

Residential Environments and Healthy Ageing: The Fit Between Homes and Diverse Ageing Trajectories

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Abstract. In the contemporary demographic context and in view of policy priorities promoting ageing in place, it has become crucial to understand how residential environments can either foster or undermine healthy ageing. Older adults face a wide range of health conditions, leading to diverse residential needs. Housing adapted to these requirements is a key factor in supporting ageing in place, a goal shared by both older people and policymakers, particularly in order to reduce pressure on care facilities. While an extensive body of literature highlights the importance of safe and accessible living environments for older adults, it is also widely recognised that remaining active and engaging in stimulating physical activity is fundamental for healthy ageing.

This mixed-methods cross-sectional study therefore examines: (1) how the stimulating and safety-related features of the home are interrelated and associated with different housing typologies; and (2) whether links can be identified between various health profiles and housing typologies.

Data was collected from 150 participants aged 75 and over, using paper-based or online questionnaires designed by the research team to assess health status and living environments. Stimulation and safety scores for each habitat were derived from those “the living environment” questionnaires, which items had been previously weighted by an interdisciplinary panel of experts. Stimulation and safety scores for the 150 habitats were first analysed jointly through correlation analysis and categorisation within a safety–stimulation matrix, in which housing typologies were mapped. Health profiles were further examined across five housing typologies using comparative analyses and cross-tabulations. Finally, each model was then subjected to an exploratory interpretative analysis with a view to enhancing comprehension of

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the results concerning safety–stimulation configurations and thematic patterns combining health statuses and housing typologies.

The present paper highlights preliminary trends, including the finding that, despite their apparent contradictions, stimulating and safe environments can coexist, provided an appropriate balance is maintained, and that no single housing typology can meet the needs of all older adults. The findings of this study call into question the conventional view that small, single-storey and secure housing is universally suitable for healthy ageing in place. Instead, the emphasis is placed on the necessity to transcend a uniform approach and to formulate residential strategies that are more nuanced and necessarily multiple in nature, this way answering the wide range of ageing trajectories.

Keywords. Healthy ageing, Ageing in place, Housing Typologies

1. Introduction

Over the past four decades, surveys have consistently shown that older adults strongly prefer to remain in their homes and neighbourhoods while maintaining as much independence as possible, despite potential challenges related to functional capacity and psychological well-being [1, 2]. Nevertheless, some older individuals recognise that relocation may eventually become unavoidable.

Since the 1990s, policies in many European countries have increasingly promoted the concept of ageing in place [1]. From the early 2000s onwards, this approach has progressively developed into a major global paradigm in ageing policy, as reflected in the growing body of academic research on the topic [3]. Widely endorsed by both individuals and governments [4], this model enables older adults to maintain familiar environments and social networks [5]. It is also associated with additional benefits, notably being considered a more cost-efficient approach to ageing and aligning with a key objective of ageing policy: reducing reliance on nursing homes [6].

However, barriers to ageing in place are often associated with the progressive health decline that accompanies ageing. This can alter older adults' environmental needs and make their homes less suitable [5]. The relationship between ageing and the home environment is therefore bidirectional, with the physical environment recognised as one of the six key determinants of healthy and active ageing [5]. An inadequate environment, lacking accessibility or safety features can create barriers to mobility, exacerbating health issues and restricting autonomy. Conversely, age-related biological and functional changes can make home maintenance increasingly challenging, especially given an ageing housing stock and limited retirement income [5, 6, 7]. As functional capacities decline, older adults increasingly rely on their physical environment to compensate for mobility limitations. In order to meet individuals' evolving needs, it is thus crucial to create safe, accessible and supportive living environments that promote autonomy, quality of life and physical activity. This also emphasises the importance of aligning well-designed spaces with healthcare services [7, 8].

The living environment is recognised as having an impact on healthy ageing, especially with regard to its influence on physical and mental health [9], [10]. This is particularly relevant for people who spend a large part of their time at home, up to 90% for older people [2, 10]. At the same time, older populations face an increased risk of leading inactive lifestyles. Ageing is often linked to reduced physical activity, mobility, and functional independence, as well as increased multi-morbidity risks [11]. However, maintaining physical capacity is widely recognised as essential for healthy ageing [12].

Regular physical activity provides a range of physiological and psychological benefits, such as improved cardiovascular and bone health, reduced risk of falls, and preservation of cognitive function and mental well-being [13]. Beyond these health benefits, participation in physical and recreational activities may also encourage social interaction, further contributing to overall well-being. Consequently, promoting physical activity and reducing sedentary behaviour among older adults has become a major public health priority [14]. More broadly, policymakers, healthcare professionals and the general public are increasingly recognising active lifestyles as a key factor in preserving physical and cognitive functioning throughout the ageing process [13]. In summary, ageing in place is a dynamic process that encompasses the key aspects of independent and active living, as well as a good quality of life, all of which are crucial for the well-being of older adults [7].

This study has therefore two main objectives. Firstly, it aims to examine the relationship between the safety and stimulation levels in the living environments of older adults, and to study how these relationships may vary across different housing typologies. Secondly, it will investigate whether distinct profiles of older adults are associated with these typologies. We hypothesise that environments that provide sufficient safety (essential for healthy ageing in place) may also offer opportunities for physical stimulation, which are crucial for maintaining health and autonomy. The design characteristics and maintenance demands of specific housing typologies may influence how safety and stimulation are experienced by residents.

2. Methodology

Firstly, a cohort of 150 people aged 75 and over was formed. Participants were recruited in such a way as to ensure maximum representativeness of the Walloon population in Belgium in terms of socio-demographic characteristics and diversity of existing housing typologies. Recruitment criteria included gender, age, housing types, residential complex type, length of occupancy, occupancy status, household composition, and socio-economic (Table 1).

Table 1. Inclusion and exclusion criteria.

Criteria	Inclusion criteria	Exclusion criteria
Age	≥ 75 years	< 75 years
Housing types	Private housing	Institutional housing (e.g. serviced residences, residential care homes, nursing homes)
Length of occupancy	≥ 2 years	< 2 years
Physical mobility	Able to move independently without using a wheelchair	Uses a wheelchair
Self-reported cognitive function	Mild to moderate cognitive impairment with preserved functional autonomy	Severe cognitive impairment leading to significant dependence and a substantial impact on daily life
Visual function	Functional vision sufficient for activities of daily living	Visually impaired or blind
Chemotherapy	No	Yes

We decided to recruit older adults aged 75 years and over. Previous research shows that the willingness to move house decreases with age, a phenomenon particularly marked among individuals aged 75 and over [15]. However, declining health, which tends to accelerate after this age, remains a major factor prompting relocation at any stage of later life [15]. Furthermore, as age increases, we encounter a growing diversity of older adults' profiles. Studies have demonstrated greater dispersion in cognitive abilities among very old adults (aged 75–92 years) [16]. This heterogeneity is also observed in physiological functions [17] and extends to behavioural, social and health dimensions [18]. Focusing on participants aged 75 and over therefore aimed to capture the wide diversity of situations and needs specific to older adults.

Data were collected from the study participants using paper-based or online questionnaires, which included questions on their socio-demographic characteristics, health status, and living environment. The items considered throughout the “living environment” part of the questionnaire (covering both the dwelling and the neighbourhood) had previously been weighted by an interdisciplinary panel of ageing experts during an earlier phase of the study, and submitted elsewhere for publication [19]. As the questionnaires were self-administered, potential reporting biases should be considered when interpreting the results. This process enabled the derivation of global physical stimulation and safety scores for each participants' living environment. The global scores of each living environment were calculated by combining the dwelling score with the neighbourhood score.

The original sample consisted of 150 participants. However, after data cleaning procedure, the analyses were conducted on 132 filled questionnaires. Several participants were excluded for various reasons (Figure 1). One participant was 73 years old and therefore did not meet the inclusion criteria (≥ 75 years). Five participants had more than 20% missing responses (coded as “NAVU” for not available) in the questionnaire and were excluded due to the substantial amount of missing data, which could affect the reliability and interpretation of the responses. Finally, twelve participants presented aberrant or missing values in the variables required for the analyses of this study.

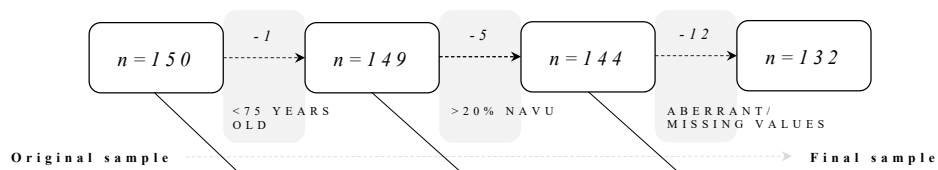


Figure 1. Flowchart of the sample selection process.

First, the variables of interest for this study were identified and classified as either categorical or continuous variables. The categorical variables included gender, education level, housing status, household composition, type of residential area, housing type, and self-reported health. Continuous variables included age, physical stimulation scores, and safety scores.

For categorical variables, frequency distributions were calculated to describe the number and percentage of participants in each category. For continuous variables, normality was

assessed using several criteria: comparison of the mean and median, inspection of histograms and boxplots, examination of Q–Q plots, and, when necessary, the Shapiro–Wilk test. Based on these assessments—commonly used for investigating the normality—, variables were classified as parametric or non-parametric, and descriptive statistics were reported accordingly (means for parametric variables and medians for non-parametric variables). Assessing normality is necessary for subsequent analyses, as the distribution of the variables determines the choice of appropriate statistical tests. The next step involved a comparative analysis of participants’ physical stimulation and safety scores, examined at three levels: global habitat, dwelling, and neighbourhood. The global score corresponds to the sum of the dwelling and neighbourhood scores. To ensure comparability across measures, raw scores were transformed into z-scores, calculated *“by subtracting the mean from a data value and then dividing by the standard deviation”* [20]. Z-scores therefore provide a standardized measure of how far each observation deviates from the sample mean [20]. These standardised scores were used to construct a two-dimensional “physical stimulation – safety” matrix, with physical stimulation represented on the x-axis and safety on the y-axis. Reference lines set at zero on both axes defined four quadrants (Q1, Q2, Q3, and Q4) corresponding to relatively high or low levels of physical stimulation and safety (Figure 2).

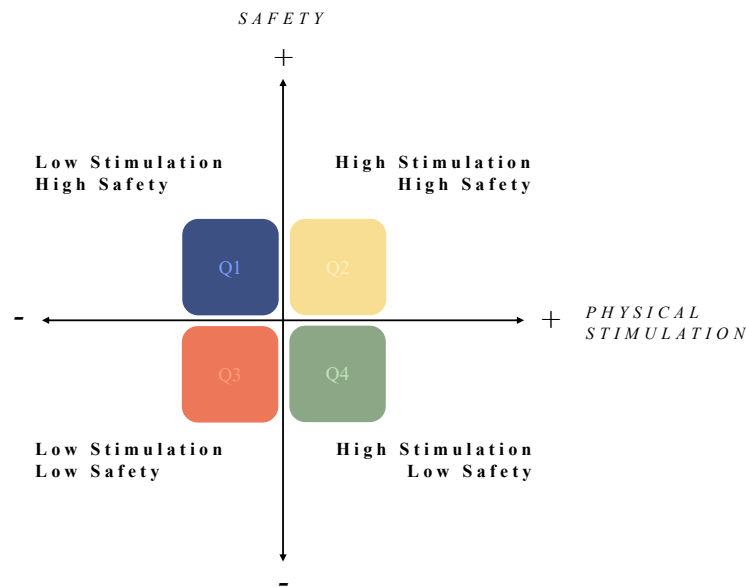


Figure 2. Two-dimensional “physical stimulation – safety” matrix.

Given the presence of three types of scores (global, dwelling, and neighbourhood), three separate matrices were constructed. In each matrix, the living environment of each participant were positioned according to their physical stimulation and safety z-scores and subsequently assigned to one of the four quadrants. Consequently, each participant was classified into a specific quadrant for each level of analysis.

As each participant was assigned to a quadrant for each matrix, we examined whether the observed distribution of participants across the quadrants differed from the expected uniform distribution. Assessing this distribution is important, as substantial imbalances between quadrants could affect the interpretability and robustness of subsequent analyses based on these groups. To this end, chi-square goodness-of-fit tests were conducted separately for each matrix. The assumptions of the test were verified beforehand to ensure that its use was appropriate: expected frequencies exceeded 5 in at least 80% of cells, and none were below 1. A $p\text{-value} \leq 0.05$ indicates a distribution significantly different from uniform, reflecting over- or under-representation of certain quadrants. Conversely, a $p\text{-value} > 0.05$ suggests that the observed distribution does not differ significantly from uniform, indicating a balanced allocation of participants across quadrants within the matrix.

Spearman's rank correlation was used to examine associations between physical stimulation and safety z-scores at the global, dwelling, and neighbourhood levels. This non-parametric method was chosen because one or both variables at each level were non-normally distributed, and it assesses monotonic relationships without assuming linearity. Correlation coefficients (ρ) and their associated p-values were reported, with a significance threshold of $p < 0.05$. A p-value below this threshold was considered indicative of a statistically significant association between the variables. Spearman's ρ measures the strength and direction of a monotonic relationship, with values ranging from -1 to 1: $\rho = 0$ indicates no correlation, $\rho > 0$ indicates a positive correlation (both variables increase together), and $\rho < 0$ indicates a negative correlation (one variable increases while the other decreases).

A Chi-square test of independence was conducted to examine the distribution of different housing typologies across the quadrants of the global and dwelling matrices. The neighbourhood matrix was excluded from this analysis because neighbourhood scores reflect general environmental characteristics, whereas housing typologies relate more specifically to certain characteristics of individual dwellings. Focusing on the dwelling level allows for an assessment of potential associations that are more conceptually coherent and interpretable. For this analysis, the "lightweight house" typology ($n = 1$) was excluded due to insufficient frequency for the calculation of expected counts, although descriptive statistics still include this category. The assumptions of the test were verified beforehand to ensure that its use was appropriate. If the Chi-square test is significant ($p \leq 0.05$), the null hypothesis of independence is rejected, indicating a significant association between the variables. Conversely, if $p > 0.05$, no significant association is detected.

When significant associations between housing typologies and quadrants were detected through the Pearson's chi-square test, standardised residuals were examined. This allows the identification of which cells of the contingency table contributed most to the typology-matrix association, thereby highlighting housing typologies that were significantly over- or under-represented within specific matrix quadrants. Values with $|\text{residual}| \geq 1.96$ ($\approx 5\%$ significance level) were considered significant contributors to the association; $r \geq 2$ indicates significant over-representation, while $r \leq -2$ indicates significant under-representation.

Finally, a chi-square test of independence was conducted to examine the association between self-reported health status and housing typology. The assumptions of the test were verified beforehand to ensure that its use was appropriate: expected cell frequencies exceeded 5 in at least 80% of the cells, and none were below 1. The same analysis was

subsequently performed to assess the association between the global matrix quadrants and self-reported health status. Statistical analyses were performed using Rcmdr, a statistical software for data processing and analysis.

3. Results

3.1. Descriptive Statistics

Descriptive statistics for the sample are presented first (Table 2). The median age of participants was 79 years (IQR 77–82), indicating a relatively homogeneous sample of older adults in advanced age. This could limit the variability in health status and potentially include more participants in poor health. However, the majority of the sample (93%) reported being in good to excellent health based on self-reported responses, which does not reflect the usual heterogeneity of health status observed in the older population. As mentioned in the “Limitations” section, these results may be affected by volunteer and social desirability biases. Nearly half of participants lived alone (45%), reflecting common living arrangements among older adults and potentially influencing daily interaction with the residential environment.

Participants were relatively evenly distributed across rural, peri-urban, and urban areas, providing variability in environmental contexts. The various individual housing typologies represented suggest variability in residential built environments, which is important for our further analysis.

Our sample also appears to have a high level of education, with 62% holding a bachelor's, master's, or doctoral degree. Educational attainment in Belgium has increased markedly over the past four decades and, for instance, in 2024, around half of younger adults (25–34 years) hold a tertiary education degree, a proportion higher than in older cohorts [21]. This suggests that the educational level observed in our sample is relatively high.

Most participants were homeowners (75%), which is higher than the Belgian (67%) and Walloon (65%) averages [22], but still unsurprising for an older adult cohort (e.g. [23]). The high level of education and high proportion of homeowners may indicate a socioeconomically advantaged sample, which should be considered when interpreting certain results.

Table 2. Descriptive characteristics of the study sample (n = 132).

Variable	Results, n (%) or median (P25–P75)
Gender	
Male	59 (45%)
Female	73 (55%)
Age (years)	79 (77–82)
Education level	
Low education (none + primary)	2 (2%)
Secondary education	43 (33%)
Higher education (Bachelor's + Master's + Doctorate)	82 (62%)
Other	5 (4%)
Housing status	
Owner	99 (75%)
Tenant	25 (19%)
Usufructuary	6 (5%)
Other	2 (2%)
Household composition	
Living alone	59 (45%)
Living with others	73 (55%)
Type of residential area	
Rural	48 (36%)
Peri-urban	44 (33%)
Urban	40 (30%)
Housing type	
Apartment (Appartement)	45 (34%)
Terraced houses (Bâti mitoyen)	23 (17%)
Semi-detached houses (Bâti semi-mitoyen)	25 (19%)
Detached houses (Bâti ouvert)	38 (29%)
Lightweight Houses (Habitat léger)	1 (1%)
Self-reported health (question from SF_12)	
Poor (Mauvaise)	2 (2%)
Fair (Médiocre)	8 (6%)
Good (Bonne)	87 (66%)
Very good (Très bonne)	29 (22%)
Excellent (Excellente)	6 (5%)

3.1.1. Physical Stimulation and Safety Scores

The following section focuses on the overall living environment scores of all 132 participants (Table 3). The median global physical stimulation score was 408 (IQR 348–498), with values ranging from 198.40 to 902.20, reflecting substantial variability among participants. The apparent maximum value was driven by an outlier; when this observation was excluded, the range in the corresponding global z-score was reduced to approximately -2.17 to 2.07 (Figure 3). After accounting for this outlier, most participants were clustered around the median, indicating that physical stimulation levels were moderately concentrated near the central tendency while a few individuals had notably higher or lower scores. Global safety scores showed a similar pattern: the mean score was 303 (SD 163), with a wide range from -106.80 to 728.55 . Most participants fell within approximately one standard deviation of the mean, suggesting that safety levels were relatively consistent for the majority, although some participants reported substantially higher or lower safety scores. Overall, there was substantial variability in both physical stimulation and safety scores across participants, although most individuals' values were concentrated around the sample's central tendency.

Table 3. Physical stimulation and safety scores of older adults' living environments (n = 132).

Matrix	Variable	Results*, mean (sd) or median (P25–P75)	Range (min–max)
Physical stimulation scores	Global score	408 (348–498)	198.40–902.20
	Global z-score	−0.18 (−0.76–0.67)	−2.17–4.50
	Dwelling score	141 (93–179)	19.90–376.00
	Dwelling z-score	0.06 (−0.76–0.70)	−1.99–4.02
	Neighbourhood score	287 (80.23)	138.60–526.20
	Neighbourhood z-score	0.04 (0.99)	−1.80–3.00
Safety scores	Global score	303 (163)	−106.80–728.55
	Global z-score	0.00 (1.00)	−2.52–2.61
	Dwelling score	188 (130–247)	−32.45–666.60
	Dwelling z-score	−0.10 (−0.68–0.49)	−2.31–4.69
	Neighbourhood score	88 (34–172)	−215.15–438.60
	Neighbourhood z-score	−0.12 (−0.58–0.60)	−2.70–2.87

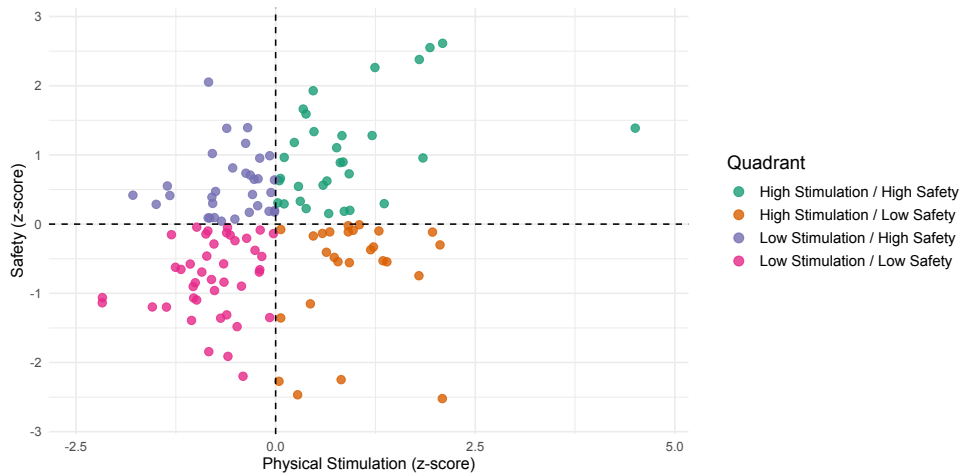


Figure 3. Distribution of global z-scores in the two-dimensional “physical stimulation – safety” matrix.

3.2. Distribution of Participants across Matrices

Afterwards, chi-square goodness-of-fit tests were conducted to assess whether the observed distribution of participants across the four matrix quadrants differed from a uniform distribution (Table 4). Participants were evenly distributed across the quadrants of all three matrices. The global ($p = 0.5272$) and dwelling ($p = 0.7771$) matrices showed no evidence of over- or underpopulated quadrants. The neighbourhood matrix exhibited a slightly lower p-value ($p = 0.132$), suggesting a minor tendency for Q3 (LoSt; LoSa) to be more populated and Q4 (HiSt; LoSa) less so, but the distribution was not

significantly different from uniform. Overall, the balanced distribution across quadrants provides a useful basis for subsequent comparisons with housing typologies or other variables. In other words, observed distribution across the quadrants didn't differ from the expected uniform distribution, thus allowing for robust analysis of other parameters.

Tableau 4. Chi-square goodness-of-fit test assessing the distribution of participants across matrix quadrants (n = 132).

Matrix	Q1	Q2	Q3	Q4	p-value
Global matrix	32 (24.24%)	31 (23.48%)	43 (32.58%)	26 (19.70%)	0.5272
Dwelling matrix	27 (20.45%)	33 (25.00%)	39 (29.55%)	33 (25.00%)	0.7771
Neighbourhood matrix	21 (15.91%)	39 (29.55%)	45 (34.09%)	27 (20.45%)	0.132

Legend. Q1: low stimulation – high safety; Q2: high stimulation – high safety; Q3: low stimulation – low safety; Q4: high stimulation – low safety. Values are presented as n (%) in each quadrant.

3.3. Correlation Analysis between Safety and Physical Stimulation Z-Scores

We next explored the correlations between safety and physical stimulation z-scores (Table 5). A weak but statistically significant positive correlation was observed at the global level ($\rho = 0.289$, $p < 0.001$), while a moderate positive correlation was found at the neighbourhood level ($\rho = 0.436$, $p < 0.001$). No significant correlation was detected at the dwelling level ($p = 0.115$). These results suggest that environments with higher physical stimulation tend to also exhibit higher safety scores, particularly at the neighbourhood scale.

Table 5. Spearman correlation between physical stimulation and safety z-scores.

Variable	Spearman's ρ	p-value
Global physical stimulation x safety	0.289	0.00076***
Dwelling physical stimulation x safety	0.138	0.115
Neighbourhood physical stimulation x safety	0.436	<0.001***

*** $p < 0.001$

3.4. Distribution of Housing Typologies across Quadrants Matrices

The contingency table presents the distribution of housing typologies across the quadrants of the global (Figure 4) and dwelling matrices (Table 6).

Table 6. Distribution of housing typologies across quadrants of the global and dwelling matrices (n = 131).

Matrix	Quadrant	Apartment	Semi-detached houses	Terraced houses	Detached houses	Count
Global matrix	Q1	19 (59.4%)	2 (6.2%)	5 (15.6%)	6 (18.8%)	32 (100%)
	Q2	12 (38.7%)	4 (12.9%)	5 (16.1%)	10 (32.3%)	31 (100%)
	Q3	14 (33.3%)	7 (16.7%)	7 (16.7%)	14 (33.3%)	42 (100%)
	Q4	0 (0%)	12 (46.2%)	6 (23.1%)	8 (30.8%)	26 (100%)
Dwelling matrix	Q1	20 (74.1%)	1 (3.7%)	3 (11.1%)	3 (11.1%)	27 (100%)
	Q2	2 (6.2%)	6 (18.8%)	9 (28.1%)	15 (46.9%)	32 (100%)
	Q3	22 (56.4%)	4 (10.3%)	4 (10.3%)	9 (23.1%)	39 (100%)
	Q4	1 (3.0%)	14 (42.4%)	7 (21.2%)	11 (33.3%)	33 (100%)

Legend. Q1: low stimulation – high safety; Q2: high stimulation – high safety; Q3: low stimulation – low safety; Q4: high stimulation – low safety. Values are presented as n (%).

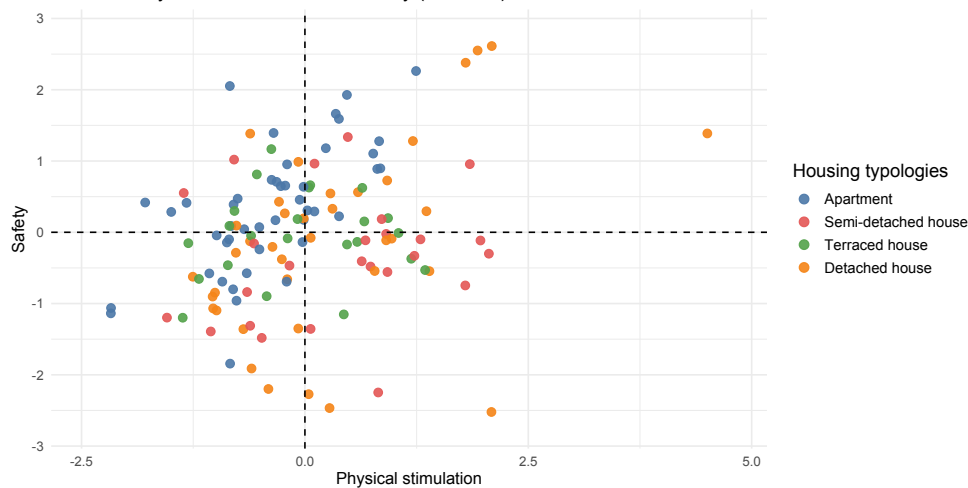


Figure 4. Distribution of housing typologies across quadrants of the global matrix (n = 131).

The distribution of housing typologies varied substantially across matrix quadrants. Apartments were predominantly located in quadrants characterised by higher perceived safety, particularly in Q1 (LoSt - HiSa) of both the global (59.4%) and dwelling matrices (74.1%). They were less represented in highly stimulating environments in both matrices. Overall, this pattern suggests that apartments are more frequently associated with environments perceived as safer but less stimulating.

In the global matrix, Q2 (HiSt – HiSa) is dominated by apartments (38.7%), whereas in the corresponding quadrant of the dwelling matrix, they were much less prevalent (6.2%). This contrast suggests that neighbourhood-level characteristics may contribute substantially to the perceived stimulation of the overall living environment. In contrast, Q4 (HiSt - LoSa) in the global matrix contained no apartments and was mostly composed of semi-detached (46.2%) and detached houses (30.8%). Detached

houses were mostly frequent in Q2 (HiSt – HiSa) in the dwelling matrix (46.9%). However, their lower proportion in the corresponding global matrix quadrant (32.3%) may indicate that neighbourhood characteristics contribute less to the stimulating character of these environments.

In the global matrix, Q3 (LoSt – LoSa) exhibited a relatively balanced distribution of housing typologies, whereas in the dwelling matrix, the majority were apartments (56.4%).

3.5. Association Analysis between Housing Typologies and Matrix Quadrants

Pearson's chi-square tests were conducted to examine the association between housing typologies and matrix quadrants. Significant associations were observed for both the global and dwelling matrix, indicating that the distribution of housing typologies differs across quadrants (Table 7). These results suggest that housing typology and matrix quadrant membership are not independent, with some housing typologies more frequently represented in specific quadrants of the matrix.

Table 7. Chi-square test of association between housing typologies and the quadrants of the global and dwelling matrices.

Matrix	χ^2	Df	p-value
Global matrix x housing typology	30.59	9	<0.001*** 0.000348
Dwelling matrix x housing typology	60.367	9	<0.001*** 0.000000001139

*** $p < 0.05$

Analysis of the standardized residuals (Table 8) allowed identification of the specific typology–quadrant combinations driving these associations. In the global matrix, apartments were significantly over-represented in Q1 (LoSt - HiSa) and under-represented in Q4 (HiSt - LoSa). Conversely, semi-detached houses were over-represented in Q4 (HiSt - LoSa) and under-represented in Q1 (LoSt - HiSa). No significant deviations were observed for terraced or detached houses. These results suggest a clear distinction between apartments, which are associated with safer and less stimulating environments, and semi-detached houses, which are more frequent in less safe and more stimulating quadrants.

In the dwelling matrix, apartments showed strong over-representation in Q1 (LoSt - HiSa) and Q3 (LoSt – LoSa), and strong under-representation in Q2 (HiSt – HiSa) and Q4 (HiSt - LoSa). Semi-detached houses were still over-represented in Q4 (HiSt - LoSa) and under-represented in Q1 (LoSt - HiSa). Detached houses were over-represented in Q2 (HiSt – HiSa) and under-represented in Q1 (LoSt - HiSa). Terraced houses did not display significant residuals in any quadrant. Overall, this pattern indicates that apartments are over-represented in environments characterised by lower stimulation and under-represented in highly stimulating environments, regardless of safety levels. Semi-detached and detached houses are more frequently represented in highly stimulating environments, but with low and high safety levels, respectively.

These findings highlight that the associations between housing typology and environmental characteristics differ between global and dwelling-level matrices, with the

dwelling matrix showing a more complex pattern of typology distribution across quadrants.

Table 8. Standardized residuals from the chi-square test examining the association between housing typologies and the quadrants of the global and dwelling matrices (n=131).

Matrix	Quadrant	Apartment	Semi-detached houses	Terraced houses	Detached houses
Global matrix	Q1	3.43	-2.13	-0.33	-1.47
	Q2	0.58	-1.00	-0.24	0.46
	Q3	-0.17	-0.48	-0.18	0.75
	Q4	-4.12	3.92	0.83	0.22
Dwelling matrix	Q1	4.88	-2.28	-0.99	-2.30
	Q2	-3.85	-0.06	1.81	2.56
	Q3	3.46	-1.67	-1.43	-0.97
	Q4	-4.38	3.94	0.64	0.63

Legend. Q1: low stimulation – high safety; Q2: high stimulation – high safety; Q3: low stimulation – low safety; Q4: high stimulation – low safety. Standardized residuals greater than ± 1.96 indicate statistically significant over- or under-representation ($p < 0.05$).

3.6. Distribution of Health Status across Housing Typologies

Self-reported health status was broadly similar across housing typologies (Table 9). The majority of participants in all housing types reported “Good” or “Very good” health, with no statistically significant differences observed between housing typologies (p -value > 0.05 ; Table 10). Overall, these results suggest that housing typology is not meaningfully associated with self-reported health in this sample, the small differences observed could be due to chance.

Table 9. Distribution of self-reported health status across different housing typologies (n = 131).

		Self-reported health				
		Poor	Fair	Good	Very good	Excellent
Housing typologies	Apartment	2 (4.4%)	3 (6.7%)	30 (66.7%)	9 (20.0%)	1 (2.2%)
	Semi-detached houses	0 (0.0%)	0 (0.0%)	17 (68.0%)	6 (24.0%)	2 (8.0%)
	Terraced houses	0 (0.0%)	1 (4.3%)	16 (69.6%)	4 (17.4%)	2 (8.7%)
	Detached houses	0 (0.0%)	4 (10.5%)	23 (60.5%)	10 (26.3%)	1 (2.6%)
		Count				
		45 (100%)	25 (100%)	23 (100%)	38 (100%)	

Legend. Values are expressed as n (%).

Table 10. Chi-square test of association between self-reported health and housing typologies (n = 131).

Variables	χ^2	df	p-value
Self-reported health x housing typology	9.954	12	0.62

3.7. Distribution of Health Status across Matrix Quadrants

The distribution of self-reported health profiles across the quadrants of the global matrix was examined (Table 11). The Chi-square test of independence indicated that there was no statistically significant association between the quadrant of the global matrix and self-reported health status ($p = 0.328 > 0.05$; Table 12).

Table 11. Distribution of self-reported health across quadrants of the global matrix (n = 131).

Quadrant	Poor	Fair	Good	Very good	Excellent	Count
Q1	0 (0.0%)	3 (9.4%)	22 (68.8%)	7 (21.9%)	0 (0.0%)	32 (100%)
Q2	0 (0.0%)	0 (0.0%)	19 (61.3%)	9 (29.0%)	3 (9.7%)	31 (100%)
Q3	2 (4.8%)	4 (9.5%)	26 (61.9%)	9 (21.4%)	1 (2.4%)	42 (100%)
Q4	0 (0.0%)	1 (3.8%)	19 (73.1%)	4 (15.4%)	2 (7.7%)	26 (100%)

Legend. Q1: low stimulation – high safety; Q2: high stimulation – high safety; Q3: low stimulation – low safety; Q4: high stimulation – low safety. Values are expressed as n (%).

Table 12. Chi-square test of association between the quadrants of the global matrix and self-reported health (n = 131).

Variables	χ^2	df	p-value
Self-reported health x global matrix	13.586	12	0.328

4. Discussion

As already mentioned, this study has two main objectives. The primary is to examine the relationship between safety and stimulation levels in the living environments of older adults, and to investigate how these relationships may differ across various housing typologies. The second investigate whether distinct profiles of older adults are associated with these typologies. To this end, physical stimulation and safety scores of the living environment were obtained for 132 older adults and combined to construct a four-quadrant matrix (Figure 1). These scores were computed at three spatial scales (global habitat, dwelling, and neighbourhood) with the global score corresponding to the sum of

the dwelling and neighbourhood scores. The discussion focuses on two principal findings and addresses two limitations of the study.

Firstly, we will discuss the relationship between stimulation and safety scores across three spatial scales. The results indicate that safety and physical stimulation scores are positively correlated at the global level. However, this association appears to be largely driven by the moderate correlation observed at the neighbourhood level, as no significant relationship was identified at the dwelling level. These findings suggest that, at the neighbourhood scale, environments perceived as safer tend to offer greater opportunities for physical stimulation and vice versa. This pattern is consistent with the idea that safe neighbourhoods encourage older adults to engage in outdoor activities such as walking, shopping, or visiting parks, thereby increasing opportunities for physical stimulation [24, 25]. However, the systematic review by Van Cauwenberg et al. [25], also highlights that neighbourhood safety can be influenced by multiple environmental characteristics, some of which are not directly related to physical activity. In the present study, neighbourhood characteristics were grouped together into composite measures and examined collectively in the correlation analysis. Consequently, the observed association between safety and physical stimulation reflects the combined influence of multiple environmental factors rather than the effect of individual characteristics.

By contrast, safety and physical stimulation appear to be largely independent at the dwelling level. A safe dwelling does not necessarily provide a stimulating environment, and a stimulating dwelling does not necessarily guarantee safety. The private dwelling environment could offer less opportunities for physical activity, which may partly explain the absence of correlation at this scale. Nevertheless, a safe and well-adapted dwelling can support older adults by reducing environmental hazards and barriers, thereby lowering fall risk and promoting functional independence and continued activity [26, 27]. In this context, certain dwelling characteristics may simultaneously contribute to both safety and physical stimulation. Conversely, some features that promote physical activity may also be perceived as potential hazards (e.g. stairs), thereby increasing perceptions of insecurity within the dwelling. This tension between safety and activity-supportive features may partly explain the absence of a correlation between these two dimensions at the dwelling level.

Further investigation of the specific dwelling elements included in the assessment could help identify which characteristics contribute to both safety and physical stimulation, or alternatively promote one dimension at the expense of the other. Extending this type of analysis to the neighbourhood level may also provide additional insight into the drivers of these correlations at both micro- and macro-scales. Importantly, the absence of a significant correlation at the dwelling level should not be interpreted as evidence that dwellings cannot simultaneously provide both safety and physical stimulation. Rather, this finding may reflect the complex balance between environmental demands and individual capacities, as highlighted by the ecological theory of ageing of Lawton and Nahemow, which emphasises the importance of achieving an appropriate fit between the environment and the individual to support optimal functioning in later life [28].

Secondly, we will address the relationship between housing typologies and matrix quadrants by analysing how they are distributed within the global and dwelling matrices. Only these two matrices were included in the analysis, since housing typologies relate more specifically to characteristics of individual dwellings, whereas the global matrix serves as a comparative reference. Importantly, the analysis of standardized residuals was used to identify typology–quadrant combinations driving associations between

housing typologies and matrices. In other words, residuals indicate whether a housing typology is over- or under-represented in a quadrant compared with what would be expected under independence, highlighting statistically meaningful deviations rather than simple descriptive majorities. The general results suggest that housing typology and matrix quadrant membership are not independent, with some housing typologies more frequently represented in specific quadrants of the matrix.

To begin with, the results show that apartments are predominantly located in low-stimulation, high-safety environments in both matrices, which is not particularly surprising. However, in the dwelling matrix, apartments are markedly over-represented in both low-safety and high-safety, low-stimulation environments. This suggests that apartments, as a typology considered independently of the wider neighbourhood context, can indeed provide a certain degree of safety but may also result in the opposite. These findings challenge the common assumption that this typology is inherently well-suited to older adults due to its perceived safety.

Furthermore, we observe that the same typology is neither over- nor under-represented, but is predominantly found in high-stimulation, high-safety environments in the global matrix. This predominance decreases drastically in the dwelling matrix. This indicates that the neighbourhood context may have a strong influence on the stimulating character of the environment. Since individuals living *“in apartments spend less time engaging in domestic physical activity and more time engaging in sedentary behaviour than those living in houses”* [29] (p.2), a stimulating neighbourhood can help compensate for the lack of activity within the dwelling itself. When considering a living environment suitable for older adults, it should not be understood solely as an adapted dwelling; the neighbourhood itself also plays a significant role [30]. We also note that apartments are never found in environments characterised by both high stimulation and low safety. These variabilities support the idea that physical stimulation and safety are not correlated at the dwelling level, as observed previously, but can nonetheless coexist.

Next, environments characterised by high stimulation and low safety predominantly consist of detached and semi-detached houses, which is not unexpected. However, the global matrix reveals that most detached houses are located in low-stimulation, low-safety environments, whereas the dwelling matrix shows that the majority are found in high-stimulation, high-safety environments. The shift in predominance between conceptually opposite quadrants when neighbourhood scores are removed implies that the neighbourhood environment can negatively influence both stimulation and safety of the global living environment. It would be worthwhile to investigate the types of residential complexes (urban, semi-urban, rural) underlying these results to understand how they are distributed across the matrix and their potential influence on neighbourhood scores. While typologies reflect dwelling scores, residential complexes may account for neighbourhood scores.

Regarding detached houses in the dwelling matrix, they are over-represented in environment characterised by simultaneously high stimulation and high safety, which may contradict general assumptions. This suggests that a detached house can offer a balance of safety and stimulation and, notably given sufficient physical, cognitive, and financial resources—even at an advanced age—this typology can provide a viable option for ageing well in place, potentially avoiding unnecessary relocation.

Finally, in the dwelling matrix, semi-detached houses are over-represented in environments with high stimulation and low safety and under-represented in the conceptually opposite quadrant. Examining the specific features of this typology that

affect safety would be valuable, with the aim of identifying the factors that consistently contribute to its lower safety scores in this study.

4.1. Limitations

The first limitation concerns the characteristics of the study sample. Participants were recruited among adults aged 75 years and over in order to capture a heterogeneous population in terms of health status. However, the sample is mostly healthy, as reflected in the results. This may be partly explained by volunteer bias¹, which is commonly observed in studies involving community-dwelling older adults. Indeed, individuals who agree to participate in research studies are often healthier and more physically active than those who do not (e.g. [31]). Furthermore, the relatively high educational level of the sample may have reinforced this bias, as higher participation rates among more educated individuals have also been documented in previous research [31]. Social desirability bias² may also have played a role, as the variable used to assess participants' health status, as well as the dwelling and the neighborhood characteristics, relied on a single self-reported question. These biases may have influenced the absence of a clear association between housing typologies and health status and between matrix quadrants at the global level and health status. Importantly, this does not necessarily imply that no association exists between these variables, but rather that the low variability in health status of the sample and/or the way health was measured may not have been optimal for examining such relationships. Future research could address this limitation by incorporating additional or more objective measures of health rather than relying solely on a single self-reported question. Conversely, social desirability bias may also have influenced the dwelling and neighbourhood scores, as individuals' attachment to their home and neighbourhood can affect how positively or negatively they evaluate these environments.

The second limitation relates to the methodological approach adopted for constructing the four-quadrant matrix. There was substantial variability in both physical stimulation and safety scores across participants, although most individuals' values were concentrated around the central tendency of the sample. This should be kept in mind when interpreting the classification of environments into four quadrants. Because the quadrant boundaries are defined by cut-off points, two living environments with very similar numerical scores may fall into different quadrants and therefore be interpreted as conceptually distinct. Such categorisation inevitably simplifies the underlying continuous variation and may lead to a loss of information or to artificial distinctions between cases that are, in practice, very similar. Nevertheless, the quadrant-based approach provides a useful analytical framework for exploring the joint distribution of physical stimulation and safety within residential environments. Structuring the data into distinct profiles facilitates the identification of broader environmental patterns and supports the interpretation of multidimensional environmental characteristics. In this sense, the matrix should primarily be understood as an exploratory tool that helps visualise and interpret complex environmental configurations, rather than as a strict typology of distinct categories.

5. Conclusion

We can assert that there is a clear relationship between a secure and physically stimulating environment at the neighbourhood level. No correlation was detected

between these two concepts at the dwelling level, although both can coexist in apartments as well as houses. However, there is indeed an association between housing typologies and the levels of stimulation and safety within the dwelling itself. This suggests that housing typologies influence opportunities for physical activity—not necessarily in the form of formal exercise, but through activities related to daily tasks and leisure. Given that older adults spend the majority of their time at home, it is encouraging that their living environment can support engagement in physical activity, which is essential for healthy ageing. Our findings also indicate that housing typologies are linked to occupants' experiences of safety. No association was observed between housing typology and health status. Future research should consider alternative indicators to define health or recruit a more diverse sample in terms of health profiles, in order to more conclusively examine the relationship between housing typology and health outcomes. Moreover, a stimulating neighbourhood may help compensate for dwellings that are less conducive to physical activity, highlighting the importance of considering both dwelling and neighbourhood contexts in promoting ageing well-in-place.

Endnotes

¹ “Self-selection bias (also called volunteer bias) refers to the bias that can occur when individuals are allowed to choose whether they want to participate in a research study. Because participants often differ from nonparticipants in ways significant to the research, self-selection can lead to a biased sample and affects the generalizability of your results.” [32].

² “Social desirability bias occurs when respondents give answers to questions that they believe will make them look good to others, concealing their true opinions or experiences. It often affects studies that focus on sensitive or personal topics, such as politics, drug use, or sexual behavior. Study participants have a tendency to answer questions in such a way as to present themselves in socially acceptable terms (...). It is especially likely in self-report questionnaires (...).” [33].

References

- [1] A. Chatterjee, Éd., *Architectures of Ageing in Place*. London: Routledge, 2025. doi: 10.4324/9781003437918.
- [2] S. M. Trecartin et S. M. Cummings, « Systematic review of the physical home environment and the relationship to psychological well-being among community-dwelling older adults », *J Gerontol Soc Work*, vol. 61, n° 5, p. 567-582, juill. 2018, doi: 10.1080/01634372.2018.1463339.
- [3] S. Wong, « Beyond the logic of promoting independent living of older adults », *Australasian Journal on Ageing*, vol. 42, n° 1, p. 6-7, 2023, doi: 10.1111/ajag.13173.
- [4] F. Zhang, A. Chan, A. Darko, et D. Li, « BIM-enabled multi-level assessment of age-friendliness of urban housing based on multiscale spatial framework: enlightenments of housing support for “aging-in-place” », *SUSTAINABLE CITIES AND SOCIETY*, vol. 72, sept. 2021, doi: 10.1016/j.scs.2021.103039.
- [5] A. A. Ajani et D. T. Olapade, « Building design considerations for healthy and active aging-in-place », *International Journal of Building Pathology and Adaptation*, vol. 43, n° 6, p. 1466-1481, janv. 2024, doi: 10.1108/IJBPA-05-2023-0069.

- [6] K. Lawler, « Aging in Place: Coordinating Housing and Health Care Provision for America's Growing Elderly Population | Joint Center for Housing Studies », 2001.
- [7] J. E. B. Xia, Q. Chen, L. Buys, C. Susilawati, et R. Drogemuller, « Impact of the Built Environment on Ageing in Place: A Systematic Overview of Reviews », *Buildings*, vol. 14, n° 8, p. 2355, août 2024, doi: 10.3390/buildings14082355.
- [8] Y. K. G. Chu, J. Kaldenberg, et K. Huefner, « The Elder's Right to Sight Collaborative: A new model of eye care delivery for the elderly », *Optometry - Journal of the American Optometric Association*, vol. 80, n° 11, p. 651-656, nov. 2009, doi: 10.1016/j.optm.2009.03.019.
- [9] WHO - World Health Organization, *World Report on Ageing and Health*. World Health Organization, 2015.
- [10] S. Fox, L. Kenny, M. R. Day, C. O'Connell, J. Finnerty, et S. Timmons, « Exploring the Housing Needs of Older People in Standard and Sheltered Social Housing », *Gerontol Geriatr Med*, vol. 3, p. 2333721417702349, avr. 2017, doi: 10.1177/2333721417702349.
- [11] C. Cunningham, R. O' Sullivan, P. Caserotti, et M. A. Tully, « Consequences of physical inactivity in older adults: A systematic review of reviews and meta-analyses », *Scandinavian Journal of Medicine & Science in Sports*, vol. 30, n° 5, p. 816-827, 2020, doi: 10.1111/sms.13616.
- [12] L. Donath, O. Faude, R. Roth, et L. Zahner, « Effects of stair-climbing on balance, gait, strength, resting heart rate, and submaximal endurance in healthy seniors », *Scandinavian Journal of Medicine & Science in Sports*, vol. 24, n° 2, p. e93-e101, 2014, doi: 10.1111/sms.12113.
- [13] L. A. Brooks-Cleator et J. P. Lewis, « Alaska Native Elders' Perspectives on Physical Activity and Successful Aging », *Canadian Journal on Aging / La Revue canadienne du vieillissement*, vol. 39, n° 2, p. 294-304, juin 2020, doi: 10.1017/S0714980819000400.
- [14] WHO - World Health Organization, « Active ageing - Physical activity promotion in older adults ». Consulté le: 9 mars 2026. [En ligne]. Disponible sur: [https://www.who.int/europe/groups/hepa-europe-\(european-network-for-the-promotion-of-health-enhancing-physical-activity\)/hepa-europe-events-and-working-groups/active-ageing--physical-activity-promotion-in-elderly](https://www.who.int/europe/groups/hepa-europe-(european-network-for-the-promotion-of-health-enhancing-physical-activity)/hepa-europe-events-and-working-groups/active-ageing--physical-activity-promotion-in-elderly)
- [15] M. Abramsson et E. Andersson, « Changing Preferences with Ageing – Housing Choices and Housing Plans of Older People », *Housing, Theory and Society*, vol. 33, n° 2, p. 217-241, avr. 2016, doi: 10.1080/14036096.2015.1104385.
- [16] J. V. Hilborn, E. Strauss, D. F. Hultsch, et M. A. Hunter, « Intraindividual variability across cognitive domains: Investigation of dispersion levels and performance profiles in older adults », *Journal of Clinical and Experimental Neuropsychology*, vol. 31, n° 4, p. 412-424, avr. 2009, doi: 10.1080/13803390802232659.
- [17] G. Kuchel, « Clinical Considerations », *Innov Aging*, vol. 4, n° Supplement_1, p. 855, déc. 2020, doi: 10.1093/geroni/igaa057.3148.
- [18] L. Barry, « Behavioral and Social Considerations », *Innov Aging*, vol. 4, n° Supplement_1, p. 855, déc. 2020, doi: 10.1093/geroni/igaa057.3147.
- [19] V. Tannoia et al., « Developing a weighting system to evaluate physical and cognitive stimulation and safety in older adults' living environments », *Manuscript under review*, 2025.
- [20] J. S. Discovery, « Z-Score ». Consulté le: 27 février 2026. [En ligne]. Disponible sur: <https://www.jmp.com/en/statistics-knowledge-portal/inferential-statistics/hypothesis-testing/z-score>

- [21] « Niveau d’instruction | Statbel ». Consulté le: 11 mars 2026. [En ligne]. Disponible sur: <https://statbel.fgov.be/fr/themes/emploi-formation/formation-et-enseignement/niveau-dinstruction>
- [22] M. Anfrie, E. Coban, A. Delinte, M. Kryvobokov, et T. Staron, « Chiffres clés du logement en Wallonie — Sixième édition », Centre d’Études en Habitat Durable de Wallonie, Rapport, 2023.
- [23] K. Heylen, « Homeownership in Flanders: a cohort approach », présenté à ENHR conference, Prague, juin 2009.
- [24] Y. L. Michael, M. K. Green, et S. A. Farquhar, « Neighborhood design and active aging », *Health & Place*, vol. 12, n° 4, p. 734-740, déc. 2006, doi: 10.1016/j.healthplace.2005.08.002.
- [25] J. Van Cauwenberg *et al.*, « Relationship between the physical environment and physical activity in older adults: A systematic review », *Health & Place*, vol. 17, n° 2, p. 458-469, mars 2011, doi: 10.1016/j.healthplace.2010.11.010.
- [26] S.-M. Cha, « A Systematic Review of Home Modifications for Aging in Place in Older Adults », *Healthcare*, vol. 13, n° 7, p. 752, janv. 2025, doi: 10.3390/healthcare13070752.
- [27] S. R. Lord, H. B. Menz, et C. Sherrington, « Home environment risk factors for falls in older people and the efficacy of home modifications », *Age Ageing*, vol. 35, n° suppl_2, p. ii55-ii59, sept. 2006, doi: 10.1093/ageing/af088.
- [28] B. Slaug, S. Iwarsson, et J. Björk, « A new approach for investigation of person–environment interaction effects in research involving health outcomes », *Eur. J. Ageing*, vol. 16, n° 2, p. 237-247, 2019, doi: 10.1007/s10433-018-0480-5.
- [29] Z. Feng, « Associations between housing type and home conditions with exercise and physical activity among older adults », *BMC Geriatr*, vol. 25, n° 1, p. 921, nov. 2025, doi: 10.1186/s12877-025-06619-9.
- [30] H.-W. Chau et E. Jamei, « Age-Friendly Built Environment », *Encyclopedia*, vol. 1, n° 3, p. 781-791, sept. 2021, doi: 10.3390/encyclopedia1030060.
- [31] P. de Souto Barreto, A.-M. Ferrandez, et B. Saliba-Serre, « Are Older Adults Who Volunteer to Participate in an Exercise Study Fitter and Healthier than Non-Volunteers? The participation bias of the study population », *J Phys Act Health*, juill. 2012.
- [32] K. Nikolopoulou, « What Is Self-Selection Bias? | Definition & Example », Scribbr. Consulté le: 11 mars 2026. [En ligne]. Disponible sur: <https://www.scribbr.com/research-bias/self-selection-bias/>
- [33] K. Nikolopoulou, « What Is Social Desirability Bias? | Definition & Examples », Scribbr. Consulté le: 11 mars 2026. [En ligne]. Disponible sur: <https://www.scribbr.com/research-bias/social-desirability-bias/>

Appendix

record_id	consensus_global_jdny	swelling_jdny	neighbourhood_jdny	z_jdny	neighbourhood_jdny	consensus_global_jdny	swelling_jdny	z_jdny	neighbourhood_jdny	z_swelling_jdny	neighbourhood_jdny	z_neighbourhood_jdny	global_matrix	dwelling_matrix	neighbourhood_matrix	neighbourhood_matrix_f	
1	664.45	2.08725224	803.5	1.789393125	343.95	0.40985457	861.35	-1.1778801	180.05	0.520005047	4	3	4	low_5_high_5p	4	low_5_high_5p	
2	287.45	0.87322524	287.45	0.87322524	287.45	0.87322524	287.45	0.87322524	287.45	0.87322524	2	2	2	low_5_low_5p	2	low_5_low_5p	
3	314.6	-1.0678905	87.9	0.84122177	226.7	0.71095182	289.5	-0.77732866	192	0.55665169	1	3	3	low_5_low_5p	3	low_5_low_5p	
4	549.75	1.29348835	388.3	0.51488235	393.45	1.29773354	287.3	0.09991321	390	0.1060238	2	3	4	low_5_high_5p	3	low_5_high_5p	
5	476.55	0.47014668	66.6	-1.20305263	410.35	1.56323358	385.1	-0.08856759	427.9	2.77752135	1	3	3	low_5_low_5p	2	high_5_high_5p	
6	459.5	0.30640244	166.95	0.62176857	292.95	0.10983513	379.7	0.33005798	382.6	-0.13682602	4	3	2	high_5_high_5p	4	low_5_high_5p	
7	287.7	-1.32456242	48.1	-1.51575185	229.6	0.551297829	280.75	0.14325051	214.65	0.1679387	1	3	1	high_5_low_5p	1	high_5_low_5p	
8	335.3	0.87345076	263.3	0.11182599	263.3	-0.25777455	328.075	-0.73232008	149.5	0.03769727	1	4	3	low_5_low_5p	1	high_5_low_5p	
9	342.5	0.40214555	373.7	0.60620529	304.3	0.24989534	520.85	0.41325934	448	2.50216234	72.85	4	2	high_5_high_5p	4	low_5_high_5p	
10	425.9	-0.01400072	69.4	-1.55751807	366.5	0.808393549	318.3	0.17621584	157.3	-0.6071935	1	3	3	low_5_low_5p	3	low_5_low_5p	
11	344.25	0.688961245	360.4	0.82165058	194.35	-1.11150376	362.2	-0.77070707	161.35	-0.35136643	218.35	3	3	low_5_low_5p	3	low_5_low_5p	
12	348.05	-0.75321016	41.7	-0.824602399	330.35	0.72754824	380.2	0.47070707	77.95	0.3136863	4	3	3	low_5_low_5p	2	high_5_high_5p	
13	384.25	-0.78107136	172.9	0.58171054	172	-1.88831623	321.4	-0.24992614	289.3	0.3149144	62.8	3	3	high_5_low_5p	2	high_5_low_5p	
14	352.75	0.67947844	300.4	0.63206351	333.7	0.04407005	334.0	0.04277987	221.95	0.40186942	88.45	1	3	high_5_low_5p	3	low_5_low_5p	
15	484.1	0.05698921	300.4	0.63206351	333.7	0.04407005	334.0	0.04277987	221.95	0.40186942	88.45	1	3	high_5_low_5p	3	low_5_low_5p	
16	396.5	-0.26012014	47.9	-0.71286391	289.9	-0.36051504	373.05	0.39974577	276.95	0.70003008	135.15	4	4	high_5_low_5p	2	high_5_low_5p	
17	400	0.93268408	355.7	0.30212202	334.3	0.621486961	394.95	0.56292438	276.95	0.70003008	135.15	4	4	high_5_low_5p	2	high_5_low_5p	
18	513.85	0.42015315	159	0.357876151	354.65	0.75982369	42.775	-2.4778133	152.875	-0.43107916	-121.15	3	3	high_5_high_5p	2	high_5_high_5p	
19	406.65	-0.25128605	139.75	-0.0380026	210.8	-0.06067411	147.25	-0.99771624	179.05	-0.8912356	-31.8	3	3	low_5_low_5p	4	low_5_low_5p	
20	389.75	-0.5103981	305.4	-0.54779774	253.35	-1.8004798	209.95	-0.7266683	384.8	0.31963133	135.1	5	5	high_5_low_5p	1	high_5_low_5p	
21	59.8	1.20827213	380.4	0.71838984	374.4	-1.18055716	519.7	-1.2803314	335.2	1.37460186	176.5	5	2	high_5_high_5p	2	high_5_high_5p	
22	283.2	-1.367635987	132.45	-0.69093784	150.75	-1.651460543	108.35	-1.1868241	51.5	-1.455513305	56.85	3	3	low_5_low_5p	3	low_5_low_5p	
23	438.5	0.460252136	279.5	-1.00323968	360.3	-0.24684332	69.75	2.05271883	246	0.40979239	391.3	2	3	low_5_low_5p	2	high_5_low_5p	
24	488.1	0.38393919	286.7	1.16186037	282.4	-0.02102457	281.5	-0.134662801	186.3	-0.11660634	95.2	3	4	low_5_low_5p	2	high_5_low_5p	
25	514.95	0.830587169	380.5	0.71278931	334.45	0.6234445	511.35	1.7830758	238.8	0.6875051	272.55	3	2	high_5_high_5p	2	high_5_high_5p	
26	464.45	0.25895646	185	0.79708653	454.45	2.17122029	728.5	0.30065287	86.25	-1.11778681	168.25	3	3	low_5_high_5p	2	high_5_high_5p	
27	494.4	0.63568821	178.7	0.698973596	315.7	0.33138312	237.25	0.46659505	76.95	-1.42881805	163.3	3	3	low_5_low_5p	2	high_5_low_5p	
28	198.6	-2.17094448	171.9	0.57780645	162.1	-1.51090354	138.6	-1.06215568	66.45	-1.31591248	64.15	1	3	low_5_low_5p	3	low_5_low_5p	
29	516.4	0.86430884	711.9	0.57780645	344.5	0.7477862	448.35	0.89778732	411.35	2.13541509	137.38	1	3	high_5_high_5p	4	low_5_high_5p	
30	340.4	0.825079622	88.7	0.627711641	231.7	0.60370374	317.75	0.08815848	180.8	-0.7146075	136.95	1	2	high_5_low_5p	1	high_5_low_5p	
31	362.65	-0.61027239	218	0.33474781	246.65	-0.48607382	283.95	-0.12549931	133.75	-0.42593223	169.2	4	3	low_5_low_5p	3	low_5_low_5p	
32	411.8	0.04188723	134.15	-0.05151097	297.65	0.16766056	-461.5	-1.27160021	34.5	-1.53517188	-304.7	4	3	low_5_low_5p	4	low_5_low_5p	
33	339.1	-0.87400339	75.8	0.04363526	263.3	-0.25777455	355	-1.84387771	-32.45	-2.30557824	36	3	3	low_5_low_5p	3	low_5_low_5p	
34	90.2	4.50377748	379	0.4228939	526.2	2.59788462	520.05	1.88679319	323.7	3.25997334	53.5	3	3	low_5_low_5p	2	high_5_low_5p	
35	329.9	-0.92497493	108.85	-0.48931628	221.05	0.780917315	180.7	0.69279265	254.25	0.53334512	-63.55	1	3	low_5_low_5p	3	low_5_low_5p	
36	413.6	-0.07888394	177.95	0.670071719	241.65	-0.25852344	464.2	0.98858844	151.45	-0.83007531	272.55	1	3	low_5_low_5p	4	low_5_low_5p	
37	388.1	-0.73628008	102.15	-0.62502014	289.95	0.027756305	421.15	0.76032392	142.75	0.5239753	280.4	1	3	low_5_low_5p	1	high_5_low_5p	
38	406.35	-0.39751608	81.5	-0.39114446	324.85	0.504465147	454.45	0.93501474	236.8	0.38877154	221.65	1	3	low_5_low_5p	2	high_5_low_5p	
39	400.15	-0.25327859	138.45	-0.191995	273.7	-0.12893868	241.8	-0.73891034	169.7	-0.32715556	72.1	4	3	low_5_low_5p	3	low_5_low_5p	
40	371.9	0.46478825	57.5	1.85780524	280.4	0.456970792	287.2	0.099254092	102.35	-0.54668804	184.65	1	4	low_5_low_5p	3	low_5_low_5p	
41	425.5	0.01023004	719.5	0.79710863	351.85	0.88081137	407.25	0.3882883	284.35	0.54835587	352.9	1	3	low_5_low_5p	2	high_5_low_5p	
42	391.5	0.37101944	312	1.20150541	381.9	0.98384997	418.6	0.7096448	133.3	0.45063037	334.65	1	2	low_5_low_5p	3	low_5_low_5p	
43	464.2	0.61200913	300.2	0.4303797	350.8	0.12353309	728.95	-1.31177637	76.2	-1.18846622	59.7	4	3	low_5_low_5p	2	high_5_low_5p	
44	469.5	0.38058884	65.4	-1.21324486	402.1	1.6107027	562.3	1.95196568	123.7	-0.8205078	438.6	2	4	low_5_low_5p	2	high_5_low_5p	
45	509.55	1.25217625	190	0.81564609	366.55	1.02587119	246.7	-0.3301326	58.35	-1.37976481	191.45	2	3	low_5_low_5p	2	high_5_low_5p	
46	507.95	0.7648921	137.15	0.01128989	370.8	1.07345997	483.05	1.10426233	286.1	0.701948376	234.95	0.92272016	1	3	low_5_low_5p	3	low_5_low_5p
47	421.2	-0.05865881	388.5	-1.24555741	338.3	-0.186855218	377.65	0.45625679	114.2	-0.38020186	263.45	1	4	low_5_low_5p	2	high_5_low_5p	
48	363.85	-0.60246443	282.5	0.85224653	173.35	-1.34663233	299.45	-0.48894485	232.15	0.54230741	43.3	3	3	low_5_low_5p	2	high_5_low_5p	
49	509.7	0.78079533	178.75	0.62394877	334.95	-0.6285368	271.05	-0.45118118	134.5	-0.14693156	80.55	4	3	low_5_low_5p	4	low_5_low_5p	
50	426.65	-0.86184549	115.25	-0.0313661	280.4	-0.08862169	226.35	0.18172496	226.35	0.11719163	30.5	3	4	low_5_low_5p	1	high_5_low_5p	

170	390	0.260283008	96	0.706193506	0.33809001	408.25	0.647518373	276.65	0.707506074	132.1	0.257727139	1	3	1 high_5_low_SP	2 high_5_high_SP
171	467.06	0.319134802	77.3	-1.022195772	1.31586724	339.95	0.22461806	236.65	0.307710142	103.3	0.012072893	1	3	1 high_5_low_SP	2 high_5_high_SP
172	597.06	1.078005419	106.6	-0.378005419	1.059193869	301.8	0.00884262	113.55	0.845494673	486.25	0.735273131	3	5	3 low_5_low_SP	2 high_5_high_SP
173	387.06	0.818460772	146.4	0.818460772	0.70587727	467.06	0.00884262	113.55	0.845494673	486.25	0.735273131	3	5	3 low_5_low_SP	2 high_5_high_SP
177	338.26	0.845494673	193.85	0.818460772	0.70587727	318	0.008695649	244.7	0.477700066	71.3	0.242502159	3	3	2 high_5_low_SP	3 low_5_low_SP
178	389.1	0.363140487	99.2	-0.602333564	0.71070185	270.1	-0.2047864	173.25	-0.2473917	96.85	-0.04211165	4	4	3 low_5_low_SP	3 low_5_low_SP
179	389.06	0.363140487	99.2	-0.602333564	0.71070185	270.1	-0.2047864	173.25	-0.2473917	96.85	-0.04211165	4	4	3 low_5_low_SP	3 low_5_low_SP
180	379.56	0.51057222	31.05	-0.80164002	0.723022559	315.7	0.23755852	143.9	0.04054292	173.25	0.067188055	1	2	1 high_5_low_SP	2 high_5_high_SP
181	403.3	0.02765741	95.2	-0.71900841	0.6319357	353.35	0.356885272	208.5	0.39546178	144.85	0.36628078	1	4	2 high_5_high_SP	3 low_5_low_SP
184	316.3	-1.03367186	148.9	0.487355151	-1.44527952	137.7	-1.305484806	122.9	0.751031476	-45.9	-1.25689628	2	4	4 low_5_low_SP	4 low_5_low_SP
185	390.76	1.359868084	224.55	1.465123409	0.768887764	351.475	0.286460009	206.275	0.38281103	145.2	0.36920788	4	3	2 high_5_low_SP	2 high_5_high_SP
188	336.46	-0.86252464	126.15	-0.39764451	-0.314007368	238.25	0.448180267	144.6	0.533885038	83.65	-0.15453231	3	3	3 low_5_low_SP	3 low_5_low_SP
189	367.86	-0.690462	109.95	0.42456085	-1.07391431	277.75	-0.15713327	183.75	0.32120843	94	-0.066462304	2	3	3 low_5_low_SP	3 low_5_low_SP
191	367.86	-0.690462	109.95	0.42456085	-1.07391431	277.75	-0.15713327	183.75	0.32120843	94	-0.066462304	2	3	3 low_5_low_SP	3 low_5_low_SP
194	574.3	1.393540973	228.75	1.3317472	0.760798644	214.7	-0.5452695	243.1	0.611796609	-28.4	-1.107804823	4	3	4 low_5_high_SP	2 high_5_high_SP
195	321.26	-1.00973352	112.95	-0.420054286	-0.338803889	185.6	-0.840077718	157.7	-0.623706806	96.7	-0.799103189	4	4	3 low_5_low_SP	3 low_5_low_SP
200	463.8	0.345419986	69.7	-1.150683858	1.362005952	573.935	1.62817197	290.725	0.583310536	283.2	1.54347286	1	3	2 high_5_high_SP	2 high_5_high_SP
205	488.55	0.10590864	178.65	0.89816938	-0.298827636	350.95	0.202212306	139.75	0.582417768	211.2	0.300812322	1	3	4 low_5_low_SP	4 low_5_low_SP
206	488.55	0.10590864	178.65	0.89816938	-0.298827636	350.95	0.202212306	139.75	0.582417768	211.2	0.300812322	1	3	4 low_5_low_SP	4 low_5_low_SP
214	405.8	0.25473625	86.5	-0.80064903	0.460564572	190.95	0.689100205	248.6	0.50816794	-57.95	-1.355482047	1	3	2 low_5_low_SP	4 low_5_high_SP
215	390.4	0.350800569	36.75	-1.707313787	0.861103056	530.125	1.385387057	364.675	0.32490566	365.45	2.24832361	1	4	1 high_5_low_SP	3 low_5_low_SP
216	390.4	0.350800569	36.75	-1.707313787	0.861103056	530.125	1.385387057	364.675	0.32490566	365.45	2.24832361	1	4	1 high_5_low_SP	3 low_5_low_SP
218	477.7	0.273035	183.3	0.28557185	0.845494673	275.5	-0.1232803	153.95	-0.4832	322	0.271784504	3	2	4 low_5_high_SP	4 low_5_high_SP
219	569.2	1.345168336	257.45	2.02100879	0.34224432	217.2	0.529902483	143.2	0.57894486	74	-0.236465738	3	4	4 low_5_high_SP	4 low_5_high_SP
224	384.5	1.964557301	191.4	0.80514846	1.248835727	284.7	0.134993019	239.8	0.438773399	44.9	-0.484632636	2	3	2 high_5_high_SP	2 high_5_high_SP
228	342.06	-0.0373365	61.35	-1.20174322	-0.048452587	173.25	0.800054645	175.25	0.271718203	341.9	-0.883342789	1	3	3 low_5_low_SP	3 low_5_low_SP
231	616.6	1.744770054	181.1	0.73115202	1.974672945	182.05	0.76964245	113.95	0.805918374	68.1	-0.286849852	2	4	4 low_5_high_SP	4 low_5_high_SP
236	389.9	1.35030868	106.7	0.50842893	1.26080538	278.55	0.12795882	329.4	1.13132046	50.85	1.299818528	1	3	1 high_5_low_SP	3 low_5_low_SP
237	512.7	0.89245196	93.25	-0.72849721	1.1759021611	448.025	0.888934213	201.425	0.04744843	246.6	1.23203701	1	4	2 high_5_high_SP	2 high_5_high_SP
238	517.96	0.89043132	139.6	0.880132062	0.319304381	333.15	0.188971156	184.1	-0.138618841	149.4	-0.404948481	2	3	4 low_5_high_SP	4 low_5_high_SP
240	373.7	0.509214431	134.9	0.218180913	-0.43728183	264.4	0.28771199	249.7	0.517834207	14.7	-0.74128622	1	3	1 high_5_low_SP	1 high_5_low_SP
245	323.1	0.98917676	88.1	-0.898449543	-0.088170828	125	-1.096638076	176.6	0.213649003	-51.6	-1.305397307	4	4	3 low_5_low_SP	3 low_5_low_SP
247	392.6	0.32994883	311.4	0.566412411	0.337010291	331	0.106601339	232.7	0.57846452	78.3	-0.2000563	1	3	1 high_5_low_SP	1 high_5_low_SP
255	497.46	0.64649405	247.95	1.86023257	-0.288613548	328.2	0.132393079	285.45	0.875504549	42.75	-0.502537555	3	5	2 high_5_high_SP	2 high_5_high_SP
258	617.64	1.792035446	186.5	1.025145038	1.464377761	680.4	2.33073986	364.85	1.489346061	34.65	2.399727317	2	3	3 low_5_low_SP	3 low_5_low_SP
260	631.15	1.93278475	192.5	0.82373732	1.513880217	718.4	2.5087712	338.65	1.47934468	379.75	2.365038516	4	4	2 high_5_high_SP	2 high_5_high_SP