

ARTICLE

What works in co-producing assistive technology solutions with older people: a scoping review of the evidence

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Abstract

Assistive technology for older people promises much, but the research evidence suggests that it delivers little. One hypothesis to explain the lack of positive impact is that assistive technology is often implemented with little involvement of older people or other stakeholders, such as family members or care staff. The suggestion is that co-production may ensure that assistive technology solutions are better tailored to people's needs, capacities and living situations. In this article, we review existing studies to examine what works in co-production in relation to processes of design and implementation of assistive technology for older people. Our results show a growing interest in co-production as an approach in this field, with a wide range of approaches being employed. We highlight a number of key lessons from the research, including key issues around who needs to be engaged in the co-production, as well as essential elements of the process itself. Our review suggests that there is considerable potential in using co-production to improve effectiveness of technological solutions to the challenges of age-related impairments. However, we also emphasise the need for more longitudinal research in this area, to examine whether such collaborative approaches can truly deliver the promise of assistive technology for older people.

Keywords: assistive technology; co-production; older people; scoping review; dementia

Introduction

The promise of assistive technology (AT) to improve quality of life for older people and simultaneously reduce social care costs has attracted policy attention for at least the past decade and a half in the United Kingdom (UK), as elsewhere (Department of Health, 2005, 2006; European Parliamentary Technology Assessment, 2019; All Party Parliamentary Group on Housing and Care for Older People, 2021; House of Lords Science and Technology Select Committee, 2021). However, the evidence base to support this promise is underwhelming at best, with large, randomised

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controlled studies such as the Whole Systems Demonstrator and the Assistive Technology and Telecare to maintain Independent Living At home in people with dementia (ATTILA) project demonstrating minimal impact for older people or services (*cf.* Cartwright *et al.*, 2013; Steventon *et al.*, 2013; Davies *et al.*, 2020; Howard *et al.*, 2021).

A key argument put forward to explain the gap between promise and delivery is that the research and much of the real-world implementation of AT fails to address the complex, emergent interactions between technology and people (Greenhalgh *et al.*, 2015). The suggestion is that AT cannot be seen as a series of simple ‘plug and play’ adaptations, but as systems which require the active involvement of older people, family members and care professionals in the processes of design and implementation if they are to deliver positive outcomes (Greenhalgh *et al.*, 2013; Gibson *et al.*, 2019). Similar arguments have been made by reviews of specific technologies, including fall detectors (Lapierre *et al.*, 2018) and smart home systems (Turjamaa *et al.*, 2019), as well as reviews of diverse forms of AT targeted at people with dementia (Lynn *et al.*, 2019).

However, co-production is no more ‘plug and play’ than AT. Aside from being a contested term (Ewert and Evers, 2012), co-production is a complex process and there are arguments regarding its assumed value (Pestoff, 2006; Flinders *et al.*, 2016). In order to address these issues, this paper applies Arksey and O’Malley’s (2005) framework to provide a scoping review of the existing evidence regarding co-production in relation to AT for older people, aiming to identify what works in different circumstances.

Co-production

Emerging originally from the work of Elinor Ostrom in the 1970s (Ostrom and Baugh, 1973; Ostrom, 1996), co-production as a concept attempts to encapsulate the ways in which people who use services are actively involved in co-creating, implementing and evaluating them, alongside other stakeholders (Needham and Carr, 2009; Realpe and Wallace, 2010):

Co-production means delivering public services in an equal and reciprocal relationship between professionals, people using services, their families and their neighbours. Where activities are co-produced in this way, both services and neighbourhoods become far more effective agents of change. (Boyle and Harris, 2009: 11)

This approach recognises that service users do not just have needs to be met, but also hold assets, particularly in the form of skills, expertise in their own circumstances and mutual support networks which can and should inform the development of services. Hence, co-production can be seen as a shift from services which do things to people, towards services which work collaboratively with people (Cummins and Miller, 2007).

On one level, this is simply a recognition of the ways in which public services have always relied on some level of user involvement. Even the somewhat caricatured picture of passive recipients dependent on professional expertise relies on service users

providing information about their needs. At another level, however, co-production offers the potential to improve services in terms of effectiveness, efficiency and customer satisfaction through the active involvement and expertise of service users (Voorberg *et al.*, 2015), as well as wider benefits for those involved, including skill development, building social capital and enhancing wellbeing (Needham and Carr, 2009). More radically, co-production has the potential to transform services by altering the locus of power and control, enabling users to plan, deliver, manage and govern services in collaboration with professionals (Pestoff *et al.*, 2011).

However, co-production should not be viewed as a straightforward panacea, since there are numerous cultural, institutional and practical barriers to overcome in order to involve users effectively as partners in service design and delivery. From an organisational point of view, co-production can seem like a challenge to existing practice, bringing new risks without immediate benefits, and requiring staff to learn new skills in partnership working (Needham and Carr, 2009; Voorberg *et al.*, 2015). From the perspective of service users, the potential for positive benefits may be more apparent, but there are nevertheless issues of risk aversion and personal characteristics (skills, impairments, confidence) which can create barriers to effective co-production processes (Pestoff, 2006; Voorberg *et al.*, 2015). Hence, whilst there are strong arguments for co-production as a means of addressing some of the challenges in public service provision around spending and user satisfaction levels (Boyle and Harris, 2009; Needham and Carr, 2009), these challenges need to be considered in order to utilise the approach effectively.

In this paper, we focus on co-production, but it is important to note the diversity of closely related terms, including co-design, user- or person-centred design/services and participative design. In using the term co-production throughout the paper (and in our search strategy) we mean to encompass these kindred terms, which indicate a more participative approach to the design or delivery of services or technology.

Co-production and AT

Evidence regarding the impacts of AT for older people seems to suggest that the promises of improved quality of life and reduced care costs may be optimistic delusions, based on techno-utopian thinking (Greenhalgh *et al.*, 2012). The two largest randomised control studies carried out in the UK, the Whole Systems Demonstrator project, focused on people with long-term health conditions, and the ATTILA project, focused on people with dementia, have both demonstrated that ATs in their current forms and service models have little impact, either for health and social care delivery or in the lives of their users. The findings demonstrate minimal effects in terms of reduction in health and social care service use (Steventon *et al.*, 2013), improvements in quality of life (Cartwright *et al.*, 2013), alleviation of care-giver burden (Davies *et al.*, 2020), enhanced cost-effectiveness or extension of time living independently (Howard *et al.*, 2021).

Alongside these trials, there is now a growing body of evidence in the academic and grey literature regarding the range of issues which can act as barriers to the effectiveness of AT for older people, in four main areas. Firstly, the design of technology itself can be problematic because it is too complex to use (Scottish Government, 2018), unreliable (Lynn *et al.*, 2019), uncomfortable or requires too

much space in the home (Stapleton and Delaney, 2015), or is simply too inflexible to meet specific needs (Bonner and Idris, 2012; Wilson *et al.*, 2012). In addition, the design of some devices relies on infrastructure, such as broadband connectivity, which may not be available or may be costly for users (Deloitte, 2017; Hung *et al.*, 2021). Secondly, the process of introducing technology can be hindered by preconceptions and anxieties amongst older people, including stigmatisation and association with unwelcome ideas of ageing (Bonner and Idris, 2012; Holliday, 2015), as well as concerns about possible loss of human contact (Mostaghel, 2016; Woolham *et al.*, 2018), being monitored or losing control of personal data (Demiris and Thompson, 2011; Mostaghel, 2016; Woolham *et al.*, 2018; Frischer *et al.*, 2020). Thirdly, older people may lack digital skills to utilise some items of AT (Downing *et al.*, 2012; Tunstall, 2020), although there can also be difficulties caused by presumptions that potential users will lack such skills (Deloitte, 2017). Gaps in knowledge and skills can also be problematic amongst those who may support older people to use AT, including family members and care staff, particularly where technology needs to be maintained or adjusted over time (Cruickshank and Trim, 2019; Hung *et al.*, 2021). Lastly, organisational barriers can arise in terms of funding issues (Greenhalgh *et al.*, 2015; Tunstall, 2020), inflexible contracts with technology suppliers (Woolham *et al.*, 2018), lack of awareness about options (Greenhalgh *et al.*, 2015), limited support from senior staff (Scottish Government, 2018) and staff under-resourcing to support AT introduction and use (Cruickshank and Trim, 2019).

This extensive list of potential problems goes some way to explain the lack of positive impacts from AT, either in research or practice. Looking across these issues, there are three important characteristics which apply to multiple barriers. Firstly, the difficulties arise at different points in the process, from initial design (*e.g.* inflexible devices), through the various stages of implementation, including identification and introduction (*e.g.* older people's concerns, lack of funding, technology assessment processes), to long-term effective use (*e.g.* skills deficits among users, deficits in professional training, lack of maintenance). Secondly, many of these barriers may be mutually reinforcing. For example, if staff lack skills and confidence in using technology, they will be unable to assist older people who may themselves lack skills and confidence with AT. Lastly, and perhaps most importantly, all of these potential barriers have a significant human element – either in terms of interactions between technology and people using it, or between different groups of people involved in the process. The issues may be related to the technology, but can also be linked to the systems of the services delivering them. As such, they are mostly not amenable to simple technical fixes. Hence, the means of overcoming these barriers, or preventing them from arising in the first place, needs to be inherently human-focused. In order to optimise the design, selection and effective implementation of AT, older people themselves need to be actively involved at every stage of the process, alongside family members, care professionals and other stakeholders (Greenhalgh *et al.*, 2013; Wherton *et al.*, 2015; Gibson *et al.*, 2019).

Recognising that such participative processes are themselves not without challenges, as set out above, this study set out to assess the existing evidence regarding co-production in relation to older people and AT. Specifically, we aimed to address the following research questions:

- (1) How is co-production being used in relation to AT for older people?
- (2) What works in co-production in relation to processes of design and implementation of AT for older people?

Methods

Given the absence of existing reviews and the diverse, primarily qualitative evidence base, our approach to the review was based on Arksey and O'Malley's (2005) framework for scoping reviews, aiming to map and summarise the literature, identify the key concepts and highlight research gaps. Building on an initial, rapid review conducted for the Promoting INclusive liVing vIa Technology-Enabled support (INVITE) project, we developed an iterative approach to identifying, assessing and extracting data from relevant studies (Daudt *et al.*, 2013).

Search strategy

Our strategy consisted of two complementary elements: searching the academic and grey literature. For the academic research evidence, we conducted a systematic search of the two largest bibliographic databases, Scopus and Web of Science. Searches were restricted to items published since 2010, on the basis that the speed of change in AT would make earlier research less relevant. Search terms were selected on the basis of team expertise using a PICO framework (Stern *et al.*, 2014) tailored to the review questions:

- Population: older people.
- Intervention: co-production.
- Context: any context excluding specialist health-care settings.
- Outcome: use of AT.

Three search strings were developed for the population, intervention and outcome elements of this framework, with context being used as a filter once the searches were conducted.

Each string was tested individually to refine the terms in order to improve sensitivity and specificity, before being combined for the final searches (for full search terms, see the Appendix). Inclusion criteria were applied to the searches, as shown in Table 1.

Table 1. Inclusion criteria

Aspect of review	Decision	Rationale
Time period	Post-2010	Speed of change in assistive technology – earlier research likely to be far less relevant
Language	English	Time and resources available
Type of publication	Peer-reviewed articles only	Excluding material which has not been peer-reviewed for quality reasons, and also excluding books for reasons of time, resources and access during the COVID-19 pandemic

After duplicate removal, papers were filtered for relevance based on title and abstract, excluding any items which did not meet our PICO framework.

The academic database search was complemented by two parallel searches of the grey literature, since we were aware of a range of reports highlighting the importance of co-production in relation to AT. Firstly, hand searches were conducted of relevant organisations’ websites, again drawing on team expertise. Secondly, the search strings were used in Google, with the first 50 returns being checked for relevant items (a cut-off point of 50 items was used because no new, relevant reports were identified after the first 30). Grey literature was similarly restricted to post-2010 and English language, with only full reports being considered, in order to exclude blog posts, news items and similar weak sources of evidence. Titles and executive summaries were used to filter items on the basis of relevance, before a full read to assess whether the identified reports contained relevant empirical evidence. Interestingly, these filters removed all the grey literature items from our review. There are repeated entreaties in the form of guidance documents, sets of principles and policy recommendations, urging AT providers and other stakeholders to employ co-production (cf. National Development Team for Inclusion, 2014; Alzheimer Scotland, 2015; Mental Welfare Commission for Scotland, 2015; French, 2020). However, we identified only three reports with any specific research regarding co-production of AT with older people (Age Platform Europe, 2014; VODG, 2017; European Parliamentary Technology Assessment, 2019), none of which reported sufficient detail on the original studies to provide evidence of value for this review.

Figure 1 sets out the combined search process, with the number of items at each stage. A total of 39 items were included in the final review, representing 33 unique studies. These are listed in Table 2, along with information about the phase, sample characteristics and co-production methods.

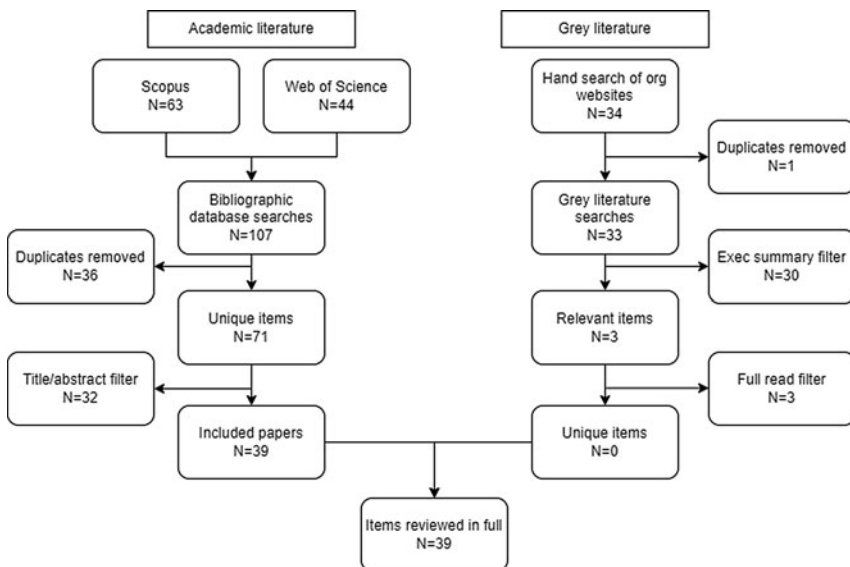


Figure 1. Search process flow diagram.

Table 2. Phase, sample and methods used in selected papers

Author and date	Title	Location	Co-production phase	Sample characteristics	Co-production methods
Astell <i>et al.</i> (2021)	Technology for healthy aging and wellbeing: co-producing solutions	UK	Design	Older people; professionals (health and social care); advocates for older people	Workshops/focus groups
Banbury <i>et al.</i> (2020)	Adding value to remote monitoring: co-design of a health literacy intervention for older people with chronic disease delivered by telehealth – the telehealth literacy project	Australia	Design	Older people (with chronic health conditions); professionals (health)	Workshops/focus groups; interviews
Botero and Hyysalo (2013)	Ageing together: steps towards evolutionary co-design in everyday practices	Finland	Design	Older people	Workshops/focus groups; cultural probes
Brookfield <i>et al.</i> (2020)	Perspectives on ‘novel’ techniques for designing age-friendly homes and neighborhoods with older adults	UK	Design	Older people	Workshops/focus groups; interviews; cultural probes
Castro <i>et al.</i> (2020)	Tailoring digital apps to support active ageing in a low income community	Brazil	Design	Older people (aged over 40)	Workshops/focus groups
Chadborn <i>et al.</i> (2019)	Citizens’ juries: when older adults deliberate on the benefits and risks of smart health and smart homes	UK	Pre-design	Older people (including typically under-represented, e.g. disabled people, ethnically diverse communities)	Workshops/focus groups
Cortellessa <i>et al.</i> (2021)		Spain, Romania	Design	Older people (with mild cognitive impairment); family	Workshops/focus groups; interviews

(Continued)

Table 2. (Continued.)

Author and date	Title	Location	Co-production phase	Sample characteristics	Co-production methods
	Co-design of a TV-based home support for early stage of dementia			members; professionals (care and health)	
Curtis and Brooks (2020)	Digital health technology: factors affecting implementation in nursing homes	UK	Design	Older people (nursing home residents); professionals (nurses)	Workshops/focus groups; interviews
Farshchian <i>et al.</i> (2017)	From episodes to continuity of care: a study of a call center for supporting independent living	Norway	Design	Professionals (call centre)	Workshops/focus groups; interviews; observations
Ferguson <i>et al.</i> (2020)	Clinician perspectives on the design and application of wearable cardiac technologies for older adults: qualitative study	Australia	Design	Professionals (health)	Workshops/focus groups
Fischer <i>et al.</i> (2021)	Co-design as learning: the differences of learning when involving older people in digitalization in four countries	Spain, The Netherlands, Canada, Sweden	Design	Older people	Workshops/focus groups
Greenhalgh <i>et al.</i> (2013)	What matters to older people with assisted living needs? A phenomenological analysis of the use and non-use of telehealth and telecare	UK	Implementation	Older people (with multi-morbidity)	Interviews; cultural probes
Greenhalgh <i>et al.</i> (2015)	What is quality in assisted living technology? The ARCHIE framework for effective telehealth and telecare services	UK	Design	Older people; family members; professionals (tech providers, care providers)	Workshops/focus groups; interviews; cultural probes

Hepburn (2018)	A new governance model for delivering digital policy agendas: a case study of digital inclusion amongst elderly people in the UK	UK	Design and implementation	Older people	Workshops/focus groups
Knight-Davidson <i>et al.</i> (2020)	Methods for co-creating with older adults in living laboratories: a scoping review	Various	Design	Older people	Living labs (incorporating workshops/focus groups, interviews, observations, surveys)
Kopec <i>et al.</i> (2018)	Older adults and hackathons: a qualitative study	Poland	Design	Older people; younger adult programmers and graphic designers	Workshops/focus groups (in hackathon)
Lan Hing Ting <i>et al.</i> (2020)	Examining usage to ensure utility: co-design of a tool for fall prevention	France	Design	Older people; professionals (health)	Workshops/focus groups; interviews; observations; survey
Leslie <i>et al.</i> (2019)	Recruitment of caregivers into health services research: lessons from a user-centred design study	Canada	Design	Family members	Workshops/focus groups
Lopes <i>et al.</i> (2016)	Co-conception process of an innovative assistive device to track and find misplaced everyday objects for older adults with cognitive impairment: the TROUVE project	France	Design	Older people (with cognitive impairment); family members; professionals (care)	Workshops/focus groups; interviews; cultural probes
Macdonald <i>et al.</i> (2012)	Hospitalfoodie: an interprofessional case study of the redesign of the nutritional management and monitoring	UK	Design	Older people; family members; professionals (health, hospital caterers, food producers, third-sector organisations)	Workshops/focus groups; interviews

(Continued)

Table 2. (Continued.)

Author and date	Title	Location	Co-production phase	Sample characteristics	Co-production methods
	system for vulnerable older hospital patients				
Malmborg <i>et al.</i> (2016)	Mobilizing senior citizens in co-design of mobile Technology	Austria, Denmark	Design	Older people	Workshops/focus groups; cultural probes
Markowski (2020)	The Teletalker – a design researcher’s tool to explore intergenerational online video connectivity in-the-wild	UK	Design	Older people; younger people (students)	Interviews; observations; surveys
McLoughlin <i>et al.</i> (2013)	Inside a digital experiment: co-producing telecare services for older people	Italy, Czechia	Design and implementation	Older people	Workshops/focus groups; interviews; observations; surveys
Mort <i>et al.</i> (2013)	Ageing with telecare: care or coercion in austerity?	Spain, The Netherlands, Norway, UK	Implementation	Older people; family members; professionals (care, social work, housing, call centre)	Workshops/focus groups; interviews; observations
Neves <i>et al.</i> (2021)	When technologies are not enough: the challenges of digital interventions to address loneliness in later life	Canada, Australia	Design	Older people	Interviews; surveys; observations
Noublanche <i>et al.</i> (2019)	The development of gerontechnology for hospitalized frail elderly people: the ALLEGRO hospital-based geriatric living lab	France	Design	Older people	Living lab
		UK	Implementation		

Procter <i>et al.</i> (2014)	The day-to-day co-production of ageing in place			Older people; professionals (telecare providers)	Interviews; cultural probes
Procter <i>et al.</i> (2018)	Hidden work and the challenges of scalability and sustainability in ambulatory assisted living	UK	Implementation	Older people (with cognitive impairment and multi-morbidity); family members; professionals (health, care, call centre, technology providers)	Interviews; observations; cultural probes
Righi <i>et al.</i> (2017)	When we talk about older people in HCI, who are we talking about? Towards a 'turn to community' in the design of technologies for a growing ageing population	Spain	Design and implementation	Older people	Workshops/focus groups; interviews; observations; cultural probes
Shadarevian <i>et al.</i> (2020)	Creating a toolkit with stakeholders for leveraging tablet computers to support person-centred dementia care in hospitals	Canada	Implementation	Older people (with cognitive impairment); family members; professionals (health)	Workshops/focus groups; interviews
Silva <i>et al.</i> (2018)	A process to evaluate an iTV platform to enhance seniors' access to information about public and social services	Portugal	Design	Older people	Observations; survey
Stokke (2018)	Older people negotiating independence and safety in everyday life using technology: qualitative study	Norway	Implementation	Older people; family members; professionals (care)	Interviews; observations
Thilo <i>et al.</i> (2016)	Involvement of older people in the development of fall detection systems: a scoping review	Various	Design	Older people	Review paper – most studies using workshops/focus groups, interviews, surveys

(Continued)

Table 2. (Continued.)

Author and date	Title	Location	Co-production phase	Sample characteristics	Co-production methods
Ventura and Talamo (2016)	Simpler is better? Analysis of a codesign session with elders	Italy	Design	Older people; professionals (care)	Workshops/focus groups
Wherton <i>et al.</i> (2012)	Designing assisted living technologies 'in the wild': preliminary experiences with cultural probe methodology	UK	Implementation	Older people	Interviews; cultural probes
Wherton <i>et al.</i> (2015)	Co-production in practice: how people with assisted living needs can help design and evolve technologies and services	UK	Design	Old people; professionals (care, telecare service providers and tech suppliers)	Workshops/focus groups; interviews; cultural probes
Wild <i>et al.</i> (2014)	Differing perspectives on a role for technology in care homes to improve the lives of older people and the work environment of staff	UK	Implementation	Older people (care home residents); family members; professionals (care)	Workshops/focus groups
Wilson <i>et al.</i> (2012)	Innovating relationships: taking a co-productive approach to the shaping of telecare services for older people	Italy, Czechia	Design and implementation	Older people	Workshops/focus groups; interviews; observations; surveys
Zamir <i>et al.</i> (2018)	Video-calls to reduce loneliness and social isolation within care environments for older people: an implementation study using collaborative action research	UK	Design and implementation	Older people	Interviews; observations; cultural probes

Note: UK: United Kingdom.

Data extraction and synthesis

The selected items were reviewed in depth, with data being extracted into a spreadsheet. Although ethical approval was not required for the study, the ethics of accurate representation of findings (Suri, 2020) were considered in this process and addressed through inter-reviewer discussions. Data extraction focused on three aspects. Firstly, the co-production phase was identified, noting whether it occurred in relation to the pre-design, design or implementation of technology, or across more than one phase. Secondly, the co-production methods were determined, alongside recording which groups of people were involved. Lastly, the papers were examined for any evidence of the effectiveness of the co-production approach, as well as any reflections from the authors on how it could be improved. The data from the spreadsheet were then narratively synthesised.

Results

How co-production is being used

Summary information about the reviewed papers is provided in Table 2. Notably, as Figure 2 shows, there is a clear trend towards more research regarding co-production, perhaps reflecting a growing recognition of the limited impact of AT for older people when it is designed or implemented without their active involvement.

A significant majority of studies (25 of the 39 papers reviewed) employ co-production techniques in the design phase, involving older people in the processes of defining the needs to be met, developing the specifications or testing prototypes as part of the development process for new items of AT. By comparison, just eight studies report on co-production during real-world implementation of AT solutions, and only four through both design and implementation phases

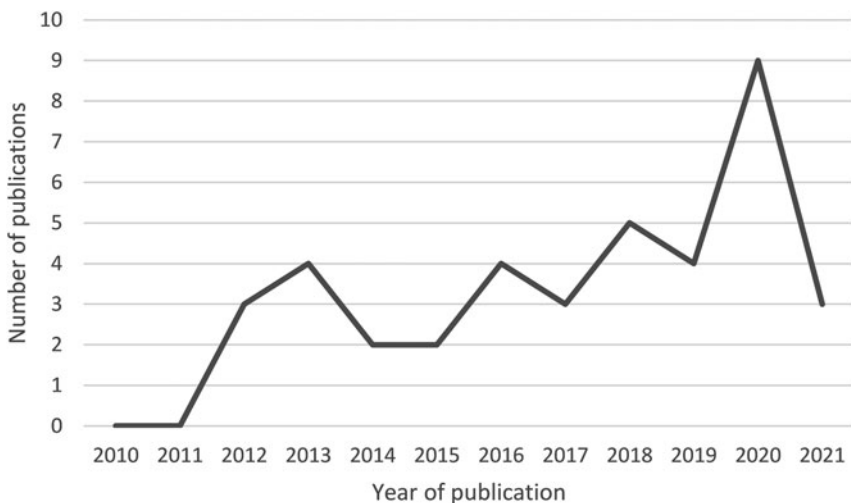


Figure 2. Publications by year.

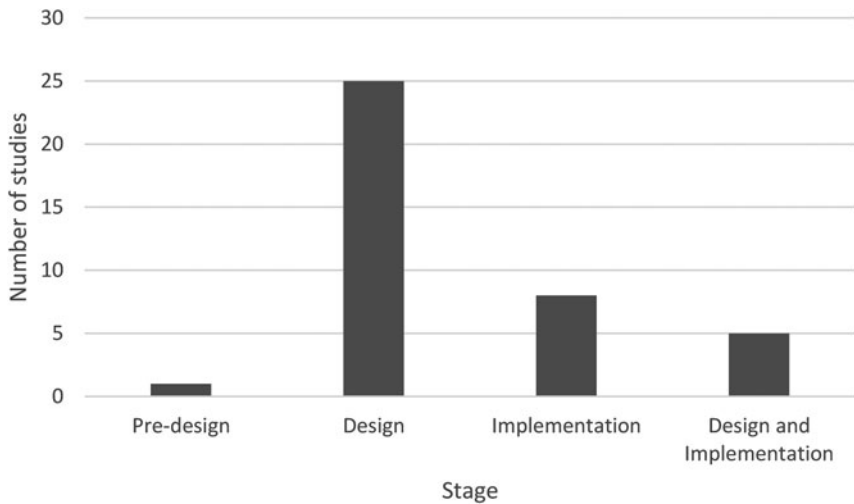


Figure 3. Stage at which co-production is employed.

(Figure 3). However, this should not be taken as firm evidence that older people are rarely involved in the process of introducing and using AT in practice, since it may in part be an artefact of the research literature. Whereas many attempts to develop new devices will inevitably be taking place in a research context, much of the day-to-day activity of implementing AT solutions happens away from the gaze of researchers.

Not only is there a limited focus on implementation and use of AT, none of the studies consider co-production around the process of selecting technology. The papers either relate to the design and/or prototyping of single devices, or aim to examine the real-world usage of technology which is already in place. Hence, there appears to be no research focused on the ways in which older people may be actively involved in choice of technology, despite the growing range of mainstream technology which can perform an assistive purpose. Indeed, this seems to reflect a wider absence of research regarding the involvement of older people in the implementation of services, including the choice and use of technology.

Unsurprisingly, the vast majority of studies (36 of 39) involve older people themselves in the co-production process, although three studies only involve family members or professionals. Ten studies involve family members, primarily engaging with those relatives who provide informal care. Just under half (18) involve health or social care professionals, whilst four involve commercial technology providers directly in the co-production process (Figure 4).

Looking in more detail at the specific co-production methods used to involve older people and other stakeholders, it is possible to identify six broad approaches and examine how they are used at different stages of AT design and implementation – workshops or focus groups, interviews, cultural probes, observations, surveys and living labs.

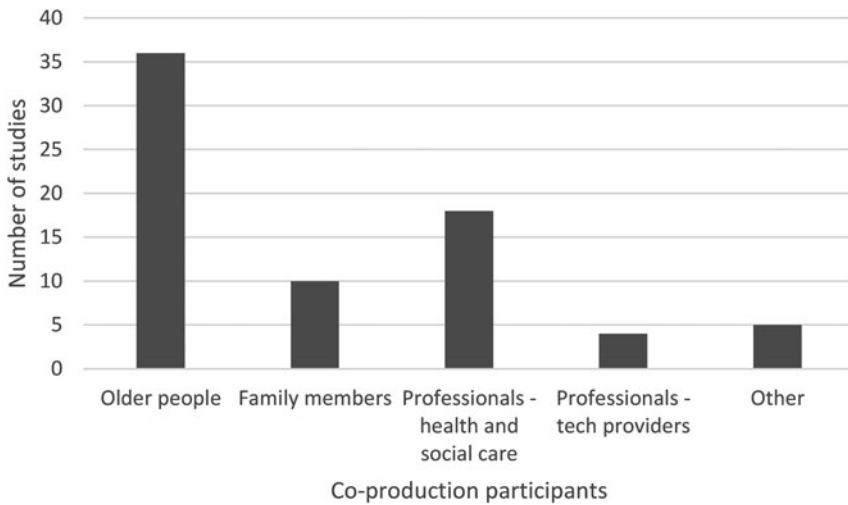


Figure 4. Stakeholders participating in co-production.

Workshops or focus groups

Group-based discussions are primarily used in the design phase, to establish needs and develop AT to meet them, with a smaller number of studies using them to gather feedback on prototypes. The ways in which such approaches are used varies considerably in terms of participants, process and depth of collaboration. Some studies use relatively complex, iterative processes of multiple workshops throughout the design phase (Botero and Hyysalo, 2013; Ventura and Talamo, 2016; Leslie *et al.*, 2019), whilst others engage in narrower, more targeted discussions to develop specifications (Cortellessa *et al.*, 2021; Ferguson *et al.*, 2020) or examine specific items of existing technology (Castro *et al.*, 2020). The workshops themselves use different techniques, ranging from relatively formal focus group discussions (Leslie *et al.*, 2019) to more innovative engagement approaches, such as using storyboards to stimulate discussion (Wherton *et al.*, 2015).

Interviews

One-to-one discussions are utilised across all the phases of design and implementation, to establish needs, gain feedback on prototypes or examine issues surrounding the use of AT in the real world. Again, there is considerable variety in terms of participants, level of formality and the number of interviews used at different points. A few studies use a relatively small number of conventional interviews with older people or other stakeholders (Wilson *et al.*, 2012; Curtis and Brooks, 2020; Shadarevian *et al.*, 2020), whilst others engage in multiple informal discussions over a lengthy time period (Hepburn, 2018; Zamir *et al.*, 2018). Notably, every study which employed one-to-one discussions always uses them alongside other methods, with some deliberately interweaving them with observations, through techniques such as walking interviews (Brookfield *et al.*, 2020).

Cultural probes

Around a third of the papers (12 out of 39) use methods of engagement which can be loosely grouped within the notion of ‘cultural probes’. However, it should be noted that half of these papers relate to different aspects of a single, large study so, although there appears to be growing interest in cultural probe methods, they are not as common as this statistic might suggest. The notion of cultural probes, which originates from Gaver *et al.* (1999), encompasses a diverse range of tools which can be used to ‘provoke responses’ (Gaver *et al.*, 1999) from older people. By leaving participants to record aspects of their daily life or their experience with AT, using tools such as maps, diaries, cameras and drawing exercises, the studies aim to gather detailed data on needs and the ways in which devices may or may not meet them (Wherton *et al.*, 2015; Lopes *et al.*, 2016; Brookfield *et al.*, 2020).

Observations

Arguably, observations are not in themselves a co-production method, since they do not directly involve older people (unless they become researchers themselves) or other stakeholders. However, they were utilised by a small number of studies alongside more collaborative methods, generally to inform the discursive process (Farshchian *et al.*, 2017; Righi *et al.*, 2017; Silva *et al.*, 2018; Stokke, 2018).

Surveys

Again, surveys or questionnaires are debatable as a co-production method, since they offer limited potential for active engagement of older people and other stakeholders. However, questionnaires were used by some studies to gather quantitative data on prototypes as part of an iterative process, compiling the survey results to inform later discussions (Lopes *et al.*, 2016; Silva *et al.*, 2018; Lan Hing Ting *et al.*, 2020).

Living labs

The concept of living labs is used in a variety of ways, but the term generally refers to approaches where designers and researchers observe users and test out technology through experimentation. This is more of a general framework than a specific method, with living lab studies using some or all of the previous five approaches (Malmborg *et al.*, 2016). Indeed, the living lab approach in its broadest sense can almost be seen as a synonym for co-production. However, there can be differences, particularly where living lab approaches involve engaging people through the use of real-world simulations to test prototypes and examine technology usage (Noublanche *et al.*, 2019; Knight-Davidson *et al.*, 2020).

What works in co-production

There are two substantial limitations to the evidence provided from the reviewed papers. Firstly, with just a handful of exceptions (Wherton *et al.*, 2012, 2015; Brookfield *et al.*, 2020; Knight-Davidson *et al.*, 2020; Astell *et al.*, 2021), the studies employ co-production techniques, but do not explicitly set out to evaluate them. Hence, evidence on what works in co-production is drawn primarily from descriptions of methods and reflections in the discussion sections of the reviewed papers.

Secondly, and more importantly, none of the studies are able to demonstrate a causal effect of co-production in terms of the intended long-term outcomes of AT, such as improved quality of life or greater independence. This is perhaps not surprising, since the causal pathways from co-production processes to long-term outcomes of AT are unavoidably complex. The findings are therefore restricted to evidence regarding the effectiveness of different approaches to co-production in terms of their ability to engage older people and other stakeholders in the processes of introducing and using AT. Where improvements in engagement are shown, it is plausible to assume that this will feed through into better long-term outcomes, since older people are more likely to use the devices concerned, but further research would be necessary to demonstrate such effects.

Bearing these caveats in mind, we identified six broad themes regarding what works, relating to the preparation for and initiation of the co-production approach, as well as to elements of the process itself. These themes are: who defines the problem and how; who needs to be involved; engagement; defining 'older people'; structure and methods; and broader process issues.

Who defines the problem and how

Even within studies selected for their use of co-production, many started with a pre-defined problem and an assumption that AT would be the solution. In some instances, older people themselves did not agree with researchers or even their own family members about the importance of the problem, such as the people with cognitive impairment in Lopes *et al.* (2016), who identified losing words as a much higher priority than losing keys. Two approaches attempted to address this issue. Firstly, using ethnography before the design process can help to understand more fully the real-world experience of age-related impairments and the everyday social practices of older people (Botero and Hyysalo, 2013; Curtis and Brooks, 2020). Secondly, Righi *et al.* (2017) advocate engaging in co-production with older people to identify issues and potential solutions before embarking on design.

Who needs to be involved

As illustrated in Figure 4, the studies involved a range of different stakeholders within their co-production processes. Involving family members, care staff and others who may play a role in supporting the use of AT can be valuable at all stages from design to implementation (Greenhalgh *et al.*, 2015; Wherton *et al.*, 2015; Zamir *et al.*, 2018), especially where the older people concerned may struggle to communicate their own needs due to cognitive impairment (Knight-Davidson *et al.*, 2020). Moreover, where devices will form part of a wider system, such as personal alarms, it can be important to involve staff working at different points in the system in order to co-produce processes as well as devices (Wilson *et al.*, 2012; Farshchian *et al.*, 2017). Clearly, involving different stakeholders has the potential to create disagreement, but well-designed co-production processes can also help people to understand each other's perspectives (Wherton *et al.*, 2015; Astell *et al.*, 2021) and envision innovative solutions to complex problems (Macdonald *et al.*, 2012).

Engagement

The process of engaging participants in co-production is heavily reliant on building trust (Knight-Davidson *et al.*, 2020), which can be assisted by working with intermediaries who know the community, such as local social housing providers (Hepburn, 2018). This can be particularly important where older people and other stakeholders have had poor prior experiences of participation (Malmborg *et al.*, 2016) or of public services more widely (Hepburn, 2018). As part of the trust-building process, studies emphasise the necessity of understanding the range of motivations that people may have for participating in a co-production process (Malmborg *et al.*, 2016) and ensuring that there is clarity around potential benefits, in order to encourage participation whilst managing expectations of the outcome (Botero and Hyysalo, 2013).

Defining 'older people'

Beyond the stage of identifying who should be involved and how to engage them, there are a number of issues related to how older people may be defined or categorised in AT research. A number of studies stress the importance of recognising diversity within the broad category of 'older people'. Notably, it is sometimes difficult to ascertain whether studies have considered this diversity, since papers often provide limited detail regarding those involved in the co-production processes (Thilo *et al.*, 2016). Understanding differences in living situation and in specific age-related impairments is essential not merely for the design of devices but also for the design of co-production processes, so that the level of participation can be tailored to people's strengths and to ensure accessibility where people have cognitive, visual or other physical impairments (Wherton *et al.*, 2012; Thilo *et al.*, 2016; Righi *et al.*, 2017; Brookfield *et al.*, 2020; Knight-Davidson *et al.*, 2020). In order to meet this requirement, there is value in exploring the specific constituency carefully before embarking on a co-production process (Botero and Hyysalo, 2013), partly to overcome any stereotypes of older people or presumptions about the methods they may engage with, in the minds of those leading the co-production (Kopec *et al.*, 2018; Brookfield *et al.*, 2020; Fischer *et al.*, 2021). Crucially, this reflective approach to preconceptions needs to extend throughout the process, including consideration of the language used, to avoid using terms which may be off-putting or stigmatising for older people, such as a one-sided emphasis on decline and impairment (Malmborg *et al.*, 2016; Righi *et al.*, 2017).

Structure and methods

In relation to the approaches used within the co-production, there are a number of basic elements highlighted by the reviewed studies, which are common requirements for any participative process. These include: recognising that most people have busy lives, so will have limited time available (Malmborg *et al.*, 2016), with drop-in approaches being useful (Brookfield *et al.*, 2020); considering the accessibility of the venue (Kopec *et al.*, 2018), ideally using locations where people are already gathered (Righi *et al.*, 2017); providing a welcoming atmosphere (Brookfield *et al.*, 2020); using skilled facilitators for any group processes (Chadborn *et al.*, 2019; Castro *et al.*, 2020); and ensuring any materials used are

accessible for participants, taking impairments, literacy and language skills into account (Brookfield *et al.*, 2020).

Beyond these basics, the specific methods need to be tailored to the stakeholders involved, the need to be addressed, the type of technology and the stage of development, from design to implementation. In order to address the issues around diversity of older people and potential differences in perspective, several studies emphasise the value of using vignettes or anonymised case studies to provide a basis for shared exploration of needs and potential solutions (Macdonald *et al.*, 2012; Greenhalgh *et al.*, 2015; Wherton *et al.*, 2015; Chadborn *et al.*, 2019; Banbury *et al.*, 2020; Astell *et al.*, 2021). Creative and visual methods can also be valuable to frame discussion or enable participants to introduce their own perspectives and experiences. Using existing photographs or mapping exercises can help as prompts, whilst asking participants to take pictures related to their own living situation can enable them to proactively shape discussion and explore the details of real life (Wherton *et al.*, 2012; Brookfield *et al.*, 2020). Such visual methods can be particularly valuable where participants have cognitive impairments, as can other approaches to identifying issues which do not require memory, such as diaries or wish lists created at home (Wherton *et al.*, 2012; Procter *et al.*, 2018), although potential barriers such as visual impairments need to be considered in using such approaches. One approach to manage such barriers is to offer participants a range of different methods (Wherton *et al.*, 2012), although care needs to be taken not to overwhelm people with multiple tools and techniques.

Whether in research or service implementation, understanding the context within which needs arise and potential solutions may be employed is crucial for the effective co-production of AT solutions. Techniques such as walking interviews can be valuable in exploring needs in real-world situations (Brookfield *et al.*, 2020). Similarly, more conventional interviews are likely to be more effective in understanding needs, strengths and specific issues to do with the use of technology when they are located in older people's homes, or other relevant contexts (Greenhalgh *et al.*, 2013, 2015; Mort *et al.*, 2013), and the same is true for testing prototype devices (Cortellessa *et al.*, 2021). Moreover, for older people to engage in co-production of specific technological solutions, it is useful to be able to try out the devices, rather than discussing them in the abstract (Wilson *et al.*, 2012; Wherton *et al.*, 2015; Astell *et al.*, 2021).

Finally, in addition to tailoring the co-production methods to fit participants and context, a successful co-production approach needs to be flexible, especially to adapt when life events and acute illness disrupt engagement at particular points (Wherton *et al.*, 2012; Knight-Davidson *et al.*, 2020).

Broader process issues

Looking across the process of design, installation and use of AT, the studies identify three important issues about the ways that co-production works. Firstly, there is a strong message that co-production which only takes place at the design phase is insufficient, since even the best design will encounter problems when implemented in the real world (Wilson *et al.*, 2012; Thilo *et al.*, 2016; Knight-Davidson *et al.*, 2020). Relatedly, the second point is that, in order to co-produce AT solutions effectively, the process needs to be long term and iterative, recognising that

solutions need to evolve rather than being created in a single step (Botero and Hyysalo, 2013). Lastly, and perhaps most importantly, studies that explore the use of AT in the real world highlight the ways in which it is always co-produced in practice, whether through their delivery within technology-enabled health or social care services (Mort *et al.*, 2013; Stokke, 2018), or within other sectors, such as housing (McCall *et al.*, 2022). This recognises that technology needs to be ‘domesticated’ by fitting it into existing everyday routines (Mort *et al.*, 2013), often involving a process of tinkering and adaptation (Greenhalgh *et al.*, 2013; Stokke, 2018). This in turn requires devices themselves to be flexible, which is often not the case (Procter *et al.*, 2014), and needs technology providers to be open to creative uses of the products (Mort *et al.*, 2013; Greenhalgh *et al.*, 2015).

Discussion

Although the evidence base regarding co-production in relation to AT for older people is relatively small, it is clearly growing. This perhaps reflects a ‘turn to community’ in the AT field (Righi *et al.*, 2017), following a similar trend in other areas of welfare provision over the past couple of decades (Rolfe, 2016).

This review of the literature suggests that a diverse range of approaches are being employed to engage older people and other stakeholders in the processes of designing, introducing and implementing AT. However, much of this diversity appears in just a few studies (Wherton *et al.*, 2012; Greenhalgh *et al.*, 2013, 2015; Procter *et al.*, 2014; Brookfield *et al.*, 2020), with most research applying a narrow range of relatively traditional methods, particularly focus groups and conventional interviews. Moreover, most studies employ co-production in a time-limited fashion, often restricted to the design phase of AT development, perhaps reflecting the techno-utopian thinking which often surrounds AT (Greenhalgh *et al.*, 2012), alongside deeper structural issues with research funding and the opportunities for researchers to engage with communities over longer, flexible timescales. Furthermore, very few studies set out to evaluate the process of co-production and, as yet, there is no research demonstrating that co-production delivers the promised long-term outcomes of AT, so the conclusions that can be drawn from the evidence base are somewhat limited. Nevertheless, the findings from this review do provide some strong messages about what works in co-production relating to AT for older people, at least in terms of facilitating greater engagement with AT, and improvements in design and implementation processes.

The effectiveness of co-production is reliant on some basic foundations in terms of defining the problem and who needs to be involved. Where older people, as the ultimate users of AT, are not engaged in defining the problem, there is a significant risk that devices will target the wrong needs or try to meet them in ways which conflict with users’ own capacities and living situations. This will inevitably exacerbate problems with AT around complexity, inflexibility and friction with the socio-spatial reality of daily living arrangements (Bonner and Idris, 2012; Stapleton and Delaney, 2015; Scottish Government, 2018). Alongside older people themselves, family members, care staff and other stakeholders often need to be involved in co-production processes, recognising their role as the social infrastructure which supports the ongoing use and maintenance of AT. All of this engagement requires

trust, which can be built through using intermediaries and by communicating clearly about expectations and benefits, bearing in mind the potential for power dynamics to limit mutual learning (Fischer *et al.*, 2021). Beyond these initial elements, co-production processes are likely to be more effective when those leading the process reflect on their own preconceptions of 'older people' to avoid inaccurate presumptions about skills or capacity (Deloitte, 2017), and to use language which is not stigmatising. Again, where preconceptions exclude some older people from participation, AT solutions are unlikely to meet their needs or fit with their strengths, so engaging the full diversity of older people is key. At the risk of infinite regress, these lessons around the foundations for effective co-production highlight the potential value of preliminary discussions with older people and other stakeholders, in order to co-produce the co-production process itself (Kopeck *et al.*, 2018; Fischer *et al.*, 2021).

Much of the evidence around specific methods for co-production points towards relatively obvious principles, especially in terms of tailoring approaches to fit the lives and capacities of potential participants. However, there are also important lessons regarding the value of techniques such as vignettes to open up shared exploration of needs and solutions, as well as creative and visual approaches to enable older people to introduce their own perspectives and experiences. These are not unique to work with older people, but can be particularly important where participants have age-related impairments related to cognition, perception or physical ability. As others have noted, people with cognitive impairment are frequently excluded from the development of AT (Meiland *et al.*, 2014). Whilst this may be partly due to a concern to protect people with dementia from distress, there is evidence to suggest that involvement in co-production processes can be empowering if done well (Span *et al.*, 2013). Crucially, co-production in relation to AT also requires consideration of how engagement techniques relate to context, since technology is used in the complex reality of people's homes and lives, not in the abstract setting of a workshop. These challenges in selecting methods and designing effective co-production processes emphasise three key lessons from this review.

Firstly, in terms of practice, co-production approaches need to be employed in a flexible, adaptive fashion (Wherton *et al.*, 2012; Knight-Davidson *et al.*, 2020), rather than being predefined by researchers, AT providers or social care organisations. In much the same way that AT needs to be selected and adapted to meet the specific needs and capacities of individual older people living in particular circumstances, so co-production must be undertaken in ways which can be moulded to suit those who need to be engaged.

Secondly, there is a need for further research to examine what works in different circumstances, starting from greater reflection on co-production processes within research (Lan Hing Ting *et al.*, 2020). The latter may be particularly useful in evidencing the wider outcomes of co-production, including impacts on trust, self-efficacy and social capital (Hepburn, 2018), although research should also consider the potential for participation to generate issues around responsibility, risk and accountability (Wilson *et al.*, 2012), as has been evidenced in other fields (Rolfe, 2018).

Perhaps most importantly, we highlight the finding from several studies that AT co-production does not end with the completion of product design, since the use of

technology is always co-produced through processes of domestication, adaptation and tinkering (Greenhalgh *et al.*, 2013; Mort *et al.*, 2013; Stokke, 2018; Gibson *et al.*, 2019). Hence, engaging older people and other stakeholders throughout the process of design, selection, installation and use is essential if AT is to generate positive outcomes for older people. Given the growing opportunities presented by the increasing ubiquity and reducing cost of a wide range of mainstream technological devices, the lack of practice and research focus regarding 'selection' of AT is particularly concerning. Further research is clearly required to examine this stage in the process, as part of a greater focus beyond the design phase. Such research should also examine longer-term outcomes, to answer the question of whether improved engagement through co-production will enable AT to deliver improved quality of life and reduced social care costs.

Strengths and limitations

The application of a rigorous search process and transparent approach, utilising Arksey and O'Malley's (2005) framework, provided a robust basis for our analysis. This is also the first significant review of co-production in relation to AT and older people, which is clearly a growing area of interest for research, policy and practice.

Our inclusion criteria, dictated partly by the resources available, may have led to the exclusion of some relevant items. In particular, it is possible that evidence regarding co-production with older people unrelated to technology could be usefully drawn upon to inform approaches in this area. However, we would argue that the distinctive issues relating to the introduction and use of AT make it important to examine co-production focused specifically on these processes.

It is also likely that there is a larger body of evidence published in other languages, particularly in terms of grey literature, which may provide useful insights regarding co-production in places other than those covered by our review. We believe our findings are sufficiently comprehensive to provide general lessons, but care should be taken in extrapolating the lessons to different cultural contexts.

Conclusion

Involving older people and other stakeholders in a process of co-production seems likely to be an essential step towards fulfilling the promises of AT, although the evidence is somewhat limited so far. Whilst the existing research does not directly demonstrate that co-production in the processes of designing and implementing AT leads to improved long-term outcomes, it does show that such collaborative approaches can increase engagement and thereby help to ensure that technology fits with the needs, capacities and living situations of older people. Although such processes need to be tailored to specific contexts, this review has highlighted a number of key issues which need to be considered, with implications for technology providers, health and social care services, policy makers and researchers. Moreover, the lessons regarding co-production with older people are likely to be of value beyond AT, since an inclusive co-production process in any field needs to consider potential barriers arising from age-related impairments, or presumptions about potential participants.

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Appendix: Search terms

Scopus

TITLE-ABS-KEY ('older people' OR 'elder*' OR 'senior citizen')

AND

TITLE-ABS-KEY ('technol*' OR 'telecare')

AND

TITLE-ABS-KEY ('co-production' OR 'coproduction' OR 'co-design')

Web of Science

TS=('older people' OR 'elder*' OR 'senior citizen')

AND

TS=('technol*' OR 'telecare')

AND

TS=('co-production' OR 'coproduction' OR 'co-design')

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