Public Health in Practice 7 (2024) 100509

Contents lists available at ScienceDirect

Public Health in Practice

journal homepage: www.sciencedirect.com/journal/public-health-in-practice

Geographical variation, demographic and socioeconomic disparities in Active Ageing: The situation in Thailand

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ARTICLE INFO

Keywords:
Older adults
Active ageing
Geographical variation
Disparities
Social determinants of health
Thailand

ABSTRACT

Objectives: Being healthy and active is a goal to achieve a better quality of life as individuals age. This study aimed to explore and validate the Active Ageing (AA) model, and examine geographic variations, and demographic and socioeconomic disparities.
Study design: Utilising a cross-sectional secondary data analysis, the analytic unit is older adults aged 60–80 across all provinces in Thailand.
Methods: Exploratory Factor Analysis explored the AA structures, and the second-order Confirmatory Factor Analysis validated the model fit. Factor scores were used to identify geographic variation and sociodemographic disparities in AA. The association between geographic, and sociodemographic characteristics, and AA was examined through hierarchical regression analysis.
Results: The AA model, comprised of 14 indicators representing three latent factors–physical health, participation, and security–exhibited an optimal fit. Geographic inequality in AA emerged across the country, with specific areas linked to lower AA. An inverse relation between participation and security was observed. Rural residence, younger age, male, being married, and adequate income were associated with better AA. The association between AA and geographic, demographic, and socioeconomic emphasised the positive role of marital and economic status.
Conclusions: This study contributes to understanding the social determinants of health by constructing a comprehensive AA model. The findings highlight the geographic variations and demographic and socioeconomic disparities in AA across Thailand. While AA generally declines with age, a better economy may help alleviate these disparities. These findings underscore the need for tailored social and public health policies, avoiding a "one-size-fits-all" approach.

1. Introduction

Globally, people are living longer, and it has become common for individuals to reach their sixties and beyond. This trend is observed worldwide, where both the size and proportion of older individuals in the population are on the rise [1]. Thailand is also undergoing rapid growth in its older population, resulting in a transition into a completed-aged society. The proportion of people aged 60 and above has surged from 7.2 % in 2002 to 23.7 % in 2024, projected to reach 35 % by 2030 [2]. This situation presents challenges for healthcare and society's preparation. Nonetheless, Thailand is in the process of developing a long-term care system. Consequently, the primary goal is to promote healthy ageing to ensure a high quality of life [3].

As people live longer, the challenge of ensuring their independent and high-quality lives aligns with global trends. The World Health Organization (WHO) promotes "Active Ageing" (AA) to optimise health, participation, and security for older individuals. AA applies to both individuals and populations, enabling physical, mental, and social well-being as people age. It facilitates participation in society according to needs, along with protection and security [4]. AA refers to ageing well and is often synonymous with terms like "successful ageing", "healthy ageing", and "productive ageing" [5].

The concept of AA has been promoted by many international organisations and public health scholars. The United Nations (UN) introduced the "Active Ageing Index" (AAI) in 2012, featuring four domains (Employment; Participation in Society; Independent, Healthy and

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https://doi.org/10.1016/j.puhip.2024.100509
Received 31 August 2023; Received in revised form 3 April 2024; Accepted 9 May 2024
Available online 16 May 2024

Secure Living; and Capacity and Enabling Environment for Active Ageing) and 22 indicators [6,7]. However, indicator availability and relevance pose challenges. Thus, Scholars devise alternate methods to measure AA, with revised indicators and methods for specific regions [8]. Advanced techniques like factor analysis and machine learning are used to quantify AA [9,10], healthy ageing [11,12], successful ageing [13], and the older persons' index of multiple deprivations [14]. These approaches allow us to quantify the health matrix and its determinants for older adults by utilising theoretical frameworks and rigorous statistical methods.

Practically applying AA requires exploring its determinants to prepare effective social and health services for successful implementation. Furthermore, despite the concept of AA existing since the late 1990s, knowledge gaps persist regarding geographical variations and disparities based on demographics and socioeconomic factors. Measuring these variations and disparities is crucial for evaluating the impact of policies on health equity. Geographic location significantly influences health-related outcomes, affecting self-rated health [15,16], functional limitations [17], health behaviours [15], and healthy ageing [12,18].

Thailand, a culturally diverse country in Southeast Asia, comprises four distinct regions, each with unique characteristics shaping the residence's culture, lifestyle, and behaviour. The Northern region, known for its mountainous terrain and traditional agrarian practices, emphasizes strong familial ties. In the Northeast, a rural landscape with a semi-arid plateau along the Mekong River maintains potential agricultural dominance and robust community support systems. The central region represents a blend of urban living and traditional values, serving as the country's administrative, political, and commercial hub. Lastly, the Southern region, with hilly rubber plantations and coastal living, integrates distinct cultural influences. These regional variations likely influence the diverse lifestyles and behaviours of older adults, potentially impacting variations in AA [19].

Moreover, these relationships can be modified by demographic and socioeconomic characteristics [9]. Sociodemographic data play a role in the complex network shaping older individuals' independence and quality of life [14]. Characteristics like age, sex, marital status, education, and income influence healthy ageing. Previous research showed women and older people tend to have worse health status, while marital partnership and higher wealth and education correlate with better health [11].

Previous literature highlighted the necessity of establishing an optimal methodology to capture the status of AA. Furthermore, variations in geographic, demographic, and socioeconomic characteristics are likely contributors to the disparities observed in AA among the older population. However, previous AA models have employed limited determinants, lacking clarity and comprehensiveness. Gaining a comprehensive understanding of these factors will facilitate the design of appropriate policies and services tailored to the needs of the older population. Therefore, the objectives of this study are: 1) to explore an alternative AA measurement approach and validate it, 2) to examine geographical variations in AA, and 3) to examine demographic and socioeconomic disparities in AA among older adults in Thailand.

2. Methods

2.1. Data source

We utilised data from the Survey of Older Persons in Thailand (SOPT) conducted by the Thai National Statistical Office (Thai NSO) in 2017 across all 77 provinces. The sampling methods for this survey employed a stratified two-stage sampling approach. The country has 77 strata, each subsequently subdivided into 2 sub-strata based on governance criteria (within municipal areas and outside municipal areas). Enumeration areas serve as the primary sampling unit, household is the secondary sampling unit [20]. The data were extracted for older adults aged between 60 and 80 years (n = 36,848) since in Thailand an older adult is defined as a person aged 60 years or above, and the average life expectancy is 80.1 years [2].

2.2. Design for the analysis

To achieve the objectives of this study, there were three steps for the analysis. First, an alternative AA measurement was developed based on indicators derived from the SOPT data. By using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA), latent factors to represent the AA characteristics of the survey participants were explored. Second, the factor scores for obtained latent factors were identified as AA scores representing AA characteristics for individual participants. By using these AA scores, geographical and sociodemographical variations in AA were examined. Finally, the relationship between the AA scores and demographic and socioeconomic characteristics was examined by hierarchical regression analyses.

2.3. Initial variables and indicators

From the SOPT dataset the following geographic, demographic and socioeconomic variables were extracted and used for this analysis. Geographical variables were region (Bangkok, Central, North, Northeast, and South) and province (all 77 provinces in the country). Demographic and socioeconomic variables were age (60–64, 65–69, 70–74, 75–80), sex (male, female), residential area (urban, rural), marital status (married, single, divorced/separated), and living arrangement: Alone: older adult living alone in the household; With spouse only: older adult living with only a spouse in the household; Young immediate household: older adults living with at least one child whether they reside with their spouse or not; Multigenerational household: older adults living with at least one child and at least one grandchild with or without a spouse; Skip-generation household: older adults living with a grandchild with the absence of their parent; and Other: those who do not fit into the categories [21]. Education levels were primary level or higher (individuals who completed elementary school or achieved higher levels such as high school, diploma, undergraduate, or graduate degrees), lower than primary level (those who had not completed elementary school or had no formal education) [20]. Income was classified as either adequate or not adequate based on respondents' perceptions.

Variables related to AA characteristics reflecting the conceptual framework on AA developed by the United Nations and WHO [6,7] were also extracted from the SOPT dataset. For further analysis in this study, the scores for individual variables were re-categorised and twenty indicators related to the AA concept were created. They were: 1) Self-rated health (SRH): 1–5 scale, higher numbers indicating better health, 2) Health deterioration: 1–4 scale, higher numbers indicating higher deterioration, 3) Activities of daily living (ADL): 1–3 scale, higher numbers indicating better ADL, 4) Functional ability: 1–3 scale, higher numbers indicating better functional ability, 5) Instrumental activities of daily living (IADL): 1–3 scale, higher numbers indicating better IADL, 6) Exercise: 1–3 scale, higher numbers implying regular exercise, 7) Participation in senior group: 1–4 scale, higher numbers indicating more participation 8) Participation in funeral welfare group: 1–4 scale, higher numbers indicating more participation, 9) Participation in other groups: 1–3 scale, higher numbers indicating more participation, 10) Join community activity: dichotomous (1 = do not participate, 2 = participate), 11) Being a homeowner: dichotomous (1 = not a homeowner, 2 = homeowner), 12) Living with family member: dichotomous (1 = living alone, 2 = with family) 13) Working status: dichotomous (1 = not working, 2 = currently working) 14) Main source of income: dichotomous (1 = no income source, 2 = have income source), 15) Income: 1–4 scale, higher numbers indicating more adequate income, 16) Saving: 1–4 scale, higher numbers indicating more savings 17) Education: 1–4 scale, higher numbers indicating higher education level, 18) Bedroom location: Dichotomous (1 = not safe, 2 = safe), 19) Toilet safety:

dichotomous (1 = not safe, 2 = safe), and 20) Health insurance: dichotomous (1 = no insurance, 2 = have insurance). Please refer to the Supplementary Table for variables obtained from the SOPT data set and created AA-related indicators.

2.4. Identifying latent factors representing AA characteristics

Twenty AA-related indicators of the participants were used for EFA to identify the latent factors representing AA-related characteristics among the participants. Construct validity was assessed through Kaiser-Meyer-Olkin (KMO). To validate the second-order model, CFA was performed, evaluating model fit through the root mean square error of approximation (RMSEA), standardised root mean square residual (SRMR), and comparative fit index (CFI), visualized in a path diagram. Through these procedures, latent factors representing AA characteristics and a structure for the AA model were identified.

2.5. Analysis of geographical and socio-demographical variations in AA characteristics

After validating the AA model, the factor score regression (FSR) was employed to generate AA scores, reflecting the selected AA characteristics for individuation participants. Higher scores indicated better AA. The AA scores were then used to examine geographic variation and sociodemographic disparities in AA scores. Geographical variations in AA scores were mapped across the country. Demographic and socioeconomic disparities were identified via t-tests and analysis of variance (ANOVA).

2.6. Multivariate analysis on relationship between socio-demographic and AA characteristics

Correlation, and multicollinearity were assessed through the correlation coefficient, and variance inflation factor (VIF). The relationship between demographic and socioeconomic characteristics and AA scores was investigated through hierarchical regression analysis in three models. Model 1 assessed AA regression estimates by region (Central region as reference), Model 2 adjusted for demographic covariates (residential area, age, sex, marital status), and Model 3 included socioeconomic covariates (education and income).

2.7. Statistical software

Descriptive statistics, and hierarchical regression analysis used IBM Statistical Package for Social Sciences (SPSS) version 29.0. Map distribution employed QGIS version 3.28.1-Firenze, while EFA, CFA, and path analysis used RStudio Desktop version 2023.09.0 + 463.

3. Results

From an initial sample of 36,848 individuals, 1084 were excluded due to missing variables (2.9 %). The final sample included 35,764 individuals, averaging 67.68 years (SD = 5.78). Participants were mostly from the Northeast (32.0 %) and Central (25.3 %) regions, with rural residents comprising 58.7 %.

3.1. Latent factors resulting from Exploratory Factor Analysis

EFA was conducted to establish latent factors from a set of indicators. After the EFA, twenty indicators were reduced (certain indicators such as ADL, being a homeowner, living with a family member, main source of income, bedroom location, and having health insurance were excluded) due to low loadings or limited relevance.

Three latent factors were developed, explaining 45.67 % variance, representing 14 indicators that exhibited adequate construct validity, (KMO = 0.749, df = 91, P < 0.001). Factor 1, accounting for 20.02 % variance, comprises six indicators: functional ability, IADL, SRH, health deterioration, exercise, and working status. Factor 2, accounting for 14.86 % variance, comprises four indicators: participation in funeral welfare group, senior group, other groups, and joining a community activity. Factor 3, accounting for 10.79 % variance, comprises four indicators: education, safety of toilet facilities, income, and saving (Table 1). Factor 1 was later identified as representative of physical health, Factor 2 as indicative of participation, and Factor 3 as reflective of security, respectively.

3.2. Active Ageing: latent model resulting from confirmatory factor analysis

A second-order CFA with a path diagram was conducted to propose and validate the AA model (Fig. 1). Overall, the model demonstrated an acceptable fit, supported by the following goodness-of-fit indices: X^2 = 9670.83 (df = 64, P < 0.001), RMSEA = 0.06, SRMR = 0.05, and CFI = 0.86. The AA model had three latent factors: physical health, participation, and security. Physical health exhibited the strongest loading (λ = 0.48), followed by security (λ = 0.46), and participation (λ = 0.22).

Physical health, a latent factor, was measured with six indicators: SRH, health deterioration, functional ability, IADL, exercise, and working status. Among these indicators, functional ability (λ = 0.78) and IADL (λ = 0.75) exhibited strong loadings with the physical health factor.

Participation, a latent factor, was measured with three indicators: participation in funeral welfare groups, senior groups, and other groups. These indicators displayed nearly equal loadings with the latent factor. The participation in senior groups (λ = 0.63) exhibited the highest loading among the indicators.

Security, a latent factor, was measured using four indicators: education, income, saving, and safety of toilet. Among these indicators, education (λ = 0.56) demonstrated the strongest loading with the security factor, suggesting a significant association between education and security.

3.3. Geographical variations in Active Ageing

Fig. 2 presents the geographic distribution of AA by factors: physical health, participation, and security. AA disparities were observed across the country. Better physical health and participation were seen in North, South, and Northeast regions, while security was higher in Central areas. Notably, an inverse relation existed between participation and security. The North and Northeast had higher participation but lower security, while the Central and South had the opposite. Southern border provinces, like Yala and Narathiwat, had lower AA scores.

Table 1
Factor structure and factor loading estimate after varimax rotation.

Indicators	Factor[a]1	Factor[a]2	Factor[a]3
Functional ability	**0.799**	−0.008	0.002
Instrumental activities of daily living	**0.760**	0.013	0.073
Self-rated health	**0.617**	0.071	0.249
Health deterioration	**−0.597**	0.039	−0.037
Working status	**0.566**	0.127	−0.152
Exercise	**0.437**	0.163	0.218
Senior group	−0.063	**0.780**	0.028
Funeral group	0.068	**0.771**	−0.110
Other group	0.033	**0.675**	0.140
Join community activity	0.218	**0.500**	−0.220
Education	0.101	−0.155	**0.680**
Safety of toilet	−0.171	−0.187	**0.668**
Income	0.111	0.044	**0.614**
Saving	0.159	0.161	**0.495**
Eigen value	2.803	2.081	1.511
Total variance explained (45.67 %)	20.02	14.86	10.79

[a] Latent factors generated from the EFA.

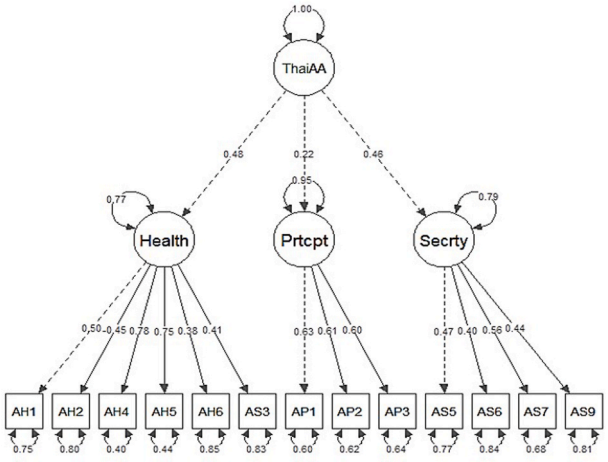

Fig. 1. The second-order confirmatory factor analysis of Active Ageing.

3.4. Demographic and socioeconomic disparities in Active Ageing

The characteristic of the older adults and their AA scores is shown in Table 2. Female participants outnumbered males (54.2 %). Most were currently married (63.9 %), with 77.4 % having low education. Over half reported adequate income (55.4 %). Regarding living arrangements, the most common type was multigenerational household (27.1 %), followed by young immediate household (22.4 %) and living with a spouse only (22.2 %).

Considering demographic and socioeconomic characteristics of Thai older adults and their AA scores. Rural residents and younger age groups had better AA ($P < 0.001$). Males, being married, and those with adequate income showed better AA ($P < 0.001$). Higher education showed better physical health and security but lower participation ($P < 0.001$). Living arrangements showed significant differences, with a spouse only indicating better AA, while skip-generation household indicated the worst security ($P < 0.001$). No multicollinearity was found among indicators (correlation <0.6, VIF <1.5).

Table 3 shows the hierarchical regression estimates of the association between AA and demographic and socioeconomic characteristics. Geography played a more important role in participation and security than in physical health. North region had a positive AA relation in all domains ($P < 0.001$). In contrast, Central provinces showed a negative relationship with physical health and participation but a positive relationship with security ($P < 0.001$). Being married and having adequate income is associated with better AA ($P < 0.001$). Education and income narrowed security gaps between regions.

3.5. Physical health

Compared with the Central region, all other regions showed better physical health scores. Adjusting for demographics (Model 2), the gap between the regions was smaller. However, the gap increased when education and income were added in the third model (Model 3). Positive physical health relations included younger age, male sex, rural residence, being married, higher education, and adequate income ($P < 0.001$). The standardised coefficient showed that age and sex had a stronger association than the other covariates with physical health.

3.6. Participation

Compared with the Central region, other regions had better participation than Central. Demographic and socioeconomic adjustments (models 2 and 3) reduced the gap. Positive participation associations included older age, male sex, rural residence, being married, and adequate income, but higher education had a negative association ($P < 0.001$). The standardised coefficient showed that regions, areas, and income had a stronger association with participation.

3.7. Security

Central had better security. Demographic adjustment (Model 2)

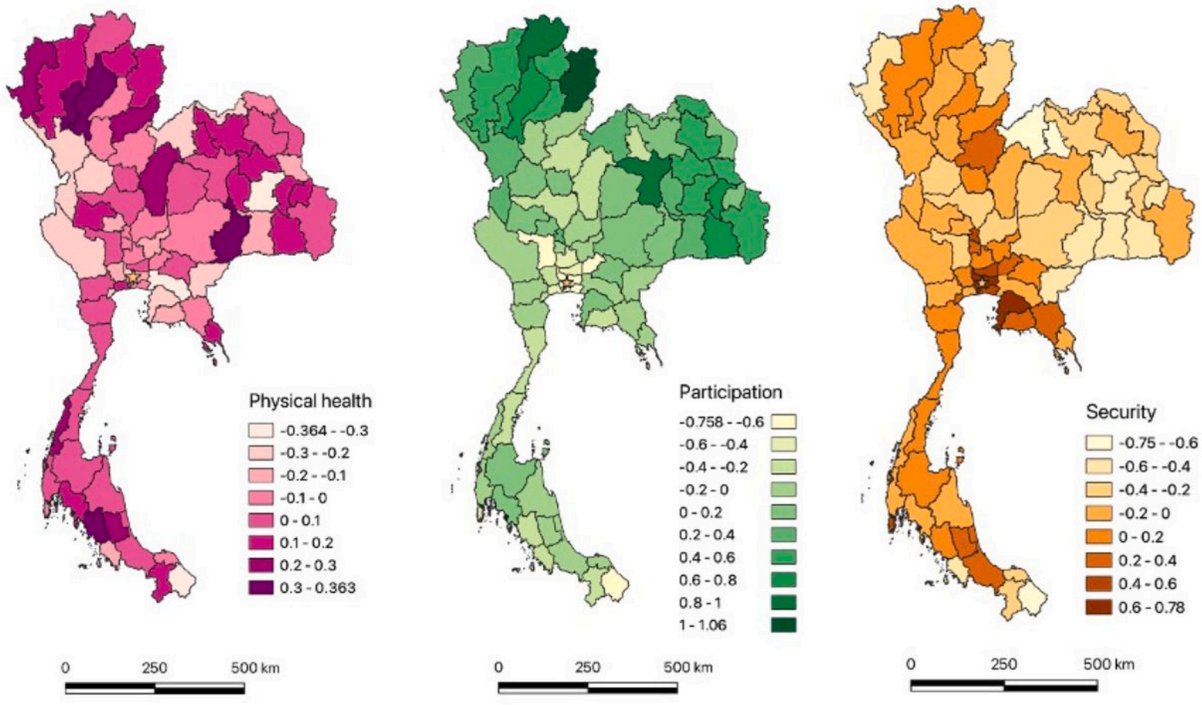

Fig. 2. The geographic variation of Active Ageing by provinces in Thailand. Geographic variation in AA is based on the latent scores of each latent factor. The darker the colour, the higher the AA scores implying better AA status; the yellow star indicates Bangkok; AA: Active Ageing.

Table 2
Demographic and socioeconomic characteristics and Active Ageing scores.

Variable		AA[a]				
	%	Physical health	P^b	Participation	P^b	Security	P^b
Region			<0.001		<0.001		<0.001
Bangkok	9.7	−0.135		−0.750		0.766	
Central	25.3	−0.091		−0.289		0.192	
North	21.3	0.084		0.280		−0.024	
Northeast	32.0	0.036		0.331		−0.362	
South	11.6	0.058		−0.171		0.017	
Area			<0.001		<0.001		<0.001
Urban	41.3	−0.042		−0.187		0.336	
Rural	58.7	0.030		0.131		−0.236	
Age			<0.001		<0.001		<0.001
60–64	37.3	0.416		−0.038		0.002	
65–69	27.5	0.136		0.025		0.008	
70–74	19.2	−0.386		0.060		−0.004	
75–80	16.0	−0.737		−0.024		−0.014	
Sex			<0.001		<0.001		<0.001
Male	45.8	0.221		0.012		0.062	
Female	54.2	−0.187		−0.010		−0.052	
Marital status			<0.001		<0.001		<0.001
Married	63.9	0.144		0.029		0.023	
Single	4.9	−0.065		−0.284		0.200	
Separated	31.2	−0.285		−0.015		−0.079	
Education			<0.001		<0.001		<0.001
≥ Primary	22.6	0.109		−0.289		1.124	
< Primary	77.4	−0.032		0.084		−0.327	
Income			<0.001		<0.001		<0.001
Adequate	55.4	0.060		0.021		0.505	
Inadequate	44.6	−0.072		−0.026		−0.627	
Living arrangement			<0.001		<0.001		<0.001
Living alone	10.4	−0.075		0.074		−0.044	
With a Spouse only	22.2	0.157		0.098		0.055	
Young immediate HH[c]	22.4	−0.011		−0.090		0.138	
Multigenerational HH	27.1	−0.119		−0.018		−0.083	
Skip-generation HH	9.6	0.096		0.159		−0.325	
Other	8.3	−0.047		−0.237		0.180	

[a] Average latent Active Ageing factors scores derived from the EFA and validated through the CFA.
[b] *P-value* from T-test, and ANOVA.
[c] HH: Household.

reduced gap, older age, male sex, and being married were positively related to security. However, when education and income were added to the model (Model 3), male sex no longer had a positive relation with security ($\beta = -0.065$, $P < 0.001$). Positive security associations included older age, being married, and North region; negative association was seen with rural residence ($P < 0.001$).

4. Discussion

This study presents significant contributions to the literature on social determinants of health by developing a comprehensive AA model in Thailand, utilising a large dataset. The model identifies three robust factors: physical health, participation, and security, which fit the data well. Geographical inequalities in AA become evident across regions. Hierarchical regression modelling uncovers demographic and socioeconomic inequalities, emphasising marital and economic roles.

Despite AA discussions and senior scholars' contributions, this study is one of the pioneering efforts to develop a reliable model capturing AA status, particularly in Asian contexts like Thailand. Our model aligns with the WHO theoretical framework [4] and UN guidelines [22]. Our methodology reduces observable variables to fewer latent factors. Likewise, previous studies have used multi-method approaches, constructing health outcome models via factor analysis, generating health scores, and examining social determinant relationships [11,14]. Our model with three distinct domains, predominantly loaded onto the first factor which can be considered a general factor encompassing questions related to physical health. Notably, functional ability and IADL strongly load onto the physical health factor, while different types of group participation equally load onto the participation factor. Additionally, savings exhibit the highest loading on the security factor. These robust loadings (Functional ability and IADL) can guide policymakers in prioritizing health-related outcomes for enhancing AA.

Using FSR-based AA, we manage weighting and aggregation, revealing geographic, demographic, and socioeconomic disparities in AA. Our nationally representative findings comprehensively illustrate geographic inequalities highlighting disparities across regions and urban/rural distinction. The Northern region excels in AA, while the Central region, more developed, showed poorer AA, particularly in the participation aspect. The study shows the contrast between higher participation and lower security.

This study highlights the influence of location on health behaviour and outcomes, supported by previous research indicating different patterns of mortality and long-term illness [12], self-rated health and functional limitations [17], and biomarkers of chronic disease and healthy ageing such as HbA1c, systolic blood pressure, and grip strength [18]. Additionally, geographical factors impact physical activity, and sedentary behaviour [15], and are intertwined with gender disparities in health, and socio-economic inequalities [14]. Our findings diverge from patterns seen in Western countries, with rural older adults facing challenges in successful ageing and participation [23]. In our study, better physical health and participation are seen in less developed and rural areas, possibly due to cultural and the more favourable social engagement environment. Similar trends are noted in Asian countries like India, where urban dwellers face disadvantages in ageing successfully, likely due to higher rates of unhealthy lifestyles [24]. Additionally, strong primary healthcare systems in Thai rural areas may contribute to

Table 3
Hierarchical regression estimates for Active Ageing.

Factors[a]	Model 1[b]				Model 2[c]				Model 3[d]			
	B[e]	95 % CI[f]	β[g]	*P*[h]	B	95 % CI	β	*P*	B	95 % CI	β	*P*
Physical Health												
North	0.187	0.186, 0.189	0.077	<0.001	0.159	0.158, 0.161	0.065	<0.001	0.177	0.175, 0.178	0.072	<0.001
Northeast	0.139	0.138, 0.141	0.065	<0.001	0.131	0.130, 0.132	0.061	<0.001	0.172	0.170, 0.173	0.080	<0.001
South	0.161	0.159, 0.163	0.051	<0.001	0.166	0.164, 0.168	0.053	<0.001	0.165	0.163, 0.166	0.053	<0.001
Age					−0.074	−0.074, −0.074	−0.426	<0.001	−0.074	−0.074, −0.074	−0.425	<0.001
Sex (male)					0.343	0.342, 0.345	0.171	<0.001	0.334	0.333, 0.335	0.166	<0.001
Rural					0.038	0.037, 0.039	0.019	<0.001	0.060	0.058, 0.061	0.029	<0.001
Single					0.062	0.059, 0.065	0.013	<0.001	0.067	0.065, 0.070	0.015	<0.001
Married					0.127	0.126, 0.128	0.061	<0.001	0.118	0.117, 0.120	0.057	<0.001
Education									0.026	0.025, 0.027	0.020	<0.001
Income									0.123	0.122, 0.123	0.105	<0.001
Participation												
North	0.697	0.696, 0.699	0.286	<0.001	0.654	0.652, 0.656	0.268	<0.001	0.637	0.635, 0.638	0.261	<0.001
Northeast	0.749	0.748, 0.751	0.350	<0.001	0.695	0.693, 0.696	0.324	<0.001	0.707	0.705, 0.708	0.330	<0.001
South	0.246	0.244, 0.248	0.079	<0.001	0.199	0.197, 0.201	0.064	<0.001	0.181	0.179, 0.183	0.058	<0.001
Age					0.003	0.003, 0.003	0.017	<0.001	0.002	0.002, 0.002	0.010	<0.001
Sex (male)					−0.002	−0.004, −0.001	−0.001	<0.001	0.009	0.007, 0.010	0.004	<0.001
Rural					0.152	0.150, 0.153	0.075	<0.001	0.140	0.138, 0.141	0.069	<0.001
Single					−0.124	−0.127, −0.121	−0.027	<0.001	−0.096	−0.099, −0.093	−0.021	<0.001
Married					0.025	0.024, 0.027	0.012	<0.001	0.024	0.023, 0.025	0.021	<0.001
Education									−0.072	−0.072, −0.071	−0.055	<0.001
Income									0.115	0.114, 0.115	0.098	<0.001
Security												
North	−0.375	−0.377, −0.373	−0.154	<0.001	−0.265	−0.267, −0.263	−0.109	<0.001	0.034	0.033, 0.035	0.014	<0.001
Northeast	−0.714	−0.715, −0.712	−0.333	<0.001	−0.580	−0.581, −0.578	−0.270	<0.001	−0.222	−0.223, −0.222	−0.104	<0.001
South	−0.369	−0.371, −0.367	−0.118	<0.001	−0.255	−0.257, −0.253	−0.081	<0.001	−0.157	−0.158, −0.156	−0.050	<0.001
Age					0.002	0.002, 0.002	0.011	<0.001	0.011	0.011, 0.011	0.065	<0.001
Sex (male)					0.098	0.097, 0.099	0.049	<0.001	−0.070	−0.070, −0.069	−0.035	<0.001
Rural					−0.454	−0.456, −0.453	−0.224	<0.001	−0.151	−0.151, −0.150	−0.074	<0.001
Single					0.122	0.120, 0.125	0.026	<0.001	0.001	−0.001, 0.002	0.000	0.495
Married					0.105	0.104, 0.106	0.051	<0.001	0.023	0.022, 0.024	0.011	<0.001
Education									0.735	0.734, 0.735	0.561	<0.001
Income									0.575	0.574, 0.575	0.491	<0.001

[a] Latent factors generated from the EFA and validated through the CFA. Region: North, Northeast, South (ref: Central); Sex (ref: female); Area (ref: urban); Marital status (ref: separated and single); Education (ref: <Primary); Income (ref: inadequate income).
[b] The unadjusted results considered geographic inequality in AA scores.
[c] The results are adjusted for demographic covariates (age, sex, area, and marital status).
[d] The results are adjusted for demographic covariates (age, sex, area, and marital status) and socioeconomic covariates (education and income).
[e] Unstandardised regression coefficient for AA scores.
[f] 95 % Confidence Interval.
[g] Standardised regression coefficient for AA scores.
[h] *P*-value from multivariate analysis.

improved quality of life [25]. However, security disadvantages persist in less developed areas [26,27], particularly in the Northeast region, attributed to lower education and inadequate income. AA disparities were observed in certain parts of the country, such as the southern border provinces impacted by political crises [28]. These areas demonstrated the poorest outcomes across all aspects of AA. This underscores the influence of political contexts on population health [29].

Demographic and socioeconomic disparities are evident, with males and those with adequate income having better AA across all factors. This aligns with the gender paradox in health, where women tend to live longer but experience poorer health compared to men. Similar patterns have been observed in China, Korea, and India, where men exhibit more successful ageing [24,30]. Considering covariates, being currently married, and having adequate income emerged as significant predictors of better AA across all factors, aligning with a study in England [11] mentioning women, with older age and lower household wealth exhibit lower health. This study emphasises the role of economic factors in AA, suggesting that higher economic status correlates with improved health, participation, and security, consistent with findings from China and South Korea indicating better financial support increases the likelihood of successful ageing [30]. Socioeconomic status, including education and income, emerges as a key determinant of AA and should be addressed to reduce security gaps across regions.

Our AA model sheds light on older adults' AA status. Extracted three factors explained 45.7 % of the variance of 20 indicators from the large dataset. This is considered to reasonably represent the situation of Thai older adults. It is worth noting these three factors represent major characteristics of AA. Further research can explore if other aspects are explaining AA by using indicators. While our emphasis on physical health is robust, there's a need for deeper exploration of participation and security domains. To enhance the understanding of the location and health, future research should explore urban-rural differences and employ longitudinal studies to track the evolving AA status over time. Also, limited data on physical environments and social welfare services

constrain our analysis. Given confirmed geographical, demographic, and socioeconomic disparities in AA, further investigations into social, environmental, and health-related inequalities are crucial. Future studies should also explore the intersectionality of factors influencing AA, including gender and socioeconomic status to provide a more comprehensive understanding of disparities in older adult populations.

Despite limitations such as the cross-sectional design and missing indicators, this study provides a reference to public health policymakers in tailoring policies at subnational levels to address AA disparities. It underscores the importance of understanding local evidence and demographics to meet the diverse needs of older adults across health, participation, and security domains.

5. Conclusion

This study developed a comprehensive AA model with three robust latent factors: physical health, participation, and security. Using FSR, we analysed how geographic, demographic, and socioeconomic factors influence AA. The findings shed light on the geographic inequality and demographic and socioeconomic disparities in the AA of older adults in Thailand. Notably, a contrasting AA pattern emerged: developed areas showed lower social participation but better security. While it is undeniable that AA tends to decline with age, this study highlights the potential of better economic status in improving AA outcomes.

The disparities in geographic characteristics and socioeconomic status in AA underscore the need for tailored social and public health policies, avoiding a "one-size-fits-all" approach.

Ethical approval

This research extracted the data from the survey conducted by the Thailand National Statistical Office (NSO), with informed consent and ethical approval being under the purview of the Thai NSO.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing interests

N/A.

Author contributions

RK: Conceptualization, acquisition of data, analysis/interpretation of data. KN: Conceptualization, interpretation of data. PT: interpretation of data. All authors were involved in drafting, revising, and finalizing the manuscript.

Submission declaration and verification

This research has not been previously published and is not currently being considered for publication elsewhere.

Data availability

The data supporting this research are openly available from the Thailand National Statistical Office (NSO) Website at http://www.nso.go.th/. To fully access the dataset, a permission from the NSO is needed.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

We would like to express sincere gratitude toward Thailand NSO for providing us with the data.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhip.2024.100509.

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