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Digital Learning Preferences: Aging in the Age of Technology

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Abstract

This research explores the digital learning preferences of aging populations aged 50 years and older, focusing on their diverse learning styles, the challenges they encounter, and the implications for educational practices and policies. With the growing integration of digital tools in education, comprehending older adults' interactions with digital learning is pivotal for developing equitable and efficient educational approaches. The study employs a mixed methods approach to gather comprehensive insights into the topic. Quantitative surveys are administered to a diverse sample of older adults to capture broad trends in digital learning preferences and styles. Concurrently, qualitative interviews provide nuanced perspectives, allowing participants to articulate their experiences, challenges, and preferences in their own words. Preliminary findings indicate a diversity of digital learning styles among older adults, influenced by factors such as prior technological experience, openness to tech, educational background, and personal learning preferences. While some older learners embrace digital platforms enthusiastically, others exhibit hesitancy or skepticism due to perceived complexities or concerns about privacy and security. Research findings contribute to the broader discussions on lifelong learning and digital inclusion. As digital technology is ever-changing, our learning models must incorporate the evolving needs of the aging population. Ultimately, fostering digital inclusion for older adults is not merely about access to technology but about creating meaningful learning opportunities that promote engagement, empowerment, lifelong learning, mental and emotional well-being, and the overall quality of life in this "age of technology".

Keywords: digital technology learning, aging populations, older adults, learning styles, educational practices, educational policies, lifelong learning

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Introduction

We live in a world of exponentially increasing technology advancements. Never in the history of mankind have so many such advancements emerged in parallel and in combination, carrying so much impact (Winarsky, 2020). We can digitally access essential services such as healthcare, online banking, and e-commerce all at the click of a few buttons. Staying connected virtually is proving vital for our emotional and mental health. While most of us have adapted to the new lifestyle, it must come as no surprise that these benefits remain limited to a section of our population. Only those who own and know how to operate smart devices can truly reap benefits of this new digital world.

This prevailing global digital divide is depriving many of our loved ones to have a connected and inclusive digital social experience. The digital divide attributes to social isolation, loneliness, increased dependency, and helplessness. The advancement of digital technology has revolutionized the way individuals acquire knowledge. While digital tools are becoming integral to education, older adults often encounter distinctive obstacles in adopting and effectively utilizing these resources.

Preliminary findings suggest that older adults exhibit a diverse range of digital learning styles influenced by factors such as **prior technological experience, openness to technology, educational background, and personal learning preferences**. While some older learners eagerly embrace digital platforms, others express hesitancy or skepticism due to perceived complexities or concerns about privacy and security. These findings highlight the necessity of tailored educational approaches that accommodate varying levels of technological comfort and competence.

Best Ways to Learn Digital Technology for Older Adults

Learning digital technology is influenced by multiple factors, including the learning medium, environment, and instructional setting. The effectiveness of digital education depends on whether learning occurs in structured or informal settings, through self-paced or instructor-led approaches, and within individual or group-based environments. Research indicates that *interactive and immersive methods, such as hands-on practice, guided exploration, and peer collaboration, enhance digital proficiency by reinforcing engagement and retention.* Additionally, the accessibility of learning spaces—whether physical classrooms, virtual platforms, or hybrid models—plays a crucial role in shaping the learning experience (Vanderbilt University, n.d.). By integrating adaptive, socially supportive, and context-driven instructional strategies, digital education can become more inclusive and effective for learners of all backgrounds and abilities.

Some of the most effective approaches include:

- **Hands-on Learning**: Engaging in real-world applications of digital tools helps individuals retain knowledge and develop technical fluency. Practical exercises, such as using mobile applications, online banking, or social media platforms, provide experiential learning opportunities.
- **Step-by-Step Guidance**: Structured, incremental instruction simplifies complex tasks and reduces cognitive overload. Providing detailed manuals, video tutorials, and guided demonstrations ensures that learners can progress at their own pace.
- **Interactive Tutorials**: Multimedia content, including videos, simulations, and gamified learning experiences, enhances engagement and comprehension. Digital

literacy courses often integrate quizzes, interactive exercises, and real-time feedback to reinforce learning.
- **Peer Learning**: Collaborative learning environments, such as group workshops, mentorship programs, and discussion forums, enable learners to exchange knowledge, gain confidence, and receive emotional support from their peers.

Older adults benefit from specific, tailored learning methodologies that address their unique cognitive and emotional needs. The following approaches have proven to be effective:
- **Personalized Learning Paths**: Customizing content based on prior knowledge, interests, and learning goals allows older adults to engage more effectively with digital education. Adaptive learning platforms that adjust difficulty levels based on performance can enhance learning experiences.
- **Slow-Paced Instruction**: Older adults often require additional time to absorb new information. Providing flexible, self-paced learning modules ensures they can revisit lessons as needed without pressure.
- **Community-Based Learning**: Engaging older adults in peer-supported environments fosters motivation and social connection. Digital learning groups in community centers, libraries, and senior living facilities encourage participation and collaboration.
- **Instructor-Led Sessions**: Combining face-to-face or virtual instructor-led training with self-learning materials allows older adults to receive real-time guidance, ask questions, and clarify doubts, reinforcing their digital skills.

Challenges and Implications

- **Technological Barriers**: Many older learners struggle with navigating user interfaces, remembering login credentials, and troubleshooting technical issues. Unfamiliarity with device settings, software updates, and accessibility features can hinder learning.
- **Privacy and Security Concerns**: Fear of online scams, fraud, data breaches, and misinformation often discourages older adults from engaging with digital platforms. A lack of cybersecurity awareness further exacerbates their reluctance to participate in online activities.
- **Limited Access to Devices**: Socioeconomic factors play a significant role in digital learning disparities. Older adults with financial constraints may lack access to personal computers, smartphones, or high-speed internet, limiting their ability to participate in digital education.
- **Cognitive Load**: Learning new digital tools requires memory, attention, and problem-solving skills. Information overload and the fast-paced nature of technological advancements can lead to frustration and disengagement.

Implications

- **Need for Accessible Design**: Developers must prioritize user-friendly interfaces, larger fonts, voice commands, and simplified navigation to accommodate older learners' needs. Assistive technologies, such as screen readers and voice assistants, can further enhance accessibility.
- **Policy Development**: Governments and educational institutions should implement digital literacy initiatives targeted at older adults, ensuring that curricula address their

specific learning needs. Subsidized programs and grants can improve access to devices and internet connectivity.

- **Community Support Systems**: Strengthening intergenerational learning programs, where younger individuals assist older adults in digital education, fosters meaningful social connections. Family involvement and mentorship initiatives can further boost confidence and motivation in digital learning.

By addressing these challenges and implementing targeted interventions, digital learning can become more inclusive, empowering older adults to participate actively in today's technology-driven world.

Research Methodology

This study employs a mixed-methods approach to gain a comprehensive understanding of digital learning preferences among older adults. By integrating quantitative surveys with qualitative interviews, the research ensures both breadth and depth in analyzing how older learners engage with digital education.

The **quantitative** component involves structured survey questionnaires administered to older adults across diverse settings, including independent living communities and assisted living facilities. This approach captures general trends, such as the most commonly used digital tools, preferred learning methods, and perceived challenges. To ensure robust statistical analysis and generalizability, a sample size of 600 participants was selected for this study.

The **qualitative** component consists of in-depth interviews aimed at uncovering personal experiences, attitudes, and motivations related to digital learning. Through open-ended discussions, participants share their challenges, learning styles, and strategies, providing nuanced insights that enrich the statistical findings. Data were collected from 40 participants, which allowed for in-depth exploration and saturation of themes relevant to the research question.

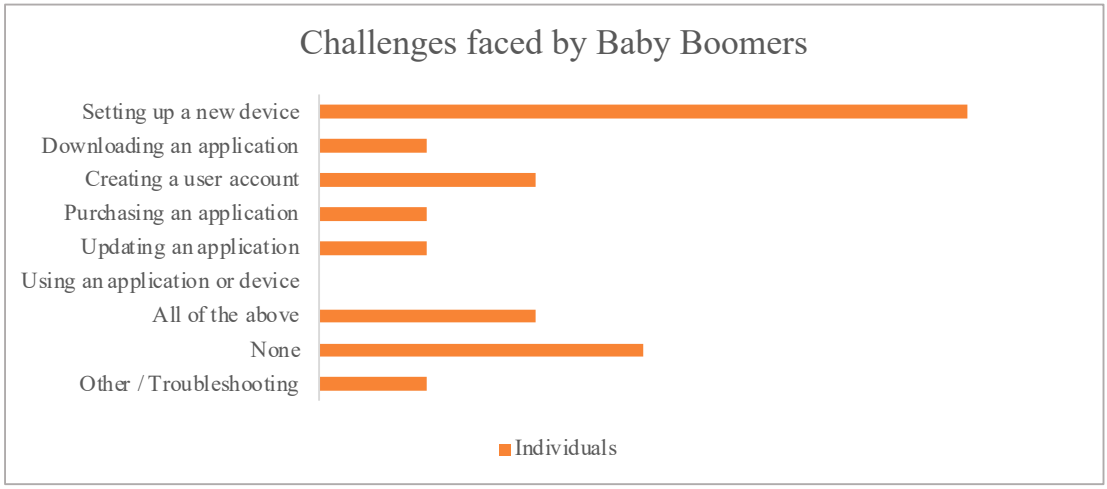
The mixed-methods approach is particularly valuable in this context, as it bridges the gap between large-scale data trends and individual learning narratives. By combining numerical analysis with personal stories, the research design ensures a well-rounded understanding of older adults' digital learning experiences.

To ensure a diverse sample, data is collected through online survey distribution and in-person outreach in assisted living facilities, senior learning centers, libraries, and community organizations. Participants include older adults with varying levels of digital proficiency, socioeconomic backgrounds, and educational experiences. Data highlights common learning barriers preferred instructional methods, and the role of social support in digital adoption. This methodology allows for a robust exploration of the factors shaping digital learning outcomes for aging populations, contributing to the development of inclusive and effective educational interventions.

Results and Insights

The figure below shows the challenges faced by the participants when interacting with digital technology.

Figure 1
Challenges Faced by Older Adults



While most older adults find "setting up a new device" and "creating a user account" as challenging, most reported "all of the above" as the most challenging.

Participants also selected their digital technology preferences for top categories (Leisure and Culture, Social Media, Online Banking, Healthcare, Smart Devices, E-commerce, Education, and Other) that they "currently use it", "would like to use it", and "don't want to use it". The figure below shows the responses.

Figure 2
Older Adults' Top Categories (Participation Preference)

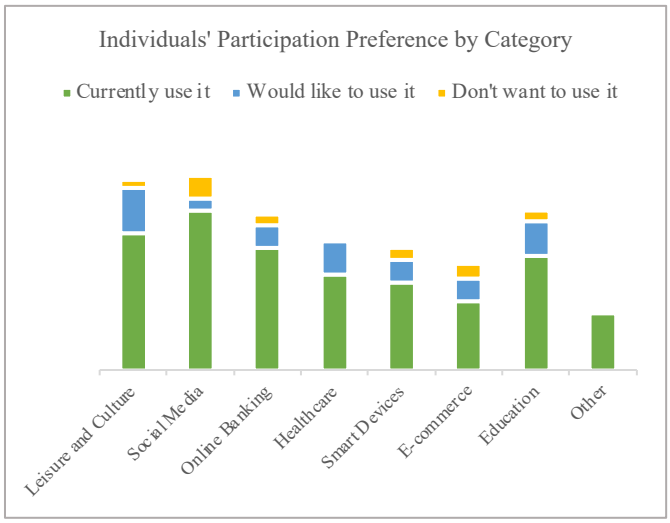
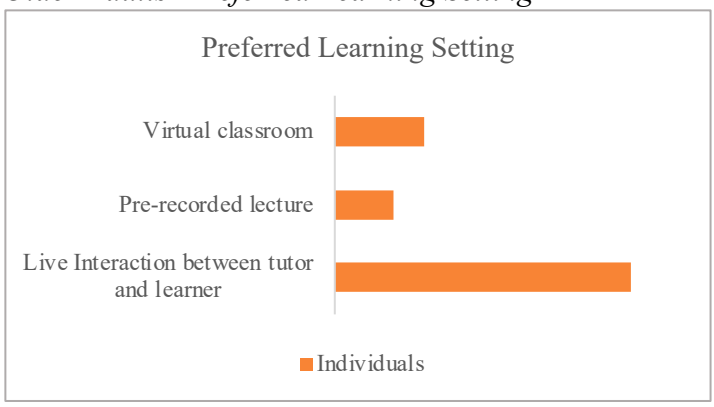


Figure 3 shows that Preferred Learning Setting indicates live interaction between tutor and learner is the most preferred by older adults.

Figure 3
Older Adults' Preferred Learning Setting



In future research, as we continue to investigate with a larger sample size, we aim to enhance the precision and external validity of the findings.

Social Aspects of Learning

Learning is an inherently social activity, and digital education for older adults is most effective when it fosters interaction, collaboration, and engagement. Social learning environments allow individuals to exchange knowledge, seek support, and build confidence in their digital skills. Peer-to-peer learning, mentorship programs, and community-based workshops create a sense of belonging and motivation, reducing feelings of isolation and frustration often associated with independent digital learning.

Intergenerational learning initiatives, where younger individuals guide older adults in digital technology, have proven to be highly effective. These interactions not only enhance digital literacy but also promote social cohesion, bridging generational divides through shared learning experiences. Social participation also encourages continuous engagement, as learners feel more comfortable experimenting with new tools when supported by a community of peers or mentors.

Furthermore, structured social learning environments, such as senior technology clubs, group training sessions, and online discussion forums, reinforce learning by enabling older adults to ask questions, share experiences, and develop strategies to overcome technological challenges. By prioritizing social engagement in digital education, learning programs can enhance motivation, improve retention rates, and ultimately foster a culture of lifelong learning among older populations.

Digital Inclusion Ecosystems

A well-functioning digital inclusion ecosystem consists of:

- **Accessible Learning Platforms:** User-friendly interfaces for diverse learners.
- **Public-Private Partnerships:** Collaboration between government, NGOs, and tech companies.
- **Ongoing Digital Literacy Programs:** Continuous learning opportunities for sustained inclusion.
- **Support Networks:** Community engagement to foster learning motivation.

Conclusion

Digital learning for older adults requires adaptive, inclusive, and socially engaging approaches. Addressing the challenges they face is essential for fostering equitable lifelong learning opportunities and enhancing their overall well-being in a technology-driven world. Promoting digital inclusion goes beyond providing access to technology—it involves creating meaningful learning experiences that build confidence, develop digital competencies, and encourage active participation. By implementing personalized learning models, fostering supportive environments, and ensuring accessible digital tools, society can empower older adults to remain engaged, informed, and connected. A well-structured digital learning ecosystem that prioritizes accessibility, community support, and continuous education will not only bridge the digital divide but also promote lifelong learning, social inclusion, and improved quality of life for aging populations.

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Telehealth on the Rise: Seniors Embrace Remote Care in Singapore

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Abstract

Telemedicine has gained prominence as a valuable healthcare tool, especially for elderly populations. Leveraging digital technologies of video conferencing, phone calls, and text messaging enables remote access to healthcare services, reducing the need for in-person visits. This study explores the factors influencing telemedicine acceptance among elderly populations in Singapore. A literature review was conducted in PubMed, surrounding keywords "telemedicine," "telehealth," "opinion," "elderly," "older adults," and "Singapore." Studies published in English from 2014-2024 were included if they focused on telemedicine and elderly populations in Singapore. Included studies were analyzed for methodology, sample size, data collection methods, and key findings. The literature search yielded 18 studies which met the inclusion criteria for analysis. Telemedicine has seen increasing acceptance from elderly populations, particularly with reduced unnecessary hospital visits. Key factors influencing telemedicine acceptance include (i) user-friendliness; (ii) trust in healthcare providers and trust in their recommendations; (iii) perceived benefits of convenience, time-saving, and reduced infection risk; (iv) strong support systems from family members, caregivers, or healthcare providers. However, certain barriers to acceptance remain. Older individuals with lower levels of digital literacy may face challenges in utilizing telemedicine technologies. Additionally, concerns remain regarding the safety of medication delivery through remote means, particularly for patients requiring additional support. This study demonstrates the growing acceptance of telemedicine among elderly Singaporeans. Key factors influencing adoption include user-friendliness, trust in healthcare providers, and perceived benefits. Addressing limitations such as digital literacy, medication safety, and quality assurance is crucial to ensure sustainable and effective use of telemedicine for elderly.

Keywords: telehealth, telemedicine, seniors

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Introduction

Telemedicine has emerged as a transformative healthcare solution, particularly for elderly populations who often face mobility challenges and chronic health conditions that necessitate regular medical attention. In Singapore, the integration of digital technologies such as video conferencing, phone calls, and text messaging into healthcare services has facilitated remote access to medical care, significantly reducing the need for in-person visits. This shift not only enhances convenience but also addresses barriers related to transportation and accessibility that many seniors encounter (Pang, 2022; Rohaidi, 2017).

The COVID-19 pandemic has accelerated the adoption of telehealth services globally, highlighting its potential to provide continuous care while minimizing exposure to health risks. In Singapore, initiatives like the Seniors Go Digital program have been implemented to bridge the digital divide, offering support and resources to older adults in navigating technology (Tan et al., 2024).

Despite these efforts, the acceptance of telemedicine among seniors is influenced by various demographic factors, including age, education level, and socioeconomic status. Understanding these factors is crucial for tailoring telehealth services to meet the unique needs of this demographic (Tan et al., 2020; Tan et al., 2024).

While many older adults express a willingness to embrace technology for healthcare purposes, significant barriers remain. These include technological literacy, perceived effectiveness of telehealth services, and cultural attitudes toward digital health solutions. Studies have also shown that older adults from lower socioeconomic backgrounds may face additional challenges in accessing and utilizing telemedicine due to limited internet connectivity and lower health literacy.

This study aims to explore the multifaceted factors influencing the acceptance of telemedicine among elderly populations in Singapore. By examining the interplay between demographic characteristics and attitudes toward technology, we seek to identify opportunities for enhancing telehealth adoption and improving health outcomes for seniors. Insights gained from this research will inform policymakers and healthcare providers on how best to support older adults in their transition to digital health solutions, ultimately fostering a more inclusive healthcare environment in Singapore's evolving landscape.

Methods

This literature review systematically explored the current state of telehealth adoption among older adults in Singapore. To identify relevant studies, a comprehensive search was conducted on the PubMed database using a combination of keywords: "telemedicine," "telehealth," "opinion," "elderly," "older adults," and "Singapore." The search was limited to articles published in English between 2014 and 2024.

The inclusion criteria required studies to focus on telemedicine or telehealth interventions specifically targeting older adults in Singapore. They also had to employ qualitative or quantitative research methods, such as surveys, interviews, or observational studies, and be published in a peer-reviewed journal.

After the initial search, articles were screened based on titles and abstracts to eliminate irrelevant studies. Full-text articles of the remaining studies were then carefully reviewed to assess their eligibility based on the inclusion criteria.

The selected studies were analyzed in detail to extract information on their research design, sample size, data collection methods, participant demographics, types of telehealth services provided (such as teleconsultations, remote monitoring, and tele-rehabilitation), and key findings related to the effectiveness, acceptability, and barriers to telehealth use among older adults.

Results

The literature review identified 18 studies that met the inclusion criteria, providing valuable insights into the acceptance and barriers of telemedicine among older adults in Singapore. It should be noted that there is widespread increase in acceptance of telemedicine among older adults.

This is attributed to 4 key factors. Firstly, the user-friendliness of telemedicine platforms is a critical factor in determining their acceptance among older adults. A simple and intuitive interface, clear instructions, and large, easy-to-read fonts can significantly enhance the user experience. Additionally, providing technical support and training sessions can help older adults overcome any initial challenges they may face.

Secondly, trust in healthcare providers and trust in their recommendations also plays a large role. Trust is a cornerstone of the doctor-patient relationship, and this is particularly important in the context of telemedicine. Older adults are more likely to adopt telemedicine if they trust their healthcare providers and believe in the efficacy of remote consultations. Building trust can be achieved through open communication, transparency, and personalized care.

Thirdly, the perceived benefits of telemedicine can significantly influence its adoption. In particular, these would be convenience, time savings, and reduced infection risk. Older adults may appreciate the convenience of virtual consultations, especially for follow-up appointments or routine check-ins. Telemedicine can also save time and reduce the risk of exposure to infections, particularly during outbreaks or pandemics.

Last but not least, another factor identified is the presence of strong support systems from family members, caregivers, or healthcare providers. Social support plays a crucial role in the successful adoption of telemedicine. Family members, caregivers, and healthcare providers can assist older adults in navigating the technology, scheduling appointments, and understanding medical advice. Strong support systems can help alleviate anxiety and uncertainty associated with remote healthcare.

Discussion

Despite the increasing adoption of telemedicine among elderly populations in Singapore, several barriers to acceptance persist that warrant discussion. One of the most significant challenges is the digital literacy gap among older adults. Many seniors may struggle to navigate telemedicine platforms effectively, which can hinder their ability to access necessary healthcare services. Research indicates that older individuals with lower levels of digital

literacy are less likely to utilize telehealth technologies, leading to disparities in healthcare access and outcomes. (Jialin, 2023; Tan, n.d.) This issue underscores the need for tailored solutions that consider the unique technological capabilities of this demographic.

Moreover, concerns regarding the safety of medication delivery through remote means present another critical barrier. Older adults often require additional support in managing their medications, and the transition to telehealth can complicate this process. Issues such as medication errors, improper dosages, and inadequate follow-up care can arise when patients rely solely on remote consultations without in-person assessments (Gleeson et al., 2022; O'Malley et al., n.d.). The potential for adverse drug events is heightened when communication between healthcare providers and patients lacks clarity or when patients are not adequately educated about their treatment plans (Kulchar et al., 2022).

To address these challenges, future research should prioritize the development of user-friendly telemedicine interfaces tailored to the needs of older adults. Simplifying navigation and enhancing accessibility features can empower seniors to engage more confidently with telehealth services. Additionally, providing comprehensive training and support programs will be essential in helping older adults overcome digital literacy barriers. Such initiatives could include workshops, one-on-one coaching sessions, and easily accessible instructional materials that demystify technology use.

Furthermore, innovative solutions for remote medication delivery and monitoring should be explored to ensure patient safety and adherence to treatment plans. This could involve integrating multidisciplinary teams, including pharmacists and care coordinators, into telehealth models to enhance medication management and reconciliation processes. Implementing standardized protocols for medication delivery can also mitigate risks associated with remote consultations, ensuring that patients receive clear instructions regarding their prescriptions and any necessary follow-up actions.

By addressing these barriers effectively, telemedicine can be further integrated into Singapore's healthcare system, improving access to care for older adults while enhancing their overall well-being. The potential benefits of telehealth are significant; however, realizing these advantages requires a concerted effort from healthcare providers, policymakers, and technology developers to create an inclusive environment that supports seniors in navigating this evolving landscape.

By addressing these issues, telemedicine can be further integrated into the healthcare system, improving access to care for older adults and enhancing their overall well-being.

Conclusions

This literature review highlights the increasing acceptance of telemedicine among older adults in Singapore. Key factors influencing this trend include the user-friendliness of telemedicine platforms, trust in healthcare providers, and the perceived benefits such as convenience, time-saving, and reduced infection risk. Strong support systems from family members, caregivers, and healthcare providers further facilitate the adoption of telemedicine. However, barriers to telemedicine adoption persist, particularly among older adults with lower levels of digital literacy. Additionally, concerns regarding the safety of medication delivery through remote means remain a significant challenge. To fully realize the potential of telemedicine for older adults, it is essential to address these limitations.

Future research should focus on developing user-friendly telemedicine interfaces tailored to the needs of older adults. Efforts should also be made to provide adequate training and support to help older adults overcome digital literacy barriers. Innovative solutions for remote medication delivery and monitoring should be explored to ensure patient safety and adherence to treatment plans. By addressing these issues, telemedicine can be further integrated into the healthcare system, improving access to care for older adults and enhancing their overall well-being.

This systematic review is subject to certain limitations. Firstly, the reliance on PubMed as the primary source of information may have limited the scope of the review. Other databases, such as Google Scholar, could have been included to identify additional relevant studies. Secondly, the inclusion criteria may have inadvertently excluded studies that did not explicitly mention telemedicine or telehealth in their titles or abstracts. Thirdly, the focus on English-language articles may have limited the inclusion of studies conducted in other languages. It is important to acknowledge that the findings of this review may not be generalizable to all older adults in Singapore. Cultural, socioeconomic, and individual factors may influence the adoption of telemedicine. Further research is needed to explore the specific needs and preferences of different subgroups of older adults.

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Exploring the Opportunities and Challenges of Implementing an Innovative Wearable Device to Improve the Quality of Care for Seniors

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Abstract

Singapore is a fast-ageing society with about 25% of citizens aged 65 years and over by 2030. The ubiquitous use of technology in Singapore means that technology could play a pivotal role in fostering independence and improving seniors' health. This paper discusses a novel gerotechnological innovation – the Smart Resident Monitoring System (SRMS) and wearable device – implemented at a Home for seniors in Singapore. Leveraging the findings from a formative evaluation of the SRMS, Ecological Systems Theory will be utilized to analyze and explore the benefits and challenges of the SRMS, and enhancements proposed to augment the independence, health and well-being of seniors residing in the Home.

Keywords: ecological systems theory, gerontology, healthy ageing, health technology, quality of life

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Introduction

Singapore is a rapidly ageing society, with the proportion of citizens aged 65 and above increasing from about 11% in 2012 to an estimated 25% by 2030 (National Population and Talent Division et al., 2022). In preparation for this 'silver tsunami', the Singapore government launched the 2023 Action Plan for Successful Ageing to address these issues, which aimed to strengthen support networks and to empower older persons to lead healthy lives while ageing-in-place (Ministry of Health, 2023). One of the thrusts under this Action Plan aims to empower seniors to age-in-place by leveraging on technology; thus, gerotechnology could play a potentially pivotal role in fostering independence and enhancing the quality of life (QOL) among Singaporean seniors.

The use of technology is already ubiquitous across various spheres of life in Singapore with smartphone ownership rates of over 92% and almost 94% of all respondents owning at least one digital device (Tadai & Tan, 2023). Among the senior population, a nationally representative study found the prevalence of digital technology use to be about 66%, but this decreased among those aged 80 years and above to just over 26% (Visaria et al., 2023). However, the same study found that health-related digital technology use among existing senior users was much lower at around 21%, and this too declined with age – from about 27% among seniors in their 60s to under 7% for seniors aged 80 and over.

A population level wearable-based initiative that promotes physical activity – the National Steps Challenge – requires participants to wear a fitness tracker on their wrist, as well as sync their activities with the Healthy365 app – had been successfully implemented in Singapore (Health Promotion Board, n.d.). Despite the need for participants to both wear a fitness tracker and use an app, the number of participants aged 60 and above grew from 16,000 in 2015 to 140,000 in 2018, and despite a dip due to the COVID-19 pandemic and related safe distancing measures, surpassed 240,000 in 2021 (Chong, 2022; Choo, 2019).

An evaluation of the National Steps Challenge found that a significant proportion of the 696,907 participants were of elevated risks of physical inactivity, for example, seniors aged 60 and over (Yao et al., 2022). However, the researchers also acknowledged that the senior study participants may not be representative of the broader senior population in Singapore. Despite this, the success of the National Step Challenge illustrates the willingness of a number of seniors to adopt some forms of technology and use wearables to track data, if a favourable ecosystem – such as a dynamic structure involving challenges and rewards, as well as a community to engage in the activities with – is put in place to support its implementation.

Getting seniors to remain physically active is important as those who are physically active are less likely to experience falls and fall-related injuries (Lee et al., 2022), and this in turn improves the probability of maintaining physical, mental and social health (World Health Organization, 2018). However, one in three community-dwelling older persons aged 65 years and above will still be expected to have at least one fall within a year (Ang et al., 2020), and falls are a leading cause of injury-related hospitalization among this population in Singapore (Health Promotion Board, 2015).

Smart Resident Monitoring System

The SRMS is an AI (Artificial Intelligence) powered, smart integrated monitoring solution that takes the form of a smart wearable device. It was partially funded by the National Council of Social Services (NCSS) in Singapore as it offered an innovative solution to help alleviate manpower challenges in the social sector (National Council of Social Service, n.d.).

The SRMS utilizes Bluetooth technology and a sensor monitoring and analytics programme to optimize the workload of care staff through a number of components that previously had to be done manually. This in turn helps staff to provide efficient and safe care for residents vis-à-vis conventional methods of routine checks and reactive care. It monitors a resident's data in a number of areas and proactively detects anomalies that indicate if an intervention is required and sends an alert to staff for their attention where needed. The SRMS consists of systems to monitor vital signs, to detect falls or violence, to manage laundry, to track residents' real time location, to grant access to rooms, as well as a health and wellness AI-driven dashboard. More details of the SRMS can be found in (Netto, 2023).

Analysis of the SRMS Wearable Device Using Ecological Systems Theory

The following section will use Urie Bronfenbrenner's (1979, 1986) Ecological Systems Theory to analyse how the SRMS had benefitted the seniors, some challenges faced in its implementation, as well as the opportunities to further enhance its ability to promote the independence, health, and well-being of seniors residing at the Home.

The microsystem involves the interrelations within the immediate setting of the individual (or senior in this instance), and occur at the level of day-to-day occurrences that steer behaviour (Bronfenbrenner, 1979). For the senior at the Home, this would include but not be limited to the staff working at the Home (nurses, nursing aids, case worker, physiotherapist, etc.), other seniors residing at the Home, their family members, their friends and other loved ones, other healthcare professionals they interact with (e.g. specialists at restructured or subsidized hospitals), as well as other community groups they may belong to (e.g. ministries in a church).

The mesosystem consists of "comprises the interrelations among two or more settings in which the developing person actively participates" or the "system of microsystems" (Bronfenbrenner, 1979, p. 25). In the context of the seniors at the Home where the SRMS was implemented, this may include the interactions between the family of the senior and the staff of the Home, or the interactions between the staff of the Home and the healthcare professionals whose patient is the senior residing at the Home.

The exosystem comprises one or more settings that do not include the person (or senior) directly, but which nonetheless can influence or be influenced by the microsystems the person is in (Bronfenbrenner, 1979). For the senior, this could include their family member's workplace – having to work long hours and not having flexible hours may prohibit them from visiting the senior at the Home regularly. However, the senior's exosystem could also include the Grassroots organisations, religious places of worship, and other support services located within that community.

The macrosystem is the broader socio-economic-political context in which the other systems exist, and also encompasses the myriad cultural norms, attitudes and beliefs that individuals

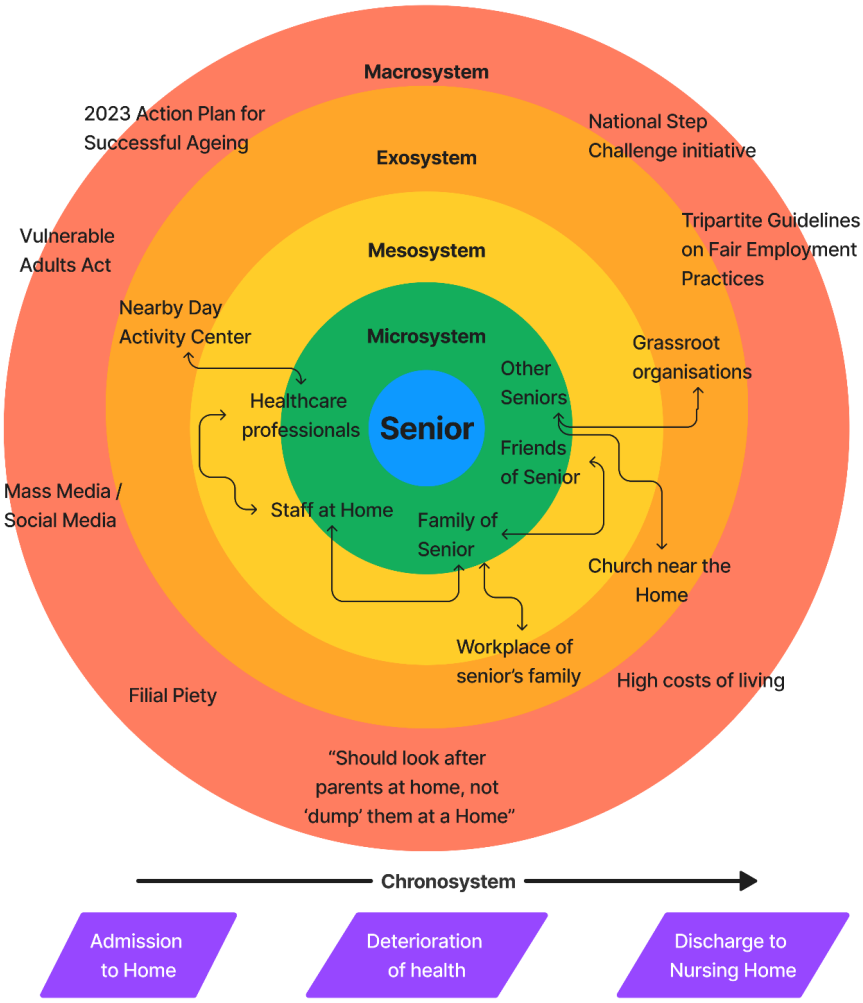
and systems exist within. For the senior at the Home, the macrosystem can take varied forms – government policies pertaining to "Ageing in Place", national level campaigns such as the National Step Challenge that aim to increase physical activity, laws against discriminating against seniors in terms of employment, the mass media's portrayal of seniors and their usage of technology, and even cultural norms of filial piety and the stigma of placing one's parent(s) in instituionalised care.

Last, the chronosystem was postulated at a later time and incorporated the influence on the person's development over time in the environments in which the person was living (Bronfenbrenner, 1986). In the context of the seniors living at the Home, these could involve their admission into the Home, their maintenance or deterioration of health over the course of their stay, as well as their transition into nursing care should they lose their functional abilities and are no longer able to care for themselves.

Please see diagram 1 for a possible Ecological Systems map depicting a hypothetical senior residing at the Home, and the corresponding entities that may exist in their respective systems.

Diagram 1

Ecological Systems Map of Hypothetical Senior Residing at the Home (created using Figma)



Less Reliance on the Microsystem to Detect Falls

In a formative evaluation conducted on the implementation of the wearable device paired with the SRMS, several benefits and challenges were found (Netto, 2023). One of the key findings related to the decrease in falls that went undetected; this has been shown in the literature to be fairly common among seniors who do not report their fall or seek medical assistance unless they are injured (Ang et al., 2020). The implications of these falls which go undetected include help not being immediately rendered which could exacerbate the prognosis of a senior's recovery, or for their health to deteriorate rapidly without necessary medical attention.

Hence, the implementation of the FVDS meant that most if not all falls would be detected and investigated by one of the staff, and for them to make an independent assessment of the senior's condition. In the past, the detection of a fall and the rendering of assistance depended on at least one of the entities within the senior's microsystem noticing the incident. However with the FVDS, there is no longer a reliance on staff or other seniors witnessing the fall as the FVDS plays the role of "informant" to automatically activate help from staff (or other healthcare professionals) when a fall is detected.

Although this is one of the clear benefits of this novel gerotechnological innovation, the SRMS has the potential to play a role in the senior's mesosystem, and further connect the senior with other elements of the microsystem. For example, could an alert or notification also be pushed to the senior's family so that they are kept apprised of their situation? Although it is acknowledged that doing so, including making connections with other parties could have disadvantages and potential consequences (e.g. inducing anxiety), there is also the potential for it to improve the relationships that the senior has with important parts of their microsystem. Maintaining information flow across entities for the senior's safety and well-being could also foster trust and transparency, further strengthening the connections between components of the microsystem, such as the relationship between the staff and the senior's family.

Similarly, data harnessed from other components such as the VSMS and HWD could be, with the senior's informed consent, shared with their healthcare professionals so as to improve the quality of care provided as the doctors and specialists could now rely on a larger dataset rather than solely on that collected during the time of their visit to the hospital or clinic. All these serve to enhance the strength of the connections within the senior's mesosystem, with the ultimate purpose of improving the senior's quality of life.

Improving Seniors' Willingness to Use Wearable Device

Research had found that wearing a fall detection device all the time can be frustrating or annoying, and the senior may also need to remember to wear the device (Hassan et al., 2023). Therefore, another challenge posed to the success of the SRMS is the seniors' willingness to use the wearable device throughout the day at the Home. It is noteworthy that one of the elements in the macrosystem (as depicted in Diagram 1) that may have been helpful in sensitizing the seniors to use a wearable device, is the Singapore Health Promotion Board's National Step Challenge (NSC) which is a national level initiative that encourage physical activity using a wearable device as well as a rewards and incentive programme using a series of challenges to encourage positive health behaviours. Those seniors who had participated in the NSC may be more likely to adopt the wearable device at the Home.

Although research had found that seniors may not see a need for fall detection devices or were embarrassed by them (Gettel et al., 2021), there had been other research that stated enablers which could encourage seniors to adopt new technology. In one study, the researchers found that the social environment could be a key factor in shaping the adoption of technology, and seniors were more confident about learning how to use new digital technologies when assistance was provided by others rather than their experimenting on their own (Tadai & Tan, 2023). Other studies also found that seniors with stronger social networks were more likely to use digital technology for health-related purposes (Visaria et al., 2023), and that social influences could help facilitate the use of technology as perceived ease of use is another factor that encouraged seniors to use technology (Perdana & Mokhtar, 2022).

Taken together, the Home could enhance the adoption and compliance of utilizing the wearable device by leveraging existing social networks of seniors to build their confidence as well as nurture organic peer support groups that could improve seniors' perceptions of the wearable device.

Digitalising Tasks and Improving Quality of Care for Seniors

There were several tasks that had been automated or digitalized by the SRMS which have not only reduced the manpower requirements to execute tasks such as tracking seniors' individual laundry or tracking their attendance at mealtimes, but also improved the quality of care provided to the seniors. For example, staff had to rely on either their observations of seniors or reports from seniors' fellow roommates to ascertain if a senior had taken their meal; with the RTLS, the seniors' attendance are automatically updated via their wearable device through the Bluetooth gateways at the cafeteria. Similarly, the ability of staff to restrict access to certain locations depends on their patrolling these areas if these locations cannot be physically restricted (e.g. lock and key). In future, the RTLS and ACS could be enhanced to grant access that is personalized and factors in information such as the specific location, the time of day, as well as the senior's risk of falling, before granting or denying access.

In this and other instances, the SRMS has the added benefit of saving the staff's time to be able to improve the quality of life of the seniors, through ways directly linked to the SRMS such as through following up on the proposed actions in the HWD, but also in other intangible ways such as in having more time to initiate informal interactions with seniors at the Home.

The SRMS also improves the decisions made by staff that directly impact the senior's well-being as it leverages technologies to process the data collected by the SRMS and wearable device to propose recommendations that may not otherwise had been devised by the staff. An example of this would be the features of the VSMS or HWD which uses AI technology to detect changes in the seniors' activities that may otherwise go unnoticed; following, staff can take pro-active actions to at least investigate or rectify issues before they worsen.

Creation or Enhancement of Senior's Mesosystem

One potential application of the SRMS that has not been fully harnessed is the creation of a connection between two or more entities in the senior's microsystem, i.e. the creation of a mesosystem connection such as between the staff and healthcare professionals the senior may visit at the hospital as an out-patient, or the strengthening of existing connections through the

exchange of information that seeks to improve the decision-making made by the respective entities for the benefit of the senior.

There may be scenarios where it is advantages for the mesosystem to be created or enhanced, as opposed to relying on the senior's provision of information. For example, some seniors may not offer information about their health status unless specifically asked, may misinterpret the information they had received, or they may simply forget to do so. Having a connection between the staff and healthcare professionals would mitigate this possibility, with the benefit of improving the quality of decisions made for the senior.

Last, there is also potential to improve the connections between the staff and the family of the senior. Seniors may at times feel that their family is not as involved in their lives when they stay in an institutionalized setting; family members may also feel anxious or even ambivalent about their loved one residing at the Home. Hence, the provision of connections which push selected information (e.g. steps taken during the day) would create a greater connection between the senior and their family living apart, and possibly allow the seniors' family to also partake in the seniors' well-being. For illustration, if a drop in the physical activity of the senior had been detected over a week, a "nudge" could be sent to the family member informing them of this and encouraging them to visit or call their loved one to check in on them. This has the potential to improve relationships and enhance the well-being of both the senior and their family.

Conclusion

With Singapore's fast-ageing population and shrinking workforce, the need to harness innovative technologies to overcome the challenges posed by these shifts in demographics (such as manpower needs) also presents an opportunity for novel practices that could enable seniors to live healthy, independent lives. A scoping review had found that technological innovations that sought to tackle fall detection and ambient-assisted living could assist seniors to "age in place" (Gettel et al., 2021). The SRMS and the accompanying wearable device is one such application of technology that could potentially benefit seniors, the quality of care they receive, thus improving their overall quality of life.

The implementation of the SRMS and wearable device encapsulates the Social Work mission of enhancing the lives and well-being of vulnerable members of our society, and is aligned with the Social Work value of augmenting the "Dignity and worth of the person" through its various features that serve to foster a more independent and empowered environment that allows the seniors at the Home to thrive.

The analysis using Bronfenbrenner's Ecological Systems Theory (1979) also highlighted the potential for the SRMS to further improve the connections between the senior and other systems in their microsystem, but also the connections between entities in the senior's microsystem (i.e. mesosystem). All these would serve to enhance the connections and resources availed to the senior and would be aligned with the Social Work value of "Importance of human relationships".

The SRMS also reduces the reliance on entities in the microsystem (staff and other seniors) to the use of technology (SRMS) to activate help where needed. This prevents scenarios where the senior may have had a fall that was undetected and medical assistance was not rendered

promptly. This in turn may reduce any anxiety the seniors may feel about falling, and decrease the likelihood that they reduce their daily activities to avoid falling.

The SRMS is able to efficiently execute labourious tasks previously undertaken by staff, such as taking a senior's attendance at mealtimes, tracking whether they had done their laundry recently, granting them access to their rooms or restricting access to unsafe areas – saving up staff's time to spend on higher value tasks that directly benefit the seniors' well-being. The SRMS is also able to integrate more sophisticated technologies, such as AI, to process data collected from the wearable device to proactively alert staff on falls so that prompt assistance can be provided, or to indicate anomalies or changes in behaviour that may otherwise not have been detected by staff.

In sum, the SRMS and the accompanying wearable device appears to be a novel gerotechnological innovation that has the potential to augment the independence, health and well-being of seniors in an institutionalized setting, with the overarching aim of enhancing their overall quality of life.

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Analysis of the Meaningful Cognition and Concerned Actions of Elderly People on Agri-Food Safety in Taiwan

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Abstract

The aging population in Taiwan is accelerating year by year. Taiwan became an aging society in 2018, and it is expected to enter a super-aged society by 2025. Food safety for the elderly is an important cornerstone of health. This study aimed to investigate the differences in demographic attributes, meaningful cognition, and concerned actions of the elderly regarding agricultural food (abbreviated as agri-food) safety. The study was conducted through a questionnaire survey and semi-structured interviews. The questionnaire survey employed purposive sampling and yielded a total of 151 valid responses. Semi-structured interviews were conducted with five elderly individuals. The quantitative data were analyzed using descriptive statistics, t-tests, and one-way ANOVA, while qualitative data were analyzed using the semi-structured interview method. We found the following: 1. Meaningful cognition of agri-food safety: Elderly individuals are concerned about agri-food safety in terms of the source, nutritional content, and labeling, but show a lack of awareness regarding utensils/containers and packaging of agri-food products. 2. Concerned actions regarding agri-food safety: Elderly individuals refuse to buy agri-food products with safety issues, yet demonstrate limited awareness of food-related terminology. 3. Differences in agri-food safety cognition by demographic variables: Purchasing behavior significantly affects both meaningful cognition and concerned actions regarding agri-food safety. The findings of this study provide useful suggestions for promoting food safety awareness among the elderly.

Keywords: agriculture food/agri-food, food safety, elderly, good health and well-being

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Introduction

Aging is an inevitable biological process commonly measured by chronological age. By convention, individuals aged 65 and older are often referred to as “seniors”. The term “elderly” traditionally encompasses those aged 65 and above, with individuals aged 65 to 74 classified as the “early elderly” and those aged 75 and older as the “late elderly” (Orimo et al., 2006; Singh, 2014; WHO, 2010). It is important to recognize that the aging process is not uniform, as it is shaped by various factors, including genetics, environmental influences, lifestyle choices, socioeconomic conditions, psychological well-being, and overall health status (Kirkwood, 2008; Singh, 2014). The mystery of aging lies in the interplay between genetic, environmental, and lifestyle factors throughout the aging process. Achieving a healthy and fulfilling life remains a central goal for elderly persons.

Ensuring food safety is therefore a critical component of healthcare for the elderly (FoodSafety.gov, 2018a; FoodSafety.gov, 2018b; University of California, Davis, 2018; University of Delaware Cooperative Extension, 2018). Graham and Bartlett (2014) discussed food safety issues specific to elderly persons and provided insights into how food safety perceptions can reduce health risks. Cultivate the elderly about the importance of food safety and empowering them to make safe food choices is essential for protecting their health, preventing disease, and enhancing their overall quality of life (Linden & Turner, 2011). Educating the elderly on food safety and helping them make informed choices is key to the SDGs' goal of promoting better health and well-being.

In Taiwan until the July 2024 census, there are currently 4,402,398 senior citizens aged 65 or older, accounting for 18.8% of the total population of 2,340,932 (Department of Household Registration, Ministry of the Interior, 2024). Taiwan has become an aging society in 2018, it is estimated that by 2025, more than 20% of the population will be elderly and Taiwan will become a super-age society (National Development Council, 2024). Taiwan in the first quarter of 2024, it broke out a number of food safety incidents, not only the ingredients of the raw materials in trouble, and many large-scale chain restaurant groups have also fallen into the worries of food safety (Chiu, 2024). The elderly are often the best attackers of unsafety food.

This study aimed to investigate the differences in demographic attributes, meaningful cognition and concerned actions of the elderly regarding agri-food safety. The concrete purposes are as followings: (1) To understand the situation of meaningful cognition of agri-food safety by elderly. (2) To understand the situation of concerned actions agri-food safety by elderly. (3) To explore meaningful cognition differences of agri-food safety by demographic variables. (4) To explore concerned actions differences of agri-food safety by demographic variables.

The Elderly and Agri-Food Safety

The World Health Organization (WHO) had highlighted the increasing number and proportion of people aged 60 and over. In 2019, there were 1 billion people aged 60 and above. By 2030, this figure is expected to rise to 1.4 billion, and by 2050, to 2.1 billion. Caring for the health and well-being of elderly is a crucial task for sustainable development (World Health Organization, 2024). According to United Nations Report of Department of Economic and Social Affairs, Population Division (2022) provided the latest global and regional population data, with a focus on the trends and impacts of population aging on

society, economy, and health. It predicts that by 2050, people aged 65 and above will constitute over 16% of the global population. According to "Act Governing Food Safety and Sanitation" it focuses on the safety of original foods and products, special dietary foods, food additives, food utensils, food containers or packaging, food cleansers, food business operators, labels, nutrition label, genetic modification, processing aid and so on (Laws and Regulations Database, The Republic China, 2025). We emphasized on selecting healthy sources of products and additives, ensuring safe and appropriate packaging of produce, and providing clear produce and nutrition labelling as the scope of the study on agri-food safety. Food occupies a substantial part of older Chinese people's daily lives (Liu & Grunert, 2020). A healthy quality of life can only be achieved if the elderly gets a proper understanding meaning of food and make informed food choices.

Food is not only a source of nutrients and energy but also a potential source of contaminants and toxicity. If educated consumers were asked about the primary sources of food contamination, they would most likely identify pesticides first, followed by environmental chemicals. Few would mention food packaging materials. However, the number of contaminants originating from food contact materials is significant: thousands of substances are used, and tens of thousands migrate above toxicological concern thresholds (Grob et al., 2006). MDPI (2023) explored the interactions between packaging materials and food products, focusing on processes such as permeation, migration, and sorption. It emphasizes that numerous chemical compounds can migrate from packaging into food, potentially posing health risks to consumers. This perspective is surprising to many people, as product packaging itself can also pose contamination risks!

Petersen et al. (1999) highlighted the trend towards the marketing of bio-based raw materials, such as starches and biologically derived monomers, as environmentally friendly packaging materials. As Grob et al. (2006) stated many appear to live with an unbalanced view, insisting on organic (pesticide-free) farming, but not realizing that other sources far more severely contaminate their foods. This becomes apparent when a compound from a packaging material migrating into "organic" food also happens to be used as a pesticide. Liang et al. (2023) showed that organic food is widely popular and that transparent packaging of organic food has a significant effect on consumer purchase intention. What are the most important considerations for food packaging/utensils/containers? Obviously, the interaction between food and packaging materials, containers and temperatures, and whether there are problems with toxin release from the contact surfaces are all factors that need to be taken into account for the elderly.

Consumers primarily learn about the source and safety of food products by reading the labels on packaging. For example, there is a rapidly increasing global demand for healthy meat products with reduced levels of fat and sodium chloride, as well as the incorporation of health-enhancing ingredients. The FDA (2025) provides guidance tailored for older adults on interpreting Nutrition Facts labels, emphasizing nutrients crucial for this age group. This resource aids in making informed dietary choices. Therefore, it is crucial for food packaging to clearly inform the elderly about the safety of agri-food ingredients, additives, and any warnings relevant to their consumption, it keeps food safety for the elderly.

Food safety labeling plays a crucial role in influencing consumer purchasing behavior. Factors such as consumers' awareness of the labels, their trust in the information provided, and their personal health consciousness significantly affect their purchasing decisions. Therefore, raising awareness of food safety labeling among elderly consumers is essential to

promoting healthy purchasing behaviors. Examining agri-food labeling worldwide, although food safety laws exist to regulate food labeling, the sheer number of agri-food items makes it extremely challenging for food safety authorities to inspect each one individually. He et al. (2019) noted that food safety is one of the fundamental needs of residents in daily life, and negative perceptions of food safety can potentially lead to public panic and dissatisfaction with government performance. Greater efforts are needed to provide direct agri-food safety protection for the elderly.

Research Design

Participants

Both of questionnaire survey and semi-structured interview are adopted in this study. The questionnaire survey was based on a purposive sampling with a total of 151 valid participants. The elderly who live in the North, Central and South regions of Taiwan, and then expanding by the social media, such as Line, email, or Facebook, and supplemented with the Google Forms and the physical questionnaires to send them to answer the questionnaires. Totally of 160 questionnaires were sent out, and 151 valid questionnaires were returned. The participants background is as shown in Table 1 Distribution of participants' background.

Table 1
Distribution of Participants' Background

Demographic Variables	Group	Number	%
Gender	1. Male	62	41.1
	2. Female	89	58.9
Age	1.65-69	71	47
	2.70-74	73	48.3
	3.up 75	7	4.6
Academic career	Below junior high school	3	2
	Senior high school	33	21.9
	Bachelor	57	37.7
	Master	30	19.9
	Ph.D.	28	18.5
Purchasing behavior	Clear label	115	76.2
	Accept clear and no label	33	21.9
	No consideration of label	3	2.0

N=151

Semi-structured interviews were conducted with 5 randomly selected respondents, each of whom took about 30 to 50 minutes to complete interview, conducting in a comfortable and familiar environment, and in accordance with the principle of confidentiality, no personal information was disclosed.

Instrument

The survey data collection tool "Survey Questionnaire on Agri-food Safety Among the Elderly" included: a brief introductory paragraph that consisted of a description of the survey objectives, purpose, definition of agri-food and a consent statement to participate in the survey. Then, the second part consisted of meaningful cognition within 7 items, the third part consisted of Concerned Actions within 7 items. Finally, there are the participants' demographic variable including gender, age, academic career and purchasing behavior.

The questionnaire items are referenced related and food safety of government regulations. It adopts Likert-type five-point scale. The overall Cronbach's alpha reliability coefficient was .911, the meaning perception level coefficient Cronbach's alpha reliability was .844, and the concerned actions level Cronbach's alpha reliability coefficient was .831. The consistency and stability of the survey questionnaire at the overall and partial levels are quite good. The semi-structured interview items follow questionnaire level and items, and inspire participants to explain why you think this way.

Data Analysis

The quantitative data were processed by descriptive statistics, t-test, and one-way ANOVA by SPSS 23.0 Software. Descriptive statistics were conducted using frequencies, percentages, and calculations of scales' means. The semi-structured interview method was used to analyze the qualitative data. Names will be given as code numbers and the statement of findings will be annotated with the code number and the date of the interview.

Results

The Situation of Meaningful Cognition of Agri-Food Safety by Elderly

Results of Questionnaire Survey

The results in Table 2 is "The situation of meaningful cognition of agri-food safety by elderly", it shows that the scores of current status of elderly meaningful cognition of agri-food safety by the elderly. Table 2 shows first in the ranking "I properly read the information on ingredients/special nutritional formulas/food additives of the agri-food products" (M = 3.92, SD = 1.10). The second in the ranking of table 3 appears "I understand the meaning of agri-food labelling/nutrition labelling/GM/processing aids" (M = 3.79, SD = 0.99).

Table 2
The Situation of Meaningful Cognition of Agri-Food Safety by Elderly

variable/ Items	No.	M	SD	Ranking
Total meaningful cognition	151	3.68	.81	
1. I understand the significance of ingredients/spe nutritional formulations/food additives in agri-f products.	151	3.71	1.08	3
2. I understand the significance of the use of utensils/containers and packaging for agri-food products/food traders.	151	3.53	1.16	7
3. I understand the meaning of agri-food labelling/nutrition labelling/GM/processing aids	151	3.79	.99	2
4. I understand the criteria for judging the safety of agri-food products.	151	3.54	1.29	6
5. I properly read the information on ingredients/special nutritional formulas/food additives of the agri-food products	151	3.92	1.10	1
6. I properly read the information on the utensils/containers and packaging/food industry used for agri-food products.	151	3.65	1.15	5
7. I properly read information on pesticide labels/nutrition labels/GMO/processing aids.	151	3.69	1.08	4

N=151

This finding is consistent with Grunert and Wills (2007), confirming that clear and readable label designs enhance the elderly's understanding of food safety. However, some elderly individuals reported difficulty understanding technical terms, highlighting the need for further simplification of label content or additional educational support.

Results of Semi-interview

Elderly E1 feedback her ideas to review meaningful cognition of agri-food safety of the significance. She said "If they don't care or don't understand it at all, eating wrongly will affect their health" (E1, 2024/08/31). Elderly E3 feedback his ideas "Food additives are also added to many agricultural food products, which requires a lot of expertise in this area, or else you won't know what it means when you read it" (E3, 2024/09/02).

According to Chen et al. (2020), the elderly tend to rely on food label information to make healthier choices, but their interpretation abilities are limited by their education level and past experiences. Food additives have consistently been a focal point of concern among the elderly. Their risk perception of these components is often accompanied by uncertainty, especially when lacking scientific knowledge impacts actions.

The Situation of Concerned Actions of Agri-Food Safety by Elderly

The results in Table 3 is "The situation of concerned actions of agri-food safety by elderly", it shows that the scores of current situation of concerned actions of agri-food safety by the elderly. Table 3 shows first in the ranking "I don't buy any agri-food products that have problems with ingredients, nutritional formulas, containers, packaging, base modifications, or additives" (M = 4.56, SD = 0.78). The second in the ranking of table 3 appears "I don't buy any agri-food products that have food hygiene or safety problems that may lead to illness or poisoning" (M = 4.52, SD = 0 .86).

Table 3

The Situation of Concerned Actions of Agri-Food Safety By Elderly

variable/ Items	No.	M	SD	Ranking
Total concerned actions	151	4.13	.65	
1. I will explore the safety of agri-food products tha may cause illness or food poisoning..	151	4.23	.91	4
2. I will pay attention to the reasonable standards o ingredients, nutritional formulations and additives of agri-food products.	151	3.63	1.02	7
3. I will judge the safety of utensils, containers and packaging, food additives of agri-food products.	151	3.93	.92	5
4. I can judge the safety of food labelling, nutrition labelling, and genetically modified technologies in agri-food products..	151	3.82	1.01	6
5. I don't buy any agri-food products that have food hygiene or safety problems that may lead to illness or poisoning.	151	4.52	.86	2
6. I don't buy any agri-food products that have problems with ingredients, nutritional formulas, containers, packaging, base modifications, or additives.	151	4.56	.78	1
7. I will take action to support food hygiene, food safety, disease reduction, poisoning prevention, and other issues related to agri-food safety.	151	4.28	.91	3

N=151

These findings indicate that elderly persons tend to be more cautious about food safety due to health concerns and a higher susceptibility to foodborne illnesses. Their avoidance of products with problematic ingredients or additives reflects a heightened awareness of food quality, which is supported by studies emphasizing the importance of labeling and transparency for consumer trust (Johnson & Chen, 2020).

Results of Semi-interview

Elderly E5 expressed her views on the return experience of defective agricultural products. She said "I'm a vegan. Once I bought a rice burger, there was something hard and transparent in the rice burger, I returned the product to Organic Shop, however, I no longer buy the processed product produced by this factory of rice burger" (E5, 2024/08/31).

Elderly E4 said about her background about operating a chain of drugstores, she focuses on great importance to food safety. She said "I am carefully in eating agri-food. If I eat problematic agri-food, the body will definitely react to sensitive phenomena, natural allergies, so I am very concerned about food and food additives. I will use the production of brands, or small farmers market past purchasing experience to make a judgement to buy the brand, I care about eating safe and secure to avoid poisoning" (E4, 2024/09/04). E4 insights underscore the role of personal experience and trust in brand reputation in influencing purchasing decisions. As noted by Wilson et al. (2022), consumers often rely on past experiences and perceived reliability when evaluating the safety of agri-food products.

Meaningful Cognition Differences of Agri-Food Safety by Demographic Variable

Results of Questionnaire Survey

The results in Table 4 is "Meaningful cognition differences of agri-food safety by demographic variables." It highlights the meaningful cognition scores regarding differences in the perceived importance of agri-food safety across demographic variables, including gender, age, academic background, and purchasing behavior. Table 4 indicates that only purchasing behavior shows significant differences in meaningful cognition ($F = 5.41^{**}$, $p < .01$). The results of statistical post-hoc comparisons reveal that individuals who prioritize clear labeling have significantly higher perception scores than those who never consider labeling. Other demographic variables (gender, age, academic background) do not show significant differences.

Table 4
Meaningful Cognition Differences of Agri-Food Safety by Demographic Variables

Demographic Variables	Group	No.	M	SD	t-test, ANOVA	p-value
Gender	1. Male	62	3.77	0.81	1.08	.28
	2. Female	89	3.62	0.81	(t-value)	
Age	1.65-69	71	3.53	.79	2.53	
	2.70-74	73	3.83	.78	(F-value)	.08
	3.up 75	7	3.71	1.05		
Academic career	1.Below junior high school	3	3.57	.49	1.059	
	2.Senior high school	33	3.77	.87	(F-value)	.37
	3.Bachelor	57	3.66	.77		
	4.Master	30	3.86	.82		
	5.Ph.D.	28	3.45	.81		
Purchasing behavior	1.Clear label	115	3.78	.76	5.41**	.005
	2.Accept clear and no label	33	3.45	.84	(F-value)	
	3.Never consideration of label	3	2.57	.93		

N=151; **p<.01

These results highlight the need for industry and policymakers to prioritize the standardization of clear and transparent food labeling. As Johnson and Chen (2020) found that consumers who actively seek clear and transparent labeling demonstrate higher levels of trust in food products and exhibit greater awareness of potential food safety risks. This behavior underscores the importance of labeling clarity in shaping consumer perceptions and purchasing decisions.

Results of Semi-interview

Elderly E3 said that "In Taiwan, organic shops, particularly those operated by Liren, are among the most credible and large-scale establishments, with clear labeling and traceable producers. However, the prices are high, and my pension is sometimes insufficient to cover the expenses. Therefore, I often choose organic foods to purchase reputable brands with clear labeling from RT-Mart" (E3, 2024/09/02). E3 perspective reflects the growing consumer demand for clear labeling and traceability in the agri-food industry, which is supported by research indicating that transparent labeling enhances consumer trust and facilitates informed decision-making (Johnson & Chen, 2020). Moreover, the economic challenges faced by E3, such as balancing the cost of organic foods and limited financial resources, highlight the need for policies that make safe and organic food more accessible to low-income populations (Lee & Park, 2020).

Elderly E4 emphasized the importance of labeling and consumer education. "The best approach would be to include warning messages on labels that explain the effects and hazards of poisoning, disease, and hygiene issues. Most people are unaware of the legal range of ingredients subject to national testing standards, and it is only when incidents occur that the causes of poisoning or standard violations are disclosed." (E4, 2024/09/04). As Zhao et al. (2019) highlighted the role of consumer engagement in enhancing food safety practices. By providing transparent and easily accessible safety information, supermarkets and vendors can bridge the knowledge gap and build consumer trust.

Concerned Actions Differences of Agri-Food Safety by Demographic Variable

Results of Questionnaire Survey

The results in Table 5 is "Concerned actions differences of agri-food safety by demographic variables" indicates that only purchasing behavior shows significant differences in concerned actions (F = 4.92**, p < .01). The results of the statistical post-hoc comparisons reveal that individuals who prioritize clear labeling demonstrate significantly higher scores than those who never consider labeling. Other demographic variable (gender, age, academic background) do not show significant differences.

Table 5
Concerned Actions Differences of Agri-Food Safety by Demographic Variables

Demographic Variables	Group	No.	M	SD	t-test, ANOVA	p-value
Gender	1.Male	62	4.03	.74	3.57	.11
	2.Female	89	4.20	.57	(t-value)	
Age	1.65-69	71	4.13	.57	.31	.73
	2.70-74	73	4.12	.73	(F-value)	
	3.up 75	7	4.32	.34		
Academic career	1.Below junior high school	3	3.52	.16	.80	.52
	2.Senior high school	33	4.18	.58	(F-value)	
	3.Bachelor	57	4.17	.49		
	4.Master	30	4.12	.92		
	5.Ph.D.	28	4.08	.67		
Purchasing behavior	1.Clear label	115	4.42	.59	4.92**	.009
	2.Accept clear and no label	33	4.35	.67	(F-value)	
	3.Never considerations of label	3	3.90	.16		

N=151, **p<.01

Johnson and Chen (2020) found that consumers who regularly examine product labels are more likely to make informed decisions about food safety, highlighting the importance of transparency in labeling practices. Actually, clearly labeled and certified organic products are perceived as safer and more reliable, which can encourage proactive purchasing behavior.

Results of Semi-interview

Elderly E5 stated that "I think many agri-food products have problems with ingredients, nutritional formulas, containers, packaging, base modifications, or additives. If you discover problems related to agri-food safety, hygiene, or labeling, you should refuse to buy them" (E5, 2024/08/31). Elderly E1 highlighted current labeling practices "At most, the date of manufacture and the expiry date are written on the packaging, but there are rarely labels advising against consumption for specific groups or warning about potential health impacts. For many consumers, the concept becomes: as long as the food is within the expiry date, it is safe to eat. However, food safety should rely on the conscience of producers and sellers" (E1, 2024/08/31).

E1's perspective aligns with findings by Wilson et al. (2022), who emphasized that insufficient labeling can lead to misconceptions about food safety. Clear and detailed labeling,

including warnings for specific populations, has been shown to improve consumer understanding and reduce the risk of foodborne illnesses.

Conclusions

Meaningful Cognition of Agri-Food Safety: Elderly People Are Concerned About Agri-Food Safety in Terms of Source, Nutritional Content and Labeling

This study found that elderly individuals show strong concern in these areas, for example, they tend to carefully read information on ingredients, special nutritional formulas, and food additives in agri-food products. They also strive to understand the meaning of agri-food labelling, nutrition labelling, genetically modified (GM) content, and processing aids. However, they often struggle to grasp key points related to the use of utensils, containers, and packaging for agri-food products. This is likely because their primary concern is maintaining their health.

As Elderly E1 emphasized that a lack of understanding or disregard for food safety could lead to consuming harmful products, thereby impacting their health. Similarly, Elderly E3 expressed a desire to understand labeling better but noted that the excessive use of complex terms, such as unintelligible additives and technical jargon, makes it difficult for them to interpret the information.

Concerned Actions of Agri-Food Safety: Refusal to Buy Agri-Food With Safety Issues and Lack of Awareness of Food Terminology

Elderly people avoid purchasing agri-food products that have issues with ingredients, nutritional formulas, containers, packaging, base modifications, or additives. They also refrain from buying agri-food products that exhibit food hygiene or safety problems that could potentially lead to illness or poisoning. However, they often lack the proactive actions needed to evaluate the reasonable standards of ingredients, nutritional formulations, and additives in agri-food products. In fact, understanding the standards for ingredients, nutritional formulations, and additives can be quite complex and challenging.

The findings on concerned actions related to agri-food safety suggest that elderly people often rely on their past experiences to determine which products are safe to buy. They may struggle to understand the legal standards for ingredients, nutritional formulations, and additives in agri-food products. This underscores the need for clearer, more accessible information about food safety for the elderly, which could help them make more informed decisions and ensure their safety when purchasing food products.

Differences in Agri-Food Safety by Demographic Variables: Purchasing Behavior Significantly Affects Both Meaningful Cognition and Concerned Actions

This study finds that only purchasing behavior among the demographic variable, shows significant effects on both meaningful cognition and concerned actions regarding agri-food safety. The results of the statistical post-hoc comparisons indicate that individuals who consider clear labeling in their purchasing decisions have significantly higher perception and action scores than those who do not consider labeling at all. Other demographic variables, such as gender, age, and academic background, do not show significant effects.

Elderly E3, who is particularly concerned about the health of his family, especially focus on clear labeling with traceability of producers. Elderly E4 emphasized that labels should ideally include warning messages to inform consumers of potential risks. Purchasing agri-food products with clear labeling provides elderly consumers with greater assurance about the safety of their food choices. Clear and comprehensive labeling including information on contents, manufacturing and expiry dates, nutritional content, additives, and health warnings should be considered standard practice for ensuring agri-food safety. Labels serve as a vital proof of identity and a safeguard for consumers' health and well-being.

According above conclusions, this study provides following suggestions. 1. Labelling of appliances, containers, packaging and manufacturers, with information on conformity certification clearly visible. 2. Create a special food sales corner for the elderly, if they have their food corner at supermarkets will be convenient to purchase what they hope to own safe agri-food. 3. Specifying the contents of agri-food labels give qualification mark. It will provide for the health and well-being of the elderly and a friendly and sustainable environment.

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Quantifying Quality of Life for Aging Populations in Singapore: A Framework for Policy

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Abstract

In this paper, I propose a flexible Quality of Life (QOL) index tailored specifically for elderly populations in Singapore, aimed at providing policymakers with a quantifiable tool for municipal planning. The index incorporates measurable latent constructs, derived from a qualitative literature review, that reflect key dimensions such as health, social inclusion, and environmental quality, with each dimension equally weighted. The data for this analysis come from open resources, including geographic, demographic, and healthcare datasets from Singaporean government platforms such as data.gov.sg, singstat.gov.sg, moh.gov.sg, chas.sg, and pa.gov.sg. Preliminary results highlight that neighborhoods in the western region of Singapore score lowest on the QOL index, suggesting targeted interventions like enhanced infrastructure investments in these areas. By enabling systematic quantification and comparison of QOL across municipalities, the index supports data-driven urban planning, advancing ageing-in-place strategies. Through this adaptable framework, policymakers can adjust factor weightings, select different latent constructs, or integrate additional data sources to better align with local priorities and objectives, allowing for responsive planning that meets the evolving needs of elderly residents. Ultimately, this QOL index provides a promising approach for local governments to gain valuable insights, align resources, and implement targeted policies to improve the QOL for aging communities.

Keywords: quality of life, urban planning, age-friendly cities, data-driven

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Introduction

Measuring Quality of Life (QOL) is essential for understanding how well-being, life satisfaction, and social equity intersect within communities (Carr et al., 1996). Although inherently subjective and multidimensional, QOL indicators are vital for guiding interventions, policy assessments, and decisions that shape people's adaptive capacity in changing environments (Addington-Hall & Kalra, 2001).

As individuals age, their well-being is increasingly influenced by the quality of their urban surroundings. In Singapore, this trend is particularly pronounced: by 2030, it is projected that one in four residents will be aged 65 or above, marking an 11% rise in the elderly population (Asian Development Bank, 2020). Globally, the number of elderly individuals is projected to reach 1.2 billion by 2025, doubling to 2 billion by 2050 (World Health Organization, 2008, 2015). Without proactive strategies, such demographic shifts risk exposing systemic disparities in health, infrastructure, and social support systems. Important considerations for equity and access to care within urban areas include age, income, and neighborhood environments (World Health Organization, 2015).

While international interest in QOL measurement is growing, Singapore's research landscape remains fragmented. As Tan and Tambyah (2024) observe, there is currently no composite index specifically designed to assess the QOL of elderly populations using open-access government data. This fragmentation makes it difficult for policymakers to monitor well-being or implement targeted, geographically informed aging-in-place strategies. Globally, employment, income, and social participation have been recognized as central pillars of QOL. However, these components are inherently subjective and interpreted differently across contexts, making it challenging to define a unified, operational framework (Dayanandan & Mehta, 2022). Moreover, many existing models fail to offer spatial granularity, limiting their utility in local urban planning.

This study responds to the current lack of spatially grounded measures of elderly QOL in Singapore by developing a flexible, data-driven Elderly QOL Index at the municipal (planning area) level. The index is constructed using open-source demographic, infrastructural, and geospatial data, and incorporates measurable latent constructs, reflecting four key dimensions of elderly well-being: social well-being, financial well-being, healthcare access, and income security.

These dimensions are selected based on their theoretical relevance to healthy aging and urban equity, and they are applied consistently across neighborhoods using a transparent and replicable scoring framework. By integrating objective proxies and geospatial methods, this study offers a quantifiable approach to assessing elderly well-being at the neighborhood level. In doing so, it provides an evidence-based planning tool to support aging-in-place strategies and inform municipal-level policy interventions.

This study is guided by the following research questions:

1. How can elderly QOL be quantified at the neighborhood level in Singapore?
    a. What data sources and methodological frameworks can be used to construct a replicable QOL index using publicly available data?
2. What are the key social, economic, and health-related dimensions that influence elderly QOL across planning areas?

   a. How do these dimensions interact or correlate, and what spatial patterns emerge across neighborhoods?
3. How can a data-driven Elderly QOL Index support policy and urban planning decisions in aging societies?
   a. What insights from spatial disparities in QOL scores can inform targeted infrastructure investment and service delivery for older adults?

Review of Related Literature

The measurement of QOL has evolved significantly, reflecting growing awareness of the complexity involved in assessing urban well-being. Early efforts by Liu (1976) relied on objective statistical indicators—such as income, employment, and access to amenities—to measure QOL in U.S. metropolitan areas. This work established the precedent for using standardized indicators at the neighborhood and city level to evaluate urban conditions. Subsequent scholars refined these foundations. Dasgupta and Weale (1992) distinguished between QOL indicators that measure the actual constituents of well-being (e.g., health, education) and those that assess access to the determinants (e.g., income, shelter, infrastructure). This conceptual clarity supports the dual emphasis on both objective services and subjective experience in later QOL models.

In the European context, Weber and Hirsch (1992) innovated the use of remote sensing (SPOT satellite imagery) and census data to derive QOL indices, demonstrating that spatial technologies can reveal urban disparities. Later studies integrated subjective well-being data with GIS-based mapping to offer a more holistic view of urban QOL, incorporating both perceived satisfaction and objective conditions (Marans & Stimson, 2011).

Hajduová et al. (2014) contributed a multi-dimensional framework that aggregates satisfaction across economic and social indicators for national and regional QOL comparisons. Similarly, Estoque et al. (2019) conducted a meta-review of QOL literature and noted that while conceptual foundations vary widely, most QOL assessments consistently include social indicators, environmental livability, and multi-scalar flexibility, using either composite indices or separate unaggregated metrics.

In Asia, India's Economic Advisory Council formalized a national-level framework for aging-related policy planning through its development of the QOL for Elderly Index (Economic Advisory Council to the Prime Minister, 2022).

Its inclusion of financial well-being, healthcare, income security, and social participation serves as an actionable model for other rapidly aging countries.

At the systems level, Papachristou and Rosas-Casals (2019) applied spatial network modeling to demonstrate how QOL is clustered around key urban modules such as housing, sustainability, and economic development. Their work underscores that QOL is not just multidimensional but structurally embedded within the spatial logic of cities.

In Singapore, a gap persists. As noted by Tan and Tambyah (2024), the country lacks a composite QOL index, and while data exists in government repositories, it is disaggregated across agencies and thematic areas. This study responds to that gap by developing a municipal-level QOL index using open-source spatial data, combining best practices from earlier work while adapting them to Singapore's demographic and policy landscape.

Table 1
Comparative Overview of QOL Research Studies

Study	Geography	Methodology	Main Contributions	Critiques
Liu (1976)	USA	Statistical Indicators	Early foundation for objective QOL analysis at urban scale	No subjective dimensions
Dasgupta and Weale (1992)	Theoretical	Philosophical-economic framework	Differentiates between QOL constituents and access-based metrics	Lacks empirical testability
Weber and Hirsch (1992)	France	SPOT Satellite + Census	Remote sensing to spatially model urban QOL	Limited to physical indicators
Marans and Stimson (2011)	Multi-city	GIS + Survey-based Integration	Objective-subjective integration using spatial mapping	High data requirements
Hajduová et al. (2014)	Europe	Aggregated Social Indicators	Regional multidimensional index for QOL comparison	Few connections to service planning
Estoque et al. (2019)	Global	Literature Synthesis	Highlights importance of social & environmental indicators	No singular operational model
Economic Advisory Council to the Prime Minister (2022)	India	Composite Elderly Index	Elder-specific pillars tied to policy planning	Context-specific design
Papachristou and Rosas-Casals (2019)	Global	Spatial Network Analysis	QOL clusters around housing, economic, sustainability domains	Not yet scaled for real-time use
Tan and Tambyah (2024)	Singapore	National Survey & Conceptual Gaps	Identifies absence of composite QOL measurement in Singapore	Fragmented data; no spatial granularity
Veenhoven (2002)	Global	Subjective Well-being Indicators	Emphasizes need for happiness/life satisfaction data in social policy	Difficult to compare across cultures

Methodology

This study proposes that open government data, when spatially aggregated and organized into aging-relevant dimensions, can be used to construct a composite index that effectively measures the QOL of elderly populations at the municipal level. The resulting Elderly QOL Index aims to offer actionable insights for localized urban planning and policy design, particularly in support of Singapore's aging-in-place strategies.

I hypothesize that measurable indicators of social well-being, healthcare access, income security, and financial stability can be systematically combined to form a robust composite index that quantifies elderly QOL at the neighborhood level. Furthermore, I posit that this index will reveal spatial disparities in aging outcomes across Singapore's planning areas, thereby serving as a practical tool for data-driven decision-making in urban development and eldercare planning.

Research Design and Approach

To test this hypothesis, this study employs a spatially grounded, data-driven research design. The methodology integrates geographic, demographic, and infrastructural datasets from open-source government platforms and applies them consistently across Singapore's planning areas to construct the Elderly QOL Index.

In response to the first research question—how elderly QOL can be quantified at the neighborhood level—the methodology is structured around thematic indicator selection, data normalization, and index construction. Indicators were chosen based on theoretical relevance to aging well-being and normalized by household counts to enable fair comparisons across districts. Four equally weighted domains were developed: (1) Social Well-Being; (2) Healthcare Access; (3) Financial Well-Being; and (4) Income Security.

Each domain is composed of standardized proxy variables representing infrastructure availability, economic stability, or community participation potential. To address the second and third research questions—understanding the relationship between dimensions and informing urban policy—the study applies Spatial Analysis, where ArcGIS was used to visualize neighborhood-level variation and to identify spatial clusters where elderly QOL is significantly higher or lower. These spatial insights from the empirical basis for recommending targeted improvements in infrastructure and service delivery. This integrated approach ensures that both the construction and the application of the Elderly QOL Index are evidence-based, transparent, and directly aligned with the broader goals of urban equity and healthy aging.

Data Sources

The data for this analysis were generated from open-source datasets published by Singapore's government agencies (see Appendix E). These include:

- Planning area boundary polygon shapefiles, park locations, and community-based facilities obtained from data.gov.sg.
- Census and household income data sourced from the Department of Statistics (singstat.gov.sg).
- Healthcare facility data, which is not fully available in structured format, was manually curated from operational and upcoming facility listings on the Ministry of Health website (moh.gov.sg).
- Supplementary sources, such as the Community Health Assist Scheme (chas.sg) and People's Association (pa.gov.sg), were used to obtain information on GP clinics, resident committees, and community centers.

Where direct datasets were unavailable (e.g., a consolidated eldercare database), I manually constructed custom location maps by extracting addresses and operational statuses from relevant government ministry websites. All data reflect conditions as close to real time as possible, spanning 2020 to 2023, and were chosen for their relevance to Singapore's Aging-in-Place policy objectives.

Quantifying the QOL Index

To generate the dataset for the QOL analysis, multiple disjointed datasets were cleaned, processed, and merged using R, with planning area names serving as the common spatial

identifier. This integration allowed for the consolidation of demographic, infrastructural, healthcare, and economic indicators across Singapore's planning areas. Each of the single-index dimensions—social well-being, healthcare access, financial well-being, and income security, were calculated by normalizing raw indicator values against the number of households in each planning area. This household-adjusted approach accounts for differences in population density and built environment capacity, enabling fair comparisons across districts of varying size and scale. This normalization process follows established practices in socioeconomic and urban QOL research, where per-household or per-capita metrics are preferred for standardizing spatial comparisons and avoiding distortions caused by absolute values (Liu, 1976; Pacione, 2003; Veenhoven, 2002).

QOL, as understood in current literature, is a function of various interrelated domains, including socioeconomic, environmental, urban, and mobility-related factors. A holistic approach is necessary to capture how dimensions such as transportation systems, tourism infrastructure, and sustainability policies intersect with broader patterns of well-being and livability (Estoque et al., 2019). This multidimensional perspective guides the design of indices that incorporate both objective conditions and subjective experiences, offering a more comprehensive reflection of residents' QOL across space and time.

Analytical Steps

1. Indicator Section. Each planning area was scored across four QOL domains:
    - Social Well-Being (e.g., parks, community centers, mobility data)
    - H Healthcare Access (e.g., eldercare services, hospitals, polyclinics)
    - Financial Well-Being (e.g., parks, community centers, mobility data)
    - Income Security (e.g., employment rate among those 60+)
2. Data Cleaning and Normalization. Conducted in Rstudio, Python and Excel, ensuring standardized naming conventions and unit consistency. Missing values were minimized through source trangulation.
3. Index Consruction. Scores were calculated as normalized per-household ratios. Each domain received equal weighting, and the final QOL index was computed as the mean of the four domein indices.
4. Spatial Visualization. Using ArcGIS Pro, planning areas were mapped into a heatmap of Elderly QOL Indexs and stratified into natural breaks using the Jenks classification method.

Composite QOL Index Construction

The dimensional indicators for the Elderly QOL Index were identified based on the Review of Related Literature. To construct the Elderly QOL Index, four key dimensions were identified and quantified into single-domain indices. These dimensions are: Social Well-Being, Health System Access, Financial Well-Being, and Income Security. All indicators were normalized by the number of households in each planning area and were equally weighted in the final index calculation.

Each dimension was assigned equal weight in the construction of the composite index. The Elderly QOL Index is derived from multiple domain-specific indices, each representing a distinct determinant of elderly well-being at the neighborhood level. These domain indices are constructed from factors that serve as proxies for social, economic, health, and environmental conditions. All four domain indices contribute equally to the final Elderly QOL Index, which serves as the dependent variable in this study. To maintain comparability

and index integrity, planning areas with incomplete data were excluded from the analysis. The formula for calculating the Elderly QOL Index is as follows:

$$Elderly\ QOL = \frac{SWI + FWI + HSI + ISI}{N} \quad (1)$$

Legend: SWI = Social Well-Being Index; FWI = Financial Well-Being Index; HSI = Health System Index; ISI = Income Security Index; N = Total Number of Indicators

Social Well-being Index

A study in Spain found that within-facility social engagement significantly lowered mortality rates among nursing home residents, with sociodemographic factors, disability, and facility features influencing the extent of engagement (Pastor-Barriuso et al., 2020). Spaces that enable social contact are foundational to QOL (Stiglitz et al., 2009), and indicators such as church attendance or union membership are also seen as valid proxies (Economist Intelligence Unit, 2005). For this study, parks, resident committees, community centers, and the number of seniors with mobility issues were selected as proxies for social well-being. These indicators reflect the extent of available public spaces for social participation. In the Singapore context, these reflect where and how seniors gather and engage with the community. Also, the number of senior citizens with mobility issues in daily activities was used for social well-being because they are likely to engage in community activities if they are physically well. The formula for the Social Well-Being Index is as follows:

$$\text{Social Well-Being Index} = \frac{\left(\frac{NCC + NRC + NP + NED}{NH}\right)}{N} \quad (2)$$

Legend: NCC = Number of Community Centres; NRC = Number of Resident Committees; NP = Number of Parks; NED = Number of Elders with Disability; NH = Number of Households in the Planning Area; N = Total Number of Indicators

Health System Index

Studies from India and China highlight that access to and maintenance of health services are fundamental determinants of elderly QOL (Ghosh & Dinda, 2020; Stiglitz et al., 2009). Population health outcomes are linked to the availability of services, including clinics, eldercare facilities, and hospitals (Sherr et al., 2017). Maintenance of health is a determinant of QOL, the availability of eldercare facilities, and healthcare facilities per household are used as proxies since they are essential in predicting health outcomes for the population. For this study, the number of general practitioner clinics, full-suite hospitals, nursing homes, and polyclinics are aggregated as proxies for healthcare access. Thus, I formulate the Health System Index as:

$$\text{Health System Index} = \frac{\left(\frac{NHF + NEF}{NH}\right)}{N} \quad (3)$$

Legend: NHF = Number of Healthcare Facilities; NEF = Number of Eldercare Services; NH = Number of Households in the Planning Area; N = Total Number of Indicators

Financial Well-being Index

Material well-being is recognized as one of the core pillars of QOL, as it reflects both the economic capabilities of individuals and the resources available to meet basic needs. Common indicators of material conditions include household income, consumption expenditure, and property security (Economist Intelligence Unit, 2005; Stiglitz et al., 2009). To capture financial well-being as a key component of elderly QOL, this study uses total household income normalized by the number of households in each planning area. This approach reflects what Dasgupta and Weale (1992) describe as measuring access to the determinants of well-being—such as income, housing, and services—rather than well-being itself. Income is widely accepted as a core indicator of socioeconomic status, especially when used to estimate material resources available for basic needs and long-term security (Braveman et al., 2005; Lustig, 2018). While imperfect, income remains one of the most robust and spatially comparable proxies for financial capacity at the neighborhood level.

This study uses combined household income per planning area, normalized by the number of households. Income levels were estimated from grouped income brackets, then aggregated to calculate total monthly income per area. Hence, the index composition is as follows:

$$\text{Financial Well-Being Index} = \frac{\left(\frac{MIHH}{NH}\right)}{N} \tag{4}$$

Legend: MIHH = Monthly Income Per Household (in $10,000 units); NH = Number of Households in the Planning Area; N = Total Number of Indicators

Income Security Index

The Income Security Index in this study reflects the degree to which older adults can maintain stable earnings or continue working beyond the traditional retirement age. The International Labour Organization proposes an Income Security Index to assess income levels up to old age or retirement, calculated based on job opportunities and individuals' access to adequate and sustained income as they age, particularly through continued employment (International Labour Organization, n.d.; Standing, 2002). Henry and Golman (2021) emphasize that later-life work participation is a key determinant of income continuity in aging societies. This study uses the number of older adults (aged 60 and above) who are employed in each planning area as a proxy for income security. This reflects both the availability of elder-friendly job opportunities and the structural capacity of neighborhoods to support active aging. The formula for this index is as follows:

$$\text{Income Security Index} = \frac{\left(\frac{NEW}{NH}\right)}{N} \tag{5}$$

Legend: NEW = Number of Elder Workers; NH = Number of Households in the Planning Area; N = Total Number of Indicators

Results and Discussion

Scope and Limitations

In this study, elderly residents are defined as individuals aged 60 to 90 years old at the time of analysis. It is assumed that older adults reside in the same planning area during the reference year in which the data were collected. Regarding financial well-being, comprehensive data on the propensity of older adults to support themselves economically up to old age were not available. As a result, the analysis includes only those elderly individuals who remain active in the labor force.

Due to data availability and completeness constraints, this study focuses on 17 out of Singapore's 60 planning areas. Areas with missing or incomplete information for one or more QOL dimensions were excluded to ensure index integrity and comparability. Additionally, the Elderly QOL Index was constructed under the assumption that all four domain indices carry equal weight. While this facilitates transparency and comparability, the weighting structure and formula components remain arbitrary. Future research should aim to validate and refine this index structure through scientific modeling techniques such as Principal Component Analysis (PCA), stakeholder weighting, or sensitivity testing.

Discussion

This study demonstrates that municipal-level measurement of elderly QOL is not only feasible using open government data but also essential for identifying underserved and vulnerable senior populations. The use of normalized, objective indicators revealed multidimensional disparities in aging outcomes, most notably in neighborhoods across western Singapore.

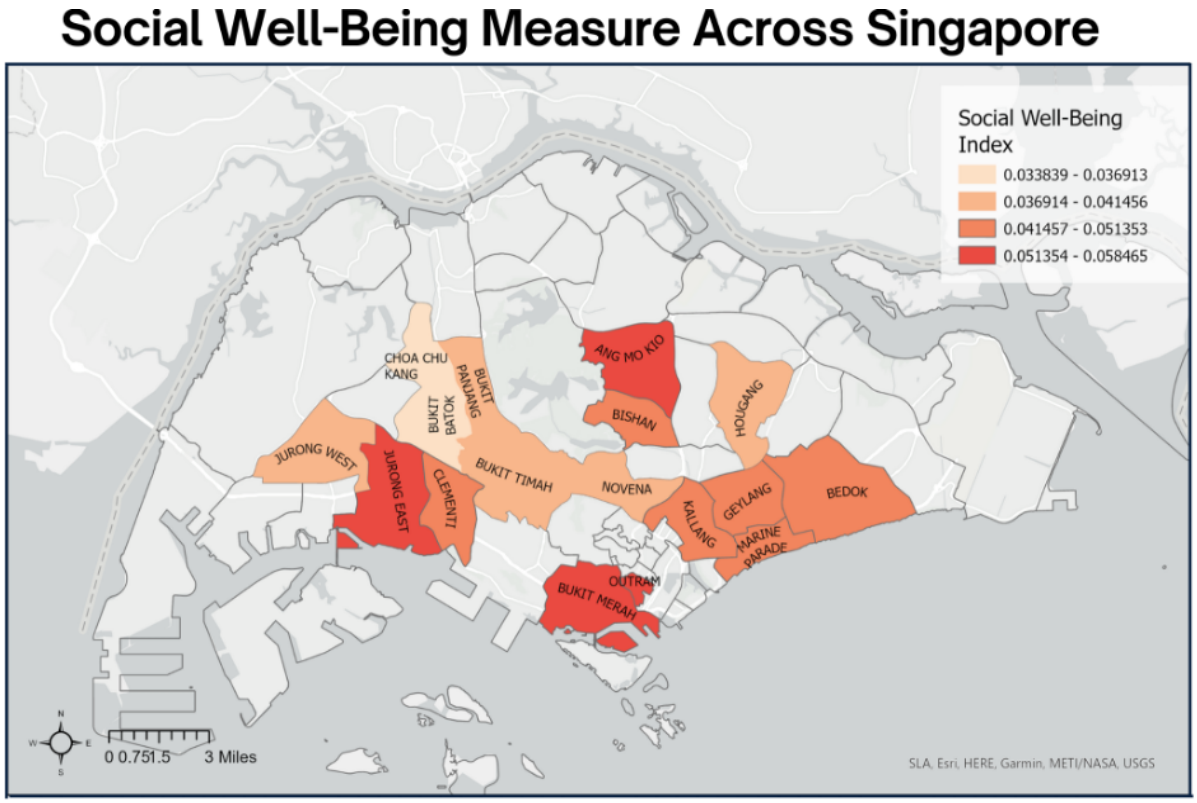
In addition to summary statistics for each index, the disaggregated components that make up the individual QOL dimensions are presented in Appendix A (Summary Statistics). Further breakdowns by planning area can be found in Appendix B (Demographics and Dimension Factors). The median composite QOL score across the 17 planning areas analyzed is 0.2573. Median values for the individual indices are: (1) Social Well-Being: 0.0475; (2) Health System: 0.00048; (3) Financial Well-Being: 0.7895, and (4) Income Security: 0.1772.

Appendix C presents each planning area's domain-specific scores, highlighting the spatial variation in QOL performance. The planning area of Outram stands out with the highest values across nearly all domains, followed by Ang Mo Kio and Bukit Merah. In contrast, Choa Chu Kang consistently scores among the lowest across all domains, followed by Bukit Panjang. Appendix D consolidates composite index values, with Outram achieving the highest overall Elderly QOL Index, driven by particularly high scores in Health System and Income Security. Bukit Timah, which ranks second, leads in Financial Well-Being, while Novena appears among the top three due to balanced high scores across domains. Meanwhile, Choa Chu Kang ranks among the lowest across all indices, particularly in Social Well-Being, Income Security, and Health System access. Bukit Panjang also ranks poorly in similar categories and has the lowest Health System Index. Bukit Batok registers the lowest overall QOL score, with persistently low Social Well-Being, indicating a need for targeted infrastructure and elder engagement efforts.

Social Well-being Index

The neighborhoods of Ang Mo Kio, Outram, and Bukit Merah recorded the highest Social Well-Being Index scores at approximately 0.058, 0.056, and 0.056, respectively. Conversely, Bukit Panjang, Bukit Batok, and Choa Chu Kang had the lowest scores at approximately 0.038, 0.037, and 0.034, respectively. As shown in Figure 1, Jurong East also falls within the highest classification level, indicating that its social infrastructure relative to the number of households is notably strong compared to other neighborhoods.

Figure 1
Social Well-being Map Includes Four Classification Categories, Based on the Jenks Natural Breaks Method

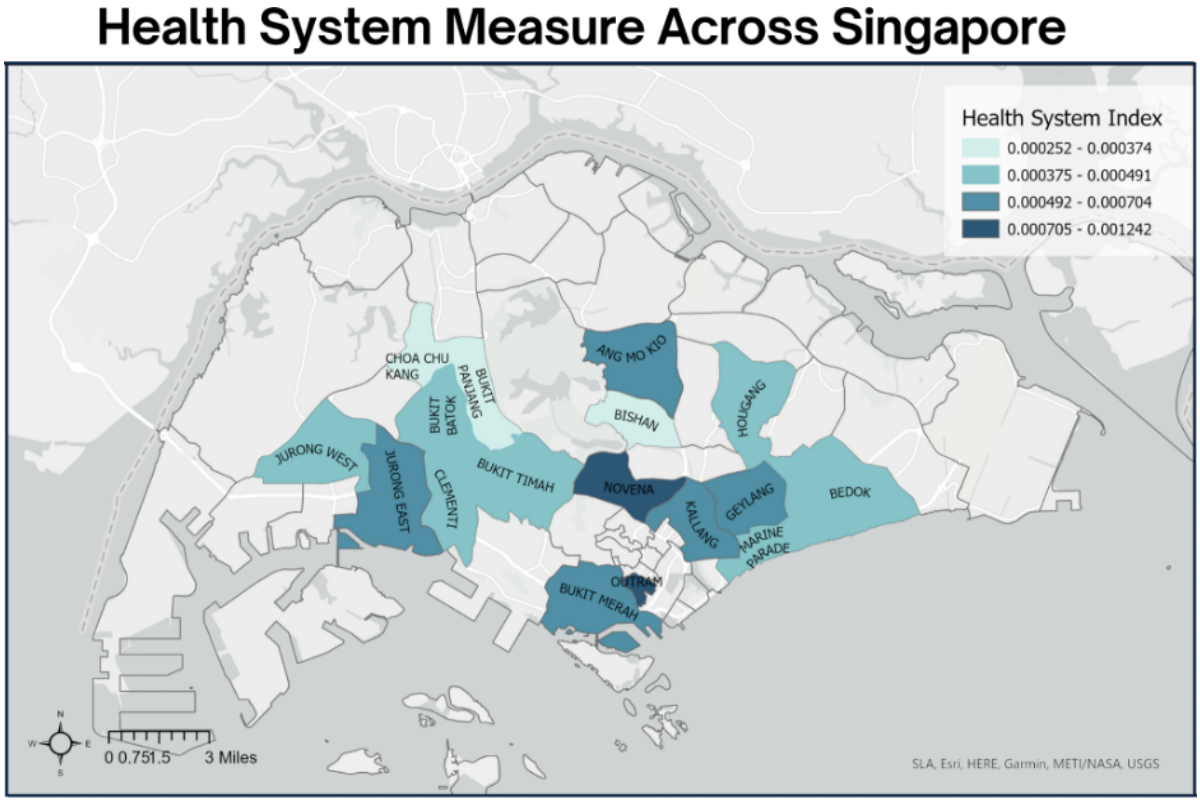


Health System Index

The highest Health System Index scores were observed in Outram (0.0012), Novena (0.0009), and Bukit Merah (0.0007). On the other end, Hougang, Bishan, and Bukit Panjang recorded the lowest scores, ranging from 0.0003 to 0.0002. As seen in Figure 2, Outram and Novena are the only planning areas that fall into the highest classification band. This suggests that, relative to the number of households, these areas have a high concentration of healthcare infrastructure, including general practitioner clinics, polyclinics, nursing homes, and full-suite hospitals. However, this does not imply that these areas have the highest absolute number of facilities. For instance, Outram has only 16 healthcare facilities, while Bedok has 87, yet the latter ranks lower due to population-adjusted density. Similarly, Ang Mo Kio, despite having the second-highest number of facilities, ranks in the second-highest classification band. This highlights that infrastructure per se does not guarantee accessibility, particularly when facility-to-household ratios are skewed.

Outram and Novena had the best per-capita access, though they did not have the highest absolute number of facilities. This emphasizes the importance of household-adjusted infrastructure density. Hougang and Bukit Panjang were notably underserved.

Figure 2
Health System Map Includes Four Classification Categories, Based on the Jenks Natural Breaks Method

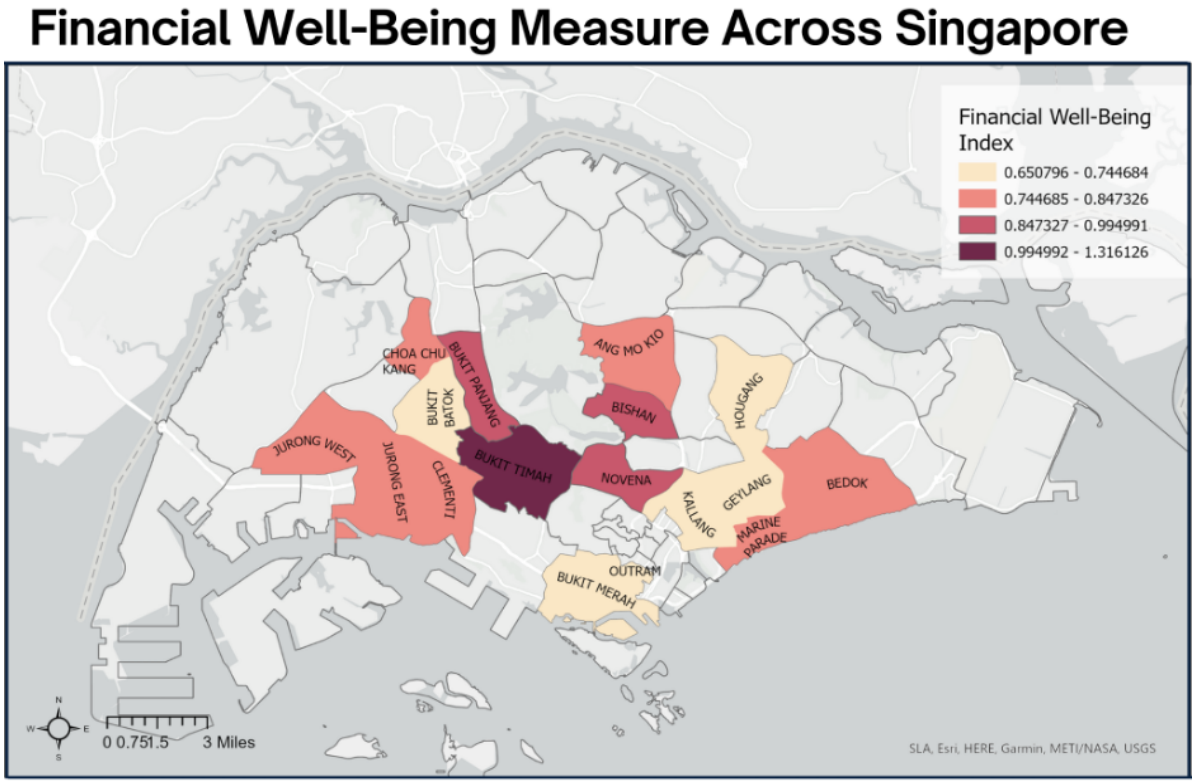


Financial Well-being Index

As depicted in Figure 3, Bukit Timah, Bishan, and Novena had the highest Financial Well-Being Index scores at approximately 1.316, 0.995, and 0.933, respectively. Kallang, Geylang, and Bukit Merah recorded the lowest scores at approximately 0.705, 0.678, and 0.651, respectively. Considering the spatial distribution of the financial well-being, the planning area of Bukit Timah stands out as the only neighborhood in the highest classification band, where the typical income level exceeds S$9,951 per month. Known for its affluent profile, Bukit Timah includes premium residential estates, reinforcing its strong financial indicators. On the other hand, Bukit Batok, Outram, and Geylang fall in the lowest classification band, with average monthly income levels between S$6,508 and S$7,445. This is shown in Appendix C.

Bukit Timah significantly outperformed other areas, while Bukit Batok and Outram fell into the lowest tier. The Income Security Index revealed that Outram and Geylang support higher senior employment, whereas Choa Chu Kang and Bukit Panjang lack such opportunities.

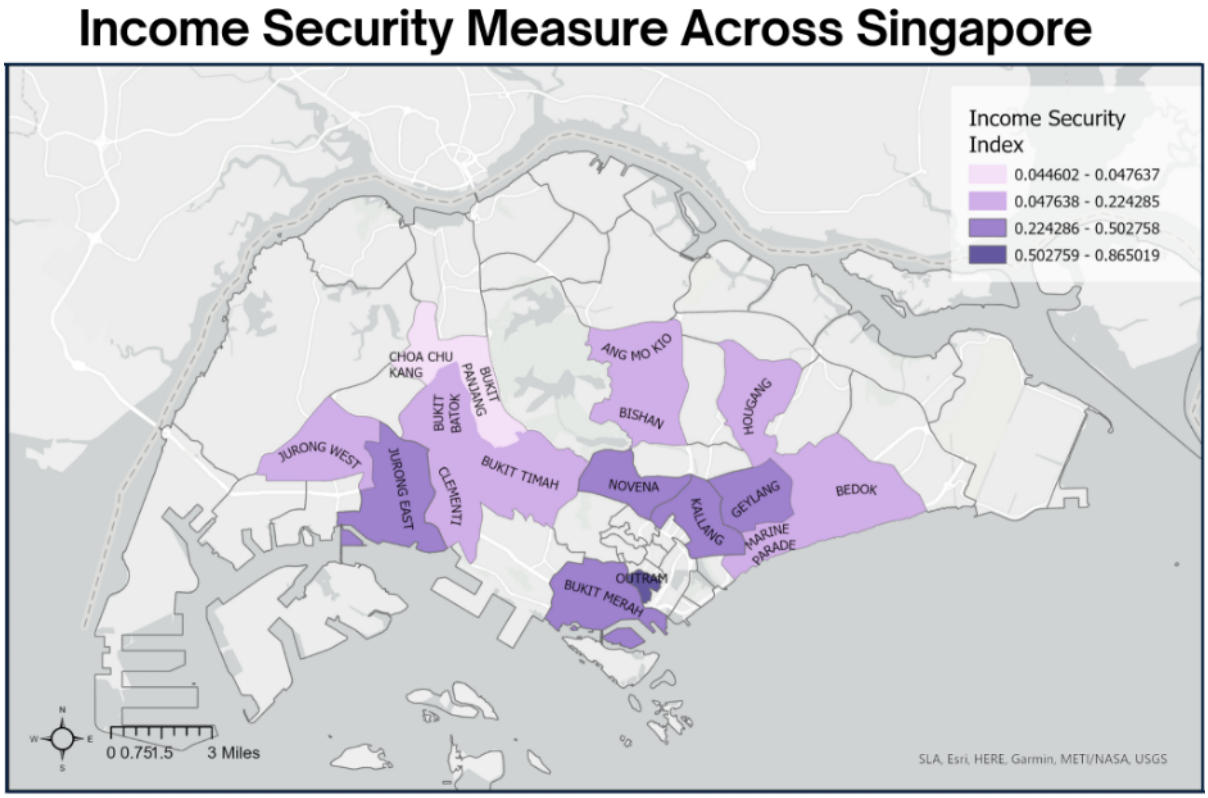
Figure 3
Financial Well-being Map Contains Four Classification Bands, Based on the Jenks Natural Breaks Method



Income Security Index

Based on the Income Security Index (see Figure 4), Outram, Geylang, and Jurong East achieved the highest scores at approximately 0.411, 0.503, and 0.323, respectively. In contrast, Jurong West, Bukit Panjang, and Choa Chu Kang scored the lowest, ranging from 0.103 to 0.045. Outram is the only area in the highest classification band, indicating that a relatively high proportion of elderly residents remain employed. This implies that Outram may offer more elder-friendly job opportunities or better support systems to the elderly population, who are still working are highly concentrated in this location in accordance with the number of households. It implies that senior citizens in this area have a chance of finding work past the typical retirement age of 60 years old.

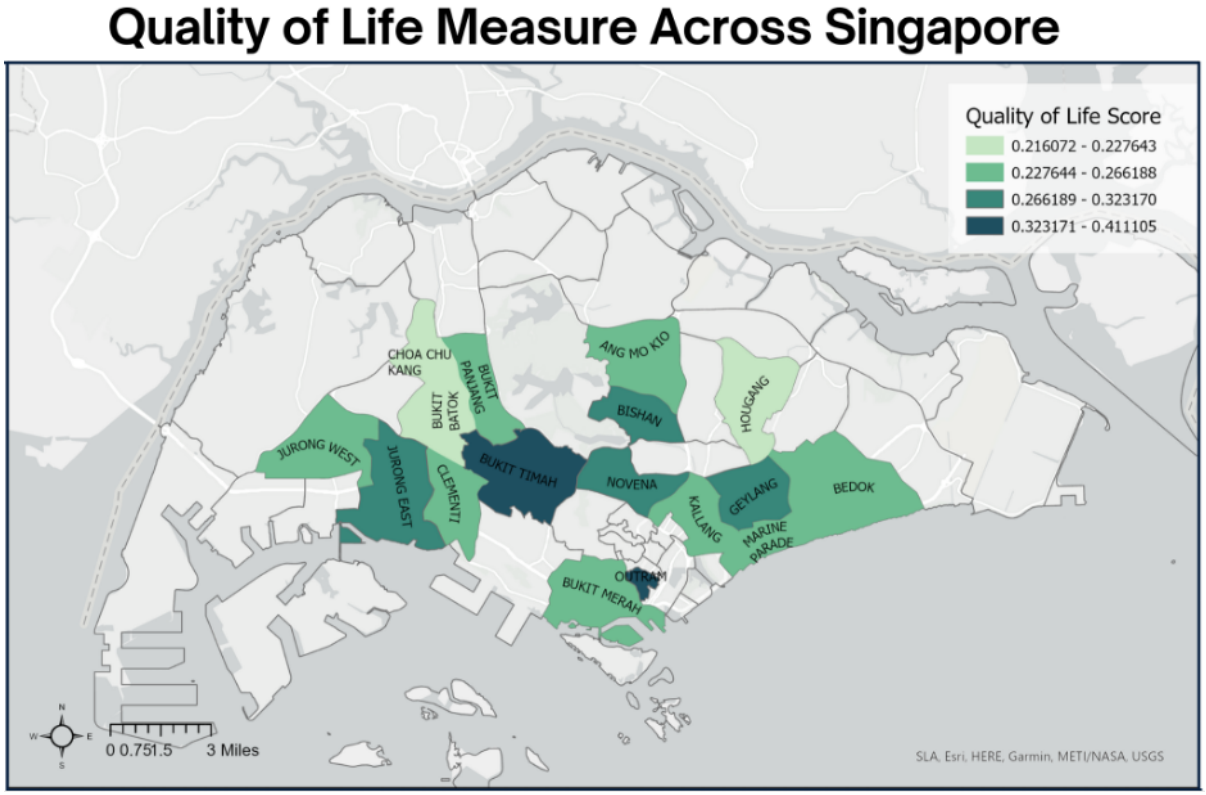
Figure 4
Income Security Index Map Includes Four Classification Categories, Based on the Jenks Natural Breaks Method



Elderly Quality of Life Index

Composite scores of the Elderly QOL Index show that Outram, Bukit Timah, and Novena lead with values of approximately 0.411, 0.382, and 0.323, respectively. Hougang, Choa Chu Kang, and Bukit Batok scored the lowest at around 0.227, 0.218, and 0.216. These planning areas seem to be underperforming across dimensions. The succeeding map, Figure 5, shows the spatial distribution of composite scores, confirming that Outram and Bukit Timah are the most favorable neighborhoods for elderly residents based on aggregated indicators across all four dimensions.

Figure 5
Elderly QOL Index Map Includes Four Classification Categories, Using Jenks Natural Breaks



Conclusion

This study introduces a flexible, municipal-level QOL Index tailored specifically to Singapore's aging population. The Elderly QOL Index reveals substantial spatial disparities across planning areas, particularly in social infrastructure, healthcare access, income security, and financial well-being. It attests a need for a foundational framework for measuring and comparing well-being outcomes for older adults across municipal boundaries as well as the value of combining spatial data and socioeconomic indicators to guide aging policy.

The results reveal clear spatial disparities in elderly QOL across Singapore's planning areas, particularly in social infrastructure. Districts such as Outram, Bukit Timah, and Novena exhibit high index scores, indicating robust elder-friendly infrastructure and access to services. In contrast, areas like Choa Chu Kang, Bukit Batok, and Hougang scored lower, highlighting the need for targeted interventions in healthcare availability, elder employment, and social infrastructure.

Municipal agencies can use the index as an evidence-based tool to allocate resources more effectively, focusing on infrastructure and employment programs that support older adults. Moreover, this research demonstrates that data-driven planning can supplement national strategies such as ageing-in-place initiatives by identifying neighborhood-level vulnerabilities. The index provides a practical, replicable tool for policymakers to monitor, compare, and prioritize resources based on localized needs. It also bridges the gap between subjective well-being goals and objective urban indicators, helping cities become more inclusive as they age.

Future Work

The development of the Elderly QOL Index offers a robust starting point for future research on aging and spatial inequality. To strengthen its analytical precision, future studies should explore the use of advanced statistical methods such as Principal Component Analysis (PCA) or machine learning to refine indicator selection and weighting. Additionally, incorporating subjective well-being data alongside objective indicators would offer a more holistic understanding of aging experiences across neighborhoods. Future enhancements should include stakeholder engagement to validate domain weights, ensuring the index reflects community-specific priorities and the lived experiences of seniors. The index also holds potential for cross-national application, particularly in other urbanized, aging societies. Comparative research could help illustrate how institutional differences shape aging outcomes, contributing to global dialogue on age-friendly cities.

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Appendices

Appendix A

Summary Statistics

Variable	Index Category	Minimum	1st Quartile	Median	Mean	3rd Quartile	Maximum
Community Center per Household	Social	0.00004063	0.00007349	0.00009510	0.00010281	0.00011717	0.00024835
Resident Centre per Household	Social	0.00008126	0.00044083	0.00050593	0.00048225	0.00053138	0.00074506
Park per Household	Social	0.00003447	0.00014694	0.00025241	0.00033266	0.00043761	0.00125955
Elder Daily Difficulty per Household	Social	0.1348	0.1580	0.1889	0.1841	0.2045	0.2327
Healthcare Facility per Household	Health	0.0005048	0.0007720	0.0008918	0.0009766	0.0010553	0.0019868
Eldercare per Household	Health	0.00000000	0.00005525	0.00007176	0.00012908	0.00018266	0.00049671
Elder Workers per Household	Income	0.0446	0.1240	0.1772	0.2379	0.2612	0.8650
Wealth per Household per Month	Financial	6,508	7,221	7,895	8,228	8,473	13,161
Social Index		0.03384	0.03984	0.04747	0.04626	0.05135	0.05846
Health Index		0.0002524	0.0004063	0.0004818	0.0005529	0.0006000	0.0012418
Income Index		0.0446	0.1240	0.1772	0.2379	0.2612	0.8650
Financial Index		0.6508	0.7221	0.7985	0.8228	0.8473	1.3161
Elderly Quality of Life Index		0.2161	0.2422	0.2573	0.2769	0.3075	0.4111

Appendix B

Demographics and Dimensions Factor

Planning Area	MIHH S($)	NHF	NCC	NEF	NP	NRC	NEW	NED	NH
BISHAN	9949.91	20	4	2	16	15	5,946	5,501	27,800
BUKIT BATOK	7070.83	42	4	3	10	29	6,509	7,974	44,000
BUKIT MERAH	6507.96	63	7	21	8	38	15,537	13,258	55,200
BUKIT PANJANG	8825.15	22	3	0	11	22	2,076	6,637	41,200
BUKIT TIMAH	13161.26	19	1	1	31	2	4,301	3,888	23,900
CHOA CHU KANG	7935.08	37	3	5	2	30	2,588	7,819	49,300
CLEMENTI	7895.21	31	2	2	11	16	7,538	6,719	30,100
GEYLANG	6777.22	42	4	8	7	20	21,146	8,184	37,500
NOVENA	9333.46	34	2	1	8	6	5,843	2,818	15,700
BEDOK	8473.26	87	10	7	37	38	12,683	1,9953	92,200
ANG MO KIO	7710.89	69	5	11	30	32	8,651	1,4016	62,600
HOUGANG	7446.84	57	6	3	18	38	9,316	12,393	64,300
JURONG EAST	7825.30	29	2	3	2	16	9,349	5,752	25,500
MARINE PARADE	8396.80	14	2	1	7	7	3,024	3,225	15,200
JURONG WEST	8294.09	65	8	7	6	44	8,674	13,406	81,600
KALLANG	7051.45	39	8	10	6	18	10,665	7,978	36,500
OUTRAM	7220.91	16	2	4	4	6	6,966	1,794	8,400

Legend: MIHH = Monthly Income Per Household (S$); NHF = Number of Healthcare Facilities; NCC = Number of Community Centres; NEF = Number of Eldercare Facilities; NP = Number of Parks; NRC = Number of Resident Committees; NEW = Number of Elder Workers; NED = Number of Elders with Disability; NH = Number of Households

Appendix C

Elderly Quality of Life Index Single Index Dimensions per Planning Area

Planning Area	MIHH S($)	NHF	NCC	NEF	NP	NRC	NEW	NED	NH
OUTRAM	**0.000248355**	**0.000745064**	0.000496709	0.222774121	**0.001986837**	**0.000496709**	**0.865019247**	7220.911462	**0.51285235**
BUKIT MERAH	0.000117253	0.000636516	0.000134003	0.222077052	0.001055276	0.000351759	0.260251256	**6507.956449**	0.40418761
ANG MO KIO	8.30E-05	0.000531385	0.000498173	**0.232746596**	0.001145799	0.000182664	0.143656592	7710.893391	0.39388907
MARINE PARADE	0.000117171	0.000410101	0.000410 1	0.188939012	0.0008202	5.86E-05	0.177163278	8396.801219	0.38959517
GEYLANG	9.51E-05	0.000475511	0.000166429	0.194579173	0.000998573	0.000190204	0.502757965	6777.223015	0.37969567
CLEMENTI	5.95E-05	0.000476063	0.000327293	0.199916689	0.000922372	5.95E-05	0.224285162	7895.206641	0.36954387
KALLANG	**0.000195925**	0.000440831	0.000146944	0.195385972	0.000955133	0.000244906	0.261192202	7051.454741	0.36515478
BUKIT TIMAH	4.06E-05	**8.13E-05**	**0.001259548**	0.157971721	0.000771981	4.06E-05	0.174752153	**13161.2628**	0.33967171
BEDOK	0.00010251	0.000389524	0.000379289	0.204539164	0.000891841	7.18E-05	0.130014044	8473.260141	0.33633689
JURONG EAST	7.35E-05	0.000587954	7.35E-05	0.211369566	0.001065667	0.000110241	0.343549039	7825.304083	0.33403153
BISHAN	0.000135846	0.000509424	0.000543386	0.186822892	0.000679232	6.79E-05	0.201935813	9949.906606	0.31482425
NOVENA	0.000109403	0.000328211	0.000437613	0.154149117	0.001859854	5.47E-05	0.319621465	9333.460 97	0.30961107
HOUGANG	7.99E-05	0.000505931	0.000239652	0.1650002	0.000758897	3.99E-05	0.124033072	7446.843 92	0.26747793
JURONG WEST	9.54E-05	0.000524565	7.15E-05	0.159825463	0.000774926	8.35E-05	0.103410866	8294.090297	0.20946874
BUKIT PANJANG	6.88E-05	0.000504819	0.000252409	0.152294631	**0.000504819**	0	0.047636531	8825.149151	0.18609454
BUKIT BATOK	7.37E-05	0.000534099	0.000184172	0.146858942	0.000773523	5.53E-05	0.119877761	7070.832643	0.18417224
CHOA CHU KANG	5.17E-05	0.000517027	**3.45E-05**	**0.134754584**	0.000637667	8.62E-05	**0.044602234**	7935.078588	**0.14942093**
OUTRAM	**0.000248355**	**0.000745064**	0.000496709	0.222774121	**0.001986837**	**0.000496709**	**0.865019247**	7220.911462	**0.51285235**
BUKIT MERAH	0.000117253	0.000636516	0.000134003	0.222077052	0.001055276	0.000351759	0.260251256	**6507.956449**	0.40418761
ANG MO KIO	8.30E-05	0.000531385	0.000498173	**0.232746596**	0.001145799	0.000182664	0.143656592	7710.893391	0.39388907
MARINE PARADE	0.000117171	0.000410101	0.000410 1	0.188939012	0.0008202	5.86E-05	0.177163278	8396.801219	0.38959517
GEYLANG	9.51E-05	0.000475511	0.000166429	0.194579173	0.000998573	0.000190204	0.502757965	6777.223015	0.37969567

Note: Figures whose planning areas have the extreme counts for the highest and lowest figures per category are highlighted in bold. Whereas numbers in green identify the top three highest figures while those highlighted in red account for the lowest figures.

Legend: MIHH = Monthly Income Per Household (S$); NHF = Number of Healthcare Facilities; NCC = Number of Community Centres; NEF = Number of Eldercare Facilities; NP = Number of Parks; NRC = Number of Resident Committees; NEW = Number of Elder Workers; NED = Number of Elders with Disability; NH = Number of Households

Appendix D

Elderly Quality of Life Index, and Individual Index per Planning Area

Planning Area	Region Name	Social Well-Being Index	Health System Index	Income Security Index	Financial Well-being Index	Elderly Quality of Life Index
BISHAN	CENTRAL REGION	0.047002887	0.000373578	0.201935813	0.994990661	0.311075734
BUKIT BATOK	WEST REGION	0.036912721	0.000414388	0.11987771	0.707083264	**0.216072021**
BUKIT MERAH	CENTRAL REGION	0.055741206	0.000703518	0.260251256	**0.650795645**	0.241872906
BUKIT PANJANG	WEST REGION	0.038280174	**0.000252409**	0.047636531	0.882514915	0.242171007
BUKIT TIMAH	CENTRAL REGION	0.03983829	0.000406306	0.174752153	**1.31612628**	0.382780757
CHOA CHU KANG	WEST REGION	**0.033839446**	0.000361919	**0.044602234**	0.793507859	0.218077864
CLEMENTI	WEST REGION	0.050194888	0.00049094	0.224285162	0.789520664	0.266122914
GEYLANG	CENTRAL REGION	0.048829054	0.000594389	0.502757965	0.677722301	0.307475927
NOVENA	CENTRAL REGION	0.038756086	0.000957278	0.319621465	0.933346097	0.323170231
BEDOK	EAST REGION	0.051352626	0.000481799	0.130014044	0.847326014	0.257293621
ANG MO KIO	NORTH-EAST REGION	**0.058464796**	0.000664231	0.143656592	0.771089339	0.24346874
HOUGANG	NORTH-EAST REGION	0.041456417	0.00039942	0.124033072	0.744684392	0.227643325
JURONG EAST	WEST REGION	0.053026127	0.000587954	0.343549039	0.782530408	0.294923382
MARINE PARADE	CENTRAL REGION	0.047469096	0.000439393	0.177163278	0.839680122	0.266187972
JURONG WEST	WEST REGION	0.040129234	0.00042919	0.103410866	0.82940903	0.24334458
KALLANG	CENTRAL REGION	0.049042418	0.00060002	0.261192202	0.705145474	0.253995028
OUTRAM	CENTRAL REGION	0.056066062	**0.001241773**	**0.865019247**	0.722091146	**0.411104557**

Note: Figures whose planning areas have the extreme counts for the highest and lowest figures per category are highlighted in bold. Whereas numbers in green identify the top three highest figures while those highlighted in red account for the lowest figures.

Appendix E

Data Sources

Indicator / Purpose	Dataset Name	URL Source
Social Well-Being	Parks,	https://data.gov.sg/dataset/parks
Social Well-Being	Resident Committees	https://data.gov.sg/dataset/residents-committees
Social Well-Being	Community Centres	https://www.pa.gov.sg/our-network/community-clubs https://data.gov.sg/dataset/family-services
Health Systems	Healthcare Facilities (e.g. Family, GP Clinics)	https://data.gov.sg/datasets/chas
Health Systems	Eldercare Services	https://data.gov.sg/dataset/eldercare-services
Financial Well-being	Monthly Household Income from Work	https://www.singstat.gov.sg/publications/reference/cop2020/cop2020-sr2/census20_stat_release2
Income Security	Geographical Distribution of Workplace	https://www.singstat.gov.sg/publications/reference/cop2020/cop2020-sr2/census20_stat_release2
Population	Resident Households	https://www.singstat.gov.sg/find-data/search-by-theme/population/geographic-distribution/latest-data
Population	Geographic Distribution Indicators	https://www.singstat.gov.sg/publications/reference/cop2020/cop2020-sr2/census20_stat_release2
Population	On Population, Annual Singapore	https://tablebuilder.singstat.gov.sg/table/TS/M810001
Population	Residents By Age Group, Ethnic Group And Sex, End June, Annual	https://tablebuilder.singstat.gov.sg/table/TS/M810671
Planning Area Census	Singapore Residents by Planning Area, Subzone, Age Group and Sex	https://tablebuilder.singstat.gov.sg/table/TS/M810671
Planning Area Census	Singapore Residents by Planning Area, Subzone, Age Group and Sex	https://data.gov.sg/dataset/planning-area-census2010?resource_id=076de3a7-eaa6-426e-8331-557469dd7ce8.
Planning Area Shapefile	Master Planning Area Boundary	https://data.gov.sg/dataset/master-plan-2014-planning-area-boundary-web

What and How Do They Play? Understanding Older Adults' Play Behaviors in Urban Parks of High-Density Cities Through AI-Powered Analysis

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Abstract

The rapid aging of populations in high-density cities presents unique challenges for urban planning and social inclusion. While play activities are increasingly recognized as crucial for older adults' wellbeing, limited research examines how they engage in play within constrained urban environments. This study investigates older adults' play behaviors in urban parks of Hong Kong through an innovative AI-powered analysis approach. We conducted observational studies across five public parks in the Tai Kok Tsui neighborhood, employing an enhanced YOLO-Pose framework to analyze video recordings from September to December 2024. The framework achieved over 89% accuracy in recognizing and classifying various play activities. Our findings reveal that older adults predominantly engage in unstructured and observational play, with social interaction being a primary motivator. Contrary to conventional assumptions about active aging, structured physical activities constitute only a small portion of observed behaviors. Environmental factors, including seating arrangements and weather conditions, significantly influence play patterns. The study also identified notable differences in mobile device usage among older adults compared to other age groups, suggesting opportunities for targeted digital interventions. These insights contribute to both theoretical understanding of late-life play and practical urban design considerations. The methodology developed demonstrates the potential of AI-powered analysis in understanding complex social behaviors, while the findings inform age-inclusive design strategies for high-density urban environments.

Keywords: older adult play, urban parks, artificial intelligence, activity recognition, age-friendly design

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Introduction

Population aging has emerged as a defining global challenge of the 21st century, especially in high-density urban environments where demographic and infrastructural aging converge—a phenomenon known as "double aging." In cities such as Hong Kong, where 36% of the population is projected to be aged 65 or above by 2046 (Census and Statistics Department, 2020), this dual transformation creates multifaceted challenges for urban livability, mobility, and inclusivity (Jian et al., 2025). The simultaneous aging of both people and place necessitates a rethinking of how cities accommodate the evolving needs of older adults, particularly in terms of access to public spaces and recreational opportunities.

Recent studies have highlighted a concerning trend among older adults: their limited engagement with outdoor spaces. Research in European contexts indicates that seniors spend merely two hours daily outdoors (Fortuijn et al., 2006), a pattern likely more pronounced in high-density Asian cities where public space is scarce. This limited outdoor engagement correlates strongly with increased social isolation and loneliness, which the World Health Organization has recognized as a critical public health crisis (Hartt, 2023). In Hong Kong, approximately 45% of older adults report experiencing loneliness, with this figure rising significantly among those with poor physical health (Tang and Chou, 2024).

Among these challenges, limited engagement with outdoor spaces among older adults has emerged as a concerning trend. While studies in European settings reveal that seniors typically spend only two hours outdoors per day (Fortuijn et al., 2006), the situation may be more acute in Asian cities like Hong Kong, where public space per capita is significantly lower. This lack of access is closely tied to elevated levels of social isolation and loneliness, which the World Health Organization has identified as a growing public health crisis (Hawkley, 2022). In Hong Kong specifically, around 45% of elderly individuals report feelings of loneliness, with those experiencing physical health problems particularly vulnerable (Tang & Chou, 2024).

Although the physical health benefits of outdoor activity for older adults are well documented, the social and emotional dimensions of outdoor engagement—especially through the lens of "play"—remain underexplored (Hartt, 2023). Traditionally associated with childhood, play is increasingly recognized as a potent mechanism for fostering joy, resilience, and social connection in later life. Yet two key gaps persist in current research: an overreliance on structured physical exercise to the exclusion of spontaneous or culturally diverse play forms, and ageist assumptions embedded in urban design that marginalize older adults' playful capacities and preferences (Cohen, 2005). Moreover, defining "play" in later life presents conceptual challenges. As Woodyer (2012) notes, play is culturally and socially contingent, often resisting fixed definitions and standardized observation. Scholars such as Brown & Vaughan (2009) and De Koven (2013) emphasize that play is inherently subjective, shaped by personal histories, affective states, and social environments. While recent tools such as the Study of Older Adult Play Spaces (SOAPS) by Hartt and Gryfe (2025) offer promising methods for observing and analyzing play behaviors, their application in dense, vertical urban environments like Hong Kong remains limited.

Against this backdrop, this study investigates how older adults engage in play within public urban parks in Hong Kong using a novel AI-powered observational approach. Focusing on the Tai Kok Tsui neighborhood, a rapidly aging and spatially constrained urban area, we apply an enhanced YOLO-Pose framework to capture and classify play-related body

movements and interactions among older adults in real-time. This approach allows us to move beyond anecdotal or survey-based data to systematically observe patterns of play in everyday urban contexts.

Our research objectives are threefold: (1) to develop and validate an AI-powered methodology for analyzing older adult play behaviors in urban settings; (2) to identify and characterize the patterns of play that emerge in high-density urban parks; and (3) to examine how environmental factors and digital technology usage influence play behaviors. Through these objectives, we seek to contribute both to the theoretical understanding of late-life play and to practical approaches for designing age-inclusive urban spaces.

By addressing these objectives, our research contributes to both theoretical understandings of play in later life and practical strategies for enhancing age-friendly urban design. As populations age globally, and especially in cities like Hong Kong with limited land and rapidly aging infrastructures, understanding how play can promote social connectedness, emotional well-being, and active aging is critical. Furthermore, our methodological innovation demonstrates the potential of AI in advancing research within environmental gerontology, urban sociology, and inclusive design.

Literature Review

Conceptualizing Play in Later Life

The conceptualization of play in later life represents a complex intersection of developmental psychology, environmental gerontology, and social theory (Sutton-Smith, 2001). While play has been extensively studied in childhood development, its role and manifestation in later life remain less thoroughly understood. Traditional definitions of play often emphasize its voluntary, pleasurable, and process-oriented nature, yet these characteristics take on different meanings when applied to older adults' experiences (Van Leeuwen & Westwood, 2008). Recent scholarship has begun to recognize play as a lifelong necessity rather than merely a developmental stage, highlighting its potential for promoting well-being across the life course.

Research indicates that older adults' engagement with play differs significantly from that of younger populations, both in form and function. While older adults may not explicitly label their activities as "play," they engage in playful behaviors through various forms of pleasure-seeking, spontaneous social interaction, and creative expression. This distinction highlights the need for a more nuanced understanding of play that accounts for the unique social, cultural, and physical contexts of later life (Yarnal, 2006).

The benefits of play in later life extend beyond mere recreation. Physical engagement through play has been linked to improved cardiovascular health, enhanced balance, and reduced risk of chronic diseases. Cognitively, playful activities support mental acuity and provide opportunities for problem-solving and creative thinking. Perhaps most significantly, play serves as a crucial mechanism for social connection, offering opportunities for meaningful interaction that can help combat the isolation often experienced in later life (Cohen, 2005).

Urban Parks in High-Density Cities: Opportunities and Challenges

Urban parks in high-density cities play a crucial role in supporting healthy aging by providing accessible spaces for physical activity, social engagement, and spontaneous play among older

adults. In densely built environments where private recreational spaces are scarce, these parks serve as vital nodes of public life and intergenerational interaction. However, their ability to fulfill this role is often constrained by a combination of design limitations, accessibility barriers, and environmental conditions (Jian et al., 2021).

Nowhere are these challenges more pronounced than in dense Asian metropolises such as Hong Kong, where public open spaces are characterized by insufficient provision, uneven geographic distribution, and access disparities (Jian et al., 2020). These structural issues significantly reduce opportunities for older adults to engage meaningfully with outdoor environments. A key reason behind these shortcomings lies in legacy planning frameworks, which have historically prioritized aesthetic landscaping and structured recreational functions over flexibility and inclusivity. As a result, conventional park designs often feature formal sports courts and ornamental elements, while neglecting adaptable and interactive spaces that could better accommodate the diverse and spontaneous play behaviors of older adults (Lo & Jim, 2012).

Beyond spatial design, environmental factors also play a pivotal role in shaping how older individuals interact with urban parks. Microclimatic conditions, including temperature, humidity, sunlight, and wind exposure, directly influence the temporal and spatial patterns of park use. Furthermore, the presence (or absence) of age-appropriate amenities—such as shaded seating, rest areas, and communal gathering points—can significantly enhance or inhibit opportunities for playful engagement and social interaction (Yung et al., 2016). Older adults, in particular, are highly responsive to these environmental cues, with their usage patterns closely tied to perceptions of comfort, safety, and sociability.

Technology and Activity Recognition in Aging Research

The integration of technology in aging research has opened new avenues for understanding older adults' behavioral patterns. Recent advances in artificial intelligence and computer vision have made it possible to analyze human activity with unprecedented detail and accuracy. The application of these technologies to study play behavior represents a promising approach for capturing the nuanced ways older adults engage with public spaces. The YOLO-Pose framework, originally developed for general human pose estimation, has emerged as a powerful tool for analyzing human movement and activity. When adapted for studying older adult behavior, this technology offers several advantages over traditional observational methods, including the ability to process large amounts of data consistently and detect subtle patterns that might escape human observers.

However, the application of AI-powered analysis in aging research also presents unique challenges. These include the need to account for the diverse movement patterns characteristic of older adults, the importance of preserving privacy in public space monitoring, and the challenge of interpreting automated observations within appropriate social and cultural contexts.

Age-Friendly Design and Social Infrastructure

While age-friendly design has become a central concern in urban planning, its application to play spaces for older adults remains conceptually and practically underdeveloped. Traditional frameworks often prioritize accessibility and safety, yet emerging perspectives call for a more holistic understanding that incorporates the social, emotional, and cultural dimensions of

space use. In this context, play serves as a critical point of convergence between spatial design and social interaction, offering opportunities for joy, spontaneity, and connection in later life (Chen & Chan, 2014).

Urban parks, as key components of social infrastructure, are particularly well-positioned to support such engagement. Their potential lies not only in enabling physical activity but also in fostering both planned and serendipitous encounters among older adults. However, the effectiveness of these spaces depends on their ability to accommodate diverse, culturally resonant forms of play, while remaining responsive to the lived experiences and preferences of aging populations. This highlights the need to rethink play space design beyond purely functional criteria, toward models that actively cultivate social inclusion and intergenerational participation within dense urban environments.

Methodology

Study Area and Context

This study was conducted in Tai Kok Tsui, a neighborhood in Hong Kong that exemplifies the challenges and opportunities of aging in high-density urban environments. The area represents a unique urban transformation, where an industrial past meets modern residential development, creating diverse spatial configurations that influence how older adults interact with public spaces. The neighborhood's demographic profile shows a significant increase in elderly residents, with many long-term residents aging in place amid urban renewal. This demographic shift, combined with limited public space provision, makes Tai Kok Tsui an ideal case study for examining older adults' play behaviors in constrained urban environments.

Data Collection Framework

Our data collection strategy employed a systematic observational approach across five public parks within Tai Kok Tsui. The selection of these parks was based on their varying spatial characteristics, usage patterns, and surrounding demographic contexts, providing a comprehensive representation of public space typologies in high-density urban environments. Data collection spanned from September to December 2024, encompassing 11 video recording sessions strategically scheduled to capture both morning (7:00-11:00) and afternoon (14:00-18:00) activity patterns. The observation schedule encompassed multiple parks: Anchor Street Park, Cherry Street Park, Ivy Street Park, Maple Street Park, and Tung Chau Street Park. Each location was observed during different times of day to account for temporal variations in usage patterns and environmental conditions. This systematic approach enabled comprehensive coverage of diverse activity patterns while maintaining consistency in data collection methods.

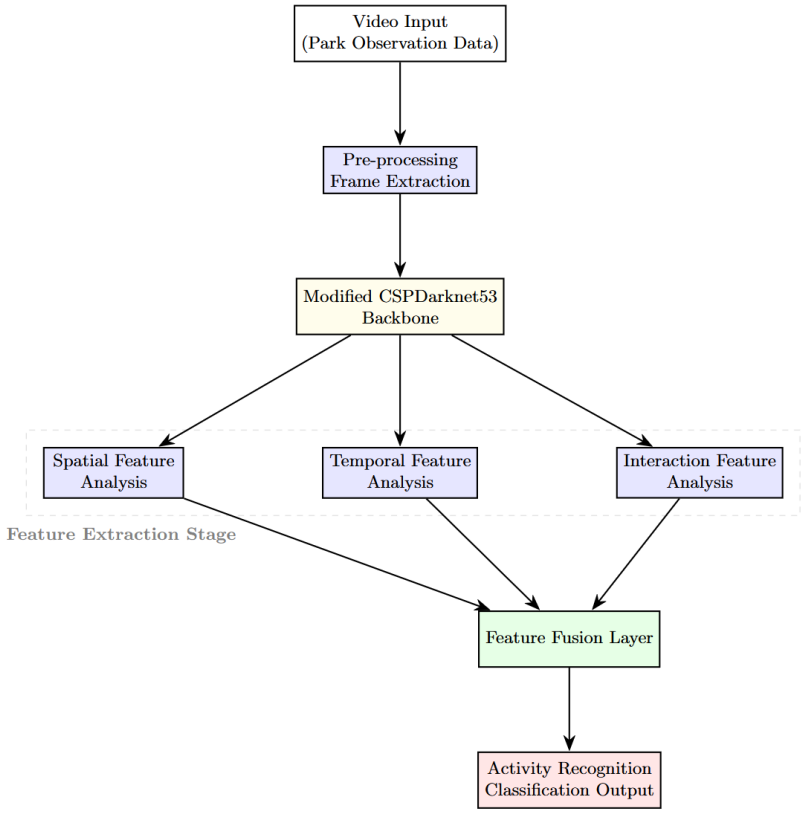
AI-Powered Analysis Framework

Enhanced YOLO-Pose Architecture

Our enhanced YOLO-Pose architecture represents a significant advancement in human activity recognition, specifically optimized for older adult behavior analysis (Figure 1). The framework builds upon traditional object detection methodologies while incorporating specialized components for pose estimation and activity recognition. At its core, the detection

module utilizes a modified CSPDarknet53 backbone, enhanced with spatial attention mechanisms and adaptive feature aggregation systems. This modification significantly improves the system's ability to detect and track older adults in complex urban environments.

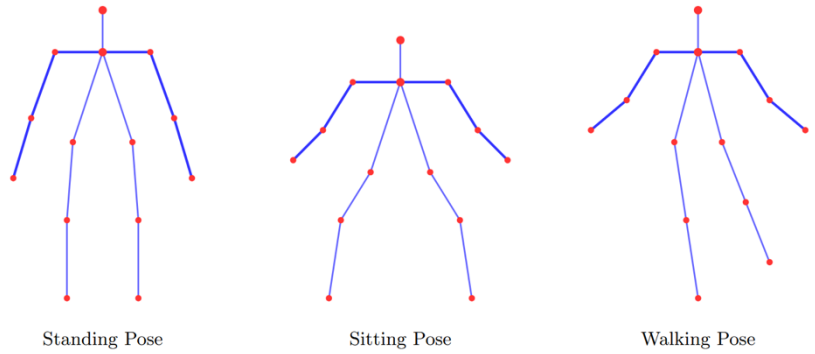
Figure 1
Enhanced YOLO-Pose Framework Architecture



The pose estimation component introduces a sophisticated 17-keypoint skeletal model, specifically calibrated for older adult posture analysis (Figure 2). This model incorporates advanced joint angle calculation algorithms and temporal consistency enforcement mechanisms, enabling accurate tracking of subtle movements and posture changes. The system's temporal smoothing capabilities ensure stable measurements while maintaining sensitivity to significant activity transitions. The activity recognition module employs a multi-branch architecture that processes spatial, temporal, and interaction features simultaneously. The spatial feature branch analyzes pose configurations and relative joint positions, while the temporal branch examines motion patterns and activity sequences. The interaction analysis branch focuses on multi-person scenarios and environmental context integration, enabling comprehensive behavior analysis in social settings.

The technical implementation of this architecture achieves significant improvements over traditional approaches, demonstrating a 7% increase in detection accuracy for older adult subjects and a 5% enhancement in activity recognition precision. The system maintains real-time performance with an average processing time of 25ms per frame, while significantly reducing computational overhead by 24% compared to conventional implementations.

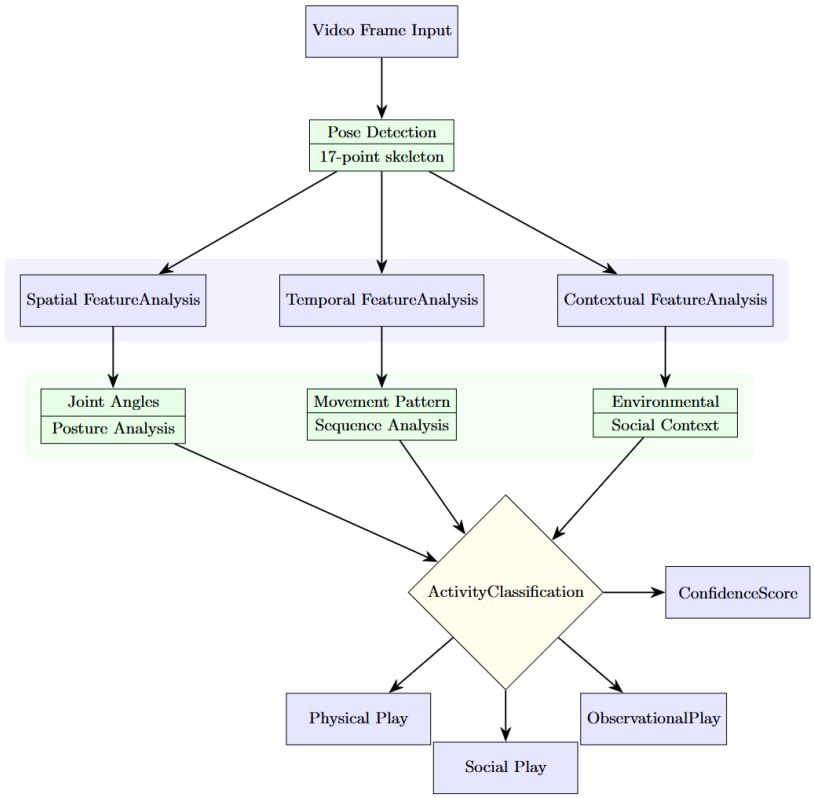
Figure 2
Enhanced 17-Keypoint Skeletal Model



Activity Definition and Recognition

The activity recognition system employs a hierarchical approach to identify and classify older adult behaviors in urban parks (Figure 3). Our framework defines activities through comprehensive spatial-temporal features, incorporating both static postures and dynamic movements. The system first identifies basic postures through precise joint angle analysis and skeletal alignment, then progresses to more complex activity recognition through pattern analysis and contextual interpretation.

Figure 3
Activity Recognition Process

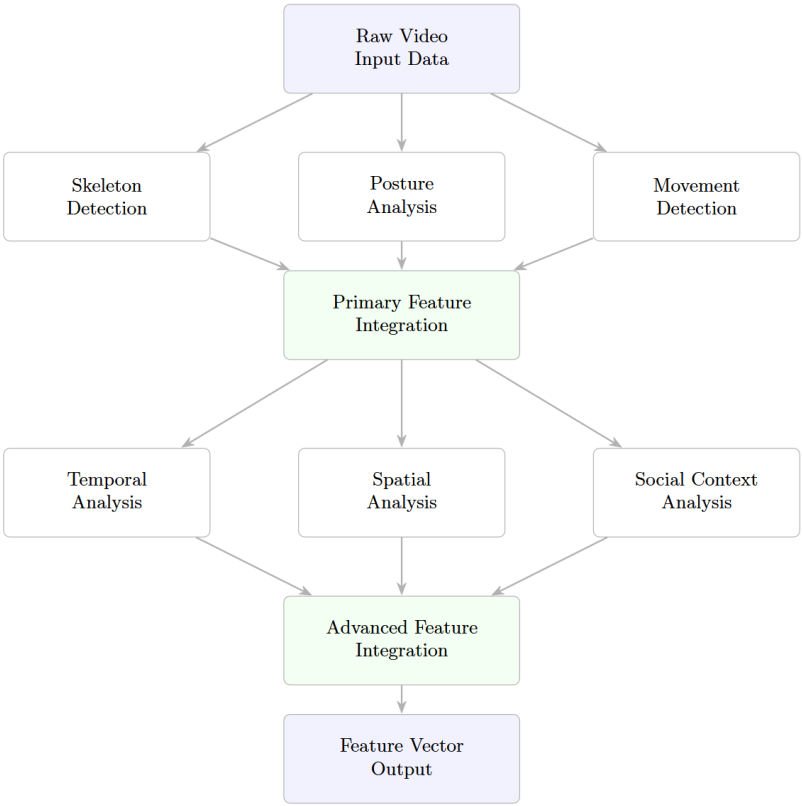


The recognition process integrates multiple data streams to ensure accuracy and reliability. Basic postures are identified through vertical spine angles, knee flexion measurements, and hip position analysis. Dynamic activities are recognized through a combination of step cycle detection, movement pattern analysis, and inter-personal distance measurements. This multi-layered approach enables the system to distinguish between similar activities while accounting for the unique movement characteristics of older adults.

Feature Extraction Pipeline

The feature extraction process implements a sophisticated three-stage pipeline that processes both individual and group behaviors (Figure 4). Primary feature extraction begins with skeletal keypoint identification and joint angle calculations, providing the foundation for more complex analysis. The system then progresses to temporal feature analysis, examining movement patterns and activity transitions over time. Finally, contextual feature integration considers environmental factors and social interactions, providing a comprehensive understanding of play behaviors.

Figure 4
Data Processing Stages for Play Behavior Analysis



Data Processing and Analysis

Our data processing pipeline employs robust pre-processing techniques to ensure data quality and consistency. Video data undergoes systematic frame extraction, resolution standardization, and lighting condition normalization. Privacy protection measures are implemented through automated facial blurring and identity anonymization. The processed

data then flows through our activity recognition system, where continuous pose tracking and pattern matching algorithms operate in parallel.

Quality Control and Ethical Considerations

The research methodology incorporates comprehensive quality control measures to ensure data integrity and ethical compliance. All video recordings adhere to local privacy regulations, with public notices prominently displayed during recording sessions. The data anonymization process occurs at multiple stages, from initial recording through final analysis. Regular system calibration and validation procedures ensure consistent performance across different environmental conditions and user groups.

Validation Framework

Our validation framework combines quantitative metrics with qualitative assessment to ensure robust results. The system undergoes regular performance evaluation through comparison with manual observations, utilizing the established SOPARC methodology as a benchmark. Statistical validation includes accuracy assessments, false positive/negative analysis, and confidence interval calculations for all measured parameters. This comprehensive methodology enables detailed analysis of older adult play behaviors while maintaining high standards of data quality and ethical consideration. The integration of advanced AI technology with traditional observational methods provides a robust framework for understanding complex social behaviors in urban environments.

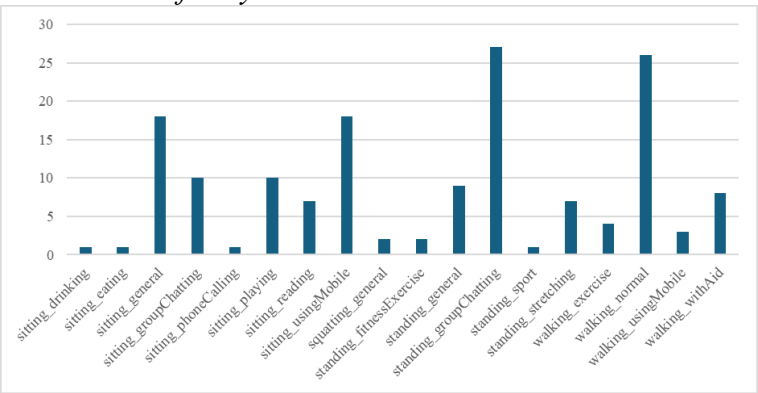
Results

Observed Play Patterns in Urban Parks

Analysis of video data collected from five public parks in Tai Kok Tsui during September to December 2024 revealed distinctive patterns of older adult play behavior. The observations, covering both morning and afternoon periods across 11 video sessions, demonstrated that older adults' play activities in high-density urban parks differ significantly from those of younger age groups.

Figure 5

Distribution of Play Activities Observed Across the Five Parks in Tai Kok Tsui



Our findings indicate that unlike younger groups who typically engage in structured sports, older adults predominantly participate in unstructured, conversational, and observational play

activities (Figure 5). This pattern suggests a distinct preference for more social and less physically demanding forms of play in urban park settings.

Social and Mobile Technology Integration

A significant observation emerged regarding the integration of mobile technology in older adults' play behaviors. While mobile device usage was observed across all age groups, older adults exhibited distinct usage patterns, primarily employing their devices for passive activities such as reading, content consumption, and casual gaming, rather than interactive or social play.

Environmental and Safety Considerations

The analysis revealed several environmental and safety factors that appear to influence older adults' play behaviors. Concerns about physical safety, particularly regarding uneven walking surfaces and inadequate lighting, emerged as potential barriers to more dynamic physical activities. These environmental constraints appear to guide older adults toward more stationary and social forms of play.

Cultural and Social Dimensions

Our observations suggest that cultural perceptions of aging play a significant role in shaping play behaviors. The data indicates that older adults may feel self-conscious about participating in more dynamic activities in public spaces, leading to a preference for more socially acceptable forms of play within their cultural context.

These findings provide important insights into how older adults utilize urban parks for play in high-density environments, particularly highlighting the role of these spaces in reducing social isolation. The results suggest that successful park spaces for older adults should prioritize social interaction zones while addressing safety and cultural considerations.

Discussion

Our findings challenge traditional perspectives on play in later life, particularly within the context of high-density urban environments. While existing literature often emphasizes structured physical activities and exercise programs for older adults, our observations reveal a more nuanced reality. The predominance of unstructured, conversational, and observational play suggests that older adults' recreational needs extend beyond purely physical benefits, encompassing important social and emotional dimensions that have been historically overlooked in urban design and aging research.

The observed patterns of play behavior align with emerging research suggesting that innovative approaches to promote social connectedness may hold particular promise in addressing isolation and loneliness among older adults. This finding is especially significant given that approximately 45% of Hong Kong's older adults report experiencing loneliness, with this issue being particularly acute among those with fair or poor physical health.

Our research suggests that current urban park designs in high-density cities may not fully accommodate older adults' play preferences and needs. The prevalence of safety concerns, such as uneven paths and poor lighting, appears to influence activity choices, often directing

older adults toward more stationary and social forms of engagement. This finding has important implications for urban design, suggesting that parks should prioritize the creation of social play zones featuring elements such as interactive seating arrangements, shaded communal areas, and age-friendly game spaces.

The observed patterns of mobile technology use among older adults present both challenges and opportunities. While older adults demonstrate regular engagement with mobile devices, their usage patterns differ significantly from younger generations, focusing more on passive consumption rather than interactive play. This finding suggests potential for developing age-appropriate digital tools that could enhance park experiences and facilitate intergenerational play, such as augmented reality games or guided movement activities specifically designed for older adults.

The impact of cultural perceptions on play behavior emerges as a crucial consideration in our study. Within the context of Hong Kong's high-density urban environment, cultural attitudes toward aging appear to influence how older adults engage in play activities. This finding highlights the need for culturally sensitive approaches to park design and programming that respect and accommodate local perspectives on aging and recreation.

Conclusion

This study contributes to a deeper understanding of how older adults engage in play within the urban parks of high-density cities, reframing play not merely as a physical or recreational activity, but as a socially and emotionally meaningful practice shaped by spatial, cultural, and environmental contexts. By foregrounding the nuanced ways in which older adults negotiate agency, safety, and sociability in public parks, the research challenges reductive assumptions about aging and activity, and opens up new possibilities for interpreting everyday urban spaces through the lens of later-life engagement.

At the theoretical level, the study expands current discourses on age-friendly design by integrating the concept of social infrastructure and highlighting the affective and relational dimensions of play in later life. Rather than viewing play as a peripheral or child-centric phenomenon, this research positions it as a critical interface between spatial design and social inclusion, particularly in aging, high-density contexts. In practical terms, the findings emphasize the need to move beyond prescriptive, exercise-focused interventions toward more flexible, culturally responsive design strategies that accommodate unstructured, informal, and intergenerational forms of play. Urban parks should not only be accessible and safe, but should actively cultivate atmospheres of belonging, spontaneity, and interaction that resonate with older adults' lived realities. The study also demonstrates the potential of AI-assisted observational methods to capture behavioral patterns and spatial dynamics that are often inaccessible through traditional approaches. This methodological innovation suggests new directions for environmental gerontology and urban studies, particularly in data-scarce or rapidly changing urban environments.

Looking ahead, future research should explore the implementation and evaluation of experimental design interventions that prioritize social play, while addressing the ongoing barriers of safety, cultural stigma, and environmental discomfort. Longitudinal and cross-cultural studies could further illuminate how different urban contexts mediate aging and play.
As cities around the world confront the intersecting challenges of demographic aging and spatial compression, reimagining parks as playful, inclusive, and socially generative

environments will be essential for enabling older adults not just to age in place, but to thrive in place.

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Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the authors used ChatGPT to proofread the manuscript. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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IoT-Enhanced Fall Detection System: Addressing the Needs of an Aging Population

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Abstract

Falls are a major cause of injury and disability among the elderly people which compromises their independence and overall quality of life. This paper presents an innovative Elderly Fall Detection and Assistance System by utilizing IoT technology for real-time monitoring and immediate response to fall events. The system is designed with a central processing unit and inertial sensors to monitor movement and orientation for fall detection. MQTT is being used for the wireless communication to deliver the alert notifications along with a user-friendly interface for smooth interaction. The fall detection algorithm identifies the sudden changes of the motion and the posture of the device which triggers the real-time alerts to caregivers including a visual indicator. Extensive testing has been done by simulating falls and routine activities which has exhibited the system's reliability, minimized false positives, and ensured timely notifications. Moreover, this detection system can offer a cost-effective solution compared to many existing options on the market, with potential for future advancements in enhancing accuracy and adaptability.

Keywords: fall detection, IoT, elderly care, real-time monitoring, MQTT protocol

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Introduction

Falls among older adults are a significant and growing public health concern globally which causes major implications for individual well-being, healthcare costs, and quality of life. Approximately one-third of seniors experience a fall each year in Canada alone (Fazal, 2022). More than one in four adults aged 65 and older experiences a fall each year, and those who have fallen once are at twice the risk of falling again. Many of these falls are never reported and people often do not get the help they need in time (Canada, 2021; Vaishya & Vaish, 2020). Although not all falls cause injury, about 37% lead to health issues that require medical care or limit the individual's mobility for at least one day (CDC, 2024). These may include broken bones such as wrists, arms, ankles, and hips or head injuries. Even if someone is not physically injured, the fear of falling again can cause them to become less active, which increases their chances of falling in the future (Vellas et al., 1997). Falls are one of the most common reasons for older adults end up in the emergency room or hospital. In the United States alone, they result in over 3 million emergency room visits and nearly 1 million hospital admissions each year (Moreland et al., 2022). Falls are the leading cause of traumatic brain injuries (TBIs) and hip fractures in this population (CDC, 2024). One particularly serious outcome is the "Long Lie," when someone remains on the ground for more than an hour after falling. This situation can lead to severe health issues or death if help doesn't arrive quickly (Horton, 2008; Lord & Dayhew, 2001). Due to these risks, timely fall detection and rapid response are essential for reducing the severity of injuries, preventing complications, and helping the older adults to maintain their independence.

Although falls among older adults are common and often serious, many currently available fall detection systems in the market have limitations that affect their effectiveness and prevent them from being widely used. These include high costs, privacy concerns, the need for manual activation, and uncomfortable or intrusive designs. Such issues make it difficult for these systems to be widely adopted, especially in home environments or among older adults with limited access to healthcare services. The Elderly Fall Detection and Assistance System developed in this project seeks to address these limitations. Leveraging Internet of Things (IoT) technologies, the system offers real-time monitoring, wireless communication via the Message Queuing Telemetry Transport (MQTT) protocol. It integrates inertial motion sensors, a central processing unit (CPU), and intelligent threshold-based algorithms to detect falls accurately and transmit alerts to caregivers promptly. This paper outlines the design, implementation, and evaluation of the system, emphasizing its potential to enhance elderly care through a non-intrusive, cost-effective solution.

Background

The development of fall detection systems has evolved significantly over the past two decades, particularly with the integration of sensor-based monitoring and wearable devices. Existing fall detection solutions can generally be categorized into three types: manual alert systems, environmental monitoring systems, and wearable sensor-based systems.

Manual alert systems, such as pendant buttons or wristbands, rely on the user to manually activate an emergency call. Although these devices are simple and affordable, the systems are ineffective in situations where the user is unconscious or unable to move after a fall. Environmental monitoring systems utilize technologies such as cameras, microphones, or floor pressure sensors to detect fall events. These solutions eliminate the need for user action. However, they are often considered invasive due to the privacy concerns and are typically

restricted to indoor use which limit their overall effectiveness (Gharghan & Hashim, 2024; Newaz & Hanada, 2023).

Wearable fall detection systems have gained substantial attention due to their portability, non-intrusiveness, and ability to function across various environments. Wearable fall detection systems, especially those utilizing inertial measurement units (IMUs), have become a widely adopted approach for monitoring motion and identifying falls. These systems often use accelerometers and gyroscopes to detect sudden shifts in body orientation. One common technique is the threshold-based algorithm, which flags abrupt deviations from regular movement patterns as potential fall events (Bourke et al., 2007). These models are efficient in distinguishing fall-like patterns from normal activities, although they can be prone to false positives if not finely tuned.

The integration of Internet of Things (IoT) technologies has significantly enhanced these systems by enabling real-time data capture, local processing, and remote alert transmission. Various communication protocols are employed in these systems to transmit data between sensors and monitoring platforms. Common protocols include Hypertext Transfer Protocol (HTTP), which provides broad compatibility but is not optimized for constrained environments, and Constrained Application Protocol (CoAP), which is better suited for low-power devices but has limited Quality of Service (QoS) features. Among the various communication protocols, Message Queuing Telemetry Transport (MQTT) is well-suited for such applications due to its efficiency, reliability, and suitability for resource constrained IoT environments. It is a lightweight, publish-subscribe messaging protocol optimized for low-bandwidth, high-latency, or unreliable networks conditions which often encountered in home environments. Compared to HTTP or CoAP, MQTT offers lower power consumption and reduced network overhead which makes it suitable for battery-powered wearable devices that require efficient and reliable communication (Chatterjee et al., 2017; Gia et al., 2018; Nazir & Kaleem, 2019; Usmani, 2021).

Despite of all these technological advancements, many commercial fall detection solutions available in market are intrusive, less user friendly or expensive as most of the systems require subscriptions and automated messages for any fall event costs extra. Our system addresses these issues by integrating cost-effective sensors with a lightweight MQTT-based communication protocol and a threshold-based detection algorithm. This design allows a real-time, non-intrusive monitoring and timely alert delivery to ensure safe and independent aging at home.

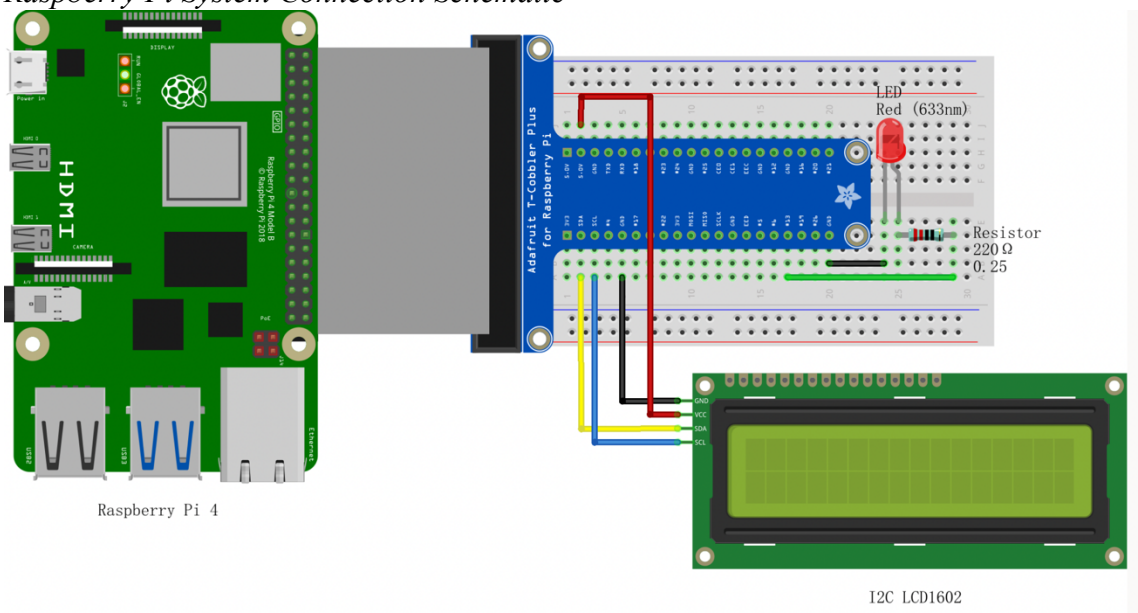
Methodology

This section outlines the technical design and implementation of the proposed IoT-based fall detection and assistance system. The methodology integrates motion-sensing hardware, local processing, and real-time wireless communication to achieve efficient fall detection and alert delivery. The system continuously monitors human movements, processes sensor data, and detect falls using a predefined algorithm. Upon detecting a fall, the system provides a visual warning, records fall events, and sends alerts to caregivers, ensuring timely medical assistance.

Hardware Architecture

The goal of this project to design an IoT-based wearable fall detection system that could monitor the user in real time and send alerts to caregivers in the event of a fall. The architecture is composed with three essential hardware components: Motion Sensing and Data Collection, Central Processing Unit (CPU) and Wireless Communication Module.

Figure 1
Raspberry Pi System Connection Schematic



Motion Sensing and Data Collection: The inertial motion sensor integrates an accelerometer and gyroscope which was being used to measure acceleration, orientation, and angular velocity in three dimensions. The sensor tracks the user's posture and movement to help detect unusual activity that may indicate a fall.

Central Processing Unit (CPU): This unit continuously receives data from the sensors and applies a threshold-based algorithm to detect falls based on patterns in acceleration and orientation. In the prototype setup, a Raspberry Pi was used for local computation, visual alerts (via LCD and LEDs), and system control (shown in Figure 1). It received raw data from the motion sensors and analyzed it using a threshold-based algorithm. Although Raspberry Pi provided a convenient platform for prototyping, the system is not dependent on it. The CPU component could be replaced with any embedded processor that supports wireless communication protocols.

Wireless Communication Module: Once a fall is detected, the CPU uses the MQTT protocol to send an alert message to a caregiver's device. The MQTT protocol was being used for its lightweight, efficient data transmission. This protocol also has few other benefits including its low power usage, low bandwidth requirements, and ability to reliably deliver messages over unstable networks (Chatterjee et al., 2017; Gia et al., 2018).

Software Architecture

The software part of the system consists of four key modules: Wireless Communication Module, Central Processing Unit (CPU), Data Files Layer, and User Interface, as illustrated in Figure 2

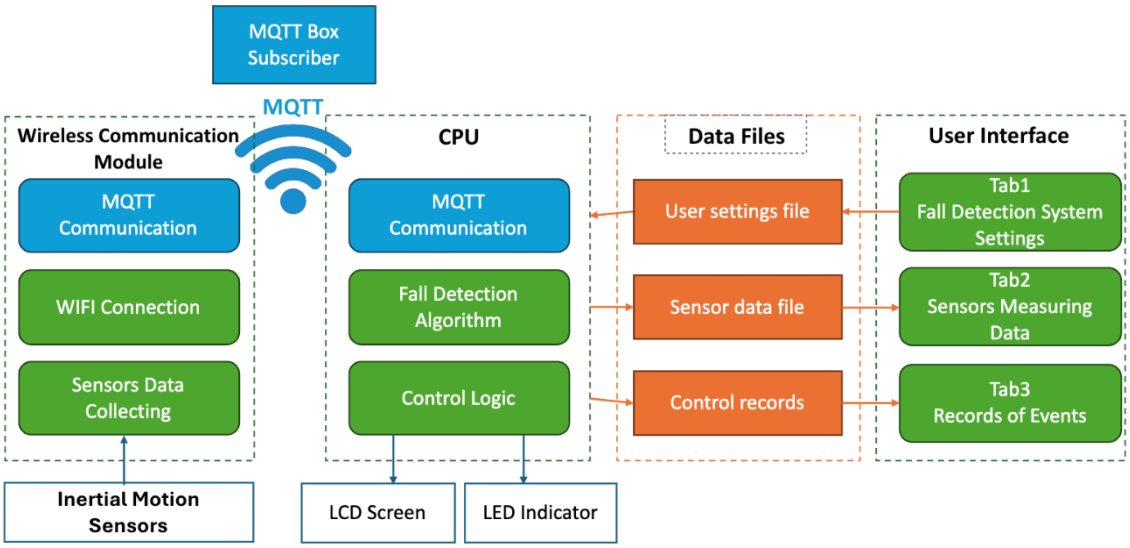
Wireless Communication Module: This module is responsible for collecting real-time motion data from inertial sensors (accelerometer and gyroscope) and transmitting it over a Wi-Fi network. It utilizes the MQTT protocol to send sensor data to the CPU. The use of MQTT ensures lightweight, efficient, and reliable communication, especially suitable for constrained environments (Usmani, 2021).

Central Processing Unit (CPU): The CPU receives sensor data via MQTT and executes the fall detection algorithm. This module also handles the control logic for visual and hardware indicators such as an LCD (I2C LCD) display and LED lights. The CPU serves as the system's core processor, enabling localized decision-making without requiring a cloud-based inference.

Data File Layer: This layer supports the structured interaction between system logic and user interface. Three types of files support the interaction between the system and the user interface: (1) User settings file, which stores custom configuration parameters; (2) Sensor data file, which logs real-time sensor readings; and (3) Control records, which track system status and past alerts.

User Interface: A web-based dashboard (built with Plotly Dash) was used to customize the system settings, real-time data visualization and to access the event logs for previously detected falls.

Figure 2
Software Architecture



This modular architecture not only supports real-time indoor monitoring but also allows for future expansion. By integrating a cellular communication module, the system could be

extended to transmit alerts without relying on Wi-Fi networks and making it suitable for outdoor use and continuous monitoring during travel.

Implementation

The successful implementation of the fall detection and assistance system focused on integrating motion sensing, data communication, algorithmic processing, and user interface control. The system was designed to be lightweight, modular, and adaptable to various environments, ensuring effective real-time monitoring and alerting capabilities. This section outlines the key stages of the system's operation from data acquisition and fall detection to alert generation and user interaction.

Sensor Data Processing and Transmission

The fall detection system continuously collects the real-time acceleration and orientation data using an inertial motion unit. The data is transmitted to a central processing unit via a wireless communication module over a predefined MQTT topic via a Wi-Fi network. The communication module first connects to the specified Wi-Fi network using the provided SSID and password. Once connected, the system establishes a communication link with a messaging broker and publishes sensor data to a dedicated topic using the MQTT protocol. In the main loop, the data is formatted into a message string and published to the MQTT topic. Meanwhile the Raspberry Pi, which subscribes the same MQTT topic, receives real-time sensor data, providing the input to the fall detection algorithm.

Fall Detection Algorithm

The fall detection algorithm is the core of the system, analyzing the sensor data to identify falls. The basic algorithm employs a threshold-based detection system (Patel, 2019), which checks if certain parameters exceed predefined thresholds within a specific time interval. When a fall occurs, there is a substantial change in acceleration within a split second, and after the fall, the person lies still for a while with no change in orientation.

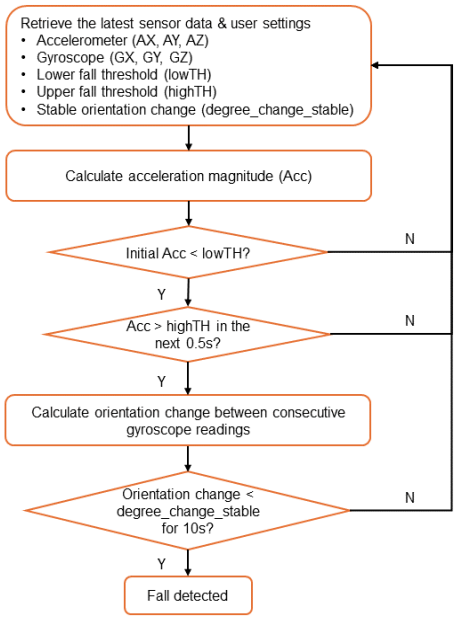
Figure 3 illustrates the fall detection algorithm. The basic steps include:

- *Data collection:* The real-time accelerometer (A_x, A_y, A_z) and gyroscope (G_x, G_y, G_z) data are collected through the MQTT connection. The system also reads user-defined thresholds from a CSV file.
- *Acceleration check:* The magnitude of acceleration *Acc* is calculated using formula (1) (Al-Dahan, Bachache, & Bachache, 2016). This check determines if the initial acceleration drops below the lower threshold and then exceeds the upper threshold within 0.5 seconds. This rapid change in acceleration is a key indicator of a potential fall.

$$Acc = \sqrt{\left\{(A_x)^2 + \left(A_y\right)^2 + (A_z)^2\right\}} \quad (1)$$

- *Orientation stability check:* The change in orientation between consecutive gyroscope readings is calculated to check if each value is below the threshold over 10 seconds, which indicates stability after the fall.
- *Fall detection:* A fall event is confirmed if both the acceleration and orientation stability conditions are met.

Figure 3
Fall Detection Algorithm



The thresholds defined in the algorithm have been extensively tested under different conditions to simulate various real-world movements. Additionally, ranges for these thresholds are provided in the user interface, allowing customization to meet the needs and preferences of different users.

Control Logic and Alert Handling

The Raspberry Pi is the central hub that manages the system's overall operation. The control logic ensures continuous monitoring of the system status and the latest sensor data. The detailed breakdown of the control logic is as follows:

- *System monitoring:* The Raspberry Pi constantly monitors the system activation state and updates the JSON file of control records based on any changes detected.
- *System activation / deactivation:* If the system is deactivated or sensor data is not received, the LED indicator is turned off, and the LCD screen displays “NO DATA.” When the system is activated and sensor data is received, the LED indicator is turned on to signify activation. Real-time sensor data is then stored in a CSV file, and the fall detection algorithm is triggered.
- *Fall detection response:* When a fall is detected, an alert message is sent to a specific MQTT topic. The fall event is recorded in the JSON file, and the LCD screen is updated to display a warning message. Additionally, the LED blinks to provide a visual warning. Devices such as personal computers or mobile phones that subscribe to the same MQTT topic can also receive the alert message. If no fall is detected, the LCD screen displays “SAFE” to indicate that the system is working with no fall occurred.

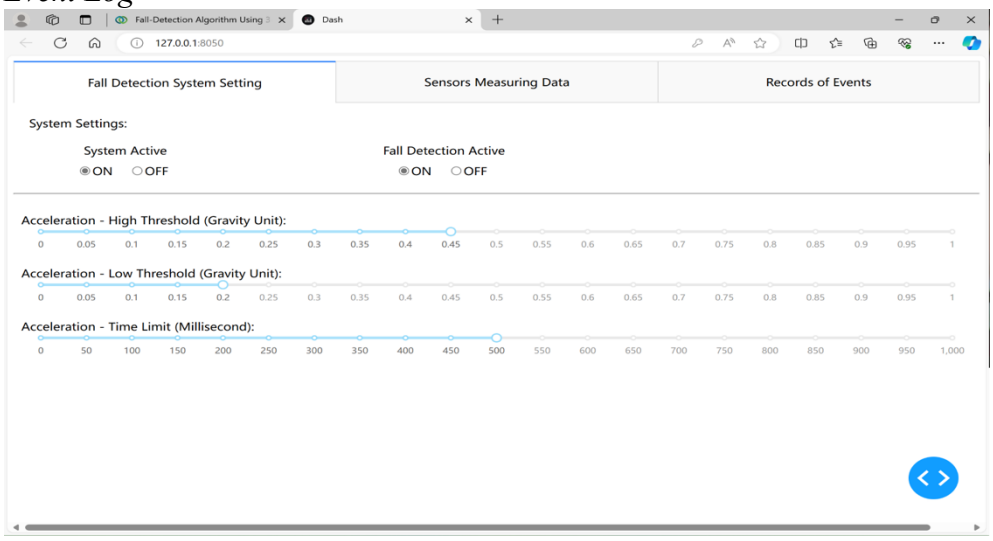
User Interface

A graphical user interface (GUI) was developed to enable interaction with the system through a local web server as shown in Figure 4. It is designed to be intuitive and user-friendly which features:

- *System settings:* It allows users to activate or deactivate the system and set three thresholds for fall detection inputs.
- *Real-time sensor data:* Figure 4 indicates the second tab of the UI. It displays the sensor measurements in real-time, including 3-axis acceleration and 3-axis angular velocity as shown in Figure 5.
- *Event records:* This tab of the UI provides a history of system status changes and fall detection events.

The UI ensures a responsive and interactive experience. Users can access the interface through a local web server, providing seamless interaction with the system. The interface is protected by a login screen to ensure secure access, making the system practical for use in both clinical and home settings.

Figure 4
User Interface (UI) for the Fall Detection System Settings, Sensors Data Measuring and Event Log



Testing and Evaluation

The testing and evaluation of the Elderly Fall Detection and Assistance System were conducted through a series of structured tests to ensure the system's functionality and reliability.

- *User Interface Testing:* The User Interface testing involved several key steps to ensure functionality and reliability. After login successfully, the interface then navigated to the system settings tab to activate or deactivate the system, set fall detection thresholds, and save these configurations, verifying their functionality. The interface was monitored for real-time updates of accelerometer and gyroscope data to ensure continuous and accurate data flow. Additionally, the logging of system status changes and fall events were verified for completeness, ensuring that all interactions were correctly captured and displayed.

- *Fall Detection Algorithm Testing:* The fall detection algorithm was refined by testing various fall scenarios and normal activities, adjusting the acceleration and orientation thresholds to improve accuracy. The test scenarios included simulated falls, fall-like movements such as lying down, sudden movements like slipping without falling, etc. Continuous monitoring ensured that falls were detected only when both acceleration and orientation stability conditions were met, validating the reliability and precision of the algorithm.
- *Sensor Operation Testing:* The sensor operation testing began with the sensor collecting baseline data in a stable environment. Simulated falls were then performed to observe significant changes in acceleration and orientation, verifying the sensor's response. Additionally, normal activities such as walking, sitting, and standing were conducted to test for false positives, ensuring that regular movements were not misidentified as falls.

Figure 5

UI Sensor Data Shows a Fall

- *Notification System Testing:* Stimulated fall detection events were triggered to monitor MQTT communication for alert messages. Devices subscribed to the MQTT topic were checked to ensure they received these alert messages, and visual indicators, such as the LCD screen and LED, were monitored to confirm they displayed the correct fall warnings.

Figure 6

The system is operating normally, and no alert has been generated (Left), A fall has been detected which is showing on the LCD screen and a blinking LED (Right)

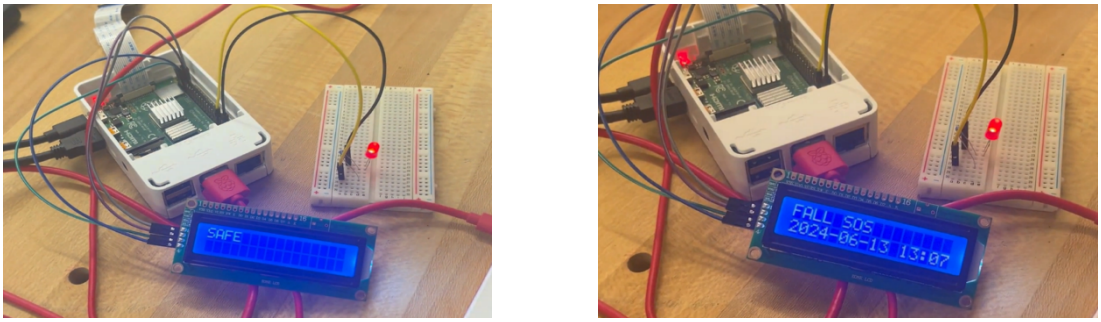


Figure 7
Display of MQTT Topic Subscription

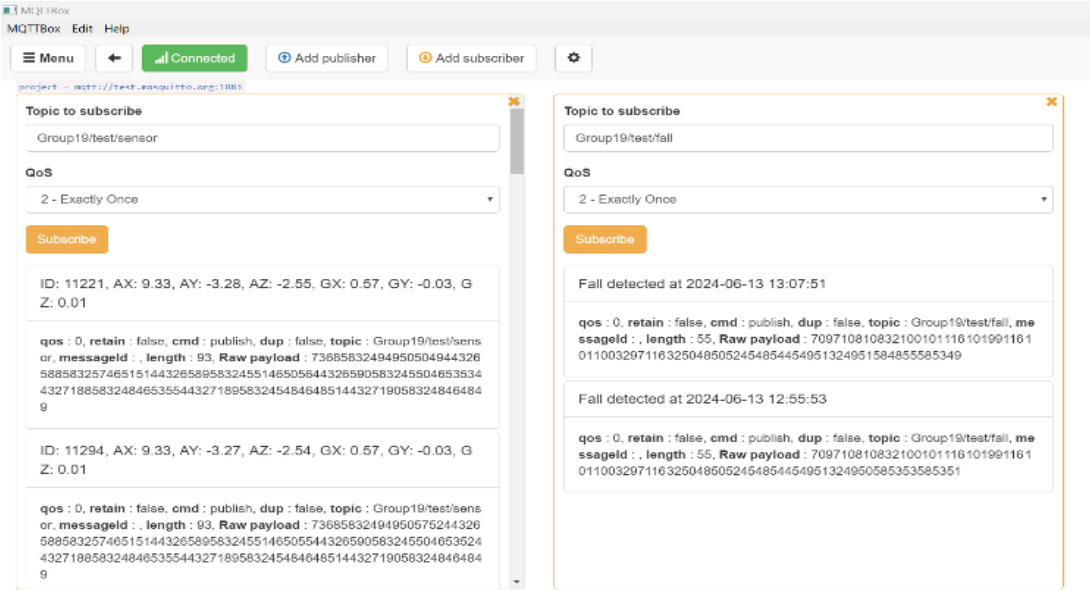
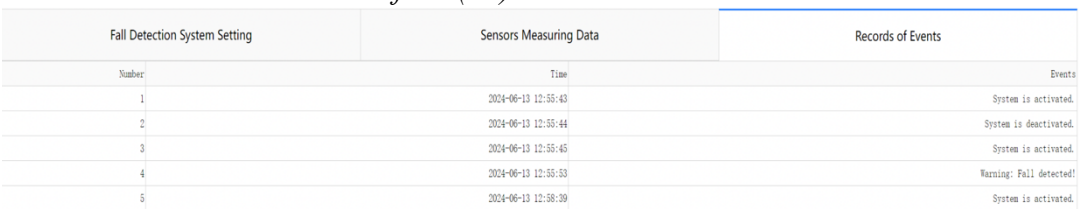


Figure 8
Event Record in the User Interface (UI)



Number	Time	Events
1	2024-06-13 12:55:43	System is activated.
2	2024-06-13 12:55:44	System is deactivated.
3	2024-06-13 12:55:45	System is activated.
4	2024-06-13 12:55:53	Warning: Fall detected!
5	2024-06-13 12:58:39	System is activated.

These tests ensured that the Elderly Fall Detection and Assistance System operated as intended, providing reliable fall detection and timely alerts to caregivers, with minimal false positives during normal activities.

Although the system exhibited strong performance in detecting falls and minimizing false alarms, several limitations were identified. The accuracy of detection is influenced by the calibration of threshold values, which can vary across individual users based on body type and movement characteristics. Furthermore, the effectiveness of the sensor is highly dependent on correct positioning on the body, which may be inconsistent in real-world scenarios. Another key limitation is the lack of field testing with elderly individuals in natural living environments, which is essential to fully validate the system's practical applicability. The current testing of the system was conducted in controlled environments with a limited number of simulated fall and non-fall scenarios. These tests helped to validate the core functionality of the system. However, they do not fully represent the complexity and variability of real-world settings. To ensure the real-world relevance, the system needs to be evaluated on a larger and more diverse dataset that includes a wider range of user behaviors, environments, and fall types. This would help to ensure the system's reliability, reduce false alarms, and improve adaptability to different user populations and living conditions.

The evaluation highlighted the robustness and potential of the system for real-world implementation in home-based elderly care. The combination of lightweight MQTT communication and localized edge processing proved effective for enabling real-time fall

detection and alert delivery. For future work, broader testing across diverse user profiles and varied environmental conditions is recommended to ensure the system's generalizability and long-term reliability.

Conclusion

In summary, the Elderly Fall Detection and Assistance System presents a reliable and practical solution to address the growing need for real-time fall detection among older adults. By leveraging inertial motion sensing, local data processing, and lightweight MQTT-based wireless communication, the system provides real-time monitoring and timely alerting capabilities. The threshold-based detection algorithm, combined with a user-friendly interface, enables caregivers to track the system’s status and respond promptly to fall events, thereby enhancing safety and support for independent living.

Future work may focus on integrating adaptive machine learning or deep learning algorithms to tailor fall detection parameters based on individual characteristics such as body type, gait, or habitual movement patterns. This could significantly enhance the system’s sensitivity and specificity while reducing false positives. Moreover, personalized behavior modeling and contextual data such as weather and environmental conditions could be incorporated to improve situational awareness. These advancements would support the development of a more intelligent, context-aware system which would be capable of delivering proactive care in both indoor and outdoor environments.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

ChatGPT was used to assist in improving the wording and clarity of the manuscript. The content and ideas are entirely the authors' own.

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The Intersection of Urban Amenities and Age: Daily, Weekly, and Monthly Routines Across Age Groups

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Abstract

As the global population ages, understanding the associations between urban environments and older individuals' lifestyles becomes increasingly important. The study investigates how age influences engagement with urban amenities and the routines shaping daily life across generations. So, the study focuses on the relationship between age and urban routines, specifically how people of age groups engage in daily, weekly, and monthly activities within urban amenities, that address a range of urban experiences. Data was gathered from 288 individuals via face-to-face questionnaires in four neighborhoods in Izmir, Turkey, characterized by their high level of provision in urban amenities and possibilities. Statistical analysis, including chi-square tests, was used to examine the routines of older and younger individuals through several variables, indicating significant differences in how they spend their time in urban amenities and places. The findings show that age significantly impacts urban routines, with older persons demonstrating distinct tendencies than younger adults. These variations emphasize the need for age-sensitive urban planning and architecture, that considers the various needs and preferences of a multigenerational community. Recognizing the different rhythms of urban life across age groups enables to design more inclusive and age-friendly cities that promote the well-being and quality of life for all residents. The research offers practical insights and recommendations for urban planners, illustrating the need to create urban environments that meet the shifting needs of an aging society.

Keywords: urban routines, age differences, urban amenities, age-friendly cities, elderly

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Introduction

As global populations age, urban environments face growing pressure to adapt to the needs of diverse age groups (Buffel et al., 2018; Golant, 2014). Cities are increasingly recognized as critical spaces where social, economic, and cultural activities intersect, shaping the routines and well-being of their residents. However, urban planning often neglects the nuanced differences in how older and younger adults engage with urban spaces. This gap has significant implications for the inclusivity, accessibility, and sustainability of urban environments. Older adults often prioritize proximity, accessibility, and familiarity in their daily routines, while younger adults tend to seek dynamic, multifunctional spaces that accommodate social, recreational, and economic activities (Levasseur et al., 2015; Wu et al., 2022). These differing preferences highlights the importance of creating age-sensitive urban designs that cater to both ends of the age spectrum. Such designs not only enhance individual well-being but also foster intergenerational social cohesion, a key factor in building sustainable and inclusive cities.

Existing research has extensively focused age-friendly environments tailored for older adults (Irwansyah & Febrina Ernungtyas, 2023). However, these studies often neglect the interactions between younger and older populations in shared urban spaces. This research investigates to fill this gap by examining how urban routines vary across different age groups, focusing on their engagement with daily, weekly, and monthly activities in various urban settings. By comparing the use of amenities such as parks, shopping areas, cultural facilities, and healthcare services, this study aims to provide actionable insights for urban planners and policymakers. The findings offer a comprehensive understanding of the diverse needs of multigenerational populations and emphasize the importance of evidence-based urban planning. By addressing the varied routines and preferences of older and younger adults, cities can evolve into inclusive environments that support the well-being and quality of life of all residents. This study contributes to the broader discourse on aging and urban planning, offering practical recommendations to ensure cities remain vibrant and sustainable for generations to come.

Conceptual Framework

The conceptual framework for this study emphasizes the interaction between urban amenities and the routines of different age groups, focusing on daily, weekly, and monthly activities. Urban amenities are categorized into three key dimensions: *social infrastructure, commercial opportunities, and routine-based activities.* These dimensions form the basis for understanding how older and younger adults engage with their environments, reflecting their distinct preferences, life cycle stages, and accessibility needs.

Social infrastructure includes amenities that facilitate cultural, recreational, and health-related activities, such as cultural facilities (e.g., theaters, libraries), healthcare facilities (e.g., hospitals), and open spaces (e.g., local parks, neighborhood parks, coastal areas, and walking paths). These spaces serve as vital nodes for physical activity, relaxation, and community engagement (Jiang et al., 2022; Kellett & Rofe, 2009; Levasseur et al., 2015; Machón et al., 2020; Wood et al., 2022). Additionally, sports facilities cater to recreational needs, while "third places" (e.g., cafes, community centers) provide opportunities for social interaction and leisure (Jing et al., 2024).

Commercial opportunities focus on spaces that support economic and social activities, such as local shops, shopping malls, and bazaars. These areas are integral to fulfilling daily needs, promoting economic activity, and fostering informal social interactions. The inclusion of third spaces -informal public gathering spaces distinct from home and work, as defined by Oldenburg[1] (Oldenburg, 1999)- further emphasizes their role in enhancing accessibility and social connectivity.

Routine-based activities encompass broader aspects of urban life, such as workplaces, household chores, and personal visits, including socializing with friends and family. These activities extend beyond specific amenities, representing the functional and relational aspects of daily life.

This framework prioritizes routines over individual amenities, emphasizing how individuals' patterns of activity shape their interactions with the urban environment. By examining categories such as shopping preferences, social infrastructure, and routine-based activities, the study provides a comprehensive perspective to evaluate the diverse needs of younger and older adults. The insights derived from this framework contribute to the development of age-sensitive urban designs that align with the evolving preferences and requirements of multigenerational populations.

Methods and Data

The aim of this study is to compare routines between age groups and investigate the various impacts on usage of an urban environment. The conceptual framework of the study was used to develop a questionnaire. The data was evaluated using a range of statistical techniques to obtain comprehensive results. The research locations were chosen for the Karsiyaka district in Izmir, which is situated in the center of the city. Each neighborhood of Karsiyaka was developed throughout the second half of the 20th century. Izmir was selected as a case study to illustrate the dynamics and characteristics of a modern metropolitan environment in a developing country.

Located in western Turkey, Izmir is the third-largest city in the country, with a population exceeding 4 million. As one of the oldest settlements in Anatolia, Izmir's urban development has historically been shaped by its strategic natural harbor. During the 17th century, the city evolved from a small coastal town into a major urban center, largely driven by the commercial expansion of its coastline (Gündüz & Kiray, 2006; Martal, 1999). This transformation reflects both pre-industrial and post-industrial urbanization dynamics. The Karsiyaka district, situated on the northern side of the Gulf of Izmir, exemplifies the city's broader urbanization trends and development patterns typical of a growing metropolis.

The study focused on 23 neighborhoods in Karsiyaka, selected based on criteria such as structured urban planning processes and their proximity to essential amenities. Key factors considered included the presence of public spaces, social infrastructure, a variety of open spaces, population density, gross density, and green space per capita. From this analysis, the neighborhoods of Aksoy, Bahariye, Bahriye Ucok, and Bahcelievler were chosen for the study. Atakent, despite meeting the selection criteria, was excluded due to its close proximity

[1] "Third places" as defined by Ray Oldenburg, are social spaces that exist outside the realms of home ("first place") and work ("second place"). These informal public gathering spots foster a sense of community and belonging by providing a neutral ground for regular, voluntary, and informal social interaction. Examples of third places include cafes, community centers, libraries, parks, and barbershops.

to the selected neighborhoods, which would have introduced similar environmental characteristics.

The questionnaire was designed based on insights from earlier discussions and existing empirical studies. It focused on urban environment measurements and routines across different age groups. Some quantitative questions were initially open-ended to reduce reporting bias and later categorized for analysis. To ensure the study's validity, a pilot test was conducted with 30 participants of diverse ages, and educational backgrounds. Following revisions from the pilot study, 300 residents were surveyed face-to-face. Specific eligibility criteria were applied to ensure homogeneity: individuals over 60 who were still employed and those under 60 who were retired were excluded to focus on age-appropriate routine patterns. The final dataset included 288 valid responses, forming the basis for statistical analysis.

The questionnaire data were analyzed using IBM SPSS Statistics 24, focusing on identifying patterns and differences in the urban routines of older and younger adults. A chi-square test was employed to examine the statistical significance of categorical variables, enabling a comparison of daily, weekly, and monthly engagement with various urban amenities and activities between the two age groups. This method provided insights into the relationship between demographic characteristics, such as age and preferences for urban spaces, and how these factors influence routines. The analysis aimed to uncover statistically significant differences, highlighting the distinct needs and preferences of multigenerational populations and offering a foundation for evidence-based urban planning recommendations.

Findings

Demographic analysis reveals significant differences between older and younger adults, which are closely related to their respective life cycle stages. Gender distribution shows that a higher proportion of younger participants are female (58.3%) compared to older participants (40.8%) ($p = .004$). Marital status further highlights life cycle differences, with older adults predominantly being married (62.5%) or widowed (27.5%), while younger participants are more likely to be single (32.1%) ($p = .000$). Educational attainment also varies significantly, with younger adults more likely to have university or postgraduate degrees (67.2%) compared to older adults (50.8%) ($p = .008$). This reflects generational shifts in access to education, which may influence preferences for certain urban amenities, such as cultural or recreational facilities. Income levels also diverge, with younger participants more concentrated in higher income brackets (53.6% earning between 15,000-30,000 TRY) compared to older adults, who predominantly fall into lower income brackets (57.5% earning 7,500-15,000 TRY) ($p = .000$). Household composition shows these differences, as older adults are more likely to live in smaller households or alone (73.4% living alone or with one other person) compared to younger adults, who predominantly reside in larger households of three or more members (68.4%) ($p = .000$). Similarly, older adults are more likely to own their homes (79.2%) compared to younger participants (57.7%), who are more likely to rent ($p = .000$).

Transportation access and use also vary, with older adults less likely to own vehicles (55.8% owning none) and using vehicles less frequently (16.7% driving daily compared to 45.2% of younger adults) ($p = .023$). These patterns illustrate how life cycle stages significantly influence daily routines and preferences for urban amenities. For example, older adults' preferences for local shopping and nearby parks can be attributed to smaller household sizes,

lower mobility, and a focus on accessibility. Younger adults, on the other hand, are more likely to seek out dynamic environments, reflecting higher income, greater mobility, and a tendency to engage in activities suited to larger households and more active lifestyles. Urban planning must consider for these life stage-driven differences to create environments that cater to the unique needs of diverse populations.

Table 1
Demographic Variables and the Comparison of Participant Groups

		Older		Younger		p
Variable	**Category**	**n**	**%**	**n**	**%**	
Gender	Female	49	40.8	98	58.3	**.004***
	Male	71	59.2	70	41.7	
Marital Status	Single	5	4.2	54	32.1	**.000***
	Married	75	62.5	100	59.5	
	Divorced	7	5.8	8	4.8	
	Widowed	33	27.5	6	3.6	
Education Level	Primary school	14	11.7	5	3.0	**.008***
	Middle school	8	6.7	6	3.6	
	High school	37	30.8	44	26.2	
	University	55	45.8	97	57.7	
	Postgraduate	6	5.0	16	9.5	
Total Income (TRY)**	7 500-15 000	69	57.5	46	27.4	**.000***
	15 000-30 000	35	29.2	90	53.6	
	30 000-60 000	14	11.7	26	15.5	
	Over 60 000	2	1.7	6	3.6	
Number of Residents	Living alone	23	19.2	15	8.9	**.000***
	Two	65	54.2	38	22.6	
	Three	22	18.3	75	44.6	
	Four and more	10	8.3	40	23.8	
Number of Children	None	5	4.2	67	39.9	**.000***
	One	29	24.2	55	32.7	
	Two	69	57.5	40	23.8	
	Three and more	17	14.2	6	3.6	
Home Ownership	Owner	95	79.2	97	57.7	**.000***
	Tenant	25	20.8	71	42.3	
Number of Vehicles	None	67	55.8	47	28.0	**.023***
	One	46	38.3	96	57.1	
	Two	7	5.8	25	14.9	
Vehicle Usage Frequency	Every day	20	16.7	76	45.2	**.000***
	Several times a week	27	22.5	32	19.0	
	On weekends	4	3.3	2	1.2	
	When necessary	15	12.5	11	6.5	

*Significance level 0.95 ($p < .005$)
**During the period the survey was conducted, the minimum retiree pension was 7,500 TRY, while the minimum wage was 11,402 TRY. (Republic of Turkey, 2023; Social Security Institution, 2023).

The analysis of daily routines reveals significant differences between older and younger adults in their engagement with various urban amenities and spaces. Older adults (48.3%) are more likely to shop locally compared to younger adults (35.1%), suggesting a preference for

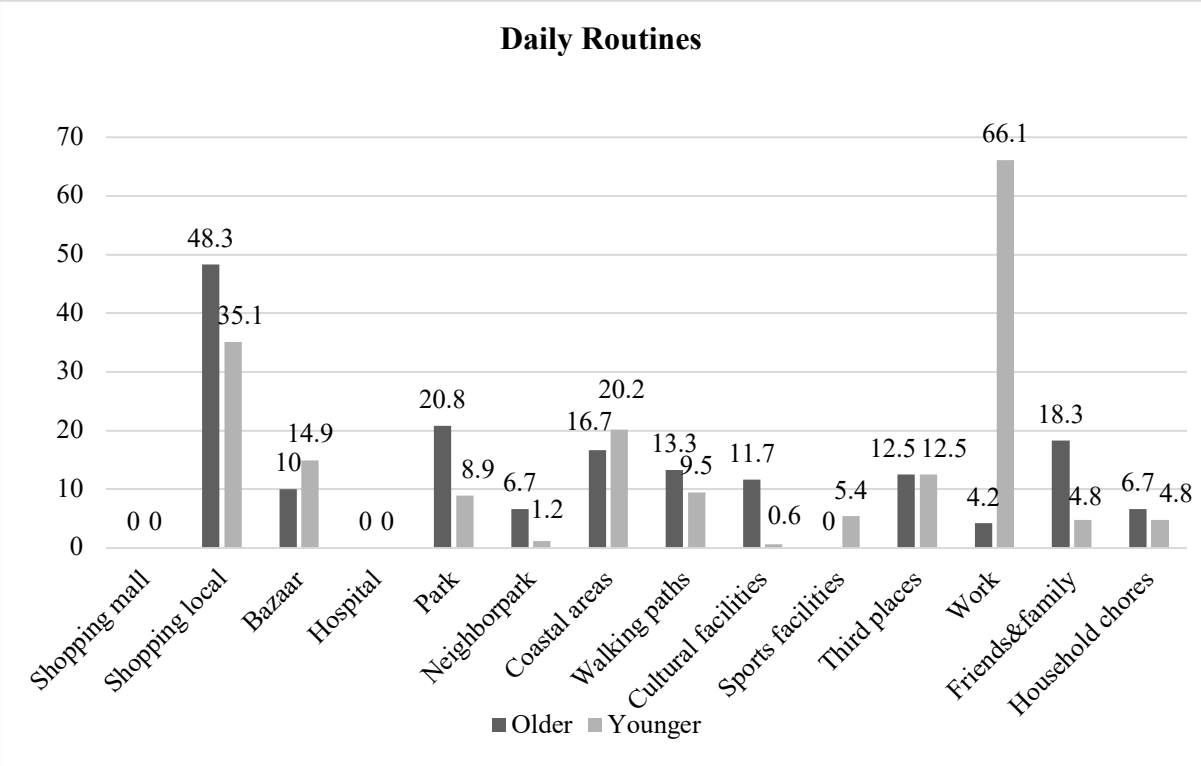
proximity and familiarity in shopping habits. Parks and open spaces show a notable age-related divide; older adults (20.8%) frequent parks significantly more than younger adults (8.9%) (p = .005). Similarly, nearby parks are utilized more by older adults (6.7%) than younger adults (1.2%) (p = .019), emphasizing the importance of accessible green spaces for this demographic. Cultural and sports facilities also highlight generational differences. Older adults (11.7%) engage with cultural facilities significantly more than younger adults (0.6%) (p = .000), reflecting their preference for activities that provide cultural enrichment. Conversely, younger adults (5.4%) are more likely to visit sports facilities compared to older adults (0%) (p = .012), showcasing a divide in recreational preferences. Social interaction further differentiates the two groups. Older adults (18.3%) are significantly more inclined to spend time with friends and family compared to younger adults (4.8%) (p = .000), highlighting the value of social networks in older adults' lives. These findings emphasize the importance of designing urban environments that address the diverse needs of different age groups. Enhancing accessibility to parks and cultural facilities for older adults, alongside providing recreational opportunities for younger populations, can contribute to more inclusive and age-friendly urban spaces.

Table 2
The Comparison of Daily Routines

Category	Older				Younger				p
	Yes		No		Yes		No		
	n	%	n	%	n	%	n	%	
Shopping mall	0	0	120	100	0	0	120	100	-
Shopping local	58	48.3	62	51.7	59	35.1	109	64.9	**.029***
Bazaar	12	10.0	108	90.0	25	14.9	143	85.1	.284
Hospital	0	0	120	100.0	0	0	168	100.0	-
Park	25	20.8	95	79.2	15	8.9	153	91.1	**.005***
Neighborpark	8	6.7	112	93.3	2	1.2	166	98.8	**.019***
Coastal areas	20	16.7	100	83.3	34	20.2	134	79.8	.541
Walking paths	16	13.3	104	86.7	16	9.5	152	90.5	.345
Cultural facilities	14	11.7	106	88.3	1	.6	167	99.4	**.000***
Sports facilities	0	0	120	100.0	9	5.4	159	94.6	**.012***
Third places	15	12.5	105	87.5	21	12.5	147	87.5	1.000
Friends&family	22	18.3	98	81.7	8	4.8	160	95.2	.000
Household chores	8	6.7	112	93.3	8	4.8	160	95.2	.603

*Significance level 0.95 (p < .005)

Figure 1
The Comparison of Daily Routine (in Percentage)



The analysis of weekly routines highlights significant differences between older and younger adults in their use of urban amenities and spaces. Shopping malls are a preferred destination for younger adults, with 23.2% visiting weekly compared to only 5.8% of older adults (p = .000). This distinction suggests that shopping malls may be less appealing or accessible to older individuals. Enhancing age-friendly features such as resting areas, improved accessibility, and senior-oriented activities could increase their appeal. Conversely, local shopping is more common among older adults, with 28.3% participating weekly compared to 14.3% of younger adults (p = .004). This preference reflects the importance of proximity and familiarity for older populations, emphasizing the need for accessible and varied local retail options.

Healthcare facility visits also reveal a generational divide, with 5.8% of older adults visiting hospitals weekly compared to only 1.2% of younger adults (p = .037). This suggests that older adults are more likely to require regular check-ups or manage chronic health conditions, indicating the importance of improving transportation options and access to healthcare facilities for this demographic.

Parks are another area where older adults demonstrate higher engagement, with 18.3% visiting weekly compared to 8.9% of younger adults (p = .021). The data highlights the importance of maintaining accessible, well-designed green spaces that cater to the physical and social needs of older adults. While neighborhood parks show a slightly higher engagement among older adults (5%) than younger adults (1.2%), this difference is not statistically significant (p = .071). Nevertheless, the trend indicates that enhancing neighborhood parks with better accessibility and tailored amenities could encourage greater use.

Sports facilities reveal a sharp contrast in usage patterns, with 7.7% of younger adults visiting weekly compared to no reported use among older adults (p = .001). This generational divide suggests the need for urban planners to develop age-inclusive recreational facilities and programs to encourage older adult participation.

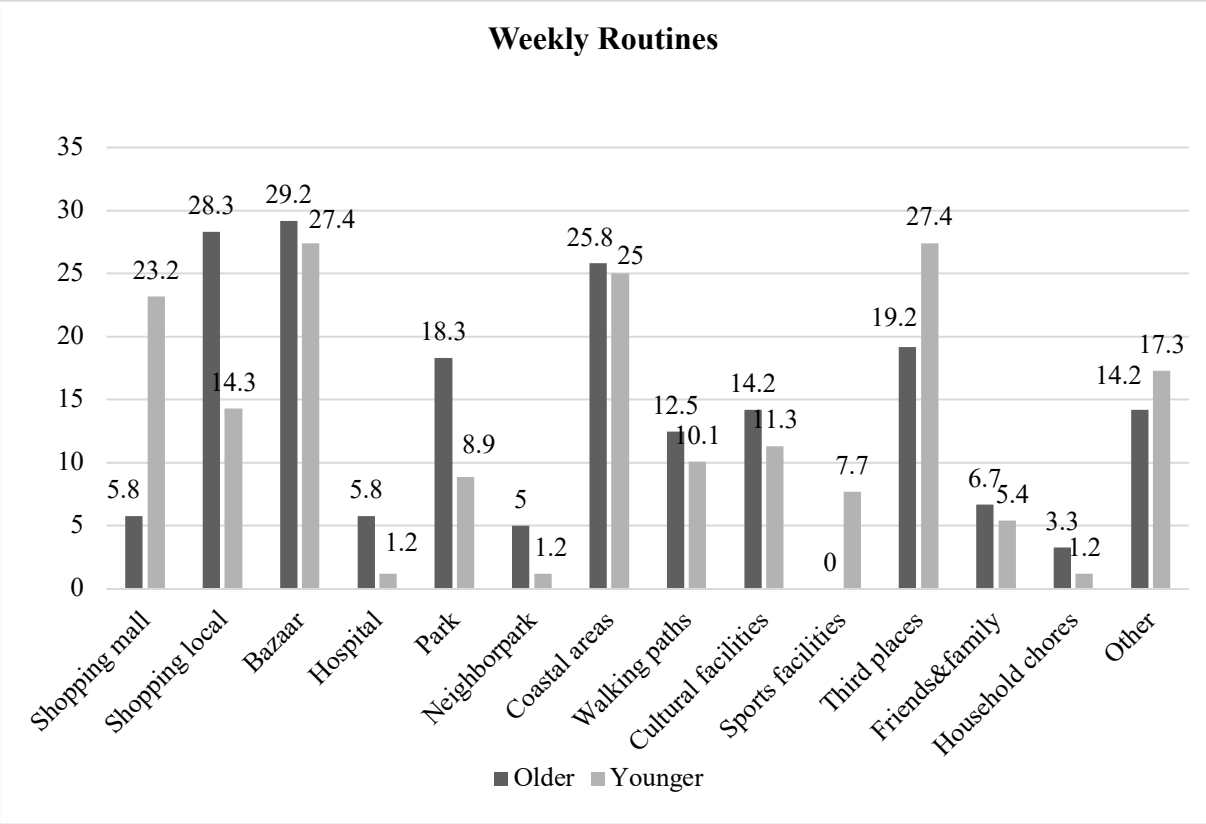
In conclusion, these findings demonstrate the diverse needs and preferences of different age groups, reinforcing the importance of age-sensitive urban planning. Urban designers should focus on creating environments that accommodate generational differences, such as making parks and local shopping areas more accessible for older adults while maintaining dynamic recreational and commercial spaces that appeal to younger populations.

Table 3
The Comparison of Weekly Routine

Category	Older				Younger				p
	Yes		No		Yes		No		
	n	%	n	%	n	%	n	%	
Shopping mall	7	5.8	113	94.2	39	23.2	129	76.8	**.000***
Shopping local	34	28.3	86	71.7	24	14.3	144	85.7	**.004***
Bazaar	35	29.2	85	70.8	46	27.4	122	72.6	.791
Hospital	7	5.8	113	94.2	2	1.2	166	98.8	**.037***
Park	22	18.3	98	81.7	15	8.9	153	91.1	**.021***
Neighborpark	6	5.0	114	95.0	2	1.2	166	98.8	**.071***
Coastal areas	31	25.8	89	74.2	42	25.0	126	75.0	.891
Walking paths	15	12.5	105	87.5	17	10.1	151	89.9	.571
Cultural facilities	17	14.2	103	85.8	19	11.3	149	88.7	.476
Sports facilities	0	0	120	100.0	13	7.7	155	92.3	**.001***
Third places	23	19.2	97	80.8	46	27.4	122	72.6	.124
Friends & family	8	6.7	112	93.3	9	5.4	159	94.6	.801
Household chores	4	3.3	116	96.7	2	1.2	166	98.8	.239
Others	17	14.2	103	85.8	29	17.3	139	82.7	.518

*Significance level 0.95 (p < .005)

Figure 2
The Comparison of Weekly Routine (in Percentage)



The analysis of monthly routines highlights notable differences between older and younger adults in their engagement with various urban amenities. Shopping malls are significantly more frequented by younger adults, with 48.2% visiting monthly compared to 26.7% of older adults ($p = .000$). This suggests that malls cater more effectively to the preferences of younger populations, possibly due to diverse retail and entertainment options. Enhancing malls with age-specific services and facilities could improve their appeal to older adults. Conversely, local shopping aligns more closely with older adults' routines, with 16.7% participating monthly compared to 8.9% of younger adults ($p = .037$). This preference indicates the importance of smaller, community-oriented retail spaces that offer convenience and familiarity.

Healthcare needs emerge as a critical distinction, with 29.2% of older adults visiting hospitals monthly compared to just 4.8% of younger adults ($p = .000$). This reflects the higher healthcare requirements of older populations and highlights the necessity of urban designs that prioritize proximity and accessibility to medical facilities. Similarly, neighborhood parks are more frequently visited by older adults (15.0%) than younger adults (4.8%) ($p = .003$), emphasizing their role in supporting older adults' routines. Improving these parks' accessibility and amenities can enhance their value as social and recreational spaces.

Sports facilities reveal a striking generational divide, with only 0.8% of older adults utilizing them monthly compared to 9.5% of younger adults ($p = .002$). This suggests the need to develop more age-friendly recreational programs and facilities that cater to older adults' interests and physical capabilities.

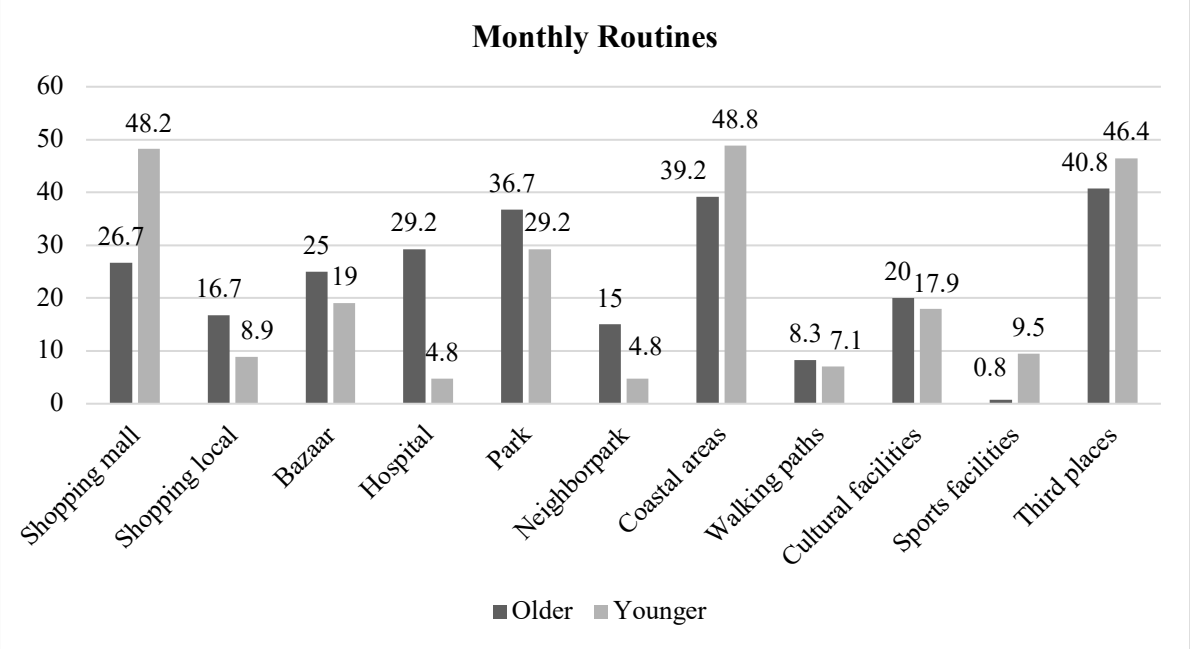
In conclusion, these findings emphasize the varied needs of different age groups and the importance of tailoring urban environments accordingly. By creating inclusive, accessible, and adaptable spaces, cities can better support the well-being and routines of both younger and older populations.

Table 4
The Comparison of Monthly Routine

Category	Older				Younger				p
	Yes		No		Yes		No		
	n	%	n	%	n	%	n	%	
Shopping mall	32	26.7	88	73.3	81	48.2	87	51.8	**.000***
Shopping local	20	16.7	100	83.3	15	8.9	81	48.2	**.037***
Bazaar	30	25.0	90	75.0	32	19.0	136	81.0	.143
Hospital	35	29.2	85	70.8	8	4.8	160	95.2	**.000***
Park	44	36.7	76	63.3	49	29.2	119	70.8	.202
Neighborpark	18	15.0	102	85.0	8	4.8	160	95.2	**.003***
Coastal areas	47	39.2	73	60.8	82	48.8	86	51.2	.119
Walking paths	10	8.3	110	91.7	12	7.1	156	92.9	.823
Cultural facilities	24	20.0	96	80.0	30	17.9	138	82.1	.649
Sports facilities	1	0.8	119	99.2	16	9.5	152	90.5	**.002***
Third places	49	40.8	71	59.2	78	46.4	90	53.6	.400

*Significance level 0.95 ($p < .005$)

Figure 3
The Comparison of Monthly Routine (in Percentage)



The comparison of most visited areas over the last three months demonstrates distinct preferences between older and younger adults, shaped by lifestyle, mobility, and accessibility needs. Shopping malls are more frequented by younger adults (11.3%) than older adults (5.8%), likely due to the variety of retail and entertainment options appealing to younger

demographics. Urban planners could increase engagement from older adults by integrating senior-friendly amenities and services in malls. In contrast, local shopping areas are more popular among older adults, with 6.7% identifying these as their most visited spaces compared to only 1.2% of younger adults. This preference reflects a need for proximity, familiarity, and a more personal shopping experience, emphasizing the importance of supporting accessible and attractive local businesses.

Bazaars are significant for older adults, with 11.7% of them reporting frequent visits compared to only 3.6% of younger adults. This may be due to the cultural and economic importance of bazaars, suggesting a focus on improving their accessibility and safety for older users. Healthcare facilities are another key area, as 15.0% of older adults list hospitals as their most visited locations, compared to just 2.4% of younger adults. This highlights the higher healthcare needs of the elderly and the importance of convenient access to medical services in urban design.

Parks and neighborhood parks show higher visitation among older adults (15.8% for parks and 6.7% for neighborhood parks) than among younger adults (4.2% for parks and 3.0% for neighborhood parks). Parks play a crucial role as recreational and relaxation spaces for older adults, indicating the need for age-friendly designs with shaded seating, accessible walking paths, and exercise equipment suited to seniors. Conversely, coastal areas are more popular with younger adults (10.1%) compared to older adults (1.7%), possibly due to the availability of dynamic recreational and social activities. Making these areas more accessible to older adults could broaden their appeal across age groups.

Walking is a preferred activity only for a small percentage of older adults (1.7%) and not listed by younger adults as a most-visited activity, indicating the need for walkable neighborhoods, especially for older residents. Cultural facilities also attract more older adults (12.5%) than younger adults (6.0%), highlighting the importance of accessible cultural spaces, like museums and theaters, with programs suited to an older audience.

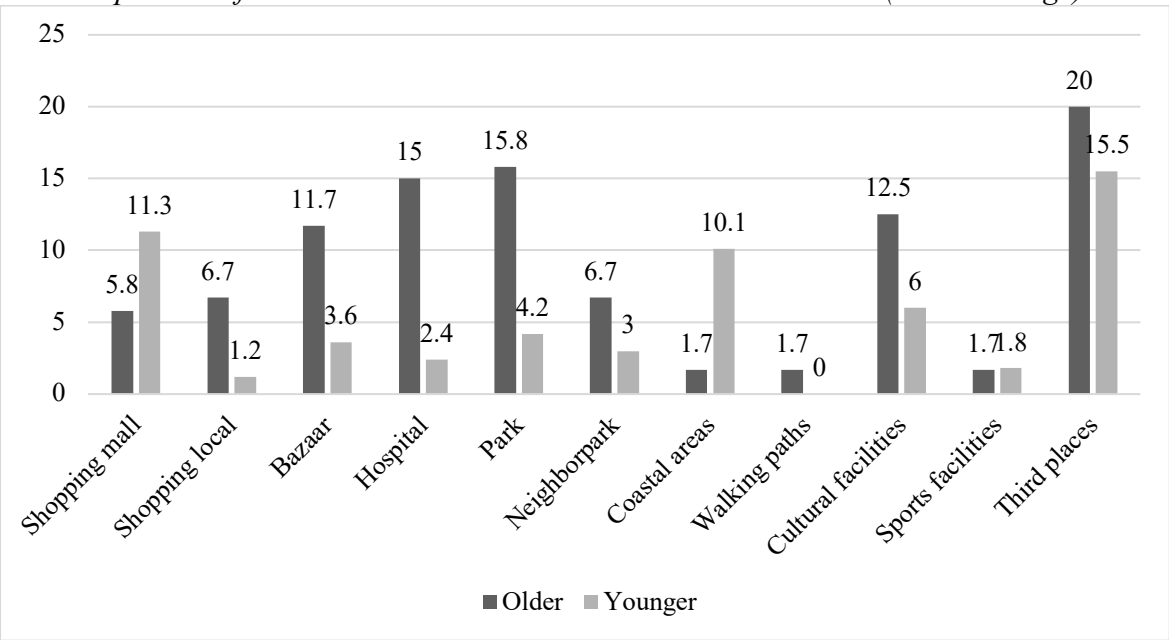
Sports facilities are infrequently visited by both age groups (1.7% of older adults and 1.8% of younger adults), though slightly higher among younger adults, pointing to a potential for developing age-inclusive recreational programs. Third places, such as cafes and restaurants, are valued by both groups, with 20.0% of older adults and 15.5% of younger adults listing these as their most-visited spaces. These findings demonstrate the importance of such spaces in fostering social interactions and community engagement across generations, suggesting a need to ensure these places are accessible and welcoming for all ages.

In conclusion, these patterns reveal that older adults favor local, accessible, and familiar environments, including local shops, bazaars, parks, and cultural facilities, while younger adults are more inclined toward shopping malls and coastal areas. This demonstrates a need for urban planners to develop age-sensitive strategies that cater to the diverse requirements of younger and older residents, enhancing the inclusivity and functionality of urban environments.

Table 5
The Comparison of Most Visited Area Within Last Three Months

	Older		Younger	
Category	**n**	**%**	**n**	**%**
Shopping mall	7	5.8	19	11.3
Shopping local	8	6.7	2	1.2
Bazaar	14	11.7	6	3.6
Hospital	18	15.0	4	2.4
Park	19	15.8	7	4.2
Neighbor park	8	6.7	5	3.0
Coastal areas	2	1.7	17	10.1
Walking paths	2	1.7	0	0
Cultural facilities	15	12.5	10	6.0
Sports facilities	2	1.7	3	1.8
Third places	24	20.0	26	15.5

Figure 4
The Comparison of Most Visited Area Within the Last Three Months (in Percentage)



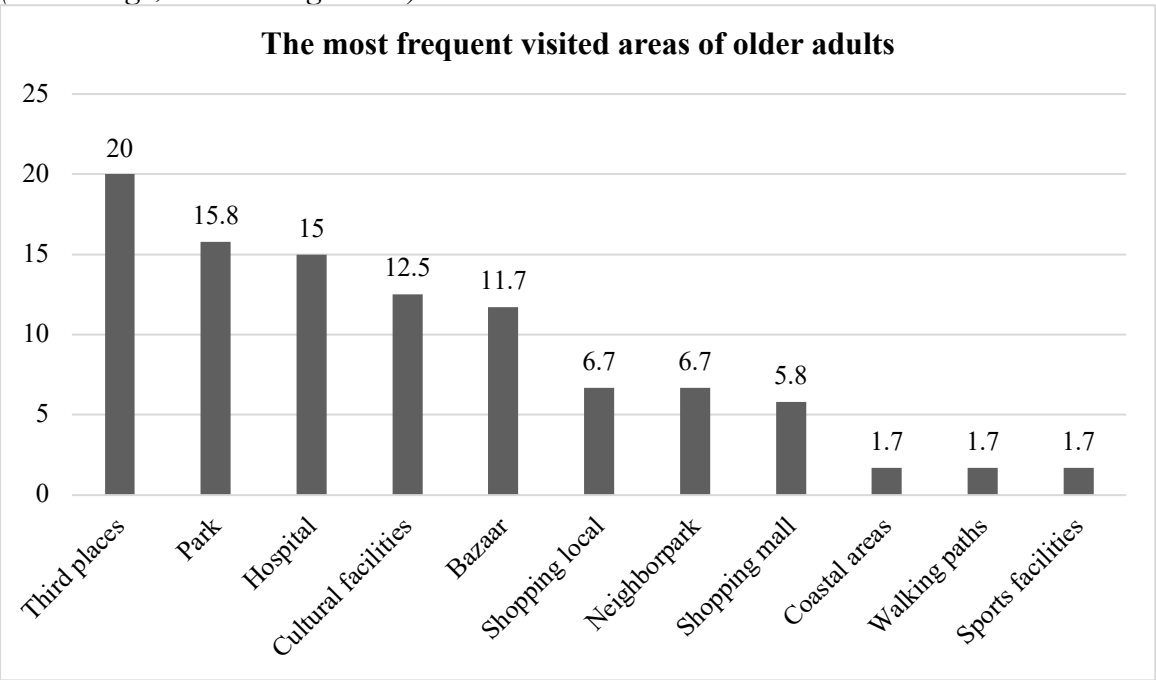
The analysis of the most frequently visited areas by older adults highlights the types of urban spaces that play a significant role in their routines and social interactions. “Third places” are the most commonly visited, with 20% of older adults frequenting these spaces. These environments likely serve as essential social hubs, offering opportunities for interaction, leisure, and community engagement. Parks (15.8%) and hospitals (15%) follow closely as important destinations. The frequent use of parks proves the value of accessible green spaces for relaxation and physical activity, while hospital visits reflect the healthcare needs and routine check-ups common among older populations.

Cultural facilities and bazaars also see substantial usage, with 12.5% and 11.7% of older adults visiting these spaces, respectively. Cultural venues like theaters, museums, and libraries provide older adults with educational and recreational experiences, while bazaars

serve as popular local shopping and social spaces. Local shopping areas and neighborhood parks, each frequented by 6.7% of older adults, fulfill daily needs and provide nearby open spaces for casual walking and relaxation.

Lower visitation rates are observed for shopping malls (5.8%), coastal areas (1.7%), walking paths (1.7%), and sports facilities (1.7%). These lower frequencies may indicate a preference for nearby, familiar amenities over larger or more distant destinations, as well as less interest in formal sports activities. This distribution suggests that mobility, accessibility, and familiarity heavily influence the choices of older adults, emphasizing the need for urban planning that enhances access to local amenities and provides age-friendly social and recreational spaces.

Figure 5
The Most Frequent Visited Area Within Last Three Months in Older Adults (Percentage, Descending Order)

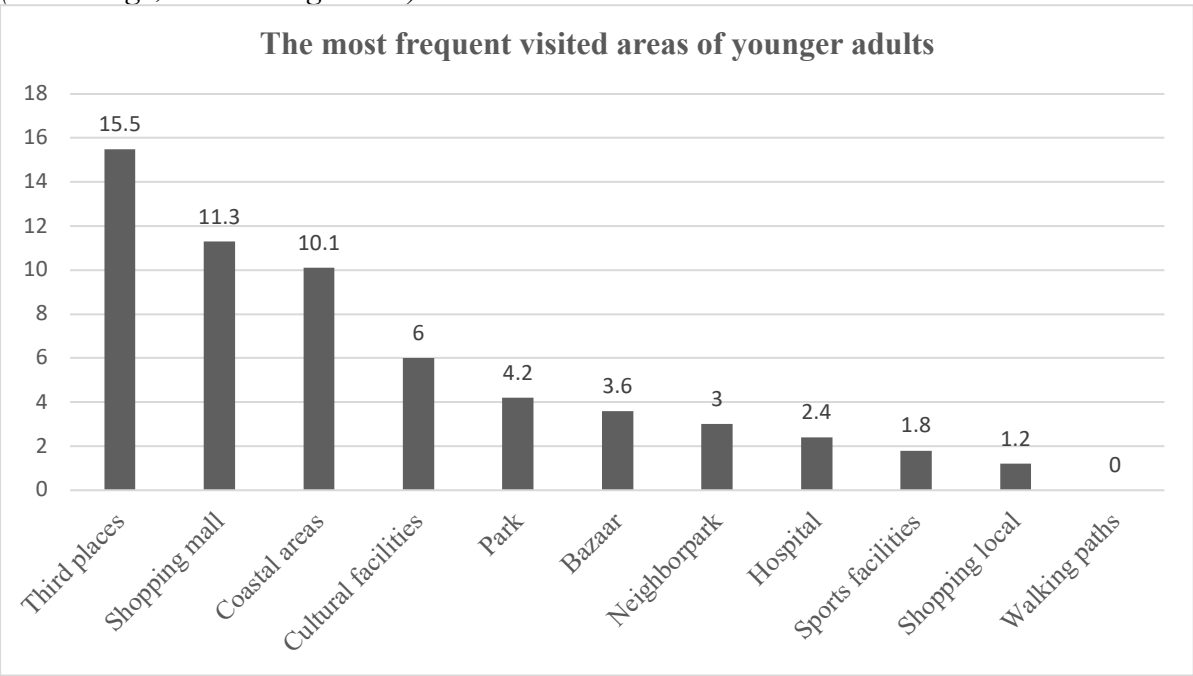


The analysis of the most frequently visited areas by younger adults highlights distinct preferences for social, recreational, and dynamic spaces. Similar to older adults, younger adults most frequently visit "third places", with 15.5% engaging in these spaces. These environments offer essential opportunities for social interaction, leisure, and remote work, highlighting their importance for all age groups. Shopping malls follow closely as the second most visited area (11.3%), suggesting that malls serve not only as retail spaces but also as hubs for socializing, dining, and entertainment, making them central to younger adults' routines.

Coastal areas rank third, with 10.1% of younger adults frequenting these spaces. The appeal of coastal areas likely stems from their suitability for outdoor activities, relaxation, and social gatherings, particularly in cities with accessible waterfronts. Cultural facilities, such as theaters, museums, and galleries, are also visited by 6% of younger adults, reflecting their interest in cultural and educational activities. However, the visitation rate is lower than that of older adults, suggesting a generational difference in cultural engagement or accessibility.

Parks (4.2%) and bazaars (3.6%) are moderately frequented, with parks seeing slightly lower usage than coastal areas. This could indicate that younger adults may prefer more dynamic, diverse outdoor spaces with recreational opportunities. Finally, visits to neighboring parks, hospitals, sports facilities, local shopping, and walking spaces (ranging from 1.2% to 3%) are relatively low, possibly due to the availability of alternative amenities or a preference for more specialized or vibrant environments.

Figure 6
The Most Frequent Visited Area Within Last Three Months in Younger Adults (Percentage, Descending Order)



Conclusion

This study displays the diverse urban routines of older and younger adults, offering valuable insights into how urban environments influence their daily, weekly, and monthly activities. The findings highlight significant differences in the use of urban amenities, shaped by life cycle stages, mobility, and preferences. These variations acknowledge the need for creating inclusive, accessible, and age-sensitive urban spaces that cater to the unique requirements of multigenerational populations. The analysis reveals that older adults prioritize local, accessible, and familiar environments, such as neighborhood parks, local shops, and cultural facilities, while younger adults are more inclined toward vibrant and dynamic spaces, such as shopping malls and coastal areas. These preferences inform several implications and strategies for urban planning:

- Age-Sensitive Urban Design: Urban environments must prioritize accessible and nearby amenities, especially for older adults. Local shopping areas, small parks, and third places should be integrated within residential neighborhoods to support daily routines. For younger adults, multi-functional spaces that combine shopping, dining, recreation, and cultural experiences can cater to their preference for dynamic environments.
- Promoting Accessibility and Walkability: Pedestrian-friendly pathways, well-lit sidewalks, safe crossings, and clear signage are critical for enabling older adults to access frequently visited amenities. Enhancing walkability in neighborhoods with

green corridors connecting different urban spaces can benefit both younger and older populations.

- Flexible and Inclusive Green Spaces: Parks and open spaces should offer features for relaxation and light exercise, such as shaded seating and walking paths for older adults, alongside dynamic zones with recreational activities for younger adults. Coastal areas, popular among younger demographics, can be enhanced with accessible walking paths, event spaces, and relaxation areas.
- Adapting Cultural and Recreational Facilities: Cultural facilities and sports centers should incorporate programs for diverse age groups. Multipurpose spaces that host events, workshops, and age-inclusive activities can bridge generational gaps, fostering social engagement.
- Improving Healthcare and Supportive Services: Urban planners must ensure healthcare facilities are evenly distributed and accessible, particularly in neighborhoods with older residents. Complementary services like pharmacies, rehabilitation centers, and senior support hubs can further enhance convenience and quality of life for older adults.
- Leveraging Data for Evidence-Based Planning: Regular surveys and data-driven approaches can help urban planners adapt to the changing needs of residents, ensuring urban environments remain relevant and supportive over time.

By integrating these strategies, cities can evolve into inclusive and sustainable environments, fostering intergenerational harmony and improving the quality of life for all residents. This research contributes to the growing discourse on aging and urban environments, offering evidence-based recommendations for age-sensitive urban planning. Future studies could explore longitudinal data and additional urban elements, expanding on these findings to promote innovative, adaptable, and sustainable urban designs that address the dynamic needs of aging populations.

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Possibilities for Implementing a Long-Term Care Insurance System in Thailand and Vietnam

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Abstract

The need for sustainable elderly care solutions is growing as countries face accelerating population aging. This study examines the feasibility of adapting the Long-term care insurance (LTCI) model in Thailand and Vietnam, analyzing critical factors such as financing structures, policy readiness, cultural values, and existing healthcare infrastructures. While both Thailand and Vietnam rely on family-based care rooted in cultural expectations of filial duty, changing demographics and urbanization trends are increasing pressure on these informal systems. This study evaluates the potential for Thailand and Vietnam to introduce similar contributory models, either through public-private partnerships or phased policy implementations, that could support a transition toward more formalized elderly care services. The study identifies possible pathways for LTCI adoption that align with each country's unique social and economic context. Findings suggest that a phased, community-supported rollout, combined with government-subsidized pilot programs, could facilitate a gradual shift toward LTCI in Thailand and Vietnam. This research provides a framework for policymakers to consider a culturally adaptable LTCI system that respects traditional caregiving practices while advancing toward sustainable, structured care solutions.

Keywords: long-term care insurance (LTCI), elderly care, cultural adaptation, public-private partnership (PPP), policy readiness

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Introduction

Population aging that requires a long-term care (LTC) is a significant demographic challenge for many countries (Doty et al., 1985). Long-term care insurance (LTCI) systems are designed to address the challenges posed by aging populations by ensuring access to comprehensive care services and mitigating the financial burden on families and individuals. These systems typically cover a range of services, including home-based care, nursing facilities, rehabilitation, and community care services, tailored to meet the needs of the elderly and those requiring long-term support due to chronic illnesses or disabilities. LTCI models vary significantly across countries, reflecting differences in cultural values, economic structures, and policy priorities (Haber, 2015).

In Japan, LTCI was introduced in 2000 as a universal social insurance program funded by a combination of mandatory premiums for individuals over 40 and government subsidies. It emphasizes aging in place through home and community-based services, which include caregiver support, assistive devices, and day-care centers (Campbell et al., 2010). Japan's system has been praised for its accessibility, but it faces challenges related to sustainability due to the rapidly aging population and shrinking workforce. Germany's LTCI, established in 1995, operates on a similar universal insurance model but places greater emphasis on cash allowances to support informal caregiving. Beneficiaries can choose between direct service provision or cash payments to compensate family members for caregiving efforts (Reinhard, 2018). This approach reflects Germany's strong cultural emphasis on family responsibility while ensuring that professional care options are available. However, concerns about the adequacy of benefits to meet rising care costs persist.

South Korea adopted its LTCI system in 2008, inspired by Japan's model but tailored to its unique demographic and social conditions. Unlike Japan and Germany, South Korea initially limited its LTCI to individuals aged 65 and above, focusing on nursing care and home-based services. Over time, it has expanded its scope to include dementia care, reflecting the country's rising prevalence of cognitive disorders among the elderly (Chon et al., 2024; Kim & Kwon, 2021). In contrast, the United States lacks a national LTCI program, relying instead on Medicaid as the primary payer for long-term care services. Medicaid, a means-tested program, limits access to low-income individuals, leaving many middle-income families to bear the high out-of-pocket costs of care. Private LTCI exists but remains underutilized due to high premiums and limited coverage options, creating significant gaps in care accessibility (Lyon et al., 2014).

In developing countries such as China and India, the challenges of implementing LTCI systems are magnified by large populations, regional disparities, and limited healthcare infrastructure. China is facing a rapidly aging population, with nearly 20% of its citizens projected to be over 60 by 2030. Traditional family-based care, rooted in Confucian values of filial piety, is under strain due to urbanization, migration, and shrinking family sizes. In response, China has begun experimenting with LTCI through regional pilot programs initiated in 2016. These programs aim to provide basic coverage for nursing homes, community care, and home-based services. Funding mechanisms rely on a mix of local government contributions, employer premiums, and individual payments, with an emphasis on cost-sharing to ensure sustainability (Z. Chen et al., 2024). However, challenges such as uneven service quality, lack of skilled caregivers, and limited coverage remain significant barriers to nationwide implementation (S. Chen et al., 2024).

India faces a dual challenge: limited formal care infrastructure and a predominantly rural demographic. Elderly care in India is still heavily dependent on family networks, with only a small fraction of the population having access to professional care services. While India lacks a formal LTCI system, some initiatives like the National Program for Health Care of the Elderly (NPHCE) provide basic health services for seniors (Vaishnav et al., 2022). Private insurance options are also emerging but remain unaffordable for most. Key obstacles include high levels of informality in the healthcare sector, insufficient public investment, and cultural resistance to institutional care (Kaushik, 2020).

These differences highlight the importance of designing LTCI systems that align with each country's social, economic, and cultural contexts. In contrast to countries like Japan and Germany, where LTCI systems provide universal or near-universal coverage, developing nations often struggle to achieve broad access due to financial constraints and infrastructural gaps. For instance, while Japan's LTCI emphasizes community care and universal participation, China's pilot programs and India's fragmented initiatives reflect a need for phased approaches that gradually expand access while building capacity. Moreover, in countries like China and India, cultural values strongly favor family caregiving, necessitating models that integrate professional care with traditional practices to ensure acceptance. Experiences from developed countries demonstrate the importance of phased implementation, public-private partnerships, and pilot programs tailored to local contexts. For instance, China's pilot LTCI programs highlight the value of testing diverse funding and care delivery models before scaling nationwide. India's efforts emphasize the need to strengthen rural healthcare systems as a foundation for LTCI development. Policymakers must also address cultural norms, affordability, and workforce training to create systems that are not only financially sustainable but also culturally adaptable.

Thailand and Vietnam exemplify nations where rapid demographic changes and urbanization challenge traditional caregiving models. Historically, family-based care rooted in filial duty has been the primary approach. However, societal transformations demand innovative solutions. Both developing countries in the South-East Asia, Thailand and Vietnam are experiencing accelerated aging, with increasing proportions of elderly populations requiring LTC. Traditional family-based care systems, rooted in cultural norms of filial piety, are under strain due to urbanization, smaller family sizes, and economic pressures. This necessitates the exploration of sustainable, structured solutions such as LTCI. This study investigates the feasibility of implementing an LTCI system in Thailand and Vietnam, focusing on financial models, policy readiness, cultural considerations, and existing healthcare infrastructures.

Methodology

This study employs a qualitative methodology comprising a literature review and a policy review. The literature review encompasses academic publications, government reports, and case studies on LTCI implementation in different countries, with a focus on lessons applicable to Thailand and Vietnam. The policy review evaluates current healthcare policies, legislative frameworks, and national development strategies in these nations. This dual approach identifies gaps and opportunities for adapting LTCI to local contexts.

Situation of Elderly Care in Thailand and Vietnam

Thailand's healthcare system is relatively robust, supported by universal health coverage (UHC) through the 30 Baht Scheme. However, LTC services are not comprehensively

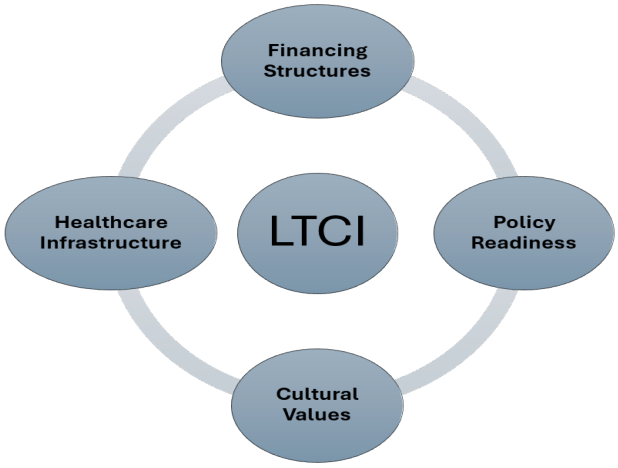
covered under this scheme, leaving families to shoulder the responsibility (Bandaogo & Van Doorn, 2021). The reliance on family members, particularly women, to provide care for the elderly is prevalent in Thailand. This situation places significant economic and emotional strain on households, especially as the need for assistance increases with age. The development of community-based models, such as elderly day care services, has shown potential in alleviating caregiver burden and providing structured support for the aging population (Piboon K, 2019). Village Health Volunteers (VHVs) play a crucial role in supporting elderly care at community level. Despite their contributions, these programs face challenges such as limited training, resources, and scalability, hindering their effectiveness in meeting the growing demand for LTC services (Lloyd-Sherlock et al., 2017). Demographic projections indicate a doubling of the elderly population by 2040, amplifying the urgency for policy interventions (ADB, 2020).

Vietnam's healthcare system has made significant strides through its Social Health Insurance (SHI) program, achieving substantial coverage among the population. However, LTC services are largely absent from this framework, leaving informal family caregivers to provide the bulk of support for the elderly. Cultural expectations reinforce this reliance on family-based care, but social norms are evolving, with an increasing recognition of the value of external LTC support (ADB, 2022a). Rapid urbanization and labor migration have weakened traditional caregiving structures. Declining rates of co-residence, driven by factors such as urbanization, migration of children for work, and shrinking family sizes, reduce the likelihood that adult children live near elderly parents, creating gaps in care for the elderly (WB & JICA, 2021). Vietnam's elderly dependency ratio is expected to rise dramatically in the coming decades. Projections indicate that the proportion of the population aged 65 and above will increase significantly, intensifying the need for comprehensive LTC policies and systems (Maheshwari & Maheshwari, 2024).

Key Factors for LTCI Implementation

We created a framework highlighting the key factors essential for implementing LTCI, as illustrated in Figure 1.

Figure 1
Factors for LTCI Implementation (by the authors)



Financing Structures

Implementing LTCI systems in Thailand and Vietnam faces challenges due to limited fiscal space for fully public models. Public-private partnerships (PPPs) emerge as a viable alternative to distribute financial responsibility. In Vietnam, the government is actively promoting PPPs in the healthcare sector to enhance services, indicating a policy environment conducive to such collaborations (VNA, 2024). Public willingness to contribute to LTCI schemes is crucial for their success. In Thailand, studies have shown that most respondents are willing to pay to insure against risks associated with long-term care expenditures, though preferences are heterogeneous (Chandoevwit & Wasi, 2019). Japan's LTCI system, introduced in 2000, combines individual contributions with government subsidies and emphasizes community-supported care models. This approach has been successful in providing comprehensive long-term care services, offering valuable lessons for Thailand and Vietnam (ADB, 2022b; Campbell & Ikegami, 2000). Adopting a similar contributory model, tailored to the cultural and economic contexts of Thailand and Vietnam, could enhance the feasibility and sustainability of LTCI systems in these countries.

Policy Readiness

Thailand's experience with universal healthcare, particularly through the UHC, demonstrates its policy readiness for integrating LTCI (Sumriddetchkajorn et al., 2019). The UCS, implemented in 2002, provides comprehensive health services to the majority of the population, showcasing Thailand's administrative capacity to manage large-scale health programs. In contrast, while Vietnam has made significant progress in healthcare reform, achieving a health insurance coverage rate of 89.3% by 2021, it still faces challenges in administrative capacity for nationwide program rollouts. The complexity of implementing integrated care requires a phased approach, as experience from other countries suggests that it is a long-term endeavor necessitating broad stakeholder engagement and systemic reforms (Quan & Taylor-Robinson, 2023; Teo & Huong, 2020). Case studies on Thailand's policy frameworks highlight the potential for leveraging existing healthcare systems for LTCI integration. The UCS's success in reducing out-of-pocket payments and improving health outcomes indicates a solid platform upon which LTC services could be built (Tangcharoensathien et al., 2018). Therefore, while Thailand's healthcare infrastructure positions it favorably for LTCI integration, Vietnam may require a more gradual, phased implementation strategy to build the administrative capacity for such a system.

Cultural Values

In both Thailand and Vietnam, traditional cultural values emphasize piety, placing the responsibility of elder care primarily on family members. This cultural norm poses challenges to the adoption of LTCI systems. However, urbanization and the emergence of middle-class values are contributing to a gradual shift toward formalized care. In both countries, the migration of adult children to urban areas has led to changes in traditional family structures, impacting the availability of informal care for the elderly. Studies indicate that rural parents with urban children may experience reduced familial support, highlighting the need for alternative care arrangements (Hoi et al., 2011; Knodel & Saengtienchai, 2007).

Community involvement plays a crucial role in fostering acceptance of formal care models. In Thailand, the Community-integrated intermediary care (CIIC) service model has been assessed for its effectiveness in enhancing family-based care for older people, indicating the

importance of integrating community support with formal care services (Aung et al., 2021). The implementation of Intergenerational self-help clubs (ISHCs) in Vietnam has shown promise in promoting health and addressing the needs of an aging population. These community-based programs have been associated with positive health outcomes among members, indicating the importance of integrating community support with formal care services (Pardoel et al., 2023). There is a dynamic interplay between cultural values and the evolving landscape of elder care in Southeast Asia. As urbanization and socioeconomic changes continue, there is a growing recognition of the need to adapt traditional caregiving norms to accommodate formal LTCI systems, with community involvement being key to this transition.

Healthcare Infrastructure

Both Thailand and Vietnam face significant challenges in their healthcare infrastructure, particularly concerning LTC facilities and trained personnel. Both countries face a shortage of professional nurses (Pagaiya et al., 2019; Tran et al., 2024), not to mention the lack of human resources dedicated to elderly care. Additionally, there is no clear framework for training or institutionalizing personnel to meet the growing demand. In Thailand, the existing healthcare system is primarily designed to address acute medical needs, with limited provisions for chronic care and rehabilitation services essential for the elderly population. This gap is evident in the shortage of specialized LTC facilities and a workforce inadequately trained in geriatric care (ADB, 2020).

Similarly, Vietnam's healthcare infrastructure is under strain due to rapid population aging. The country lacks a comprehensive LTC system, resulting in families bearing the primary responsibility for elderly care without adequate support. This situation is exacerbated by a scarcity of trained healthcare professionals specializing in geriatric care, further limiting the quality and accessibility of services for the elderly (WB & JICA, 2021). To address these challenges, community-based care models have been proposed as transitional solutions (Piboon K, 2019). Additionally, government-subsidized pilot programs can play a crucial role in developing LTC services. As an example, the ADB has supported technical assistance projects aimed at building capacity for community-based LTC systems in several countries, including Vietnam. These initiatives focus on developing care models that are culturally appropriate and sustainable, providing insights for phased implementation strategies in similar socioeconomic contexts (ADB, 2019). Implementing community-based care models and pilot programs can serve as effective transitional solutions to bridge the existing gaps in LTC infrastructure and workforce capabilities in Thailand and Vietnam. These approaches offer scalable and culturally sensitive pathways to enhance elderly care services in the region.

Table 1 summarizes key aspects of implementing LTCI in Thailand and Vietnam, showing Thailand’s relative advantage in policy readiness and infrastructure compared to Vietnam, while both nations share cultural challenges and fiscal constraints that necessitate phased and context-sensitive implementation of LTCI.

Table 1
Comparison of Key Aspects of Implementing LTCI in Thailand and Vietnam

Aspect	*Thailand*	*Vietnam*
Financing Structures	- More experience with PPPs.	- Limited fiscal space; requires external funding and phased models.
	- UCS demonstrates potential for contributory LTCI models.	- Public willingness to contribute depends on trust in the system.
Policy Readiness	- Relatively advanced legislative frameworks for universal healthcare.	- Healthcare reforms are ongoing but lack capacity for nationwide LTCI implementation.
	- Strong administrative capacity for pilot program implementation.	- Phased approach needed due to limited administrative structures.
Cultural Values	- Strong filial piety, but urbanization is shifting caregiving norms.	- Similar reliance on filial duty, with increasing pressure from urban migration.
	- Greater acceptance of integrating formal care with family care due to demographic trends.	- Resistance may be higher; public awareness campaigns needed to build cultural acceptance.
Healthcare Infrastructure	- More established healthcare system with basic facilities to support LTCI pilot programs.	- Significant gaps in infrastructure, requiring investments in training and facility development.
	- Community-based care is viable and aligns with existing healthcare delivery systems.	- Heavy reliance on family-based care; formal care systems are underdeveloped.
Implementation Feasibility	- High feasibility for a phased rollout supported by government subsidies and PPPs.	- Moderate feasibility; requires donor funding and targeted pilot programs to assess scalability.

Recommendations

To effectively implement LTCI in Thailand and Vietnam, a phased approach beginning with pilot programs in high-need urban areas is recommended. Co-payment schemes can balance affordability with financial sustainability, while PPPs can share financial and operational responsibilities, ensuring service quality. Investments in caregiver training and healthcare infrastructure upgrades are crucial to addressing workforce and capacity gaps. Community-supported models that leverage local networks and provide incentives for family participation can help bridge traditional and formal care. Awareness campaigns are essential for educating stakeholders about LTCI benefits, fostering trust and participation. This gradual, inclusive framework aligns with cultural norms and promotes long-term sustainability.

Conclusion

In Southeast Asia, traditional family-based caregiving is under strain due to declining fertility rates, increased life expectancy, and urban migration. Simultaneously, healthcare systems in Thailand and Vietnam are underdeveloped relative to the demands of an aging population. LTCI systems offer structured solutions for sustainable elderly care. However, their applicability in developing economies requires careful adaptation to local conditions. While challenges remain, Thailand and Vietnam possess the potential to adopt LTCI systems tailored to their unique contexts. A phased, culturally sensitive rollout supported by community engagement and government subsidies offers a pathway toward sustainable care. By balancing tradition and modernization, LTCI could provide these nations with a vital tool to address the pressing issue of aging populations.

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Work Life Beyond Retirement: Experiences and Expectations of Post-retirement Work Engagement

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Abstract

Older workers, possessing valuable functional knowledge, remain capable and productive across various work modes, evidencing that post-retirement work is increasingly common and benefiting work organizations. Sri Lanka is experiencing the fastest population aging in the South Asia, and by 2042, one in four Sri Lankans will be over 60. In Sri Lanka, the unique interplay of economic, socio-cultural, and workplace factors influences post-retirement engagement decisions. Yet, very few studies have explored retirees' experiences and expectations on work environments, thus leaving gaps in designing future work settings. This study examines the experiences and workplace expectations of Sri Lankan retirees in their post-retirement work engagements through qualitative interviews. The sample includes retirees aged 57 and above selected purposively from five districts in Sri Lanka. The study is grounded in continuity theory, life course theory, and socioemotional selectivity theory. The findings highlight that retirees have both positive and negative experiences at the post-retirement work place. Positive experiences are associated with a sense of freedom and a greater sense of peace in life, while negative experiences are linked to feelings of disconnection, rejection, distance from younger colleagues, and strong pride and nostalgia for their former workplaces. Retirees' work place expectations include low-stress work, autonomy in the workplace, flexible work schedules and a healthy work-life balance, an active social life, a sense of serenity, and pride and recognition from others. The study concludes by suggesting implications for individual job crafting, organizational emphasize for emotional well-being, and support for meaningful relationships at post-retirement work.

Keywords: experiences and expectations, post-retirement engagement, retirees, work life

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Introduction

Population aging has affected the workforce and work organizations across the world. As the population ages, the upcoming trend is fewer younger workers entering the labor market and a large proportion of elderly people growing at the workplace. This demographic shift creates issues such as labor shortages for production, increased demand for healthcare and retirement benefits, and the need for workplace adaptations to accommodate older employees. Further, organizations may face reduced productivity and innovation unless they implement strategies for upskilling older workers, fostering age-diverse teams, adjusting policies to encourage longer workforce participation, and, in all, making them ready for life-long adaptation and well-being. Therefore, post-retirement engagement of people becomes a sensitive and sensible issue for the work organizations as well as the society.

These demographic transitions necessitate that nations appropriately set development priorities and policy interventions (United Nations Department of Economic and Social Affairs, Population Division [UNDESA], 2023). Among South Asian countries, Sri Lanka exhibits the most rapid population aging, with projections showing that one in every four Sri Lankans will be over 60 years old by 2042 (De Silva & de Silva, 2023). Declining fertility, changes in mortality rates, shifts in age structure, and migration patterns are the primary drivers of population aging trends in Sri Lanka (United Nations Population Fund [UNFPA], 2024). Moreover, UNFPA (2024) notes that Sri Lanka missed the opportunity for a first demographic dividend in 2018. Thus, to leverage the potential of a second demographic dividend, the country must understand how to invest in the new demographic trends.

Dychtwald et al. (2024) observe several qualities and competencies of older workers. Qualities such as commitment, loyalty, and engagement, which are increasingly rare, are consistently present in older workers. They possess functional and organizational knowledge and skills suited to their roles, and further, they are capable, experienced, and productive in any work mode, whether part-time or hybrid. Organizations can tap into this resource by offering phased retirement programs and refresher courses, as well as recruiting through retiree networks. Older employees can be entrusted with coaching and mentoring roles, and can contribute effectively to multigenerational teams (Dychtwald et al., 2024), which may become a key requirement in today's workplaces. Therefore, it is essential for work organizations to adapt their functions and practices to meet the expectations of the post-retired workforce (Finsel et al., 2023).

Amid the demographic shifts in the workforce, post-retirement work is becoming increasingly common. Post-retirement engagement offers retirees a pathway to continued growth, purpose, and contribution in their later years (Cornell University, 2019). As societies face the challenges of aging populations, encouraging post-retirement engagement will be essential in fostering positive aging (Bar-Tur, 2021), and it may help promoting intergenerational solidarity, and sustaining economic and social contributions well into later life (Pak et al., 2023). It is true that by staying involved in meaningful activities, retirees not only improve their own physical and emotional well-being but also contribute to work organizations (Rai & Yadav, 2022) and society as a whole by sharing their skills, experiences, and wisdom (Haidhir & Dahlan, 2021; Sanders & McCready, 2010). Therefore, the reasons retirees choose to work after retirement are varied and cannot be fully understood through a simple model.

There are multiple diverse reasons why retirees engage in work during their post-retirement period (Wu et al., 2024). In addition to recent literature reviews on factors influencing post-retirement work (Galkutė & Herrera, 2020; Mori et al., 2024), there are empirical studies examining the reasons for retirees to work in different contexts from different viewpoints. While exploring the post-retirement career decisions, Fasbender et al. (2016) examined social, personal, financial, and generative meanings that retirees ascribed to post-retirement engagement in the context of Germany. Employee- and work-related factors of work engagement of older employees -in Lithuania- (Korsakienė et al., 2017), factors influencing post-retirement work engagement -in Nigeria- (Faronbi et al., 2021), who continues to work -in Denmark- (Zaccagni et al., 2024) and intentions to work after retirement -in India- (Tarkar et al., 2016) are some of the other notable studies. These studies have examined (or found) the antecedents of post-retirement work engagement in broader categories such as socio-demographic characteristics, factors responsible for engaging in economic activities, employee related factors, work related factors, demographic factors, and life style factors. Galkutė and Herrera (2020), find in their systematic literature review that socio-demographic, implicit, work-related, and life-related factors affect post-retirement work engagement. They note the existence of inconsistent and inconclusive results on the presence of the socio-demographic and life-related factors across countries. However, little is known about how retirees experience their post-retirement engagement and how such experiences lead to their expectations of work organizations.

In the context of Sri Lanka, we understand that the economy, life style, and work availability-related factors that possibly affect post-retirement engagement decisions could be considerably different from those of other nations. Except an empirical study conducted in Sri Lanka to search the determinants of post-retirement employment in a quantitative survey using a convenient sample (Perera & Weerakkody, 2018), there is a dearth of explorations on what make Sri Lankan retirees engage in post-retirement work.

Postretirement workforce is going to be an asset which could be an alternative to the labor shortage in organizations. Thus, organizations should design practices suited to elderly workforce (Wilckens et al., 2021). Upgrading the skills of elderly workers (Habib, 2019) and encouraging bridge employment (Dingemans et al., 2017) have been noted as some of the organizational strategies to address the challenges of an aging workforce. Despite the studies focused on human resource practices for post-retirement workers (Armstrong-Stassen, 2007; Farr-Wharton et al., 2023; Finsel et al., 2023), and successful accommodation of aging workers (Rinsky-Halivni et al., 2022) there is lack of knowledge on how retirees themselves expect work organizations to be. This could be an important dimension to look at when designing the work practices and the work settings in future organizations.

Therefore, the research questions this study plans to answer are: (a) how do retirees experience post-retirement work engagement, and (b) what are the expectations of retirees engaged in post-retirement work regarding organizational support, culture, and opportunities in their workplaces. This understanding would help us make sense of the background conditions of post-retirement work engagement of Sri Lankan retirees and their expectations of work organizations. Further, many public and private sector employees are retiring annually in the Sri Lankan organizations. However, we have no sufficient knowledge on their engagements and the extent of such engagements. This information would be helpful for future policy planning, organizational work arrangements, job crafting of individual retirees, and enhancing inclusivity and generative engagement in organizations.

Literature Review

Retirement[1] has been traditionally seen as disengagement from the formal work place; however, in recent years, due to demographic changes in the workforce and changing generational dynamics, it is recognized as an opportunity for continued engagement and personal growth for retirees (Dychtwald et al., 2024).

Post-retirement engagement refers to retirees staying involved in meaningful activities, whether through part-time work, volunteering, hobbies, or lifelong learning (James et al., 2010). This shift in how we perceive retirement is crucial, given the demographic reality of an aging population and the desire for many retirees to maintain a sense of purpose and contribution. Exploring the value of post-retirement engagement reveals significant benefits for individuals, society, and economies.

Population aging research in the Sri Lankan context has been intensively focused from the viewpoints of demographic analysis (Hewage et al., 2022), labor market dynamics (Nilmini & Samaraweera, 2022; Vodopivec & Arunatilake, 2008), sustainability and urban aging (Premaratna et al., 2023), generativity and engagement (Dohlman et al., 2023), retirement age decision (Madhuwanthi, 2020), perceptions of successful aging (Perera, Watt, et al., 2015), dimensions of health (Østbye et al., 2009), workplace spirituality (Perera, 2023), healthcare needs (Samaraweera & Maduwage, 2016), well-being, quality of work life of elderly workers (Gunathilaka et al., 2024), quality of life (Wijesiri et al., 2023), and social participation (Marsh et al., 2018). However, researches from the viewpoints of post-retiree workers themselves and organizational viewpoints in the Sri Lankan context are limited.

This study will be based on three theoretical stances; (a) continuity theory (Atchley, 1989), (b) life course theory (Elder et al., 2003), and (c) socioemotional selectivity theory (Carstensen et al., 1999). Continuity theory sees the retirement as a part of the individual growth process in which they adapt to changes as they grow, while life course theory posits that retirement is a transition within the life course and that people's history, personal resources, and context will affect the diverse pathways they choose and the outcomes they eventually achieve. Both of these theories support the view that retirees engage in meaningful work even after retirement.

The socioemotional selectivity theory (Carstensen, 2021; Carstensen et al., 1999) also known as a life span theory connects time remaining in life and the life goals. SST posits that as people perceive their time remaining is limited, especially in the later life or at the time of retirement, they become increasingly selective about how they spent or invest their remaining time, remaining energy, and social interactions. Accordingly, older adults prioritize emotionally meaningful goals and relationships over new knowledge-seeking or future-oriented pursuits. This shift leads them to focus more on present-moment satisfaction, emotional well-being, and soon-rewarding social bonds. SST has been used to understand how older adults use their time at the old age. It is suggested for understanding social and

[1] Even though the term 'retirement' lacks conceptual clarity, Denton and Spencer (2008) suggest that both objective and subjective components should be taken into consideration.
Objective measures of retirement are noted as nonparticipation in the labor force and in receipt of pension income, or only worked less than a specified number of hours or earned less than a specified amount and also received pension income. Subjective measures of retirement include the four aspects such as leaving the main employer, working fewer hours than before, those hours fall below some minimal level, and the person must regard himself or herself as retired (Denton & Spencer, 2008, p.23).

emotional needs of workers as they age (Cubrich & Petruzzelli, 2020). Carstensen and Hershfield (2021) used this theory in the investigation of marketing communication to older adults. This theory is used as the underlying theory of the present study as it explores the experiences and expectations of retirees in the post-retirement pursuits.

Research Method

This was an exploratory study employing a qualitative approach, utilizing focus group discussions to explore how retirees experience their post-retirement engagement and their expectations of work organizations. Purposive sampling was used to select participants from four districts which are highly populated in Sri Lanka. Participants were identified through government officials in roles such as Grama Niladhari, Samurdhi Officer, armed officer-in-charge, or community leaders. The recruitment criteria were: (1) age 57[2] years or above, (b) engaged in a work of economic benefit, and (3) receiving pension benefits. The participation was voluntary, and participants were informed of the study's purpose at the outset, after providing their informed consent.

The composition of the focus groups was 5 – 6 members. The participants were asked to narrate their post-retirement life. The group conversation was directed to reveal their retirement life story, post-retirement work engagement and experiences, and how they compared their pre-retirement work life with their post-retirement work life. The discussions were held one hour to one and half hours. The discussions were digitally recorded with the permission of participants, and field notes were taken during the discussions. In addition, reflective journaling was undertaken followed by the discussions.

Findings and Discussion

The study included a total of 23 retired individuals, aged between 58 and 81 years, who were engaged in economically beneficial activities ranging from agriculture and business to private sector employment. Among the participants, only two were female. All were former government employees, except for one. Nearly 50 percent of the participants were involved in agricultural activities as their post-retirement engagement. The table 1 below provides a summary of the participant profile for the study.

[2] The minimum retirement age in Sri Lanka ranges from 57 to 60 years, depending on the effective date of the relevant Gazette notification (Parliament of the Democratic Socialist Republic of Sri Lanka, 2021).

Table 1
Participant Profile

Participant Code	Age	Gender	Previous Employment	Current Employment/ Engagement	Source of Income
K1	75	Male	Water meter reader	Mason work	Pension, other
K2	73	Male	Machine operator	Agriculture, Traditional arts	Pension, other
K3	72	Male	Hospital attendant	Informal sector employment	Pension, other
K4	76	Male	Clerck	Odd jobs	Pension, from odd jobs
N1	61	Male	School principal (Govt)	School principal (private)	Pension, current job
N2	68	Male	Technical officer	Agriculture	Pension, other income
N3	64	Male	School teacher (Govt)	Own business (part-time)	Pension, business
M1	74	Male	Clerck	Agriculture	Pension, other income
M2	69	Male	Police officer	Agriculture, business	Pension, other income
M3	62	Male	School teacher (Govt)	Agriculture	Pension, other income
M4	75	Male	Minor staff	Lottery selling	Pension, lottery selling
M5	61	Male	School teacher (Govt)	School Inspector (Primary)	Pension, employment
M6	62	Male	School teacher (Govt)	Agriculture	Pension, other income
M7	73	Male	Civil force officer	Agriculture (dairy)	Pension, business
M8	59	Male	Armed force officer	Agriculture (paddy-field), property renting	Pension, rental, other income
M9	58	Male	Navy officer	Construction, Agri-business (diary)	Pension, other income
M10	81	Male	Driver	Agriculture	Pension, other income
A1	66	Male	Staff officer	Agriculture (paddy-field)	Pension, other income
A2	60	Male	Police officer	Overseas job, agriculture (diary)	Pension, diary production
A3	72	Male	Health inspector	Resource person (Govt projects)	Pension, other employment
A4	66	Male	School principal (Govt)	Employed as a cashier	Pension, employment
A5	69	Female	Nursing officer	Visiting instructor, trainer	Pension, part-time employment
A6	66	Female	School teacher (Govt)	Private teaching	Pension, employment

Experiences of Post-retirement Work Engagement

Retirees expressed both positive and negative aspects of their post-retirement work engagement experiences. Positive experiences were associated with a sense of freedom from

heavy responsibilities and a greater sense of peace in life. In contrast, negative experiences were linked to feelings of disconnection, rejection, distance from younger colleagues, and strong pride and nostalgia for their former workplaces. The detailed findings are discussed below in accordance with these themes.

Freedom at Work

Many retirees stated that even they are currently engaged in a work, still they experience "relief" from a high workload which was under stipulated rules and regulations and strict supervision. As implied, post-retirement work has not been so strict. Thus, currently they enjoy work being out of regular, scheduled and compulsory work. Several participants were with the view that the work engagement before the retirement were a huge responsibility. A retired female government teacher who is currently conducting tuition classes (home-based) for young school children stated:

> It is not like in the school time now, I am free to select what I teach and the time for me to commit to this work. Even children are ok with it. I am happy, I really experience the freedom.

Peace in Life

An important observation made during the FGDs was the lightness shown by participants in their current day-to-day work life. On one hand, the post-retirement work had not been felt serious or highly responsible. Thus, they experienced a peaceful life course which was reflected through "I am relaxed now", and "life is slowed down after the retirement, so we work slowly".

A former employee at the provincial council (76) who is currently engaged in work for day-to-day earnings stated "no need to rush out now. Life is spent so calm. No running race any more. I just work for my day-to-day living". This shows that pre-retirement work had been much obligatory and stressful. In addition to this, it was observed that retirees were not in much expectations of future life. They did not need to think about a long future, but just to live the life until the end. This was implied by another participant stating that "now I do not work for accumulating resources. I don't need it".

Disconnectedness

Almost all participants were in the view that they experience disconnectedness at the post-retirement workplace. Some retirees explained it in terms of age-based disconnection while others implied the loosely-coupled relationships at the post-retirement workplace. A retiree (66) who previously worked at the Land Commissioner's Office, and currently actively engaged in agriculture informed:

> I feel like being out of the society-maybe as I have no active involvement with people as before. My current encounters are limited only to those who come to buy my crops. I happily remember my previous work life; it is full of happy memories.

Another participant (81) who was a driver in the government transport service implied the social isolation even at current engagement stating that:

> It is good that we have the chance to work at this age. But this is not the same like before. Now it is more than 20 years I have retired, I have continuous feeling of isolation even I have neighbors around.

As social relations (Miura et al., 2022) and social participation (Löfgren et al., 2022) are identified as the key to successful ageing, while feeling of disconnectedness can be viewed as a negative experience in the post-retirement work engagement.

Rejection

Several participants implied the experience that they are not recognized and treated as before due to their categorization as "retired" or "out of focus". They felt like 'not in the central focus'. This termed to be a kind of discrimination (or elimination) where retirement itself is experienced as an endorsement of "not in the formal service". A male government teacher (66) who retired at 60 notified that "retirement" is a label, and retired people are not recognized in the society. He emphasized the need of attitudinal change of the society towards retirees.

Another male participant (72) formerly worked as a hospital attendant regretted the missing of previous work life. According to him:

> During my formal job, I attracted the attention of many patients in my ward. Everyone praised me. Not only doctors and nurses, even relations of patients talked to me with respect. I enjoyed it very much. It was not the money that I always thought of but the goodwill came from others. Now I am into informal sector work. No one knows and no one cares. I highly admire my former work and that workplace.

National Academies of Sciences, Engineering, and Medicine (2022) explains this situation closer to workplace discrimination where the society perceives retirees as a category in which perceivers' attitudes, beliefs, stereotypes, and emotional prejudices play a role.

Distant to Young Colleagues

Several participants of the study highlighted their experience of being distant to young people at work. Interestingly, retirees did not show any displeasure over the attitudes or behavior of their young counterparts, but instead they accepted it as a natural phenomenon. However, a regret was implied when they understood the physical and psychological differences between them and the young workers. For an instance, a retiree (66) from the archeological department, currently engaged in agri-business stated;

> I understand that we are now not fitting to the young workforce. There are so many things to create this difference. We cannot stand with youngsters. I am sure young people also feel the same disparity. That is how it is, I accept it.

This is partly explained in the research on generational differences at work (Twenge, 2010). However, some past studies have found that generational perceptions in the workplace are varied among different age groups (von Humboldt et al., 2023).

Pride and Nostalgia for the Former Workplace

By recalling the memories of pre-retirement work life, almost all retirees disclosed a deep sense of pride and nostalgia for the former jobs. This sentiment was evident in statements such as "feel lonely without connections with former workplace friends"; "my previous workplace holds happy memories"; "I still have pleasant relationships with people from my former workplace"; "I greatly admire my previous job"; "I am very proud of the work I did"; "it makes me happy to recall my former job"; "my pre-retirement work life was the best period of my life"; "I feel sad to miss the previous workplace"; and "I am satisfied with how my life was spent during my former job".

Although this is not an experience related to post-retirement work engagement, it reflects how strongly retirees remain attached to their former jobs and workplaces in comparison to their current engagements.

Expectations of Retirees Engaged in Post-retirement Work

The expectations of retirees were further explored in the study, as outlined in Research Question Two, with the aim of understanding the implications for contemporary and future organizations. The main findings include: (a) a minimalist lifestyle with only a subsistence-level income, (b) low-stress work, (c) autonomy in the workplace, (d) flexible work schedules and a healthy work-life balance, (e) an active social life, (f) a sense of serenity, and (g) pride and recognition from others. The codes and illustrative interview excerpts that informed these themes are presented in Table 2 below.

Table 2
Themes, Codes and Interview Extracts for Identifying the Workplace Expectations of Retirees

Theme	Code	Interview extract
Subsistence income and minimalist life	Flexibility Less working time	"We need more leisure time now" "Why should we fully engage in jobs now?"
Low-stress work	Less workload No routine work No difficult tasks	"Now I do not want to do much work" "We can't work now like before, "I prefer simple tasks now"
Freedom	Less responsibility Light work Work with young workers	"I don't want to work like before. My job was full of responsibilities. Why should I do like that now? No need" "I wish to help young people to do their job. That's enough now"
Flexible work schedules and work-life balance	Flexibility Less working time	"We need more leisure time now" "Why should we fully engage in jobs now?"
Active social life	More involvement in community More engagement in society (with peers) Enjoy time with contemporaries Spend time with family	"I enjoy spending time with my work-time friends" "Now I can spend more time with friends and neighbors" "Now I enjoy time with my family because I have more time for that"
Serenity in life	Peaceful life Relaxed life	"I want more free time now, still I wish to work" "I don't want to be busy"
Pride and admiration by others	Recognition of previously held status (position/ rank) Appreciation of past experience (wisdom)	"I don't want to engage in a low-status work after retiring" "We have done our best in the job; people around know it well"

These findings closely align with the experiences shared by retirees in the above section and provide several key implications, as outlined below.

Conclusion and Implications

The experiences of post-retirement *work* engagements appear to differ from other types of engagements, such as civic, political, or voluntary activities. Returning to economically beneficial work after formal retirement has, to some extent, reintegrated retirees into the rhythm of working life. This conveys an encouraging message to work organizations. The expectations they shared also provide valuable insights.

Retirees engaged in post-retirement work report both positive and negative experiences. Many view the freedom from obligatory burdens as a significant positive aspect. However, they also experience a sense of social displacement—feeling disconnected, isolated, or marginalized from social groups or the community—following retirement. While retirees enjoy remaining active through work, they tend to prefer lighter, less demanding roles during this stage of life. This preference may be influenced by Sri Lankan cultural values, which

regard later life as a time for reflection and peaceful living. Interestingly, retirees often express strong emotional attachment and admiration for their former workplaces, and as a result, they tend to expect similar respect and recognition in their post-retirement engagements.

As suggested by Socioemotional Selectivity Theory, working retirees tend to prioritize emotion-related goals over knowledge-related ones during their post-retirement work engagements. Their desire for meaningful relationships and appreciation from others supports this theoretical perspective. From a practical standpoint, this study highlights the importance of workplaces being more attuned to the emotional well-being of retired employees. Rather than focusing solely on quantifiable achievements, valuing the quality of work and interpersonal relationships may prove more effective for engaging retired workers. Since retirees often feel more comfortable with roles similar to their previous positions, offering comparable job opportunities can lead to more satisfying and productive outcomes. Additionally, the study emphasizes that allowing retirees to craft their own jobs—by giving them the autonomy and flexibility to shape their roles in ways that align with their strengths, interests, and values, while still meeting organizational goals—can be a simple yet powerful strategy for cultivating a motivated and content retired workforce.

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Declaration of AI-Assisted Technologies in the Writing Process

I declare that I used ChatGpt (AI-assistive technology) to proof-read certain paragraphs of this manuscript. It was used with the purpose of correcting possible language errors in the writing.

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Data-Driven Approach to Understanding Senior's Needs: An Automated Unsupervised Learning Solution for Feedback Analysis in Singapore

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Abstract

The Silver Generation Office (SGO), under the Agency for Integrated Care (AIC), supports seniors in Singapore through home visits to understand their situation and connect them with services to address their needs, if any. Through these visits, valuable qualitative feedback on policies affecting them are collected. This study aims to develop a self-help tool using unsupervised natural language processing to analyse uncategorised free-text feedback to reduce manual effort required in summarising the feedback. A total of 41,891 anonymised and uncategorised free-text feedback collected from April 2022 to March 2023 were analysed using topic modelling algorithm, Non-Negative Matrix Factorisation (NMF), developed on Anaconda JupyterLab. The feedback was analysed by creating a Document-Term Matrix which represents the frequency of terms in each feedback, followed by applying NMF to extract topics with representative keywords. Human evaluation with inter-rater reliability (IRR) assessment was conducted with ten evaluators to assess its accuracy. Results showed that the model achieved over 75% accuracy, with high IRR coefficient above 0.876 after two rounds of evaluation. The model uncovered valuable insights that were previously challenging to obtain through manual efforts. The extracted topics help SGO to better make sense of the data, facilitating sharing of insights with stakeholders to highlight seniors' needs and preferences which will improve existing policies, programs, and services for seniors. The self-help tool is developed and currently in-pilot, allowing users to automate data preprocessing, conduct textual analysis, and generate visualisation charts. It may potentially enhance SGO's operational efficiency and reduce man-hours spent on data analysis.

Keywords: aging, seniors, topic modelling, text analysis, natural language processing, unsupervised machine learning, preventive health visit

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Introduction

Background

Singapore will be a super-aged society by 2030 with one in four citizens aged 65 and above (NPTD Singapore, n.d.). Within the community, Agency of Integrated Care (AIC) adopts a Touch-Hold-Care model to build an integrated ecosystem of care that supports seniors and clients. Silver Generation Office (SGO), the outreach arm of AIC, aims to care for seniors by supporting their aspirations and addressing their ageing needs. SGO's volunteers, the Silver Generation Ambassadors (SGAs), conduct Preventive Health Visits, identifying seniors' health, financial and social needs through the Senior Engagement Form. This helps SGO to refer seniors to relevant support through SGO's network of community partners and government agencies. SGAs also record seniors' feedback on senior-centered government policies and schemes through the form, which encompass feedback regarding Healthcare, Finance, Digital Literacy and other general feedback. The feedback is captured through either pre-defined sub-categories (e.g. High daily living expenses, Employment challenges, Request for senior-friendly equipment/infrastructure etc) or a free-text option in the form.

With an average of 300,000 home visits conducted by SGAs and staff yearly across 17 Satellite Offices, SGO receives a significant amount of qualitative feedback data from seniors. Limited by manual effort alone to scan and sieve through the feedback, SGO is unable to gain a comprehensive understanding of seniors' sentiments and identify emerging trends. These insights can be shared with relevant stakeholders to improve the provision of care and support for seniors. With Singapore's growing ageing population, the needs of seniors are becoming even more diversified. Furthermore, with recent national initiatives such as Healthier SG (preventive health) and Age Well SG (ageing in place), the insights gathered from the feedback may be valuable in the shift towards active ageing. The search for a more effective solution to address this analytical need thus becomes even more imperative.

Importance of Text Analysis

Currently, feedback captured under pre-defined sub-categories (Healthcare, Finance, Digital Literacy, General Feedback) is analysed by sentiment (i.e. Happy or Concern). This allows for an understanding of areas of concern or satisfaction among seniors nationwide. However, a significant portion of feedback, particularly the free-text responses that fall under the "Others" subcategory, remains largely unexamined. Hence, it leaves a significant gap in understanding the sentiments of seniors. This unexamined feedback is a rich source of information, offering insights that are not covered in the pre-selected categories. The manual process of reading through and interpreting this free-text feedback is not only labour-intensive and time-consuming but also prone to inefficiencies and inaccuracies. It is challenging to identify and categorise common themes across numerous responses manually, especially when dealing with large volumes of data.

Advanced text analytics and unsupervised machine learning techniques can be applied to systematically mine this unstructured data, allowing data analysis of seniors' needs, concerns, and experiences. Insights gained can contribute to national initiatives to tailor services that better meet the needs of seniors, and ultimately enhance the quality of care and support provided. This novel approach is also significant to uncover emerging trends from the older adults to allow us to better appreciate and address new expectations from the cohort effects of the fast-ageing population in Singapore.

Goal of this Study

The goal of this study is to develop, validate and implement a comprehensive framework for analysing free-text feedback provided by seniors during SGA visits, particularly focusing on the unstructured responses gathered under the "Others" subcategory.

By leveraging unsupervised machine learning technique, specifically Non-Negative Matrix Factorisation (NMF), this study aims to systematically identify and extract underlying topics and themes from seniors' feedback. Other than generating insights, a key objective is to establish a robust, self-help text analytics tool that can be utilised by SGO to perform data analysis of seniors' feedback and to uncover insights and emerging trends for reporting to stakeholders.

Methodology

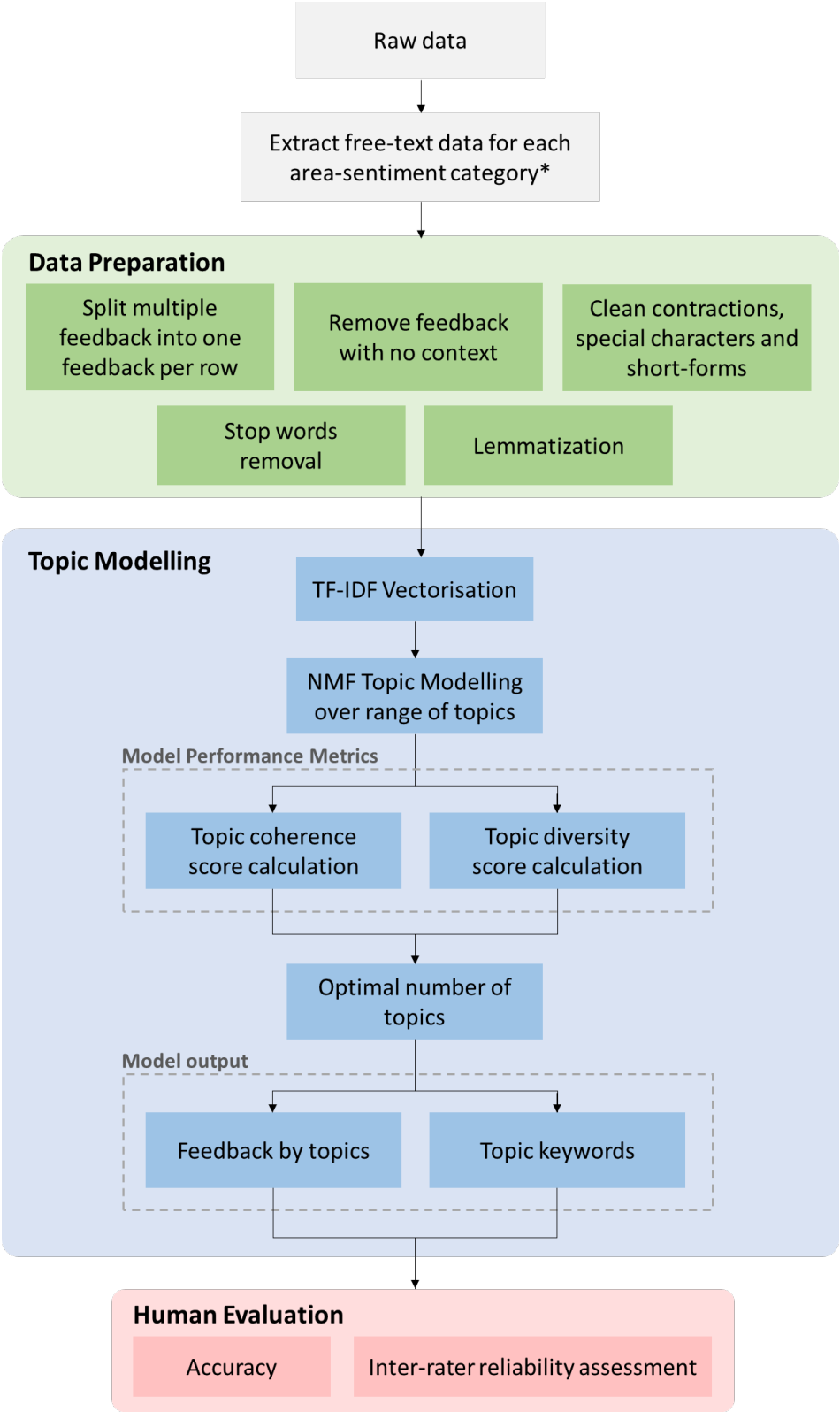
Overview

The approach of this study involves the implementation of a self-help tool that automates feedback analytics and reporting. Data preparation involves preprocessing of the raw data so that it is suitable for further processing and analysis. Key steps include cleaning, stop words removal, and lemmatisation. The data was categorised into eight area-sentiment categories. The processed free-text data are then analysed via topic modelling to extract latent topics underlying each area-sentiment category. Human-in-the-loop evaluation was conducted to evaluate the accuracy of the topics predicted, with inter-rater reliability (IRR) assessment to measure degree of agreement between evaluators. Finally, the workflow was implemented for users to self-help for management reporting.

Figure 1 outlines the research methodology for this study which involves three main stages: data preparation, topic modelling, and human-in-the-loop evaluation.

Data preparation involves preprocessing of the raw data so that it is suitable for further processing and analysis. Key steps include cleaning, stop words removal, and lemmatisation. The data was categorised into eight area-sentiment categories. The processed free-text data are then analysed via topic modelling to extract latent topics underlying each area-sentiment category. Human-in-the-loop evaluation was conducted to evaluate the accuracy of the topics predicted, with inter-rater reliability (IRR) assessment to measure degree of agreement between evaluators. Finally, the workflow was implemented for users to self-help for management reporting.

Figure 1
The Research Methodology for the Analysis of Seniors' Feedback



*Refer to Table 1 for list of area-sentiment categories

Data Preparation

Feedback data from SGA visits conducted between April 2022 and March 2023 was extracted for this study, with a total of 162,269 raw feedback collected regarding Healthcare, Finance, Digital Literacy and other general feedback.

Several data cleaning and corpus preparation steps were involved during data preparation. As each recorded feedback from a senior could contain multiple feedback, splitting of each record into individual feedback was done to ensure that every feedback was captured separately. Rows of data that did not provide contextual information were then removed from the dataset. The resulting corpus was then cleaned by removing contractions, special characters, and stop words. Lemmatisation was also performed to reduce words to their base form. There were 88,676 feedback after data pre-processing, out of which 47.2% (41,891 feedback) were tagged to subcategory "Others". The data were categorised into their respective area-sentiment category according to how the feedback question was structured in the engagement survey which helps to guide SGAs when filling in the feedback of seniors (Table 1).

Table 1
List of Area-Sentiment Categories

No.	Area-sentiment category
1	Digital Literacy, Concern
2	Digital Literacy, Happy
3	Finances, Concern
4	Finances, Happy
5	General Feedback, Concern
6	General Feedback, Happy
7	Healthcare Services and Schemes, Concern
8	Healthcare Services and Schemes, Happy

Topic Modelling

Topic Modelling Algorithm

Latent Dirichlet Allocation (LDA) and NMF are two commonly used and popular topic modelling techniques (Mifrah & Benlahmar, 2020). In this study, NMF topic modelling was used to extract meaningful topics underlying the corpus of feedback. NMF has two main advantages over LDA. First, NMF provides consistent and reproducible results due to its deterministic algorithms, as opposed to LDA which is a probabilistic technique (Svensson & Blad, 2020). Second, NMF allows for an easier tuning and manipulation of its parameters (Purpura, 2018).

NMF was chosen over LDA due to its deterministic nature, making it easier to interpret and more consistent in producing similar results across different runs. NMF has also proven its effectiveness in mining short texts (Athukorala & Mohotti, 2022), which is suitable for this use case where the word count of feedback recorded is of median of nine words. In addition, NMF is found to be more in line with human judgment than LDA (Egger & Yu, 2022).

Applying NMF on Text Corpus

NMF is a linear algebraic method that factors the document-term matrix (V) into two smaller non-negative matrices, document-topic matrix (W) and topic-term matrix (H), such that $V \approx W \times H$. Matrix W shows the distribution of the topics across the corpus of feedback, while matrix H captures the significance of terms within each topic.

Feedback from each area-sentiment category is processed separately, creating distinct corpora of text for each category. Topic modeling using NMF is then applied to these individual corpora. For each lemmatised text corpus, TfidfVectoriser transfers the textual data into the term frequency-inverse document frequency (TF-IDF) matrix which represents the importance of terms within each feedback, relative to the entire corpus. The vectoriser was configured to remove common stop words specific to each area-sentiment category, and it also considers both single words and bigrams to capture more context.

NMF topic modelling was then iterated over a range of number of topics from two to 20. Two metrics were used to assess the performance of each iteration – topic coherence and topic diversity. Topic coherence score was generated to measure the degree of semantic similarity among the top words of each topic, which helped in evaluating the interpretability of topics generated by the model. Topic diversity score was calculated using the pairwise word embedding distances to measure how distinct the top words in each topic were from other topics, which helped in evaluating how well-separated the topics were. Ideally, the top words within each topic are expected to be highly semantically related, while those across topics are to be as distinct as possible. The optimal number of topics is determined based on the highest coherence and diversity scores, ensuring that the topics generated are both interpretable and diverse.

The dominant topic for each feedback was determined based on the weights of topics in the document. After review and discussions amongst the researchers, consensus was reached to recommend a minimum weight threshold of 0.04, which was appropriate to determine the outlier feedback from the topics identified. The topic with highest weightage will be selected as the dominant topic for each feedback.

Evaluation

A 10% stratified sample was extracted for each area-sentiment dataset and evaluated by a panel of ten evaluators to measure the accuracy of the topic model in predicting the topic for each feedback. The panel of evaluators (refer to Appendix, Table 4) recruited were from the Headquarters and Satellite Offices of SGO with expertise and domain knowledge in seniors feedback reporting.

Figure 2
Evaluation Workflow

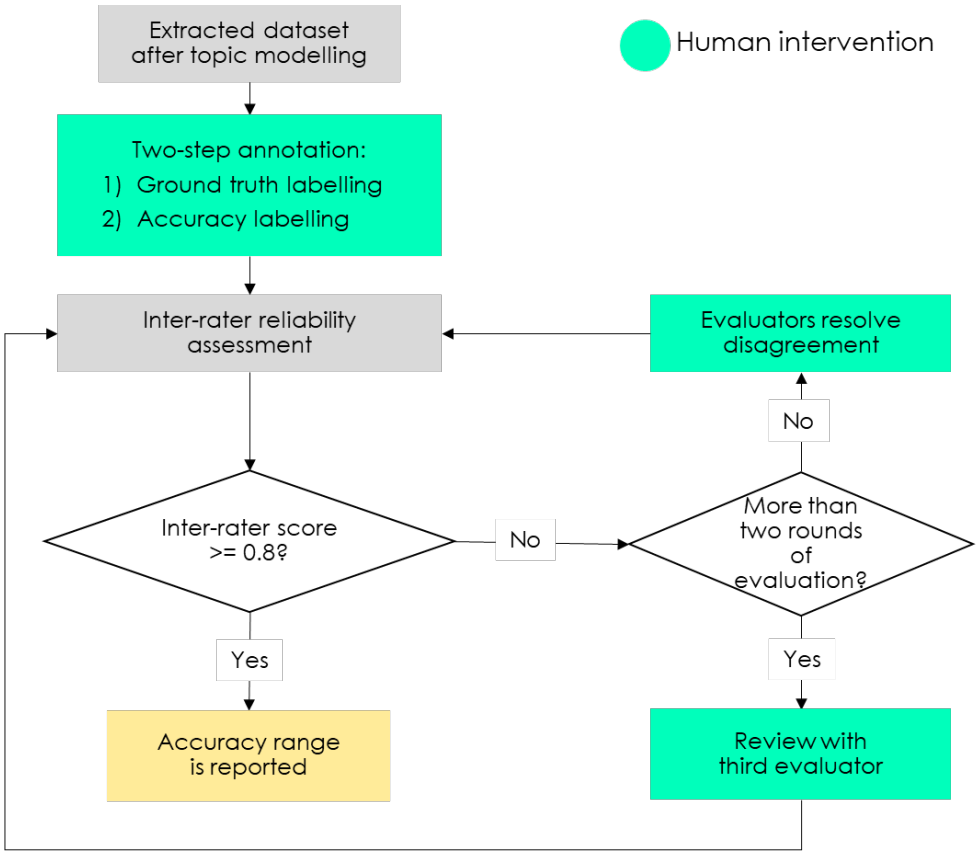


Figure 2 illustrates the workflow for the evaluation exercise. Each feedback was assessed by two evaluators to ensure unbiased evaluation. Each evaluator independently conducted a two-step annotation by firstly labelling the ground truth for each feedback, followed by reviewing the predicted topic against the ground truth label and annotating the accuracy of topic prediction.

IRR assessment was integrated in the workflow to quantify and validate the level of agreement between evaluators. IRR was calculated using the *irrcac* Python package, which closely follows the general framework of IRR assessment presented by Gwet (Gwet, 2014). The Landis and Koch scale was used to interpret the level of concordance between evaluators, providing a systematic approach to evaluating the consistency of the evaluators' assessments (Landis & Koch, 1977).

A threshold of 0.8 was set as the acceptable level of agreement according to the Landis and Koch scale (Landis & Koch, 1977). If the IRR coefficient was equal to or exceeds 0.8, it indicated a high level of agreement, and the accuracy of the evaluations was reported based on the evaluators' responses. Conversely, if it fell below 0.8, indicating a lower than acceptable level of agreement, the evaluators were required to resolve their disagreement in responses. Following the resolution discussion, the re-evaluated responses were subjected to a second round of IRR assessment to ensure that a minimal level of agreement is achieved. In the event if the first round of resolution failed to achieve an acceptable level of agreement, the involvement of a third reviewer is recommended to provide an additional layer of

evaluation. This approach ensures that the evaluation process is robust, thereby enhancing the validity of the assessment outcomes.

Results

Topic Modelling

The topic modelling analysis aims to uncover underlying topics present in the feedback provided by seniors under the “Others” subcategory. By applying NMF to the textual data, topics were identified for each area-sentiment category.

Table 2
Optimal Number of Clusters by Area-Sentiment Category

Area-sentiment category	Number of optimal clusters
Digital Literacy, Concern	5
Digital Literacy, Happy	19
Finances, Concern	20
Finances, Happy	7
General Feedback, Concern	4
General Feedback, Happy	19
Healthcare Services and Schemes, Concern	9
Healthcare Services and Schemes, Happy	5

Table 2 summarises the optimal number of clusters identified for each area-sentiment category, representing the number of distinct topics that emerged from the feedback data. The determination of these topics involved evaluating metrics such as topic coherence and topic diversity to ensure the relevance of each topic and distinction across topics. The variation in optimal number of clusters highlights the diverse nature and the complexity of feedback across different area-sentiment categories. For example, "Digital Literacy, Concern" was found to have five distinct topics, while "Finances, Concern" had a higher complexity of feedback nature, yielding 20 optimal clusters.

The topics extracted for each area of feedback are included in the Appendix (Table 5). For each topic identified, the top five keywords by weightage are listed, providing a snapshot of the underlying theme.

Digital Literacy

Key concerns in digital literacy revolved around the use of government apps and online payment services, fast-paced digitalisation, and fear of scams. Topics like “scam, afraid, government, worry, afraid scam” and “fast, digitalisation, catch, digitalisation fast, pace” may reveal the seniors’ struggles with adapting quickly to digital changes and are concerned with online safety. Topic “English, understand, Chinese, language, learn” highlighted the challenge of understanding English or learning Chinese, possibly pointing to issues of accessibility in digital services for non-English speakers.

The happy sentiment focused more on appreciation for learning opportunities, with topics like "good, educate, government, government good", "learn, slow, computer, good, thankful", "lesson, glad, glad government, conduct lesson" and "skill future, fund" indicating satisfaction with the digital literacy programs and skills upgrading support provided by the government. There were also recurring mentions of online transactions, such as payment and appointment booking, showing an acknowledgment of the convenience brought by these digital solutions, despite some ongoing concerns with fast pace of digitisation.

Finances

Concerns around finances were focused on the rising cost of living, with topics like "cost living, high", "food expensive, market, costly", "expense, medical, living expense, expense high" indicating worry over inflation and affordability of essentials, especially food, medical and housing expenses. Seniors also expressed hope for more government support, as seen in the topics "government, hope, government help" and "support, financial support, government" which suggested expectation or desire for further financial assistance or subsidies.

Positive finance feedback reflected satisfaction with the care provided by government (e.g., "care, government, care citizen") with the various government payouts and support received. There were also mentions of specific support programs such as Silver Support Scheme (SSS), Community Development Council (CDC) vouchers, Assurance Package scheme and Goods and Services Tax vouchers (GSTV), signalling a sense of relief from receiving financial support to curb rising cost of living.

General Feedback

The main concerns in general feedback echoed the financial worries faced by the seniors, particularly on the cost of living, with topics such as "cost live, high cost". The mention of "complaint, town council, neighbour" highlighted localised issues the seniors faced regarding the community they lived in.

In contrast, positive sentiments revolved around overall satisfaction with government schemes and policies. Repeated compliments for the government such as "good government", "satisfied government" and "appreciate government" showed the seniors' appreciation towards government's policies and schemes. Other areas of satisfaction include community relationships and environment, with topics like "good neighbour" and "environment, facility good" indicating positive social and physical environments, which could contribute to overall well-being of the seniors. Some seniors also expressed gratitude towards SGA visits ("SGA visit, appreciate visit") and safety of Singapore ("Singapore, country, safe, live").

Healthcare Services and Schemes

Concerns in healthcare were focused on rising medical costs, with topics such as "increase medical, cost" and "expensive, medication, fee expensive" being dominant. Other concerns include service standards at polyclinics/hospitals with topics like "polyclinic, long, wait time, appointment".

Positive feedback was centred on the government's healthcare subsidies and care programs, with topics like “subsidy, medical, healthcare, health, care” indicating appreciation for government’s efforts in keeping healthcare services affordable.

Evaluation Outcomes

The results of the evaluation process, including IRR and accuracy assessments are summarised in Table 3. This table presents the IRR coefficients from two evaluation rounds and the accuracy of topic predictions for each area-sentiment category.

Table 3
IRR Assessment and Accuracy Results

Area-sentiment category	IRR coefficient (Evaluation round 1)	IRR coefficient (Evaluation round 2)*	Accuracy
Digital Literacy, Concern	0.735	0.952	78.1-81.4%
Digital Literacy, Happy	0.876	-	86.7%
Finances, Concern	0.935	-	87.9-91.4%
Finances, Happy	0.622	1.00	86.0%
General Feedback, Concern	0.529	0.974	75.9-76.8%
General Feedback, Happy	0.908	1.00	95.0%
Healthcare Services and Schemes, Concern	0.962	-	96.6-97.7%
Healthcare Services and Schemes, Happy	0.979	-	97.7-100%

*Round 2 is conducted when round 1 IRR falls below 0.80

Responses from the panel of evaluators were in concordant within two rounds of evaluation. High levels of agreement were observed in categories related to the Healthcare, with coefficients above 0.962, indicating a strong consensus among evaluators. Conversely, “General Feedback, Concern” showed the lowest IRR coefficient of 0.529 in the first round, which improved to 0.974 in the second round after resolving disagreements.

In terms of accuracy, the topic model achieved over 75% accuracy across all categories, with six categories exceeding 85% accuracy. In general, for machine learning models, industry standards are between 70% and 90% (Hendricks, n.d.). Healthcare exhibited the highest accuracy above 96.6%, whereas “General Feedback, Concern” and “Digital Literacy, Concern” displayed relatively lower accuracy, possibly due to the complexity of these feedback categories and highlights the opportunity for further refinement in the topic modelling technique.

Discussion

Principal Findings

Overall, the extracted topics via topic modelling has provided a granular view of the various concerns and satisfactions expressed by seniors, offering valuable insights into the areas where support is needed or appreciated.

In Digital Literacy, seniors express anxiety around fast-moving digitalisation and scams. However, government-supported educational initiatives seem to mitigate some of these concerns, providing a sense of empowerment through learning. Inflation is a major theme across both Finances and General Feedback categories. Financial pressures are significant, but at the same time, government interventions are acknowledged and appreciated. This indicates that while there are financial concerns, seniors feel that they are not left unsupported. Positive feedback in General Feedback tends to focus on satisfaction with governance, particularly in areas of healthcare support and financial handouts. This could suggest that policies resonate well with seniors when they directly benefit from these programs. For Healthcare, medical expenses are a significant concern. At the same time, there are positive feedback on the government's healthcare subsidies and support that assisted the seniors in alleviating healthcare cost.

There were several overlapping themes across the different categories of feedback, which highlights interconnected concerns and sentiments that seniors express across various aspects of their lives.

1. Cost of Living and Financial Concerns

The recurring theme of financial concerns across Finances, General Feedback, and Healthcare Services and Schemes emphasises that economic pressures are central to seniors' lives. The rising cost of living and healthcare is a constant concern, while positive feedback about government support suggests relief from these concerns. This indicates that seniors view financial stability as integral to their overall well-being.

2. Government Support and Services

Seniors consistently express satisfaction with government support across all categories. Output from the positive sentiments categories frequently revealed appreciation for government's schemes and policies, emphasising positive perceptions of the government's support in various areas, from digital literacy initiatives to healthcare and financial support. Across the categories, seniors also frequently expressed their hope for further government support. The recurring theme of government support across domains underscores how the importance of public assistance programs to seniors' well-being. Regardless it being financial aid, healthcare subsidies, or digital education programs, seniors are dependent on government intervention to improve their quality of life.

3. Healthcare Access and Affordability

The rising cost of healthcare is a common concern highlighted across in Finances, General Feedback and Healthcare categories. Worries about affordability of healthcare amplifies overall financial concerns. Though there are worries on healthcare cost, several topics reflect appreciation for financial support related to healthcare.

The overlapping themes across categories illustrate the interconnected nature of the issues seniors face. These recurring concerns and satisfactions underscore the importance of integrated solutions that address multiple aspects of seniors' life.

The evaluation outcomes underscore the effectiveness and limitations of the topic modeling framework. High IRR in categories such as Healthcare suggests that these categories are relatively straightforward for evaluators to interpret and classify, while lower reliability in "General Feedback, Concern" reflects the broader and diverse nature of this category. The

significant improvement in IRR reliability from the first to the second round demonstrates the efficacy of iterative resolution in enhancing evaluator agreement.

The accuracy results show that the topic modeling framework overall performs well, with most categories achieving high accuracy of above 85%. Categories such as "General Feedback, Concern" and "Digital Literacy, Concern" achieved slightly lower accuracy (>75%). The diverse nature of feedback within "General Feedback, Concern" may have contributed to challenges in effectively capturing the context of all feedback through the predicted topics. On the other hand, "Digital Literacy, Concern" had the smallest dataset size, hence some feedback which had context related to "cyber wellness" and "learn", were not fully captured by the predicted topics. This suggests room for further refinement in the topic modeling approach to better handle complex feedback categories and improve the model's predictive accuracy regardless of dataset size.

Overall, the topic modelling analysis has deepened our understanding of seniors' needs and preferences. The following outcomes were achieved from the analysis:

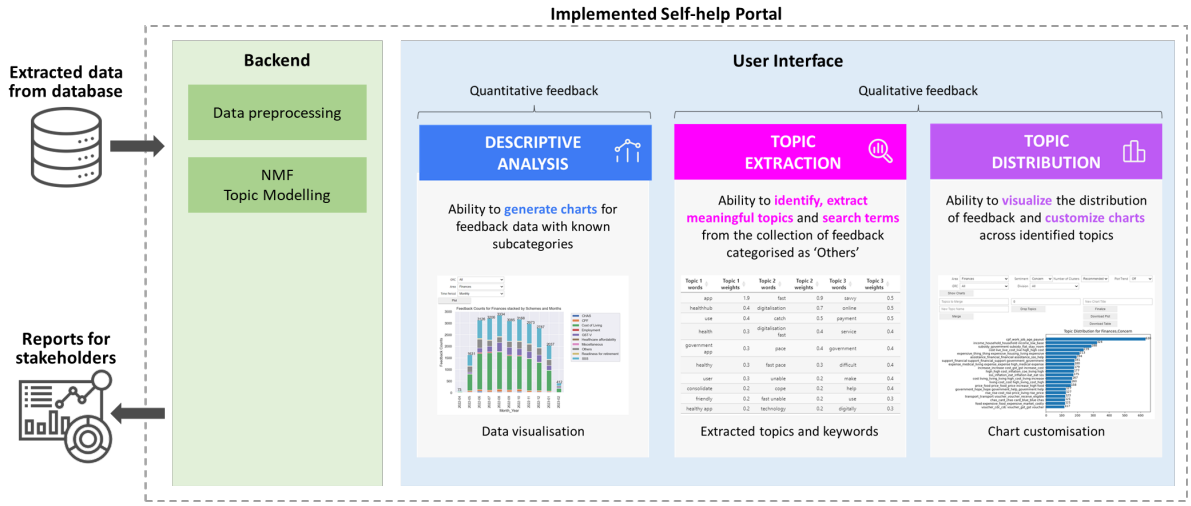
- Pinpointed the areas where seniors feel vulnerable, particularly in relation to modern challenges like digitalisation, rising living costs, and healthcare affordability.
- Identified areas where seniors are satisfied, allowing for reinforcement and scaling of programs or services that work well, such as healthcare subsidies and the various financial assistance provided.
- Provided a comprehensive understanding of how seniors perceive different aspects of their lives — in areas of digital literacy, finances, healthcare, and general well-being — and how their concerns are interconnected.

With a systematic analysis of seniors' free-text feedback which was previously unexplored, stakeholders can now leverage these insights from the topics to suggest targeted improvements to existing policies, programs, and services for seniors.

Model Implementation

Figure 3

Backend and User Interface of Implemented Self-Help Tool



The study demonstrated the use of NMF to develop an automated solution for analysing seniors' feedback. The results of the textual analysis through human evaluation showed that

the topic model can accurately identify topics from the feedback. This study also saw the implementation of a self-help tool (Figure 3), offering an interactive environment for users to run automated data preprocessing, textual analysis, visualise outputs and review the output for management reporting.

Key Features of the Self-Help Tool

The implemented self-help tool provides three key features designed to enhance the analysis of feedback.

1. Descriptive Analysis

This feature is for the quantitative analysis of feedback tagged with preexisting sub-categories, allowing users to generate data visualisations to gain insights into the distribution of feedback over time.

2. Topic Extraction

This feature is for the qualitative analysis of free-text feedback, allowing users to run NMF topic modelling to extract meaningful topics, providing insights from the unstructured feedback which were previously unexplored. During this process, users have the flexibility to specify the exact number of topics they wish to extract from the feedback data. Alternatively, they can opt to use the number of topics recommended by the model, which is determined based on topic coherence and topic diversity scores. Additionally, users can adjust the minimum weight threshold for topic inclusion, which is set to 0.04 by default.

3. Topic Distribution

Once the topics have been extracted, this feature enables users to visualise how these topics are distributed. Users can also customise the charts to facilitate reporting.

Users and Stakeholders Reporting

The users of the tool is representatives from SGO Headquarters (HQ) and SGO cluster offices. HQ disseminates feedback to public agencies, while cluster offices analyses the feedback more granularly for each Satellite Office within their cluster for sharing with Grassroots Advisers.

At HQ, the outputs will be grouped by topics which are relevant to respective public agencies. For example, if there are topics generated on speeding bicycles on pedestrian footpaths and long waiting times for bus services, these topics would be grouped together and shared with Singapore's transport regulatory government agency. The aim is for such public agencies to act on the feedback to improve policies and services for the elderly population.

At cluster offices, the outputs are grouped by the areas and sentiments in Table 1 for each precinct which are represented by a group of Grassroot Advisers (GRA). The outputs are represented in the form of charts to give an overview and included in a quarterly update to GRAs. The aim is to leverage on their influence to move community resources towards addressing the feedback.

Benefits and Impact

The use of the self-help tool has benefited SGO in several ways.

1. Greatly increased SGO's operational efficiency, reducing approximately 210 man-hours per year spent to manually scan the feedback to provide insights for the quarterly GRA reports. The time saved freed up more productive hours to perform analysis of the charts and to provide insights from feedback data.
2. Uncover insights which might not have been previously detected through manual effort. Through the categorisation of feedback in topics, SGO was able to identify topics with significant numbers and uncover emerging trends from the seniors' sentiments.
3. Increase awareness of ground issues by community leaders. These feedback topics provide insights to the seniors' sentiments within their constituencies and help Grassroots Advisers focus on the relevant support and services required by seniors.
4. Improve policies and enhance services by public agencies through actionable insights. Public agencies are made known the growing concerns and issues that the elderly face which would help them to formulate better guidelines and programmes that address ground concerns.
5. Improve training curriculum for SGAs through the review of feedback themes generated, to educate them on the common feedback received and ways to better record the feedback for effective data analysis.

Limitations and Future Work

While the topic modelling framework has demonstrated effectiveness in analysing seniors' feedback, several limitations have been identified that suggest areas for improvement for future research and implementation.

Several predicted topics exhibited overlapping contexts, which could affect the interpretability of results. This overlap suggests a need for semantic understanding of the textual data. Transitioning to embedding-based algorithms allow semantic understanding and enhance the model's ability to distinguish between subtly different topics. This will reduce the manual effort required to combine duplicated topics together.

The developed solution was helpful to provide a high-level categorisation of feedback into topics but has room for enhancement to delve into the deeper details of each topic. A potential enhancement could complement topic modelling with language models to summarise the feedback keywords and themes into a short phrase to represent the category, and to query actionable insights on specific concerns or praises shared by seniors on a particular area (e.g. Frequency of bus 183 could be improved). This will reduce manual effort required to summarise the feedback themes and allow sharing of specific, deeper insights with stakeholders.

Furthermore, as some agencies have requested for aggregated data or anecdotal information, it would be very helpful if the raw feedback could be further categorised by the deeper and sharper topics. This would allow less resource-intensive methods to isolate and analyse raw feedback to generate further insights for stakeholders.

Conclusion

The study successfully developed and validated a framework for analysing free-text feedback with NMF topic modelling. The framework demonstrated its effectiveness in identifying and extracting underlying topics from unstructured feedback, and providing valuable insights into seniors' experiences and needs. Notably, the topic model, which was validated through human evaluation and IRR assessment, achieved high accuracy over 75% across all area-sentiment categories, with six categories exceeding 85% accuracy.

While the study demonstrated the developed framework's capabilities, several areas for future enhancement were identified. Opportunities for enhancement include the use of embedding-based algorithms for semantic understanding of feedback, and complementing with the capability of language models to derive deeper insights.

Overall, the study's outcomes contribute to better understanding of seniors' concerns and satisfaction, which might not have been previously detected through manual effort. A self-help tool has been implemented which enhances SGO's operational efficiency and reduce man-hours spent on data analysis. This novel approach is also significant to uncover emerging trends from the older adults to allow us to better appreciate and address new expectations from the cohort effects of the fast-ageing population in Singapore.

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Appendix

Table 4
Panel of Evaluators

SN	Description of Role	Title	Years of Service
Evaluator 1	User rep for IT systems of SGO	Senior Assistant Director	More than 3 years
Evaluator 2	User rep for IT systems of SGO	Assistant Manager	1 – 3 years
Evaluator 3	Media, and Communications rep for SGO to manage communication materials	Senior Executive	1 – 3 years
Evaluator 4	Strategy rep for SGO, liaise with external stakeholders	Assistant Manager	More than 3 years
Evaluator 5	Deputy Head for Satellite Office managing ground outreach operations of SGO	Manager	More than 3 years
Evaluator 6	Deputy Head for Satellite Office managing ground outreach operations of SGO	Manager	More than 3 years
Evaluator 7	Deputy Head for Satellite Office managing ground outreach operations of SGO	Manager	More than 3 years
Evaluator 8	Deputy Head for Satellite Office managing ground outreach operations of SGO	Manager	More than 3 years
Evaluator 9	Deputy Head for Satellite Office managing ground outreach operations of SGO	Senior Manager	More than 3 years
Evaluator 10	Deputy Head for Satellite Office managing ground outreach operations of SGO	Senior Manager	More than 3 years

Table 5

Extracted Topics for Each Area-Sentiment Category With NMF Topic Modelling

Area of Feedback	Topics Extracted for Concern Sentiment	Topics Extracted for Happy Sentiment
Digital Literacy	1) app_healthhub_use_health_ government app 2) fast_digitalisation_catch_ digitalisation fast_pace 3) savvy_online_payment_service _ government 4) scam_afraid_government_worr y_ afraid scam 5) english_understand_chinese_ language_learn	1) good_educate_government_ government good_good government 2) learn_slow_computer_good_ thankful 3) app_health_life_like_book 4) savvy_savvy concern_concern scam _generation_difficult 5) lesson_glad_glad government_ conduct lesson_conduct 6) course_organise_government good_ good organise_organise course 7) use_payment_need_use mobile_cash 8) government_handle_public_fas t_ process 9) skill_future_skill future_fund_future fund 10) help_voucher_help learn_ government help_appointment 11) singapore_accessible_internet_ world_fast 12) phone_mobile phone_mobile_ coaching_smart phone 13) keen_keen learn_know_competent_ usage 14) scam_wary_concern scam_savvy concern_government 15) digitalisation_come_book_ appointment_book appointment 16) class_good_attend_conduct_wa nt 17) care_content_government_ government good_smart 18) online_singpass_provide_ implement_make payment 19) function_want_want learn_initiative _handphone
Finances	1) cost living_living_living high_cost_ living increase 2) food expensive_food_expensive_ market_costly 3) cost live_live_cost_live high_high cost 4) government_hope_hope government_help_government help 5) price_food price_food_price increase_high food 6) living cost_cost high_living_ cost_high	1) care_government care_ government_care citizen_citizen 2) receive_sss_receive sss_cash bonus _bonus 3) voucher_cdc_cdc voucher_ receive cdc_help 4) support_financial_government _ financial support_provide 5) payout_government payout_ government_appreciate_apprec iate government 6) package_assurance package_ assurance_satisfied_satisfied

	7) sss_inflation_eat_inflation eat_eat sss 8) increase_increase cost_gst_gst increase_cost 9) support_financial support_ financial_support government_ government 10) high_high cost_inflation_coe_living high 11) transport_transport voucher_ voucher_receive_eligible 12) rise_rise cost_rise price_living rise_price 13) voucher_cdc_cdc voucher_gst_gst voucher 14) subsidy_government subsidy_flat_ stay_room 15) expense_medical_living expense_ expense high_medical expense 16) cpf_work_job_age_payout 17) chas_card_chas card_blue_blue chas 18) assistance_financial_financial assistance_sso_help 19) expensive_thing_thing expensive_ housing_living expensive 20) income_household_household income_low_base	assurance 7) gstv_gstv receive_recently_receive recently_receive
General Feedback	1) cost live_live_cost_high_high cost 2) living_cost_high_cost living_living cost 3) government_hope_hope government_help_support 4) complaint_town_council_town council_neighbour	1) government_good government_ government scheme_thank_overall 2) government good_good_good job_ job_good government 3) government care_care_care elderly_ elderly_care elder 4) neighbour friendly_friendly_ neighbour_friendly environment_ facility good 5) policy_government policy_policy good_policy care_content 6) care citizen_citizen_government citizen_government_support citizen 7) appreciate_appreciate government_ financial handout_financial_handout 8) support_government support_support scheme_support government_scheme 9) satisfied_satisfied government_ overall satisfied_overall_ government government 10) help_government help_help elder_ elder_help citizen 11) good care_care_elderly_care

		elderly_benefit 12) payout_government payout_payout yearly_yearly_receive 13) environment_facility_facility good_ environment facility_friendly environment 14) look_government look_look people_ people_good look 15) visit_sga_sga visit_appreciate visit_ appreciate 16) subsidy_medical_medical subsidy_government subsidy_sss 17) singapore_country_safe_singapore safe_live 18) neighbour good_neighbour_good_ good neighbour_good government 19) recognise_job_good job_indonesia_ proud singaporean
Healthcare Services and Schemes	1) increase medical_medical cost_increase_medical_cost 2) expensive_medication expensive_ medication_cost expensive_fee expensive 3) subsidy_hope_government_hope government_hope subsidy 4) high_cost_cost high_high cost _medical cost 5) expense_medical expense_ medical _expense high_fee 6) polyclinic_long_wait_time_ appointment 7) card subsidy_low_subsidy help _help low_help 8) chas_card_chas card_blue_blue chas 9) medisave_use_use Medisave_ pay_cash	1) discount supermarket_ supermarket _discount_ supermarket pay_pay 2) good_government_care_ government care_service 3) satisfied_privilege_satisfied privilege_privilege government_ privilege subsidy 4) support_government support_ government_support subsidy_ subsidy 5) subsidy_medical_health care_ health_care

Protecting Our Brain to Reduce the Burden of Stroke: The Role of Stroke Alliance For Europe (SAFE)

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Abstract

For many individuals, achieving a healthy life expectancy beyond the age of 65 is significantly impacted due to health and social determinants including stroke, a leading cause of disability and the second cause of death worldwide. Stroke not only reduces life expectancy but also disproportionately affects healthy life years, especially for those with risk factors. Stroke contributes to a significant burden on general health, social and economic systems. Reducing the number of strokes must be a global priority. The Stroke Alliance for Europe (SAFE), a non-profit umbrella organization of over 35 stroke support organizations, advocates for equitable access to stroke care and support along the entire care pathway. In 2024, SAFE relaunched an innovative educational platform dedicated to stroke prevention. It provides accessible information on modifiable and non-modifiable risk factors, aiming to educate the public on strategies for primary and secondary stroke prevention to improve brain health and to reduce the likelihood of first and recurrent strokes. Through collaborative initiatives such as the Stroke Action Plan for Europe (SAP-E 2018-2030), led by SAFE and the European Stroke Organization (ESO), and the Global Stroke Action Coalition, led by the World Stroke Organization (WSO), these organizations continue to involve multinational stakeholders to address knowledge gaps in stroke and risk factors. With effective prevention, early intervention, and comprehensive rehabilitation including "life after stroke" which involves all years after formal hospital rehabilitation has ended, it is possible to reduce the global burden of stroke. This in turn will "democratize the concept of longevity."

Keywords: stroke prevention, secondary prevention, FAST Heroes, Stroke Support Organizations (SSOs), Stroke Alliance for Europe (SAFE)

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Introduction

Stroke is one of the most serious public health challenges of our time, with consequences that not only affect survivors but also have deep impact on their families, communities, and social welfare systems worldwide. Stroke is not only a medical emergency, but also a life-altering event that can lead to permanent long-term disability, a loss of independence, and, in many cases, premature death (Rimmele & Thomalla, 2022). According to global data, stroke consistently ranks as the second leading cause of death and remains the main cause of adult disability (Feigin et al., 2023), emphasizing the urgent need for greater awareness, prevention, and care strategies. Every year, around 12.2 million people experience a stroke for the first time, and sadly, about 6.5 million of them do not survive (Diener & Hankey, 2020). In Europe alone, the impact of stroke is profound, with over 1.1 million new cases recorded every year, creating substantial medical, social, and economic burdens (Feigin et al., 2023).

Beyond the lives that are abruptly disrupted, the needs of people who have had a stroke also place a significant strain on national healthcare systems and social welfare programs, with the costs of long-term care, rehabilitation services, and lost productivity adding up to billions of euros every year (Yarnoff et al., 2019). For stroke survivors, recovery often involves a prolonged and demanding journey of physical rehabilitation, emotional adjustment, and reintegration into society, a process that can extend for many years, if not a lifetime (Rimmele & Thomalla, 2022). Family members and caregivers are also deeply affected, as they frequently bear the responsibility of providing long-term care, often without sufficient resources, training, or institutional support (Gillespie & Campbell, 2011).

Importantly, stroke should not be viewed as a fated part of aging or an unfortunate twist of destiny. Although it is more common among older adults (Simmons et al., 2023), it is significantly preventable. In fact, research shows that nearly 80% of strokes can be avoided through lifestyle modifications and management of medical conditions (O'Donnell et al., 2016). Effective stroke prevention begins with primordial prevention - keeping populations healthy and preventing the development of risk factors through public policies, education, and overall healthy environments. This is followed by primary prevention, which focuses on identifying and managing modifiable risk factors, those aspects of our health and lifestyle that we can influence and change. These modifiable risk factors include high blood pressure, widely recognized as the most significant contributor to stroke risk, smoking, poorly controlled type 2 diabetes, physical inactivity, poor dietary habits, and excessive alcohol consumption (Maksimova & Airapetova, 2019).

These are not rare complications; they are common, everyday realities for many people, especially in fast-paced, modern societies. Addressing these factors through public education, routine screenings, access to healthcare, and supportive policies has the potential to significantly reduce the number of strokes occurring each year (Feigin et al., 2023). At the same time, non-modifiable risk factors, such as age, biological sex, genetic predisposition, and family history, still require awareness and monitoring, especially in populations considered at high risk.

Considering the profound impact that strokes have on both individuals and societies, its prevention should be a central priority on both national and international health agendas. The cost of inaction is reflected not only in the number of lives lost each year but also in the loss of quality of life for survivors, the emotional and financial strain placed on their families and caregivers, and the escalating pressure on already overwhelmed healthcare and social welfare

systems (Lucas-Noll et al., 2023). For these reasons, prioritizing prevention is not just a medical necessity; it is a matter of social responsibility and ethical urgency.

In this broader context, the work of organizations such as the Stroke Alliance for Europe (SAFE) has become especially significant. SAFE plays a critical role in raising public awareness, advocating policy change, and ensuring that stroke survivors and their families receive support throughout the entire care pathway, from primary prevention and emergency response, through acute care and rehabilitation, to long-term recovery, guaranteeing that no one affected by stroke is left behind (SAFE, n.d.).

Building on this urgent need for coordinated action, this paper explores the comprehensive role of SAFE in stroke prevention and support. SAFE's work spans a multidimensional approach: from primary prevention, through public education and endorsement of intergenerational awareness programs such as FAST Heroes; to secondary prevention, via accessible digital tools and platforms designed to reduce the risk of recurrence; and post-stroke support through the development of Stroke Support Organizations (SSOs) across Europe.

The Stroke Alliance for Europe: Initiatives and Impact

Established in 2004, SAFE has grown into one of the most influential pan-European non-governmental organizations, connecting more than 35 national SSOs from across the continent. SAFE combines patient advocacy, practical research, policy development and public education to better support not only stroke survivors, but also their families, caregivers, and healthcare professionals involved in stroke care.

One of the most impactful contributions of SAFE in recent years has been its co-development of the Stroke Action Plan for Europe (SAP-E), in collaboration with the European Stroke Organisation (ESO). Launched in 2018, this comprehensive policy framework lays out a strategic vision for improving stroke prevention, treatment, and recovery across Europe by the year 2030 (Norrving et al., 2018). Instead of treating stroke as a series of isolated issues, SAP-E offers a unified view of care - covering everything from early prevention to long-term recovery. Among its key targets are: reducing the total number of strokes in Europe by at least 10%, ensuring that 90% or more of patients receive care in dedicated stroke units as their first level of treatment, and encouraging all member states to establish national stroke plans that cover everything from primary prevention to long-term rehabilitation and life after stroke (Norrving et al., 2018).

SAP-E identifies seven key domains for coordinated action: primary prevention, organization of stroke services, acute care, secondary prevention, rehabilitation, evaluation of outcomes and quality assurance, and life after stroke (Norrving et al., 2018). These domains serve not just as focus areas but as interconnected parts of a system that need to work together to offer fair, coordinated, and meaningful support to stroke survivors. Furthermore, the plan calls for the full implementation of national strategies that address broader determinants of stroke risk, including socioeconomic disparities and health literacy (Norrving et al., 2018). From this perspective, SAP-E frames stroke not only as a medical issue, but also as a deeply social one, requiring long-term cooperation between healthcare, policy, social welfare, community stakeholders and people with lived experience.

SAFE also expands its reach through close partnerships with international organizations like the World Stroke Organization (WSO). By aligning with globally recognized institutions,

SAFE contributes to the development of consistent stroke care and social welfare strategies that can be adapted to different national healthcare systems. Beyond its policy and advocacy efforts, SAFE places substantial emphasis on public education and raising awareness about stroke. A key example is the annual European Stroke Awareness Day, which was created to help educate the public about the warning signs of stroke, associated risk factors, and the urgency of immediate medical response. Through wide-reaching public campaigns, community-based events, digital media outreach, and collaboration with national stroke organizations. SAFE promotes initiatives that are critical in reducing stigma, improving symptom recognition, and promoting long-term behavior changes, such as routine blood pressure monitoring, smoking cessation, and improved dietary and physical activity habits, that collectively reduce stroke risk across populations (Feigin et al., 2023).

Alongside its public education and policy work, SAFE actively supports research efforts that help improve how stroke is understood, treated, and managed (SAFE, n.d.). It also plays a key role in sharing important findings with healthcare providers, policymakers, and the public to ensure that new knowledge reaches those who can put it into practice. The strong and ongoing connection between research and real-world care ensures that the latest scientific evidence reaches frontline care, leading to better patient outcomes and access for stroke survivors across Europe.

Prevention: Digital Tools and Accessible Resources

Prevention (primary and secondary) is one of the core pillars of SAFE's strategy to reduce stroke-related deaths and disability. One of the main goals of this effort is educating the general public about stroke symptoms and the importance of early recognition and action (SAFE, n.d.).

To further its prevention goals, SAFE has developed an important tool, strokeprevention.info, a free and accessible digital platform that provides practical, evidence-based resources for stroke survivors, caregivers, and healthcare professionals (SAFE, 2024). The development of strokeprevention.info reflects SAFE's understanding that many stroke survivors and their families often feel overwhelmed and lost after hospital discharge, facing a lack of accessible, trustworthy guidance on how to prevent another event (Rimmele & Thomalla, 2022). To address this need, the platform brings together medical expertise, patient-friendly language, and practical, easy-to-use tools, all in one place. One of its most valuable features is its broad accessibility: the content is currently available in more than 100 languages, making it one of the most inclusive stroke prevention tools in Europe (SAFE, 2024). By respecting cultural and linguistic diversity, it ensures that vital information reaches people where they are.

While primary prevention remains a cornerstone of public health, addressing the risk of recurrent stroke (secondary prevention) is equally urgent, if not more so, for individuals who have already experienced a stroke or a transient ischemic attack (TIA) (Flach et al., 2020). Secondary prevention focuses on reducing the likelihood of another stroke event, which is often more disabling, costly, and fatal than the first (American Journal of Managed Care, 2024). Approximately 23% of ischemic strokes are recurrent, and these subsequent strokes carry a significantly higher risk of mortality and long-term disability (American Journal of Managed Care, 2024). Research suggests that mortality rates following a second stroke can be as much as 15% higher than after the first, often with greater disability (American Journal of Managed Care, 2024).

The economic burden is also considerable: recurrent strokes can cost up to 38% more than initial strokes, with first-year expenses exceeding $85,000 when adjusted for inflation (Lucas-Noll et al., 2023). These costs often include hospital readmissions, rehabilitation, and long-term caregiver support (American Journal of Managed Care, 2024). Beyond the human and financial toll, hospital readmission rates and caregiving needs also rise sharply after a recurrent stroke; this makes proactive, coordinated post-stroke care not just a clinical concern, but a broader public health priority (Yarnoff et al., 2019). Globally, investing in stroke prevention has demonstrated benefit-to-cost ratios as high as 10.9, reinforcing its importance not only for clinical outcomes, but for health system sustainability (Bertram et al., 2018).

Fortunately, secondary prevention is not only medically effective, but also one of the most cost-efficient strategies in stroke management. Global health and economic models estimate that investing just $1.50 per person per year in cardiovascular disease prevention could prevent up to 13 million strokes by 2030, with benefit-to-cost ratios of 5.6 to 10.9 when both economic and social returns are considered (Bertram et al., 2018). These projections are backed up by national programs. In the United States, the Paul Coverdell National Acute Stroke Program (PCNASP) showed that coordinated investments in hospital and system-wide quality improvement led to better outcomes, including faster treatment times and better survival rates (Yarnoff et al., 2019). These types of interventions don't rely solely on medications or new technologies; they depend on building stronger health systems - training and supporting clinical teams and providing stroke survivors and their families with the tools they need to manage their condition over time. In Europe, SAFE is advancing this kind of patient-centered, preventive approach through accessible, multilingual digital tools that support and empower stroke survivors and caregivers in reducing the risk of recurrence.

SAFE has extended its efforts beyond digital resources by contributing to policy discussions to help ensure that secondary stroke prevention becomes a more consistent part of national healthcare strategies. By engaging with policymakers, healthcare providers, and stroke experts across Europe, the organization advocates for the integration of standardized follow-up care and long-term support for stroke survivors and their families (Norrving et al., 2018). These efforts help guarantee that resources like strokeprevention.info are not only available but actively included within healthcare systems. In recent years, SAFE's advocacy has contributed to increased awareness, funding, and political commitment toward reducing stroke recurrence and improving the quality of life after stroke. Central to these efforts is the role of SSOs, which play a vital part in empowering survivors and caregivers throughout the recovery journey.

SAFE also endorses effective initiatives that help people who suffer a stroke identify early signs of stroke in order to get to the hospital on time for treatment and reduce the burden of disability, for example the FAST Heroes program. This is a global school-based campaign developed in collaboration with the Angels Initiative and based on the Child-Mediated Stroke Communication (CMSC) model (Williams et al., 2012). The program teaches children aged 5 to 9 how to spot the signs of stroke using the FAST acronym (Face, Arms, Speech, Time), and encourages them to share this knowledge with their families, especially grandparents, who are often at higher risk due to age (Tsakpounidou et al., 2020). By becoming messengers between school and home, children help their families learn life-saving information in a way that is age-appropriate, emotionally engaging, and easy to remember. As research has shown, children who participate in FAST Heroes are significantly more likely to retain stroke-related knowledge, including the ability to recognize symptoms and respond by calling emergency services (Tsakpounidou et al., 2021).

Using a playful and child-centered approach, the FAST Heroes program integrates storytelling, games, and hands-on activities that make stroke education both fun and impactful. Through a carefully designed sequence of lessons, the program introduces four animated superhero characters, each representing a symptom in the FAST acronym: Franc (Face), Armando (Arm), Sophia (Speech), and Timmy (Time). These characters work together to defeat the villain "Evil Clot," helping children understand that a stroke is serious but not invincible (Tsakpounidou et al., 2020). By using story-based characters, the message sticks in a way children can easily understand and remember.

Several studies have shown that the program works well in enhancing stroke awareness among children and their families (Tsakpounidou & Proios, 2021). Children who took part in the program became much better at spotting key stroke symptoms, such as facial drooping and arm weakness, and they remembered to call the emergency number (112) during stroke simulations. Notably, a 2023 study by Baskini et al. found that even four years after completing the program, children retained a remarkable level of stroke-related knowledge compared to their peers who had not engaged with the program. In the same evaluation, children who had previously participated were 24% more likely to recognize facial drooping, 43% more likely to identify arm weakness, 29% more likely to name incoherent speech, and 81% more likely to recall the emergency number (112). These results highlight the program's lasting educational impact, probably because it uses spaced repetition, colorful storytelling, and fun, emotional activities to help children retain what they learn effectively.

A key element of the FAST Heroes campaign is its focus on family and community engagement. Rather than keeping the learning confined to the classroom, children are encouraged to share what they have learned with their families through drawings, posters, storytelling, and take-home materials designed to initiate intergenerational conversations (Proios et al., 2022). These materials, such as posters, stickers, magnets, and storybooks, are tailored not just for children, but for parents, caregivers and grandparents as well, helping to turn every home into a learning environment (Tsakpounidou & Proios, 2021). This approach does more than reinforce the child's understanding; it meaningfully extends the program's impact to adult family members, especially older relatives who are at the highest risk of stroke due to age. In fact, follow-up evaluations revealed that grandparents who received these materials significantly improved their ability to recognize stroke symptoms and were more likely to report that they would call emergency services in case of a suspected stroke (Orologa et al., 2024). By transforming children into "health messengers," the program facilitates knowledge transfer within families, making stroke literacy a shared responsibility across generations.

Another reason behind the FAST Heroes program's success is its global scalability and cultural adaptability. Since its official launch in 2019, the program has been implemented in over 20 countries and translated into more than 30 languages, allowing it to reach diverse communities and educational systems (Tsakpounidou et al., 2022). While some regional variation exists, often due to differences in school infrastructure, parental engagement, or access to digital tools, the overall impact has remained consistently promising. In particular, awareness of local emergency numbers showed significant improvement between the first and second waves of implementation, suggesting not only that children absorbed the information themselves, but also that community-level awareness was strengthened through repeated exposure and family participation (Baskini et al., 2023). These findings demonstrate that FAST Heroes can be flexibly adapted to different contexts without losing its core educational value and effectiveness, making it a sustainable and inclusive tool for global stroke literacy.

SAFE also leads a wide range of public awareness campaigns aimed at reducing the incidence of stroke through education and behavioral change. These initiatives specifically focus on modifiable risk factors such as high blood pressure, smoking, poor diet, physical inactivity, and excessive alcohol consumption, which are key contributors to preventable strokes across Europe. Campaigns are disseminated through traditional media, digital platforms, and community-level collaborations, ensuring accessibility across age groups and regions (SAFE, n.d.). In collaboration with organizations such as ESO and WSO, SAFE's efforts reflect a coordinated strategy to improve stroke literacy and promote healthier lifestyles.

Stroke Support Organizations (SSOs): Empowering Survivors and Caregivers

Stroke survivors often face a range of physical, emotional, and social challenges after they leave the hospital, from mobility issues and fatigue to anxiety, depression, and isolation (Rimmele & Thomalla, 2022). To meet these complex needs, SAFE has supported the development and expansion of SSOs across the continent. SSOs are community-based groups that offer practical, hands-on support to both survivors and their families, including emotional counseling, social reintegration activities, informational guidance, and essential assistance for managing everyday tasks and decisions.

SSOs play a crucial role in filling the gap between formal medical care and the realities of daily life after stroke (SAFE, n.d.). By creating safe spaces for dialogue, facilitating access to services, and fostering meaningful connection, SSOs empower survivors and caregivers to regain a sense of agency and rebuild their lives with support that is local, sustained, and rooted in real-world needs, helping them move forward with greater confidence and independence.

SAFE recognizes that starting a stroke support organization can feel overwhelming, especially for survivors or caregivers without formal experience. This is why SAFE will support new local SSOs as they take their first steps, helping them grow into stable, community-led support systems, from registering legally and setting up governance, to finding funding and building a volunteer base (SAFE, n.d.)

As importantly, SAFE connects SSOs into a broader supportive European network. Whether it is a new SSO in Romania learning from a well-established team in Portugal, or several organizations collaborating at the European Life After Stroke Forum, this kind of peer-to-peer model helps everyone grow stronger together (European Life After Stroke Forum, n.d.). Today, many SSOs run monthly caregiver meetings, offer psychological support, and even represent the stroke community in national health policy discussions. And the impact of SSOs is real: survivors feel more understood and regain a sense of direction about their next steps, families feel less isolated, and caregivers finally receive the recognition and structured support they deserve (SAFE, n.d.).

Each SSO that is a member of SAFE also has the flexibility to adapt to the specific needs of its own local community (SAFE, n.d.). Whether in urban centers or rural regions, these organizations shape their services based on the local language, culture, and healthcare realities of the people they support. For example, some run stroke awareness events in schools or community centers, while others prioritize home visits, accessible transport for survivors with mobility challenges, or digital check-ins for those living alone. Many SSOs are founded and led by stroke survivors or caregivers themselves, which makes the support feel personal and grounded in lived experience (SAFE, n.d.). This kind of peer-led care builds trust and helps people feel heard - not just treated. SAFE continues to support these groups by offering training

in areas like fundraising, volunteer management, and digital communication (SAFE, n.d.). Since the COVID-19 pandemic, many SSOs have also expanded into online formats, using helplines, Zoom groups, and webinars to keep their communities connected, even from a distance.

SSOs are more than just service providers, they are a reflection of how communities come together to care for one another (SAFE, n.d.). By helping bridge the gap between medical care and everyday life, SSOs make sure that stroke survivors and their families don't have to face recovery on their own. With ongoing guidance from SAFE, these groups continue to grow, share ideas, adapt, and support each other across borders, creating a pan-European network that gives voice, real visibility, and value to the lived experience of stroke. In doing so, their work completes the circle of stroke care: from prevention to recovery, and ultimately, to reclaiming life after stroke.

Conclusion

Stroke is not merely a medical event; it is a profound life disruption that echoes through the daily lives of survivors, families, communities, healthcare systems, and social welfare structures. The immense personal and societal toll it exacts demands comprehensive, compassionate, and proactive solutions. Within this challenging landscape, SAFE has emerged as a key advocate, advocating for a stroke response that is not only clinically robust but fundamentally human.

SAFE's multilingual platform, strokeprevention.info, offers stroke survivors and their caregivers clear, practical guidance to help improve brain health and reduce the risk of having a first and/or recurrent stroke. These tools show a clear understanding of the everyday challenges stroke survivors face, and the need for support that doesn't end at hospital discharge but continues where life actually happens that is "life after stroke."

One of SAFE's most important contributions is its support for SSOs. By guiding community-based groups across Europe, SAFE helps build networks grounded in shared experience, understanding, and care. These peer-led organizations are shaped by the needs of their communities and provide personalized, practical support. SSOs help reduce isolation, bring people together, and make recovery feel a little more manageable - and a lot less lonely. In many cases, this kind of support fills the gap between medical care and daily life in a way nothing else can. As stroke remains one of the most pressing public health challenges of our time, SAFE offers a path forward that's built on connection, compassion, and real-life experience. By listening to SSOs that are members of SAFE and in turn support stroke survivors, families, caregivers and in turn working across sectors, and with the prevention website, SAFE is helping to shape a future where stroke and prevention is not only more effective - but more human. A future where no one must face stroke or face it alone.

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Analysis of Causes and Current Status of Converting China's Schools Into Care Homes

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Abstract

To cope with an aging population, Chinese investors have started converting abandoned school buildings, set aside by all provinces consequent to the school merging policy, into care homes. Because most current studies on these projects are case analyses, as the conversion trend has become more apparent, theoretical references for implementation are urgently needed. Besides that, data on China's care homes is not publicly available, so, hopefully, this study can provide researchers with information to save groundwork cost. Specifically, most conversions into care homes are located in China's central and eastern regions. Primary schools have been the most frequently converted, but all other types have been included. In urban areas, investors are mainly entrepreneurs, but in rural areas, investors are mainly governments aiming to provide living accommodations for older adults. Compared to urban conversions, rural conversions have generally smaller building sizes and fewer stories, accommodating relatively fewer residents; however, all conversions generally have one to three floors. Urban conversions' architecture is usually beam-column, and rural conversions are also predominantly framed but include some brick-concrete structures. Overall, the study compares design strategies and occupancy between urban and rural conversions, thereby providing a theoretical foundation for implementing future conversion programs.

Keywords: care homes, building conversion, school merging, urban–rural disparities, China

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Introduction

In recent years, China has entered rapid urbanization, leading to extreme imbalance between urban and rural development and a wide gap between the rich and the poor in urban and rural areas, respectively. Many young adults have migrated from the countryside to cities in search of better jobs and better educational environments for their children (Zhou, 2023). At the same time, promulgation of the 1971 family planning policy has led to a sharp decline in China's birth rate and a steady increase in the aging population, causing serious social problems (The Chinese Central Government's Official Website, 2013).

Since 1986, China has suffered an acute shortage of highly skilled personnel and has therefore attached great importance to spreading education by establishing at least one school in every village and an extremely large number of primary and middle schools in rural areas (Ji, 2012). However, with rapid urbanization and reduced birth rates in rural areas, village primary and middle schools have experienced difficulties recruiting students, financial constraints, and lack of income to cover expenditures (Lan & Li, 2017). Consequently, from 1998 to 2010, to reduce financial pressure and improve teaching quality, the State Council of China implemented a school merging policy in rural areas, rearranging and eliminating a huge number of rural primary and middle schools throughout the country and concentrating students in a relatively small number of urban schools (Shan & Wang, 2015). From 1997 to 2010, the number of rural primary schools decreased by nearly 300,000, that is, 81.3% of all schools abolished nationwide (China National Bureau of Statistics, 2024). This action left many school buildings unused, seriously affecting regional vitality and worsening the rural exodus.

Compared with urban areas, China's rural areas are aging more severely, with a higher demand for care services. In 2020, China had an urban older population of 143 million and a rural older population of 121 million that is, 22 million more older people living in urban than in rural areas, 15.4% of the total. Urban areas have 310,000 institutions (94.6% of the total) for older adults, but rural areas have only 17,000—195,000 fewer. The urban older adult's ratio to the number of institutions is 458:1; the rural older adult's is 7,118:1—revealing a serious shortage, aggravated by the population's aging (China National Bureau of Statistics, 2023, 2024).

School buildings and care homes are frequently similar in site selection and building volume. Converting unused school buildings into care homes can avoid wasting building resources, enhance the region's vitality, and meet the older adult's needs (Su & Dong, 2022). However, the feasibility and superiority of converting schools into care homes are uncertain. In addition, urban and rural areas differ significantly in economic level and population characteristics, and some differences lie in converting needs and strategies. Therefore, through comparison of urban and rural, this study describes school conversions' current situation and characteristics to provide a reference for conversion practices.

Current Research Status

China, South Korea, Japan, and multiple other countries have initiated school mergers due to declining school-age populations. South Korea's "Small School Merger Policy" was introduced 1982, although this was accompanied by an anti-merger movement that succeeded in bringing about the Namhansan Junior High School's rebirth. This victory led to reconstruction of many elementary schools on the verge of abandonment (An, 2013). Against

this background, South Korean scholars such as Kim, Nam, and Park. conducted a census on school building conversions in Korea, including such basic information as the number of conversions in each province. Through case studies, they explored types of conversion plans and specific strategies, laying a foundation for research on conversion of abandoned school buildings into elderly facilities in South Korea (Kim, 2019; Nam, 2011; Park & Park, 2007).

Since the 1950s, Japan has seen three large-scale campaigns to merge rural schools, with a declining birth rate spurring the third campaign (Mishima et al., 2015). In the 1980s, the Japan Society for the Revitalization of Vacant Classrooms conducted a study on school revitalization methods. In 2004, Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT) published the "Survey on Effective Reuse of Abandoned Schools" and the corresponding "50 Cases of Abandoned School Rehabilitation" to promote abandoned schools' reuse and explore ways to use the buildings effectively. In 2010, MEXT implemented the "Everyone's Abandoned Schools" project, which solicited facilities' registration for reuse and matched them with interested companies. Under these policies, most abandoned schools slated for merging have been converted, indicating that proactive policies and research can effectively improve conversion's efficiency and the territory's vitality (Mishima et al., 2015; Yamamoto et al., 2012).

In Japan's sparsely populated areas, vacant geographical resources, such as vacant schools, will be converted into care homes, thereby meeting most Japanese residents' need for local welfare facilities (Mori et al., 2020). Architectural resources' conversion into care homes not only provides some economic benefits but also a familiar living environment for older residents (Kato et al., 2021). Japanese scholars have conducted research from multiple perspectives, including preconversion planning, conversion methods, postconversion evaluation, and conversion's advantages and disadvantages versus new construction of care homes (Arita & Terauchi, 2021; Yan et al., 2005). These researchers generally used the fixed-point observation method to conduct fieldwork. Their conclusions include the following: traditional Japanese houses' conversion can positively impact residents; residents need continuity in public space; conversion needs to eliminate completely the difference between indoor and outdoor heights; conversion should focus on adjusting the dynamic line to avoid crossing it; and the site and the school building's shape restricts construction of care homes, etc., thus providing a reference for the practice of converting buildings into care homes in Japan. Because some studies and conclusions have obvious regional specificity, they are not universally applicable. Therefore, this paper draws on relevant research methods and explores the basis in China for converting buildings into care homes.

As noted above, since 1998, rural Chinese schools have undergone a large-scale merging effort that led to many abandoned facilities. Published in 2001, the "State Council on Basic Education Reform and Development of the Decision" mentioned that former school buildings and other assets should be used for other educational undertakings' development. However, the provisions did not mandate a clear reuse method, resulting in widespread confusion about school property rights and leading scholars to conduct research on the issue (Qin, 2009; Wu & Wang, 2009; Yu, 2013). In 2017, the State Council issued "Opinions on Further Stimulating the Vitality of Investment in the Social Sector," suggesting that abandoned facilities' use should be prioritized for education, pension, medical, culture, sports, and other social fields. In architecture prior to 2012, almost no relevant research existed on abandoned school conversion (Liu, 2022). However, as local governments introduced various disposal methods for abandoned assets and facilities, effective remodeling gained attention, and interested scholars began paying more attention to abandoned school conversion. Focusing

mainly on adaptability research and design strategies, some scholars have concentrated on conversion to older adult care facilities (Dong, 2021; Su & Dong, 2022; Wang, 2019; Zhong, 2017). These studies consist primarily of field visits to case studies, summarization of their shortcomings, suggestions for a targeted design strategy, and design simulation.

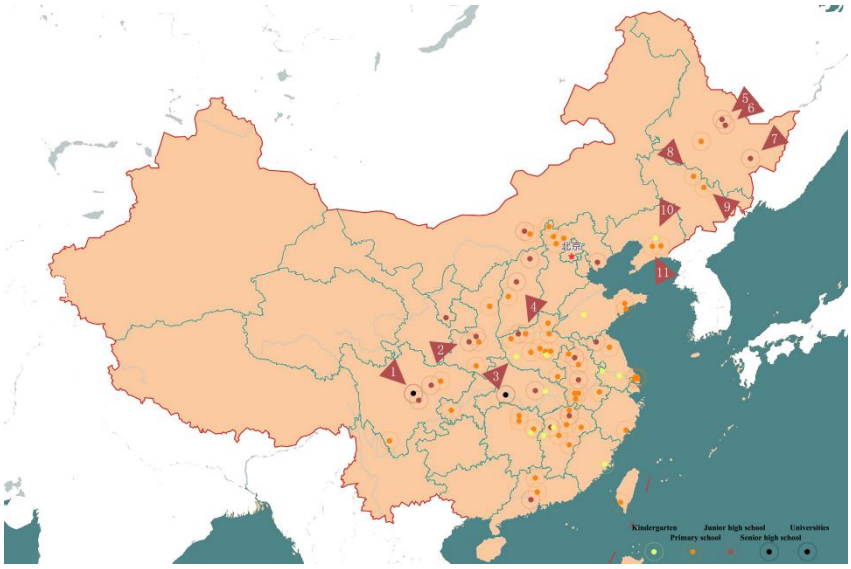
At present, due to lack of public data on care homes' operation in China and the difficulty of conducting broad on-site research, scholars have focused primarily on individual case studies. No comparative studies have discussed national conversion status and relevant differences between rural and urban regions. Therefore, to clarify differences in design focus and provide a basis for future development of appropriate design strategies for both rural and urban contexts, this paper compares 86 rural and urban abandoned schools converted into care homes.

Methods

To collect the most comprehensive information on China's nationwide school conversion into care homes, the researchers conducted a large amount of online work from November 2023 to October 2024. Data were crawled from government website announcements and news reports and also collected from multiple sources by distributing online questionnaires. Among other means, the data's reliability was cross-verified through field visits. The collection content includes the nationwide conversions' geographic locations, construction time, conversion time, buildings' basic conditions, investment amounts required, the conversion's reason, and so on.

Meanwhile, the researchers randomly selected 11 conversion cases from the census data above (August 16–September 25, 2024) and conducted fieldwork research during which they interviewed older residents and managers and mapped the buildings. Figure 1 illustrates the geographical distribution of the network research and fieldwork cases.

Figure 1
Geographic Location of Network Cases and Fieldwork Cases

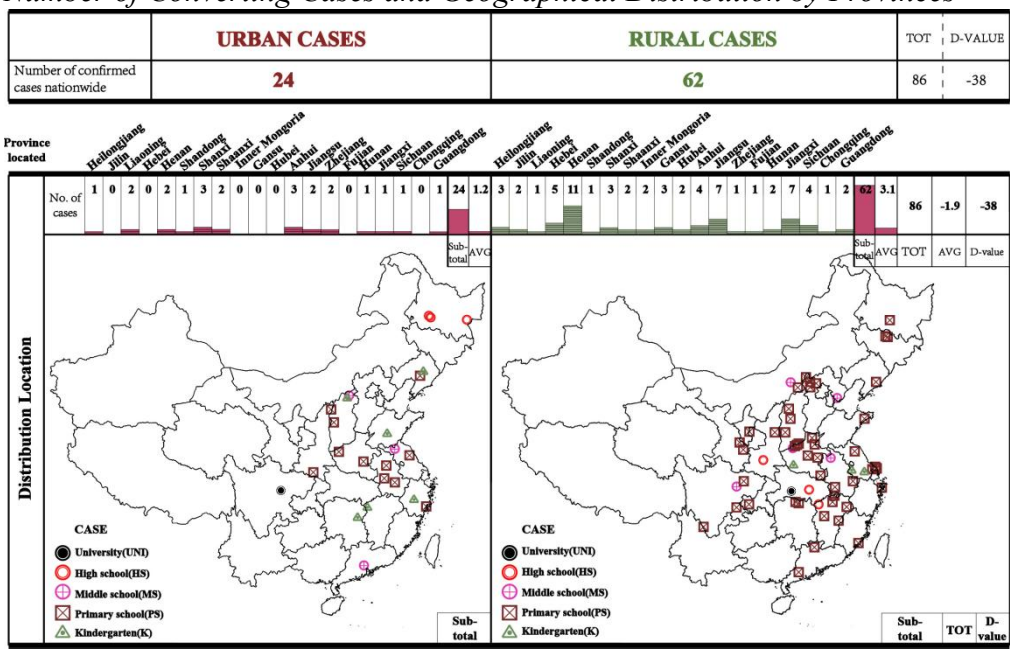


Results and Discussion

Distributions

Figure 2

Number of Converting Cases and Geographical Distribution by Provinces



This paper summarizes the survey data by number and geographical distribution, as Figure 2 shows. At 24, the number of China's urban conversion cases was approximately one-third the number of rural conversion cases, at 62. In other words, the current greater demand is for rural conversions to care homes. The types of preconversion school buildings are distinguished and labeled separately on the map. Most conversions were formerly small schools located in China's central and eastern regions.

The number of urban cases did not vary much across provinces, with the highest number in Henan Province (11). Henan Province also had the highest number of rural conversions, also 11, followed by Jiangsu and Jiangxi Provinces. All Chinese provinces now have conversions, and using abandoned schools as care homes is gradually trending across the country.

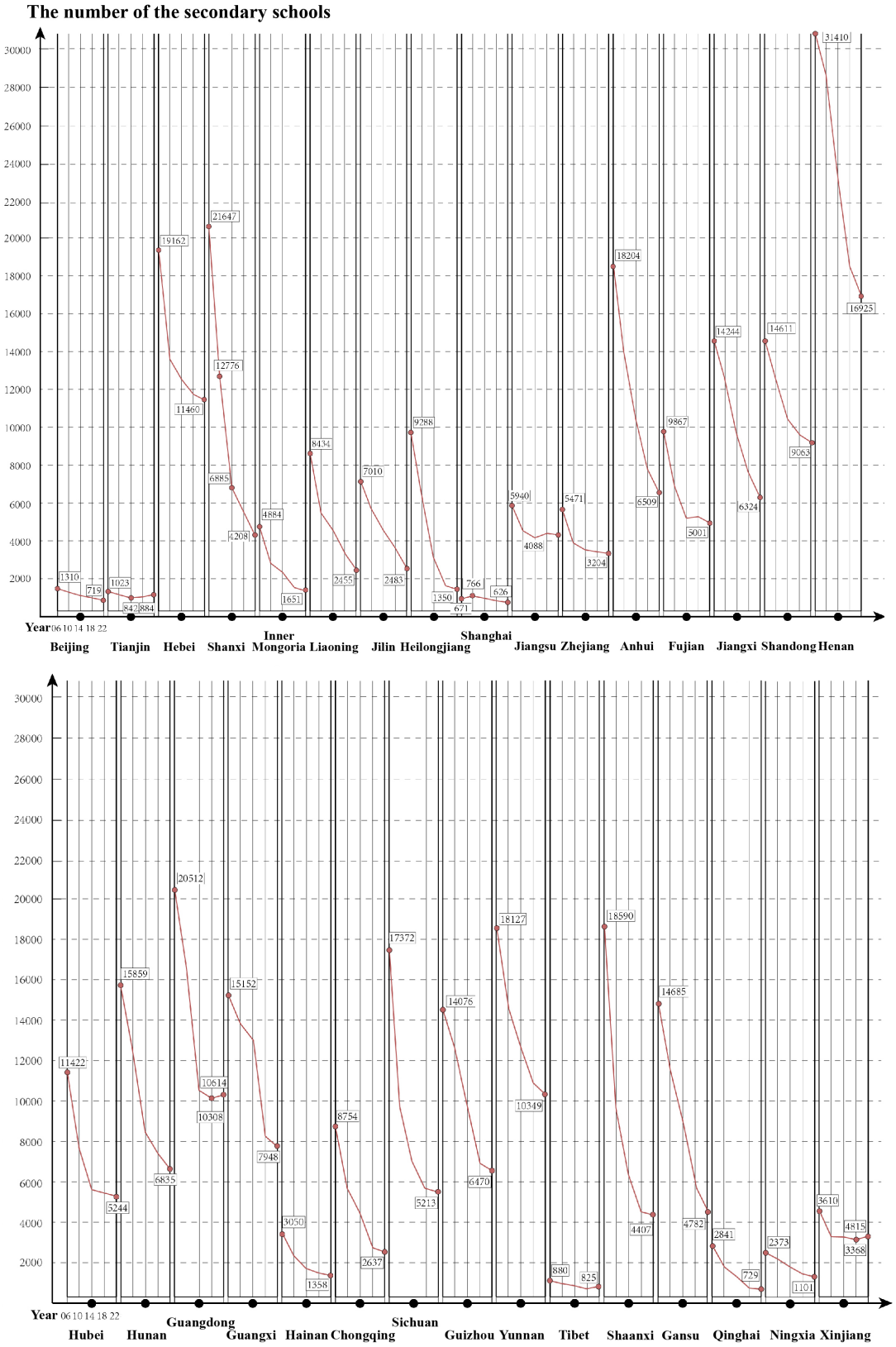
Policy

Figure 3
The Process of Issuing and Amending China's School Merging Policy

Before 1986, the number of children in rural areas was high, the education system was inadequate, and transport was underdeveloped In many counties, education departments made it a rule to build schools within 2.5 kilometers of villages, so students could go to school nearby. Moreover, the pattern of primary schools in villages and middle schools in townships then resulted in townships having many school buildings. According to the China Rural Statistical Yearbook, in 1995, rural areas had 559,000 primary schools and 45,000 middle schools.

Figure 4

Changes in the Number of Primary Schools by Province From 2006 to 2022



Against China's rapid urbanization and improving birth outcome policy, the country's birth rate is drastically low, school enrollment is difficult, and families cannot make ends meet.

Therefore, in 1998, the Ministry of Education issued "Opinions on Consolidation and Improvement of Work after the Acceptance of the Two Fundamental Principles," proposing rational adjustment of primary and middle schools' locations, and from then on, the prelude to the policy of school merging policy. In the years that followed, the State Council, the Ministry of Finance, and others issued documents such as the "Circular on the Layout Adjustment Plan for Primary and Secondary Schools" and the "Circular on Improving the Management System for Compulsory Education in Rural Areas," further encouraging rural primary and middle schools' abolition and merger. During this period, some local governments implemented these actions forcefully and blindly, disregarding actual situations, and leading to many rural schools' abandonment. Given this phenomenon, the Ministry of Education issued documents such as the "Guiding Opinions on Strengthening the Management of Primary and Middle Schools" and "Standardizing School Operation Behaviors" to amend rural schools' consolidation and elimination policy, in the hope that localities could pragmatically and selectively implement rural schools' consolidation and elimination according to the actual situation. Eventually, in 2012, the State Council promulgated "Opinions on Regulating the Layout and Adjustment of Rural Compulsory Education Schools," which ended the 14-year initiative to abolish and integrate schools.

Table 1

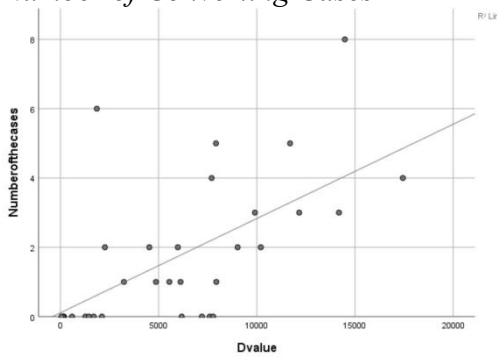
Number of Reduced Schools and Number of Converting Cases by Province

PROVINCE	BJ	TJ	HE	SX	NM	LN	JL	HL	SH	JS	ZJ	AH	FJ	JX	SD	HA
D-value	591	181	7702	17439	3233	5979	4527	7938	140	1852	2267	11695	4866	7920	5548	14485
Convert Cases	0	0	4	4	1	2	2	1	0	6	2	5	1	5	1	8

PROVINCE	HB	HN	GD	GX	HI	CQ	SC	GZ	YN	XZ	SN	GS	QH	NX	XJ
D-value	6178	9024	10204	7204	1692	6117	12159	7606	7778	55	14183	9903	2112	1272	1447
Convert Cases	0	2	2	0	0	1	3	0	0	0	3	3	0	0	0

Figure 5

Results of SPSS Correlation Analysis Between the Number of Reduced Schools and the Number of Converting Cases



Correlations

		Dvalue	Numberofthe cases
Dvalue	Pearson Correlation	1	.602**
	Sig. (2-tailed)		.000
	N	31	31
Numberofthecases	Pearson Correlation	.602**	1
	Sig. (2-tailed)	.000	
	N	31	31

**. Correlation is significant at the 0.01 level (2-tailed).

As a result of the school merging policy and the low birth rate's impact, the number of all schools in all provinces has decreased drastically, especially primary schools. Figure 4 shows changes in each province's number of primary schools from 2006 to 2022, with numbers of

primary schools in each province decreasing sharply. Henan Province had the most primary schools in 2006, but after the school merging policy, the number has shrunk by half. Shaanxi Province has reduced primary schools the most, by 17,439 or one-fifth of the number in 2006. In other words, the consolidation policy strongly impacted primary schools, leading to each province having tens of thousands of unused schools.

To verify the school elimination policy's impact on conversion to care homes, this paper compares the number of unused schools and the number of conversions in each province. Pearson correlation analysis was conducted using SPSS software. The significant P-value of the number of schools was reduced, and the amount of conversions was 0.000, less than 0.05, indicating a significant test result. That is, the number of school closures and the number of conversions in each province are correlated, again verifying that the school merging policy generated many unused school buildings, thus potentially contributing to the conversion of former school buildings into care homes.

Time

Figure 6

Statistical Chart of Important Time Points of Each Converting Case

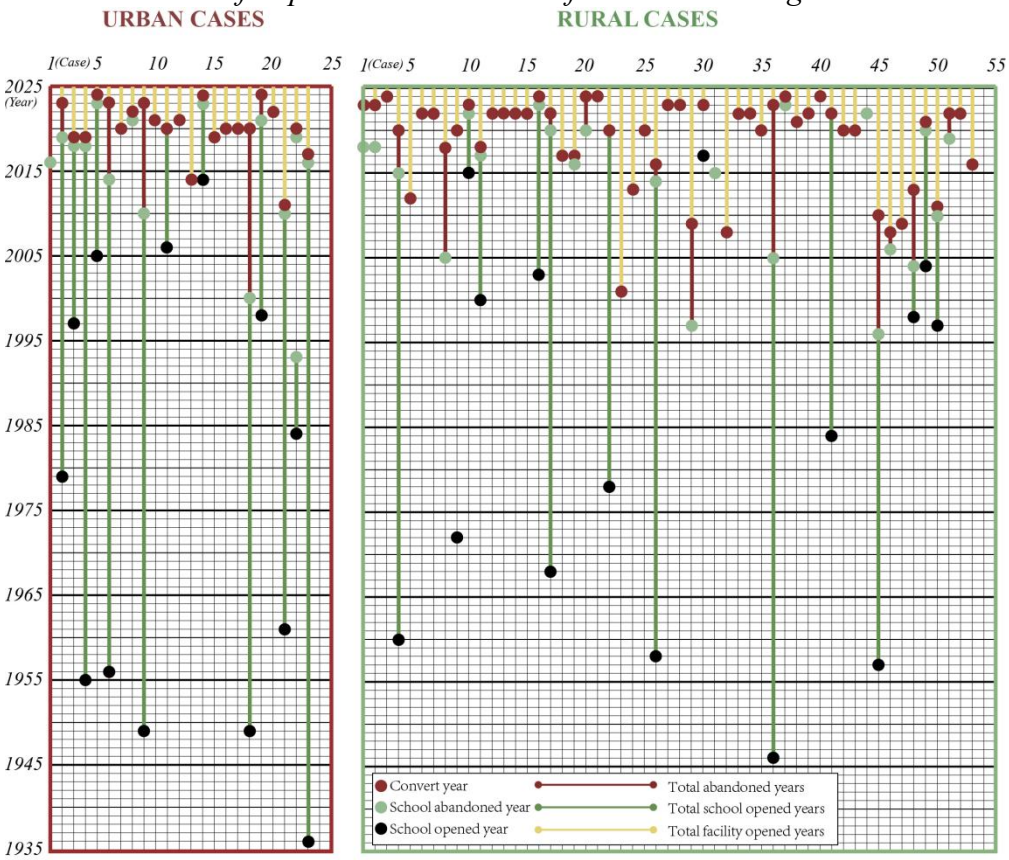
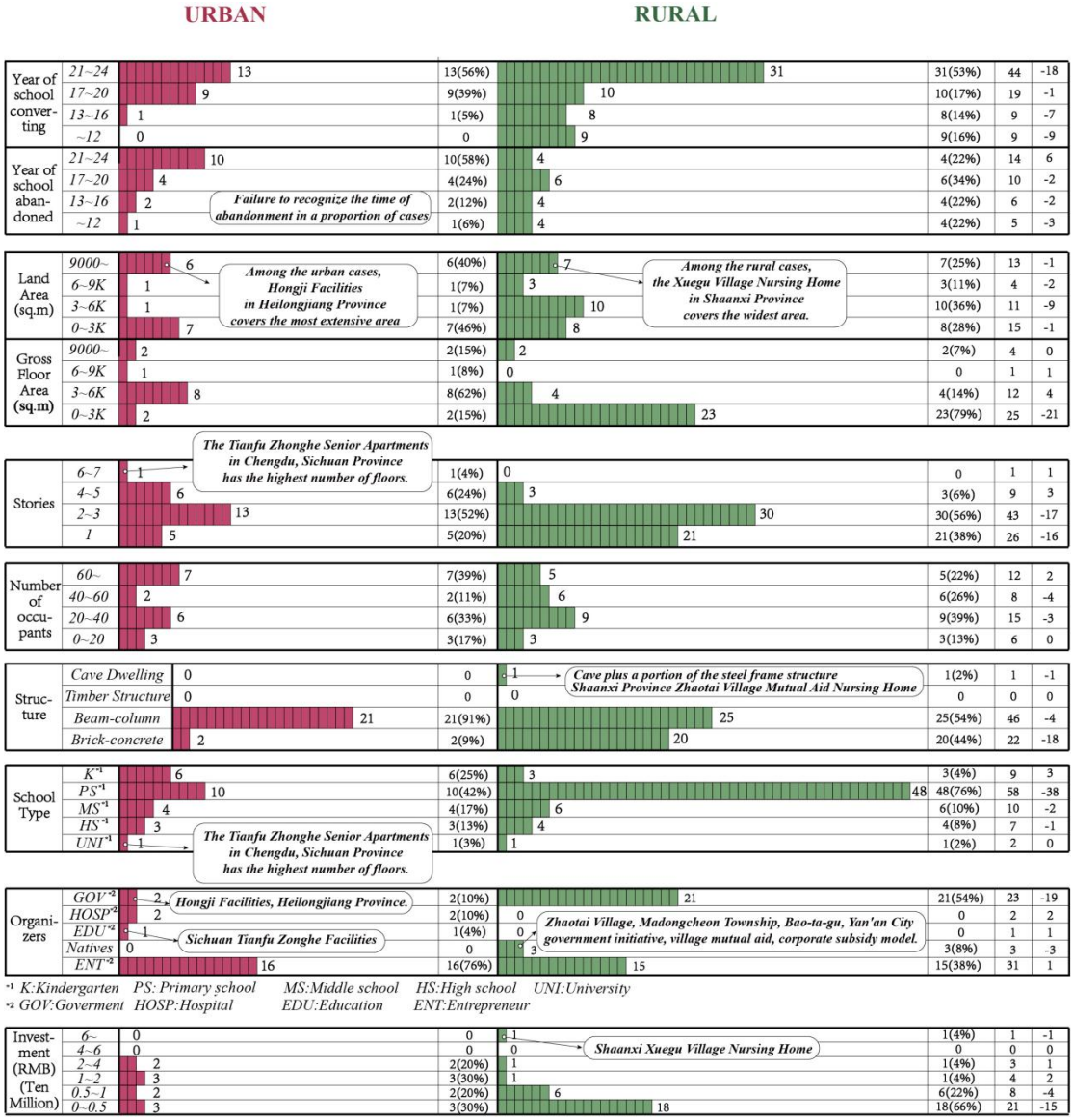


Figure 7

Comparison of Case-Specific Summary Information Across Urban and Rural Areas



During implementation of the merging policy, schools were abandoned and converted at different times. This paper explored differences between rural and urban areas in school buildings' construction, abandonment, and conversion times. Different colored dots in Figure 6 represent the year each school opened, was abandoned, and then converted into an elderly care facility. The line segments' lengths express how long the school operated, was abandoned, and how long the older adult care facility has been operated.

In Haiyang City, the earliest elderly care facility was established in 1958, and it served as a good model for the earliest known school conversion, the Beichengyang Street Primary School, converted in 2001. After the north Chengyang Street Primary School was converted, many care homes were established in the city within a short period. The oldest school known to have been converted is the Tatung National Elementary School in Taiwan Province. Established in 1937, the school converted one school building and 10 classrooms into an elderly care facility in 2016. There, intergenerational communication can be facilitated while meeting the older adult's needs.

As Figure 7 shows, each school's abandonment and conversion time was divided into four parts for statistical comparison. For most city conversions, abandonment occurred from 2021 to 2024, (i.e., 58%). The highest number of urban cases also converted from 2021 to 2024, suggesting that in urban cases, conversion is efficient, with a clear trend in recent years.

Unlike urban cases, rural cases have even distribution of abandonment times. In contrast, their conversion time is concentrated from 2021 to 2024, suggesting that rural cases are not converting efficiently and are typically having a period of inactivity before conversion. In recent years, moreover, rural and urban schools have shown a growing trend toward conversion.

Scales

Figure 7 shows comparison of each case's land area and gross floor area. Urban buildings had the highest proportion (46%) of floor area less than 3,000 m^2. This proportion is followed by floor areas of 9,000 m^2 or more (40%). The highest proportion (36%) of rural schools converted were those with floor areas of 3000–6000m^2.

After rapid urbanization, cities' transport is well-developed, with easy access between settlements and unused schools, and more unused school buildings are available in cities. In some cases, the investment is huge, and converters hope to provide better services and accommodate more older adults, so they choose large-area unused buildings. Individual entrepreneurs have converted other buildings; they often invested less money and so chose a smaller footprint to build small, sophisticated care homes.

In rural areas, transport is inconvenient, and villagers often walk, ride buses or bicycles, among other means. Unused schools' accessibility is generally poor, leaving only a small number easily accessible. Since the need for elderly care is high in all villages, rural converters tend not to be selective in screening suitable unused schools. Therefore, compared to urban, rural conversions have a relatively more even proportion of floor space.

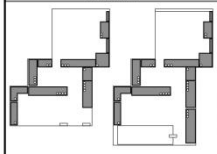
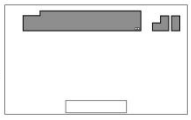
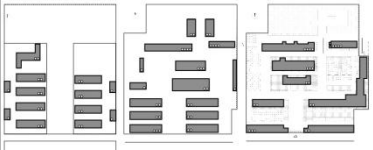
Among urban cases, the largest is Dating Hongji Retirement Facility, formerly High School 28, with a land area of 71,600m^2, a gross floor area of 35,700m^2, and a plot ratio of 0.67; the investor is the local government. The rural case with the largest area is Shaanxi Houji Elderly Care Facility, formerly Xuegu High School, with a land area of 45,000 m^2, a gross floor area of 11,500 m^2, and a much lower plot ratio; the investor is an entrepreneur.

Among urban conversions, the number with a gross floor area of 3,000–6,000 m^2 is the highest (62%), but rural conversions had the highest number with a gross floor area of less than 3,000 m^2, (79%). In other words, rural conversions' gross floor area is generally smaller than that of urban conversions.

Most urban and rural conversions have two to three floors (52% and 56%, respectively). The proportion of rural conversions with one story is also high, at 38%. School buildings are generally low-rise due to building code treaty restrictions. Because older adults and children are relatively physically weaker, lower floors are more conducive to their use—a favorable factor for converting schools into care homes.

Figure 8

General Plan Changes and Floor Area Ratio Changes

School Construction Year	1974	2006	19? ?	1958
Converting Year	2023	2020	2024	2020
Name of the school	Daqing 28th Middle School	Tianfu College of Southwestern University of Finance and Economics	Wujin Primary School, Baiqi Town, Jilin Province	Xuegu High School
Name of the Facility	Daqing Hongji Elderly Care Facility	Tianfu Zhonghe Elderly Care Facility	Wujin Village Elderly Care Facility	Houji Elderly Care Facility
Land Area(sq.m)	71600m² (Largest in the urban case)	-	5400m²	45000m² (Largest in the rural case)
Gross Floor Area(sq.m)	35700m²	4120m²	1000m²	11500m²
Site Plan	 *1974 Plan* *2023 Plan*	*2006~2020 Plan*	 *1990~2024 Plan*	 *1958 Plan* *1995 Plan* *2020 Plan*
Note	The school's floor-area ratio at the time of construction in early 1974 was approximately **0.68.** After the 2023 converting, part of the yard was added as a car park and some underutilised buildings were still not fully utilised, reducing the floor-area ratio to **0.67.**	In this case, only the first ~ seventh floors of one student dormitory have been converted. The origen school's playground and other activity spaces are shared.	The floor-area ratio in this case is approximately **0.25**. The building is low, the area of the sports field is large and the floor area ratio is low. The floor-area ratio did not change because spatial modifications were carried out only on the abandoned buildings.	When the school was built in early 1958, the floor-area ratio was low at about **0.21** due to the low buildings and large playground area; after the school was first renovated in 1995, the number of buildings and building storeys increased, the playground area was reduced and the floor-area ratio increased to **0.57** at its highest point. After the remodelling of the endowment by 2020, public toilets, teaching buildings and other buildings were removed, lifts and employee accommodation were increased and the floor-area ratio decreased to **0.51**

Occupants

Figure 7 compares numbers of older adults residing in urban and rural conversions, with urban facilities having the larger proportion (39%) of residents (60+). This is followed by elderly facilities with 20–40 residents, at 33%. Rural conversions had the larger proportion (39%) of 20–40 occupants. Conversions with fewer than 20 residents were the smaller proportion, at 13%.

Compared to urban areas, rural areas have relatively fewer occupants, contrary to the growing demand for elderly care in rural areas. This paper hypothesizes that the reason is that the rural older adults lack the capital to move in. When they can secure basic living conditions, they delay going to a facility for as long as possible. Another reason is that the rural buildings' small size and the small number of people they can accommodate lead to high occupancy rates but smaller numbers of residents.

Structure

Most urban and rural school buildings converted were of beam-column construction, 91% and 54%, respectively. The proportion of brick-concrete buildings in urban areas is low, at 9%, but in rural areas, it is 44%. Because brick-concrete structures have lower construction and technical costs, conducive to village resources, many rural school buildings were built by villagers themselves. In addition, the Zhao Tai Village Mutual Aid Elderly Care Facility has a kiln structure with unique regional characteristics. In some cases, steel and wooden frames were used to build semi-outdoor activity spaces in courtyards to increase their diversity.

Figure 9

Case Diagram of Different Structure Types

Beam-column ***Brick-concrete*** ***Cave Dwelling***

School Type

School buildings converted in urban and rural areas include kindergarten, elementary, middle school, high school, and college campuses. Urban conversions had the higher percentage (42%) of former elementary schools; kindergartens followed at 25%. In rural areas, elementary schools account for 76% of conversions, followed by middle schools at 10%. One urban and one rural university campus have been converted: a student dormitory at the Tianfu College of Southwest University of Finance and Economics in Sichuan Province (urban) and the Changyang Tujia Autonomous County Elderly Care Facility in Hubei Province, formerly the Qingjiang Development Company Vocational and Technical School (rural).

Figure 10

Case Map of Converted Older Adult Facilities in Different School Types

KINDERGARTEN *PRIMARY SCHOOL* *MIDDLE SCHOOL* *HIGH SCHOOL* *UNIVERSITY*

Organizer

Rapid urbanization brings significant economic benefits to cities. Of urban school conversions, entrepreneurs build 76%. Remaining investors are local governments and health and education sectors. A special case is the education sector: the Tianfu College of the Southwestern University of Finance and Economics invested in the Tianfu Zonghe elderly care facility in Chengdu, Sichuan Province. The college's School of Nursing converted a student dormitory into an elderly care facility, integrating industry-academia-research and providing practical opportunities for medical students, for instance, in the Baifuyuan elderly care facility in Daqing. The hospital funds the elderly care facility and provides convenient medical services for its residents while also increasing the hospital's income.

Rural areas are relatively poor, residents lack capital, and investment projects do not yield high returns; therefore, fewer investors are willing to undertake projects in the countryside. Governments that apply for funds and approve construction initiated 54% of rural conversions. Governments also propose some cases for rental announcement and bidding. Furthermore, governments have organized 8% of conversions, and on their initiative, villagers have converted buildings now operated through the mutual aid model for older people. Representative examples of government-invested construction include the Wujin Village elderly care facility in Jilin Province. A representative example of the villagers' mutual assistance model is the Zhaotai Village elderly care facility. A representative example of entrepreneurs' investment and construction is Haojiaying Township's (Hebei Province) elderly care facility, which members of Alibaba's village mission converted.

Investment

Comparison of each conversion's investment cost reveals even distribution in cities, despite investors' differing financial resources and the scale of rehabilitation. In contrast, rural investment costs are generally under 5 million CNY (Chinese Yuan) (66% of the total). Most rural conversions aim to meet local residents' needs, so investment costs are compressed as

much as possible to coincide with the rural elderly's finances. Urban areas, however, face competition, so the investment objective is relatively more important to construction quality.

Only one conversion required an investment of 60 million CNY or more: the Houji Elderly Care Facility in Shaanxi Province, financed and built by Haihong Elderly Care Enterprises. With the broadest service area despite its location in the remote village of Xuegu, it accommodates people from neighboring villages and the Xi'an and Xianyang districts.

Conclusion

These analyses lead us to conclude that most school to elderly care facility conversions are located in China's central and eastern regions, with rural conversions approximately three times more common than urban conversions. Subsequent to the school merging policy, tens of thousands of school buildings have been set aside in all provinces, contributing to the current trend of converting schools into care homes. Because the conversion trend has become more apparent in recent years, conversion implementation urgently needs theoretical references.

Compared to urban conversions, rural conversions have smaller areas and fewer floors. Overall, however, the number of floors is generally one to three, and this is an advantage for converting school buildings into care homes. Due to rural school buildings' size, rural conversions have relatively fewer residents, generally from 20 to 40. Urban conversions' architecture is mostly beam-column, while rural converted buildings are also predominantly framed, but they do include some brick and concrete structures, which are good for spatial conversion. Conversions include kindergartens, primary schools, middle schools, high schools, and colleges, with primary schools the most frequently converted types. Investors in urban conversions are mainly entrepreneurs, who choose either large buildings with many residents or small but exquisite buildings. In rural areas, investors are mainly governments, followed by entrepreneurs. The rural investment amount is smaller, generally under 5 million CNY and focused mainly on accommodating more older adults' basic needs.

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Implementation and Evaluation of a Multi-professional Participatory Health Promotion Project in Residential Care Facilities in Austria

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Abstract

The project "Health Has No Age: Transfer Carinthia" (January 2023 – December 2024) aimed to enhance health promotion in residential care facilities in Austria. Building on previous initiatives and projects, it involved a multi-professional team from Carinthia University of Applied Sciences (CUAS) and was implemented in cooperation with Diakonie de La Tour, who provided access to three of their nursing homes. The project was funded by the Austrian Health Promotion Fund. The project targeted employees, volunteers, residents, and their relatives, focusing on increasing contentment and well-being through participatory health-promoting measures. Key activities included a participatory needs assessment, the implementation of the "Joy of Living" occupational therapy programme, improved communication among nursing staff through peer support, and activation and relaxation exercises. Additional measures included a "Health Day" for residents with intellectual disabilities and an event focused on dementia. Evaluation showed high satisfaction across all target groups, highlighting improvements in health and working atmosphere. Challenges included integrating health promotion into busy schedules, emphasizing the importance of multipliers for long-term success. The project underscored the necessity of tailored health promotion measures based on specific needs assessments. The knowledge gained will be integrated into CUAS teaching and potentially transferred to other care homes.

Keywords: health promotion, interdisciplinarity, participatory approach, applied research, evaluation

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Introduction

Health promotion in residential care facilities is particularly relevant because it takes place in a setting which poses unique challenges to its employees and at the same time provides opportunities to strengthen the health determinants of care home residents and their relatives. The number of people in need of care in residential care homes for the elderly will most likely continue to increase in the future. At the same time, there is a lot of untapped potential with regard to health promotion efforts for residents and their relatives in this setting in Austria.

There seems to be a lack of concepts for the sustainable integration of health promotion into everyday life in care homes (Bühler & Kuhlmey, 2019; Hasseler, 2011). What must be at the centre of the design process of health promotion activities in this setting are, on the one hand, the particularities of care work and, on the other hand, a focus on successful interactions in everyday life in the care home, which are the basis for work success, work satisfaction, and the well-being of employees and residents alike (Böhle, 2018, cited in Pfabigan & Pleschberger, 2021). Finally, it also has to be taken into account that caregivers, who are the main occupational group in inpatient long-term care, are among the occupational groups whose health is impacted the most by their work in Austria (Glaser et al., 2018).

The project "Health Has No Age: Transfer Carinthia", which was carried out by a multi-professional team from Carinthia University of Applied Sciences (CUAS) together with Diakonie de La Tour as a practice organisation, focused on the advancement of health promotion in residential care facilities. Researchers from the fields of occupational therapy, healthcare and nursing, and physiotherapy worked together with employees, residents, their relatives, and volunteers to empower them to lead a healthier lifestyle and thus strengthen and improve their capacity to act. The project also focused on creating and improving health-promoting conditions and structures in the participating long-term care facilities in Carinthia, Austria.

The Project "Health Has No Age: Transfer Carinthia"

The project "Health Has No Age: Transfer Carinthia" (January 2023 until December 2024) was implemented as a transfer project in the southernmost state of Austria. This means that similar projects had been realised in other parts of Austria before, whose experiences the project team was able to build on to expand the idea of bringing health promotion to residential care facilities. Addressing everyone who works or lives in a nursing home (employees, volunteers, residents) or is otherwise connected to it (residents' relatives) meant that the project was also an integrated health promotion project (Styria vitalis, 2017).

The project was funded by the Austrian Health Promotion Fund and implemented in close cooperation with Diakonie de La Tour, who provided access to three of their nursing homes. In addition to the multi-professional team behind the project, researchers from the Institute for Applied Research on Ageing (also located at CUAS) were brought in to conduct the evaluation of all project activities.

The project aimed to achieve an increase in contentment and well-being of all target groups in the setting. It wanted to uncover their individual resources and stresses, and encourage their participation in health-promoting measures. The project also intended to strengthen, build, and sustainably anchor health resources in the setting. Overall, the project aimed for

the joint development, implementation, and evaluation of health promotion measures which are tailored to the needs of their respective target group.

Participatory Needs Assessment

The first step on the way to implementable health-promoting measures was a participatory needs assessment involving all target groups. Employees were asked to fill out a specially-designed questionnaire, which included questions about their current use of health promoting measures, their wishes for additional measures, what they would need to be able to use measures regularly, their views on the communication and cooperation within their teams, their work-related sense of coherence (Bauer et al., 2015; Broetje et al., 2020), and how rested they felt at the beginning of their shifts and after their breaks. Employees were also invited to attend interactive kick-off workshops. These workshops followed the principles of the Appreciative Inquiry method with its 4D process: (1) Discovery: Reflection and discussion of positive experiences with and aspects of the object of inquiry, (2) Dream: Imagination and description of the ideal state of the object of inquiry, (3) Design: Development of concrete ideas to achieve aspects of the ideal state, (4) Destiny: Participants make self-determined commitments to take action and work on the implementation of ideas (Bushe, 2012). During the kick-off workshops, the focus was put on employees' past and current resources (Discovery), their visions for a healthy workplace (Dream), their wishes for health promotion measures (Design), and their willingness to work on the conception of certain measures or to make use of them once they are implemented (Destiny).

Residents were invited to take part in activating interviews. Originating from the field of civic participation, this method uses open and exploratory questions to allow researchers to gather information while at the same time encouraging participants to think about their environment and uncover hidden potentials for change (Richers, 2018). Residents were asked if they participated in events and activities in their respective care homes, which events and activities they would like to happen in the future, what they liked and disliked about their respective homes, what they would like to see addressed with regard to the topic of health in their homes, and what the most important thing was which they wanted to do for their own health.

The needs of residents' relatives were also assessed by using a specially-designed questionnaire. This questionnaire touched upon relatives' satisfaction with various aspects of the care home (e.g., communication, information flow, contact to other relatives), their experiences as relatives of residents of the care home (e.g., being included in decisions, experiences with employees, contact persons in the home, their interest in becoming volunteers), their knowledge and wishes regarding services and options to get information and connect with other relatives provided by the home, and, finally, their views on health promotion in the home and as how important they would rate the role of relatives in this regard. In addition, relatives were invited to one-on-one conversations in order to discuss their needs in more depth.

Lastly, the target group of volunteers was invited to a focus group. The group discussion was guided by a number of questions which touched upon volunteers' well-being and health, their experiences with volunteering in their respective homes, which services provided by the care home they used and their experiences with them, and their views on the importance of health promotion targeted at residents. Volunteers were also asked to fill out a specially-designed questionnaire. They were asked about their use of current health-promoting measures, their

wishes for new measures, what they would need to be able to use measures regularly, and their experiences and wishes with regard to the communication with other volunteers and with employees.

In order to round out the needs assessment, several interviews were conducted with management and in-house psychologists to talk about their views on the resources and needs of all target groups.

After combining and analysing the data of all needs assessment activities, the following key results emerged: Employees (questionnaire n = 61, kick-off workshops n = 36) wanted to improve the communication within their teams, and they were interested in activation and relaxation exercises for their stressful working days. The main wish of residents (activating interviews n = 47) was to preserve their skills, their health, and their activeness. Relatives (questionnaire n = 50, one-on-one conversations n = 3) were often struggling with the role change from being an active informal carer to being the relative of a nursing home resident. They also wanted to be better informed about all things concerning their relatives in the nursing home, like doctor's visits or events in the near future. Finally, volunteers (focus group n = 4, questionnaire n = 14) also expressed a wish for better communication, especially between employees and themselves, mostly to make it easier for them to organise their volunteering. These results were the basis for the design of the following health-promoting measures.

Health-Promoting Measures

The programme "Joy of Living – Engaging in Meaningful Doing in Everyday Life®" is a health-promoting and evidence-based occupational therapy programme which supports self-determined living. In a group moderated by occupational therapists, participants explore what they like to do and what they can do in their current life situation to strengthen or promote their ability to act. The following objectives are addressed in the context of eight group modules and two one-on-one meetings: (1) Strengthening participants' life skills, (2) strengthening participants' health skills, (3) strengthening people's participation, (4) supporting people in shaping their everyday lives.

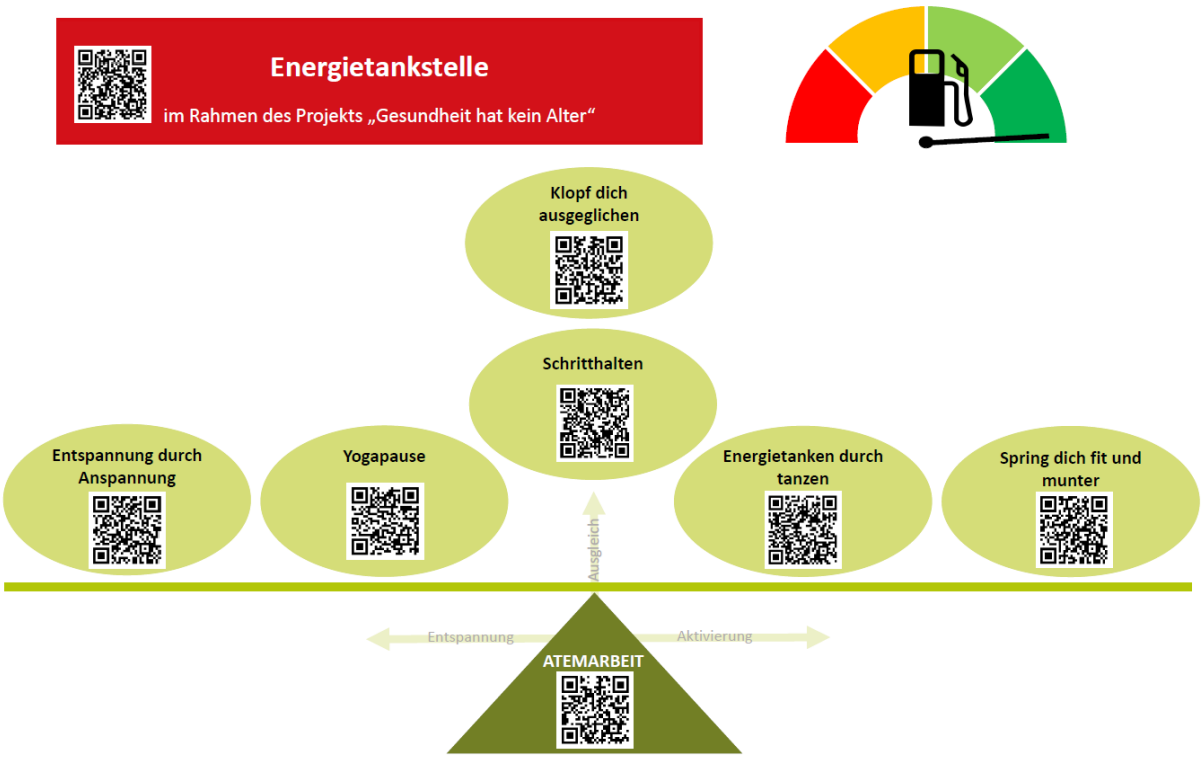
The programme was initially developed and evaluated by Ursula Costa together with seniors, occupational therapists, master's students, and stakeholders (Costa et al., 2018). In the project "Health Has No Age: Transfer Carinthia", the programme was expanded to address not only residents of care homes but also their relatives.

The healthcare and nursing team developed a way to improve communication among employees in order to better equip them to deal with difficult situations in their daily work by making use of peer support. Since various methods to help with the exchange within teams were already in place in the care homes, the toolbox "Communication" linked existing communication tools with new aspects and a collegial counselling approach. The toolbox was introduced in kick-off workshops, where participants also had the opportunity to practise using the tool and to reflect on the approach. After a few weeks, the participants met for follow-up meeting, where they worked on developing key competences, reflected on experiences so far, and discussed possibilities for a sustainable implementation.

Finally, the physiotherapy team focused on the topic of activation and relaxation during long shifts for employees and developed the so-called "Recharging Station" as a mix of activation

and relaxation exercises. The exercises were introduced in kick-off workshops, where employees could try and practise them. In follow-up workshops, employees reflected on their experiences with the exercises, they were able to ask and answer open questions, and discuss options for a sustainable implementation. Different refreshers to brush up on the exercises, help establish a routine, and adapt exercises to current issues were also implemented. Figure 1 illustrates the Recharging Station. The exercises were available as print versions with digital guidance videos, supported by a written handout and instruction cards.

Figure 1
Recharging Station Developed During the Project



Additional Measures

One of the care homes that participated in the project specialises in the care of older adults with intellectual disabilities. The employees at this home wanted an intervention designed especially for their residents, as they felt that their area of work is often overlooked. This gave rise to the idea of organising a special day for the residents of this care home incorporating aspects of the concept of Basal Stimulation® (Bienstein & Fröhlich, 2021). This “Health Day” was designed and implemented by the healthcare and nursing team together with students of Healthcare & Nursing. It was made up of different stations including stations to experience hand massages, foot massages, or tactile-haptic stimulation. As such, it put the residents’ health and well-being into the centre of attention.

Additionally, in the course of the project it became apparent that the nursing homes’ employees were eager to refresh their knowledge about the topic of dementia. Based on this, the project team conceptualised an event called “Focus on Dementia”. In the course of an afternoon, various support options for people with dementia and their relatives were presented from an interdisciplinary perspective. By using a case study, experts from occupational therapy, healthcare and nursing, physiotherapy, psychology, and community nursing discussed the different ways in which their respective fields of expertise could help

support people with dementia and their relatives. In addition, participants had the opportunity to experience challenges associated with dementia first-hand.

Evaluation

The purpose of the evaluation was, on the one hand, to support the specification of the project objectives and, on the other hand, the formative and summative evaluation served to evaluate the course of the project and to contribute to an ongoing reflection on the individual project steps.

Methods

The evaluation of the project "Health Has No Age: Transfer Carinthia" followed a mixed-methods approach, combining qualitative and quantitative methods to provide a comprehensive understanding of the research question. This approach offers a deeper and broader perspective by considering both numerical data and detailed, contextual information (Kelle, 2019).

The evaluation was conducted on three different levels: interventions, target groups, and employees.

A quantitative survey aimed to gather feedback on the implemented interventions. The target group included all participants in the interventions of the "Communication" toolbox, "Recharging Station", and the "Joy of Living®" programme, i.e., residents, employees, relatives, and volunteers. The evaluation form covered areas such as satisfaction with the conditions and content of the measures as well as the assessment of health impacts. The data was analysed descriptively using SPSS (Tausendpfund, 2022).

At the target group level, qualitative interviews and a quantitative evaluation form for the "Focus on Dementia" event were used. In the interviews, residents and relatives were asked about areas such as the experience of the measures, goals and expectations, and suggestions for improvement. The interviews were conducted in person or online and documented via audio recording. The data was transcribed verbatim and analysed inductively based on qualitative content analysis (Mayring, 2015).

The "Focus on Dementia" event aimed to raise public awareness about dementia and illustrate a multiprofessional approach. The evaluation form covered areas such as satisfaction with the event and the assessment of the significance of the information received. The data was analysed quantitatively and descriptively using SPSS.

To investigate subjective health perception and work-related sense of coherence, standardised instruments were included in the semi-annual employee survey of the practice partner Diakonie de La Tour. The supplementary survey took place at three measurement points and covered areas such as the use of health promotion measures, teamwork, and assessment of recovery and performance. The data was statistically analysed.

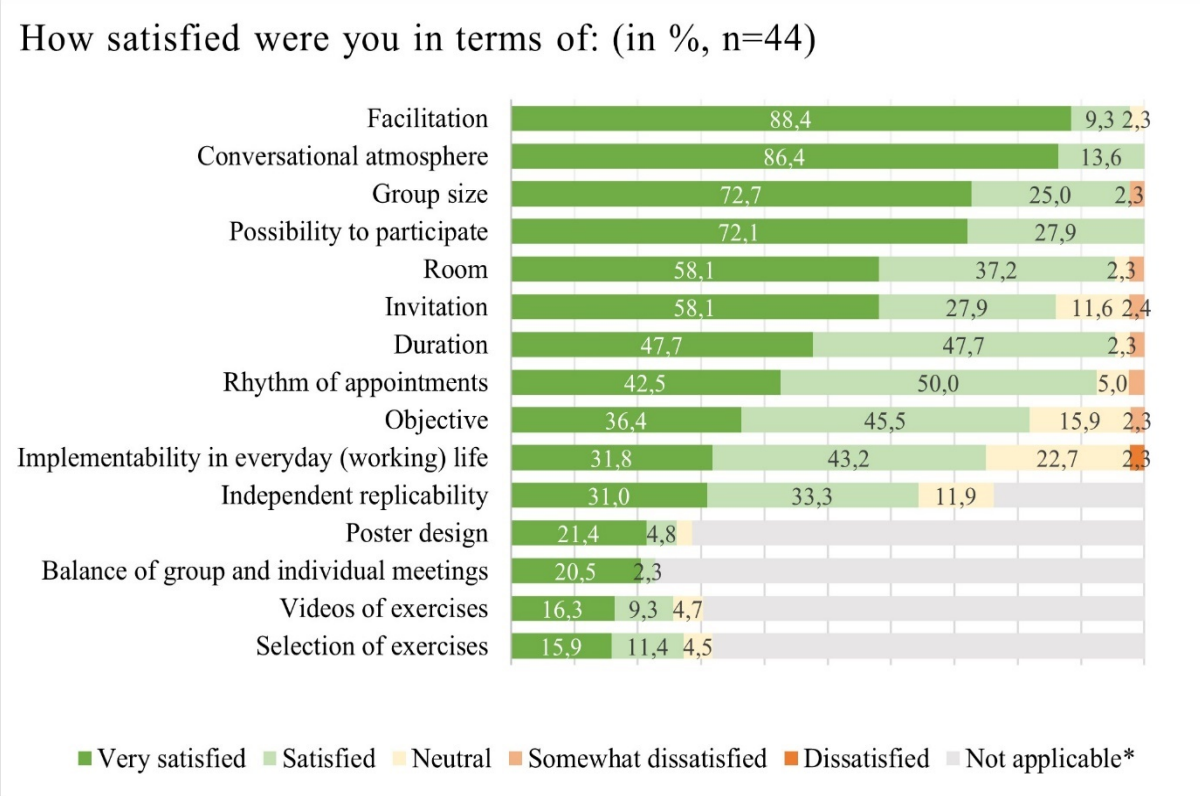
This article focuses on the results of the quantitative questionnaire for participants of all measures, provides a brief insight into the qualitative interviews and the evaluation and feedback from the event "Focus on Dementia".

Results

Results of the Interventions Level

As shown in Figure 2, the feedback was overwhelmingly positive. Satisfaction was measured using various indicators such as facilitation, conversational atmosphere, group size, participation opportunities, room, and invitation. The majority of respondents were very satisfied or satisfied, indicating that the measures met the needs of the target group and were well-conducted.

Figure 2
Feedback on Interventions



Many participants reported that the measures contributed to their health. Despite being conducted during daily work life, many recommended the measures to others and expressed a desire for more participants.

Results of the Qualitative Interviews

Interviews with employees: The results showed positive experiences due to the consideration of different professional groups. The interprofessional approach was highly appreciated.

> It's a cool thing. It also brings the team together a bit. I think it's good that you can get different professional groups involved across different floors and employees. I really like the system. (IP6)

Communication within and between groups was evaluated positively. New ways of communication were found, which facilitated daily work life.

> Yes, this exchange is better, to be honest. If there is a concept (note: collegial counselling) behind it rather than if you just talk about it and say anything and everything and then get frustrated. But if you have a concept [...] it's different. It's more professional and you can really take something away from it and that's what it's all about. (IP7)

A lack of time was mentioned as an obstacle to the long-term integration of measures in daily work life.

> It's difficult to find enough time. That's the biggest problem. Not because it's not possible institutionally or in terms of the daily routine, but rather that the employees feel they can't take the time. (IP6)

Interviews with residents: The results showed that residents had very positive experiences with the programmes.

> It was a good company, we had good friendships, it was nice. (IP1)

The goals and expectations were met, illustrated by positive examples of personal benefits and changes in daily life.

> The programme should definitely be offered more often in many care homes! For residents. And for staff too, please! (P2-B)

Interviews with relatives: The results showed that relatives also had very positive experiences with the programme and the associated changes, meeting their goals and expectations.

> That I take more care of myself [...]. Yes, that we were all pretty much on the same wavelength and had similar problems. That was the most striking thing for me. (P2-A)

There were positive examples of personal benefits and changes in daily life.

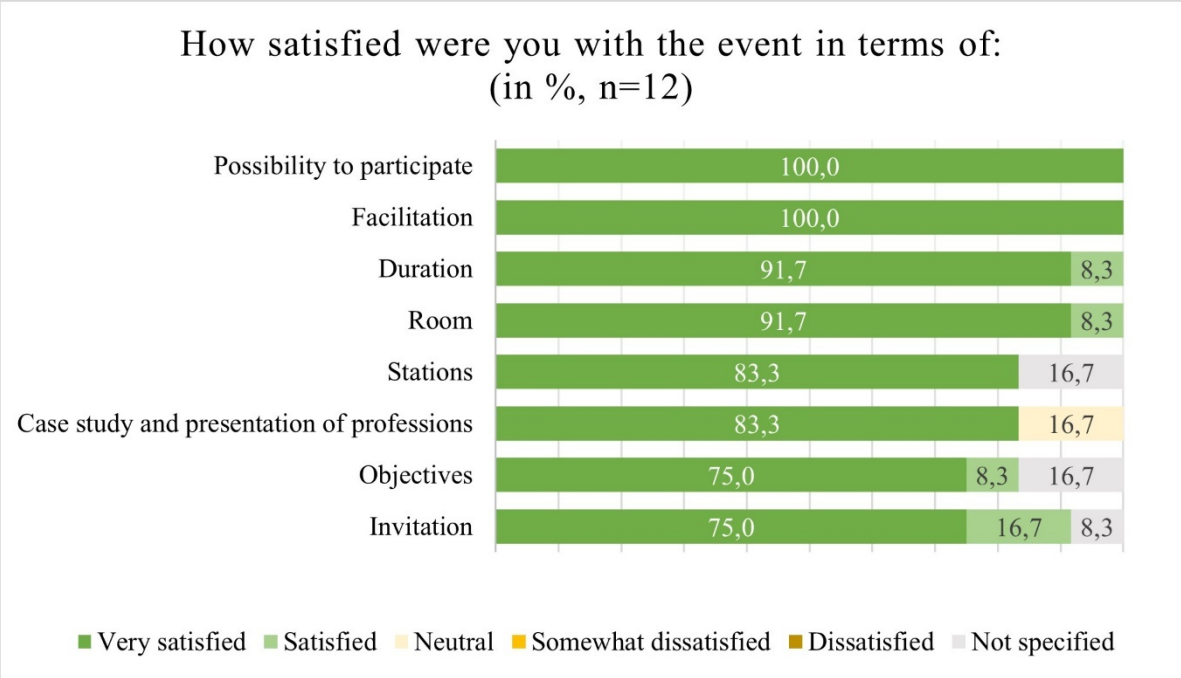
> Even my children said: Mum, you're learning so much [...]. Because you're changing (laughs). [...] And I have the same feeling. (P5-A)

Relatives had no suggestions for improvement or additional wishes.

Feedback on the Event "Focus on Dementia"

The event was interprofessional with a diverse programme and various involvement opportunities for visitors. A questionnaire was used to assess visitor satisfaction. Visitors were very satisfied or satisfied, particularly with participation opportunities, facilitation, duration, room, and the different stations where they could gain practical experience and information. The case study and presentation of professions as well as the objectives and invitations were also highlighted positively (see Figure 3).

Figure 3
Feedback on the Event "Focus on Dementia"



Visitors also had the opportunity to provide qualitative feedback on the feedback form. All respondents felt they received important information.

Evaluation Summary

The evaluation revealed high satisfaction across all target groups. There were improvements in health and working atmosphere within residential care homes. Personal well-being and awareness of health promotion were also increased, which had an impact on the personal and professional environment. The opportunity to deal with issues that make everyday (working) life challenging on different levels was also seen as a major benefit. The participatory involvement was a notable aspect of this project. The participants felt heard and valued, which boosted their motivation and commitment.

Conclusion and Outlook

The project "Health Has No Age: Transfer Carinthia" implemented multi-professional health promotion measures in residential care facilities in Austria. Implementing the project revealed several important aspects which have to be taken into account when attempting to introduce and anchor health-promoting measures in this setting. Motivating employees to take part in or make use of health promotion activities is a big challenge. Their very busy and structured schedules make it very difficult to incorporate anything new into their working days. For this reason, multipliers are central to implementing health promotion measures in residential care homes because they can remind people to engage in health promotion and they can also lead by good example. Working with multipliers can thus greatly increase the chances for the long-term implementation of health promotion measures. By bringing the topic of health to the forefront of people's minds, the project raised awareness of the importance of health and also of the necessity for personal initiative. This is important because health promotion only works if people actively engage in it. Finally, an important lesson learnt is that needs and approaches are unique to every setting and implementing top-

down measures designed without taking people"s specific needs into account have less chances of being successful. This is why basing the design of measures on target group-specific needs assessments is paramount.

After the end of the project, the team will continue to work on several transfer topics. The practical knowledge gained from the project will be transferred to the teaching of all involved departments at CUAS. The "Health Day" for residents with intellectual disabilities will be repeated, and there are plans to turn "Focus on Dementia" into a regular event. The collegial counselling approach will continue to be one of the communication methods used in the care homes, the digital version of the Recharging Station will be anchored permanently, and there are plans to transfer the approach used in the project to other care homes. Finally, the team wrote a manual to help disseminate the experiences and results gathered during the project (see Hagendorfer-Jauk et al., 2025).

Implementing health-promoting measures for everyone living and working in the setting of a residential care facility comes with its unique challenges. By letting the needs and wishes of employees, residents, their relatives, and volunteers guide the implementation, health promotion in this setting can be a successful and rewarding undertaking.

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Correlation Between Sleep Duration, Exercise Time, Toe Flexor Strength, and Balance in Older Adults

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Abstract

The toe flexor strength contributes to maintaining the body's center of gravity and recovering balance in potentially hazardous situations such as slips or falls. This study examined the correlation between sleep duration, exercise time, toe flexor strength, and balance ability in older adults. This study included 59 older adults aged 65 and above (mean age 72.5 ± 5.4 years). Self-reported data on sleep duration and exercise time per week were collected through a structured questionnaire. Toe flexor strength was measured using a handheld dynamometer (Hoggan), and balance parameters were evaluated using the Quiet Stand (closed-eye, 30seconds) test on the Force Decks system (Vald). Sleep duration was significantly associated with the area of the center of pressure (CoP) ellipse, a metric of balance ($r = 0.34$, $p < 0.05$). Exercise time was significantly correlated with right toe flexor strength ($r = 0.33$, $p < 0.05$). In terms of the relationship between toe flexor strength and balance, right toe flexor strength influenced the CoP medial range ($r = 0.33$, $p = 0.12$), while left toe flexor strength showed a non-linear relationship with balance. These findings suggest that while muscle strength naturally decreases with age, exercise time is strongly correlated with toe flexor strength, which significantly impacts balance. Enhancing these factors through targeted interventions may help improve functional health and reduce fall risk in older adults.

Keywords: sleep duration, exercise time, toe flexor, balance, older adults

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Introduction

Aging leads to a general decline in physical functions, and especially the decrease in balance ability is directly associated with an increased risk of falls among older adults (Tinetti et al., 1988). Various studies have shown that the deterioration in balance is closely related not only to the decline in muscle strength but also to sleep quality and the level of physical activity (Chennaoui et al., 2015; Smagula et al., 2016). Impaired balance ability makes it difficult for older adults to perform independent daily activities and serves as a major factor in increasing the risk of fractures and long-term functional impairments due to falls. Sleep deprivation can negatively affect postural control by impairing muscle recovery and the nervous system (Chennaoui et al., 2015; Paillard, 2023). Previous studies have reported that older adults with shorter sleep duration show poorer balance and a higher risk of falls (Fu et al., 2017; Smagula et al., 2016). However, the relationship between sleep duration and toe flexor strength has not been clearly established.

Toe flexor strength is a crucial factor in gait and postural stability, and a decrease in toe flexor strength is likely to be directly associated with impaired balance (Mickle et al., 2016; Quinlan et al., 2020). On the other hand, regular physical activity plays an important role in improving lower extremity strength and balance in older adults (Nagai et al., 2012; Quinlan et al., 2020). Lower limb and toe flexor strength have a significant impact on gait stability and balance, and reduced toe flexor strength is linked to altered gait patterns and increased risk of falls (Quinlan et al., 2020). However, studies specifically analyzing the effects of exercise time on toe flexor strength and balance are limited.

Therefore, the purpose of this study is to investigate the relationships among sleep duration, exercise time, toe flexor strength, and balance in older adults and to provide foundational data for developing effective intervention strategies to prevent balance decline and falls.

Methods

59 older adults aged 65 years and above (mean age 72.5 ± 5.4 years) participated in this study. Self-reported data on sleep duration and exercise time per week were collected through a structured questionnaire. Toe flexor strength was measured using a portable handheld dynamometer (Hogan Handheld Dynamometer, USA), and balance ability was assessed using the Quiet Stand (closed-eye, 30seconds) test on the Force Decks System (Vald, Australia).

Results

Correlational analysis was conducted to achieve the study's objectives.

Table 1
Correlations Among Sleep Duration, Exercise Time, and Toe Flexor Strength

	Sleep Duration	Exercise Time	Rt. Toe Max	Lt. Toe Max
Sleep Duration	1			
Exercise Time	0.221	1		
Rt. Toe Max	-0.056	**0.329**	1	
Lt. Toe Max	-0.081	0.259	**0.697**	1
Gap: Rt.Max-Lt.Max	0.076	0.183	**0.455**	-0.112

($N = 59$, $p < 0.05$)

Sleep and exercise time did not significantly affect most variables. However, exercise time showed a significant correlation with right toe flexor strength (r = 0.329), which may reflect the dominant right-hand/right-foot characteristic among older Korean adults. Additionally, stronger toe flexor strength on one side was associated with higher strength on the opposite side (r = 0.69), and the difference in toe flexor strength between the right and left foot (Gap Rt. Max – Lt. Max) was primarily influenced by the right toe flexor strength (Rt. Toe Max: r = 0.46).

Table 2
Correlations of Sleep and Exercise With Balance Variables Based on CoP Measures

	Sleep	Exercise Time	Area of CoP Ellipse	CoP Range: Anterior-Posterior	CoP Range: Medial-Lateral
Sleep Duration	1				
Exercise Time	0.221	1			
Area of CoP Ellipse	**0.343**	0.093	1		
CoP Range: Anterior-Posterior	0.222	0.053	**0.790**	1	1
CoP Range: Medial-Lateral	0.264	0.129	**0.536**	0.374	
Total Excursion	0.248	0.183	**0.662**	0.755	-0.112

(N = 59, p < 0.05)

Sleep duration showed a significant correlation with the CoP (Center of Pressure) ellipse area, a major indicator of balance ability (r = 0.34). The CoP ellipse area also showed strong correlations with the CoP range in the anterior-posterior direction (r = 0.79), the medial-lateral range (r = 0.54), and the total path length (r = 0.66). These findings suggest that the CoP ellipse area is a comprehensive indicator of balance ability, and sleep duration may influence it.

Table 3
Associations Between Toe Flexor Strength and Balance Parameters

	Rt. Toe Max	Lt. Toe Max	Gap: Rt.Max-Lt.Max
Rt. Toe Max	1		
Lt. Toe Max	**0.697**	1	
Gap: Rt.Max-Lt.Max	**0.455**	-0.112	1
Area of CoP Ellipse	0.021	-0.105	0.214
CoP Range: Anterior-Posterior	0.077	-0.079	**0.386**
CoP Range: Medial-Lateral	**0.326**	0.290	0.228
Total Excursion	0.065	-0.117	**0.320**

(N = 59, p < 0.05)

Right toe flexor strength showed a significant correlation with the medial-lateral range of CoP (r = 0.33), indicating that toe flexor strength can influence lateral balance. The difference in toe flexor strength between both feet was also significantly correlated with the anterior-posterior CoP range (r = 0.39) and the total path length (r = 0.32), suggesting that imbalance in toe flexor strength may affect overall balance control.

Table 4
Correlation Between Age and Toe Flexor Strength Asymmetry

	Age	Rt. Toe Max	Lt. Toe Max	Gap: Rt.Max-Lt.Max
Age	1			
Rt. Toe Max	0.153	1		
Lt. Toe Max	-0.044	**0.700**	1	
Gap: Rt.Max-Lt.Max	**0.408**	**0.455**	-0.112	1

(N = 59, p < 0.05)

There was also a significant correlation between age and the difference in toe flexor strength between both feet (Gap: Rt Max - Lt Max, r = 0.34), indicating a tendency for the strength difference to increase with age. This may imply that the strength of the more frequently used foot is better preserved, while the less used foot experiences a greater decline in strength.

Discussion

Sleep Duration and Toe Flexor Strength

Sleep duration did not show a significant correlation with toe flexor strength. This suggests that sleep duration may not directly affect the toe flexor strength, or other physiological factors may mediate the relationship. This result is consistent with Fu et al. (2017), who also reported that while sleep affects general physical function, its influence on isolated muscular strength such as toe flexors may be limited. Sleep may affect overall function or balance more than isolated muscular strength.

Exercise Time and Right Toe Flexor Strength

Exercise time was significantly correlated with right toe flexor strength, which may be related to the dominant side characteristic among Korean older adults. This finding aligns with previous studies (Mickle et al., 2016; Nagai et al., 2012), which emphasize that regular physical activity contributes to the preservation of muscular strength, particularly in the dominant limbs. These studies support the notion that exercise enhances strength asymmetrically in favor of the dominant side.

Correlation Between Both Feet's Toe Flexor Strength

There was a strong correlation between the toe flexor strength of both feet. This indicates that greater strength in one foot is likely accompanied by greater strength in the other, reflecting the tendency for symmetrical development or decline in muscle strength. This finding agrees with Mickle et al. (2016), who observed bilateral symmetry in foot muscle strength decline with aging, implying systemic factors in muscle degeneration.

Effect of the Right Foot on Toe Flexor Strength Asymmetry

The difference in toe flexor strength between both feet was mainly influenced by the strength of the right foot. This suggests that higher usage frequency of the dominant foot may help preserve its strength, while the non-dominant foot experiences more significant decline. This asymmetry has been noted in prior literature (Mickle et al., 2016), which also reported that habitual loading on the dominant foot leads to relatively better preservation of muscle mass and function.

Correlation Between Sleep Duration and Balance Ability

Sleep duration showed a significant correlation with the CoP ellipse area, indicating that sleep may positively affect balance maintenance (Fu et al., 2017; Paillard, 2023). This result reinforces the conclusions drawn by Fu et al. (2017) and Paillard (2023), both of whom reported that inadequate sleep negatively affects neuromuscular control and postural stability. The CoP ellipse area demonstrated a strong correlation with both anterior-posterior and medial-lateral sway, indicating that the various components of postural balance are functionally interrelated. This interdependence is further supported by the quantitative analysis of sway dynamics conducted by Quinlan et al. (2020).

Conclusion

This study examined the correlations among toe flexor strength, balance indicators, exercise time, and sleep duration in older adults. The findings revealed that, overall, sleep and exercise time were not significantly associated with toe flexor strength. However, exercise time showed a significant positive correlation with right toe flexor strength, which may reflect dominant-side usage patterns in this population. Sleep duration was significantly correlated with balance-related indicators, particularly the CoP ellipse area, underscoring the potential role of sleep in postural control. In addition, asymmetry in toe flexor strength between both feet emerged as a possible factor influencing balance ability.

These results suggest that balance control in older adults is shaped by a multifaceted and dynamic interplay of physiological, behavioral, and lifestyle factors. The observed associations align with existing literature emphasizing the multifactorial nature of balance decline in aging populations (Mickle et al., 2016; Paillard, 2023; Quinlan et al., 2020). Specifically, previous studies have demonstrated that muscle strength, sleep quality, and neuromuscular coordination are key components in maintaining postural stability and preventing falls.

Given these findings, future research should employ more comprehensive models that account for individual characteristics such as age, sex, physical activity level, and habitual asymmetries. Moreover, intervention strategies targeting toe flexor muscle strengthening and promoting adequate sleep duration may serve as practical and effective approaches for improving balance and mitigating fall risk in older adults. Such strategies are consistent with preventive frameworks proposed in prior studies and may contribute meaningfully to aging-in-place and fall prevention efforts in community and clinical settings.

However, this study has several limitations that should be considered when interpreting the results. First, the cross-sectional design precludes causal inferences regarding the relationships among variables. Second, the relatively small and homogeneous sample limits the generalizability of the findings to broader older adult populations. Additionally, self-reported data on exercise time and sleep duration may be subject to recall bias and may not fully capture behavioral patterns. Future studies employing longitudinal or experimental designs with larger and more diverse populations, along with objective measurements of sleep and physical activity, are warranted to validate and extend the current findings.

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