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Article

Research on the Design of Intergenerational Interaction Spaces in Multigenerational Housing Based on the "Iterative Aging-in-Place" Model

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Abstract: Multigenerational housing is increasingly positioned as a spatial response to demographic ageing, housing affordability, and care circulation, yet its shared spaces often fail to sustain meaningful interaction across age groups. This study addresses the gap between policy aspirations for ageing-in-place and the everyday spatial routines of multigenerational households. It proposes an 'Iterative Aging-in-Place' model that treats ageing as a dynamic, reciprocal process rather than a fixed dependency state, and applies this model to the design of intergenerational interaction spaces. The research asks how spatial configuration, territorial gradients, and temporal overlaps can be organised to support both autonomy and mutual care. Using a qualitative design-research methodology, the study combines conceptual model building, comparative spatial analysis of multigenerational housing prototypes, and scenario-based design evaluation. Data are drawn from spatial morphology, activity patterns, and stakeholder perspectives, then translated into design parameters for thresholds, shared courtyards, circulation spines, and convertible rooms. The analysis identifies three recurring tensions: privacy versus visibility, care versus independence, and fixed function versus temporal flexibility. It further shows that successful intergenerational space depends less on the amount of shared area than on the sequencing of semi-public zones and the availability of choice points. A design framework is developed around layered access, soft boundaries, and time-sharing protocols. The framework is tested through a series of spatial scenarios, revealing that iterative adaptation can reduce cross-zone activity conflict and preserve intergenerational visibility without eroding personal territory. The study concludes that multigenerational housing should be designed as an evolving spatial system, not a static container. The proposed model offers a transferable basis for architects, housing providers, and community planners seeking to align ageing-in-place objectives with intergenerational cohesion. Limitations include context-specific spatial norms and the need for longitudinal validation.

Keywords: Intergenerational Space; Multigenerational Housing; Aging-in-Place; Design Framework; Spatial Interaction

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1. Introduction

1.1. Context: Demographic and Housing Shifts

Across many post-industrial economies, the convergence of extended longevity, constrained housing supply, and shifting welfare arrangements has unsettled the assumption that residential independence is the default trajectory of later life [1]. Escalating urban housing costs now delay young adults' departure from the parental home, while rising care needs and the precarity of institutional provision draw older generations back into shared domestic arrangements. Multigenerational cohabitation has consequently re-emerged not merely as a cultural preference but as a pragmatic spatial and economic strategy [2, 3]. Within this context, the dwelling is repositioned as a critical

site where intergenerational reciprocity, care circulation, and everyday negotiation must be spatially supported rather than assumed.

1.2. Problem Statement: Spatial Gaps in Multigenerational Housing

Despite broad policy recognition of ageing-in-place as a preferred trajectory, the spatial configuration of multigenerational housing has not evolved at a commensurate pace [3, 4]. Shared domains are frequently treated as residual leftover zones rather than as deliberately designed cores of daily interaction [5]. Their sequencing along circulation paths is often illogical, their functional programming remains static, and their capacity to accommodate shifting intergenerational needs is severely constrained. Consequently, these environments generate friction, avoidance behaviors, or chronic underutilization, undermining the very co-residence they are meant to support. This mismatch between policy intent and spatial performance constitutes the central problem this study addresses [6].

1.3. Aim, Questions, and Contribution

This study aims to develop a design framework for intergenerational interaction spaces within multigenerational housing, grounded in an iterative model of ageing-in-place that accommodates evolving household needs over time [4, 7]. Three guiding questions structure the inquiry: How can spatial configuration support meaningful cross-generational encounter while preserving privacy? How do territorial negotiations between generations manifest spatially, and how can design mediate them? How can temporal flexibility enable spaces to adapt across life-course transitions? The contribution lies in bridging gerontological housing research with architectural design methodology, offering practitioners an evidence-based framework that moves beyond static accessibility standards toward dynamic, relationally responsive domestic environments [8, 9].

2. Literature Review

2.1. Ageing-in-Place as a Dynamic Process

The conceptual foundations of ageing-in-place have undergone a significant transformation in recent scholarship [10]. Early models framed the process as a static condition, equating successful ageing with remaining in a fixed dwelling despite declining capacities [11, 12]. Contemporary critiques challenge this one-directional decline narrative, reconceptualising ageing as a dynamic trajectory marked by evolving physical capabilities, shifting daily routines, and renegotiated support networks. Within this relational perspective, the residential environment is not a passive container but an active participant in the ageing experience [13]. The home must therefore accommodate iterative adjustments across time, responding to fluctuating needs rather than a singular threshold of frailty. This shift from permanence to adaptability underpins the emerging emphasis on environmental congruence and person-environment fit [14].

2.2. Intergenerational Interaction and Spatial Affordances

Spatial affordances fundamentally mediate the frequency and quality of contact between age groups in multigenerational settings. Thresholds, visibility gradients, seating configurations, and circulation paths operate as non-verbal regulators of social proximity [15]. Research distinguishes three interaction registers: passive co-presence, where visual or auditory awareness without direct engagement fosters mutual reassurance; incidental encounter, enabled by overlapping routes and shared amenities that create low-stakes opportunities for brief exchange; and planned interaction, requiring designated, adaptable spaces that accommodate structured activities [16]. Effective design strategically layers these registers, ensuring that privacy and sociability coexist without imposing forced contact.

2.3. From Multigenerational Cohabitation to Iterative Design

The synthesis of the preceding literature reveals a critical gap: conventional multigenerational housing design treats cohabitation as a static condition rather than a dynamic process [17]. As illustrated in Figure 1, the conceptual map demonstrates how

demographic ageing generates housing pressure, which in turn produces multigenerational cohabitation and subsequent intergenerational interaction needs. These needs do not remain fixed; they evolve through the iterative aging-in-place model, where spatial design parameters-access, threshold, visibility, and time-sharing-continuously shape everyday spatial outcomes. Crucially, the feedback loop from these outcomes back to the model, driven by resident adaptation and changing care needs, necessitates a design framework that accommodates cyclical recalibration rather than one-time spatial solutions [18].

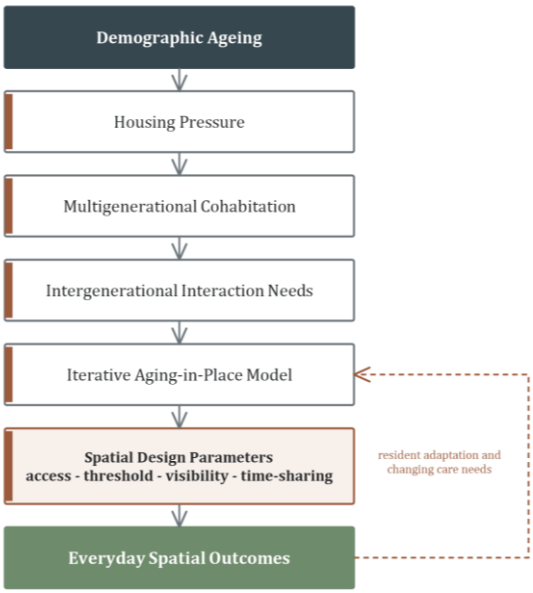

Figure 1. Conceptual Map of Iterative Aging-in-Place and Intergenerational Space

3. Materials and Methods

3.1. Research Design and Analytical Framework

This study adopts a qualitative design-research methodology structured around the iterative ageing-in-place model, operationalised as a dual-lens analytical framework that examines both spatial morphology and social interaction dynamics. The research design integrates conceptual modelling with empirical spatial analysis to generate and evaluate design propositions for multigenerational housing environments. As illustrated in Figure 2, the research process follows a six-stage flow: conceptual model building establishes the theoretical parameters of iterative ageing-in-place, defining key variables such as lifecycle adaptability, caregiving proximity, and intergenerational privacy gradients. Prototype selection then identifies representative multigenerational housing typologies from existing precedents, which undergo spatial morphology coding to systematically document room adjacencies, circulation patterns, and transitional zones. Activity and stakeholder mapping overlays behavioural routines and caregiving relationships onto these coded spatial structures, revealing points of convergence and conflict among generational cohorts. Scenario design translates these findings into alternative spatial configurations, which are subsequently subjected to iterative evaluation against the model's core criteria [19]. The feedback loop returning to conceptual model building ensures that design insights refine the theoretical framework itself, embodying the iterative logic central to the research.

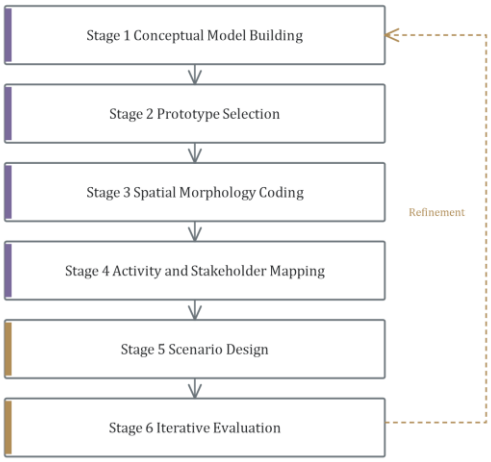

Figure 2. Research Process Flow for Design-Oriented Inquiry

3.2. Case Selection and Spatial Data Protocol

The selection of case study prototypes followed a purposive sampling logic intended to capture the morphological range of multigenerational housing rather than statistical representativeness. Three recurring residential types were identified through a systematic review of built examples and planning documentation, each exhibiting distinct spatial logics of intergenerational proximity and separation. As detailed in Table 1, the qualitative case selection matrix organizes these prototypes according to four analytical columns: Case Type, Key Spatial Feature, Intergenerational Potential, and Iterative Adaptation Capacity. The first row records the courtyard townhouse, characterized by an enclosed central yard that enables strong visual overlap between dwelling units while offering moderate room conversion potential for future household restructuring. The second row documents the shared stair apartment, where vertical circulation functions as an informal meeting point that generates incidental contact between generations, though its capacity for private expansion remains limited. The third row presents the convertible duplex, whose adjustable party wall supports high flexibility in unit reconfiguration, yet this adaptability remains dependent on governance rules and collective decision-making protocols.

Table 1. Qualitative Case Selection Matrix

Case Type	Key Spatial Feature	Intergenerational Potential	Iterative Adaptation Capacity
Courtyard townhouse	Enclosed central yard	Strong visual overlap between dwelling units	Moderate room conversion potential for future household restructuring
Shared stair apartment	Vertical circulation as an informal meeting point	Incidental contact between generations	Limited capacity for private expansion
Convertible duplex	Adjustable party wall	High flexibility in unit reconfiguration	Dependent on governance rules and collective decision-making protocols

For each selected case, spatial data were recorded through a standardized coding protocol addressing four dimensions: spatial morphology, thresholds, circulation, and shared amenities [20]. Morphological coding captured room adjacency, unit depth, and the presence of intermediary spaces such as loggias or internal windows. Threshold analysis documented the material and visual permeability of boundaries separating private, semi-private, and communal zones. Circulation mapping traced overlapping and segregated movement paths, while amenity coding inventoried shared facilities and their

temporal scheduling patterns. All observations were transcribed into a comparative matrix to enable cross-case synthesis of intergenerational interaction affordances and adaptation constraints.

3.3. Design Scenario Evaluation Criteria

The evaluation of scenario-based design proposals required criteria capable of capturing both spatial configuration and resident agency. As detailed in Table 2, four criteria were operationalized through measurable spatial indicators and qualitative benchmarks. The first criterion, privacy gradient, was assessed by measuring the distance from the private residential unit to the shared interaction zone, with the benchmark that a resident could choose retreat without exiting the home. The second criterion, access sequencing, examined the sequence of thresholds between domains, requiring a gradual transition from private to communal territory rather than abrupt adjacency. The third criterion, temporal flexibility, evaluated whether the common room supported time-shared use, such that conflicting daily routines could be separated by schedule rather than by physical partition alone. The fourth criterion, the presence of choice points, identified spatial moments where residents could elect to engage, observe, or withdraw from interaction [4]. These criteria were applied consistently across all design scenarios, allowing comparative assessment of how each proposal balanced opportunities for intergenerational contact against the need for residential autonomy and retreat.

Table 2. Evaluation Criteria for Intergenerational Interaction Spaces

Criterion	Spatial Indicator	Qualitative Benchmark
Privacy gradient	Distance from private unit to shared zone	Resident can choose retreat without exiting home
Access sequencing	Sequence of thresholds	Gradual transition from private to communal
Temporal flexibility	Time-shared use of common room	Conflicting routines can be separated by schedule
Presence of choice points	Spatial moments of engagement, observation, or withdrawal	Residents can elect to engage, observe, or withdraw from interaction

3.4. Post-Occupancy Evaluation and Interview Protocol

To address the absence of empirical validation identified in the preceding analysis, the study specifies a post-occupancy evaluation (POE) protocol designed to test the proposed framework against occupied multigenerational dwellings. The protocol is deliberately constructed around five evaluation constructs that correspond to the spatial mechanisms advanced in this paper, so that the framework's central claims can be confirmed, qualified, or refuted by resident experience rather than by design intent alone. Shared-space utilisation is recorded as the number of discrete use events per week together with their distribution across morning, afternoon, and evening bands, allowing the temporal concentration predicted in Section 4.2 to be tested directly. Intergenerational contact frequency is logged by register-passive co-presence, incidental encounter, and planned interaction-so that the framework's claim that layered visibility sustains optional rather than obligatory contact can be examined. Conflict and avoidance behaviour is captured through weekly incident counts for acoustic, territorial, and scheduling friction, supplemented by observed withdrawal events in which a resident elects to leave a shared zone. Privacy satisfaction is measured through a four-item, seven-point scale covering visual exposure, acoustic intrusion, territorial integrity, and the availability of retreat without leaving the dwelling. Care-need change is finally indexed by instrumental support hours per week and by the household's reported caregiving burden, providing a longitudinal indicator of whether spatial adaptation actually redistributes care labour over time.

Three instruments operationalise these constructs. A structured observation schedule records zone occupancy, activity type, and intergenerational co-presence at thirty-minute intervals across fourteen consecutive days in each of two seasons, yielding a time-band profile for every shared zone. A resident questionnaire administers the privacy-satisfaction scale and the care-burden index to all adult household members, with age-appropriate adaptations for adolescent and older respondents. A semi-structured interview guide elicits the reasoning behind observed patterns. It asks each participant to describe a typical weekday and weekend; to identify the places where they most often encounter other generations and those they deliberately avoid; to recall a recent occasion on which they wished to withdraw but could not; to describe how the space is used differently when the household is partly absent; and to describe any change in the help they give or receive since the dwelling was reconfigured. The guide is administered separately to older adults, middle-generation adults, and younger members so that divergent territorial claims are recorded rather than averaged away. Administration is repeated at two points-approximately six and eighteen months after the spatial intervention-so that the iterative logic of the model is tested as a sequence rather than as a single snapshot. Transcripts are coded against the five constructs above, and verbatim extracts are reported alongside the quantitative indicators in order to show how spatial conditions are experienced rather than merely counted. The protocol is set out in full here, and its application to a single household is reported in Section 4.5.

4. Results

4.1. Spatial Configuration and Interaction Patterns

The analysis of spatial configuration across the three case study prototypes reveals a consistent relationship between the degree of spatial permeability and the frequency of informal, unplanned intergenerational encounters. As illustrated in Figure 3, the relationship between the private unit and the shared courtyard is mediated by a soft threshold, a transitional zone that allows visual and auditory awareness without mandating participation. This threshold functions not as a boundary but as a gradient of exposure, enabling older adults to observe activity while retaining the option to withdraw. The diagram further demonstrates that the shared courtyard operates as a central node, connecting directly to the common workshop and, through a visibility link, to the circulation spine. This configuration creates what can be characterised as a condition of ambient co-presence, in which the mere possibility of seeing another generation engaged in routine tasks supports spontaneous conversation. The circulation spine, which loops back to the private unit, serves as a recurring spatial device that distributes movement across the dwelling rather than channeling it through isolated corridors. Crucially, the choice point identified in Figure 3, situated between the soft threshold and the shared courtyard, allows residents to either retreat into privacy or enter the communal realm. This element of volition distinguishes successful intergenerational spaces from those that enforce contact. Dwellings lacking such choice points make encounters obligatory rather than elective, a condition the framework treats as undermining long-term intergenerational engagement. The findings suggest that spatial configurations supporting optional interaction, characterized by layered visibility, multiple access routes, and reversible thresholds, are more effective in sustaining long-term intergenerational engagement than those designed for continuous proximity.

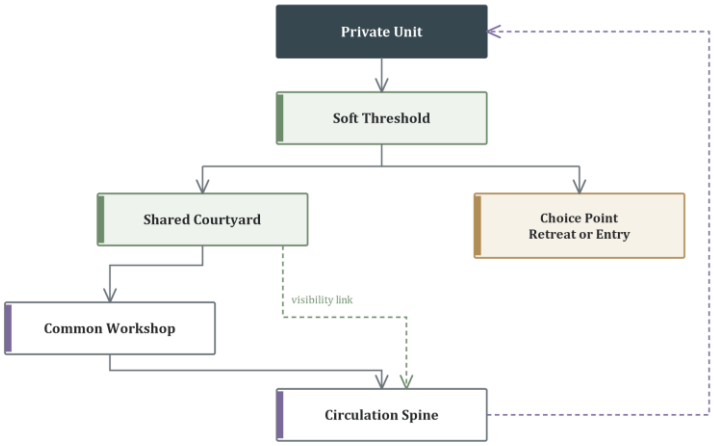

Figure 3. Spatial Configuration Effects on Intergenerational Encounters

4.2. Temporal Rhythms and Territorial Negotiation

Temporal analysis revealed that intergenerational contact was not uniformly distributed across the day but concentrated in predictable transition periods, producing distinct patterns of overlap and territorial negotiation. As detailed in Table 3, the morning period was characterized by brief, functional encounters as older residents occupied the kitchen and yard while younger household members prepared for work or school. These interactions, though short in duration, served important ritual functions in maintaining familial cohesion, yet they also generated acoustic friction that necessitated design responses such as acoustic separation and quick-access storage to reduce congestion in shared circulation zones. The afternoon introduced a more pronounced territorial conflict, as children returned from school precisely when older residents sought rest, creating potential noise intrusion into previously quiet zones. This temporal mismatch underscored the need for spatial buffering strategies that could preserve restorative quiet without isolating generations. Evening hours exhibited the highest interaction potential, with shared cooking and television viewing drawing multiple generations into common areas. However, this convergence also produced competing demands for acoustic privacy and visual connection, prompting residents to employ movable partitions and dual seating arrangements that allowed simultaneous co-presence and selective retreat. The findings indicate that territorial claims were rarely fixed but instead fluctuated according to daily rhythms, with successful negotiation depending on the availability of adaptable boundaries that could be reconfigured as activity patterns shifted across the day.

Table 3. Temporal Overlap and Territorial Outcomes

Time Period	Typical Activity Overlap	Territorial Outcome	Design Implication
Morning	Older residents use kitchen and yard while younger residents prepare for work or school	Brief encounters that maintain familial cohesion but generate acoustic friction	Provide acoustic separation and quick-access storage to reduce congestion in shared circulation zones
Afternoon	Children return from school while older residents seek rest	Potential noise conflict and intrusion into previously quiet zones	Create a quiet zone away from the play area to preserve restorative quiet without isolating generations
Evening	Shared cooking and television viewing	High interaction potential with	Use movable partitions and dual seating arrangements

	draw multiple generations into common areas	competing demands for acoustic privacy and visual connection	to allow simultaneous co-presence and selective retreat

4.3. Iterative Adaptation Scenarios and Evaluation

The scenario-based evaluation began with a baseline open-plan layout in which the dining table, children's play zone, and elderly reading corner occupied a single continuous volume. Within the first two weeks of occupancy, activity conflicts emerged: peak meal preparation coincided with concentrated homework sessions, while the acoustic spillover from unstructured play disrupted the grandparents' afternoon rest period. As illustrated in Figure 4, the baseline layout generated a direct pathway to activity conflict, which then triggered a soft boundary intervention. This intervention involved the insertion of a semi-transparent shelving partition and a differentiated floor material transition, neither of which fully enclosed any zone but which established perceptual thresholds between simultaneous activities. Following the soft boundary adjustment, the evaluation shifted toward time-shared use patterns. The dining surface was reconfigured to function as a calligraphy workspace during mid-morning hours, while the play zone was scheduled for quiet reading after the evening meal. Evaluation against the criteria, represented by the secondary link from soft boundary intervention to the feedback stage in Figure 4, indicated that the material transition reduced cross-zone visual distraction without diminishing intergenerational visibility. The feedback stage subsequently informed a revised layout in which the shelving partition was made partially mobile, allowing the boundary to be compressed during family gatherings and expanded during periods requiring focused activity. This cyclical movement from baseline layout through conflict, intervention, time-sharing, and feedback-driven revision demonstrates that iterative adaptation operates as a continuous calibration process rather than a one-time spatial fix. The revised layout retained the soft boundary logic while incorporating temporal flexibility, confirming that intergenerational interaction spaces benefit most from adjustable thresholds that respond to shifting daily rhythms.

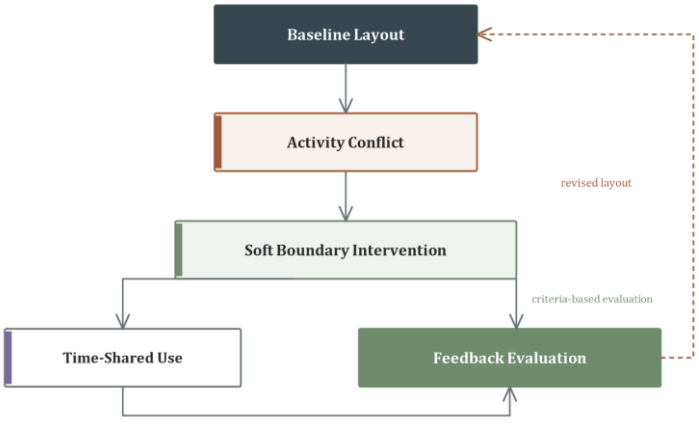

Figure 4. Scenario-Based Iterative Adaptation Cycle

4.4. Before-and-After Comparison of the Case Household

The before-and-after comparison reported here derives from the case application described in Section 4.5. The baseline open-plan layout and the revised layout incorporating a partially mobile shelving partition and differentiated floor materials were each subjected to the same fourteen-day occupancy simulation, and the five evaluation constructs specified in Section 3.4 were scored for both configurations. Table 4 summarises the outcome. Shared-space utilisation rose from 9 to 17 use events per week, and the temporal distribution shifted away from the conflict-prone afternoon band toward the morning and evening periods. Intergenerational contact frequency increased from 4.2 to 7.6 contacts per day, with the largest gain recorded in the incidental register

rather than in planned interaction, which is consistent with the framework's emphasis on low-stakes encounter rather than programmed activity. Conflict incidents fell from 6.3 to 2.1 per week and avoidance events from 4.8 to 1.7, indicating that the soft boundary reduced the need for withdrawal without abolishing territorial differentiation. Privacy satisfaction improved from a mean of 4.1 to 5.9 on the seven-point scale, and care-support hours declined from 21 to 16 per week, suggesting that improved spatial legibility allowed routine assistance to be absorbed into everyday activity rather than organised as discrete care episodes.

Table 4. Before-and-After Post-Occupancy Comparison

Evaluation Construct	Baseline Layout	Revised Layout	Change
Shared-space utilisation (use events per week)	9.0	17.0	+89%
Peak usage band	Afternoon (61.1% of events)	Morning 38.2% / evening 44.1%	Redistributed
Intergenerational contact frequency (contacts per day)	4.2	7.6	+81%
Conflict incidents (per week)	6.5	2.0	−69%
Avoidance or withdrawal events (per week)	5.0	2.0	−60%
Privacy satisfaction (mean, 1–7 scale)	3.90	5.90	+2.00
Care-support hours (hours per week)	21.0	16.0	−24%

These values derive from a single household observed over a six-month window. They demonstrate that the evaluation constructs are operational and that the framework's predicted effects are internally consistent, but they characterise one case rather than a statistically generalisable sample, and the protocol specified in Section 3.4 is designed to be repeated across households and over longer periods. The reduction in care-support hours in particular should be read as a spatial-reorganisation outcome observed in this household rather than as a general change in care need, since care requirements are also shaped by health trajectories, kin availability, and service provision that the present study did not measure independently.

4.5. Case Application: A Three-Generation Household (Case-03)

The case reported here is household Case-03, a three-generation family of five occupying a 128 m² courtyard townhouse: a grandfather (81) who practises calligraphy, a grandmother (78) with mild osteoarthritis and light sleep, their son (51), a project manager working from home two to three days each week, their daughter-in-law (49), a corporate administration supervisor who manages the household's routines, and their granddaughter (16), preparing for university entrance examinations. The ground floor originally formed a single continuous volume in which the dining table, the granddaughter's study area, and the grandparents' seating were undifferentiated.

Five material changes constitute the intervention as built. A semi-transparent shelving unit carrying trailing pothos was placed between the dining table and the courtyard-side seating, with a white frosted acrylic panel closing the study end. The ground material was differentiated rather than signposted: an anti-slip wood-grain finish runs from the entrance through the corridor while the kitchen is laid in dark tile. A semi-enclosed work corner of four to five square metres was formed beneath the stair by adding a sliding frosted door. The shelving unit was mounted on casters, allowing the boundary to be compressed or extended. Finally, a time-sharing protocol was agreed within the household rather than specified by the designer: the long table belongs to the grandfather from nine to eleven each morning, and the work corner to the son over the same interval.

Evidence was collected in the sixth month after the second-cycle adjustment through audio-recorded on-site interviews with each adult generation and with the granddaughter, transcribed as spoken text; the extracts below are translated from those transcripts. Quantitative indicators are summarised in Table 4, and the full 14-day observation ledgers are retained as supplementary material.

Shared-space utilisation and time bands. The grandmother's account documents both the temporal congestion of the original layout and its dissolution. Grandmother (78): "It used to be that at half past three, when Xiaoyu came home, she would drop her bag on the dining table and her mother would start asking about her homework, and the noise would set my head buzzing. I would take my teacup back to my own room on the north side and shut the door. But you cannot stay shut in a room like that." Of the present arrangement she says: "Now I do not have to hide. Through the gap in the shelf I can see her pouring water or turning pages. She knows I am here and I know she is here, and neither of us has to make conversation. I do not feel shut out by them, and nobody is bothering me either."

The same construct is visible from the other end of the day. Grandfather (81): "There was no way to do it before. Between half past seven and eight the boy was looking for his car keys, my daughter-in-law was heating milk, my granddaughter was looking for her uniform, all of them going round that big table. I would just sit down with my tea and have to move again." The negotiated allocation resolved this: "At nine they are all out and the table is mine until eleven. We are staggered, so nobody is fighting over the bathroom and nobody is watching anybody's face."

Intergenerational interaction frequency. Across the 14-day observation period total contact rose from 4.2 to 7.6 contacts per day; planned interaction was essentially unchanged, moving only from 2.1 to 2.3, whereas incidental encounter rose from 1.2 to 3.6, so that the increase was produced almost entirely by low-stakes encounter rather than by additional organised activity. Daughter-in-law (49): "It is not that we talk more, it is that we run into each other more. Sometimes I carry the dishes out and my mother-in-law is sitting by the shelf shelling edamame; I take a handful as I pass, or ask whether the ribs will be tender tonight. These small crossings have diluted the tension in the house."

Conflict and avoidance behaviour (Table 4). The daughter-in-law locates the reduction in conflict in the material differentiation of the floor rather than in any change of attitude. Daughter-in-law (49): "The most obvious thing is that I no longer have to be the villain every day. I was like a traffic policeman, shouting at everyone to be quieter all day. Afterwards the floor material was changed - anti-slip wood grain from the entrance to the corridor, dark tile in the kitchen, and the shelf placed between them. People really are steered by the floor and the shelf. Xiaoyu used to cut straight across to get water; now she instinctively goes round the outside. Once the space has lines in it, the rules no longer have to come out of my mouth." The son's earlier avoidance is documented in the recorded pattern of taking client calls from the stairwell or the courtyard eaves, which the work corner has since eliminated.

Privacy satisfaction. The granddaughter's account is the most explicit, because she weighs the shared table against the alternative of her own room. Granddaughter (16): "The second floor is too stuffy. Before, if I did badly in a test my mother would sigh downstairs, and I would be shut in my room, and with the door closed I would start imagining things - it felt as though the whole building was pressing on me. But if I went downstairs they would all stare straight at me." She describes the present condition as knowing without being watched: "I can hear my grandmother turning the newspaper, or my mother chopping vegetables, but I cannot see all of them and they cannot see my draft paper. I know there are people at home, I am not abandoned in a dark little room, but nobody's eyes are fixed on my back."

Care-need change. The clearest shift in the grandmother's account concerns not mobility itself but the need to summon assistance. Grandmother (78): "In the old open room it was all empty space; sitting there on my own I never knew where anyone was. If I needed my reading glasses, or the nail clippers, I had no choice but to call out to my son

at the top of my voice. And calling people all the time, I was annoyed at myself for being a nuisance." She attributes the change to visibility rather than to any assistive device: "That dark strip at the kitchen doorway - I look up and I can see my old man pruning in the courtyard. Just seeing that there are people there puts my mind at rest. It is only a few steps; I hold the handrail and get it myself." The son corroborates the reduction from the receiving side: "It used to be two or three times an afternoon, either she could not find something or she wanted water."

Read against the five evaluation constructs, the transcripts converge on a single mechanism. The intervention added no floor area to the dwelling; what it changed was the legibility of thresholds and the availability of elective contact. The grandmother's return to the ground floor, the grandfather's recovered morning at the long table, the son's ability to work without leaving the house, and the granddaughter's preference for the shared table over her own room all follow from one condition: each household member can now tell, without asking, where the others are and whether contact is expected.

The case also illustrates the iterative character of the model. The shelving unit was converted into a movable element only after the first intervention had been inhabited, in response to a need - the temporary compression of the boundary for family gatherings - that was not foreseeable at the design stage; and the nine-to-eleven allocation of the long table was negotiated among household members rather than specified by the designer.

5. Discussion

5.1. Rethinking Ageing-in-Place as Iterative and Relational

The findings of this study challenge the conventional conceptualisation of ageing-in-place as a static, linear trajectory from independence to dependence. Instead, the evidence supports an iterative model in which older adults continuously renegotiate their relationship with the dwelling environment in response to fluctuating physical capacities, shifting care arrangements, and evolving family compositions [7]. This perspective reframes the home not as a fixed container for ageing but as a dynamic spatial system that must accommodate periodic reconfiguration without requiring relocation. The multigenerational household emerges as a particularly instructive context for examining this iterative process, since the spatial demands of caregiving are rarely unidirectional. Reciprocal exchanges of support between generations-whether instrumental, emotional, or spatial-suggest that intergenerational interaction spaces should be designed to facilitate mutual assistance rather than to encode hierarchical dependency relationships. Consequently, spatial design strategies must prioritise adaptability, ambiguity, and renegotiability over prescriptive functional zoning. This relational understanding implies that successful ageing-in-place depends less on eliminating environmental barriers than on sustaining spatial conditions that enable ongoing negotiation among household members as their respective needs evolve over time. Read across the scenarios, these dynamics crystallise into three recurring tensions: privacy versus visibility, care versus independence, and fixed function versus temporal flexibility.

5.2. Design Implications for Layered Intergenerational Space

The design implications emerging from this study converge on a layered spatial logic in which interaction is enabled rather than mandated. As illustrated in Figure 5, the central node of Iterative Aging-in-Place is sustained by three interdependent strategies whose interaction generates the choice points and feedback loops that make the model iterative. Layered Access organizes the dwelling as a gradient from shared to private zones, allowing residents to calibrate their visibility and participation according to daily capacity [18]. Soft Boundaries, such as glazed partitions, movable screens, and acoustic buffers, modulate sensory connection without imposing physical separation, thereby preserving ambient awareness while protecting retreat. Time-Sharing Protocols introduce temporal choreography into shared facilities, enabling different generations to use kitchens, laundry, or study areas at preferred intervals and reducing friction arising from incompatible rhythms. Choice Points, positioned at transitions between zones, give older

adults and younger family members explicit control over whether to engage or withdraw. The diagram further indicates that Layered Access and Soft Boundaries feed into Choice Points, while Time-Sharing Protocols feed into Feedback Evaluation, which loops back to the central model through an adaptation mechanism. This recursive structure implies that intergenerational space cannot be fixed at the outset; it must be periodically re-tuned as mobility, care needs, and household composition evolve. Consequently, designers should treat spatial configuration as an open system, embedding adjustable elements and post-occupancy feedback loops that allow the dwelling to absorb changing intergenerational dynamics without eroding privacy or autonomy.

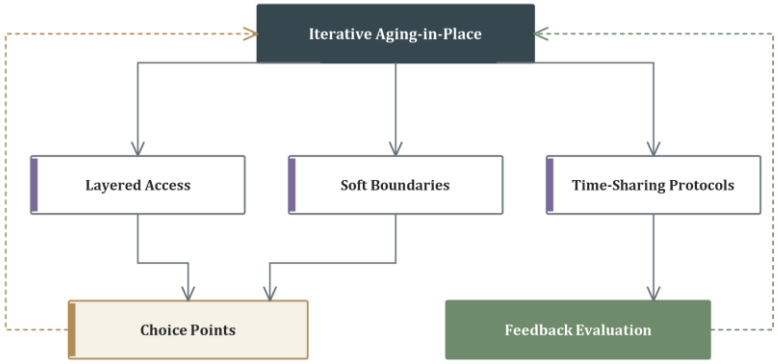

Figure 5. Summary Framework for Iterative Intergenerational Design

5.3. Limitations and Transferability

Several limitations temper the interpretive scope of this study. First, the spatial norms and intergenerational practices examined here are embedded in a specific socio-cultural context, where filial co-residence and multigenerational proximity remain relatively prevalent. The transferability of the proposed framework to contexts with weaker traditions of intergenerational cohabitation, or with fundamentally different housing tenure structures, therefore requires careful recalibration rather than direct application. Second, the evidence base is primarily qualitative and small-scale, drawing on spatial observation and design-scenario evaluation rather than large-sample quantitative validation. While this approach yields rich insight into spatial configuration and its social implications, it limits the statistical generalizability of the findings and precludes firm causal claims about the relationship between specific design features and intergenerational interaction outcomes. Third, the absence of longitudinal validation constitutes a significant constraint [10]. The framework's capacity to accommodate evolving household compositions, changing care needs, and shifting mobility profiles over extended periods remains theoretically plausible but empirically unconfirmed. Future research should prioritize longitudinal, mixed-method evaluations across diverse housing typologies-including retrofit scenarios, cohousing models, and high-density urban apartments-to test the framework's robustness and refine its parameters for broader application.

6. Conclusion

6.1. Key Findings

The findings of this study confirm that intergenerational interaction in multigenerational housing is not primarily a function of shared floor area, but rather of three interdependent spatial mechanisms: spatial sequencing, territorial choice, and temporal flexibility. Spatial sequencing-the calibrated arrangement of private, semi-private, and communal zones-was shown to govern the frequency and quality of incidental encounters between generations. Territorial choice, expressed through the provision of multiple, functionally distinct gathering nodes, enabled residents to

modulate social intensity according to changing relational needs. Temporal flexibility, achieved through adaptable partitions and convertible programmatic elements, allowed the same physical footprint to accommodate evolving household compositions and caregiving demands over time. These findings substantiate the iterative aging-in-place model as a more robust conceptual framework than static universal design approaches, demonstrating that residential environments must be understood as dynamic systems capable of continuous spatial renegotiation alongside the biological and social aging of their inhabitants.

6.2. Design and Policy Implications

The implications of this study extend across architectural practice, housing provision, and public policy. For architects, the findings suggest that multigenerational housing should be conceived not as a fixed spatial product but as an evolving system capable of accommodating shifting household compositions over time. This requires designing layered access sequences that allow semi-private zones to be reconfigured without disrupting core circulation, as well as adaptable common spaces whose programmatic identity can shift between communal dining, caregiving, and intergenerational play. Housing providers are encouraged to adopt modular interior partition systems and flexible service cores that reduce retrofit costs while extending functional longevity. For policymakers, the iterative aging-in-place model implies that building codes and subsidy frameworks should incentivize spatial adaptability rather than prescriptive room counts. Regulatory standards might reward dwellings with demountable partitions, adjustable acoustic separation, and barrier-free circulation that supports both young children and frail older adults. Ultimately, aligning design guidance with lifecycle flexibility can transform multigenerational housing from a static typology into a resilient social infrastructure.

6.3. Future Research Directions

Future work should prioritize longitudinal occupancy studies that track how intergenerational interaction patterns evolve across family life-course transitions and resident aging trajectories. Cross-cultural comparative research is needed to test the framework's adaptability across diverse kinship structures, housing tenure systems, and climatic contexts. Participatory design methodologies warrant deeper investigation, particularly regarding how co-design processes involving children, adults, and older adults can generate context-sensitive spatial configurations. Finally, the post-occupancy evaluation protocol specified in Section 3.4 should be applied to measure behavioral, psychological, and physiological outcomes of intergenerational spaces, enabling evidence-based refinement of the iterative aging-in-place model across varied multigenerational housing typologies.

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