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HOME ENVIRONMENT SAFETY RISKS AND PERCEIVED SAFETY AMONG EMPTY-NESTER ELDERLY IN NANCHANG, CHINA: A MIXED-METHODS STUDY

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Abstract

China's rapid population ageing and urbanisation have resulted in a growing number of empty-nester elderly living in housing environments not designed to support ageing in place. Despite policy initiatives such as Healthy China 2030, a critical gap persists between age-friendly policy ambitions and the actual safety conditions of domestic environments. This study adopts a mixed-methods approach to examine home safety risks and the adoption of smart elderly care among 384 empty-nester adults (aged ≥ 60) across six urban districts in Nanchang, Jiangxi Province. A structured survey was complemented by in-situ observations of ten purposively selected households to capture lived spatial practices and environmental conditions. The findings demonstrate that home environmental factors significantly influence perceived safety, explaining 89.7% of the variance ($R^2 = 0.897$, $p < 0.001$). Key determinants include mobility safety ($\beta = 0.409$), non-slip surfaces ($\beta = 0.326$), and adequate lighting ($\beta = 0.191$). Qualitative insights reveal the normalisation of unsafe adaptive practices, such as reliance on handheld lighting for night-time mobility and the use of temporary floor coverings to mitigate uneven surfaces. Spatial disparities across districts further highlight uneven implementation of age-friendly planning principles, with newer developments exhibiting barrier-free features, while older neighbourhoods remain inadequately retrofitted. The study contributes to urban planning discourse by exposing the disconnect between age-friendly policy frameworks and micro-scale residential realities. It calls for a more integrated planning approach that combines housing retrofitting strategies, inclusive design standards, and smart care technologies within local governance systems.

Keywords: Home safety, empty-nester elderly, smart elderly care, ageing in place and elderly housing retrofitting

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INTRODUCTION

China faces rapid demographic aging, with 297 million elderly (21.1% of population) by end-2023, exceeding 15.4% for those aged 65 and above (Cho & Yoon, 2024; Lu et al., 2023). This deep aging phase (14% 65 and above since 2021) is projected to reach 430 million (34.69%) by 2057 (South China Morning Post, 2024), straining traditional family care as seniors live independently. Home environments remain hazardous: 46.4% lack handrails, 46.3% have slippery floors, and 42.8% lack age-appropriate facilities (Chen, Lin, & Li, 2019), making falls the leading injury cause. Health challenges persist, with healthy life expectancy lagging; seniors comprise 40.01% of discharged patients, 79.7% reporting poor health (Fang, Chen, & Zhou, 2019), driving demand for emergency calls (67.74%) and location services (60.74%) (Hu & Zhu, 2025). While the 14th Five-Year Plan (2022) prioritizes home-based tech-integrated care (Hu & Zhu, 2025), implementation gaps persist due to uneven urban-rural resources (Li, Gao, & Yan, 2019) and institutional inefficiencies (Wang & An, 2020), notably lacking incentives to merge age-friendly modifications with smart technologies. Current research fragments physical and smart interventions, overlooking their synergy and underrepresenting older residents' views, especially in cities like Nanchang. Addressing this, the study asks: i) What home attributes risk empty-nester safety in Nanchang? ii) How do perceptions/well-being shape perceived safety? iii) How do smart-home features enhance it?

LITERATURE REVIEW

Physical Environment Deficiencies in Age-Friendly Housing Design

Existing literature highlights that many urban housing environments in China lack alignment with age-friendly principles. Common shortcomings include suboptimal layouts, inadequate lighting, and missing safety features like handrails and non-slip flooring (Ma & Wang, 2021). These deficiencies increase fall risks and reduce mobility confidence, acting as key barriers to safe ageing-in-place.

Health Monitoring Gaps and Emergency Response in Ageing-in-Place Systems

Existing smart ageing-in-place systems show critical gaps in integrating health monitoring and emergency response. Ma & Wang (2021) rank emergency rescue as seniors' top priority, followed by fall detection. Yet, as Wang & Zuo (2024) note, prevalent shortcomings in real-time surveillance of vital signs (e.g., heart rate) and environmental hazards (e.g., gas leaks) delay risk detection, allowing health declines and dangers to escalate before intervention.

Barriers to Smart Technology Adoption Among Older Adults: Digital Divide and Usability Challenges

Literature identifies persistent barriers to smart ageing technology adoption despite promotional efforts. Wang & Zuo (2024) attribute this to a widening digital divide, citing age-related physical/cognitive declines, low digital literacy, and non-age-friendly interfaces. The same authors further note that privacy risks—including data breaches, unauthorized access, and financial exploitation—undermine older adults' trust and willingness to adopt these systems, underscoring that uptake hinges on accessibility, trust, and inclusive design, not mere availability.

Theoretical Foundation: The Competence–Press Model and Person–Environment Fit in Ageing

Lawton and Nahemow's (1973) Competence–Press Model frames late-life well-being and safety as a dynamic balance between personal competence (health, sensory, and cognitive capacity) and environmental press (physical demands). Excess press undermines outcomes (e.g., falls, anxiety), while aligned environments bolster safety and autonomy. Smart home technologies serve as adaptive tools that enhance person–environment fit by mitigating press via responsive design and real-time support.

Global Perspective

Positioned within global aging-in-place planning, this study offers critical insights for Malaysia while drawing on local scholarship. Abdullah and Salleh (2023) advocate shifting from macro-policy to micro-level retrofits in dense housing, a view reinforced by Ismail and Othman (2022), who stress aligning technological solutions with local socioeconomic realities and support mechanisms. Further enriching this evidence base, Hafiszah et al. (2024) and Ismail et al. (2023)—published in the *Journal of Malaysian Planning*—highlight intergenerational variations in senior housing needs, cautioning against sole reliance on physical modifications. Collectively, these perspectives mirror the implementation gaps facing Nanchang City in actualizing national age-friendly guidelines.

METHODOLOGY

An explanatory sequential mixed-methods design was employed, initiating with a quantitative survey before transitioning to qualitative participant observation to statistically identify and then contextually interpret key relationships. The study spanned six purposefully selected districts in Nanchang, Jiangxi: Donghu and Xihu (aging, high-density urban core); Qingyunpu (transitional, mixed-use industrial); Honggutun (new development with smart-city integration);

Qingshanhu (industrial-tech corridor with varied housing); and Xinjian (peri-urban fringe with limited infrastructure) (see Figure 1). (refer to Figure 1).

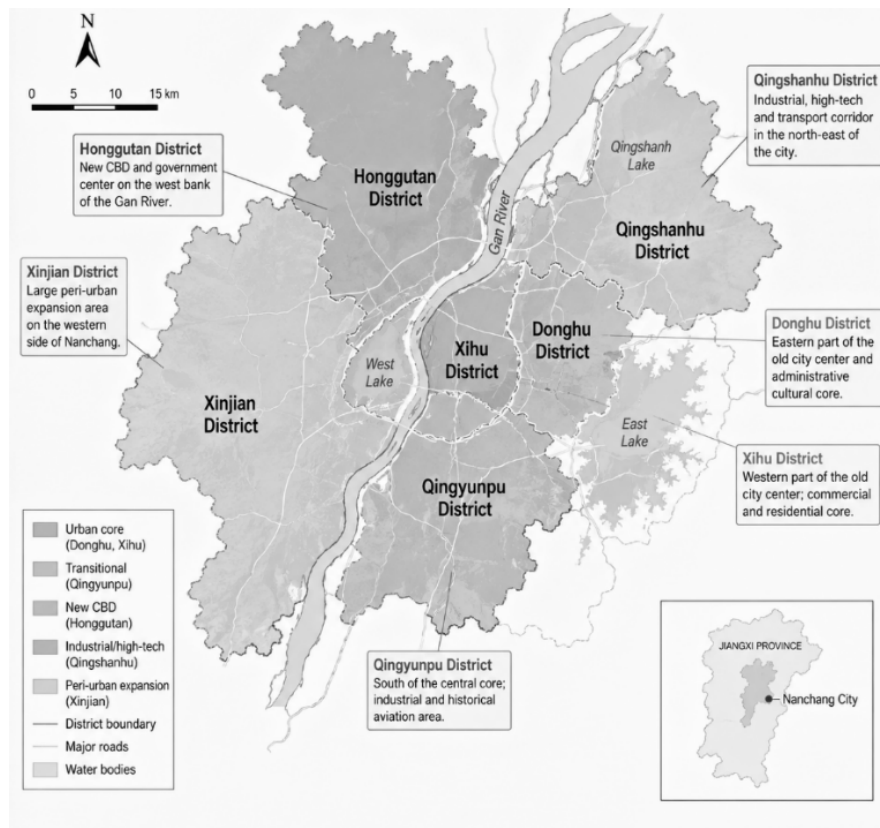


Figure 1: The conceptual map of six urban districts of Nanchang, Jiangxi Province.
Source: Author

Stage 1: Quantitative Data using Survey

The target population comprised empty-nester older adults aged 60 years and above residing in urban Nanchang. A stratified random sampling strategy, based on district, residential type, and age group, was employed. A total of 400 questionnaires were distributed, of which 384 were deemed valid, yielding a usable response rate of 96.0%. Data were collected through face-to-face structured interviews to ensure accuracy and completeness. The overall 31-item scale demonstrated excellent internal consistency, with a Cronbach's alpha coefficient of 0.962.

Measurement and Reliability

The instrument comprised 31 items: five constructs of five items each (25 attitudinal items) and six demographic items. All attitudinal items used a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). The constructs are defined as follows (refer Table 1):

Table 1: Construct Measurement and Reliability Statistics

Construct	Items	Source	Reliability (α)
Home-Environment Safety (HES)	5	Environmental-gerontology	0.962 (Overall)
Well-Being Outcomes (WBO)	5	Established well-being measures	0.89
Perceptions & Usability (PUE)	5	Davis (1989) TAM	0.91
Smart-Home Systems (SHS)	5	Smart-home safety literature	0.88
Elderly Safety (ES) - DV	5	Safety-appraisal literature	0.90

The instrument was validated through a pilot study ($n = 40$) using item-total analysis ($KMO = .712$; Bartlett's test significant), which refined it from 35 to 25 attitudinal items; the main-study instrument achieved an overall Cronbach's α of 0.962, and the principal component analysis confirmed the expected five-factor structure. Subscale Cronbach's α coefficients are reported alongside the overall scale reliability to evidence reliability at both levels.

Stage 2: Qualitative Data using Participant Observation

Ten purposively selected empty-nester households from the quantitative sample underwent 3–4 hour in-situ participant observations across three contrasting districts: Donghu (aging high-density), West Lake (notable safety deficits), and Honggutan (modern barrier-free). This design facilitated cross-case comparisons of environmental impacts on elderly safety and mobility. The protocol encompassed a structured safety checklist, contextual inquiry via integrated semi-structured questions on daily routines, and photographic documentation of non-identifiable home features.

RESULT AND FINDINGS

Findings from the Questionnaire Survey

Demographic Characteristics

Table 2 reveals a balanced gender split (47.4% male, 49.0% female) and a predominantly younger-old cohort (68.2% aged 60–69). While 65.9% held a

Bachelor's degree or higher, 53.6% reported annual incomes below ¥5,000, highlighting severe socioeconomic constraints affecting tech affordability. Crucially, the reported "monthly personal income" reflects China's tiered pension system. Generous state-funded pensions for public institution employees contrast sharply with lower benefits for enterprise and urban/rural residents. Consequently, even highly educated retirees often face a "high-income, low-pension" paradox due to low replacement rates in enterprise schemes.

Table 2: Summarises the demographic characteristics of the 384 respondents.

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	182	47.4
	Female	188	49.0
	Rather not say	14	3.6
Age (years)	60–64	151	39.3
	65–69	111	28.9
	70–74	61	15.9
	75–79	35	9.1
	85 and above	26	6.8
Marital Status	Single	117	30.5
	Married	202	52.6
	Divorced	39	10.2
	Widowed	13	3.4
	Separated	13	3.4
Annual Income	Below ¥3,000	75	19.5
	¥3,000–5,000	131	34.1
	¥5,001–8,000	85	22.1
	¥8,001–12,000	63	16.4
	Above ¥12,000	30	7.8
Education	Primary school	26	6.8
	Secondary school	57	14.8
	Vocational training	48	12.5
	Bachelor's degree	149	38.8
	Master's degree	83	21.6
	Doctoral degree	21	5.5

Descriptive Analysis of Safety Risks in the Home Environment of Older Adults

The descriptive statistics on home-environment safety risks revealed key findings shown in Table 2. Flooring safety recorded the lowest mean score (HES2: $M = 2.30$, $SD = 1.49$), indicating the most critical safety concern, followed by lighting adequacy (HES1: $M = 2.40$). In contrast, confidence in movement showed the highest mean (HES5: $M = 2.86$), suggesting adaptive behavioural responses to environmental risks. Positive skewness values (0.13–0.77) further indicate responses were clustered toward lower safety ratings, reflecting a general

perception of unsafe home conditions. Table 3 presents descriptive statistics for the five items measuring safety risks in the home environment. The items are on a 5-point Likert scale, where lower scores mean higher perceived risk.

Table 3: Descriptive Statistics of Home-Environment Safety Risks (N=384)

Item	Mean	Std. Deviation	Skewness
HES1: Adequate lighting	2.40	1.19	0.151
HES2: Safe flooring (even, trip-free)	2.30	1.49	0.770
HES3: Non-slip surfaces (bathroom/kitchen)	2.68	1.23	0.131
HES4: Mobility safety (move without obstacles)	2.70	1.20	0.140
HES5: Confidence in movement	2.86	1.35	0.130

Inferential Analysis: Regression Model

A multiple linear regression analysis was performed to examine the predictive effects of home-environment safety factors on perceived elderly safety (dependent variable). The model identified four significant predictors ($p < 0.001$) as presented in Table 4. Mobility safety (HES4) was the strongest predictor ($\beta = 0.409$), followed by non-slip surfaces (HES3) ($\beta = 0.326$), adequate lighting (HES1) ($\beta = 0.191$), and confidence in movement (HES5) ($\beta = 0.111$). In contrast, safe flooring (HES2) was not a significant predictor ($\beta = -0.036$, $p = 0.130$), indicating that flooring evenness and trip-free conditions did not independently influence perceived safety when other factors were controlled (refer to Table 5).

Table 4: Summary of the regression model

Model	R	R Square	Adjusted R Square	Std. Error of Estimate
1	0.947	0.897	0.896	0.352

The regression model was highly significant ($F=660.229$, $p<0.001$).

Table 5: Regression Coefficients Results

Predictor	Unstandardised B	Std. Error	Standardised β	t	Sig.
(Constant)	0.282	0.047	–	5.959	<0.001
HES1: Adequate lighting	0.176	0.030	0.191	5.762	<0.001

Predictor	Unstandardised B	Std. Error	Standardised β	t	Sig.
HES2: Safe flooring	-0.026	0.017	-0.036	-1.517	0.130
HES3: Non-slip surfaces	0.290	0.069	0.326	4.210	<0.001
HES4: Mobility safety	0.372	0.069	0.409	5.396	<0.001
HES5: Confidence in movement	0.090	0.017	0.111	5.166	<0.001

Prior to interpretation, diagnostic tests confirmed all regression assumptions: VIF values (1.18–2.37) indicated no multicollinearity, while residual normality, homoscedasticity, and independence were also satisfied. A Pearson correlation revealed a very strong positive link between home-environment safety and perceived safety ($r = 0.914$, $p < 0.001$, $N = 384$). Consistently, the regression model was significant ($F = 660.229$, $p < 0.001$) with substantial variance explained ($R^2 = 0.897$), confirming a robust positive effect and rejecting the null hypothesis.

Findings from the Participant Observation

Observation Procedure and Protocol

Following an explanatory sequential design, household observations were conducted after the questionnaire survey to provide an in-depth explanation of the statistical findings. Using purposive maximum-variation sampling, 10 households (coded H1–H10) were selected across three districts with significant disparities and covering the full spectrum of smart-home adoption: Honggutan District (high income, high adoption rate; $n = 3$), Donghu District (moderate level; $n = 4$), and Xihu District (low income, zero adoption rate; $n = 3$). Each home visit lasted 3 to 4 hours, utilizing a structured observation checklist organized around four core constructs: home-environment safety, well-being, perceptions and usability, and smart-home systems. The researcher walked through the homes with the residents to record the presence, condition, and functionality of safety-related facilities. Concurrent contextual interviews were conducted using open-ended questions to understand residents' daily safety practices, experiences with existing technologies, device usability, and views on privacy. Throughout the visits, photographic evidence was collected, and reflexive field notes were documented.

Coding Method

Data analysis followed Braun and Clarke's (2006) six-phase thematic analysis using NVivo. A hybrid abductive approach was adopted, using four conceptual constructs as a deductive framework while inductively coding resident accounts and observations through the standard six phases. Ultimately, all themes were mapped to the study's constructs. Analytical rigor was ensured through supervisory peer debriefing, member checking, audit trails, and reflexive journaling.

Ethical Considerations and Safeguards

The study was approved by the University of Malaya Ethics Committee (UMREC/2025/SS-073). Written informed consent was obtained following cognitive screening, with data anonymized and securely stored. Participants could withdraw anytime, and visits were scheduled at their convenience to minimize disruption. Photographs required explicit consent and excluded identifiable facial features.

Integration with Survey Data

Using an explanatory sequential design, observational and survey data were integrated via "joint displays" to link quantitative findings with qualitative explanations, revealing four core mechanisms; i) A risk awareness effect where high physical mobility correlated with greater risk-taking and fewer safety installations; ii) An integration effect where isolated devices (e.g., automated lighting, standalone alarms) offered negligible security versus valued integrated systems with family notifications; iii) A cognitive association between continuous, integrated monitoring and perceived security, driving sensor dominance; iv) Structural inequality and an awareness gap, wherein stratified services revealed fall-detection devices were exclusive to low-income households as passive post-incident measures which is absent in tech-rich homes highlighting disparities rooted in awareness, not capability.

Theme 1: Perceived Safety as a Product of Personal Adaptation. Across the observations, perceived safety was not primarily derived from the original design quality of the home but from residents' ongoing, self-initiated adaptations to mitigate environmental risks. Participants described safety as an outcome of accumulated experience, where behavioural adjustments and incremental modifications, rather than inherently safe housing conditions, played a central role in maintaining everyday security. The participants responded as;

"On the whole, my home is comfortable, but there are minor threats. The shower makes the bathroom floor slippery, so I fitted a mat. The hallway lighting was

previously very low, but sensors come in handy. Nevertheless, I am still very careful, more so at night.” (East Lake’s Participant P1)

“I am very sure that my home is very safe now, but it took effort to make it so. I got my son to install grab bars in the bathroom and near the stairs. Before this, I had nearly fallen on both occasions.” (West Lake’s Participant P2)

Observational evidence corroborated these accounts: homes in East Lake commonly exhibited deliberate safety modifications such as grab bars, additional lighting, and non-slip mats, whereas West Lake homes showed limited evidence of such interventions.

Theme 2: Lighting and Visibility as Determinants of Safety

Adequate lighting and clear visibility emerged as fundamental determinants of perceived and actual safety within the home environment. Participants’ accounts revealed that safety is highly contingent on the ability to visually navigate spaces, particularly during nighttime or low-light conditions. The absence of reliable lighting was associated with disorientation, loss of spatial awareness, and increased risk of collision or falls, underscoring the critical role of illumination as both a preventive and enabling environmental factor.

“The time when the power went off at night was a time when I felt insecure. I did not know where to go in the kitchen due to the dark conditions and hit a chair. After that, I installed emergency lighting, which comes on automatically.”
Participant P2

Inadequate lighting compromises safety and triggers reactive adaptations, such as emergency lighting. Observations confirmed this: 70% of homes had adequate lighting, but disparities existed. Honggutan featured proactive, built-in motion sensors, while East Lake residents independently installed battery-operated sensors. Conversely, West Lake relied on minimal lighting; some residents used handheld torches, a functional but risky coping strategy due to limited illumination.

Theme 3: Flooring and Surface Risks.

Flooring conditions were identified as a key contributor to slip-and-fall risks, particularly in wet areas such as bathrooms and kitchens. Participants’ accounts highlighted how smooth or wet surfaces directly increase the likelihood of accidents, often leading to safety modifications after minor falls or near-miss events. This reflects how flooring safety is experienced in daily life as an ongoing risk requiring adaptation.

“Approximately one year ago, I fell slightly, leaving the shower due to the floor being wet and smooth. It frightened me, though I was not seriously injured. I then fitted an anti-slip mat and grab handle.” (Participant P1)

This statement shows how even minor incidents prompt immediate behavioural and environmental adjustments to reduce future risk. Observations confirmed these findings. Six of ten (60%) homes had adequate flooring safety. All Honggutan homes used uniform anti-slip matte flooring, while some East Lake homes had partial anti-slip mats. In contrast, all West Lake homes had polished tiles in wet areas without anti-slip measures, indicating a higher persistent slip risk. Slippery and uneven flooring was a major concern.

Theme 4: Structural Inequalities in Home-Environment Safety Across Districts

A cross-case and comparative analysis finding of this study is that home safety conditions are not evenly distributed, but are shaped by broader structural and spatial inequalities. Differences in housing age, urban development policies, and access to retrofit support have produced distinct levels of safety and technology adoption across districts, beyond individual household control or awareness.

This pattern highlights that safety outcomes are strongly influenced by structural conditions such as construction era, municipal investment in inclusive infrastructure, household income levels, and access to retrofit or ageing-in-place programmes. Rather than reflecting differences in personal safety awareness or motivation, the findings indicate that inequality in the built environment significantly shapes the level of protection available to older adults across districts (refer to Table 6).

Table 6: District Safety Features & Smart Home Adoption Levels

District	Housing Type	Safety Features	Smart Home Adoption
Honggutan	Modern high-rise, barrier-free	Built-in motion lighting, anti-slip floors, grab bars	High (integrated systems)
East Lake	Older mixed	Self-initiated adaptations (grab bars, mats, sensor lights)	Partial (standalone devices)
West Lake	Oldest stock, unmodified	Polished ceramic tiles, no grab bars, no anti-slip	None (cost and support barriers)

Theme 5: Normalised Hazards Uncovered by Observation

Participant observation uncovered unreported home hazards—including rugs masking uneven tiles (Donghu), bedside torches (Xihu), poor drainage causing shower stagnation (Xihu), and walkway obstructions (both districts)—underscoring observation’s value. These risks, normalized through long-term exposure, were invisible to residents yet clearly visible during visits, explaining critical underreporting in self-reported data.

DISCUSSION

This study establishes home-environment safety as the predominant determinant of perceived elderly safety, accounting for 89.7% of variance, corroborating Xu et al. (2026) on lighting and physical design in Jiangxi. Extending Lawton and Nahemow’s (1973) Competence–Press Model, mobility safety emerged as the strongest predictor, indicating perceived safety is driven more by navigational ease than static features. While safe flooring lacked statistical significance (contra Cho & Yoo, 2024), qualitative data revealed persistent slip hazards in West Lake, suggesting non-significance stemmed from low flooring-type variability in standardized Nanchang housing rather than risk absence. Notably, psychological confidence ($\beta = 0.111$) proved an independent predictor, augmenting the Ecological Theory of Aging by foregrounding subjective adaptation alongside functional competence (Zhou & Wu, 2022). Integrating mixed methods thus elucidates how perceived safety synthesizes physical conditions and subjective experience, exposing limitations in survey-only assessments.

Policy and practical implications follow accordingly: i) prioritizing mobility through retrofits that ensure clear, widened circulation pathways (Zhang & Liu, 2024); ii) deploying low-cost, high-impact interventions such as motion-sensitive lighting and anti-slip surfaces to mitigate prevalent hazards; iii) directing structural subsidies toward aging, low-income housing particularly in high-risk, underserved districts such as West Lake in redress systemic inequities; and iv) integrating wireless or voice-activated emergency systems within high-risk zones (e.g., bathrooms and bedrooms) to enhance responsiveness and safety (Zhang & Li, 2023).

CONCLUSION

This study examined the relationship between home-environment safety and perceived safety among empty-nester elderly in Nanchang, China. Findings show that home-environment safety explains 89.7% of the variance in perceived safety, with mobility safety, non-slip surfaces, adequate lighting, and confidence in movement as significant predictors, leading to the rejection of the null hypothesis. Complementary qualitative findings revealed normalized hazards, district-level structural inequalities, and adaptive coping strategies that surveys alone missed.

The study contributes theoretically by extending the Ecological Theory of Aging to show psychological confidence as an independent determinant of safety; methodologically by highlighting participant observation to identify hidden risks; and practically by guiding age-friendly housing interventions that prioritize mobility, lighting, anti-slip surfaces, and equitable retrofits.

Despite limitations of its cross-sectional, single-city design and small qualitative sample, future research should adopt longitudinal approaches and comparative studies. Furthermore, integrated frameworks linking housing design, smart technology, and community governance are needed. Notably, while the quantitative model highlights physical factors as primary predictors, the qualitative phase revealed that smart technologies act as a complementary layer of security, particularly in high-income districts.

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