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Original Article

# Latent cognitive profiles and their associations with instrumental activities of daily living among older adults without dementia: A United States national cross-sectional study

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ABSTRACT

*Background:* Conventional dichotomous classifications of cognitive status in older adults (normal vs impaired) may obscure distinct domain-specific deficits. Identifying nuanced cognitive profiles could enable personalized interventions, particularly when tailored to instrumental activities of daily living (IADLs).
*Objectives:* To identify distinct cognitive profiles in older adults without dementia and assess their associations with overall and domain-specific IADL performance.
*Design/Setting/Participants:* Cross-sectional data from 2219 adults aged ≥65 years without dementia in the nationally representative National Health and Aging Trends Study.
*Measurements:* Latent profile analysis classified participants across six cognitive domains: episodic memory, executive function, orientation, psychomotor function, visual attention, and working memory. Logistic and linear regression models with Holm-Bonferroni corrections evaluated relationships between cognitive profiles and IADL performance.
*Results:* Five profiles emerged: **Profile 1**: Overall intact (50.5 % of participants); **Profile 2**: Isolated moderate orientation impairment (15.6 %); **Profile 3**: Mild global impairment with preserved orientation (22.0 %); **Profile 4**: Mild global impairment with significant orientation impairment (5.5 %); **Profile 5**: Moderate global impairment (6.2 %). Compared with **Profile 1**, all other profiles exhibited significantly higher overall IADL difficulty and were more likely to experience challenges with shopping, medication management, meal preparation, and banking (all *adjusted* $p < 0.05$). **Profile 4** had the highest odds for difficulties with shopping (*OR*, 2.19; 95 % *CI*, 1.41–3.38; *adjusted* $p = 0.005$) and banking (*OR*, 3.98; 95 % *CI*, 2.62–6.04; *adjusted* $p < 0.001$), whereas **Profile 5** showed the greatest risk for medication management (*OR*, 2.55; 95 % *CI*, 1.66–3.90; *adjusted* $p < 0.001$) and meal preparation (*OR*, 2.22; 95 % *CI*, 1.49–3.31; *adjusted* $p = 0.001$).
*Conclusion:* Nearly half of older adults without dementia exhibit distinct cognitive profiles warranting tailored interventions. **Profile 5** requires comprehensive strategies, whereas **Profiles 2, 3**, and **4** may benefit from orientation-targeted and intensity-varied training in other cognition domain. Incorporating specific IADL tasks (e.g., meal preparation, medication management for **Profile 5** and shopping, banking for **Profile 4**) into cognitive interventions may concurrently enhance cognitive health and functional independence.

## 1. Introduction

By 2050, older adults will represent 22 % of the global population-double the current rate [1]. Such demographic shifts have made dementia and functional dependence major public health challenges, imposing substantial economic burdens on health systems, social services, caregivers, and patients. In 2019, global societal costs of dementia were estimated at US $1.3 trillion [2], while annual costs related to limitations in functional independence reached approximately US $27.4 K societally, US $24.2 K for health care, and US $7.5 K for personal expenses [3]. Cognitive decline is prevalent, with up to 15 % of community-dwelling older adults exhibiting mild cognitive impairment [4]. Although dementia is currently incurable, early or subtle cognitive decline may represent a pre-onset stage that offers a critical window for intervention, with the goal of slowing or delaying progression and reducing its impact on function [5]. Instrumental activities of daily living (IADLs), such as cooking,

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cleaning, transportation, laundry, financial management, and medication adherence are crucial for older adults to maintain independence and successfully age in place [6,7]. Given that cognitive function plays a crucial role in everyday activities and decision-making, impairments are closely linked to IADL difficulties [8–11]. In fact, IADL disability has been reported in as many as 46.8 % of older adults [12], highlighting the need to improve cognitive health and functional performance to promote healthy aging, preserve independence, and enhance quality of life.

Traditional classifications of cognitive status (normal, mild cognitive impairment, dementia) fail to capture the varying domain-specific declines in areas such as episodic memory, executive function, spatial orientation, psychomotor skills, visual attention, and working memory. These declines arise from a complex interplay of biological, psychological, lifestyle, and environmental factors. For instance, aging differentially affects brain regions: the inferior frontal gyrus rapidly loses volume, the dentate gyrus declines steadily, and the entorhinal cortex remains relatively stable over time [13], thereby disproportionately impacting specific cognitive domains [14,15]. In addition, health conditions like cardiovascular disease and diabetes exacerbate cognitive decline by impairing cerebral blood flow and increasing inflammation [16,17], contributing to selective deterioration [18]. Moreover, lifestyle factors also play a critical role; regular physical activity improves processing speed and executive function, and social engagement enhances memory and executive abilities, whereas toxin exposures and occupational hazards can impair performance [19,20]. This heterogeneity suggests that latent cognitive profiles exist among older adults without dementia, yet they remain underexplored. Identifying these profiles is key for developing profile-targeted, group-based interventions that strike a balance between one-size-fit-all population-level approaches and costly personalized interventions, ensuring they are scalable, cost-effective, and capable of delaying progression to dementia.

This gap is particularly significant when considering that successful IADL performance depends on the intricate interplay of multiple cognitive domains [8,9]. A comprehensive systematic review has found that mild cognition impairment is associated with deficits in IADL functioning [9]. This seminal review, along with other key studies, has demonstrated that global cognitive impairment is significantly linked to difficulties in managing everyday tasks such as medication management [8,11], shopping [8], and financial management [11]. However, these investigations often overlook the nuances of domain-specific decline. A detailed understanding of these relationships could facilitate the integration of cognitive training with IADL-focused practice—an approach that not only enhances cognitive function but also promotes daily autonomy. Such a dual-targeted strategy holds promise for reducing functional decline and improving quality of life.

Therefore, this study addresses these gaps by applying latent profile analysis to representative United States data from older adults without dementia to identify distinct cognitive profiles that inform profile-targeted and group-based interventions. We further examine how these profiles relate to specific IADL difficulties, thereby informing the integration of IADL support into cognitive training, ultimately fostering greater cognitive well-being, independence, and quality of life.

## 2. Methods

### 2.1. Study design and data source

We conducted a cross-sectional analysis using data from the 11th and 12th waves (2021–2022) of the National Health and Aging Trends Study (NHATS), a longitudinal, nationally representative survey of Medicare beneficiaries aged ≥65 years in the United States. Data were collected during in-home interviews. For participants present in both waves, only wave 12 data were used to capture the most recent cognitive and IADL assessments. These two waves were selected because the comprehensive six-domain cognitive performance assessment was introduced in wave 11, while earlier waves only included a three-domain cognitive assessment. The final sample comprised 245 participants from wave 11 and 1994 from wave 12 (total n = 2239).

### 2.2. Participants and sample size calculation

Participants were community-dwelling individuals aged ≥65 years deemed cognitively intact, defined as the absence of both potential and probable dementia. Following previous NHATS protocols, potential dementia was identified if a participant scored ≥1.5 standard deviations below the mean in one cognitive domain, while probable dementia was indicated by similar scores in two or more domains, meeting AD8 criteria, or having a documented clinical diagnosis of dementia [21]. Simulation studies suggest that a sample size of approximately 500 is sufficient to reliably identify latent profiles [22].

### 2.3. Measures

#### 2.3.1. Cognitive performance assessment

Cognitive performance was evaluated across six domains using both traditional measures (episodic memory, executive function, and orientation) and computerized measures administered via a tablet-based Cogstate battery (psychomotor function, visual attention, and working memory), which has been implemented in NHATS since wave 11 [23].

Episodic memory was assessed through a word recall task. In this task, participants were presented with a list of 10 words and subsequently asked to recall as many words as possible immediately and after a delay. The combined score from the immediate and delayed recall trials yields a total score ranging from 0 to 20, reflecting the ability to encode, store, and retrieve verbal information.

Executive function was evaluated using the clock drawing test, participants were instructed to draw a clock showing a specific time. This test measures planning, visuospatial organization, and abstract reasoning. Scores range from 0 to 5, with higher scores indicating better performance in executive processing.

Orientation was measured by asking participants questions related to time and key political figures, including the date, month, year, day of the week, and the names of the president and vice president. The orientation score ranges from 0 to 8, capturing participants' awareness of temporal and contextual information critical for daily functioning

Psychomotor function was assessed using the Cogstate Detection task, which measures simple reaction time. In this task, participants are instructed to tap the screen as soon as a card turns face up. Reaction times, recorded in milliseconds and log-transformed to reduce skewness, serve as an index of psychomotor speed and processing efficiency.

Visual attention was measured with the Cogstate Identification task, where participants classify the color of a card (red or black) as quickly and accurately as possible. Reaction times for correct responses are recorded in log-transformed milliseconds, providing a sensitive measure of attention and visual processing speed.

Working memory was evaluated through the Cogstate One Card Back task, which assesses working memory and continuous performance. Participants were shown a sequence of cards and asked to indicate whether the current card had appeared previously. Accuracy on this task reflects the capacity to hold and manipulate information over short intervals.

#### 2.3.2. IADL measurements

IADL function was self-reported, and the tasks assessed included managing medication, laundry, shopping, meal preparation, and banking. For each task, responses were categorized as indicating difficulty if the participant selected '1′ (Did not do by self in the past month), '3′ (Did by self in the past month with difficulty), and '5′ (Don't know or refuse, with difficulty). Responses were categorized as indicating no difficulty if the participant selected '2′ (Did by self in the past month with no difficulty) and '4′ (Don't know or refuse, with no difficulty). Each IADL task was then dichotomized based on the presence (yes: responses 1, 3, or 5) or absence (no: responses 2 or 4) of difficulty. Additionally, the total number of difficulties across all IADL tasks (ranging from 0 to 5) was calculated as a continuous variable. This summative count approach is a common and practical method for capturing overall limitations in independence [24].

#### 2.3.3. Socio-demographics and covariates

Covariates included age, sex, living arrangement, race, income status, and self-rated health. All covariates were entered as categorical variables for both description and regression model adjustment. Age was grouped into five categories (70–74, 75–79, 80–84, 85–89, and ≥90). Sex was coded as a binary variable (female, male). Self-rated health was categorized into five levels (poor, fair, good, very good, excellent). Race was classified into four groups (Asian American/Pacific Islander, Non-Hispanic Black, Hispanic, Non-Hispanic White). Living arrangement was dichotomized (alone vs. living with someone), and income status was categorized into three groups (poverty: ≤100 % Federal Poverty Level [FPL], low-income: >100 % to ≤200 % FPL, normal: >200 % FPL).

### 2.4. Statistical analysis

Overall, Latent Profile Analysis (LPA) was performed on standardized cognitive performance scores to identify latent cognitive profiles, followed by logistic or linear regression with Holm-Bonferroni corrections to examine associations between these profiles and IADL difficulties. All analyses were performed using R (version 4.4.0).

#### 2.4.1. Data transformation and checking

Cognitive scores were first transformed so that higher scores uniformly indicated greater impairment, and then standardized into z-scores for each of the six cognitive domains. Standardizing to z-scores allowed us to compare domains on a common scale, ensuring that differences in the original scoring metrics did not bias the latent profile analysis. A correlation matrix was generated to assess multicollinearity; all coefficients were below 0.55[25]. Outlier detection was performed using the 1.5 × interquartile range (IQR) rule [25]. Participants with outlier scores in more than one domain (i.e., scores below Q1–1.5 × IQR or above Q3+1.5 × IQR) were excluded from the analysis, resulting in the removal of 20 participants.

#### 2.4.2. Latent profile analysis

LPA was applied to the six-domain z-scores to determine the optimal number of cognitive profiles. Models with one to six profiles were tested under the assumption of equal variances and zero covariances. Model selection was guided by three criteria [25]:

Model fit: Evaluation using Akaike Information Criterion (*AIC*), Bayesian Information Criterion (*BIC*), and sample-size adjusted BIC (*SABIC*), where lower values indicate better fit.

Incremental fit improvement: The Bootstrapped Likelihood Ratio Test (*BLRT*) was used to assess whether adding an additional profile significantly improved model fit.

Profile characteristics: Consideration of the number and size of profiles, as well as entropy values, with values closer to 1 signifying clearer delineation between profiles.

#### 2.4.3. Reporting and interpretation of profiles

For each identified profile, mean z-scores across the six cognitive domains were reported. Given the absolute value of z-scores ($|z|$) range across all domains in this study (from 0.09 to 2.7), to facilitate interpretation, deviations in z-scores were categorized as mild ($|z| < 1.0$), moderate ($|z|$ 1.0–1.5), or significant ($|z| > 1.5$).

#### 2.4.4. Exploring the associations between profiles and IADL difficulties

We examined associations between latent cognitive profiles and IADL difficulties using regression analyses. The profiles were treated as categorical independent variables, with the best-performing profile serving as the reference group. Dependent variables included difficulties in individual IADL domains (shopping, laundry, banking, meal preparation, and medication management) and a cumulative IADL sum score derived by aggregating difficulty responses across domains. Logistic regression was employed for individual IADL difficulties (categorical outcomes), while linear regression was used for the total number of difficulties (a continuous outcome). All models adjusted for potential confounders, including sex, age group, self-rated health, race, living arrangement, and income status. Holm-Bonferroni-adjusted p-values were applied to control for multiple comparisons, thereby preserving the family-wise error rate and enhancing the robustness of significant findings.

## 3. Results

### 3.1. Participants' demographics and characteristics

The analytic sample (N = 2219) was composed of 56.3 % female, 77.0 % White individuals, with the most common age range being 75–79 years (33.6 %). Additionally, 36.0 % lived alone, 40.0 % rated their health as "good", and 43.4 % reported having a normal income. Detailed demographics, cognitive scores, and IADL difficulties are presented in Table 1.

### 3.2. Identification of latent profiles

A five-profile model was selected based on optimal model fit, evidenced by the lowest *AIC, BIC*, and SABIC values, highest entropy (0.853), and a significant Bootstrapped Likelihood Ratio Test (*BLRT*; p < 0.001) (see Appendix 1). Fig. 1 displays the mean z-scores and sample sizes for each profile, while Appendix 2 details the z-scores, original scores, and standard deviations. The profiles, defined by predefined z-score deviation thresholds, are as follows:

**Profile 1** (Overall intact, n = 1123; 50.5 %): Exhibited below-average impairments across all cognitive domains (all z-scores < 0), representing the healthiest cognitive group.

**Profile 2** (Isolated moderate orientation impairment, n = 346; 15.6 %): Characterized by a moderate deficit in orientation (z-score = 1.06) while other domains remained average (z-scores between −0.21 and 0.21).

**Profile 3** (Mild global impairment with preserved orientation, *n* = 489, 22.0 %): Demonstrated slight impairments across all cognitive domains (z-scores between 0.14 and 0.89) but showed relatively preserved orientation (z-score = −0.47).

**Profile 4** (Mild global impairment with significant orientation impairment, *n* = 123, 5.5 %): Showed significant impairment in orientation (z-score = 2.7) alongside slight impairments in other domains (z-scores between 0.4 and 0.91)

**Profile 5** (Moderate global impairment, *n* = 138, 6.2 %): Represented the most cognitively impaired group, with moderate impairments across all domains (z-scores between 0.78 and 1.43).

In summary, **Profile 1** exhibited the healthiest cognitive performance; **Profiles 2** and **4** were marked by orientation deficits (with **Profile 4** also showing broader impairment); **Profile 3** had mild global impairments but relatively preserved orientation; and **Profile 5** demonstrated the most extensive global impairment.

### 3.3. Association between the profiles and IADLs

Overall, compared with **Profile 1** (the healthiest group), all other profiles were associated with higher odds of difficulties in individual

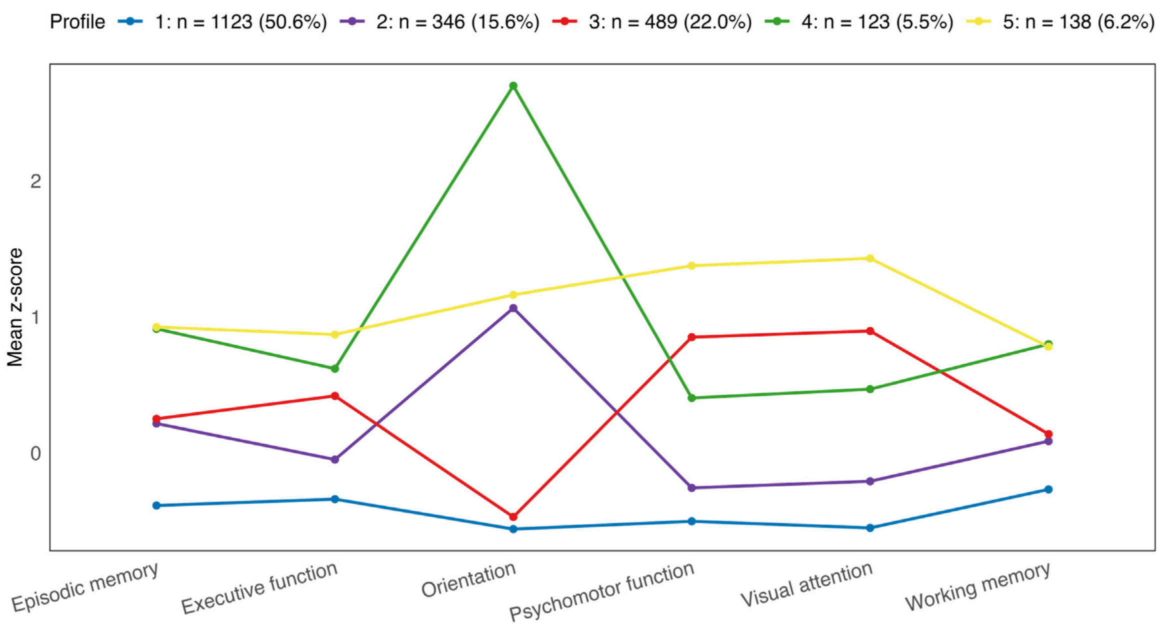


**Fig. 1.** Mean z-scores across six cognitive domains and corresponding profile sizes.

IADL tasks (medication management, shopping, meal preparation, and banking) as well as a higher cumulative IADL difficulty score, after adjusting for confounders and applying Holm-Bonferroni correction. No significant associations were observed for laundry. Detailed regression model results are presented in Table 2, and the significant associations are visualized in Fig. 2.

For medication management, compared with **Profile 1, Profile 5** exhibited the highest risk, with a 2.55-fold increase in the odds of experiencing difficulty (*OR* = 2.55, 95 % *CI*: 1.66–3.90; *adjusted p* < 0.001). This was followed by **Profile 4**, which had a 2.15-fold increase (*OR* = 2.15, 95 % *CI*: 1.36–3.40; *adjusted p* = 0.008), then **Profile 2** (*OR* = 2.06, 95 % *CI*: 1.51–2.81; *adjusted p* < 0.001), and **Profile 3** (*OR* = 1.56, 95 % *CI*: 1.16–2.09; *adjusted p* = 0.017).

In shopping difficulties, compared with **Profile 1**, the highest risk was observed in **Profile 4** (*OR* = 2.19, 95 % *CI*: 1.41–3.38; *adjusted p* = 0.005). Profile 5 also showed a substantial association (*OR* = 2.03, 95 % *CI*: 1.35–3.06; *adjusted p* = 0.007), followed by **Profile 2** (*OR* = 1.77, 95 % *CI*: 1.35–2.31; *adjusted p* < 0.001) and **Profile 3** (*OR* = 1.65, 95 % *CI*: 1.30–2.11; *adjusted p* = 0.001).

For meal preparation difficulties, compared with **Profile 1, Profile 5** exhibited the highest risk (*OR* = 2.22, 95 % *CI*: 1.49–3.31; *adjusted p* = 0.001), followed by **Profile 4** (*OR* = 2.07, 95 % *CI*: 1.36–3.15; *adjusted p* = 0.007), with **Profiles 2** and **3** both associated with a 1.52-fold increase in odds (**Profile 2**: *OR* = 1.52, 95 % *CI*: 1.16–1.99; *adjusted p* = 0.017; **Profile 3**: *OR* = 1.52, 95 % *CI*: 1.19–1.94; *adjusted p* = 0.007).

Banking difficulties showed the strongest associations overall. The highest risk was observed in **Profile 4**, with nearly four times the odds of difficulty compared with **Profile 1** (*OR* = 3.98, 95 % *CI*: 2.62–6.04; *adjusted p* < 0.001). This was followed by **Profile 5** (*OR* = 3.25, 95 % *CI*: 2.19–4.81; *adjusted p* < 0.001), then **Profile 2** (*OR* = 1.81, 95 % *CI*: 1.38–2.37; *adjusted p* < 0.001), and **Profile 3** (*OR* = 1.48, 95 % *CI*: 1.15–1.90; *adjusted p* = 0.017).

In contrast, regarding laundry activities, none of the profiles demonstrated a statistically significant association after adjusting for multiple comparisons. Specifically, **Profile 2** (*OR* = 1.16, 95 % *CI*: 0.88–1.54; *adjusted p* = 0.434), **Profile 3** (*OR* = 1.17, 95 % *CI*: 0.91–1.51; *adjusted p* = 0.434), **Profile 4** (*OR* = 1.51, 95 % *CI*: 0.98–2.35; *adjusted p* = 0.198), and **Profile 5** (*OR* = 1.52, 95 % *CI*: 1.00–2.30; *adjusted p* = 0.198) did not reach statistical significance.

In linear regression analyses of the cumulative IADL difficulty score, all profiles were associated with significantly higher scores compared with **Profile 1. Profile 5** was associated with the largest increase ($\beta$ = 0.83, 95 % *CI*: 0.57–1.09; *adjusted p* < 0.001), followed closely by **Profile 4** ($\beta$ = 0.82, 95 % *CI*: 0.55–1.10; *adjusted p* < 0.001), then **Profile 2** ($\beta$ = 0.46, 95 % *CI*: 0.29–0.64; *adjusted p* < 0.001), and **Profile 3** ($\beta$ = 0.37, 95 % *CI*: 0.21–0.52; *adjusted p* < 0.001).

## 4. Discussion

Using a nationally representative dataset from the United States, we identified five distinct cognitive profiles among older adults without dementia, underscoring considerable heterogeneity. The largest group (**Profile 1**, 50.5 %) demonstrated intact cognition across all domains, whereas a small subgroup (**Profile 5**, 6.2 %) exhibited pronounced impairments across all domains, suggesting the need for comprehensive cognitive interventions. Two profiles were characterized by orientation deficits: **Profile 4** (5.5 %) showed mild global impairments with a significant orientation deficit, and **Profile 2** (15.6 %) exhibited isolated orientation-specific impairment with otherwise average functioning. In contrast, **Profile 3** (22.0 %) presented mild global impairments but retained strong orientation. With regard to IADLs, compared with **Profile 1** (overall intact), all other profiles **(Profiles 2–5)** were associated with increased risk for difficulties in nearly every domain except laundry. Notably, the highest risk varied by task, with **Profile 4** (mild global impairment with significant orientation impairment) showing the greatest risk for banking and shopping difficulties, and **Profile 5** (moderate global impairment) demonstrating the highest odds for challenges in medication management and meal preparation. Both **Profiles 4** and **5** consistently exhibited higher risk across IADL domains (except laundry) than **Profile 2** (isolated moderate orientation impairment) and **Profile 3** (mild global impairment with preserved orientation). These findings suggest that a one-size-fits-all approach to cognitive training is inadequate, and underscore the importance of tailoring interventions to address both domain-specific cognitive deficits and associated IADL challenges.

**Table 1**
Participant demographics, cognitive scores, and instrumental activities of daily living (IADL) difficulties ($n = 2219$).

| Variable | N/mean | %/SD |
|---|---|---|
| **Demographics (n, %)** | | |
| Sex | | |
| Female | 1249 | 56.3 |
| Male | 970 | 43.7 |
| Age group | | |
| 70–74 | 214 | 9.6 |
| 75–79 | 745 | 33.6 |
| 80–84 | 614 | 27.7 |
| 85–89 | 391 | 17.6 |
| ≥90 | 255 | 11.5 |
| Self-rated health | | |
| Poor | 66 | 3.0 |
| Fair | 427 | 19.2 |
| Good | 883 | 39.8 |
| Very good | 673 | 30.3 |
| Excellent | 169 | 7.6 |
| Race | | |
| Asian American/Pacific Islander | 41 | 1.9 |
| Non-Hispanic Black | 368 | 16.6 |
| Hispanic | 79 | 3.6 |
| Non-Hispanic White | 1709 | 77.0 |
| Living arrangement | | |
| Alone | 798 | 36.0 |
| Living with someone | 1421 | 64.0 |
| Income status | | |
| Poverty | 846 | 38.1 |
| Low Income | 409 | 18.4 |
| Normal | 964 | 43.4 |
| **IADL difficulties (n, %)** | | |
| Difficulty in medication | | |
| No | 1787 | 80.5 |
| Yes | 432 | 19.5 |
| Difficulty in laundry | | |
| No | 1316 | 59.3 |
| Yes | 903 | 40.7 |
| Difficulty in shopping | | |
| No | 1210 | 54.5 |
| Yes | 1009 | 45.5 |
| Difficulty in meal preparation | | |
| No | 1366 | 61.6 |
| Yes | 853 | 38.4 |
| Difficulty in banking | | |
| No | 1499 | 67.6 |
| Yes | 720 | 32.5 |
| **Cognition (mean, SD)** | | |
| Episodic memory, range: 0 to 19 | 10.11 | 3.18 |
| Executive function, range: 0 to 5 | 0.83 | 0.88 |
| Orientation, range: 0 to 7 | 0.94 | 1.29 |
| Psychomotor function, range: 2.36 to 3.26 | 2.65 | 0.13 |
| Visual attention, range: 2.57 to 3.21 | 2.82 | 0.10 |
| Working memory, range: 0 - 1.26 | 0.33 | 0.24 |

*Note:* IADL: instrumental activities of daily living; SD: standard deviation; NA: not applicable.

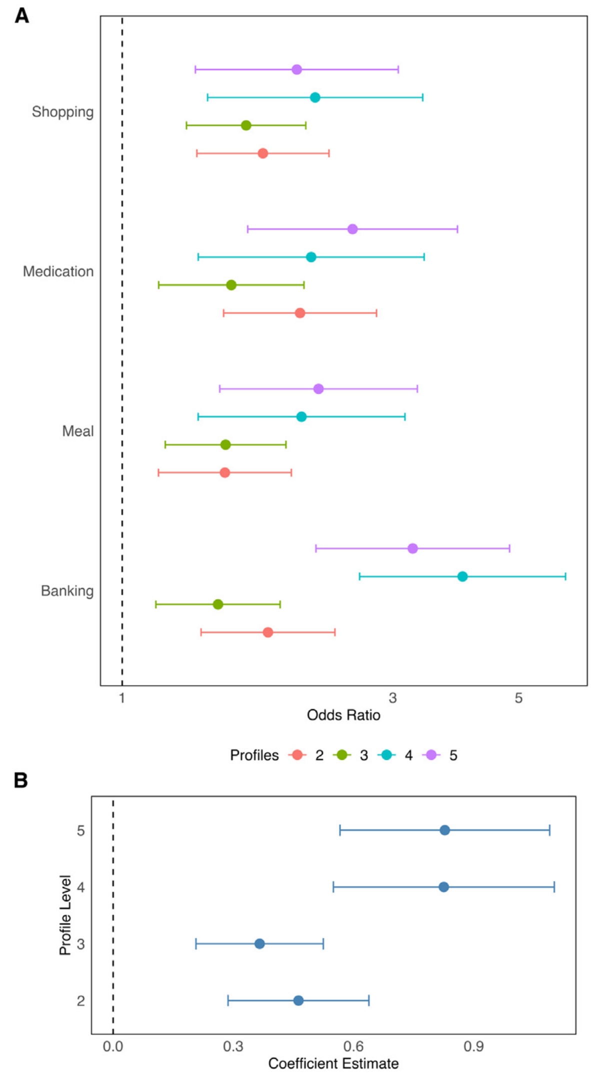


**Fig. 2.** Adjusted associations between cognitive profiles and IADL outcomes relative to Profile 1. Panel A: Associations with individual IADL domains. Panel B: Associations with overall IADL difficulty.
*Note*: Each regression model was adjusted for potential confounders, including sex, age, race, income, living arrangement, and self-rated health status. *P* values were adjusted using the Holm-Bonferroni correction.

### *4.1. Profiles' characteristics and tiered interventions*

A profile-group-based approach offers a balanced alternative to both one-size-fits-all programs and the high costs of fully personalized interventions. In particular, individuals in **Profile 5** (moderate global impairment) appear to be at the greatest risk for dementia [26]. Targeted interventions for this group should systematically address deficits across multiple cognitive domains. For example, deficits in episodic memory may be countered with physical exercise, computer-based tasks, and psychopedagogical sessions designed to enhance memory function and counteract negative beliefs about memory decline [27]. In addition, incorporating caregiver collaboration, structured training models (such as ACTIVE), and varied cognitive exercises using multiple stimuli has shown promise in improving episodic memory [27]. Enhancing executive function can be achieved through exercises that promote cognitive flexibility (e.g., task-switching), inductive reasoning tasks (such as identifying patterns in sequences), and activities that encourage goal-directed behaviors in daily life [28,29]. For psychomotor function, coordinated activities like tai chi, yoga, or fine motor tasks (e.g., knitting) have demonstrated benefits [30]. Interventions to improve visual attention might include scanning exercises, computer-based training programs, and environmental modifications—such as clear signage and contrasting colors—to facilitate better visual processing [31]. Working memory can be strengthened through exercises like digit span and n-back tasks, dual-task sessions that combine physical activity with memory challenges, and strategies that manage cognitive load (e.g., chunking) [32]. Finally, to enhance orientation, interventions such as reality orientation therapy, environmental enrichment using clocks and calendars, and assistive technologies like electronic reminders and Global Positioning System (GPS) systems have proven effective in supporting temporal and spatial awareness [33,34].

Relative to **Profile 5** (moderate global impairment), the other three profiles present less severe impairments, but varying orientation needs. A tiered intervention strategy can adapt the multi-domain regimen de-

**Table 2**
Regression analysis of associations between cognitive profiles and domain-specific and overall IADL difficulties relative to Profile 1.

| Domain-specific or overall IADL | Independent variable (ref: Profile 1) | *OR/b* | 95 %*CI* | *p* | *Adjusted p* |
|---|---|---|---|---|---|
| Logistic regression (*OR*) | | | | | |
| Medication | Profile 2 | 2.06 | (1.51, 2.81) | <0.001 | <0.001 |
| | Profile 3 | 1.56 | (1.16, 2.09) | 0.003 | 0.017 |
| | Profile 4 | 2.15 | (1.36, 3.40) | 0.001 | 0.008 |
| | Profile 5 | 2.55 | (1.66, 3.90) | <0.001 | <0.001 |
| Laundry | Profile 2 | 1.16 | (0.88, 1.54) | 0.292 | 0.434 |
| | Profile 3 | 1.17 | (0.91, 1.51) | 0.217 | 0.434 |
| | Profile 4 | 1.51 | (0.98, 2.35) | 0.064 | 0.198 |
| | Profile 5 | 1.52 | (1.00, 2.30) | 0.049 | 0.198 |
| Shopping | Profile 2 | 1.77 | (1.35, 2.31) | <0.001 | <0.001 |
| | Profile 3 | 1.65 | (1.30, 2.11) | <0.001 | 0.001 |
| | Profile 4 | 2.19 | (1.41, 3.38) | <0.001 | 0.005 |
| | Profile 5 | 2.03 | (1.35, 3.06) | 0.001 | 0.007 |
| Meal preparation | Profile 2 | 1.52 | (1.16, 1.99) | 0.002 | 0.017 |
| | Profile 3 | 1.52 | (1.19, 1.94) | 0.001 | 0.007 |
| | Profile 4 | 2.07 | (1.36, 3.15) | 0.001 | 0.007 |
| | Profile 5 | 2.22 | (1.49, 3.31) | <0.001 | 0.001 |
| Banking | Profile 2 | 1.81 | (1.38, 2.37) | <0.001 | <0.001 |
| | Profile 3 | 1.48 | (1.15, 1.90) | 0.003 | 0.017 |
| | Profile 4 | 3.98 | (2.62, 6.04) | <0.001 | <0.001 |
| | Profile 5 | 3.25 | (2.19, 4.81) | <0.001 | <0.001 |
| Linear regression (*b*) | | | | | |
| Total number of IADL difficulties | Profile 2 | 0.46 | (0.29, 0.64) | <0.001 | <0.001 |
| | Profile 3 | 0.37 | (0.21, 0.52) | <0.001 | <0.001 |
| | Profile 4 | 0.82 | (0.55, 1.10) | <0.001 | <0.001 |
| | Profile 5 | 0.83 | (0.57, 1.09) | <0.001 | <0.001 |

*Note*: IADL: instrumental activities of daily living (including medication management, laundry, shopping, meal preparation, banking); Cognitive Profiles: Profile 1 (overall intact), Profile 2 (isolated moderate orientation impairment), Profile 3 (mild global impairment with preserved orientation), Profile 4 (mild global impairment with significant orientation impairment), Profile 5 (moderate global impairment); Regression models adjusted for sex, age, race, income, living arrangement, and self-rated health status; P values adjusted using the Holm-Bonferroni method.

veloped for **Profile 5** by adjusting the intensity—in terms of dosage, frequency, and duration [35]—while also accounting for each group's unique orientation training requirements. For example, **Profile 4** (mild global impairment with significant orientation impairment) may require a slightly lower overall intervention intensity, but with a greater emphasis on orientation, whereas **Profile 2** (isolated moderate orientation impairment) might benefit from an even lower intensity across all domains with simplified, less frequent orientation exercises alongside basic training in other cognitive areas. Meanwhile, **Profile 3** (mild global impairment with preserved orientation), which demonstrates intact orientation but deficits in other domains, may benefit from minimal orientation reinforcement combined with more intensive interventions targeting the affected domains. This tiered approach enables targeted, tailored interventions that address the distinct cognitive profiles and orientation capabilities of each group.

### *4.2. Associations of profiles with IADLs*

Our findings on the association between cognitive profiles and both overall and domain-specific IADL performance deepen our understanding of the interplay between cognition and daily functioning. In general, more impaired cognitive profiles were associated with a higher risk of overall IADL disability and difficulties across nearly all IADL domains—with the notable exception of laundry. **Profiles 2–5**, characterized by greater cognitive impairments, demonstrated pronounced difficulties in IADL performance, consistent with prior studies linking cognitive decline to impaired daily functioning [8,9]. However, the absence of differences in laundry performance likely reflects its low cognitive demand; as a habit-based, routine task involving predictable steps—operating a machine, hanging, folding, and putting away clothes [36]—laundry is often performed on autopilot using preserved procedural memory. Moreover, physical capacity and habitual factors can mask cognitive effects, as variations (e.g. a strong but forgetful person versus a weak but cognitively sharp person) may introduce unrelated variance. In our sample of older adults without dementia, this uniformity suggests that laundry is a less sensitive indicator of early cognitive decline than tasks like managing finances and medications that require planning, problem-solving, and memory.

Notably, each profile displayed unique IADL demands. **Profile 5** (moderate global impairment) exhibited highest challenges with medication management (*OR*: 2.55) and meal preparation (*OR*: 2.22), while **Profile 4** (mild global impairment with pronounced orientation deficits) had the greatest difficulties with shopping (*OR*: 2.19) and banking (*OR*: 3.98). Using our thresholds (*OR* 1.68=small effect, 3.47= medium, 6.71=large) [37], the challenges for **Profile 5** fall between small and medium, whereas **Profile 4**'s banking difficulty exceeds the medium threshold, indicating a more clinically significant impact. Orientation, a complex cognitive function that integrates sensory information, attention, and memory, is essential for navigating one's surroundings [38]. Deficits in orientation may disproportionately affect tasks requiring spatial navigation and environmental awareness; for example, banking and shopping, which are typically conducted in less familiar settings than the home, demand effective spatial interpretation and route planning. When orientation is impaired, locating services and navigating layouts become particularly challenging. Clinically, these findings suggest that patients in **Profile 4** may benefit from targeted interventions—such as environmental modifications and enhanced support services—to maintain independence and safety, while streamlined strategies in routine tasks might ease the burden for **Profile 5**.

Integrating each profile's specific IADL demands into cognitive training holds promise for simultaneously improving underlying cognitive function and mitigating real-world functional decline. For instance, we hypothesize that interventions for **Profile 4** (mild global impairment with significant orientation impairment) could incorporate practical, simulation-based modules for financial tasks and shopping alongside targeted orientation drills such as calendar management and spatial navigation exercises. In contrast, the comprehensive impairments observed in **Profile 5** (moderate global impairment) might benefit from a multi-domain regimen that combines structured cognitive exercises with real-world activities, such as medication scheduling workshops and guided meal preparation sessions. Meanwhile, the milder deficits in **Profile 2** (isolated moderate orientation impairment) and **Profile 3** (mild global impairment with preserved orientation) may call for a more focused approach—with minimal orientation reinforcement for **Profile 3** and simplified, scaled interventions for **Profile 2** to support their cognitive functions—while integrating IADL scenarios at a mild level may be sufficient. This tiered, integrated strategy not only aligns intervention intensity with specific cognitive deficits but also addresses their IADL demands, thereby providing a framework for future studies to evaluate the efficacy of group-based interventions that strike a balance between scalability and personalization to promote cognitive well-being and independence among older adults without dementia.

### *4.3. Limitations*

Several limitations warrant consideration. First, the cross-sectional design precludes the assessment of the stability and transitions of cognitive profiles over time, and causality between cognitive profiles and IADL performance cannot be inferred. Longitudinal research is essential to determine the stability of these cognitive profiles and to better understand the causal relationships between cognitive decline and functional impairments. However, this study represents an important initial step in building evidence in this area. Second, focusing exclusively on older adults in the United States limits generalizability; distinct cultural, social, or economic contexts may yield different cognitive profiles or associations (for example, laundry practices may vary in low-resource settings). Third, although eligibility was set at 65 years and older, all final participants were aged 70 and above. This is likely due to attrition or aging of those initially aged 65–69, which may limit the applicability of our findings to the younger segment of older adults. Fourth, since the six-domain cognitive assessment was introduced in Wave 11 and repeated in Wave 12, the one-year interval may not be sufficient to capture significant longitudinal changes in cognitive performance. While a longitudinal latent profile analysis would be informative, future studies should consider this approach once additional waves of data become available. Finally, reliance on self-reported IADLs may introduce bias, particularly among participants with subtle cognitive impairments. For example, some individuals may underreport or overreport difficulties due to recall issues, social desirability bias, or a lack of insight into their own functional limitations. Future research should incorporate objective or performance-based measures of IADL performance to confirm these results.

## 5. Conclusion

This study identified five distinct cognitive profiles among older adults without dementia. Approximately half of the participants exhibited robust cognition (**Profile 1**: overall intact), while the remaining half showed varying levels of impairment. Notably, 6.2 % experienced significant all-domain deficits, and the other three profiles demonstrated milder impairments with differing orientation needs. Cognitive training for **Profile 5** (moderate global impairment)should address all cognitive domains systematically, whereas interventions for **Profile 2** (isolated moderate orientation impairment), **Profile 3** (mild global impairment with preserved orientation), and **Profile 4 (mild global impairment with significant orientation impairment)** should tailor intensity and orientation-focused components according to their specific needs. Compared with **Profile 1, Profiles 2** to **5** showed higher overall IADL risks in nearly all domains except for laundry, which may be a less sensitive indicator of cognitive well-being. Integrating profile-specific cognitive training with corresponding IADL tasks (e.g., medication and meal preparation for **Profile 5**, and shopping and banking for **Profile 4**) may enhance real-world functionality. These findings provide a foundation for designing group-level, profile-tailored interventions that balance the limitations of broad population-based programs with the high costs of fully personalized approaches, ultimately enhancing the well-being of older adults.

## Declaration of generative AI and AI-assisted technologies in the writing process

No Generative AI or AI-assisted technologies were used in the writing of this document.


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None.


## Data availability

The data involved in this study is openly accessible at: https://www.nhats.org.

## Declaration of competing interest

No conflicts to disclose.

## CRediT authorship contribution statement

**Jiaying Li:** Writing – original draft. **Sarah L. Szanton:** Writing – review & editing. **Junxin Li:** Writing – review & editing.


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## Appendix 1. Fit statistics for six test models in latent profile analysis

| Number of profiles | AIC | BIC | SABIC | Entropy | BLRT_p |
|---|---|---|---|---|---|
| 1 | 37,801.49 | 37,869.95 | 37,831.83 | 1.000 | NA |
| 2 | 36,299.03 | 36,407.42 | 36,347.06 | 0.736 | 0.010 |
| 3 | 35,719.41 | 35,867.73 | 35,785.13 | 0.767 | 0.010 |
| 4 | 35,314.80 | 35,503.06 | 35,398.21 | 0.823 | 0.010 |
| 5 | 34,813.19 | 35,041.38 | 34,914.30 | 0.853 | 0.010 |
| 6 | 35,149.47 | 35,417.59 | 35,268.27 | 0.664 | 0.010 |

*Note*: Model fit statistics from 6 latent profile analysis models (1–6 profiles). *AIC*: Aikake information criteria; *BIC*: Bayesian information criteria; *SABIC*: sample size-adjusted Bayesian information criteria; *BLRT_p*: p-value for the bootstrapped likelihood ratio test.

## Appendix 2. Z-scores and original scores for cognitive domains across five latent profiles

| Cognition | Profile 1 | Profile 2 | Profile 3 | Profile 4 | Profile 5 |
|---|---|---|---|---|---|
| Z-scores: mean (standard deviation) | | | | | |
| Episodic memory | −0.39 (0.93) | 0.21 (0.93) | 0.25 (0.86) | 0.91 (0.82) | 0.92 (0.76) |
| Executive function | −0.34 (0.80) | −0.05 (0.90) | 0.42 (1.05) | 0.62 (1.03) | 0.87 (1.14) |
| Orientation | −0.56 (0.32) | 1.06 (0.36) | −0.47 (0.37) | 2.7 (0.54) | 1.16 (0.40) |
| Psychomotor function | −0.5 (0.68) | −0.26 (0.75) | 0.85 (0.80) | 0.4 (1.00) | 1.38 (0.99) |
| Visual attention | −0.55 (0.66) | −0.21 (0.77) | 0.89 (0.71) | 0.47 (1.09) | 1.43 (0.78) |
| Working memory | −0.27 (0.84) | 0.09 (0.99) | 0.14 (1.04) | 0.8 (1.08) | 0.78 (1.09) |
| Original scores: mean (standard deviation) | | | | | |
| Episodic memory | 8.88 (2.95) | 10.79 (2.95) | 10.9 (2.75) | 13.01 (2.60) | 13.05 (2.41) |
| Executive function | 0.53 (0.70) | 0.79 (0.79) | 1.2 (0.92) | 1.37 (0.90) | 1.59 (1.00) |
| Orientation | 0.22 (0.41) | 2.31 (0.47) | 0.33 (0.47) | 4.41 (0.70) | 2.43 (0.51) |
| Psychomotor function | 2.59 (0.08) | 2.62 (0.09) | 2.76 (0.10) | 2.71 (0.13) | 2.83 (0.12) |
| Visual attention | 2.76 (0.06) | 2.8 (0.08) | 2.91 (0.07) | 2.86 (0.11) | 2.96 (0.08) |
| Working memory | 0.27 (0.20) | 0.35 (0.24) | 0.36 (0.25) | 0.52 (0.26) | 0.52 (0.26) |

*Note*: Z-scores were computed after transforming the cognitive test scores such that higher scores indicate greater impairment. Original scores reflect the raw cognitive performance measures.

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