International Association of Societies of Design Research Congress 2023
LIFE-CHANGING DESIGN
Politecnico di Milano
9-13 October 2023

Developing future kitchen for older adults: a model and participatory design approach based on literature review and ethics framework

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doi.org/10.21606/iasdr.2023.798

The kitchen is a vital space in households and is closely related to the health and well-being of older adults. With the continuous development of technology and society, the future kitchen faces more challenges and opportunities. How to create a future kitchen suitable for older adults through design has become a pressing issue. Informed by literature review and inspired by a latest ethics framework for ageing research, this paper proposed a model for future kitchen design to adapt to future changes in the lives of older adults. Furthermore, a preliminary participatory design method combining design metaphors and enactment is proposed to help participants understand and express their relationship with the kitchen from a new perspective, to inspire the expectations and needs of the older adults, and collectively generate metaphors and visions for the future kitchen.

Keywords: ageing; older adults; future kitchen; participatory design

1 Introduction

The COVID-19 pandemic has propelled our lives into a more distant future, fundamentally exacerbating challenges faced by humanity as a whole (Pee et al., 2021). In the post-pandemic era, every aspect of people's lives, such as lifestyle, work, and education, has undergone significant changes. To cope with these life changes, design decisions need to be informed by future possibilities and take responsibilitys for the unknown changes. This requires for designers to face the uncertainties of the future with a positive and inclusive attitude, considering diversity and various possibilities (Reeves et al., 2016), and seeking innovative approaches to address them.

The global ageing population is one of the significant changes facing in contemporary life. Older adults play important roles in family and social participation, and their daily life quality has become increasingly important. For older adults, their living space has a critical impact on their physical and mental health, as well as their social relationships. As the central space in daily life, the kitchen plays

a significant role in nurturing family health and well-being (Bell & Kaye, 2002; Blasco et al., 2014). It is a place where many interactive behaviors occur every day and where new technologies and traditions intersect, making it one of the most transformative spaces for older adults in daily life (Maguire et al., 2014). As older adults' physical functions and cognitive abilities decline, they face many challenges and difficulties in the kitchen, such as operating complicated equipment. Therefore, it is critical to design an inclusive kitchen space for older people. This requires strengthening their participation in the design process and gaining a deeper understanding of their needs and expectations.

This study utilized a systematic literature review to identify the key knowledge and research gaps and developed an original future kitchen model. To evaluate and validate the model, user research will be conducted to refine it. A participatory design method was adopted in this study, using design metaphors (Stromberg et al., 2020) combined with enactment techniques (Buchenau & Suri, 2000; Burns et al., 1994) to explore the needs and expectations of older adults and to co-create design solutions for the future kitchen. The advantage of this approach is that it enables older adults to participate in the design process, using metaphors to help them express their ideas and feelings about the ideal kitchen space and enactment that allows them to show tangible experiences and contextualization through physical behavior. Older adults' unique viewpoints and experiences can provide valuable insights for future kitchen design and offer guidance for design practice.

Research questions (RQs) are as follows:

- RQ1: What are the main questions of focus in existing research on kitchen design for older adults? What gaps and limitations exist in these studies? How can this study fill these gaps and promote further development in this field?
- RQ2: How can design metaphors and enactment be developed and applied to stimulate the creativity and imagination of older adults in the co-creating process, to promote their creative thinking about the future kitchen?
- RQ3: How can trust and empathy be established between older adults and designers during the co-creating process to facilitate effective participation and communication, and fully explore older adults' needs and expectations?

2 Ageing and kitchen design

2.1 "The future of ageing" ethics framework

To address the challenges brought about by life's "changes" and the "future" of ageing, an ageing study report titled: "The Future of Ageing: Ethical Considerations for Research and Innovation" was published by the Nuffield Council on Bioethics (NCOB) 2023 in the UK, which proposed three ethically significant areas of research related to ageing: Research into biological ageing, Assistive, monitoring, and communications technologies such as health apps and smart home technologies, and Innovative predictive and diagnostic technologies (NCOB, 2023). The NCOB report also proposed an ethics framework that identifies the values, principles, and factors that are most important in the context of research and innovation linked to ageing research, which includes six principles: Demonstrating trustworthiness, Supporting flourishing in older age, Shifting power, Promoting equity, Challenging ageism, and Enabling sustainability (NCOB, 2023). These considerations can serve as valuable tools to help all those concerned with the development, conduct, and implementation of research relating to

living well in older age think through the ethical implications of their work. In the context of kitchen design, the research could consider adopting the ethical framework of ageing studies to enhance the quality of life for older adults by integrating these principles. The design should prioritize principles of fairness and inclusivity, taking into account older adults' physical conditions, cultural backgrounds, and emotional needs to ensure equitable treatment and experiences in the kitchen. These explorations are crucial for the sustainable development of an ageing society in the future.

Current research on kitchen design for older adults mainly focuses on ergonomic problems, safety layout of the kitchen, care and intelligent assistive technologies, as well as cultural and emotional experiences in kitchen space.

2.2 Kitchen ergonomic problems and safety

Researchers have explored ergonomics, safety, and spatial layout problems in kitchen design for older adults. Camara et al. (2010) found that older adults have an increased risk of accidents in kitchen activities as their physical sensory functions decline, identified key points of needs and difficulties, and proposed safer and more comfortable layouts and environments (Camara et al., 2010). Sims et al. (2011) investigated the experiences, needs, and desires of older adults in the kitchen, analyzed the problems in daily kitchen life, and ultimately proposed strategies to improve the experience and usability of the kitchen for older adults (Sims et al., 2011). Ibrahim and Davies (2012) investigated the cooking difficulties and safety of older adults in the kitchen, finding that the decline of physical function and unreasonable kitchen design have resulted in difficulties in cooking activities (Ibrahim & Davies, 2012). Maguire et al. (2014) focused on the physical health and ergonomic problems that older people face in kitchen life as they age: e.g., touch, bending, dexterity, and vision. They proposed innovative kitchen design solutions that are more flexible and adaptable to their changing needs (Maguire et al., 2014). Klos et al. (2012) found that visual impairments in older people increase the risks of using the kitchen, and investigated their wishes and needs, providing kitchen furniture design solutions for visually impaired older people to improve their living comfort (Klos et al., 2012). Wang et al. (2022) investigated the relationship between the efficiency of daily activities of older adults and the spatial layout of the family kitchen and suggested that the moderating role of cognitive function could help provide a basis for future design and optimization of residential spaces (Wang et al., 2022). Yoshifumi et al. (2022) developed software for a video database and search of older adults' behavior, and successfully investigated how older adults use consumer products by combining insights from the database and experiments. Their goal was to improve the safety of older adults in their daily lives and to create a safe universal design of environments (Yoshifumi et al., 2022).

2.3 Kitchen care and smart assistive technologies

The advancement of technology has brought innovative devices, functionalities, and interactions to kitchen design. These new technological means can assist older adults in performing daily activities in the kitchen, reduce the likelihood of injuries, and enhance their sensory experience. Scholars have developed various kitchen assistive technologies to improve user experience. Ficocelli and Nejat (2012) designed a cognitive-assisted interactive kitchen system for older adults with cognitive impairment. This system helps users overcome attention and memory deficits and perform activities of daily living (ADLs) in the kitchen, such as storing and retrieving items and accessing cooking recipes (Ficocelli & Nejat, 2012). Blasco et al. (2014) developed Ambient Assisted Living (AAL) services for smart kitchens, which increase the autonomy of elderly and disabled people in kitchen-related activities through

contextual and user awareness, appropriate user interaction, and artificial intelligence (Blasco et al., 2014). Zaric et al. (2021) proposed a monitoring and decision-making system that recognizes cooking activities and enhances the safety of home kitchens. The aim is to meet the needs of older people in modern living environments, allowing them to live comfortably and safely at home (Zaric et al., 2021). Roy (2020) developed a prototype of a futuristic kitchen robot assistant driven by artificial intelligence that enables automation of food recognition and service processes in the kitchen, including perception, remote control, navigation, and path planning. It also proposes to look forward to empowering this kitchen assistant with more intelligent functions in the future (Roy, 2020). Perotti and Strutz (2022) developed a voice-controlled interactive robotic arm as a kitchen assistive system to help older people perform difficult tasks (Perotti & Strutz, 2022).

2.4 Kitchen cultural and emotional experience

Kitchen is multifunctional and an important place of culture, memory, and communication (Maguire et al., 2014). Older adults can make cultural and emotional connections in the kitchen. Wang et al. (2022) suggested that family factors of homebound older adults need to be considered in kitchen studies. e.g., family attachment, family and friend care, memories, and values (Wang et al., 2022). Sims et al. (2012) proposed design recommendations for sustainable future kitchens by interviewing people's memories of their kitchens throughout their lives, in terms of people's changing life needs (Sims et al., 2012). Meah and Jackson (2016) proposed how the kitchen, as a specific site of memory, is part of the construction of personal memory and family identity (Meah & Jackson, 2016). Scicluna (2015) enacted the ethnographic narrative to invite older women to share their life experiences through memories of the family kitchen space, exploring specific experiences and imaginative ways of understanding it. In this study, the kitchen was a controversial, transformative, and political domestic space (Scicluna, 2015).

The literature review shows that there are still gaps and challenges in current research on kitchen design for older adults. The various needs and expectations of older adults have not been fully addressed. Kitchen design not only needs to meet the ergonomics and safety layout, but also should consider the multi-sensory experience of the older adults in the kitchen and enhance the multimodal interaction, such as tactile, visual, olfactory, gustatory, and auditory interaction functions. Furthermore, the kitchen design should also pay attention to the psychological factors and emotional needs of older people. The kitchen becomes a kind of memory space, evoking emotional memories and connections through scenes. In addition, kitchen design should also pay attention to the psychological factors and emotional needs of older adults.

3 A model inspired by an ethics framework

Informed by the literature review, and inspired by the Nuffield ethics framework, the authors constructed an original future kitchen model for older adults (Figure 2). The model includes four dimensions: Health and well-being, culinary culture and emotional connection, intelligent technology and multi-sensory experience, and sustainability and diversity.

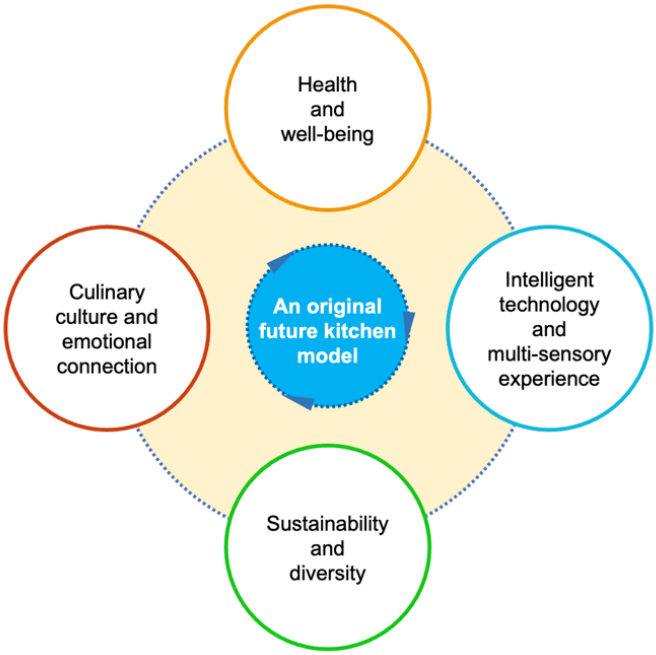

Figure 1. An original future kitchen model for older adults

3.1 Health and well-being

As the core area and space of the home (Blasco et al., 2014), the kitchen is an important part of older adults' daily activities, with many interactions occurring every day that are closely related to their health and well-being (Hu, 2016; Kim et al., 2019). In the kitchen space, the physical and mental health of older adults are both challenged. Therefore, the future kitchen should monitor their health condition through intelligent devices and provide nutritious, safe, and balanced food options to improve their physical health (Roy, 2020). In addition, the accessibility and comfort of the kitchen space environment and equipment should be improved to reduce operational difficulties and risk factors (Zaric et al., 2021). At the same time, encouraging older people to participate in kitchen activities can help improve their physical function and self-awareness, empower them, and promote their flourishing in older age. Ramsamy-Iranah et al. (2021) presented that a more inclusive kitchen space design can make life easier for older people (Ramsamy-Iranah et al., 2021). The kitchen needs to be comfortable and functional and provide a better user experience, allowing older people to express their emotions and enjoy their lives.

3.2 Culinary culture and emotional connection

“Culinary culture and emotional connection” is also an important dimension to be considered in future kitchen design. Future kitchens should serve as a place for passing down cooking skills and knowledge, enabling each older adult's unique culinary skills to be culturally transmitted and promoting spiritual inheritance between different generations, adding meaning and value to cooking activities and kitchen space (Maguire et al., 2014). Moreover, future kitchen spaces should become a space for communication and interaction, allowing older adults to cook and share food with family and friends, building emotional connections, and supporting each other to enhance their quality of life and sense of happiness (Wang et al., 2022). Additionally, older adults' self-esteem and sense of identity should be taken into account, providing them with an environment that can meet their identity and value needs (Meah & Jackson, 2016). Older adults need emotional support and recognition in their lives,

and the kitchen should be a warm, comfortable, and welcoming space that allows them to cook and dine, feel valued and respected, and maintain their independence and dignity.

3.3 Intelligent technology and multi-sensory experience

The integration of intelligent technology and multi-sensory experiences in future kitchen design will provide older people with a more convenient, safe cooking and eating experience, enhancing their quality of life (Blasco et al., 2014; Perotti & Strutz, 2022; Roy, 2020; Zaric et al., 2021). They can easily operate kitchen equipment and appliances through natural and simple human-machine interaction. Furthermore, intelligent monitoring during kitchen activities can reduce the risks and pressures faced by older adults, eliminate age discrimination, increase their participation and sense of independence, and establish confidence and trust. In addition, various sensory elements such as visual, auditory, tactile, olfactory, and gustatory senses will be fused in the kitchen space, creating a relaxing cooking environment through multi-sensory interaction, which can improve happiness and reduce loneliness. Smart technology can also provide older adults with personalized diets and health plans.

3.4 Sustainability and diversity

As global climate change and resource scarcity become increasingly pressing issues, sustainability, and diversity are crucial considerations. Sustainable practices and environmental protection should be prioritized in future kitchen design (Sims et al., 2012); this includes equipping older adults with energy-efficient devices, reducing food waste, and using environmentally friendly materials. In addition, older adults are not a homogenous group; they have different cultural backgrounds, health conditions, life experiences, and cognitive abilities. Their needs are diverse and varied, such as dietary preferences and psychological and physical requirements. Therefore, future kitchen design should take these differences into account and provide diverse design solutions to meet the different needs of older adults (Maguire et al., 2014).

4 A participatory design approach: design metaphors and enactment

To further advance the original model, we propose a participatory design approach that encourages participants to generate metaphors and create visions for the future kitchen through designing and enactment, aiming to provide insights for future user research.

4.1 Design metaphors and enactment

Metaphor is a rhetorical device used to compare one thing or concept to another (Steen, 2002). Comparing two different objects or ideas to convey common attributes between them, helps people to better understand and feel the meaning expressed. Metaphors are the foundation for thinking, reasoning, and imagining in daily life (Lakoff & Johnson, 2008), existing in all areas of human endeavor; they are multidisciplinary and interdisciplinary (Hekkert & Cila, 2015).

Metaphors have been extensively explored in the field of design. Generative metaphors are used in the design process to help construct problems and determine directions for solutions (Schön, 1979), such as guiding users' interactions with technology and creating meaningful product experiences (Cila, 2013; Hey et al., 2008). Metaphors can also be used as design thinking tools to inspire designers' creativity and generate new design concepts. Hekkert and Cila (2015) proposed the concept of using metaphors in product design, product metaphors, where the connection between the metaphor's source and the target (product) was created by mapping physical properties from the source to a

blended target (Hekkert & Cila, 2015). Product metaphors can be multimodal, suggesting metaphors through various modes (e.g., form, interaction, sound, material, etc.) that product designers can use to design more attractive products. In human-computer interaction (HCI) design, Jung et al. (2017) used metaphors to convey to users how to interact with computer applications in a familiar form, such as the classic desktop metaphor of personal computers (Jung et al., 2017). Using metaphors as a foundation for design can help inspire interaction design, and designers can use metaphors to design interaction interfaces that are easier for users to understand and operate (Ju, 2015). Flemisch et al. (2003) used metaphors in the autonomous vehicle's design to handle the interaction consequences of the vehicle's increased agency (Flemisch et al., 2003). Other studies have proposed specific metaphors for human-vehicle relationships, such as between a rider and a horse, a husband, and wife, or players on the same team (Davidsson & Alm, 2009; Ju, 2015).

Although metaphors have been widely used in the field of design research, they are difficult to extend to complex interactive environments and scenarios (Jung et al., 2017), which poses significant challenges for research on design metaphors. Therefore, it is worthwhile to explore how to select appropriate metaphors and apply them to design research.

Metaphors need to be expressed and exploited to explore how relationships impact each scenario and interaction (Jung et al., 2017). Some studies have explored the design of future interactions that can be supported by a combination of design metaphors and enactment techniques. Metaphors can act as a common language to facilitate the creation of a joint conceptual vision of relationships, and enactment creates tangible experiences and contextualizes design concepts (Stromberg et al., 2020). Enactment is a flexible and rapid method for exploring the future design and can be influenced by interactions between context, scenario, personal motivation, and external factors (Buchenau & Suri, 2000). It provides a common space and stage for co-creation between designers and users. Enactment can better explore the user's interaction with the environment or system, and discover specific metaphorical ways of constructing metaphorical mental models. This method has been applied to research user expectations of future autonomous driving systems and interactions (Pettersson, 2017).

4.2 A preliminary participatory design approach

To develop and evaluate the model, we anticipate the following steps for participatory design:

- Initial presentation
  The researchers first share images and case studies of existing kitchen designs with the participants. The participants share their existing experiences and discuss their perceptions and needs for future kitchens, creating initial concepts.
- Generate metaphors and create visions
  ‘metaphors as a projective technique’ (Morgan & Krueger, 1998) will be used to include participants in the generation of metaphors. The researchers provide participants with open questions, such as ‘If you can give the kitchen a name, what would it be, and why?’. Each participant will be asked to describe their future kitchen using generative metaphors. Enactment scenes will be employed to support the concept development.
- Reflection and feedback
  Finally, a semi-structured interview will be conducted to encourage feedback and discussion among the participants, to further explore their ideas.

5 Conclusion and further work

This paper combined ageing and kitchen design literature with the 'ethics framework' of ageing research to construct a future kitchen model, which includes four dimensions. Subsequently, we proposed a participatory design method that utilizes metaphors and enactments to stimulate the creativity of older adults and facilitate the expression of their needs and expectations, thus offering effective insights and innovative pathways for the early stages of design.

This study has provided a preliminary reference for future kitchen design research. The validity and value of the proposed model and method need to be verified and evaluated through follow-up studies.

Acknowledgements

This research is supported by "Postgraduate Research & Practice Innovation Program of Jiangsu Province" (NO.KYCX23_2431), "CHINA SCHOLARSHIP COUNCIL" (NO.202206790035), and "The National Social Science Foundation Project of Art" (NO.20BG129).

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