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Innovating the Future of Elderly Housing: A Multi-Layered Analysis of Affordability and Sustainability

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ABSTRACT

The growing elderly population presents challenges in ensuring affordable and elderly-friendly housing that supports ageing in place. Many elderly individuals prefer to remain in their homes, yet existing housing options often fail to meet their evolving needs. This study examines the research landscape of elderly-friendly affordable housing, focusing on ageing in place as a sustainable solution. A threefold methodological approach is adopted: (1) a scientometric analysis to identify research trends in elderly housing and ageing in place, (2) a systematic literature review to assess key factors such as accessibility, safety, affordability, and social integration, and (3) semi-structured interviews with elderly individuals and communities to gain insights into their housing preferences and challenges. The findings highlight significant gaps in elderly housing provisions, underscoring the need for policy reforms, improved housing design, and stronger community support. By integrating research trends, literature synthesis, and empirical data, this study provides evidence-based recommendations for policymakers, urban planners, and housing developers to create sustainable, elderly-friendly housing solutions for ageing societies.

1. Introduction

World Health Organisation (WHO) stated that the global population of people aged 60 years and above is projected to reach two billion by 2050, nearly doubling from 12% in 2015 to 22% in 2020 [1]. In 2020, the number of older adults aged 60 years and older outnumbered those aged five years and younger. Meanwhile, Malaysia in 1970 had a predominantly young population and at that time, only 5.5% of the total population was over the age of 60, while 44.5% were below the age of 14 [2,3]. This demographic structure reflected the early developmental stage of the country, with a high birth rate

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and a relatively low elderly population. Fast forward to 2024, Malaysia's population structure has shifted significantly. The percentage of people below the age of 14 has declined to 22.2%, while the proportion of those aged 60 and above has risen to 11.6% [4]. This means that approximately 3.9 million of Malaysia's 34.1 million population are aged 60 and above in 2024. This notable increase in the elderly population highlights the country's transition towards an aging society. Looking towards the future, Malaysia is expected to become an aged nation by 2040, when more than 17% of the population will be aged 60 and above. This shift will continue, and by 2057, Malaysia will reach the status of a super-aged society, with 20.5% of the population projected to be over the age of 60 [4]. This transition emphasizes the urgency of addressing the needs of an aging population, particularly in terms of housing, healthcare, and social security. These projections underscore the importance of preparing for the demographic shift towards a more elderly population, a trend that is occurring faster than anticipated. Policies and infrastructure must adapt to meet the demands of an aging society, making elderly care, home security, and the promotion of aging in place critical areas for future development.

Consequently, the demand for effective strategies to ensure well-being of the older adults has become paramount (.ibid). As the population of older adults continues to rise, so does the likelihood of physical, cognitive, and sensory impairments [5]. These impairments often limit their ability to perform daily activities independently and significantly affect mobility. The decline in an individual's independence increases the risk of accidents and injuries within their living environment, thereby encouraging feeling of vulnerability. Thus, developing elderly-friendly housing is crucial for the success and quality of housing projects aimed at senior citizens. It is essential to understand the specific preferences and limitations of the elderly in terms of housing features, and to design homes [6] that ensure both their physical safety and psychological comfort, while meeting their unique needs. Elderly- friendly homes, including their outdoor green infrastructure and assisted living facilities, play a crucial role in addressing the impairments associated with aging. To address these challenges on risks and vulnerabilities, elderly-friendly homes must incorporate key features such as clear pathways, handrails and elder-friendly technology can assist elderly residents in navigating their surroundings greater ease and safe. In addition, home security systems and well-designed ingress and egress routes further enhance the indoor environment, promoting sense of security and safety within the home [7].

The concept of elder-friendly homes extends beyond basic construction safety, incorporating safety and design considerations for both indoor and outdoor living experiences. The importance of the outdoor living space security should not be underestimated, as they significantly contribute to the well-being of elderly by meeting the recreational and social needs. Exposure to outdoor green spaces has positive effects on cognitive functions on elderly [8]. Furthermore, creating safe, well-maintained outdoor environments foster social interaction and physical activity, which are essential for the well-being of elderly residents [9]. These outdoor areas, when designed with adequate security measures, provide a space that balances safety with an improved quality of life [10]. This paper explores the multifaceted dimensions of construction safety and security in elderly-friendly homes by integrating three comprehensive approaches such as qualitative interviews, scientometric analysis and systematic literature review (SLR). By examining these aspects from multiple perspectives, this paper aims to identify best practices for enhancing the safety and security of elderly-friendly homes. Furthermore, it offers actionable recommendations for policymakers, practitioners as well as researchers, to improve the living condition of elderly, allowing them to navigate their homes with confidence and ease.

The expanding elderly population poses considerable problems to delivering affordable and elderly-friendly housing that promotes ageing in in place. While previous study has looked into

housing affordability [7] and technology interventions [6], there is still a fundamental gap in understanding the comprehensive integration of elderly-friendly technologies with community-driven solutions. This exclusion hinders the capacity to create a comprehensive framework that combines technology improvements with social and community-based support systems. To enhance the study's contribution, it specifically emphasises" and related modifications. First, there has been little research on how elderly people perceive and adjust to smart home technologies, and how these adaptations affect their quality of life. Second, there is a scarcity of empirical research on the relationship between affordability, sustainability, and older preferences in home adjustments. By emphasising these areas, the study provides a stronger basis for investigating both the technological and social aspects of older housing, ensuring a balanced and inclusive approach.

2. Methodology

The initial phase focused on research objectives 1 and 2, utilising a quantitative approach through scientometric analysis and a SLR to map the existing research landscape on technologies in elderly housing. This method provided a broad overview of relevant themes, key research trends, and technological advancements in the field. For research objective 3, a qualitative approach was adopted through semi-structured interviews with 14 elderly individuals residing in rural areas. These interviews explored their home environment, safety, and security concerns, offering valuable insights into their lived experiences. The respondents were aged 60 and above and were either living alone or with a spouse. To ensure the selection of suitable participants, a purposive sampling strategy was employed in collaboration with village leaders. These leaders, being well-acquainted with the local community, played a crucial role in identifying individuals who met the study's criteria. They were briefed on the necessary respondent characteristics, enabling them to facilitate the recruitment process effectively. Table 1 presents a summary of the research objectives and the corresponding methodologies used in the study.

Table 1
Summary of research objectives and methodologies

Research Objectives	Methods	Type of analysis
To explore research trends in the integration of technology into elderly housing	Quantitative	Scientometric
To identify and evaluate technological solutions that enhance safety, accessibility, and independent living in elderly housing	Quantitative	SLR
To examine the housing preferences, needs, and challenges of the elderly	Qualitative -Semi structure interview	Thematic

2.1 Identification

The scientometric and SLR process in this study was conducted in three key stages to select relevant research papers. In the first stage, keywords and related terms were identified using various sources, including thesauruses, dictionaries, encyclopaedias, and previous studies. After determining the appropriate terms, search queries were formulated and applied to the Scopus and Mendeley databases, as outlined in Table 2.

Table 2
The search strings

Scopus	TITLE-ABS-KEY ((security OR safety) AND ("smart technologies" OR "digital technologies" OR technology) AND (elderly OR oldest) AND (home OR housing)) AND PUBYEAR > 2018 AND PUBYEAR < 2025 AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (OA , "all"))
Mendeley	Challenges OR Issues AND Sustainable Affordable House*

2.2 Screening

The screening process involved assessing a collection of potentially relevant research materials to determine their alignment with the research objectives. The initial criterion prioritised literature such as research articles, which served as primary sources of valuable information. Additionally, other sources, including reviews, meta-syntheses, meta-analyses, books, book series, chapters, and conference papers that had not been extensively explored in recent studies, were also considered. The review was restricted to publications in English and covered research from 2019 to 2024. Duplicate papers were removed from the dataset to ensure accuracy. Following the exclusion of 3,178 articles, a total of 174 papers were shortlisted for further evaluation in the second phase of screening, based on specific inclusion and exclusion criteria as shown in Figure 1.

2.3 Eligibility

During the eligibility stage, which represents the third phase of the selection process, an initial set of 168 articles was examined. Each article underwent a thorough evaluation, focusing on its title and core content, to ensure compliance with the study's inclusion criteria and relevance to its objectives. As part of this meticulous review, 151 articles were excluded due to various factors, such as a lack of relevance to the research topic, discrepancies in titles, research areas, or abstracts, and restricted access to full-text content containing empirical data. Following this stringent selection process, only 17 articles remained for further analysis. This final collection of studies formed the basis for the in-depth evaluation conducted in this research.

2.4 Data Abstraction and Analysis

Between 2010 and 2024, a scientometric analysis was performed using data extracted from the Scopus database. The collected information included publication year, author details, article titles, journal sources, keywords, and citation count, all retrieved in PlainText format. The analysis was conducted using mapping and clustering techniques through VOSviewer software (version 1.6.19), incorporating the Multidimensional Scaling (MDS) method proposed by Van Eck *et al.,* (2010). VOSviewer calculates association strength (ASij) based on the following Eq. (1):

$$AS_{ij} = \frac{c_{ij}}{\omega_i \omega_j} \quad (1)$$

In the SLR, an integrative analysis was conducted to examine and synthesise various research approaches, including quantitative, qualitative, and mixed-method studies. The expert evaluation process aimed to identify key issues and subtopics, with data collection serving as the foundation for theme development. A total of 17 articles were reviewed as shown in Figure 1, with the authors analysing content relevant to the study's themes. In the second stage, key groupings were identified,

and challenges associated with elderly housing were further explored. To ensure the accuracy and relevance of the findings, experts in ageing in place and housing studies were consulted. Their feedback played a crucial role in validating the sub-themes, ensuring clarity, relevance, and alignment with domain validity. Input from both experts and readers contributed to refining the study's conclusions.

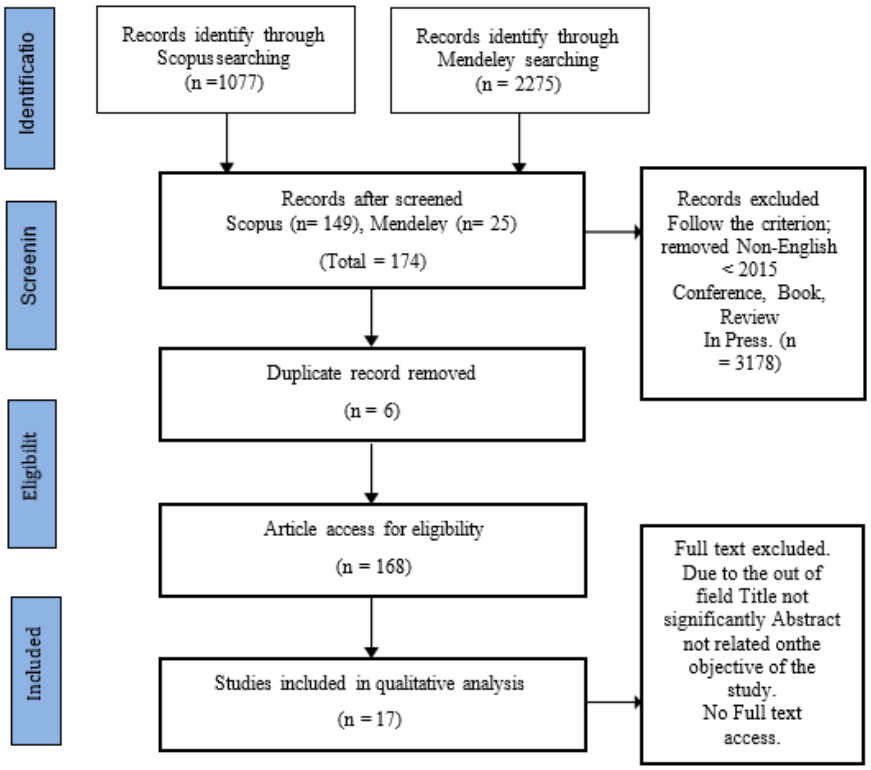

Fig. 1. Flow diagram of the proposed search study for SLR [11]

3. Results

3.1 Scientometric Analysis

The scientometric analysis of applying technologies in elderly homes for elderly security, based on co- occurrence of author keywords and all keywords, reveals several critical insights into the current state of research in this field. The provided VOSviewer figures from the scientometric analysis highlight how various technological themes connect to elderly home safety and security. Figure 2 shows five clusters, which the red cluster, focused on "elderly", "technology", and "aging", emphasizes the role of technological advancements like "robotics" and "health prevention" systems to enhance the quality of life for elderly individuals. These technologies are vital in elderly homes, offering support in monitoring health and assisting with daily tasks. The green cluster, centered on "older adults," "aging in place," and "ICT," stresses the importance of "information and communication technology (ICT)" in enabling older adults to live independently. In elderly homes, ICT is used for remote monitoring and telehealth, ensuring that residents can age in place with continuous health and safety monitoring. The blue cluster, featuring "Internet of Things (IoT)", "healthcare," and "security," underscores the integration of smart devices and IoT in elderly homes. These technologies provide real-time health and security monitoring, such as fall detection and emergency alerts, making them essential for maintaining the safety of elderly residents. The yellow

cluster highlights "smart home technology," linking it to the “independence” of elderly individuals. Smart home systems automate daily tasks and enhance home security, supporting independent living while ensuring safety in elderly homes. Finally, the purple cluster, focusing on "information technology" and "independent living," points to the importance of IT solutions in elderly care. IT systems facilitate seamless communication and health management, crucial for supporting elderly individuals’ independent living in homes designed with their safety and security in mind. All these five clusters collectively showcase how applying technology in elderly homes can enhance safety, security, and independence for elderly residents.

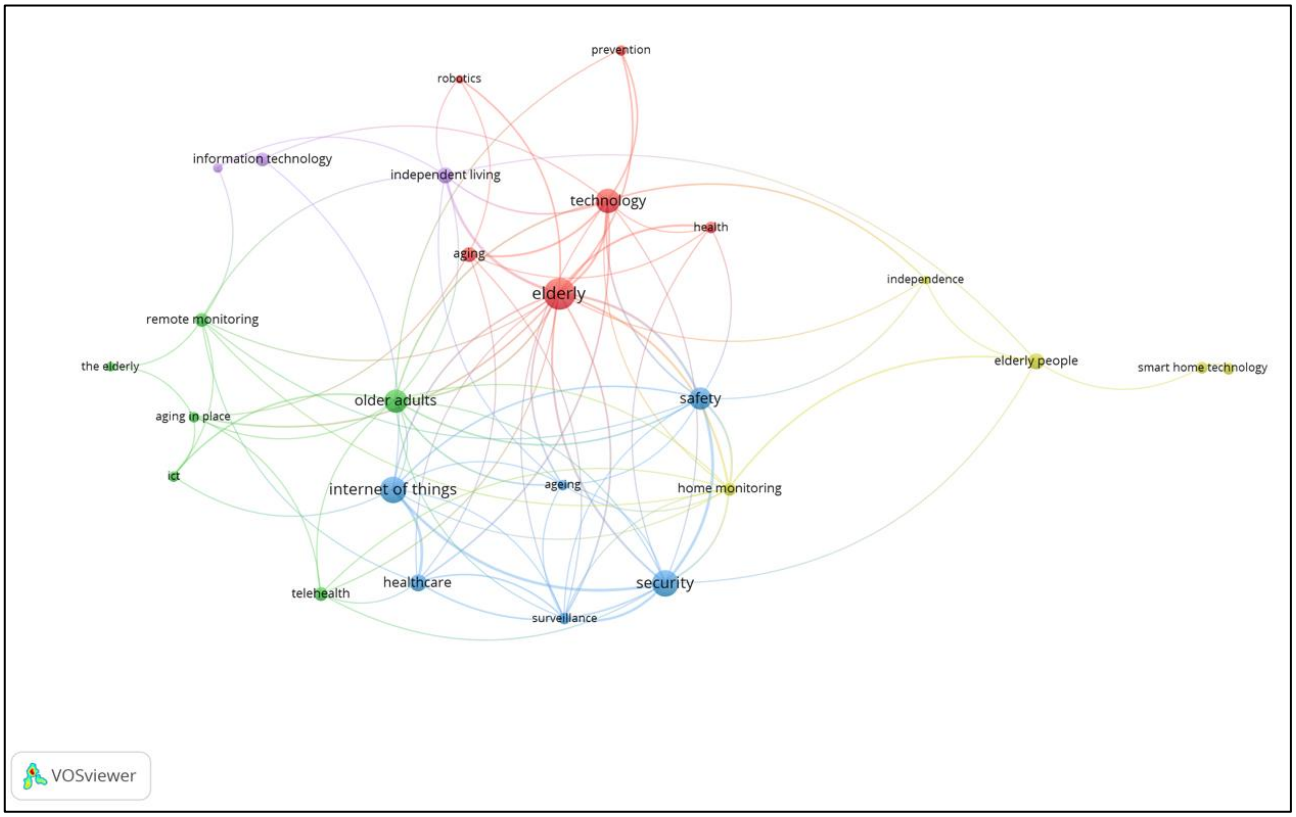

Fig. 2. Co-occurrence and author keyword

3.2 SLR analysis

A SLR drawing upon data from Scopus and Mendeley has identified two overarching themes as fundamental to ensuring safety and security in elderly homes: technological advancements and home design. These themes are particularly pertinent within the context of ageing in place, where the emphasis is on fostering both safety and independence among older individuals [12,13]. Within the technological domain, two key sub-themes have emerged: the IoT and communication technologies. These innovations play a crucial role in enhancing the quality of life for elderly residents by creating safer and more responsive home environments. Table 3 illustrates the key themes, sub-themes, and scholarly discussions on the subject. Notably, approximately 12 academic studies have explored the various applications of IoT technologies in enhancing home safety for elderly individuals. One of the most extensively examined topics is precise fall detection, which is critical for injury prevention given the heightened risk of falls among older adults [14]. For instance, integrating RFID-enabled smart carpets facilitates real-time movement monitoring, allowing for immediate intervention in emergency situations. Additionally, machine learning algorithms such as K-Nearest Neighbours (KNN) have demonstrated high accuracy rates, reaching up to 99% in detecting falls, thereby ensuring timely

assistance and reducing risks associated with prolonged immobility. Another significant advancement is the automation of daily tasks to assist elderly individuals with mobility challenges. The deployment of pre-programmed robotic systems, such as the Cyborg robot, has enabled essential household functions, including switching off lights, watering plants, and controlling gas usage. These automated systems contribute to preserving the autonomy of elderly residents while enhancing overall household safety [14,15].

Furthermore, IoT solutions encompass smart home efficiency systems designed to automate essential household functions, such as lighting and temperature regulation, thereby promoting enhanced comfort and safety for elderly individuals [16,17]. Motion detection technologies have also been explored, particularly through the implementation of three-dimensional convolutional neural networks (3D CNNs), which facilitate continuous monitoring of movement patterns and enable rapid responses to anomalous activities [18]. These advancements not only contribute to improved safety but also provide reassurance for caregivers and family members. Several studies have examined the development of personalised IoT environments, in which safety features are customised to align with the specific needs of elderly residents. These adaptive systems dynamically adjust based on individual health conditions, mobility constraints, and personal preferences, thereby creating an effective and tailored safety framework [19,20]. A significant area of focus within this body of research is the integration of AI-IoT platforms, which merge artificial intelligence with IoT technologies to anticipate and mitigate potential hazards. This synergy facilitates proactive intervention strategies, allowing for the early detection of risks such as falls or deteriorating health conditions before they escalate into critical incidents [21]. Beyond technological advancements, affordability remains a central concern, as the accessibility of IoT solutions across diverse socioeconomic groups is essential to ensuring equitable benefits for elderly individuals without imposing financial burdens [22]. However, despite the numerous advantages, the reviewed literature also highlights security concerns associated with IoT adoption in elderly care. In particular, the protection of privacy and personal data is a critical issue, with several studies emphasising the need to address security vulnerabilities to prevent unauthorised access or breaches of sensitive health-related information. Strengthening security measures is therefore imperative to ensure that IoT applications in elderly care enhance safety without inadvertently introducing additional risks [23].

Wireless communication technologies play a critical role in enhancing safety and security for elderly individuals living independently or in care facilities. Technologies such as Long Range (LoRa) communication, Wireless Sensor Networks (WSN), beacon technology, and artificial intelligence (AI) are increasingly used for real-time monitoring, risk detection, and improved interaction between elderly residents and their environments [22]. For example, LoRa has proven effective for monitoring elderly individuals in remote areas with deficient mobile network coverage. It allows for long-distance data transmission, ensuring that even those living in isolated locations can be monitored for health issues, falls, and other emergencies. WSNs combined with AI improve safety by detecting falls, fires, and other risks, alerting caregivers or authorized individuals in real-time [24]. Such systems have achieved high accuracy rates, like 98.89% in detecting potential risks, ensuring timely interventions [24]. Smart homes equipped with wireless communication enable elderly individuals to interact with their environments more effectively, automating daily activities and allowing caregivers to monitor them remotely. Beacon technology, for instance, detects inactivity or risky behavior, such as activating certain kitchen appliances— and automatically sends alerts to caregivers. While these systems improve safety, they raise privacy concerns due to continuous surveillance. To address this, approaches like federated learning and the use of convolutional neural networks (CNNs) are employed to store personal data locally and ensure secure data transmission, maintaining privacy while providing essential safety features [18]. Despite these advantages, challenges related to the

infrastructure required to support these systems persist. The integration of Building Information Modelling (BIM) with wireless communication has improved the efficiency and safety of elderly care by optimizing the management of staff and resources [25]. However, the success of these systems depends on the availability of reliable communication networks, particularly in remote areas [26]. Additionally, privacy and data security remain significant concerns that must be addressed to balance the benefits of continuous monitoring with ethical considerations.

Home design has also emerged as a critical theme in ensuring the safety and well-being of elderly individuals. Thoughtfully planned and cost-effective home designs, including optimised bathroom layouts and reliable heating systems, play an equally significant role in enhancing elderly safety [27]. Research suggests that bathrooms and toilets are among the most common locations for accidents involving older adults, underscoring their importance in home design tailored to support ageing in place. A study focusing on elderly populations in Malaysia identifies key concerns regarding bathroom and toilet design, namely quality, functionality, cost, and overall design. The findings underscore the primary user requirements, which include comfort, safety, affordability, accessibility, and anti-slip flooring. Technical interventions, such as anti-slip ramps, strategically placed small drainage systems beneath toilet doors, and the repositioning of accessories, are instrumental in minimising fall risks while enhancing overall functionality. These modifications align with the broader principles of universal design, which advocate for adaptable and user-friendly home environments that promote mobility and mitigate potential hazards. Moreover, the integration of emerging technologies into home design is increasingly recognised as a means of improving both safety and sustainability [28]. For instance, the incorporation of hydrogen-based technologies for heating and cooking is gaining traction as part of efforts to achieve a net-zero society. However, consumer acceptance of such innovations is contingent upon multiple factors, including safety considerations, environmental impact, and the perceived reliability of the technology. Scholars emphasise the necessity of engaging consumers in the hydrogen economy by conducting in-depth analyses of technology acceptance dynamics to facilitate decarbonisation strategies. This approach is vital not only for fostering sustainability but also for ensuring that homes are future-proof and capable of addressing the evolving safety needs of elderly individuals.

Table 3
Summary of SLR

No.	Themes	Sub-themes	Authors	Topic Discuss
1.	Technology	IoT	[14]	Explores the effectiveness of IoT-based fall detection systems in elderly homes, ensuring timely intervention and reducing injury risks.
			[15]	Investigates smart home automation for elderly individuals, focusing on energy efficiency, security, and comfort.
			[18]	Analyses motion detection technologies using three-dimensional convolutional neural networks (3D CNNs) for monitoring elderly movements and detecting unusual activities.
			[19]	Examines IoT-based safety solutions that optimise home environments to support elderly independence and well-being.
			[16]	Discusses AI-integrated IoT platforms designed to enhance elderly safety through predictive hazard detection and automated assistance.
			[21]	Explores factors influencing elderly adoption of IoT-enabled smart homes and their benefits in maintaining

				safety and comfort.
			[13]	Investigates the preventive potential of IoT-enabled smart homes in mitigating risks such as falls, health deterioration, and emergency situations.
			[12]	Analyses the affordability of IoT solutions for elderly care, focusing on cost-effective technologies that maintain elderly independence.
			[20]	Examines the role of smart home technologies, such as automated lighting and voice-activated assistants, in enhancing elderly safety and mobility.
			[17]	Addresses security concerns in IoT-enabled elderly smart homes, with a focus on protecting personal data and preventing cyber vulnerabilities.
			[23]	Identifies key IoT security vulnerabilities in elderly care applications and discusses strategies to enhance data protection and system integrity.
		Communication	[25]	Evaluates the impact of wireless communication technologies in improving elderly care and emergency response efficiency.
			[24]	Explores the implementation of wireless sensor networks in elderly homes to monitor health status and detect critical incidents.
			[22]	Investigates low-cost remote monitoring solutions using communication technologies to enhance elderly safety and reduce caregiver burden.
2.	Home design	Home design	[27]	Examines essential elements of safe and affordable bathroom designs, including anti-slip flooring, accessibility features, and cost-effectiveness.
			[28]	Explores the integration of hydrogen-based heating technologies in elderly homes, focusing on safety measures and consumer acceptance in sustainable housing.

3.2 Thematic Analysis

To address the research objective no.3, semi-structured interviews were conducted with elderly individuals and community representatives to gain in-depth insights into their housing preferences, needs, and challenges. This qualitative approach enabled a nuanced understanding of their lived experiences, allowing participants to express their perspectives on affordability, accessibility, safety, and sustainability in elderly housing. The interviews focused on key themes such as interior design features, the importance of communal spaces, and the role of outdoor environments in fostering mobility and well-being. Additionally, the study explored barriers that hinder independent living, including financial constraints, housing modifications, and technological adaptations. By incorporating firsthand narratives, this research ensures that elderly housing models are designed to align with the real-world expectations and evolving needs of ageing populations. The Figure 3 highlights specific areas in residential design where modifications and enhancements are critical. These include safe bathroom layouts, optimised kitchens, accessible entryways, corridors, as well as well-designed communal areas.

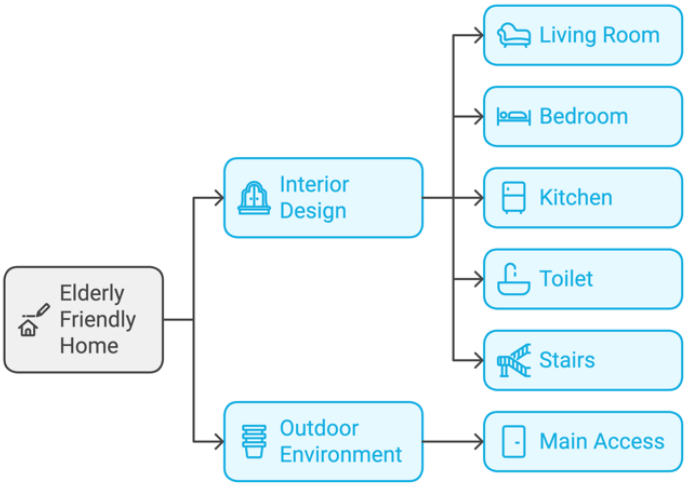

Fig. 3. Key housing components for the development of elderly-friendly homes

3.2.1 Living room

Findings from the fieldwork highlight innovative approaches in elderly housing design, particularly in maximising accessibility and safety through optimised living spaces as shown in Figure 4. A key innovation observed in many elderly-friendly homes is the adoption of spacious living areas with minimal furniture, strategically arranged to reduce potential safety hazards. The prevalent design trend involves placing furniture along the walls, creating an open central space that facilitates ease of movement and ensures unobstructed pathways. This layout is particularly beneficial for elderly residents using mobility aids such as walkers and wheelchairs, as it allows for seamless navigation without obstructions. A notable innovation in these homes is the multi-functional role of furniture, where larger pieces are strategically positioned to serve as stability aids, helping elderly individuals maintain balance and reducing fall risks. This design approach extends beyond aesthetics, integrating functional adaptability that enhances safety while maintaining a homely environment. The open-concept layout observed in multiple respondents' homes reflects a widely adopted solution aimed at fostering inclusive and adaptable housing. By incorporating universal design principles and human-centred innovations, elderly housing can be further optimised to enhance independence, promote well-being, and ensure long-term liveability. These innovations are critical in developing future-proof housing models that align with the evolving needs of an ageing population, supporting the broader movement towards sustainable and accessible elderly housing solutions.

Fig. 4. Open living area (source: respondent's house)

3.2.2 Bedroom

The Malaysia Standard MS1184 specifies essential bedroom design requirements for elderly individuals, ensuring accessibility and comfort as shown in Figure 5. These include adequate space to facilitate unrestricted wheelchair movement around the bed, the incorporation of acoustic systems to reduce noise disturbances, and convenient access to bedside tables for storing medicines or essential items. Additionally, the standard emphasises the need for seamless transitions from the bed to key areas such as the toilet, ablution space, or prayer area, ensuring ease of movement and enhanced functionality for wheelchair users.

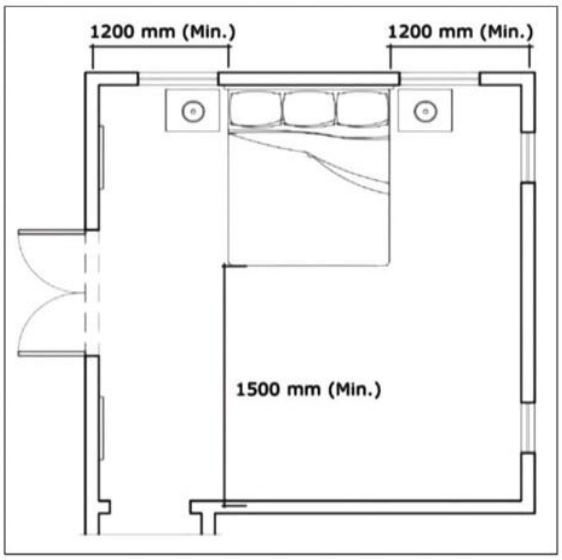

Fig. 5. Elderly bedroom layout

Analysis of the collected data revealed two distinct sleeping preferences among respondents. While some elderly individuals preferred sleeping in their bedrooms, others chose to convert their living rooms into sleeping areas. Those who lived alone were more inclined to utilise the living room as their primary sleeping space, whereas individuals residing with a partner preferred sleeping in the bedroom. Additionally, interview findings indicated that none of the respondents encountered space limitations when using a wheelchair in their bedrooms, highlighting the adequacy of available space for mobility.

> "Up to now, we haven't encountered any space issues. We use a wheelchair, and if the bedroom feels too confined, we simply use the living room as our sleeping area instead." – Respondent 3

3.2.3 Kitchen

Accessibility, particularly in terms of the ease of reaching stored items, is a key factor in kitchen design. Findings from the fieldwork revealed that none of the respondents' homes featured upper cabinets, with all storage confined to countertops and lower cabinets. When asked about the most convenient place to store items, respondents identified the countertop as the most practical option. This preference stems from the fact that storing items in lower cabinets requires bending down, while upper cabinets necessitate climbing, both of which can be physically challenging. The photograph in Figure 6 illustrates a respondent's kitchen, showing a common design choice among all participants

kitchens without upper cabinets. As depicted in the Figure 6, items are stored in lower cabinets and on countertops.

Fig. 6. Respondent's kitchen (source: respondent's house)

3.2.4 Toilet

For elderly individuals, bathroom accessibility and safety are among the most crucial considerations. Having the toilet and bathroom within the same space is generally considered more practical, particularly for older adults. However, findings from the fieldwork revealed that many respondents had separate bathrooms and toilets, a practice influenced by Shariah compliance. In contrast, integrating the toilet and bathroom is often done to optimise space, especially in urban housing such as apartments. This approach has become widely accepted. The homes visited during the fieldwork were located in villages, typically built on privately owned or inherited land, where space constraints were not a concern. As a result, residents opted for separate bathroom and toilet facilities.

3.2.5 Stairs

Elderly individuals tend to feel less comfortable in homes with stairs due to mobility challenges and the increased risk of falls. Most respondents living in multi-storey homes have adapted by limiting their daily activities to the ground floor. To enhance safety and convenience, many have relocated their sleeping arrangements to a downstairs bedroom, avoiding the need to frequently use the stairs. This adjustment allows them to maintain their independence while reducing physical strain and the likelihood of accidents. In some cases, elderly residents also modify their living spaces by incorporating essential amenities on the ground floor, ensuring easier access to frequently used areas such as the kitchen, bathroom, and living room.

3.2.6 Main Access

Based on the data collected, the majority of homes occupied by wheelchair users lack essential accessibility features, such as permanent ramps to facilitate movement. However, many of these homes have only minimal differences in floor levels. As shown in Figure 7, the respondents' homes generally exhibit slight variations in floor height, which do not significantly hinder wheelchair users' mobility. While these minor level differences pose little challenge, they do not fully address the

accessibility needs of individuals with mobility impairments. In some cases, residents have implemented makeshift solutions, such as wooden planks or temporary ramps, to improve ease of movement. Nonetheless, the absence of properly designed infrastructure highlights the need for more inclusive housing modifications that prioritise long-term accessibility and safety for wheelchair users.

Fig. 7. A wood as a temporary ramp (source: respondent's house)

Green open space is generally defined as land or surface areas predominantly covered with vegetation, serving various functions such as ecosystem protection, environmental conservation, infrastructure security, or agricultural use. The primary goal is to create conditions that support both physical and spiritual well-being. For elderly individuals, access to outdoor spaces can greatly improve their overall quality of life. Engaging with green environments allows them to experience enjoyment, foster social connections, and gain significant physical and mental health benefits. Regular interaction with nature encourages an active lifestyle, reduces stress, and enhances emotional well-being, making green spaces essential for promoting a healthier and more fulfilling life for the elderly. Interviews with elderly respondents revealed that their daily routine after dawn prayers typically includes having breakfast followed by spending time outdoors. Most of the respondents' homes featured open spaces with flowering plants, either in gardens or on balconies. The presence of greenery in their living environment appears to positively influence their perception of their own health and overall quality of life as shown in Figure 8 below. There is a notable connection between access to green spaces, gardens in elderly homes, and their well-being for various reasons. A garden that is easily accessible can serve as a space for social interaction or as a private retreat, contributing to both social and emotional well-being. Additionally, gardens encourage horticultural activities and provide sensory stimulation, which can enhance both physical and mental health for elderly individuals.

Fig. 8. Two different respondents' homes (source: respondent's house)

4. Future Study

Future research should consider increasing the sample size to include a diverse range of elderly individuals from urban, suburban, and rural locations to better represent the broader elderly population. Incorporating longitudinal studies would provide a comprehensive understanding of how elderly housing needs change over time. Comparative studies of different socioeconomic groups may offer valuable insights into variations in housing needs and accessibility. Furthermore, a holistic approach to elderly housing must integrate community-based and non-technological solutions to ensure a sustainable and inclusive living environment. Key non-technological solutions include improving neighborhood and community design to foster safe, walkable areas with access to essential services, reducing elderly isolation. Implementing age-friendly housing policies, such as government incentives for senior-friendly housing development and financial assistance for home modifications, can significantly improve housing accessibility. Encouraging intergenerational living models, where younger residents support elderly neighbors, enhances social inclusion and overall well-being. Strengthening local support networks can provide an alternative to technology-based monitoring, ensuring elderly individuals receive community-based care and assistance. These measures ensure that technological advancements are complemented by human-centered approaches, leading to a more comprehensive and sustainable model for elderly housing.

5. Discussion and Conclusion

This study provides a significant contribution to both academic research and practical policy development in elderly housing. By integrating scientometric analysis, SLR, and qualitative interviews, this study fills critical gaps in understanding the intersection of affordability, sustainability, and ageing in place. Its interdisciplinary approach advances the field of elderly-friendly housing by incorporating insights from urban studies, gerontology, and digital technology, offering a comprehensive framework for improving housing conditions for ageing populations. The findings emphasize the role of smart home technologies, IoT-driven safety solutions, and universal design principles in creating more accessible and affordable housing solutions for elderly individuals, particularly in rapidly ageing societies like Malaysia. Beyond academic contributions, this research provides evidence-based recommendations for policymakers, urban planners, and housing developers. It highlights the urgent need for policy reforms that integrate elderly-friendly housing into national urban planning frameworks, ensuring sustainable and inclusive living environments. By advocating for the adoption of smart home adaptations, fall prevention technologies, and community-based support systems, this study influences future housing policies to be more age-

inclusive, safety-focused, and environmentally sustainable. Furthermore, it underscores the importance of regulatory improvements in Malaysia's National Housing Policy (NHP) and urban development strategies, promoting affordable and accessible housing options for low-income and marginalized elderly groups. From a societal perspective, this research reinforces the significance of ageing in place as a strategy for enhancing elderly autonomy, dignity, and quality of life. The study also promotes the integration of community support networks, shared spaces, and outdoor green areas, which play a vital role in social well-being, cognitive health, and mobility among older adults. Ultimately, this research not only advances scholarly discussions on elderly housing but also serves as a practical guide for governments, developers, and caregivers in shaping sustainable, future-proof housing solutions that empower ageing societies to live safely, independently, and with dignity.

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References

[1] World Health Organization. *Ageing and Health*. 2022. https://www.who.int/news-room/fact-sheets/detail/ageing-and-health.
[2] Abdul Rashid, Saharani, Puzziawati Ab. Ghani, Noorizam Daud, Zulkifli Ab Ghani Hilmi, Siti Noorul Ain Nor Azemi, Sharifah Norhuda Syed Wahid, and Mohd Rizal Razak. "Malaysia's ageing population trends." In *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2014) Business and Social Sciences*, pp. 981-990. Springer Singapore, 2016. https://doi.org/10.1007/978-981-10-1458-1_88
[3] Department of Statistics Malaysia (DOSM). *Vital Statistics 2022*. 2022. https://open.dosm.gov.my/publications/vitalstatistics_2022.
[4] Department of Statistics Malaysia (DOSM). Technical Notes. 2024. https://open.dosm.gov.my/publications/technical-notes.
[5] Abraham, Alison G., Chris Hong, Jennifer A. Deal, Brianne M. Bettcher, Victoria S. Pelak, Alden Gross, Kening Jiang, Bonnielin Swenor, and Walter Wittich. "Are cognitive researchers ignoring their senses? The problem of sensory deficit in cognitive aging research." *Journal of the American Geriatrics Society* 71, no. 5 (2023): 1369-1377. https://doi.org/10.1111/jgs.18229
[6] Mnea, Aysha, and Mohd Zairul. "Housing design studies in Saudi Arabia: A thematic review." *Journal of Construction in Developing Countries* 28, no. 1 (2023): 317-339. https://doi.org/10.21315/jcdc-09-21-0153
[7] Sohaimi, Nor Suzylah, Mohd Azren Hassan, Mohd Nazaruddin Yusoff, Sharif Shofirun Sharif Ali, and Norlaila Abdullah Chik. "The aspiration for a sustainable affordable housing framework in Malaysia." In *AIP Conference Proceedings*, vol. 2827, no. 1. AIP Publishing, 2023. https://doi.org/10.1063/5.0166456
[8] Song, Yiling, Yunxi Liu, Xiaotian Bai, and Hongjun Yu. "Effects of neighborhood built environment on cognitive function in older adults: a systematic review." *BMC geriatrics* 24, no. 1 (2024): 194. https://doi.org/10.1186/s12877-024-04776-x
[9] Kaplan, Rachel, Stephen Kaplan, and Terry Brown. "Environmental preference: A comparison of four domains of predictors." *Environment and behavior* 21, no. 5 (1989): 509-530. https://doi.org/10.1177/0013916589215001
[10] Sohaimi, Nor Suzylah, Mohd Azren Hassan, Mohd Nazaruddin Yusoff, Sharif Shofirun Sharif Ali, and Norlaila Abdullah Chik. "The aspiration for a sustainable affordable housing framework in Malaysia." In *AIP Conference Proceedings*, vol. 2827, no. 1. AIP Publishing, 2023. https://doi.org/10.1063/5.0166456
[11] Moher, David, Alessandro Liberati, J. Tetzlaff, and Douglas G. Altman. "PRISMA 2009 flow diagram." *The PRISMA statement* 6, no. 1000097 (2009): 0-1371. https://doi.org/10.1371/journal.pmed.1000097
[12] Akhmetzhanov, Batyrzhan, Bauyrzhan Akhmetzhanov, SUAT ÖZDEMİR, and Nurkhat Zhakiyev. "Advancing affordable IoT solutions in smart homes to enhance independence and autonomy of the elderly." *Journal of Infrastructure, Policy and Development* 8, no. 3 (2024). https://doi.org/10.24294/jipd.v8i3.2899
[13] Iten, Raphael, Joël Wagner, and Angela Zeier Röschmann. "On the adoption of smart home technology in Switzerland: results from a survey study focusing on prevention and active healthy aging aspects." *Smart Cities* 7, no. 1 (2024): 370-413. https://doi.org/10.3390/smartcities7010015

[14] Alharbi, Hatem A., Khulud K. Alharbi, and Ch Anwar Ul Hassan. "Enhancing elderly fall detection through iot-enabled smart flooring and ai for independent living sustainability." *Sustainability* 15, no. 22 (2023): 15695. https://doi.org/10.3390/su152215695
[15] Alshdadi, Abdulrahman A. "Evaluation of IoT-based smart home assistance for elderly people using robot." *Electronics* 12, no. 12 (2023): 2627. https://doi.org/10.3390/electronics12122627
[16] Bertini, Leonardo, Dario Bruneo, Massimo Mecella, and Emilia Reda. "ASSISTO eCARE 4.0-An IoT-and AI-based architecture for assisted active aging." *EAI Endorsed Trans. Pervasive Health Technol.* 7, no. 28 (2021): e5. https://doi.org/10.4108/eai.6-8-2021.170666
[17] Elsaid, Mayada, Sara Altuwaijri, Nouf Aljammaz, and Anees Ara. "Design and Analysis of Secure Smart Home for Elderly People." *Int. J. Distrib. Parallel Syst* 10, no. 6 (2019): 1-13. https://doi.org/10.5121/ijdps.2019.10601
[18] Ji, Qingnan. "The Design of the Lightweight Smart Home System and Interaction Experience of Products for Middle-Aged and Elderly Users in Smart Cities." *Computational intelligence and neuroscience* 2022, no. 1 (2022): 1279351. https://doi.org/10.1155/2022/1279351
[19] Jung, Chuloh, Jihad Awad, and Afaq Chohan. "The planning of smart elderly housing in Dubai with IoT technologies." *Open House International* 46, no. 4 (2021): 668-681. https://doi.org/10.1108/OHI-08-2020-0121
[20] Oladinrin, Olugbenga Timo, Jayantha Wadu Mesthrige, Lekan Damilola Ojo, João Alencastro, and Muhammad Rana. "Smart home technologies to facilitate ageing-in-place: Professionals perception." *Sustainability* 15, no. 8 (2023): 6542. https://doi.org/10.3390/su15086542
[21] Zhou, Chengmin, Yawen Qian, and Jake Kaner. "A study on smart home use intention of elderly consumers based on technology acceptance models." *Plos one* 19, no. 3 (2024): e0300574. https://doi.org/10.1371/journal.pone.0300574
[22] Lousado, José Paulo, Ivan Miguel Pires, Eftim Zdravevski, and Sandra Antunes. "Monitoring the health and residence conditions of elderly people, using lora and the things network." *Electronics* 10, no. 14 (2021): 1729. https://doi.org/10.3390/electronics10141729
[23] Yamout, Youssef, Tashaffi Samin Yeasar, Shahrear Iqbal, and Mohammad Zulkernine. "Beyond smart homes: An in-depth analysis of smart aging care system security." *ACM Computing Surveys* 56, no. 2 (2023): 1-35. https://doi.org/10.1145/3610225
[24] Zhang, Cheng. "The Design of a Wireless Network Home-Based Elderly Care System Based on Artificial Intelligence Technology and Its Impact on the Construction of the Social Security System." *Wireless Communications and Mobile Computing* 2022, no. 1 (2022): 5746759. https://doi.org/10.1155/2022/5746759
[25] Yu, Tiantian, and Ruping Wang. "Design and implementation of a smart elderly positioning management system based on wireless communication network." *EURASIP Journal on Wireless Communications and Networking* 2021, no. 1 (2021): 147. https://doi.org/10.1186/s13638-021-02021-2
[26] Chen, Mu-Yen. "Establishing a cybersecurity home monitoring system for the elderly." *IEEE Transactions on Industrial Informatics* 18, no. 7 (2021): 4838-4845. https://doi.org/10.1109/TII.2021.3114296
[27] Hussain, Mohd Rizal, Nuzul Azam Haron, Raja Ahmad Azmeer Raja Ahmad Effendi, Fakhrul Zaman Rokhani, Siti Anom Ahmad, Asmidawati Ashari, Mohd Khair Hassan, Mohd Shahrizal Dolah, and Saiful Hasley Ramli. "Design Requirement of Bathroom and Toilet for the Elderly in Malaysia." *Pertanika Journal of Science & Technology* 31, no. 4 (2023). https://doi.org/10.47836/pjst.31.4.15
[28] Gordon, Joel A., Nazmiye Balta-Ozkan, Anwar Ul Haq, and Seyed Ali Nabavi. "Heterogeneous preferences for living in a hydrogen home: an advanced multigroup analysis." *Sustainable Energy & Fuels* 8, no. 12 (2024): 2601-2648. https://doi.org/10.1039/D4SE00392F