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Scaling home designs for healthy cognitive ageing: a realist evaluation perspective

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ABSTRACT

We present an empirically grounded theory of change (ToC) to support delivery at scale of home design for healthy cognitive ageing. Using a realist evaluation lens, we analyse how contexts, mechanisms, and outcomes (CMO) identified in the 'Designing homes for healthy cognitive ageing' (DesHCA) research shape scalability. Design principles and features were co-produced with older adults and housing professionals through VR-supported workshops, and in parallel a modified e-Delphi that prioritised outcomes for people and providers. The e-Delphi converged on five cross-cutting outcomes – independence, physical activity, enjoyment, safety, and adaptability – and highlighted system enablers (legislation/regulation, industry and public awareness) and the centrality of 'value for money'. Workshop CMOs indicated that small, low-cost changes (e.g. contrast, lighting, storage, switch/socket placement) are implementable within existing standards; that flexibility in layouts is critical for diverse and changing needs; and that meaningful engagement between providers and occupants improves adoption. We synthesise these insights into a ToC specifying activities (knowledge, products, procurement levers, curriculum/CPD, local standards), assumptions, and short- and medium-term outcomes that culminate in scaled delivery through both new-build and retrofit. We discuss strengths and limits of the approach and its transferability. The ToC is now guiding an implementation programme in Central Scotland, with early signals of feasibility through cross-sector partnerships and professional demand for practical guidance.

1. Introduction

Dementia and age-related cognitive change² are increasing public health challenges worldwide (World Health Organisation and Alzheimer's Disease International, 2012). Alongside clinical approaches, there is a growing international consensus that the design of everyday environments – especially homes – can enable people to live well with cognitive change (Fleming et al., 2022). Yet two gaps persist: older people have rarely shaped mainstream housing design, and delivery at scale has been limited, with activity concentrated in small pilots or specialist schemes, and little systematic retrofit (Bowes et al., 2024a).

This paper focuses on scalability. We use findings from the 'Designing homes for healthy cognitive ageing' (DesHCA) research,

which aimed to identify design principles and design features to support healthy cognitive ageing that can be delivered cost-effectively and at scale. By healthy cognitive ageing we mean living the life a person wishes, maximising well-being, despite potential cognitive challenges. We build an empirically-derived theory of change (ToC) that can steer implementation. Adopting a realist evaluation perspective, we ask what works, for whom and in what circumstances when seeking to embed cognitively supportive design across volume house-building and in retrofits to existing stock. While our focus is cognitive support, co-occurring physical and sensory changes are common in later life; therefore the principles emergent from this research emphasise flexibility and usability for diverse capabilities and preferences, whilst aligning with established principles of environmental sustainability.

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² We use the neutral term 'cognitive change' as this can manifest in different ways, and is not necessarily a continuous downhill trajectory.

2. Background: the scalability issue in home design for healthy cognitive ageing

A prior review (Bowes et al., 2023) identified five barriers to scale. Firstly, real world application of cognitively supportive design has generally been in a context of small, experimental developments (e.g. (Beach, 2015)), commonly led by small organisations or charismatic individuals who lacked ‘reach’ into the wider building industry or policy landscape. There has been weak engagement from volume house-builders and mainstream housing providers, wary of cost and market risk (e.g. (Greater Manchester Combined Authority (GMCA), 2018)). Secondly, research has lacked the perspectives of older people themselves, with little more than token involvement of older people, as research ‘subjects’ rather than active participants who can influence questions investigated and conclusions drawn. This may reflect ageism in wider society, including self-ageism whereby older people themselves prefer not to think about their own ageing (World Health Organisation (WHO), 2021). Thirdly, there is lack of clarity and agreement on desired outcomes, which have been largely researcher-defined and often quite narrow. Fourthly, issues of scalability have not been explored, so there is for example poor understanding of knowledge and information needs, or the specific challenges that housing providers, whether private or public sector, may face. Fifthly, a key aspect of the scalability has been almost entirely neglected: most people, certainly in the developed world, live and will continue to live in existing housing. This presents the challenges of retro-fitting, how to make existing homes more cognitively supportive.

Even so, examples at municipality level (Danziger & Chaudhury, 2009) show system-wide approaches (policy, procurement, standards) can embed supportive features at scale. Meanwhile users report better quality of life where accessible, legible, and adaptable homes are available (Lauriks et al., 2020). Poor quality of life, along with poverty, poor physical and mental health, poor amenities and sub-standard housing make cognitive ageing less healthy and risks of developing dementia greater (Gale et al., 2019) (Livingston et al., 2020). This in turn implies a preventative dimension to the impact of good design. The literature also underscores heterogeneity in ageing (Feldwieser et al., 2016), implying the need for flexible design solutions rather than fixed blueprints.

Both the gaps and insights from previous literature motivate our direct focus on scalability using realist logic: clarifying contexts, specifying mechanisms that stakeholders find workable, and linking both to outcomes they value. Our ToC synthesises those links for practical use. People with dementia typically experience compounded challenges from cognitive, physical and sensory changes, underscoring the need for design solutions that prioritise cognitive support while also addressing functional decline more broadly.

It is also important to emphasise that people with dementia typically experience more profound loss of functional capacity than their peers without dementia, due to the compounding of cognitive impairment with other age-related conditions. UK cohort data show that older adults with dementia are several times more likely to have severe functional impairment than those without and dementia is rarely experienced in isolation from other age-related impairments (Matthews et al., 2016) For this reason, we maintain a primary focus on cognitive support, while recognising that many design features simultaneously address physical and sensory needs.

2.1. The realist evaluation approach

Approaching the evaluation of change at a large scale is complex and multifactorial. Our chosen approach, realist evaluation, specifically identifies what works, for whom, and in what circumstances, differing from other evaluation approaches in several ways. Firstly, it is grounded in the context in which change occurs without assuming that change will occur in the same way elsewhere. Secondly, it examines the mechanisms

that bring about change, going beyond the surface appearance of change. Thirdly, rather than simply measuring outcomes, it attempts to uncover why and how outcomes are achieved. Fourthly, it requires a ‘programme theory’, an assessment of how change may occur which is grounded in an empirically-based understanding of real world experiences, organisations and desired outcomes.

However, realist evaluation has tended to be used for intervention-level study, rather than considering issues of scale (Pedersen & Rieper, 2008). Junge et al. (Junge et al., 2020) discussing potential approaches to evaluating complex systems, emphasise that these do not change in a linear fashion, and that emergent factors will inevitably come into play. They concur with Feinstein (Feinstein et al., 2019) that evaluation needs to be a dynamic process in such situations. Fletcher et al. (Fletcher et al., 2016) identify that realist approaches are now widely used in medical intervention research to assist in developing ToCs, and argue that they can also inform scaling these into routine practice. Their key advantage is that realist approaches necessitate focus on context and on the complex ways in which interventions play out in the real world. Byrne and Callaghan (Byrne & Callaghan, 2022) concur that realist evaluation is compatible with a complexity framing of the nature of social issues. Fletcher et al. (Fletcher et al., 2016) envisage a ‘step-change’ (p 297) in research quality if realist approaches are used in the development of programme theory and processes of scaling up. In agreement with Fletcher et al. (Fletcher et al., 2016), Shearn et al. (Shearn et al., 2017) comment on the general tendency for underreporting of how theories of change are generated.

Our approach takes into account the complexity of scaling up interventions and the imperatives to understand context and incorporate emergence. It is underpinned by a critical ecological perspective on ageing (Keating & Phillips, 2008) that considers the person as they age in their environment, including its natural, social, economic and built dimensions. This perspective focuses attention on issues of sustainability of the home in every sense.

Starting with a programme theory which sets out the expected course of developments, the realist evaluator identifies, through empirical investigation, the key outcomes of change desired, then sets out the context in which actors and systems operate. They then identify mechanisms whereby the desired outcomes can be achieved. This process serves to evaluate and improve the programme theory to produce an evidence-based ToC. In setting out the approach in this way, we are drawing on the work of Pawson and Tilley (Pawson & Tilley, 1997), Pawson (Pawson, 2013) and using the guidance provided by Nesta (Nesta, n.d.), a UK innovation agency focused on social good.

Learning from the gaps and lessons in the literature, our initial theory is that home designs aimed at supporting healthy cognitive ageing that are informed by the views of older people and sector professionals will lend themselves more easily to producing these stakeholders’ desired outcomes. If they can see that the designs address their agendas, they will be more likely to adopt the changes. This will enable design modifications to be delivered at scale.

3. Methods

We analyse two DesHCA datasets through a realist lens: first, a modified e-Delphi exercise with 74 participants to surface and prioritise desired outcomes for older people and the housing sector and second, three rounds of virtual-reality(VR)-assisted workshops with 94 participants to elicit design principles and features perceived to work in practice. In addition, the research team came together to ‘brainstorm’ the key findings to facilitate identification of the most significant, that inform the ToC. Fig. 1 provides an overview of the process of generating the ToC.

3.1. e-Delphi: understanding outcomes

Central to the realist approach is understanding the outcomes that a

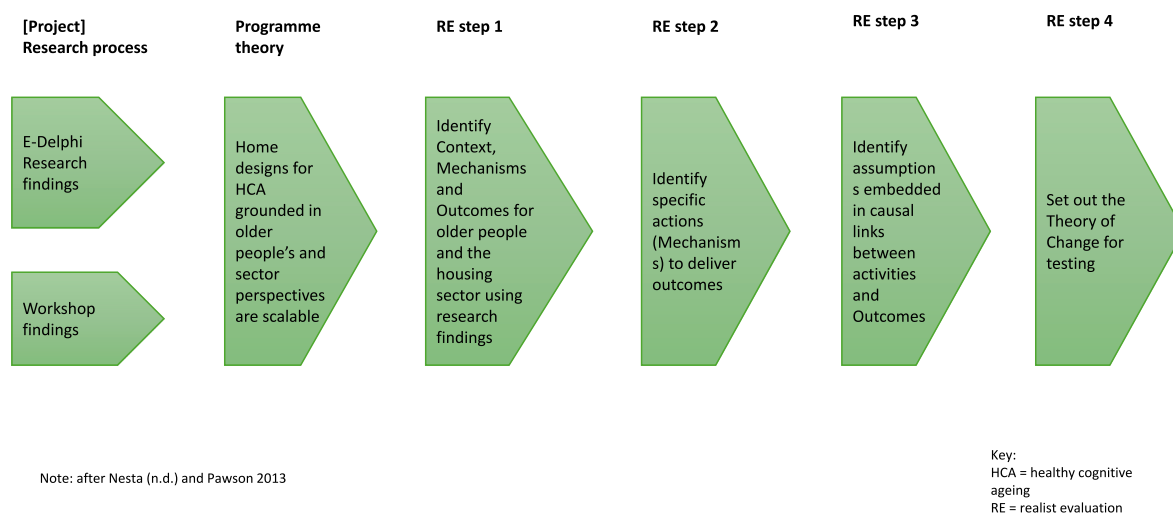


Fig. 1. Overview of the process.

programme of change is intended to achieve. The modified e-Delphi exercise took a systematic approach to ascertaining priorities for older people and the housing sector and examined the extent of agreement and disagreement about outcomes. Detailed methods and results of the exercise are published elsewhere (Bowes et al., 2024): here, we concentrate on the high-level results.

Fig. 2 summarises the process. Participants were recruited through networking and snowballing, and varied in age (26->86), housing tenancy, professional experience, and health status. The older participants, who self-identified as such, included people experiencing activity limitations and some with cognitive impairment. Our aim was to include a diverse range of participants, rather than achieving a representative sample.

3.2. Co-design workshops: delivering expectations

Three rounds of workshops were conducted, involving professionals in housing and people aged 55 and over who self-defined as 'older'. Table 1 provides a breakdown of participants.

Professional participants included architects, builders, housing and planning managers, recruited through professional networks. They all had existing interest in developing supportive housing. The older people (20 men and 25 women) were recruited through existing community groups, ranged in age from 55 to 94, and held different housing tenures, including owner-occupation and renting, thus including different socio-economic groups.³ None of the older people disclosed that they were living with cognitive impairment. In recruiting the sample, we aimed for diversity rather than representation of the population.

In the first round of workshops, participants viewed in VR two home designs resulting from an earlier period of consultation conducted during the project 'Demonstrating impact in housing, health and social care'⁴ (Palmer et al., 2024). These designs used principles of dementia-friendly design in the Dementia Services Development Centre's 'Environments for ageing and dementia design audit tool' (EAD-DAT) (Dementia Services Development Centre (DSDC)) guidance, whilst also being similar to standard volume-built homes. The VR headsets enabled participants to 'walk through' the homes, a one-storey house or

apartment and a two storey house. Whilst viewing, participants were invited to describe what they saw and to comment on it from the point of view of supporting their own ageing. Following the viewings, they took part in a group discussion, focusing on their reactions to the designs and the extent to which they felt these could support healthy cognitive ageing. Individual comments and the group discussion were recorded, and comments collated by members of the research team into thematic categories. This analysis was used to modify the designs and to produce new designs for the next round, which took a similar format. The results of round two were collated and the designs modified to produce a further version.

The third round focused on what worked best for older people and the housing sector and emphasised the practicalities of delivering the designs in the real world. Comments were collated into themes which informed a final iteration of the designs, which is now available via an interactive on-line web-viewer, accompanied by guidance for users. (Designing Homes for Healthy Cognitive Ageing (DesHCA), 2024).

To focus on scalability, data analysis aimed at identifying collective accounts of what works for older people and sector professionals in what circumstances. This was not at the level of detailed changes, but in terms of underlying principles: for example, we do not report the debates which occurred about whether there should be doors between the kitchen and living area, but identify the underlying principle of the need for flexibility of space to allow doors or not and thus permit individual choice. These 'principles' could be considered, in Pawson's (Pawson, 2013) (p117ff) terms, 'latent mechanisms of action', reflecting the possibility for mechanisms of action to be identified at different levels. The surface level might be doors or no doors as a rigid design choice, whereas the underlying or latent principle of flexibility may have cross-context applicability. The final versions of the designs (Designing Homes for Healthy Cognitive Ageing (DesHCA), 2024) are therefore not blueprints, but demonstrate principles and features, and help viewers visualise different possibilities according to their own preferences and requirements.

There are some limitations in both the e-Delphi data and the workshop data. Neither group of participants is representative of the general population, in that they were already interested in design for healthy cognitive ageing. Arguably however, that is advantageous, as they came to the exercises engaged with the issues and keen to contribute. Their diversity was important and provided a good range of insights. However, they were not ethnically diverse, and we were not able to explore in detail how cultural differences might influence perspectives.

³ Tenure provides a reasonable proxy for socio-economic status in a UK context, with owner-occupiers in general more affluent and renters less so.

⁴ Funded as part of the Escalator Fund of CHERISH-DE (Grant No. 30 E) by the Engineering and Physical Sciences Research Council (EPSRC) in collaboration with the CHERISH-Digital Economy research centre at Swansea University.

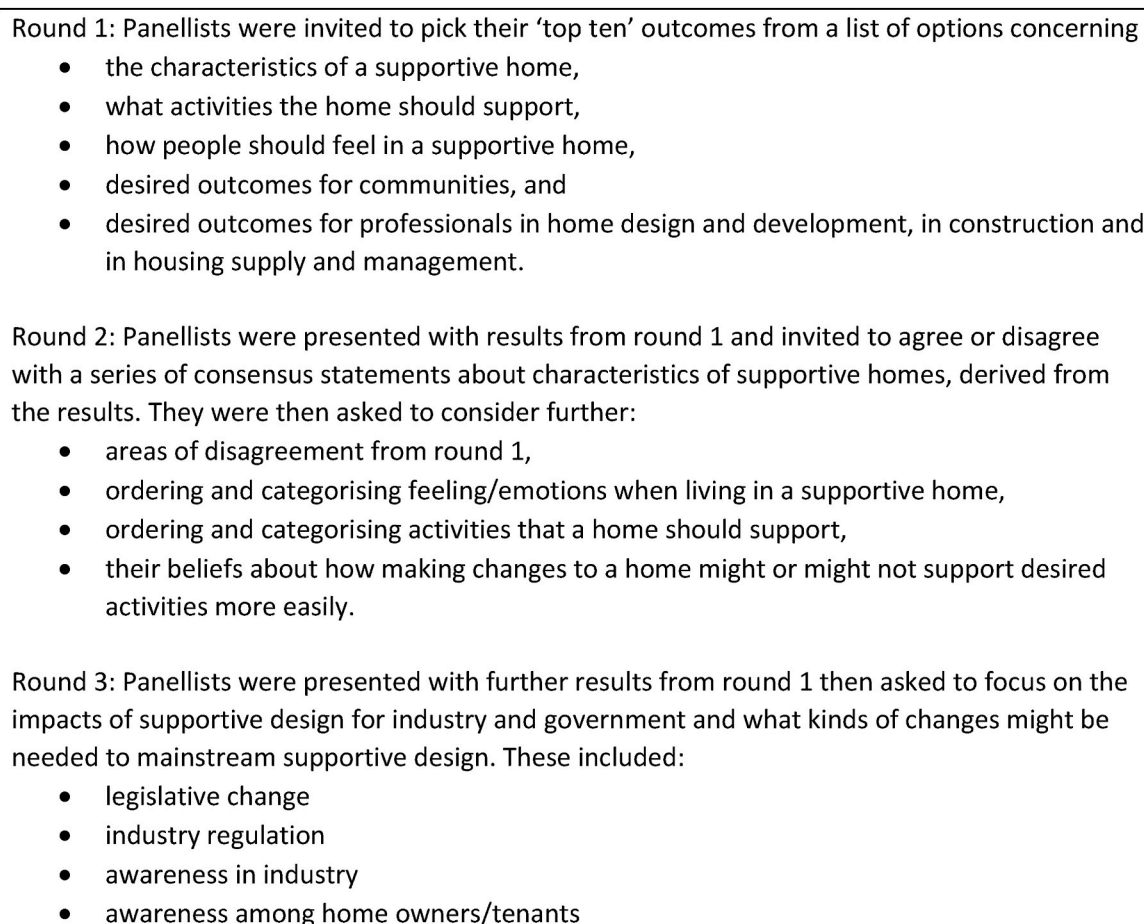


Fig. 2. Modified e-Delphi overview.

Source: Bowes et al. (Bowes et al., 2024) p4

Table 1
Workshop participants.

	Aged 55+	Housing professionals ^a	Total
Round 1	7	18	25
Round 2	10	10	21
Round 3	28	21	49
Total	45	49	94

^a One professional attended twice but is included once in the overall total of 94.

4. Findings

4.1. Outcomes

E-Delphi participants constantly prioritised five interlinked outcomes: staying independent, physical activity, enjoyment, feeling safe, and having an adaptable/flexible home that could be changed to provide support as needed. Each incorporated more detailed outcomes that panellists considered contributed to the high level, more general ones. For example, 'staying independent' included maintaining control over personal care, living a 'normal life', being able to socialise and getting out and about. There was overlap across categories, so, for example, personal care was also seen as contributing in a small way to physical activity and enjoyed activities, and socialising and getting out and about were seen as important for physical activity. These overlaps illustrate the interconnectedness of the five key outcomes, and imply that in considering making change, there is a need to adopt a holistic approach,

rather than focus on more narrowly defined outcomes.

Panellists considered that systemic change would be necessary to deliver cognitively supportive housing at scale and that this could entail legislation, industry regulation, industry awareness and improved public awareness. The housing sector was perceived as potentially benefiting from change via enhanced reputation, access to markets and improved, different opportunities for professionals contributing to job satisfaction. Panellists commented on the complexity of these areas of change, seeming more confident of the possibilities of delivery at a lower level by individual home dwellers or designers adopting changes, and organisations such as social housing providers or local authorities improving provision. The twin recognition of the potential at individual and local system level reflects evidence in the literature that scaling up at this level is achievable.

Value for money emerged throughout the e-Delphi process as an issue. Professionals were concerned with working within budgets, and older people with the benefits of spending their money or alternatively obtaining funding to support change, or persuading landlords to fund change. Affordability in all these respects was a key driver of our design recommendations, and many of the features highlighted have no impact on budgets. For example, choice of paint colour or flooring colour is cost-neutral, thus enabling the use of contrast to be easily implemented. Using widely available products such as glass fronted kitchen cabinets and deep drawers under kitchen cabinets also allows cognitively supportive design to be delivered at low cost. Where a developer is considering building new homes, or a housing provider refurbishment, including design principles and features that support healthy cognitive ageing does not necessarily add to costs. However, we also found that

where features were built in from the beginning, they were vulnerable to change as developments proceeded and could be deleted or downgraded unless there was a clear commitment to keep them to the fore.

Making an economic case for cognitively supportive housing is complex, given the distribution of both costs and benefits. In terms of outcomes to include in the ToC regarding scalability, we include 'value for money' as an outcome, whilst recognising that this will vary according to context and perspective.

Sustainable home design was considered across ecological, social, and cognitive dimensions. While new housing will increasingly be required to meet carbon-neutral standards in response to climate change, embedding cognitively supportive design can also ensure that homes contribute to social inclusion, and long-term economic resilience as populations age. Crucially however, the most sustainable homes are those that already exist. Retrofitting therefore carries particular importance; incorporating cognitively supportive features alongside insulation, energy efficiency measures and reduced fossil-fuel use offers a practical route to making existing housing environmentally, economically, socially, and cognitively sustainable.

5. Discussion: consensus on outcomes?

The five broad outcomes, with their underlying level of detail, suggest that the ToC needs to consider the nuances of meaning within them, particularly in relation to their relevance for sector professionals or older people. Some of the nuances however could be seen to reflect problematic conceptions. For example, younger professionals in particular seemed not to recognise that older people wanted to have fun, or to enjoy an attractive home environment, and focused in several instances on needs for support. Such conceptions, we suggest, reflect a wider societal 'othering' of older age, that is, thinking of older age as an experience that affects not oneself, but 'other people', a separate, different and often denigrated category. This provides an element of the context and challenge for scalability of cognitively supportive design. The post-pandemic context in which the research was conducted has also been observed to exacerbate ageism and othering of older people, especially those facing physical and cognitive challenges (Naughton et al., 2021) (Grenier et al., 2023).

Findings about the perceived need for systemic change, alongside the identified areas for change on a more limited scale, emphasise the complexity of the context that the ToC needs to address. Akin to the need to understand where ageism may be influential is recognition of where systemic issues come into play in delivering housing development and modification. For example, understanding the extent to which social housing provision is influenced by space norms, recognition that budgetary considerations can be perceived as an obstacle to change, and acknowledgement of limitations in professional training and reflection processes are all systemic issues requiring consideration. As the workshop findings will illustrate, these can be perceived as insurmountable obstacles, but there are clear opportunities either to work within them or to advocate for change.

6. Workshop findings

We present findings from the workshops for professionals and older people respectively, bringing insights on the context and mechanisms relevant for each group.

6.1. What works for housing professionals?

6.1.1. Context

Findings emphasised that realities of delivering housing for professionals include structural/system constraints. Any process of change needs to engage with these, including for example space and budgetary constraints, building regulations, environmental sustainability issues and the challenges of cross-professional working.

Many professional participants emphasised these constraints, but also provided examples of how they were able to work within system and budgets and produce improved housing. This could occur in different ways. For example, the appropriate siting and visibility of electric plug sockets was perceived as something that could be achieved without extra costs and within regulations: sockets would simply be placed higher up, and appropriate decor could ensure they contrasted with the wall. Social housing providers could take advantage of funding schemes targeted at supportive housing, and if successful, could use the additional funds to ensure, for example, that their new or refurbished developments included some wheelchair-friendly homes. Others were more pessimistic about possibilities for change, referring back to 'the way we do things' as if working to an unmodifiable template.

There was knowledge of and expertise in cognitively supportive design among these professionals: it is probable that they were not wholly representative of their professions, being an interested and to some extent self-selected group, but this knowledge and expertise provides indications of how professionals can develop commitment. Much of their knowledge had been stimulated by personal interest, from experience of living with dementia of relatives, professional workshops or professional communications. Notably, professionals discussed design features that could support physical impairment more readily than they considered cognitive impairment. Sensory impairments were rarely mentioned. However, the findings do indicate awareness of and willingness to consider supportive design that could provide a foundation for innovation and further learning.

However, some of the reservoirs of knowledge were limited, and influenced by assumptions about older people. For example, the widespread use of certain aids and adaptations that were negatively viewed by housing consumers was taken for granted. This could be costly: for example, some providers supplied wet-rooms of a standard design that they reported tenants did not like, and when homes acquired new tenants, these had been removed at their request. For some professionals, it was difficult to move away from standard designs, even though they were in the long-term adding to costs for their provider organisations. These providers contrasted with others who spoke about ensuring that appropriate drainage and flooring for wet-rooms was included as standard and allowing the home occupier to determine appearances.

Participants thus brought their own assumptions and knowledge to discussions, reflecting in some cases wider societal contexts. They were working within or around complex systems of housing provision and often reflecting societal views about older people, which led to promotion of standardised approaches to older people's needs and wants. Tellingly, following discussion which reflected on the DesHCA designs and suggested multiple modifications, participants were asked whether they would like to live in the homes themselves: the response was frequently 'no', reflecting design ideas that were perceived as for others.

Professionals discussed costs issues, focusing on working within budgets, whether those set by housing providers or by private clients, and the constraints that could thus be imposed. At the same time, they recognised that many design features, such as plug socket positioning, décor supporting contrast, or evenness of flooring tone, were low cost or no cost, especially when considering new build, but also when modifying existing homes through normal cycles of redecoration/refurbishment. One group discussed the wider cost implications of more supportive homes by referring to the costs of unsuitable housing, noting that small modifications to homes were of negligible cost compared for example to a hospital stay necessitated by a fall caused by issues in the home. Thus multiple aspects of cost can come into play when considering scalability of innovation.

6.1.2. Mechanisms

Workshop discussions identified several potential mechanisms that could advance change. There was manifest demand from these professionals for more knowledge and training about housing for healthy cognitive ageing and they made several suggestions for achieving this,

recognising that not all professionals necessarily have an interest in this area or any previous knowledge. Thus it was acknowledged that knowledge and training need to be provided in appropriate and accessible forms. For new cohorts of professionals, they perceived a need for healthy cognitive ageing to be covered in educational curricula, whilst acknowledging that these are already full. For current professionals, they noted, time is at a premium, and training and reflection are difficult to incorporate into professional life and design processes, whilst agreeing that time spent on design for healthy cognitive ageing would be highly desirable.

Whilst regulations could be constraining in some respects, participants also recognised opportunities for local authorities to promote different standards, staying within but improving upon more general regulations. A key example given was that of the Glasgow Standard (Glasgow City Council, 2017) which works within existing national guidelines such as Housing for Varying Needs (Scottish Homes, 1998) (under review) to deliver higher standards of, *inter alia*, accessibility, flexibility for future adaptations and sustainability.

Professionals highlighted that, whilst opportunities to influence local councils and social housing providers were challenging but nevertheless identifiable, promoting design for healthy cognitive ageing amongst volume builders was much more difficult. Some participants were openly sceptical, suggesting that profit motives would prevail, and these types of design would be considered commercially detrimental. However, there were signs of innovation among a minority of builders. Some operated at a small scale, offering options for future-proofing homes to their clientele, whom they had found receptive to these when they were explained. Others, including one volume builder, were seeing the offer of age and cognitively supportive housing as a commercial opportunity, and including it within their mass market new-build homes. These examples suggest that both education of people seeking homes for their future (to increase demand) and promoting the commercial opportunities provided by innovative design (to increase supply) may be appropriate mechanisms for professionals to deliver change.

When commenting on the prototypical designs to identify possible improvements, professionals focused on detailed features of the homes, as well as broader principles. Thus, in addition to commenting on the general desirability of natural light and good artificial light for example, they looked at the location and visibility of light switches, and spotlighting provided in areas such as bed-sides or kitchen worktops. This attention to detail was also reflected in the group discussions after the viewings, where many small design features were highlighted. There was a clear message that small design changes could be helpful and make a real difference. Thus small, affordable changes are considered worth making, and particularly in retro-fitting, an 'all or nothing' approach is neither necessary nor sensible. Nearly every property will be able to include some cognitively supportive design features, many of which are low-cost. Thus the ToC needs to consider small changes as well as overall design, supporting the identification and use of both design principles and design features.

Participants noted that they felt consultation with future occupants of homes being designed or retro-fitted would be highly desirable. However, they also observed, as does the literature (Beach, 2015), that older people were rarely consulted about home design, and housing professionals rarely have the opportunity to evaluate developments post-occupancy. This observation presents a further opportunity for change, to bring together those who provide and those who live in homes to deliver changes that meet all parties' aspirations.

6.2. What works for older people?

6.2.1. Context

A core purpose of DesHCA was to produce design principles and features authentically informed by older peoples' views, experiences and aspirations. The process of co-design grounds our recommendations in older people's own perspectives. It was notable that, even though

using a headset and experiencing the VR models was a novel experience for nearly all the older people who took part, they reported finding the experience positive, and the designs realistic. They were able, they reported, to see exactly what the home would be like, and were forthcoming about what they liked and disliked, what changes they would like to see, and how the design would enable them to live the lives they preferred.

The diversity of the older participants and of their current homes is a reminder that a detailed recipe for cognitively supportive housing is unlikely to be successful, and is a key reason for our focus on identifying underlying design principles, highlighting particular design features and emphasising that the prototypical designs are illustrations of how these may be delivered rather than a one-size-suits-all prescription for home design.

Workshop findings emphasised the need for spaces to be flexible, allowing for different lifestyles and activities. For example, the second bedroom in the VR home was presented as a bedroom, prompted by many older participants' emphasis on wanting to be able to accommodate visitors and a potential live-in carer. Participants identified many different ways in which the room might be used, including for hobbies, gaming or additional equipment storage. Similarly, the kitchen and living room were presented initially as open plan, eliciting debate about whether or not the space should be divided. In our final recommendations, we emphasise flexibility, and the models demonstrate different configurations of the spaces: the second bedroom is shown as such, and alternatively as a multi-purpose space, and the kitchen and living room have sliding doors that can be opened or closed as the resident prefers. The kitchen also has an alternative version suitable for a wheelchair user.

Older participants identified assumptions about ageing that emphasised infirmity and dependence. In viewing the VR models, they frequently referred to older people as other than themselves, despite having self-identified in research recruitment processes as being in an older age group. This 'othering' was similar to that seen among the professionals. It was also expressed in explicit dislike of conventional 'adaptations' supplied to older people, such as grabrails, ramps or standard wetrooms (echoing the professionals' comments). The DesHCA designs did include these features, but not in their conventional versions. Feedback was that the DesHCA versions were 'much nicer', partly in terms of aesthetics, but also of preferences not to be identified as an older person by others, and not to perceive oneself as such.

Older participants demonstrated practical views on housing as well as perspectives on the value and meaning of home across the lifespan. These views reflected the e-Delphi exercise regarding preferred outcomes, including the aspiration to live one's preferred life in a home that facilitated this. Participants' observations were made in the context of continuity across the lifespan, contrasting with perspectives that might promote a need for specialist homes for older people. It was clear that what might suit an older person could also be a lifetime home: there were frequent comments for example on the need for storage for a pushchair/stroller, wheelchair or bicycle, depending on the people living in the home. Storage issues in older age were observed to have the potential to become more pressing, if supportive equipment was needed.

An important element of these practical considerations was affordability, with discussion considering the balance of benefits of making changes to the home with the cost of doing so. Participants appreciated design features perceived to be easy and cheap to deliver, such as increasing colour contrasts when redecorating or fixing extra lighting under or inside cupboards (using cheap and widely available battery-operated LEDs). This reflects the unsurprising reality that whilst modifying whole home designs for newly built homes is desirable, scalable innovations through retro-fitting need to be simple and affordable for older people themselves.

6.2.2. Mechanisms

Older participants' interest in and enthusiasm for the design

principles and features demonstrated indicates an appetite for knowledge and an appreciation of innovations that can support them to live as they wish in their own homes whilst facing challenges of cognitive ageing. Increased knowledge can lead to increased agency, in the sense that people who understand design principles and features that can support healthy cognitive ageing can use this knowledge to inform choices made when considering home improvements or when moving to a new home.

If researchers simply disseminate information and hope it will 'land' effectively with the intended audience, they are unlikely to achieve the desired results, especially where the perceptions of researchers and their audiences differ (Martin, 2011). Processes of engagement and exchange are much more likely to be effective. Thus tools such as discussion packs for community groups, publications for professionals to use with clients and accessible information available where people spend time are key outputs for increasing knowledge and hence demand. Outputs co-produced with older people are more likely to engage effectively and engender increased demand.

Our findings suggest multiple routes should be used to disseminate knowledge of cognitively supportive home design. We found that older people gain knowledge from internet sources, as well as hard copies of information available in public places (such as libraries or doctors' surgeries) and activities run by community groups. Personal contacts also had a big role to play. This reflects other research that emphasises the role of word of mouth in conveying and evaluating health (and other) information (Pauli et al., 2023).

The potential productivity of improved interaction between those who design and build/provide homes and those who live in them was demonstrated in the reported experience of the workshops. Enthusiasm about the VR experience and the clear understanding produced were prevalent. Professionals had commented that the feedback on the designs was much more useful than they would normally get by showing clients drawings. Improved dialogue between older people and professionals will, our findings suggest, help ensure that homes designed for healthy cognitive ageing both meet older people's aspirations, and provide professionals with the reward that comes from satisfied clients.

Older participants frequently highlighted detailed aspects of the designs, noticing small things, such as the positioning of lighting or plugs, the ease (or otherwise) of shower controls, and the decoration of rooms, and commenting that these improved on their current experience. They also commented on the overall designs, for example on the amount of natural light that coming into the homes, or overall perceived convenience. It is significant that both the design principles and features were noted. In terms of mechanisms, this highlights that for older people considering making retrofitting changes to their homes, or moving to new homes, design advice and guidance can usefully be provided at these different levels. Furthermore, this illustrates again that an 'all or nothing' approach is probably not appropriate, as many homes can benefit from small changes that make them more supportive. Clearly, advice on and help with small changes can be both welcome and beneficial.

The enthusiasm for the designs and the VR experience is also significant for occurring in a convivial and sociable environment, in which participants shared comments and ideas, including ideas about their own homes. Comparisons were made between participants' experiences and preferences, reinforcing the need for guidance to take account of individual preferences and for design to be flexible. The workshop experience contrasts with a common scenario in which the home can suddenly become more difficult to live in, following a crisis such as a fall, a hospital stay or a sudden illness, and emphasises the benefits of considering design advice and design changes before finding oneself in a crisis.

Affordability is a key consideration for older people, especially in context of the cost-of-living crisis occurring at the time of the research, and is relevant for making changes to an existing home as well as moving to a different one. Some older participants spoke of trade-offs between

potential costs and their own life expectancy, suggesting for example that they would not bother replacing old and draughty windows as they would enjoy the benefits only for a short time. Thus when recommending design changes for older people, affordability issues need to be front and centre. Designs which are high-end or very costly are unlikely to appeal: fixtures and fittings suggested need to be affordable, ideally mass-market and readily available, and suggestions for supportive changes need to be in tune with changes that people may be making anyway. For example, re-decorating can be done to provide cognitive support, with good use of contrast, or in ways that will be difficult for anyone experiencing cognitive impairment, such as 'colour drenching', in which every feature of a room – walls, ceilings, doors, cupboards – is painted the same colour.

7. Generating the ToC

The CMO (Context-Mechanisms-Outcomes) analysis provides the basis for developing a ToC to guide work towards delivering cognitively supportive housing at scale. The theory is evidence-based, informed by the research findings which identified key factors that might support scaling and others that might prove obstacles. The ToC is presented in Fig. 3 and is constructed following Nesta guidelines (Nesta).

The relevant aspects of context, derived from the workshop findings, are listed first. There follows a list of activities directed towards promoting delivery at scale: these are derived by the research team from the detailed understanding of contexts relevant to both professionals and older people, and the potential mechanisms through which change can occur. Each activity involves assumptions, i.e. prerequisites for change, which are specified in the next column. Outcomes are classified as shorter and medium term outcomes, with the shorter term outcomes being practical steps towards the realisation of the medium term outcomes identified through the e-Delphi exercise. Activities and short term outcomes can contribute to more than one medium term outcome. The ultimate goal in the final column refers back to the focus of the programme theory about delivering cognitively supportive housing at scale.

8. Discussion and limitations

The realist evaluation approach has supported the development of a ToC which highlights necessary steps towards achieving the desired ultimate goal or long term outcome – cognitively supportive home design – in ways which are in tune with the views of older people and housing professionals, and also meet empirically-based short and medium term outcomes. It also enables identification of systemic change that may be required.

Our findings sit within a wider evidence base which demonstrates that community-dwelling people with dementia are far more likely to experience severe functional dependence than peers without dementia: in the UK cognitive Function and Ageing Study (CFAS) II, 60.8 % of older adults with dementia had severe functional impairment compared with only 2.7 % of those without dementia (Matthews et al., 2016). Cognitive impairment thus frequently intersects with physical and sensory impairments to create compounded disability. Consequently, while many of the design principles highlighted in our study – such as good lighting, tonal contrast, and spatial legibility – are beneficial for visual or mobility impairments, their primary importance lies in enabling people to live well with cognitive change. In practice, designing for cognitive support necessitates designing for functional support more broadly, whereas designing only for physical or sensory impairments risks excluding the distinctive challenges of cognitive ageing.

As discussed, in a process of change in a complex system, the ToC will require review and updating, as changes in the context occur, and as path-dependent factors emerge during the process: this could be seen as a limitation of a ToC developed in this way, and of the realist evaluation perspective that underpins it, in that both may appear linear. Potentially, the process of review could be supported by a tool such as the

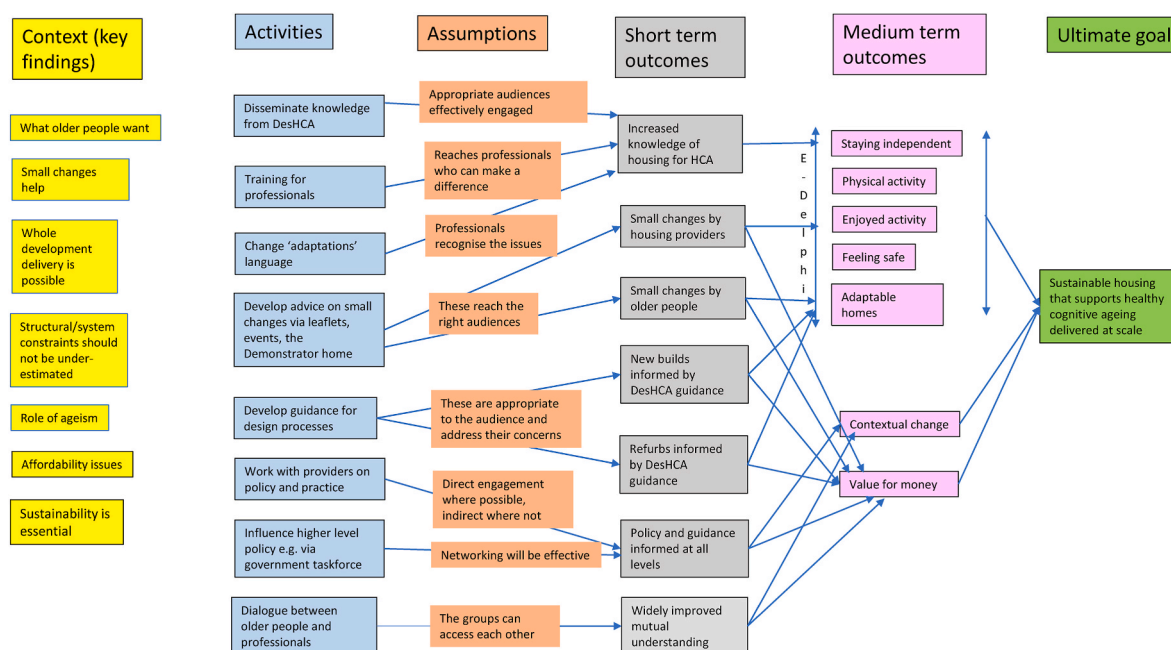


Fig. 3. ToC for scaling up cognitively supportive home design.

Scaling Scan (Jacobs et al., 2021), which interrogates scaling strategy, focusing on ten mainly organisational ‘ingredients’ of success. The Scan incorporates a ‘responsibility check’, which calls attention to the interests of groups that may be or become excluded from change processes and would help ensure that the attention to older people’s perspectives which is at the root of our work is maintained. This approach would strengthen the value of the ToC and the realist perspective.

The realist evaluation approach is grounded in an understanding of context, which means that the ToC may not be transferable to other contexts. DesHCA was working in the context of the UK cultures, ageing population and housing system, which differ in various ways from others. However, wider lessons could be drawn from the DesHCA ToC by using a realist synthesis methodology, which is able to capture cumulative lessons from evidence that have more general applicability (Pawson, 2013). Furthermore, underlying the contextual aspects of the analysis are principles of cognitively supportive design that can and have been applied across different national and cultural contexts in different ways, albeit with the continuing focus on the small scale (Fleming et al., 2020). Thus the research has resonance for other contexts.

The starting point for DesHCA was the views and experiences of older people and housing professionals. This contrasts with the often top-down approach to innovation implementation in other fields, such as implementation science used to guide healthcare interventions (Braithwaite et al., 2018) (Greenhalgh & Papoutsi, 2019). Arguably, DesHCA could have involved policy professionals more fully, but, as Greenhalgh and Papoutsi (Greenhalgh & Papoutsi, 2019) following Shaw et al. (Shaw et al., 2017) argue, interventions that are grounded in the real-world perspectives of those directly affected are more likely to be successful than those driven by high-level policy decisions. Nevertheless, others have argued, especially in the field of economic development (e.g. (Jacobs et al., 2021)), that leadership and organisational level commitment are essential ingredients of successful implementation. The DesHCA approach has not discounted these but has approached them from the ground upwards.

Research on housing has frequently been criticised for being under-theorised (Bates & Collins, 2023). DesHCA was underpinned by a critical ecological approach (Keating et al., 2008), and this supported the focus on context required in realist evaluation. Further theoretical

development could, we suggest, more fully utilise complexity theory that has been highlighted as promising in analyses of health and social care interventions (Carroll et al., 2023). In particular, recent articulations (such as Byrne and Callaghan (Byrne & Callaghan, 2022)) embed natural environmental factors in their approach. Whilst DesHCA did not explore the ecological dimension of sustainable housing in depth, this forms essential background to the recommendations. Housing is clearly a ‘complex adaptive system’ as Braithwaite et al. (Braithwaite et al., 2018) characterise healthcare, and engendering system-wide change presents comparable challenges.

9. Conclusions and next steps

We have developed a scaling-focussed ToC for cognitively supportive home design derived from e-Delphi and VR-enabled co-design with older adults and housing professionals. It prioritises flexible, affordable features; practical knowledge pathways; and use of local standards and procurement to normalise adoption.

The ToC now guides an implementation programme in Central Scotland which has a mix of rural and urban housing, mixed tenures, socio-economic diversity and a rapidly ageing population, within which numbers of people living with cognitive change are increasing. Integrated into a programme of economic development, the project engages with housing designers, developers and providers to take the DesHCA design principles into real world implementation at scale. The development is outward looking, with a focus on highlighting national and international lessons. Whilst the next stages of the evaluation will need to be conducted over coming years, promising evidence of what works for whom in what contexts is appearing. This includes the value of partnerships in taking change forward, the need to involve commercial, public and private organisations to produce necessary areas of change, and enthusiasm amongst professionals for improved learning and understanding of older people’s perspectives.

CRedit authorship contribution statement

Alison Bowes: Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation,

Conceptualization. **Sadhana Jagannath:** Writing – review & editing, Visualization, Validation, Resources, Investigation, Formal analysis, Data curation. **Mary Njoki:** Writing – review & editing, Validation, Resources, Investigation, Formal analysis, Data curation. **Catherine Pemble:** Writing – review & editing, Validation, Resources, Methodology, Investigation, Formal analysis, Data curation. **Martin Quirke:** Writing – review & editing, Validation, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation. **Lisa Davison:** Writing – review & editing, Validation, Resources, Methodology, Investigation, Formal analysis, Data curation. **Alison Dawson:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Data curation.

Ethical approval

For the research was given by the University of Stirling General University Ethics Panel as follows:

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Declaration of competing interest

The authors declare they have no competing interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssaho.2025.102186>.

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