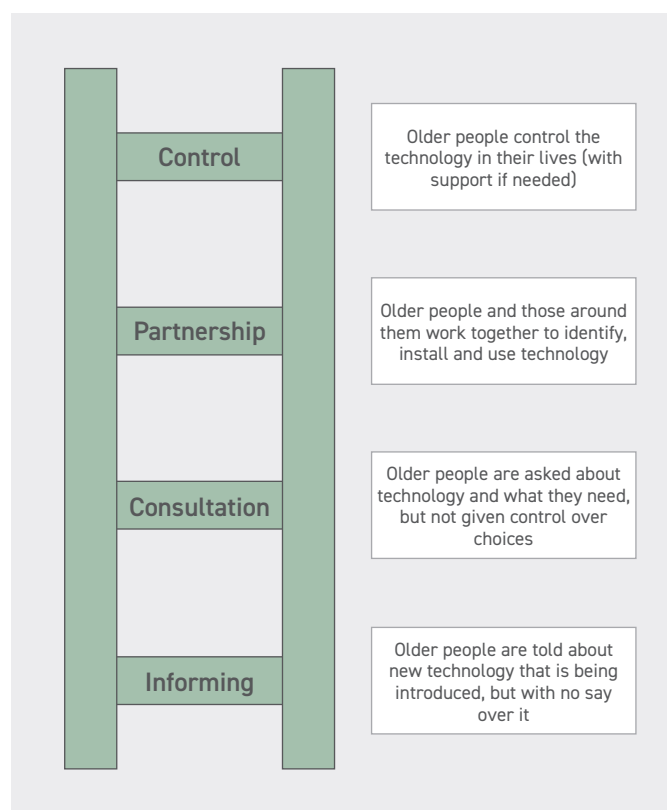
- 1. Identifying the desires, needs and capacity of older people**
- 2. Identifying and/or developing possible technology options**
- 3. Introducing technology**
- 4. Using technology**
- 5. Improving, maintaining and continuing to use technology**

Different approaches to co-production may be appropriate at different stages of the process. It should also be noted that the process is rarely simple or linear in practice, since the later stages of using technology may lead to identification of new needs, or a consideration of different solutions.

Secondly, we need to consider who is involved in each stage of the process. As well as older people themselves, this may also include family members, other informal caregivers, housing organisation staff, care staff and partner agencies. Again, different approaches to involving different groups of stakeholders may be appropriate at each stage of the process.

Lastly, different approaches to co-production enable different levels of involvement. Drawing on the notion of a 'ladder of participation' developed by Arnstein¹⁷, we can examine the ways in which co-production approaches offer opportunities for people to be informed, consulted, work in partnership or gain control over assistive technology¹⁸.¹⁹ (see Figure 2). These ideas do not necessarily mean that approaches which are 'higher' on the ladder are inherently better, but rather that it is important to understand the level of involvement which different approaches may offer and how they fit the people involved at each stage of the process, including consideration of how age-related issues such as cognitive impairment may affect the way that people can participate²⁰.

Figure 2 – Ladder of participation in relation to assistive technology (drawing on Arnstein)



3.3 Evidence about ‘what works’ in co-production approaches

The evidence base regarding co-production in relation to assistive technology is relatively thin and can be roughly categorised into two areas. Firstly, a number of studies employ forms of co-production in the early phases, engaging older people and other stakeholders in the process of identifying needs, designing technological solutions and testing prototypes. Secondly, there are studies which look at the ways in which elements of co-production may play a role in the later stages, exploring how older people and their support networks go on to use, adjust and (in some cases) abandon technology.

- **Co-design studies**

Many forms of assistive technology are in a developmental stage, so it is perhaps unsurprising that a range of studies focus on co-design, involving older people in defining the requirements for a particular device or system and, in some cases, testing out the prototype²¹⁻²⁷. For the most part, these projects use relatively predictable methods of involving participants, exploring needs through focus groups and/or interviews and collecting feedback on prototypes through observation, discussion during use and surveys. A few studies employ more ‘innovative’ approaches to co-design and understanding older people’s perspectives on technological solutions, including deliberative citizens juries⁶, appreciative enquiry²⁸, use of vignettes and

storyboards¹⁶ and, in one case, different approaches ranging from the use of photos, mapping, drawing and model-making to Talking Mats and walking interviews²⁹.

Since this review is focused on implementing existing technology, rather than developing new devices, these studies are of relatively limited value, but there are nevertheless some findings of relevance to any co-production approach involving older people and assistive technology. Firstly, there is a need to recognise that some forms of technology do not stand alone, but operate as part of a service, such as alarm/alert systems. In such instances, the device cannot be co-designed separately from the design of the service itself, which ideally requires involvement of staff as well as the older people who will use the system²³. Secondly, it is both important and challenging to focus effectively on the needs and desires of older people, especially where they have a degree of cognitive impairment. Since many co-design studies start from at least a conceptual ‘solution’ to a pre-defined problem, it can be difficult to recognise and accept that older people engaged in the process may not see the problem as a priority for them, although others may disagree. For example, in a project aiming to develop a ‘lost item location device’, older people with mild cognitive impairment viewed losing things as less distressing than losing words and memories, although family caregivers highlighted the problems caused by lost keys, phones and other important items²⁵. Thirdly, the elements of a co-production approach need to be tailored to the issue under consideration and the stage of the process. For example, doing interviews in the physical space where technology might be introduced can help to contextualise discussions about issues affecting day-to-day life, as can vignettes based on others’ experiences, whilst visual methods such as photo-elicitation can enable people to highlight valued aspects of their environment within which technology might be introduced^{16, 29}. Lastly, as with any process which aims to engage people, co-production approaches need to consider the basics such as convenience of time and venue, skilled facilitation and a supportive atmosphere²⁹.

Beyond individual co-design projects, some researchers have attempted to review the methods and processes of involving older people used in relation to specific forms of technology (fall detection systems¹⁸), or in particular contexts (living labs¹⁹). Looking across different studies, these reviews highlight some further lessons arising from challenges experienced in engaging people in co-design. They emphasise the importance of considering diversity within the simplistic category of ‘older people’, since many studies fail to report accurately on who they are working with. The implication of this lesson is that co-production approaches need to be tailored to the strengths and age-related impairments of the individuals

involved, including consideration of working with family/ carers alongside older people where cognitive impairment limits their capacity to engage¹⁹. This is tied closely to the concept of different levels of participation outlined above, since individuals' capacity may affect the extent to which they are able to participate at different points¹⁸.

Finally, looking across the co-design studies, there is a clear message that co-production which focuses only on the design phase of developing and introducing technology is insufficient, since even the best designs often fail when challenged by the reality of people's lives and homes^{18, 19, 27}.

- **Co-production in using technology**

Very little research has been published which explicitly employs a co-production approach beyond the design phase, although there are a growing number of studies which examine the reality of older people's experience of technology. Such work emphasises the need to examine how technology is deployed within the physical environment of older people's homes and how it is used in relation to their everyday lives, rather than in an artificial lab context^{7, 8}.

In terms of specific approaches to co-production, studies which consider processes relating to identification and choice of technology highlight the necessity of people being able to see and try out devices, rather than considering technological solutions in the abstract^{16, 27, 30}. Once technology is in place, there is some limited evidence that a variety of methods including the use of digital cameras, list prompts and self-completion diaries can assist people to reflect on their experience of using and interacting with assistive technology³¹. However, the same study also reinforces the message about challenges arising from cognitive and other age-related impairments, since the majority of participants engaged with the process to a very limited extent.

Taking a wider perspective, some authors argue that assistive technology and related services are always co-produced, since older people themselves are always involved in how the technology is used on a day-to-day basis^{32, 33}. Hence, in order to understand how technology can be successfully introduced to assist older people, we need to consider how they may 'domesticate' it into everyday life in a process of 'shared work'³², since the alternative will be resistance and abandonment of the technology. This is seen in processes of tinkering with and adapting technology to fit the home, to address shortcomings in design, or to join disparate elements together^{8, 9, 33}. Crucially this does not mean that co-production happens automatically – we still need to take account of individuals' impairments, support networks and home contexts. Moreover, the extent to which individuals may be able to co-produce the practical use of technology can also be influenced by the form of

technology itself, since some devices are more flexible and amenable to adaptation and tinkering than others³².

The complete process of designing, introducing and using assistive technology therefore requires continuous co-creation, which takes a flexible and adaptive approach to the technology itself and how it used, and to the co-productive approach around how older people (and other stakeholders) are engaged in making decisions^{7, 27}.

3.4 Summary of key lessons from the co-production literature

Drawing together the evidence from across this range of research studies, it is possible to identify a number of key messages about what works in terms of the co-production of assistive technology with older people:

- Involving older people, family members, care (and housing) staff is essential to ensure that assistive technology works in practice, not just in the lab or in the imaginations of those designing and implementing it.
- Technology is only of any use if it actually meets the needs and wants of older people. At every stage of the process, we need to clarify these needs and wants, to ensure that the technology itself is not taking over.
- In order to engage with and make choices about possible technological solutions, those involved need to actually see and use the devices.
- Co-production does not end once a piece of technology has been designed, chosen or installed. It will be tinkered with, adapted and used in unpredictable ways, so we need to focus on the continuous, shared work of using and maintaining technology over time.
- Understanding the adaptability of the technology itself, together with the strengths and impairments of the individual is essential.
- Different 'levels' of participation may be appropriate for different individuals at different stages of the process.
- Technology does not exist in isolation, so the services which surround it also need to be co-produced.
- Just as technology is adapted in use, so co-production processes need to be flexible and adaptive, rather than pre-defined.

One further implication of recognising the ways in which technology and related services are continuously adapted and co-produced is that assessments of impact become more complex. As one study expresses it, "approaching telecare as shared work means rethinking categories such as effects, effectiveness and causality"³². The next section of this report examines the range of assistive and everyday technology available and the impacts it may have on wellbeing and social connectedness for older people, bearing in mind this complexity.

4 Types of technology and evidence of impact

Attempting to define, categorise and list the available forms of assistive and mainstream technology can seem at times like a fool's errand. Whilst the historic model of assistive technology focused on the development of specialist devices, the boundary between dedicated 'assistive technology' and mainstream technology has blurred considerably in recent years³⁴. For example, text-to-speech systems which were originally developed as specialist software for visually impaired people are now built into mobile phones, tablets and computers. This shift has, in turn, sped up the widespread availability of some types of technology of use to older people, such that it is very challenging to create a comprehensive list of devices, particularly since relevant technology includes software as well as hardware – any such catalogue would need to be a continually updated online resource, rather than a publication which will rapidly date. This section therefore reviews the existing literature to provide a general overview, rather than a comprehensive list, attempting to highlight the important issues to be considered in identifying and selecting technological options, including evidence of impact.

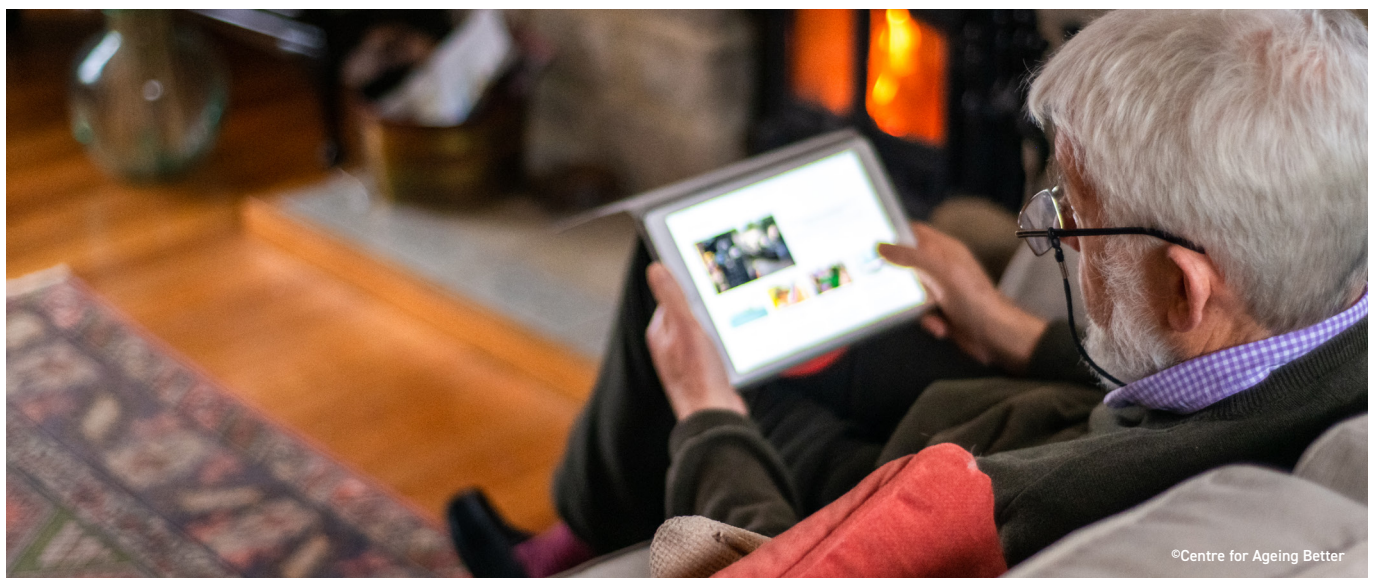
4.1 Identifying and categorising technology

From a research perspective, studies which have attempted to review and categorise assistive technology have taken a number of different approaches, often influenced by the authors' academic discipline. Thus, researchers with expertise in the technology itself tend to create typologies based on the technical function of devices^{35, 36}, whilst those coming from a health background tend to focus on the ways in which different devices may address age-related health conditions³⁷. In some cases, categories become blurred between types of device and their intended use¹⁵, perhaps reflecting that some devices have more than one application.

This review is focused on the impact of technology in terms of the wellbeing and social connectedness of older people, so it makes most sense to explore the types of technology from this perspective. In this respect, the World Health Organization's definition of assistive technology provides a useful starting point:

“Assistive devices and technologies are those whose primary purpose is to maintain or improve an individual's functioning and independence to facilitate participation and to enhance overall well-being.”³⁸

Thus, we can attempt to categorise technology in relation to its potential impact on different aspects of wellbeing and social connectedness. Starting from this perspective aims to emphasise positive outcomes and capacity of older people, rather than focusing primarily on the age-related impairments which may often be the immediate reason for seeking technological solutions. **Table 1** below provides an overview of types of technology on this basis. This is not intended to be a comprehensive list, but provides an indication of the range of technology available and how it relates to the outcomes we are most interested in. Note that there are inevitably overlaps between the outcomes, so some forms of technology can impact on more than one – for example, technology which helps people to remain socially connected is likely to have positive effects on their mental wellbeing. For simplicity within this table, we have largely avoided repeating items.



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Table 1 – Types of technology categorised by potential outcomes

Outcome	Function	Hardware	Software/Services
Social connectedness <ul style="list-style-type: none"> • Family relationships • Friendships • Community connections 	Text-based communication	Mobiles, tablets, laptops/PCs	Various options – SMS, Messenger, WhatsApp, etc.
	Audio communication	Adapted landline phones (e.g. large button, single button dialling)	N/A
		Mobiles and tablets	Various options – e.g. via Google, Facebook, WhatsApp
	Video communication	Mobiles, tablets, laptops/PCs, dedicated devices (e.g. Portal)	Various options – e.g. Zoom, Skype, Google, Facebook, WhatsApp
Overcoming communication-related impairments	Specific AAC devices – high and low tech (e.g. speech synthesisers, Talking Mats, etc.)	Different options for different impairments (e.g. speech recognition, text-to-speech)	
Autonomy and independence <ul style="list-style-type: none"> • Control of daily life • Control of living environment 	Reminding/prompting (appointments, daily activities, etc.)	Specialist reminder and/or memo devices, clocks and signage for time/place orientation.	
		Mobiles, landline phones	Reminder message/call services
		Mobiles, tablets, smarthome devices	Various options – calendars, reminder apps
	Assistance with day-to-day activities	Multiple options to overcome different impairments – e.g. stairlifts, kettle tipplers, easy-grip utensils, etc.	
	Controlling home environment	Smart home installations to control heating, lighting, etc. more easily	
	Getting around the outside environment	Physical assistance devices – e.g. walking sticks, mobility scooters	
Specialist navigation devices for visually impaired individuals			
Mobiles		Various navigation apps	
Mental health and wellbeing <ul style="list-style-type: none"> • Maintaining cognitive capacity • Emotional and mental health 	Entertainment	Accessible games, craft and sports equipment	
		Aids to using computers, TV, etc.	
		Mobile, tablet, computer, games consoles	Online games, videos, social media, etc.
	Mental stimulation and learning	Mobile, tablet, computer	'Brain games', reminiscence software/apps
Mobile, tablet, computer		Online training programmes and information resources	
Physical health <ul style="list-style-type: none"> • Physical fitness • Managing health conditions 	Physical exercise	Adapted sports equipment	
		Mobile, tablet, computer, games consoles	'Exergames', online exercise classes, etc.
	Monitoring health conditions	Specific health monitors for particular conditions (e.g. blood pressure, blood sugar, etc.)	
		Mobile, tablet, computer	Specific health consultation systems (e.g. NHS Attend Anywhere)
		Mobile, smartwatch	Apps monitoring activity levels, blood pressure, etc.
	Managing medication	Automated pill dispensers	
Reminder systems – see above			
Safety <ul style="list-style-type: none"> • Managing risks to physical health • Managing social and financial risks 	Getting help when needed	Alert systems – pendants, cords, etc.	Connected to on-site staff and/or response service
		Smart home devices	Voice-activation of phone, message or alert system
		Fall detection systems – ambient sensors and wearables	Connected to on-site staff and/or response service
	Maintaining mobility Preventing	Ambient sensors, detectors and cameras in the home	
		Mobile, smartwatch, wearable sensors	Apps monitoring mobility
		Mobile, smartwatch, wearable sensors	Fall prediction software
	Home security	Door entry systems – audio and/or video	
		Security cameras	
		Telephone blockers to prevent nuisance calls	
	Safety out and about	Specialist GPS locators	Connected to alert service, and/or staff or relatives
Mobile		Remote location apps	

¹Augmentative and Alternative Communication – systems designed to assist people with communication difficulties to express themselves.

Exploring the specific technology options available within the broad headings in **Table 1** has been made easier in recent years by the development of online portals and comparison sites, including:

- **AskSARA** – <https://equipu.livingmadeeasy.org.uk/>
Provides options for equipment to ‘make daily living easier’ in response to basic questions. Covers a wide range of equipment to address any impairment. Run by the Disabled Living Foundation.
- **Living Made Easy** – <https://www.livingmadeeasy.org.uk/>
Comparison site for assistive technology – less interactive than AskSARA, but can be searched for specific items. Run by the Disabled Living Foundation.
- **MeetAdam** – <https://meetadam.co.uk/>
Similar portal to AskSARA, but specifically focused on technology that will be of use for people with dementia. Run by Alzheimer Scotland, with Scottish Government support.

These sites all tread the slightly difficult line between focusing on age-related impairments and problems, and trying to identify technology to deliver positive outcomes based on older people’s capacity.

In the process of identifying useful technology, it is important to consider potential impacts for other stakeholders. Whilst **Table 1** focuses on the outcomes for older people themselves, many forms of technology will have benefits (or costs) for other individuals, or organisational implications. For example, ambient monitoring systems designed to identify when an individual has not moved for a long time, or has left the property should deliver safety benefits for that individual, but may also be designed to provide reassurance to family members and/or improve efficiency for providers by reducing the necessary level of staff monitoring. As discussed in the previous section, this highlights the importance of involving different stakeholders in the process of selecting and implementing assistive technology.

This consideration of outcomes for different stakeholders leads on to a further issue around the locus of control, especially in relation to people with dementia. The form of technology and the way that it is implemented influences whether it can be used by, with, or on older people³⁹. For example, some devices such as adapted telephones or easy-grip utensils are explicitly designed to facilitate independent living and are therefore primarily used ‘by’ older people, including those with dementia. Other forms of technology such as communication aids may be primarily used ‘with’ people, whilst surveillance devices such as GPS locators and ambient sensors in the home may be used ‘on’ people with dementia to monitor their behaviour for their own safety, but also for others’ peace of mind. The extent to which older people themselves have control over technology is clearly related to their cognitive capacity and skills, but also to the ways in which it is implemented and the extent of co-production in the process.

4.2 Impacts of technology

There is a growing body of research which attempts to evaluate the impacts of assistive technology. However, the evidence base is still relatively limited for several reasons. Firstly, because of the speed of innovation in some areas, the research literature is often running to keep up, in some cases evaluating devices which are already being superseded. This is particularly true in those areas such as video communications where mainstream technology has overtaken specialist options. Secondly, in a parallel with the co-production studies discussed earlier, many research studies are concerned with development and prototyping of new devices in lab or quasi-experimental settings, which provides only limited evidence of potential impact in the real world. Although ‘living labs’ which try to replicate home settings are an improvement, they still fail to match the messy diversity of people’s real homes and lives. And lastly, evaluating the impacts of assistive technology is inherently complex – even where a study focuses on just one device, there are multiple possible outcomes to consider and impact may vary considerably depending on the individual contexts within which the device is used, as well as how it is used in practice.

Bearing all of these issues in mind, this section provides a brief overview of some of the evidence regarding impact of a select range of assistive technology. The aim here is to provide an indication of trends within the research literature, rather than a comprehensive review of the impact evidence across all types of technology. The types of technology covered here were selected to provide examples of the different levels of evidence available.

• Telecare systems

The largest body of research regarding impacts of assistive technology focuses on telecare (and telehealth) systems. As with many elements of technology, the definition of telecare is not always clear or consistent. Essentially, however, telecare covers the range of technology from community alarm systems to ambient systems to monitor motion, location and risks such as fire, flood or falls^{40, 41}. The wide range of forms of technology covered by this definition and the large number of studies makes it difficult to provide a clear picture of impact. Nevertheless, findings from large studies and reviews indicate some important points. This section outlines these points, focusing on telecare, rather than telehealth, and excluding the large amount of literature around fall detection systems which is mostly rather negative in terms of impact thus far.

The two largest UK studies, funded by the Department of Health, are the Whole Systems Demonstrator (WSD) programme, examining impacts of telehealth and telecare in general, and the Assistive Technologies and Telecare to Maintain Independent Living At Home (ATTILA) trial, focused more specifically on clinical impact and cost-effectiveness of assistive technology (largely telecare)

for people with dementia. As noted earlier, the published findings from the WSD programme show no significant impact on health or social care service use¹⁰, whilst the emergent findings from the ATTILA trial also suggest that telecare has no significant impact on burden, anxiety and depression experienced by family caregivers¹² or on length of time living independently prior to care home admission, and may even worsen quality of life⁴². However, there are some slightly more positive findings from the WSD programme in relation to mental health and wellbeing, suggesting that the reassurance provided by telecare may at least go some way to ameliorating mental health decline in older adults⁴³.

Looking across the research literature more broadly, reviews covering multiple studies also find relatively little in the way of strong evidence for significant impacts of telecare systems. However, this is at least partly due to the limitations of the research, since randomised controlled trials which treat assistive technology as a simple 'intervention' may not be the best approach to evaluating complex processes such as the real world use of technology. It is also difficult to demonstrate effectiveness when some of the technology is relatively new or still in a developmental phase^{44, 45}. Some of the most recent reviews suggest that this situation may be improving. Thus, for example, the technical ability of sensor networks to monitor daily activities has improved in recent years⁴⁶ and there is somewhat tentative evidence that telecare systems can improve safety, promote independence and give a sense of security for people with dementia¹⁵. There is also evidence that where older people trust and gain a sense of 'social presence' through telecare systems, this improves their perception of service quality more broadly⁴⁷.

Echoing the earlier discussion around co-production, however, the most consistent message across the research literature is that impact is closely tied to the complex processes of introduction and use of telecare systems^{15, 48}. Thus, the reasons why telecare has been unsuccessful in its current form as assessed by randomised, controlled trials may be because of how such technologies are being delivered. In particular, emerging evidence from the ATTILA trial highlights the ways in which assistive technology can have different effects, depending on the ways in which it is fitted into everyday routines, is used to replace normal care, or disrupts everyday life and care practice⁴⁹.

• Video communication systems

The research around the use of video communication systems can be roughly divided into two categories. Firstly, there are a large number of studies examining the use of video communications technology for health purposes, including remote consultations with health professionals, peer support for people with long-term health conditions, and health education interventions.

Secondly, some studies have examined the role of video communication purely for social connectedness, especially in more recent years as improved broadband connections and developments in mainstream technology have made video calling much more accessible.

The evidence from the first group of studies suggests that video communication based approaches can have some positive impact on health outcomes. For example, a review of videoconferencing used for group-based health education and peer support noted some improvement in health outcomes, particularly in terms of mental health⁵⁰, whilst a combination of remote monitoring of health indicators with video consultations has been shown to improve self-rated health and reduce demand on services⁵¹. Unsurprisingly, however, the evidence is varied across different studies and different approaches taken to the use of video communication, with some research showing very little positive health impact^{21, 52}.

Looking across both groups of studies, there is relatively strong evidence that video communication technology can have significant positive impacts on older people's social connectedness – reducing loneliness, isolation and depressive symptoms, and improving perceived quality of life^{21, 50, 52-55}. Moreover, there is some evidence that the use of tablets to facilitate communication with family, amongst other forms of intervention (e.g. games, digital memory books) can also improve engagement, reduce agitation and improve quality of life for people with dementia⁵⁶. However, as with other areas of technology, many of the studies undertaken so far are focused on piloting or prototyping services, with relatively limited research on the effectiveness of technology for social connectedness in real-world settings⁵⁷. Clearly this is an area in need of additional research, given the explosive growth of video communications during the coronavirus pandemic, including among older people.

• Physical exercise technology

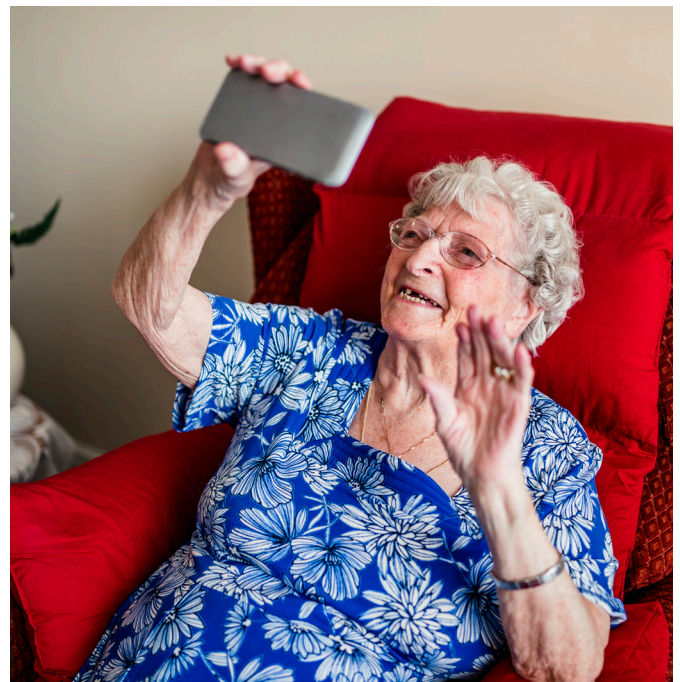
A small, but growing area of research looks at the use of technology to encourage and support physical exercise amongst older people, to maintain physical and mental health. Again, the evidence is somewhat limited so far, because this is a relatively new area for technology use and many of the studies which have been conducted are relatively small. A review of research focused on 'exergames' using mainstream technology, such as the Nintendo Wii and Xbox Kinect, notes that there is some emerging evidence of positive impacts on physical and mental health, although more research would be necessary for firm conclusions⁵⁸. One of the difficulties here is that such mainstream devices can become obsolete quickly and manufacturers are not necessarily cognisant of the specific needs of older people. More recent work in this area suggests the potential for significant impacts in terms of improved physical

condition and reduced frailty⁵⁹, but again the study is small and relatively short-term. Similarly, research looking at reducing sedentary behaviour among older people indicates the potential for technological elements such as a monitoring/reminding wristband to have a positive effect⁶⁰, but work in this area is still largely at the pilot study stage.

4.3 Summary of key points on types and impact of technology

The wide range and constantly evolving field of assistive and mainstream technology can make it difficult to develop a clear picture of the available options. Moreover, any selection of technological solutions is made additionally complicated by the rather tentative evidence available regarding impacts. However, we can draw a number of key points from this review:

- Focusing on the intended outcomes for older people themselves provides a useful starting point for examining technology options.
- Potential impacts on other stakeholders also need to be taken into account, alongside outcomes for older people – this includes impacts for family members/caregivers, care staff, housing staff and other partner agencies.
- Online tools are available which can help with identifying technology options.
- The limited evidence of impact highlights the range of potential barriers that can hamper successful implementation of technology.



- Although impact evidence is still rather limited, it is clear that involvement of older people and other stakeholders makes a significant difference to implementation and impact in most situations.

The next section of this report examines the research literature further to pick up the last two of these points in more detail – exploring the barriers to successful introduction and use of technology, and how they can be addressed, especially by aspects of co-production.

5 Barriers and facilitators

This section draws on a wide range of academic and non-academic literature to explore the key barriers to wider adoption and uptake of assistive technologies, both within a UK context and globally. Lessons from a variety of contexts are highlighted to improve awareness of potential barriers and support strategies to minimise the effect of these barriers.

Table 2 summarises the main barriers, which are discussed in more detail below, setting out the types of barriers which may occur at different phases of technology identification and implementation.

Table 2 – Barriers to successful introduction and use of assistive technologies

Stage	Perceptions of technology	Skills, knowledge and confidence	Organisational issues	Issues with technology itself
Identifying the desires, needs and capacity of older people		<ul style="list-style-type: none"> Lack of skills to elucidate person's own awareness of their abilities and limitations 	<ul style="list-style-type: none"> Lack of organisational readiness, staff resourcing and skills deficits to carry out needs assessments 	<ul style="list-style-type: none"> Emphasis on technology itself rather than outcomes for users Tech may emphasise disabilities rather than users' strengths
Identifying and/or developing possible technology options		<ul style="list-style-type: none"> Insufficient knowledge of options for technology and its potential utility among agencies and staff 	<ul style="list-style-type: none"> Funding issues for providers and local authorities Inflexibility of contracts with existing suppliers of technology Low organisational awareness of technology options 	
Introducing technology	<ul style="list-style-type: none"> User concerns about sense of infirmity and dependency on tech, plus loss of control User concerns about wearability and stigma Assumptions from staff/agencies that older people are digitally illiterate Staff and user concerns about replacing care and reduced or disrupted face-to-face interaction Dislike of being monitored Concern about confidentiality, privacy/ethics, data security or service intrusion/overreach 	<ul style="list-style-type: none"> Skills deficits around installation Anxiety and confidence issues in using technology 		<ul style="list-style-type: none"> Technology that fails to meet specific needs, cannot be personalised, is complex to use, unreliable, uncomfortable, or requires too much space Cost to users of tech and infrastructure (e.g. broadband)
Using technology	<ul style="list-style-type: none"> Increased dependency on technology, removing sense of control from the user 	<ul style="list-style-type: none"> Skills deficits around installation Limited digital skills amongst users Under-familiarity with hardware/software in both staff and end-users 	<ul style="list-style-type: none"> Workload demands, potentially leading to staff resistance Lack of support from senior staff members responsible for implementation Lack of co-ordination between organisations who need to support operation of technology 	<ul style="list-style-type: none"> Technology that is startling or discomfoting Technology that places excessive demands on users Technology that fails to do what it is supposed to do Infrastructure issues (e.g. connectivity)
Improving, maintaining and continuing to use technology		<ul style="list-style-type: none"> Users and staff lack knowledge and skills needed to maintain or adjust technology 	<ul style="list-style-type: none"> Staff time and effort required to maintain and adjust technology over time 	<ul style="list-style-type: none"> Technical limitations or issues which impede users' continued use and lead to abandonment

5.1 Wider context

Structural and cultural barriers to broad adoption and uptake across the UK feature strongly across the literature. The UK ranks behind other parts of Europe in terms of adoption⁶¹. The European Commission attributes these shortcomings to a range of factors: lack of agreed regulatory standards for data protection and security, poor inter-operability of technology, inequalities in patient and carer access, cultural resistance from health professionals and insufficient public funding⁶¹. Additionally, there are notable differences at government level in relation to the way in which technology is planned for and implemented nationally⁶². The UK lacks clear policy direction when planning for solutions to address healthy ageing, lacks a clear strategy for assisted living technologies, often focusing on community-based pilot schemes which fail to translate to national-level implementation. This approach has been contrasted with the top-down, pro-active strategies undertaken by other European member states, such as Norway, a country that has managed to secure scalability in pilot projects⁶². Thus, in the context of UK policy and technology enabled care, it appears there is still some way to go in promoting wider-scale adoption and ensuring that assistive technology meets end-users' requirements.

5.2 Perceptions of technology

The process of introducing technology can often be hindered by preconceptions and anxieties about the implications of new devices. For some older people, assistive technology can be associated with unwelcome ideas of ageing, infirmity and loss of control^{63, 64}. Similarly, some technology that is designed to be worn in public may carry a sense of stigma for some people, as well as raising concerns about comfort and wearability⁶⁴⁻⁶⁷. Notably, alongside the evidence that skills deficits can undermine technology usage (see next section), barriers to technology introduction can also arise where organisations or staff make assumptions of digital illiteracy which are not necessarily accurate^{57, 65}.

For some forms of technology, such as remote monitoring systems, older people and staff may have concerns that the technology will be used to replace carers and will reduce or disrupt face-to-face interactions and relationships^{15, 37, 64, 68-70}. Perhaps unsurprisingly, there is also evidence that some people dislike being monitored in their own homes¹⁵, whilst alert systems can generate anxiety about the risk of accidentally triggering them⁷¹. In addition, systems which collect data of any form can lead to concerns about data security, confidentiality, intrusive data collection and how data might be shared, making people more reluctant to accept technology^{6, 37, 56, 65, 68, 70, 72, 73}.

In order to respond to such preconceptions and anxieties we need to:

- Recognise that technology can create legitimate anxieties and fears amongst all those involved.
- Encourage people to be open about such concerns and explore whether they can be addressed through choosing different technology, providing more information about the technology, or changing how it is used.
- Ultimately, be open to the possibility that technology which may seem like a good solution to some problems will not work in practice if concerns cannot be addressed.

5.3 Skills, knowledge and confidence

All of those involved in the process of understanding needs, identifying technological solutions, and introducing and using technology need a certain amount of skill, knowledge and confidence, although these can all be developed over time.

During the process of identifying needs and capacity of older people, problems can arise when staff lack skills in assisting older people to develop full awareness of and express their abilities and impairments⁶⁸. In turn, matching appropriate technology to the individual can be undermined when health and social care providers, support staff or older people themselves have inadequate knowledge about the options available^{7, 69, 74-76}. Skills deficits can also cause difficulties at the point of installation⁶⁹, whilst a lack of confidence amongst older people can also create anxiety at this stage^{37, 66, 72}.

Unsurprisingly, skills issues are also vital once technology is in place, in terms of limited digital skills amongst older people^{52, 66, 68}, lack of familiarity with particular hardware or software amongst both older people and staff⁵⁶, and gaps in knowledge and skills needed to maintain or adjust technology over time⁶⁹.

To address such skills issues it is useful to:

- Ensure that the early phases of work to identify needs and consider technological solutions enable the development of shared understandings about skills, knowledge and confidence between older people, staff and other stakeholders.
- Review these understandings over time – confidence with one device does not necessarily translate to another.
- Explore ways of enhancing the skills, knowledge and confidence of everyone involved.

5.4 Organisational issues

In terms of identifying the needs of older people, systemic issues at the level of the technology provider or the organisation working directly with older people can cause difficulties. These include a lack of organisational readiness, staff under-resourcing and skills deficits required to carry out assessment of older people's technology needs and desires^{7, 64, 69}.

Beyond the level of needs matching, funding issues^{7, 56, 75}, the inflexibility of contracts with existing technology suppliers⁶⁸, and low awareness among health and social care providers about the range of technology options⁷⁵ often preclude the identification of the widest range of possible technological solutions.

In terms of introducing and supporting the use of technology, there are risks around workload demands, potentially leading to staff resistance⁶⁹, or insufficient resource to maintain and adjust technology over time¹⁵. For alert systems, organisations and staff can face challenging demands where panic buttons or detection systems are activated when help is not actually required, especially with people with dementia⁷¹. Lack of support from senior staff can also undermine implementation⁶⁶, as can coordination difficulties between the different organisations involved in supporting technology use and operation⁶³.

To mitigate such organisational barriers we need to:

- Develop collaborative approaches to assessing needs, focusing on positive outcomes for older people – involving older people themselves, family members, staff and potentially other stakeholders as appropriate. These should build on existing skills within the staff team, as well as existing relationships.
- Develop mechanisms for collaboratively identifying and (where possible) testing new technology options.
- Ensure funding arrangements for any new technology are sustainable.
- Ensure that workload demands are manageable for housing and social care staff, as well as anyone else who may be involved in supporting the use of technology. This needs to ensure that people have enough time at each stage of the process – before installation, during the initial 'domestication' process and at any point where technology needs to be adjusted, updated or adapted.

5.5 Issues with the technology itself

In addition to barriers relating to preconceptions of technology, skills and confidence, and organisational issues, the literature identifies a number of other problems that can arise around the technology itself.

During the process of identifying needs and desires that may be addressed by technology, there is always

a risk that the emphasis is placed on the technology itself, rather than outcomes for users⁶⁴, and also that the process and the technology focuses on impairments rather than strengths⁶⁴.

A wide range of studies highlight problems with the design of assistive technology, especially where there has been insufficient involvement of older people themselves, as discussed in the co-production section earlier^{6, 7, 64}. Design problems can mean that technology fails to adequately meet specific needs or cannot be appropriately personalised^{7, 27, 64}, that it can be too complex to use^{64, 66}, is unreliable¹⁵, uncomfortable⁷¹, or simply requires too much space in the home⁷¹. The emergence of voice-activated 'smarthome' systems has also been accompanied by evidence that some people find them startling or discomforting⁷¹. Some technology can also require users to do things which may be difficult for them, such as fall detectors which people with cognitive impairment may forget to put on⁶⁷, whilst false alarms or failure to activate in such systems are particularly problematic⁷¹. All of these issues with the design and practicality of technology can in turn lead people to stop using them over time^{54, 73}.

Beyond the design of devices, infrastructure issues such as internet connectivity can cause problems with some technology^{56, 65, 69}. Depending on the housing situation, network issues can be related to the cost to users, which can also create barriers where older people or their families need to buy technology themselves⁶⁵.

To mitigate these potential barriers caused by issues around the technology itself it is useful to:

- Retain a focus on the intended outcomes for older people (and others) and avoid getting distracted by the technology itself.
- Consider every aspect of devices and ideally test them out with people in the real world to pick up problems early, including infrastructure issues.
- Where possible, ensure that costs of technology are not a barrier for older people and/or their families.

5.6 Summary – overcoming the barriers

The research evidence about barriers to successful implementation of assistive technology can be disheartening, since there are multiple potential problems at each stage of the process. However, none of these issues are insurmountable. Most importantly, the majority of the responses to the potential barriers revolve around ensuring the involvement of older people, staff and other stakeholders in an effective co-production process.

In the final section of this report, we bring together the lessons from across the research evidence to provide some key pointers for the process of effective technology adoption.

6 Conclusions

This report provides a brief overview of the existing research evidence regarding assistive and mainstream technology, in order to inform processes and decision-making. We have focused on the ways in which involving older people and other stakeholders throughout the process of identifying, introducing and using technology may help to overcome some of the barriers experienced in previous research projects and in practice settings. In this conclusion, we draw together the evidence from the previous sections to set out some guidance for anyone considering the possible introduction of assistive technology.

Identifying the desires, needs and capacity of older people

Although assistive technology may have significant benefits for family members, staff or organisations, the primary goal has to be the wellbeing of older people themselves. The starting point therefore has to be the desires and needs of older people, situated within the context of their day-to-day lives and the environment where they live. To get to grips with this, the early stages of assessing need and discussing the possibilities of technology need to consider the following:

- The emphasis should be on positive outcomes and capacity. Problems and age-related impairments are important, since technology is only likely to be of interest if it solves a problem, but they should not be the primary focus.
- At this stage, most of the discussion should not be about technology itself – focusing on existing knowledge of technology may limit the discussion of actual needs and desires.
- Exploring existing use of, and confidence with technology is likely to be valuable, but should be done carefully to avoid reinforcing any fears of technology.

Identifying and introducing possible technology options

In order to move from identified needs and desires to possible technological solutions, we should take the following into account:

- People may find it difficult to consider technological options unless they can see and try them out.
- Older people (and others) may have concerns about a number of different aspects, which need to be addressed:
 - Worries that technology could be used to replace face-to-face contact
 - Concerns about becoming dependent on technology and losing control or independence
 - Possible stigma associated with some technology and/or a sense that it visibly represents a sign of ageing and infirmity
 - Comfort issues for wearable technology
 - Worries about lack of skill to work new technology
 - Concerns about data security and confidentiality
 - Not wanting to be monitored
- It's very easy for the process to be taken over by the technology itself – once a device is identified the discussion may focus on what it can do, rather than what is needed. So, we need to retain the focus on the identified needs.

- Technology doesn't work itself, so we need to consider whether older people will be able to work it and/or whether staff or others can provide any support necessary. This includes being aware of physical and cognitive impairments.
- We need to be aware of the skills and confidence of staff (or carers, family members, etc.) in using any specific piece of technology. This also means that we need to consider resilience – if technology usage is based on just one person's skills, it will stop being used if they are not available.
- Cost is important. We need to consider the immediate costs of purchase, plus any ongoing costs (e.g. software licences) or likely future costs (e.g. maintenance, replacement) and who will have to meet them.

Using, adapting and continuing to use technology

The central learning point from across the research literature is that the implementation of assistive technology should not be seen as a simple 'plug and play' process. Technology needs to fit into people's lives, homes and everyday routines, and should complement or enhance rather than disrupt or undermine existing relationships and support systems. To effectively implement technological options and ensure that they continue to be useful over time, we need to consider the following:

- How any particular piece of technology can be adapted in situ, to best meet the needs of each individual user.
- The skills required by older people and others to use each device effectively. This needs to include ways to build skills and confidence, and identifying supporters where an individual needs help.
- The importance of monitoring and reviewing how technology is actually being used day-to-day to identify problems or ways in which the technology needs to be adapted to suit changing circumstances.
- How any new technology is impacting on staff workloads and the implications for wider service delivery.
- How any new technology is impacting on family caregivers or care staff and the implications for support arrangements.

Focusing on these learning points at each stage of the process should improve the chances of implementing the right technology, in the right way, to meet the desires and needs of older people, as well as delivering benefits for family members and other stakeholders.

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