Design for Ageing in Place in Isolated Contexts: A Methods Literature Review

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Abstract. Aging in place is one of the answers to the changing needs of older global demographics. After evaluating alternatives for aging in place, the effects of the COVID-19 pandemic lockdowns, and the challenges of living in remote contexts, the need to integrate a Human-Centered Design approach to increase the usability of the Built Environment became evident. This literature review describes different methods and instruments that can be used for data collection in the context of a Human-Centered Design process for the built environment. Contributions of this research include the application of a user-centered theory of the built environment focused on the user experience.

Keywords: Human-Centered Design, Ageing In Place, Older People, Usability.

1 Introduction

1.1 Healthy Ageing

Statistics show how a large number of the global population is getting older. By 2050 more than two billion people will be over 60 years old, compared with one billion in 2020 [1]. In the United Kingdom, by 2043, more than 10 million households will be headed by someone aged 65 or more, increasing the numbers of 2016 by 54% [2]. Specifically in Scotland, in 2019, reports showed the demographic age shift, increasing by 31% the group of people aged 75 or more, while on the other hand, the population group aged 0-15 decreased by 8% [3].

The Healthy Life Expectancy (HLE) refers to the number of years a person will enjoy good health. The gap between HLE and the actual Life Expectancy is getting bigger, and the HLE projection for Scottish people shows that males born in 2015-2017 can expect to spend 62.3 years of good health. For females, the number is 62.6 years;

variations are mainly defined by gender and access to services [3]. This projection suggests that people might struggle with health issues for about 15 to almost 20 years and explains why there is an interest in focusing on healthy aging.

However, healthy aging is a concept that needs clarification. For many years, the MacArthur Model of Successful Aging [4] was used as a reference to determine the quality of the aging process. The model considers three aspects: low risk of disease, maintenance of high mental and physical function, and continued engagement with life [4]. Healthy aging is defined by the World Health Organization (WHO) [1] as 'the process of maintaining the functional ability that enables wellbeing in older age.' An individual achieves functional ability by an intrinsic capacity (physical and mental health) and their environment (extrinsic factors) [5]. Healthy aging is frequently associated with the concept of ‘wellbeing,’ other sources [6] align with the WHO describing it as the balance point between resources and challenges faced by the individual.

1.2 Wellbeing and the Built Environment

Wellbeing is a complex and non-static perception; there are several affirmations in the literature that agree it can be achieved despite illness, successfully managing health conditions, and executing most activities independently [6-8]. Nevertheless, this balancing act frequently gets impacted by the Built Environment (BE), i.e., housing characteristics. The House of Commons [9] lists housing characteristics that affect older people's wellbeing, such as ‘low quality, un-adapted, hazardous, poorly heated and poorly insulated’ accommodations. The Centre for Ageing Better adds other features such as small room sizes, steep stairs, baths rather than showers, and steps outside as some common problems with mainstream housing [10]. Some consequences of poor housing can be: reduced mobility, depression, chronic and acute illness, falls, social isolation, loneliness, and depression [3]. ‘Appropriate’ housing should enable users in several ways, keeping them warm, safe, and healthy, close to their social circle and allowing them to execute activities they consider important [10], support them in living independently, and reduce the need for social care [11-13].

There is a global trend on housing policies to focus on aging-in-place [14-16] as a response to the increase in older demographics which has been explained previously and also to the fact that only a few homes have accessibility features. Specifically, in the UK, only 7% of the housing stock includes accessible characteristics (level access and accessible threshold, WC at entrance level, wide doors, and circulation space for wheelchairs) [10]. The National Health Service (NHS) [17] offers a support program for older adults to adjust their properties and allow them to stay at home for longer and increase their independence. In Scotland, this program is delivered via an organization called Care and Repair Scotland[18]. This type of policy focuses on retrofitting a segment of the other 93% corresponding to not accessible properties. Modifications can go from adding grab rails to fitting a stairlift.

2 Background

2.1 Alternatives for Aging-in-Place

The alternatives for aging in place can be determined by users' age, level of independence, and level of care needed, and different options vary from general needs to specialized solutions [19, 20]; a comparison is shown in Figure 1.

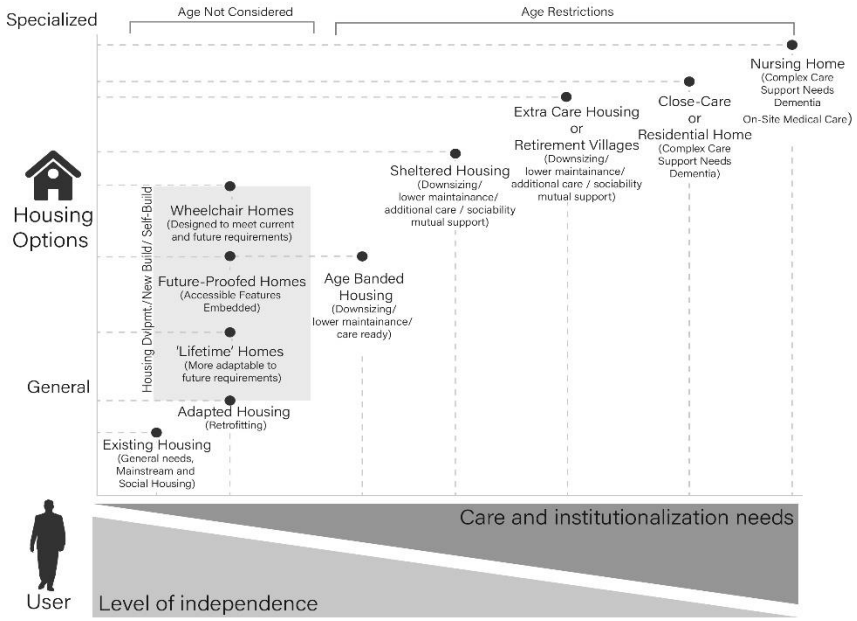

Fig. 1. Comparison of alternatives for aging-in-place, according to the level of specialization of housing and user's age, level of independence, and need for care. Based on [19, 20]

The alternatives which do not consider age restrictions and that promote user independence (Adapted Housing, Lifetime Homes, Future Proofed Homes, and Wheelchair Homes) will be described next.

Adapted Housing. Modifications to the BE, or Home Adaptations (HA), have been studied thoroughly [10, 11, 14-16, 21-32]. HA apply to existing housing and can be classified as minor (i.e., additional grabrails in stairs and bathroom, installing shower seat) or major (i.e., installation of stairlift, replacing bath with shower). Other authors classify them in more specific categories: the sense of being at home, usability, and safety [14]. Most longitudinal studies present positive results, i.e., Carnemolla and Bridge [21] measured the impact of this type of HA on older people's wellbe-

ing; they found that improving accessibility led to a 40% increase in Health-Related Quality of Life.

On the other hand, on occasions, users delay HA installations because they perceive them as “stigmatizing associations with decline and vulnerability” [29, 30], often causing HA product acceptance until reaching a crisis point. Other literature based on phenomenological methods describes discoveries of inconsistent and unintended uses for HA products after immersing into users BE with novel approaches [33]. These polarized results in HA use present the need for a Human-Centered approach while planning and performing changes to the BE.

For some users, transforming their BE is not a viable alternative, and moving home to age successfully in place might be the only option. A study by Age Scotland [34] on the Orkney Islands describes how older people use government programs to adapt their houses to increase comfort. Subjects were asked about their current and future housing plans, showing that 61% do not intend to move in the future. Only 11% have considered moving because their facilities are perceived as unsuitable (high running costs and single level property is preferred). Other studies show that most of the respondents don't want to move due to getting older, only relocating voluntarily when downsizing or convenience reasons [7, 35], and the action can be taken after crisis (i.e., increased frailty, reduced mobility, etc.) or planning ahead proactively[20].

Lifetime Homes. Refers to a design guide [36] that complements (and enhances) the Building Regulations [37] and also increases the building's adaptability. The aim of the guide is to improve the user experience while facing challenges of different moments in life, i.e., using the entrance of a dwelling with a pushchair or with a walking aid [36]. These design principles can be applied to communal residences or single-family dwellings. Some initiatives like HOME (Housing Made for Everyone) advocate for including these guides as basic standards[38] for new-build housing.

Future-Proof Homes. This concept refers to houses designed to be easily adaptable to changes in user’s needs, and some features might be embedded from the planning stage[20].

Wheelchair Homes. These homes follow the Approved Document M2 -Part 3 of the Building Regulations [39] to allow a wheelchair maneuvering through all the living spaces without. The focus is on describing minimum spaces, widths of doors, the height of working spaces and sockets, storage, and accessible layouts.

After describing the non-age-restrictive alternatives for aging in place to promote independence, it’s also necessary to add that BE theories include other aspects as well, such as location [30].

2.2 Remote and Isolated Contexts

When evaluating and designing the BE, the physical environment is framed by multiple levels: Immediate surroundings, neighborhood, and community[20, 30, 40, 41]. In some cases, integrating the three levels can be challenging. The context of this research is in the north of Scotland, which is described as one of the most remote and sparsely populated parts of the UK [42]. One of the consequences of geography is isolation from various service provisions, especially healthcare. The study 'Scotland's

Wellbeing' shows the perception of the quality of public services such as transport and health services has been decreasing in rural areas [43]. Other sources mention that ‘older people in rural areas are more likely to experience ill-health conditions caused by poorer housing conditions,’ frequently facing fuel poverty, with properties that are difficult to maintain and with inefficient heating [44]. This situation was foreseen since 2011 when the Strategy for Housing Scotland's Older People was published [45] and dictating ‘should be accessible and adaptable and meet the needs of older people,’ considering the lack of availability of suitable housing for older people in remote and rural areas. The strategy remarks on the importance of new build to meet the needs of an ageing population, and specifies that new options to have an increased potential of accommodating people with mobility needs.

After the previous description, it can be suggested that some characteristics of remote living can be comparable to recent lockdown living. With increased time at home due to COVID-19 Pandemic, the relationship between users and the BE has changed dramatically [46-48]. Elderly and disabled people have suffered consequences of not living in a place that suits their needs while spending more (if not all) time indoors emphasized good and bad aspects of BE where people live [47, 49]. Quoting a segment of an article related to the effect of the pandemic in social experiences, ‘As we navigate through life, much of what fulfills us are the bonds we create with other people, and more often than not, those bonds materialize through physical interactions.’ [50] It became apparent that housing solutions must consider social connections, even in remote or isolated contexts.

2.3 Best Practices and Local Considerations

The framework for dimensions and features to be taken into account when designing a BE to age in place are described in the Approved Document M Category 2 [37] of the Building Regulations. However, other resources provide additional information to be considered as best practice. The National Design Guide [51], in the section dedicated to homes and buildings, defines ‘well-designed’ homes as functional, accessible, sustainable, and providing internal environments and external spaces that support their users' health wellbeing. The 'Housing our aging population' reports [44, 51, 52] encourage the industry to introduce 'care ready' features in houses, integrating new home technologies, keeping users connected, and increasing their sense of autonomy. They also provide design principles and rural proof principles to be considered while designing the BE, i.e., generous internal space standards to allow overnight visitors/carers, adaptability, and ‘care aware’ design that is ‘digitally’/’technology-enabled.’

For local considerations, the Design Brief for building Homes for the Highlands [53] is being addressed. Even though the audience for this document is Affordable Housing Providers, it includes information for good practice, such as heating systems requirements, supplementary low or zero-carbon technologies, and considerations for diverse needs (inclusive design for sight loss, hearing loss, limited mobility, and dementia).

Despite the best practices and local considerations mentioned, technologies and care-ready features do not offer specific information on which technologies should be taken into account. Studies about smart homes and IoT for older people have categorized technologies according to Activities of Daily Living (ADLs) [54]. The categories are safety, health and nutrition, physical activity, personal hygiene and care, social engagement, and leisure.

2.4 Usability

Usability happens with every user-product interaction, and the product can be a tangible product, a service, or an interactive system [55]. According to BS EN ISO 9241-11:2018, usability refers to an 'extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use,' and when considering appropriate usability during product development, it can improve the User Experience (UX) [55].

Usability evaluation has been systematically explored in the area of Human-Computer Interaction. On the other hand, this has been less investigated in the field of the BE. Some of the approaches found in the literature are interface design evaluation (i.e., of service controls) and risk assessment on existing housing to prescribe minor or major home adaptations. Vischer published an article back in 2008, mentioning the need to create a user-centered theory applied to the BE; however, the approach from the author focused mainly on office-work scenarios [56].

Recently, a Draft for a standard on the usability of the BE was proposed. According to the Draft of BS ISO 15928-7 [57], usability is the BE's characteristic to be used by everybody in convenience and safety. The draft also describes the dwelling's performance, which is defined as houses' behavior related to users' needs. This approach of defining usability needs to be differentiated from accessibility. While accessibility is based on objective information, usability is loaded with subjective perceptions [25].

For this research, usability will be considered when referring to the user's interaction with the residential BE and with technologies that promote aging-in-place.

2.5 Human-Centered Design

The National House Building Council Foundation [58] framed the question: 'Could well designed, stylish and safe homes suited to downsizing or single person occupancy become a more common new house type within 20 years?' This research focuses on the residential BE as a product. The so-called 'industrial house' [59] has been present since the early 20th century [60] and has become an alternative to an increased housing shortage in several countries [61, 62]. The industrial house concept is related to the Offsite Manufacturing (OSM) process, which refers to producing construction elements in a factory facility or other controlled environment [63].

OSM process requires adding value by integrating stakeholders in the design stage [57], which is one of the benefits of applying human-centered Design (HCD). References for HCD process and tools are explained by Maguire [64], Bowmast and Tait [65], and ISO 13407 standard on human-centered design [66, 67].

Currently, there are only a few pieces of literature available regarding HCD applied to the BE; most of the theory is applied to Healing Environments, adaptations to homes for rehabilitation, or smart interfaces at home [32, 68-70]. Some authors suggest that the construction sector lacks the use of Human Factors and HCD fundamentals[56, 70].

This research aims to answer the question: which HCD methods for data collection can be employed to integrate users' inputs when selecting and prioritizing features and technologies to age in place?

3 Methodology

A literature review took place online in scientific databases, analyzing peer-reviewed journal articles and conference papers involving Human-Centered Design methods for data collection applied to the BE and related to aging in place, usability, or assistive technologies.

The methods and instruments identified were analyzed by type of user, type of data collected, and elements considered.

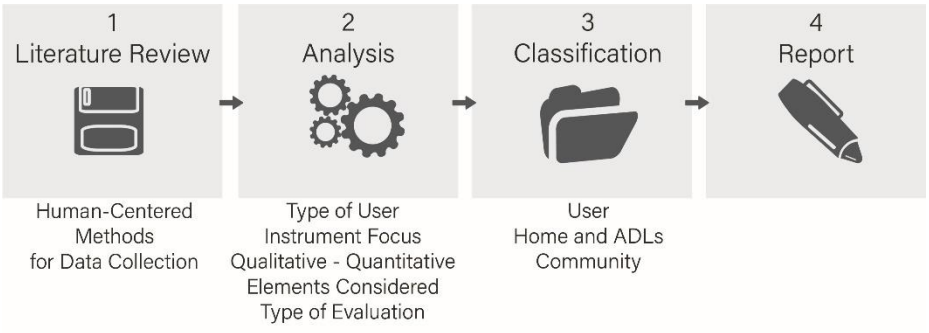

Fig. 2. Methodology diagram.

Methods and tools were classified according to relevant HCD elements and finally reported as part of a new framework of design for the BE.

4 Results

The result of the methods and instruments are described in this section. After reviewing 43 journal papers, eight were selected. The criteria for the selection of instruments was the detail of description for the application, focus related to the aspects of BE for aging in place (home adaptations, wellbeing, independence), or assistive technologies.

Specifically for quantitative data instruments, validity and refinement were also considered.

All the methods and instruments included demographic and background data; this feature is not included in Table 1 to avoid repetition. The first column refers to the name of the instrument or tool; the second one describes the type of user or the focus of the application. The third column defines if the data collected is qualitative or quantitative. The fourth column enlists the elements considered by the method or tool, and the last column provides a reference to the authors.

Table 1. Analysis of methods for data collection.

Name of Instrument	Type of User	Instrument Focus	Qualitative / Quantitative	Elements Considered	Type of Evaluation
UIMH Survey [25-27]	Older and disabled users.	HA	Quant.	Activity aspects, personal and social aspects, and physical environmental aspects.	Usability Scale
USAE Survey[71]	Older users.	Technologies	Quant.	Mobile phone use frequency and usability, social activity, environmental awareness.	Usability Scale
HAST Template [72]	Older users and carers.	HA	Qual.	Type of care, functional limitations, built environment, smart home technology, outcomes of smart home tech., general highlights.	Open questions, guide answers in template.
Board Interactive Interview [73]	Not age-related. Early adopters and early majority technology users.	Technologies	Qual.	Temporal approach (different times of a day), activities, control devices, appliances, features, and interaction styles.	Open questions, descriptive interactions.
MoCA [27]	Older users.	HA	Quant.	Cognitive assessment (short-term memory, visuospatial abilities, executive functions, attention, concentration, working memory, language, and orientation in time and place).	Test/Scores.
ADL Staircaise [27]	Older users.	HA	Quant.	Independent living assessment (feeding, mobility, using the toilet, dressing, bathing, cooking, transportation, shopping, and cleaning) and shows how independent the individual is in these situations.	Independence Scale.
Service Controls Interfaces Usability tool [74]	Not age-related. Users of heating systems.	Technologies	Quant.	Cognition, physical ergonomics, and Affordances.	Yes/No/I don't know answers.

Lived Experience Method [33]	Older and disabled users.	HA	Qual.	HA, process of getting the HA, analysis of before and after HA, other users of the HA, and further adaptations.	Semi-Structured interviews and Wearable camera use

Five of the gathered methods have a qualitative approach, and the other three, a quantitative one. The same proportion describes their focus; five relate to HA, and three to technologies at home. Two of the methods do not consider older people as part of their approach; however, the instruments can be used to gather insights from older people regarding interaction with appliances, services, and other interfaces.

In order to classify them, a model was developed based on the HAST Model (Human/Activity/Space/Technology) [22] and the Just Living Target Model [20]. The new schematic considers the main users, their home, their ADLs, and their Communities (Figure 3).

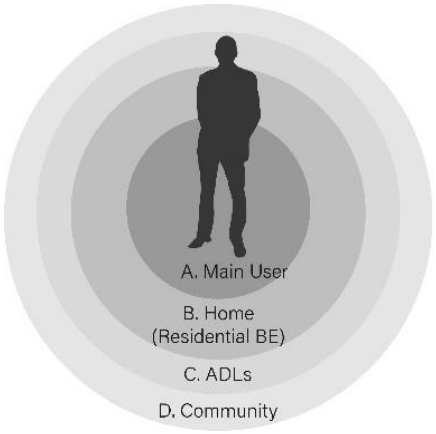

Fig. 3. HCD Model to Design Homes for aging in place in isolated contexts.

This schematic analysis starts with the main user at the center (Level A). The MoCA and ADL Staircase tools [27] can be applied to understand the levels of well-being experienced at home, functional ability, mental capacity, and the level of independence of the user through cognitive and independence assessments, as well as collecting demographic data.

After gathering information from level A, levels B and C can be approached and correlated, detailing the relationship between different areas of the home and the execution of ADLs. The methods to gain this understanding are: the UIMH [25-27], Lived Experience Method [33], the HAST template [72], the Board Interactive Interview [73], and the Service Controls Interfaces Usability tool [74]. It is suggested that

integrating the five methods can provide a deep understanding of the usability of the areas of the residential BE as well as the elements involved to enable the users, including furniture, HA, appliances, and other technologies that allow them to live independently.

For the last level (D), the USAE Survey is proposed, linking the user with its community, including accessibility, informal and formal care, and engagement with the community (neighbors, shops, etc.). It is important to mention that these interactions can be physical and/or virtual, to enhance the user-community bond, especially in isolated and remote contexts.

Table 2. Methods Classification

Focus	Aspects to Understand	Methods
Main User (A)	Wellbeing (functional ability and physical and mental capacity) and Self Care (Independence)	MoCA [27] ADL Staircase [27]
Home (Residential BE) (B) and Activities of Daily Living (ADL's) (C)	Usability of Areas, elements (furniture, adaptations, appliances, technologies, etc.)	UIMH Survey [25-27] Lived Experience Method [33] HAST Template [72] Board Interactive Interview [73] Service Controls Interfaces Usability tool [74]
Community (D)	Accessibility (physical and virtual), Care (informal and formal), and engagement with the community.	USAE Survey[71]

This review demonstrates that several methods are available to obtain data from users for interventions in the BE and to evaluate and increase its usability as well as its application to technologies that promote independence and engagement with the community.

The proposal of the present work is to integrate users' input to the equation (through the methods evaluated) for designing new residential houses as well as home technologies. It is to be further investigated how adding this knowledge to best practices, lessons learned from HA, and the Building Regulations can have a positive effect on users' everyday lives. As pictured in Figure 4, the expected impact of this approach would help to improve the levels of wellbeing of users while increasing their independence and reducing the need for extra care, lowering the need to move home in later stages of life.

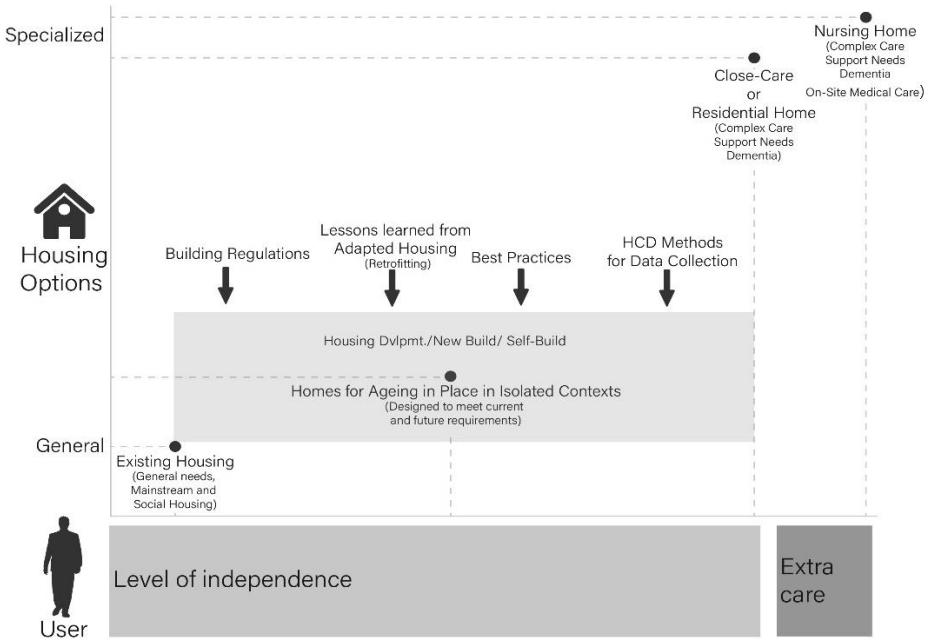

Fig. 4. Integration of methods and instruments in the HCD process to develop homes for aging-in-place in isolated contexts.

Conclusion

Deschamps-Sonsino [75] provided a detailed historical analysis about the evolution of the home and how some electrical appliances and smart devices have been incorporating into it gradually, after solving basic health milestones, quoting the author:

'Once the basics of Maslow's pyramid of needs had been resolved and the sanitation of a home was good enough to prevent pest and disease, the next thing to do was to find ways for the home to offer us opportunities for self-fulfillment, creativity, and exploration- especially with new industrialized products […]'

After facing a global health threat again, such as the COVID-19 pandemic, a new window to re-think about wellbeing at home has been opened.

As mentioned earlier in this paper, besides COVID-19, the UK is facing the challenge of having almost all of the housing stock inaccessible or with hazardous conditions, when on the other hand, the population is getting older with changing needs. Designers, developers, and professionals of the BE and smart home technologies should use available methods to consider the real needs of users, as well as considering best practices instead of only the minimum standards. This integration could help avoid usability 'psychopathologies' like the ones mentioned by Norman in his book The Design of Everyday Things [76].

This review is expected to contribute to the HCD framework for designing the residential BE, collecting data to prioritize elements and technologies to be implemented at home, to allow users to age-in-place and keep them connected to their communities.

The possible impact of applying these methods is to provide brighter scenarios in new-build houses, where people can find the balance for wellbeing while at home, for as long they might need to (such as in lockdowns) and for as long as they prefer to.

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