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Heart of the future home: a multidimensional model of inclusive kitchen for older people in the UK

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With the development of smart technology and aging societies, the living and housing environments for older people are undergoing transformation. Designers must understand the changing capabilities, lifestyles, preferences, and inspirations of older people for their future homes, in which the kitchen is seen as the heart. To gain a deeper understanding of the requirements of older people in promoting healthier lifestyles and inclusive daily practices, the authors identified five key factors of kitchen design through a literature review, developing an initial model. Subsequently, a focus group was conducted in the UK to explore the perspectives and expectations of older people, where metaphors for future kitchens were collected, and further insights were used to refine the model. The refined model for a future-inclusive kitchen encompasses six dimensions: Environment/space, Technology/interaction, Emotion/affect, Health and safety, Human factors and well-being, and Sustainability. Through using metaphors, this study offers a multidimensional lens to investigate the future user experience of inclusive kitchens. The significance of this study lies in the originality of combining a literature review, and user study with design metaphors. A future-proof inclusive kitchen design model is proposed to provide guidance for future design directions of age-friendly environments.

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Introduction

The extension of life expectancy among the population triggers transformations and adjustments in societal objectives (Pericu, 2017). Confronting new challenges, designers must reimagine and reconsider innovation to construct a more optimistic outlook for the future (Reeves et al., 2016). According to the World Health Organization's (WHO) definition, older people are those aged "60 or 65 years and over" (WHO, 2007). The increase in life expectancy has led to a rapid growth in the aging population, presenting a challenging issue of maintaining a good quality of life (Tiraphat et al., 2017). Age-friendly environments have been shown to have a significant relationship with the quality of life of older people, particularly in terms of physical, safety, and social environments (Tiraphat et al., 2017). Thus, enhancing the quality of life for the aging population necessitates the creation of environments that are friendly to older adults (Cramm et al., 2018). To address global population aging, the WHO has developed guidelines for age-friendly environments, encompassing eight domains: housing, transportation, outdoor spaces and buildings, community support and health services, communication and information, social participation, respect, and social inclusion, as well as civil participation and employment (Steels, 2015; WHO, 2007). Age-friendly environments aim to support active aging by optimizing opportunities for health, participation, and safety, thereby enhancing the quality of life for the aging population (Tiraphat et al., 2017; WHO, 2017).

The majority of older people prefer to spend most of their time at home, resulting in most of their activities occurring within the home environment (Mitzner et al., 2010; Peace, 2016). This underscores the critical importance of creating age-friendly home environments (Kavšek et al., 2021). The home environments must be designed to support the safety, comfort, and independence of older adults. Therefore, reimagining and designing living spaces and environments suitable for older people is of paramount importance. Inclusive design aims to address the diversity of abilities and meet the needs of older people; this enables older adults to live independently and enhances awareness of health practices (Afacan, 2013; Goddard and Nicolle, 2012). The kitchen is one of the most frequently used spaces within the home, serving as a functional and family activity hub and is often regarded as the heart of daily life (Bell and Kaye, 2002). It is a physical/material, social, and psychological environment encompassing both public and private spaces (Sims et al., 2012). Contemporary kitchens have been endowed with multiple roles and possibilities, such as the integration of new technologies, storage spaces, and social hubs, thus rendering them one of the most transformative spaces in the daily lives of older people (Maguire et al., 2014). Kitchen activities have been demonstrated as a root cause of quality of life issues for older people and disabled people (Oliver et al., 2001). As the capabilities, behaviors, and lifestyles of older people change, the importance of the kitchen is not only limited to its practical function, but is also closely related to caregiving, emotions, and being a place of friendship, and comfort (Milligan, 2005). Future kitchen design necessitates the elimination of not only physical barriers but also social and cultural impediments (Peace, 2016). Therefore, delving deeper into the perspectives of older people regarding kitchens, understanding their expectations and needs, and enhancing their involvement in the design process is crucial (Le Bel and Kenneally, 2009; Peace et al., 2018).

This study aims to explore the creation of a future age-friendly inclusive kitchen for older people. The research question of this study is as follows:

Q1: What are the identified key factors of current kitchen design research cater to the needs of older people?

Q2: What are the main challenges faced by older people in using current kitchen designs and how can these be overcome in future designs?

Q3: How can metaphors be effectively used to capture and integrate the expectations of older people into the conceptual design of future kitchens?

This study began with a literature review, synthesizing existing kitchen design research. Subsequently, a focus group was conducted on the challenges and difficulties encountered by older people in their daily use of kitchens. Their needs, expectations, and metaphorical descriptions of future kitchens were captured. A model of future inclusive kitchen was developed based on the literature review and the focus group study. The insights generated serve as a foundation for future kitchen design, promoting inclusive and sustainable age-friendly environment solutions.

Literature review

An aging future and inclusive living. With the increasing number of older population, society presents new complexities in areas such as health, healthcare, social interactions, and lifestyles (Cozza et al., 2019). Maintaining well-being and quality of life for the aging population will be extremely challenging (Shergold et al., 2015).

Research has proposed concepts and guiding strategies for the future of aging. For instance, the Royal College of Art introduced the concept of "Designing for our future selves," encouraging young designers to perceive aging as a natural part of the life process (Clarkson et al., 2003). Clarkson and Coleman (2015) challenge traditional assumptions about the needs and lifestyles of older adults, emphasizing the significance of presenting a future vision that is age-friendly. It needs a rethink of basic household elements, ranging from kitchens and bathrooms to furniture, clothing, and products.

To address the challenges brought by the "future" of aging, the UK Nuffield Council on Bioethics published a report in 2023. It proposed an ethics framework for research and innovation linked to aging 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 tools to guide aging research.

To create a vision for future living, the housing sector in Scotland launched a future-thinking program, leading to the conceptual framework for "Inclusive living" (McCall, 2022). It encompasses three key elements: social inclusion and equality, physical space and design, and connections and relationships. The framework aims to create better living spaces for individuals, supporting health, quality of life, and well-being, while considering the holistic nature of future housing designs through an inclusive living perspective (McCall, 2022).

Inclusivity in kitchen design. Inclusive design takes full account of the diversity of users to produce better products (Clarkson, 2009). The implementation of inclusive design requires adherence to the following five principles: (1) People: place people at the core of the design process; (2) Diversity: recognize and respect individual differences; (3) Choices: provide choices that a single solution cannot accommodate for all users; (4) Flexibility: ensure flexibility of use; (5) Convenience: ensure that design products are convenient and pleasant for everyone (Patrick and Hollenbeck, 2021). Therefore, understanding users' capabilities, needs, and expectations is vital for inclusive design; the home environment stands out as a critical scenario (Langdon et al., 2015). The

kitchen is one of the most important spaces in daily life, and the new era has given it diversified roles and functionalities. The demand for inclusivity in kitchen design is a multidimensional task (Afacan and Demirkan, 2010). Lenker et al. (2016) conducted research into usability issues encountered by different user groups in domestic kitchen environments and proposed a conceptual framework for universal design aimed at improving product and environmental usability. Afacan (2016) investigated the cognitive processes and behaviors of older adults related to inclusive kitchen design. The study involved the creation of three kitchen personas, namely the “healthy user,” the “user with a lack of acceptance,” and the “extreme user.” The research also identified three categories of needs for inclusive kitchen design: comfort, simplicity, and safety. Porto and Rezende (2017) emphasized the significance of universal design in the kitchen environment for older people and kitchen utensil design, offering solution examples.

Researchers have also focused on the relationship between human factors and spatial environments in kitchen design, exploring ways to optimize spatial layouts to meet the needs of older people. Wang et al. (2022) studied the relationship between the efficiency of daily activities and the spatial layout of the kitchen of older people. Pinto et al. (2000) employed an ergonomic approach aimed at enhancing the home environment through the design of technical equipment to improve the quality of life and daily activities of older adults, offering specific recommendations for kitchen design to enhance self-sufficiency. The decline in physical functioning and unreasonable kitchen design contributed to older people’s difficulties in cooking (Ibrahim and Davies, 2012). Maguire et al. (2014) focused on physical health and ergonomics issues faced by older people in kitchen living, including concerns related to reach, bending, dexterity, and visual impairments; they proposed innovative design strategies that are more flexible and adaptable to older people’s evolving needs. Sundaram and Rukmangadhan (2016) emphasized the importance of security in kitchen space design for older people and recommended the adoption of simple design interventions to reduce ergonomic risk factors.

With the advancement of technology, enhancing kitchen inclusivity through new technologies has become a key research area. Current research defines technology as any electronic or digital product or service (Mitzner et al., 2010). The adoption of technology is indispensable in modern society, improving efficiency in daily tasks. For older adults, technology can enhance their quality of life, aiding them in maintaining their health and independence for longer periods (Geraedts et al., 2014; Heinz et al., 2013). It also has the potential to improve cognitive and sensorimotor functions (Demiris et al., 2008). In human-computer interaction (HCI) research, technology encompasses gesture recognition, voice control, brain-computer interfaces, and facial expression control, enhancing interaction freedom and efficiency (Bai et al., 2020; Greenwell et al., 2023; Lin et al., 2022; Sun et al., 2023; Zhou et al., 2023). In anthropology, technology is defined as “a human-created system that utilizes knowledge and organization to produce objects and techniques to achieve specific goals.” This definition encompasses a broad range of innovations (Carroll, 2017; Volti and Croissant, 2024). In this area, research on technology highlights the reciprocal influence between technology and cultural and social structures, enhancing our understanding of the interplay between society, culture, and technology (Bruun and Wahlberg, 2022; Pfaffenberger, 1992).

Currently, technology has become an important part of kitchen design. Its integration not only resolves practical difficulties in the kitchen but also significantly enhances the cooking experience (Kerr et al., 2014). Specifically, technology within kitchen design encompasses aspects such as smart home systems (Demiris et al.,

2008), automated cooking assistance robots (Sharath et al., 2018; Sugiura et al., 2010), and intelligent kitchen appliances like smart refrigerators (Nath et al., 2023). These technologies are used to enhance the functionality, accessibility, and safety of the kitchen environment. Therefore, when addressing “technology” in kitchen design, it should be defined as any device, system, or feature, including smart appliances, interactive interfaces, and robots, that collectively foster a more intelligent and interactive cooking environment.

Researchers have developed intelligent systems and robotic assistants to enable older people to work comfortably and safely in the kitchen (Perotti and Strutz, 2023; Roy, 2020; Zaric et al., 2021). Environmental assistive and electronic technologies offer additional functionalities to the kitchen environment, making it more user-friendly for individuals of all age groups (Maguire et al., 2011). To promote independent living among older people, assistive tools and technologies can be utilized to aid in food preparation and dining experiences (Holt and Holt, 2011). An intelligent kitchen innovation design for Ambient Assisted Living (AAL) was developed to enhance the autonomy of older people and disabled individuals in kitchen activities (Blasco et al., 2014). Market research was conducted to explore user preferences and needs to develop inclusive kitchen layouts (Bonenberg et al., 2019).

The cognitive and sensory functions of older people in the kitchen were also researched. Based on the sensory function of older people, safer and more comfortable kitchen spaces and environments were proposed to accommodate the difficulties they face (Camara et al., 2010). A “cognitive kitchen” was proposed to support daily kitchen activities for individuals with cognitive impairments, with principles encompassing safety and simplicity (Johansson et al., 2011). Ficocelli and Nejat (2012) designed a cognitive assistive interactive kitchen system for older individuals with cognitive impairments, aiding users in overcoming attention and memory deficits and carrying out kitchen activities of daily living.

Furthermore, studies have focused on users’ emotional experience and dietary health. The kitchen is often considered a multidimensional space of culture, memory, and communication (Maguire et al., 2014). The kitchen can be used as a site for personal and family identity construction, which is closely linked to people’s memories, life experiences, and values (Meah and Jackson, 2016; Scicluna, 2015; Wang et al., 2022). The kitchen is a space imbued with rich cultural and ceremonial significance, often perceived as a locus of ritual significance (Nyström, 2003; Zeiner et al., 2018). Family mealtime rituals exemplify this role, serving as a medium for emotional exchange among family members, cultural transmission, and the reinforcement of family bonds (Petrelli and Light, 2014). Dickinson et al. (2014) aimed to explore the correlation between kitchen living and household food safety. The results indicated that food safety is associated with factors such as trust in the food supply, food shelf-life, sensory logic (e.g., taste or smell of food), and food waste. Regarding the impact of the design of home cooking and dining spaces on dietary behaviors and habits, relevant design features included dimensions and layout, connectivity with other spaces, fixed fixtures and accessories, and indoor environmental quality (Sal Moslehian et al., 2023). Parrott et al. (2008) demonstrated that the appearance and esthetics of the kitchen are crucial factors influencing people’s lives.

Additionally, research has also focused on the use of kitchens throughout people’s lifecycles and sustainable strategies (Hagejård et al., 2020; Vu et al., 2023). Maguire et al. (2014) argue that kitchens serve various purposes, including functional and social aspects. They proposed kitchen strategies that promote inclusive design and social inclusivity throughout the lifespan. Sims et al. (2012) found

Table 1 Preliminary factors of inclusive kitchen design.			
Factors	Explanation	Category	Source
Environment	This factor considers the optimization of kitchen space to ensure a harmonious, safe, and comfortable environment that supports the independence and welfare of older people.	Human factors and spatial environments	Pinto et al. (2000)
		Space security	Ibrahim and Davies (2012)
		Comfort	Sundaram and Rukmangadhan (2016)
Technology	The “Technology” factor encompasses the adoption of advanced smart home systems and human-computer interaction technologies, such as automated intelligent appliances, visual interfaces, voice-controlled devices, and intelligent assistant robots. The aim is to enhance safety, improve usability, and increase adaptability for older people in the kitchen environment.	Appearance and esthetics	Camara et al. (2010)
		Intelligent and assistive technologies	Afacan (2016)
		Usability	Parrott et al. (2008)
		Simplicity	Roy (2020)
Health	The health factor emphasizes that kitchen design must consider aspects of the user’s physical, and mental health, and behavior to create a space conducive to overall well-being.	Cognition and perception	Zaric et al. (2021)
			Perotti and Strutz (2023)
			Lenker et al. (2016)
Emotion	This factor highlights the creation of a warm and comfortable kitchen environment that satisfies the emotional needs of older people, enhancing their sense of well-being and belonging.	Dietary behaviors and habits	Holt and Holt (2011)
		Food safety	Afacan (2016)
		Physical health	Camara et al. (2010)
		Memories	Johansson et al. (2011)
		Communication	Ficocelli and Nejat (2012)
Sustainability	Sustainability means that kitchen design should consider future possibilities and diversity, focusing on the long-term adaptability of the design.	Personal and family identity construction	Sal Moslehian et al. (2023)
		Life experiences	Dickinson et al. (2014)
		Social inclusion	Ibrahim and Davies (2012)
		Flexibility and adaptability	Maguire et al. (2014)
			Sims et al. (2012)

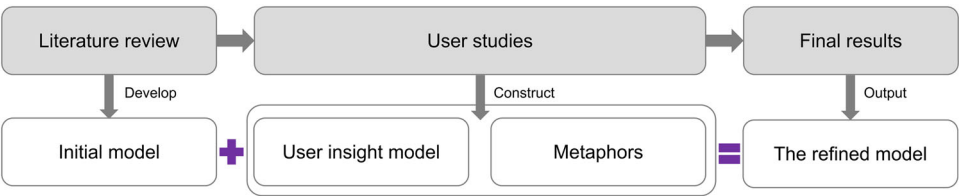


Fig. 1 Research framework. The figure shows the overall process and framework of this study, beginning with a literature review to develop an initial model. It progresses through user studies to further construct a user insight model, employing metaphors to aid in explaining concepts. This culminated in the formation of a refined model.

that as people age, their kitchens may no longer be as convenient or suitable for their needs. Drawing on individuals’ memories of kitchens throughout their lives and contemporary kitchen experiences, they offered design recommendations for sustainable kitchens, considering both the kitchen itself and the evolving life needs of individuals. By studying both past kitchen experiences and present kitchens, Ramsamy-Iranah et al. (2021) proposed that a more inclusive kitchen space design could make life easier for older adults.

Much of the existing research related to kitchen design has explored the capabilities, needs and emotions of users, proposing corresponding solutions. However, there has not been an emphasis on the future expectations of older adults, and their needs and desires for future kitchens remain insufficiently addressed. A truly inclusive kitchen design necessitates an understanding of users’ future expectations and perspectives, taking into account the diversity among users (Clarkson, 2009; Langdon et al., 2015). This includes differences in the kitchen usage requirements among older individuals from different cultures and regions, their emotional and cultural needs, as well as boundary issues related to future kitchens. The kitchen is bordered by other spaces of domestic life, and its boundaries become blurred, meaning far beyond food-related activities. It is

especially important for people’s health, mobility, and care needs (Wills et al., 2013). Therefore, it is essential to conduct research to explore the genuine cognition and expectations of older adults for the future kitchen.

Existing literature provides valuable explorations of kitchen design from different perspectives, and Table 1 summarizes the literature to preliminarily define key factors of inclusive kitchen design.

Methodology

The research framework is shown in Fig. 1. In the first stage, a literature review and analysis on inclusive kitchen design was conducted to extract and identify key factors from existing kitchen studies, leading to the development of an initial model of inclusive kitchen. In the second stage, user research was conducted through focus groups with older people. The collected data were then analyzed to construct the second version of the inclusive kitchen model—the user insight model. At the same time, metaphorical descriptions of the ideal future kitchen from the perspective of older people were obtained. In the third stage, combining the initial model, the model derived from the user study, and metaphorical descriptions of future kitchens, we developed a refined model.

Table 2 The demographic characteristics of participants.

Participant	Gender	Age	Property type	Household type	Frequency of using the kitchen each day	Educational status	State of health and physical independence
P1	M	67	Flat/apartment	Lives alone	16times	Higher than bachelor's degree	Good health condition
P2	F	75	Detached house	lives with a child/children	More than 10 times	Below bachelor degree	Good health condition
P3	M	75	Bungalow	Lives with a spouse/partner	More than 10 times	Bachelor degree	Good health condition wears a hearing aid
P4	M	79	Semi-detached house	Lives with a spouse/partner	About 10 times	Higher than bachelor's degree	Good health condition
P5	F	80	Detached house	Lives with a spouse/ partner	More than 15 times	Bachelor degree	Good health condition
P6	M	80	Detached house	Lives with a spouse/partner	More than 10 times	Bachelor degree	Mobility impaired, uses a wheelchair
P7	F	68	Terraced house	Lives with a spouse/partner	About 20 times	Below bachelor degree	Mobility impaired, uses a cane

Study design. This study adopts a user-centered perspective through an exploratory qualitative study. A focus group session was conducted at a university in London, with ethics approval (44614-LR-Aug/2023-46925-2). The focus group is an open and exploratory method designed to collect qualitative data. It provides insights into the details of actual use and the strengths and weaknesses of technology in various domains (Krueger, 2014). The advantage of focus groups lies in their ability to provide insights into user research through group interactions (Barrett and Kirk, 2000; Bruseberg and McDonagh-Philp, 2002). This approach can guide designers to understand users from the initial stages of design and delve deeper into their thoughts and needs (Barrett, 2005; Blain-Moraes et al., 2012; Bruseberg and McDonagh-Philp, 2002; Savory et al., 2012).

Sampling. The participants were defined according to the WHO's definition of older people (60 or 65 years and older). In total, seven participants (3 females, 4 males; age range: 67–80, Mean = 74.86, SD = 5.46; one with hearing impairments, one with mobility impairments—a wheelchair user, and five without any specified disabilities) were recruited from the Greater London, UK, mainly through the Brunel Older People's Reference Group. Each participant signed an informed consent form and received a small Thank You gift at the end of the study. The demographic characteristics of participants are shown in Table 2.

Procedures. The focus group session had a moderator, a research assistant, and an audio recorder. Focus groups with older people should be kept as simple, brief, and with fewer topics as possible (Barrett and Kirk, 2000). The whole session lasted approximately 120 min, structured into four steps. The procedures are shown in Fig. 2.

- (1) Preparation and warm-up (5 min)
The moderator introduced the purpose of the study and encouraged interaction and communication among participants, aiming to foster a relaxed atmosphere in preparation for active discussion.
- (2) Introduction and overview (10 min)
The moderator presented with images and case studies of existing kitchen designs. The participants were encouraged to speak and discuss freely, sharing their perspectives and concerns. This facilitated the establishment of initial impressions and concepts regarding the kitchen.
- (3) Topic Discussion (100 min)

- Topic 1. Kitchen environment, spatial layout, and ergonomic issues (20 min)
- Topic 2. Kitchen smart assistive technologies (20 min)
- Intermission/breaks (10 min)
- Topic 3. Culinary culture, emotional connection, health, and well-being (20 min)
- Topic 4. Future kitchen expectations and metaphors (30 min)
- (4) Reflection and feedback (10 min)

All participants had the opportunity to express any additional opinions or viewpoints. The moderator expressed gratitude to the participants and concluded the session.

Data collection and analysis. The data were transcribed, coded, and categorized using qualitative data analysis methods (Corbin and Strauss, 2014). The analytical process followed that of thematic analysis, utilizing a systematic procedure for data coding (Braun and Clarke, 2006). Specifically, two doctoral researchers in design studies undertook a manual analysis using open coding techniques to familiarize themselves with the data, generate initial codes, and further identify themes. Next, an additional researcher joined, reviewed, and discussed the themes, merged a number of similar expressions to reach a consensus, and defined and named the themes. Finally, an expert with over two decades of user research experience reviewed the themes and confirmed the final themes and sub-themes.

Design metaphor

Metaphor is a powerful tool to help us understand complex concepts and ideas, serving as the foundation for thinking, reasoning, and imagination in everyday life (Lakoff and Johnson, 2008). Generating metaphors is often used to deeply explore and understand participants' expectations and visions for the future (Schön, 1979). This section reviews design metaphors and explores their potential as a tool for conceptualizing future kitchens.

A metaphor is the transfer of knowledge from a known source domain to the understanding of an unknown domain (Choi and Kim, 2017). Metaphors are often utilized to compare one thing or concept to another (Steen, 2002). Conveying common attributes between two things or ideas by comparing them helps people to understand and feel the meaning being expressed in a deeper and more intuitive way. Metaphors play a crucial role in the setting of problems, not by concentrating on the resolution of problems but by facilitating the creation of new cognitions, interpretations, and inventions (Schön, 1979).



Fig. 2 The focus group procedures. This figure shows the entire procedure of the focus group. The procedure is divided into four main steps: Preparation and warm-up, Introduction and overview, Topic discussion, Reflection, and feedback.

Metaphors have been extensively explored in the domain of design, throughout every stage of the design process, including the conceptualization of design ideas, the framing of design situation, and the definition of goals and constraints (Casakin, 2006). Metaphors can be generated during the design process as interpretative tools for critical analysis to help the construction of problems and determine the direction of the solution (Schön, 1979).

In the studies of human-computer interaction, metaphors are frequently employed to describe concepts such as the desktop, menu, and folder metaphors, which have become ubiquitous elements within user interfaces, allowing users to apply physical objects they already understand (e.g., actual folders) to digital interfaces (Carroll et al., 1988; Hurtienne et al., 2008; Pitt and Casasanto, 2022). Designers have used metaphors as a foundational element in interaction design to create interfaces that are more easily understood and navigated by users (Ju, 2015). For instance, the classic desktop metaphor for personal computers exemplifies how metaphors can convey to users the manner of interacting with computer applications in a familiar form (Jung et al., 2017). Metaphors help maintain logical consistency and rigor by transforming familiar physical objects into experiences within the digital realm, thereby enhancing the coherence and precision of the interaction process.

In the field of product design, Hekkert and Cila (2015) introduced the concept of “product metaphor,” where the connection between the metaphor’s source domain and the target domain was established by mapping the physical attributes of the source onto the blended target. Product metaphors have various modes such as form, interaction, sound, and materials. Designers can utilize metaphors as a foundation to create more appealing products, thus translating abstract qualities of the source domain into tangible product features that enhance user experience and product attractiveness (Cila et al., 2014).

“Spatial metaphors” refer to psychological metaphors with space as their source domain, representing a metaphor based on individuals’ interactions with their spatial environment, which are often used to remember the past and plan for the future (Pitt and Casasanto, 2022). Spatial metaphors predictably shape the ways individuals think, feel, and behave (Gottwald et al., 2015). Spatial metaphors are shaped by the specifics of people’s spatial experiences. Many metaphors link vertical space to emotional valence (Gottwald et al., 2015). For example, a fundamental spatial metaphor associates “up” with positive emotional valence and “down” with negative emotional valence (Lakoff and Johnson, 2008). Therefore, designers can enhance user experience by designing interactions that are congruent with people’s implicit spatial metaphors, tapping into the underlying structure of users’ minds. Neglecting or contravening these metaphors can lead to user experiences that are unintuitive, unpleasant, or even dangerous (Pitt and Casasanto, 2022).

Metaphors effectively transfer known concepts or experiences to new domains, conveying non-verbal information and emotions and enhancing the expressiveness and depth of thought in design. In kitchen design, metaphors act as a bridge, serving as

powerful communication tools in user research. They facilitate users’ expression of their visions and expectations for future kitchens and reveal their perceptions of the kitchen’s functional and emotional values. By guiding users to describe their ideal kitchens through metaphors, designers can gain profound insights into users’ functional and emotional values, thus enriching their understanding of user needs, expectations, and behavioral patterns. This enhanced understanding enables the creation of kitchen designs that are both practical and rich in emotional value. Specifically, designers use metaphors to transform abstract concepts into tangible design elements, allowing users to experience the emotions and ideas conveyed by the design during their interaction with the kitchen. For instance, in the design of smart kitchens, metaphors are employed to develop more intuitive and user-friendly interfaces, thereby enhancing the user experience and strengthening the emotional connection between users and the kitchen space. This study employs metaphors as cognitive bridges to explore the complexities of older people’s interactions with kitchen spaces and their unexpressed experiences and emotions. This approach aims to develop more attractive and inclusive kitchen designs that enhance the emotional depth and cultural significance of the space, making the kitchen a true reflection of older people’s lifestyles and values.

Results

Literature review outcome. Five key factors of inclusivity in kitchen design were extracted and summarized, including Environment, technology, health, emotion, and sustainability (Table 1). An initial model of inclusive kitchen design was built based on the literature synthesis, shown in Fig. 3.

The “Environment” factor refers to the need for inclusive kitchen design to consider the optimization and harmony of space to ensure a safe, comfortable, and efficient environment. This encompasses four categories: human factors and spatial environments, space security, comfort, and appearance and aesthetics. The “Technology” factor means the potential application of smart technologies in kitchen design to enhance usability and guide older people towards safer, healthier lifestyles. It includes three categories: intelligent and assistive technologies, usability, and simplicity. The “Health” factor underscores that inclusive kitchen design should thoroughly consider the multi-dimensional aspects of users’ health, including cognition and perception, dietary behaviors and habits, food safety, and physical health. The “Emotion” factor aims to create a kitchen environment with emotional connections, meeting the emotional needs of the user, including memories, communication, personal and family identity construction, and life experiences. The “Sustainability” factor in inclusive kitchen design implies considering future flexibility and adaptability, with social inclusion also being a vital consideration. This model lays a foundation for user research data analysis and knowledge extraction.

Focus group outcome. The results of the user study identified six dimensions: Environment/space, Technology/interaction, Emotion/

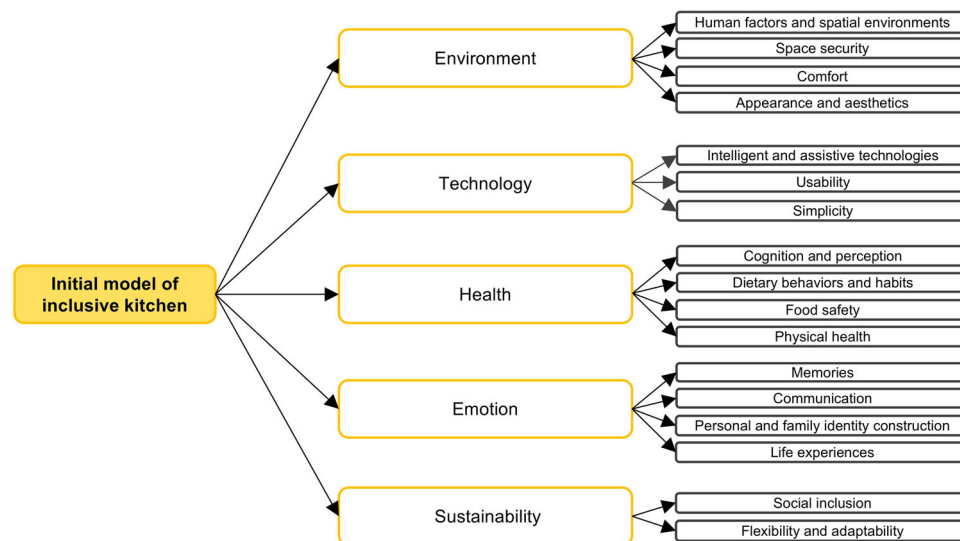


Fig. 3 An initial model of an inclusive kitchen. This figure presents an initial model developed from literature reviews, including five main dimensions: Environment, Technology, Health, Emotion, and Sustainability. Each dimension is further subdivided into multiple sub-dimensions. This model aims to lay the foundation for further user studies by considering various key aspects.

affect, Health and safety, Human factors and well-being, and Sustainability. Based on the findings, we constructed a user insight model of an inclusive kitchen, as shown in Fig. 4.

Environment/space. The “Environment/space” dimension consisted of five themes: Spatial layout and ergonomics, Furniture and fixtures/appliances, Indoor environmental quality (IEQ) and Connectivity, Cleanliness and waste management, and Personalized Space Design. Kitchen environments and spatial design are particularly critical to the lives of older people as their living and lifestyle needs change. Many layouts and ergonomic issues in kitchen environments need to be improved to accommodate older adults’ daily activities and enhance their experience. The participants indicated that attention should be paid to storage space and worktop heights, cabinet accessibility, ensuring ease of movement, reducing physical strain, and improving efficiency. They wanted furniture and appliances in the kitchen with good usability.

[Spatial layout and ergonomics] “It was installed a long time ago, and the cupboards are 60 centimeters deep or deeper. So to get to the back of the cupboard I have to get on my hands and knees and go over and around.” [P5]

[Furniture and fixtures/appliances] “I think the fridge has to be designed to fit different things like jars, and small things. It needs to be easy to get to things and easy to access. Everything inside the fridge needs to be easy to move.” [P4]

Indoor Environmental Quality (IEQ) includes four aspects, namely indoor air quality (IAQ), visual comfort (IAQ), aural comfort (AC), and thermal comfort (TC). Specifically, this could relate to air temperature, relative humidity, acoustics, air quality, lighting, ventilation, and air distribution (Clausen and Wyon, 2008; Wong et al., 2008). During the focus group discussions, the participants highlighted various concerns, including lighting issues (sufficient lighting, natural daylight, and efficiency), air quality (gas burning, CO₂), ventilation (windows), noise, smoke, and fire. For example:

[IEQ and Connectivity] “I have LED lighting underneath all the cabinets. You walk in there ... very relaxing and nice to work in.” [P3]

The boundaries of the kitchen are blurred and kitchens may border other living spaces in the home, becoming spaces with connectivity (Wills et al., 2013). One participant said:

[IEQ and Connectivity] “In my house, usually after I prepare the food, I need to bring it to the table. Since my dining table is not in the kitchen, it is in the next room, so I was wondering if you could help me automatically bring the food to the table. Or a hole through the wall? living room with the kitchen all in one, yeah.” [P6]

Furthermore, the participants emphasized the importance of cleaning solutions, ensuring that the kitchen remains tidy at all times and effectively addressing various waste disposal needs. One participant expressed a desire for personalized design in terms of spatial arrangements, colors, and materials based on individual preferences and needs.

Technology/interaction. The “Technology/interaction” dimension consisted of five themes: Intelligent automation and Assistive technology (AT), Integrated Information Network, Human-machine relationships, Simplicity, and New/disruptive technology. Some participants expected to improve their daily kitchen activities through intelligent and assistive technologies, such as food health and safety (food expiration), meal recommendations and recipes, intelligent storage, smart cleaning, and voice control. The application of smart technologies in everyday appliances has enhanced user interaction and decision-making in the kitchen, improving the overall culinary and dining experience through detailed personalization.

[Intelligent automation and AT] “I want to have a smart fridge where I can put my food in, and the fridge will tell me when the food is going to expire. This fridge wouldn’t just track what’s stored, it would also provide meal suggestions based on the available ingredients. That way, I can use up the stuff before it expires and avoid buying duplicates or wasting anything.” [P4]

Some participants expressed a desire for new technologies to be shown and demonstrated, allowing them to quickly grasp the functionalities of the new devices. This will aid users in comprehending and integrating new technologies into their kitchen

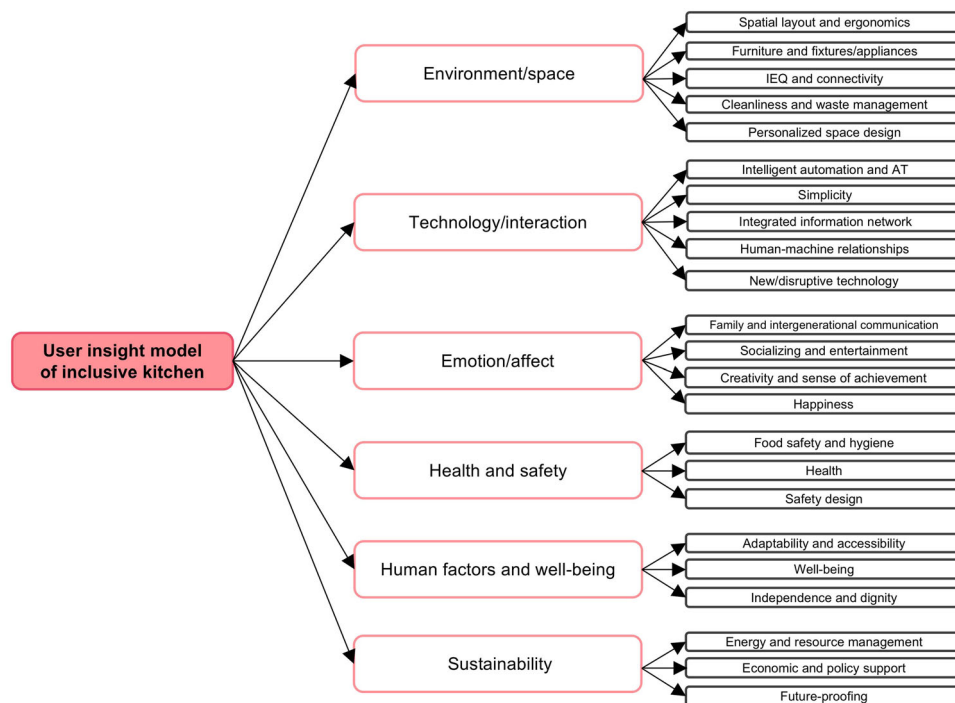


Fig. 4 A user insight model of inclusive kitchen. This figure displays a user insight model, encompassing six dimensions: Environment/space, Technology/interaction, Emotion/affect, Health and safety, Human factors and well-being, and Sustainability. The model effectively maps user needs and expectations, providing significant value to the research.

routes, ensuring that they fully understand the functionalities of smart devices without feeling overwhelmed or confused.

[Intelligent automation and AT] “if you do give people technology, our generation particularly, you want to have something to show them how to use it. ... you’ve only seen it once. They need to have a demonstration. Smart devices in the kitchen should come with clear demonstrations and user-friendly tutorials.” [P1]

Additionally, some participants wanted an intelligent home control system that allows interconnectivity between devices, allowing users to monitor and control these devices via a mobile application. This system would simplify the management of appliances and devices, offering convenience and efficiency. This enables users to effortlessly manage their home environments, even from remote locations.

[Integrated Information Network] “I want an integrated intelligent system that can manage the operation of all the appliances in my kitchen, allowing me to control these devices remotely via an app when I am not at home.” [P4]

With the advancement of intelligent technology, particularly in robotics, continue to progress, the functionality of machines in our daily lives has enhanced. These technologies have brought conveniences, especially within the domestic kitchen setting, where people enjoy the benefits provided by technologies.

One participant described their ideal kitchen assistant, a robot named Alex.

[Human-machine relationship] “I’d like a robot in the kitchen, named Alex. You’d just say ‘Alex, make me a chicken breast,’ then you go away. By the time you’re back, there’s your chicken breast, cooked to perfection. And if you fancy a fruit salad, just say ‘Alexa, make a fruit salad,’ it’s ready when you return. Honestly, with a robot like that, I’d hardly

need to step into the kitchen myself. Perhaps it could be a robotic arm that handles all the cooking and prepping automatically.” [P5]

This technology (robotics) not only improves efficiency but also facilitates those who are either too busy or lack cooking skills. It has altered the way people interact with kitchen spaces, enabling cooking to become a fully automated process that requires no direct human intervention.

The participants expressed a desire for designs to be simpler, ensuring that all technological features and functions are easy to understand and use. This would enable those who are unfamiliar with technology to quickly adapt and utilize it.

[Simplicity] “There was an easy way to open something and access it that would be wonderful for your future kitchen design, please.” [P5]

The participants also expressed an interest in the adoption of emerging or disruptive technologies.

[New/disruptive technology] “New technology never seen before.” [P1]

Emotion/affect. The “Emotion/affect” dimension consisted of four themes: Family and intergenerational communication, Socializing and entertainment, Creativity and sense of achievement, and Happiness. The kitchen is not merely a place for cooking but also serves as a central hub for family interactions and communication. For older adults, the kitchen is often a place where family bonds are strengthened, which makes older adults feel more valued and connected. Additionally, kitchens are frequently seen as places for socializing and entertainment. The participants indicated that social interactions often take place in the kitchen, hosting guests, and organizing gatherings, reducing feelings of isolation. Furthermore, they wanted the kitchen to be

an entertaining environment, giving them relaxation and pleasure.

[Family and intergenerational communication] “I’ve always baked with my granddaughter. It’s something you do together in the kitchen, I cooked with her, and my granddaughter now cooks wonderful cakes on her own. I’m baking great. That is something we do together.” [P5]

[Socializing and entertainment] “We party with friends; we gather the family and everything emotional is there because that’s where we’ve had our birthday celebrations. Christmas in the living room with the kitchen, kitchen all in one, yeah.” [P1]

Cooking relates to a sense of achievement and pride. For example:

[Creativity and sense of achievement] “It gives you a sense of achievement. If you cook something, it’s essential. Using the kitchen helps us to build self-confidence and pride.” [P4]

Moreover, the kitchen is often associated with emotions of well-being.

[Happiness] “Could you make some nice food, and then people say to you, my God, that’s lovely. Even if it’s awful, it makes you feel good. Your kitchens are spaces that you want to be in and make things.” [P2]

Health and safety. The “Health and safety” dimension consisted of three themes: Health, Food Safety and Hygiene, and Safety design. “Health and safety” are regarded as central considerations, due to their direct implications on individual’s well-being. Future kitchen designs should prioritize facilitating healthy lifestyles, thereby contributing to the overall health and well-being of users. The objective is to establish a kitchen environment that not only considers food safety and hygiene but also enhances the quality of life for older people.”

[Health] “I hope the future kitchen really pays attention to products that are good for my health, both physically and mentally. For example, I’m worried about gaining weight, and I’d love to have some smart devices that could offer me dietary advice and serve up healthy, nutritious food so I can eat healthy.” [P1]

In the future, intelligent technologies can provide users with safe, nutritious, and balanced food choices, enhancing their overall health. Some participants noted:

[Food Safety and Hygiene] “I wish I had a fridge that tells me what’s already inside and what’s about to expire, so I can use everything before it goes bad. That would really make sure my food is safe to eat. It should also remind me about expired food so I can toss it out and avoid any health issues.” [P5]

Safety includes features such as slip-resistant flooring, easy-to-grip cabinets and drawer handles, and worktops and storage spaces at appropriate heights.

[Safety design] “And no carpets in the kitchen? a lot of older generation, they need carpets in their kitchen, because there’s often a lot of water on the floor, making it super slippery. Older people can easily fall because of that. So, in the future, we should consider putting down carpets to make sure it’s safe to walk around in the kitchen.” [P2]

Human factors and well-being. The “Human factors and well-being” dimension consisted of three themes: Adaptability and Accessibility, Well-being, and Independence and Dignity. Human factors and their associated well-being in the kitchen are considered key factors. For older people, this topic directly relates to the quality and autonomy of their daily lives.

[Adaptability and Accessibility] “So for the future, you have to have drawers to put everything in so they can see everything always.” [P5]

The kitchen, as the central area and hub of a home, is not just a place for cooking but also a space where people interact, share, and relax. A kitchen space imbued with warmth and comfort directly influences the psychological well-being of its occupants:

[Well-being] “Kitchen can be related to your well-being, you know.” [P1]

Additionally, kitchen design goes beyond mere functionality; it pertains directly to their dignity and self-esteem.

[Independence and dignity] “I want to build my confidence in the kitchen, I’m afraid of people disrupting my cooking while I’m working. This can put me in a bad mood and I am perfectly capable of doing the cooking alone.” [P4]

Sustainability. The “Sustainability” dimension consisted of three themes: Energy and resource management, Economic and policy support, and Future-proofing. Future kitchen designs should prioritize sustainable practices and environmental protection.

[Energy and resource management] “In kitchen renovation, decoration materials such as environmentally friendly and renewable materials can be used.” [P2]

Economic and policy support can drive the pace of sustainable practices in kitchen design.

[Economic and policy support] “Inflation in our country is now so bad that poverty is increasing in the UK. It’s like a return to the Victorian era where people can’t afford the energy they use in their daily lives, such as gas, and the increase in the price of heating. I hope the government can help support our lives, especially by making essential energy for daily living more affordable and easing our financial burden.” [P4]

Kitchens also need to have future-proof attributes that can be used by older people without adaptation. The changing needs of older people in the future, and future design should take these differences into account and provide a diverse range of design solutions to meet the different requirements of older people.

Metaphors of the future kitchen. During the focus group, each participant was asked to describe the kitchen using metaphorical expressions. The metaphorical descriptions of the “future kitchen” and specific interpretations are shown in Table 3. Sometimes several metaphors were given by a participant.

The refined model for future-inclusive kitchen. Integrating the initial model from the literature review, the user insight model gained from the focus group, and the metaphors of the future kitchen, the researchers have developed the refined model for future-inclusive kitchen design, shown in Fig. 5. This model encompasses six dimensions: Environment/Space, Technology/Interaction, Emotion/Affect, Health and Safety, Human Factors and Well-being, and Sustainability. These dimensions may serve as a framework to guide inclusive kitchen design.

Table 3 Metaphorical descriptions of the future kitchen.			
Metaphor	Explanation	Relationship themes	Relationship dimensions
10 min	The efficiency and functionality of the kitchen.	Efficiency	Technology/ interaction
Center of the home	The kitchen is the center of the home, the central place where family members interact, share, and reunite with each other.	Well-being	Human factors and well-being
A place to be proud of	The kitchen is a place where people can build their confidence and proudly present themselves.	Creativity and sense of achievement	Emotion/affect
A place to create	The kitchen is a place for creative activities, not just cooking, but as a versatile space that inspires creativity and fosters the creation of cherished memories.	Creativity and sense of achievement	Emotion/affect
Brainstorming and family	The kitchen is a place for creative thinking, communication, and family togetherness.	Creativity and sense of achievement/ Family and intergenerational communication	Emotion/affect
Comfortable cooking center	The kitchen is the center of cooking and should provide a comfortable environment for cooking.	Comfort	Environment /space
Kitchen living	This suggests that the kitchen is not just a place to cook, but also an essential part of life.	Well-being	Human factors and well-being
My sociable kitchen	Kitchen is a place to socialize and interact with family and friends.	Family and intergenerational communication / Socializing and entertainment	Emotion/affect
Food factory	The efficiency of the kitchen is emphasized, like a food production line.	Efficiency	Technology/ interaction
Central island	It refers to the fact that the kitchen is like an island in the center of the home and is the focal point for family interactions and a versatile workspace for cooking and socializing.	Spatial layout and ergonomics	Environment /space

Specifically, the refined model integrates data from three distinct sources, aiming to examine the direction of future kitchen design from an inclusive and comprehensive perspective.

The “Environment/space” dimension underscores the need to consider harmony for future kitchens. The significance of the kitchen environment is particularly pronounced for older people (Camara et al., 2010). This dimension encompasses a comprehensive range of aspects including space security, comfort, appearance and esthetics, spatial layout and ergonomics, furniture and fixtures/appliances, indoor environmental quality (IEQ) and connectivity, cleanliness and waste management, and personalized space design. The metaphoric expressions: “Central island” and “Comfortable cooking center” highlight the vision of future kitchens as comfortable, safe, efficient, and expandable cooking hubs. These comprehensive considerations reflect the value of future kitchens as the heart of home life.

The “Technology/interaction” dimension aims to integrate emerging technologies into future kitchen designs, enhancing the interactive experience, usability, and convenience of the kitchen. This dimension includes usability, intelligent automation and assistive technology (AT), integrated information networks, human-machine relationships, simplicity, and new/disruptive technology. The metaphors “10 min” and “Food factory” illustrate the future kitchens need to improve the interactive experience and efficiency, ensuring that users can perform tasks in the kitchen simply and efficiently. At the same time, future kitchen environments need to interact with technology.

The “Emotion /affect” dimension includes the categories of memories, personal and family identity construction, life experiences, family and intergenerational communication, socializing and entertainment, creativity and sense of achievement, and happiness. These categories reflect the profound significance kitchens hold, touching the depths of human emotion. The future not only shapes the physical space of the kitchen but also endows it with emotional value, making it a space for family heritage,

memories, and the establishment of values. Metaphors such as “A place to be proud of”, “A place to create”, “Brainstorming and family”, and “My sociable kitchen” illustrate older people’s expectation that future kitchens will be more than just cooking spaces. They envision them as spaces where they can proudly showcase, create, share, and enjoy social interactions.

The “Health and safety” dimension emphasizes the need to consider promoting users’ physical and mental health, as well as their dietary behaviors and habits in the design, aiming to make future kitchens a space conducive to healthy living. This includes categories of cognition and perception, dietary behaviors and habits, physical health, food safety and hygiene, health, and safety design. The integration of health and safety into kitchen design aims to create an environment that not only promotes the healthy living of older people but also ensures their safety.

The “Human factors and well-being” dimension encompasses adaptability and accessibility, well-being, independence, and dignity. Design metaphors “Center of the home” and “Kitchen living” signify older people’s expectations for future kitchens to be the heart of the home, aimed at supporting their health, and enhancing their quality of life. Maintaining the ability of older people to live independently is crucial for preserving their independence and dignity.

The “Sustainability” demonstrates the long-term adaptability of the kitchen, not only for the present but also for the future. It addresses the requirements of diverse user groups, promoting diversity and equality. This dimension includes social inclusion, flexibility and adaptability, energy and resource management, economic and policy support, and future-proofing. Future-inclusive kitchen designs are sustainable on both economic and environmental dimensions.

These six dimensions collectively constitute the refined model of future-inclusive kitchens, indicating the multidimensional factors that need to be integrated in future designs. This study promotes the field of kitchen design towards greater inclusivity, intelligence, and sustainability.

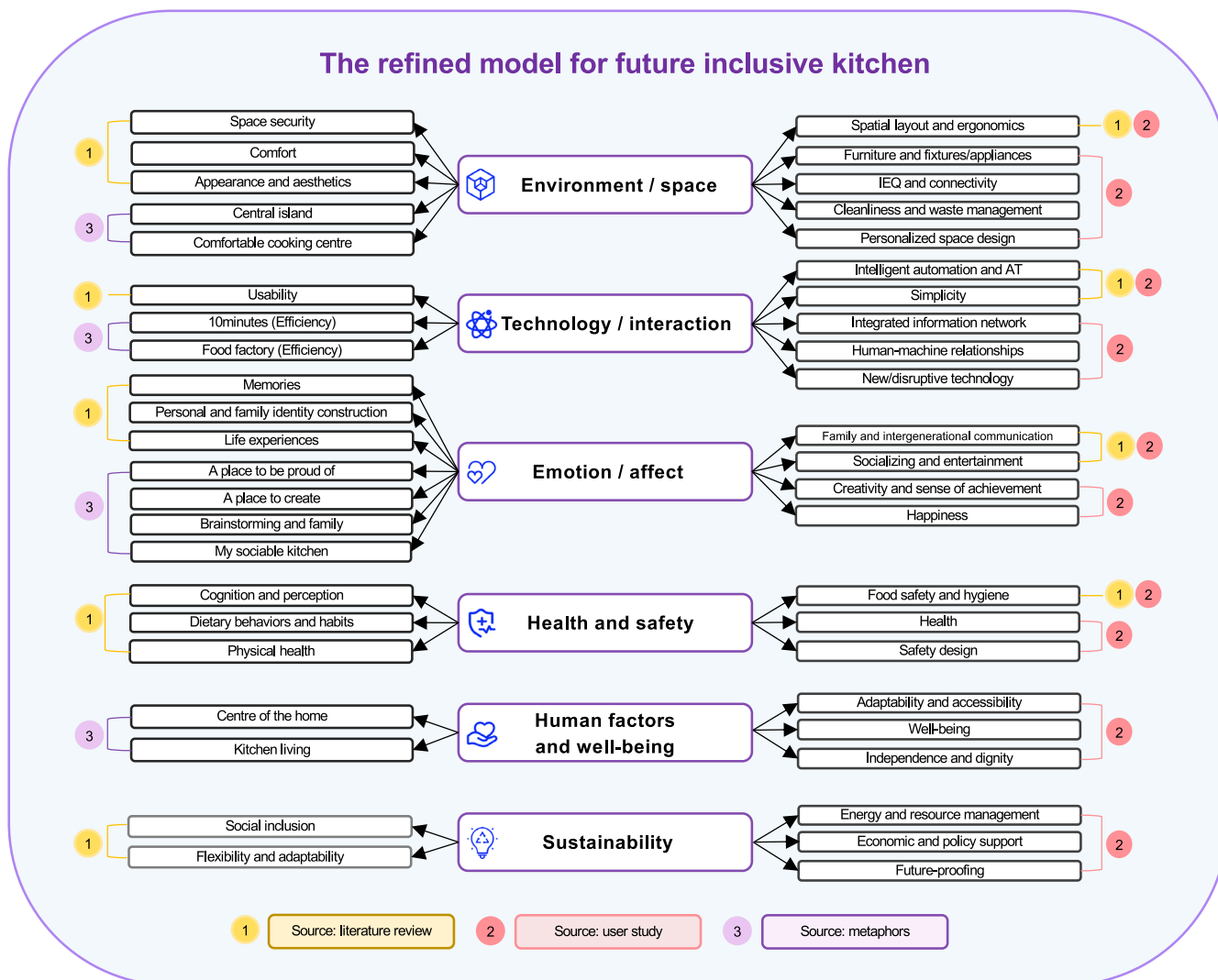


Fig. 5 The refined model for future-inclusive kitchen. This figure displays the refined model that is developed from a synthesis of literature reviews, user insights, and metaphors. The model encompasses six key dimensions: Environment/space, Technology/interaction, Emotion/affect, Health and safety, Human factors and well-being, and Sustainability. It provides a theoretical framework and guidelines for the design of inclusive kitchens. We have used different colors and numbers to denote categories from various research stages. Each component of the dimensions is marked with different colors and numbers, where number 1 indicates sources from literature reviews, number 2 from user studies, and number 3 from the application of metaphors.

Discussion

This study explored the critical factors and dimensions of future kitchens and proposed a model for future-inclusive kitchen design. These findings are vital for enhancing the quality of life of older adults in future home environments.

Inclusive kitchen for the future. The key factors in the refined model were from different sources; they collectively create an overview of future kitchens, incorporating older people's perspectives.

Specifically, the "Environment/space" dimension from the focus group corresponds to the "Environment" factor from the literature review, emphasizing the necessity of spatial optimization and harmonious design to ensure a safe, comfortable, and efficient environment. This also corroborates the "physical space and design" concepts proposed in "Inclusive Living" (McCall, 2022). An interesting finding is that "Appearance and esthetics" in the literature review was not specifically mentioned in the user study. The quality of the kitchen environment, cleanliness, and waste management were more concern for older people, indicating a

focus on health and safety in their kitchen lives. They desire personalized space design to their specific situations, for example, a participant using a wheelchair mentioned: "I want to have a hole in the kitchen wall, whenever my wife cooks a meal, it can be passed through a belt, through the hole, automatically. I don't need to go to the kitchen to get the food."

The "Technology/interaction" dimension from the focus group is aligned with the "Technology" factor from the literature review. A surprising finding is that the participants are very willing to accept emerging technologies and use advanced products. They hope the application of intelligent technology can improve the usability of kitchens and guide them toward a safer, more efficient, and healthier lifestyle. Smart home technology, intelligent, and assistive technologies have been shown to impact the lifestyles of older people (Mennicken and Huang, 2012; Shergold et al., 2015; Weber et al., 2023; Yang and Han, 2023). The results of the focus groups suggest that older people are actually not necessarily concerned with the development of emerging technologies, but with the harmony of the relationship between humans and machines. Designers need to consider how to integrate advanced technologies into kitchen designs to maintain

simplicity of operation and avoid increasing cognitive load for users.

The “Emotion/affect” dimension from the focus group highlights the central role of the kitchen in family communication and social activities, aligning with the “Emotion” factor identified by literature, which is to create a kitchen environment connected to user emotions. Kitchen design should consider supporting family and intergenerational communication, socializing, and entertainment, as well as being a place for creating and sharing pleasant memories (Maguire et al., 2014; Meah and Jackson, 2016; Scicluna, 2015; Wang et al., 2022).

The “Health and safety” dimension from the focus group is an enhancement and expansion of the “Health” factor from the literature review, with the initial model focusing on older people’s physical and mental health and dietary habits. Through the focus group, the researchers found that older adults are concerned with the safety and origins of food, so design can provide them with peace of mind when using the kitchen. Therefore, the kitchen is seen as a space of care (Yates-Doerr and Carney, 2016).

The “Human factors and well-being” as a new dimension added to the user study. It highlights the importance of adaptability and accessibility, well-being, independence, and dignity. This suggests future kitchen designs should aim to maintain older adults’ ability to live independently, safeguarding their dignity (NCOB, 2023).

The “Sustainability” dimension from the focus group aligns with the “Sustainability” factor from the literature. Kitchens are recognized as having the ability to bring about positive sustainability effects, the findings of this study reveal users’ expectations for the use of eco-friendly and sustainable materials within home kitchens, associated with circular consumption in households (Hagejård et al., 2020; Vu et al., 2023). This dimension also underscores the importance of designing kitchens with long-term adaptability, highlighting the need for economic and policy support. Additionally, it is essential that kitchen designs accommodate diverse user needs to enhance inclusivity and equality. This aligns with the understanding that sustainability significantly impacts the kitchen environments and lifestyles of older and disabled people (Lewandowska et al., 2017). It also aligns with the future of aging framework, focusing on enabling sustainability (NCOB, 2023).

The inclusive kitchen design model focuses on six key dimensions, it aims to meet the needs and expectations of older people in the UK. This model is particularly suitable for future residential environments, accommodating families with older people or multigenerational households. It supports the independence of older adults while fostering familial connections and social interaction. Additionally, the potential applications of this model extend to future older people community centers, enhancing older people’s participation and well-being through social dining activities.

Moreover, the model integrates and expands upon existing kitchen design research and empirical user study data, including the use of metaphors, providing unique insights. This study particularly emphasizes the application of technology, identifying that older adults prioritize technology-driven solutions, such as intelligent assistive robots and remotely controllable smart kitchen systems, to enhance their user experience. Furthermore, the model underscores the importance of emotion and well-being. Beyond meeting functional requirements, it focuses on designing spaces that enhance social and emotional interactions during cooking and dining, recognizing these activities as central to improving the quality of life for older adults.

Unique insights gained from design metaphors. This study provides a unique perspective by introducing metaphorical

descriptions, the application of which helps to capture the nuanced views of older people. Generating metaphors were employed to delve deeper into, explore, and understand participants’ expectations and visions for the future kitchen, assisting in framing questions and pinpointing directions for solutions (Schön, 1979). Through the use of metaphors, designers and researchers can uncover the underlying values and preferences of older people, transforming these insights into specific design factors that resonate with them on a personal level.

In this study, the exploration of metaphors for future kitchens was particularly enlightening. The older participants highlighted their ideal kitchen visions and key factors through metaphor generation (Table 3). Generating metaphors offers the researchers a unique way to gain an insight into older people’s desires for the future kitchen. It not only facilitates a deeper exploration and comprehension of older people’s expectations, emotional experiences, and visions for future kitchens but also reveals their intrinsic cognition of this space.

Specifically, the study explores how the understanding and application of metaphors can significantly enhance their relevance to kitchen design models. The introduction of metaphors provides additional support for kitchen design models, enriching their conceptual framework. Each specific metaphor offers insights into the functional and emotional needs of future kitchens and directly influences design strategies to better meet the specific requirements of older adults.

The metaphors “Comfortable cooking center” and “Central island” emphasize the need for a comfortable environment in cooking areas, fitting within the “Environment/space” dimension of kitchen design models. Future kitchen designs should incorporate ergonomic considerations such as appropriate counter heights, adequate lighting, and spacious work areas to ensure user comfort and safety in the kitchen, particularly with respect to the potential physical limitations of older adults. This is also consistent with the concept of “Comfort” and “Spatial layout and ergonomics” as described in previous research (Maguire et al., 2014; Sundaram and Rukmangadhan, 2016).

The metaphors “10 min” and “Food factory” emphasize efficiency and functionality in kitchen design, classified within the “Technology/interaction” dimension of kitchen design models. This inspires future kitchen designs to incorporate advanced equipment and automation technologies to minimize response and wait times, thereby enhancing the efficiency and experience of cooking and operations. This is also consistent with the concept of “usability” as described in previous research (Lenker et al., 2016).

The metaphors “Brainstorming and family” and “My sociable kitchen” emphasize the kitchen’s role as a venue for familial social interactions and emotional exchanges, aligning with the “Emotion/affect” dimension of kitchen design models. The future kitchen can be envisioned as an open and inclusive space, not only used for cooking but also suitable for family activities and social gatherings. It will serve as a bond of emotional connection for the family, acting as the central zone where family members can communicate and share experiences. This confirms that whether it’s enjoying time with family or severing the food they’ve prepared, these experiences enhance the sense of well-being and fulfillment in older people (Wang et al., 2022). The metaphors “A place to be proud of,” “A place to create,” and “Brainstorming and family” are all part of the “Emotion/affect” dimension. These metaphors emphasize the kitchen as a platform for individual creativity and self-expression, presenting it as a customizable space that inspires creativity. This allows users to tailor their kitchens according to their own preferences, engaging in activities that foster a sense of achievement within this space.

The metaphors “Center of the home” and “Kitchen living” emphasize the concept of well-being and belong to the “Human

factors and well-being” dimension of kitchen design models. These metaphors underscore the kitchen’s role as the hub of social interaction and living within the home, reflecting a shift in future design priorities towards emotional comfort and social engagement. This recognizes the kitchen’s integral role in enhancing the quality of life.

By incorporating these metaphors into the refined kitchen design model, this study not only enhances the functionality of kitchen designs but also elevates their emotional and social value, transforming them into the heart of future homes. This metaphor-based approach makes kitchen designs more human-centered, better responding to users’ lifestyles and expectations. These metaphors not only reflect the ongoing transformation of the kitchen into a multifunctional living space but also reveal its potential to support older adults’ social participation and well-being. Hence, metaphors offer a profound method for understanding the expectations and experiences of older people and are crucial tools for designing more inclusive and adaptable kitchens.

The concept of “change” in the inclusive kitchen. In the context of aging, aging is a dynamic process involving changes in physical, cognitive, and emotional capacities. These changes necessitate flexibility in the living environment to continue supporting individuals’ independence, safety, and comfort. Modular and adaptable design principles are crucial to meet these evolving needs, providing effective solutions that ensure kitchen spaces can adjust in response to user requirements. For instance, within the “Environment/space” dimension, kitchen countertops and cabinetry can be adjusted according to the physical conditions of the users to reduce strain and enhance safety and usability. Improved lighting and the use of tactile-friendly materials also help older adults use the kitchen more safely and comfortably. Furthermore, adaptable design encompasses not only improvements to the physical environment but also crucial technological adaptability. Empowered by technology, the kitchen becomes a space that genuinely supports the independence of older people. For example, intelligent kitchen systems can be operated via voice control or simple touch interfaces, allowing older people with reduced hand dexterity to easily manage kitchen devices. This technological adaptability not only enhances the usability of the kitchen but also increases the safety of older people. In the “Emotion/Affect” dimension, modular design supports the creation of more open and flexible spaces, fostering social interaction and emotional well-being. For instance, a kitchen island that can be converted into a dining area adapts to social gatherings, enhancing the kitchen’s role as a social hub. The adaptable design also incorporates considerations of the “Sustainability” dimension. By utilizing environmentally friendly materials and energy-efficient appliances, and designing spaces that can accommodate future technological upgrades. This forward-looking design allows the kitchen to adapt to changing user needs and environmental standards, avoiding frequent and extensive renovations and achieving true sustainability.

The model in this study aims to address the dynamic process of aging by discussing how to adapt to the changes in the lives of older people from multiple dimensions. By designing to meet the functional, health and safety, emotional, and sustainability needs of the older people, this model provides designers with a comprehensive guide for action.

Limitations. While an initial exploration has been made in this study, there are many aspects for future attention. This study’s literature review exhibits certain limitations. The review predominantly focused on aspects such as environment, technology, health, emotion, and sustainability, while overlooking other areas

like cultural backgrounds and intergenerational use. This imbalance may potentially impact the scope and findings of our research, neglecting cultural and social factors in kitchen design. Future research should strive to address these gaps by broadening the literature search scope and employing a systematic review to remedy this shortfall, ensuring a more comprehensive understanding of the topic.

Another limitation of this study was the incomplete collection of critical information about participants’ economic status and technical skills, which may have restricted the generalizability of the findings. Our sample was recruited from the Brunel Older People’s Reference Group and primarily comprised well-educated, middle-class older people, living in the Greater London area. Consequently, the focus group outcome is very much limited by the participants’ experience. Moreover, the focus group consisted of only seven participants, and four were men. Few qualitative studies about kitchen design involved more men than women, this gender imbalance provided unique insights into the subject. Discussions within the focus group revealed significant interest in and varying levels of proficiency with technology among participants. Notably, there was a high level of acceptance and willingness to use emerging technologies, which may relate to the greater number of males in the group. Given the small scale and composition of the focus group, the findings are substantially influenced by the personal experiences of the participants. Future research should address these critical factors to more comprehensively evaluate the applicability and acceptance of technological solutions among older people. A deeper exploration of these insufficiently studied areas will enhance our understanding of the technological needs and challenges faced by older people.

Furthermore, the validity and value of the proposed model for future-inclusive kitchen design need to be evaluated. The metaphors collected in this study are the initial ideas of older people. Although the metaphors collected provide initial insights, their abstract nature may not sufficiently capture detailed user needs. Relying solely on metaphors to describe kitchen concepts may not reflect the depth of users’ needs and ideas. Future studies should introduce a more structured framework and employ multimethod, incorporating prototype development and testing. By inviting older adults to interact directly with design prototypes, deeper and more sustained user engagement can be facilitated, further stimulating the creative thinking of older people. Beyond addressing the current needs of older people, this study endeavors to further explore their visions for future living.

Conclusions

The kitchen, being central to the future lives of older people, necessitates a reconsideration and redefinition of its function and significance. The results of the study are briefly summarized below, based on the three research questions: The first research question—What are the identified key factors of current kitchen design research that cater to the needs of older people?—This question was addressed by reviewing existing literature on aging and kitchen design to identify gaps and develop an initial model for future kitchen designs, as shown in Fig. 3. Key factors were identified through the literature review and further validated by focus group findings. Each factor specifically addresses crucial needs essential for enhancing the quality of life of older people. The second research question—What are the main challenges faced by older people in using current kitchen designs and how can these be overcome in future designs?—Through a focus group study, we identified the expectations of older people for future kitchen designs and the challenges posed by current designs. This led to the construction of a user insight model, with the details of the model reported in Fig. 4. The incorporation of feedback from older adults is crucial to developing practical solutions that genuinely

meet their needs and preferences. The third research question—How can metaphors be effectively used to capture and integrate the expectations of older people into the conceptual design of future kitchens?—This question was answered by collecting participants' metaphorical descriptions of future kitchens. Table 3 presents these metaphorical descriptions, along with interpretations and the relationship dimensions associated with these metaphors. These metaphors helped translate abstract desires into concrete design information that resonated with the users' experiences and aspirations. Combining the answers to these three research questions, the final refined model for a future-inclusive kitchen developed from the combination of theoretical insights and practical user feedback. The refined model considers six dimensions of future-inclusive kitchen design: Environment/space, Technology/interaction, Emotion/affect, Health and safety, Human Factors and well-being, and Sustainability. "Environment/space" focuses on physical layout and atmosphere; "Technology/interaction" considers the role of advanced technologies and systems; "Emotion/affect" discusses the emotional connection of the user; Health and safety emphasizes the prevention of accidents and the promotion of health; Human Factors and well-being highlights improving quality of life and maintaining independence. Sustainability reflects energy, environmental, and future-proof attributes. These dimensions collectively comprise a comprehensive framework that underscores the importance of inclusivity, provides information, and directs the development of future-inclusive kitchens. This framework ensures that future kitchen designs adapt to the diverse and evolving needs of older people, fostering an age-friendly environment that supports their independence and well-being.

The results of this study can serve as a blueprint to guide designers and researchers in creating age-friendly environments that are inclusive, adaptive, and forward-looking. The significance of the study lies in the model which combines insights from the literature review, focus group, and metaphors. The rigor is demonstrated by the evidence-based approach to constructing the model. The model is original and will help guide the design of future kitchens, enhancing the quality of life for older people by fostering age-friendly environments. This study proposes the following guidelines for future kitchen design: Firstly, the research emphasizes that future kitchen designs should be flexible and adjustable to accommodate the varying physical abilities of older adults. This design significantly reduces physical strain and enhances overall kitchen comfort. Secondly, it is recommended to integrate smart technology into kitchen designs, focusing on simplifying the operation of smart devices to increase efficiency and reduce the physical burden of older individuals during kitchen activities. This enhancement not only improves quality of life but also promotes independence and self-confidence. Thirdly, the safety and health of the kitchen should be strengthened. This includes designing to prevent accidents with features such as non-slip flooring, adequate lighting, clear signage, and emergency response systems, all crucial for enhancing kitchen safety. Lastly, kitchen designs should incorporate elements that promote emotional and social interactions, allowing family members or friends to engage freely within the kitchen space. By utilizing warm colors and materials, a comfortable and welcoming environment is created, enhancing the social engagement of older adults. These practice guidelines facilitate ongoing discussions on age-friendly environments, supporting daily activities for older people and enhancing their quality of life, thereby making the kitchen a true central hub of the future home.

Data availability

All data generated or analyzed during this study are included in this published article.

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Author contributions

Conceptualization: ZX, YB, and HD; Methodology: ZX, YB, and HD; Investigation: ZX and HD; Data curation: ZX, YW, and GT; Formal analysis: ZX, HD, YW, and GT; Writing—original draft preparation: ZX; Writing—review and editing: ZX, YB, and HD;

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Competing interests

The authors declare no competing interests.

Ethical approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Brunel University London (Date: 21 August 2023/No.44614-LR-Aug/2023-46925-2).

Informed consent

Informed consent was obtained from all participants.

Additional information

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