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A Two-Factor Model of Functional Independence Among Community-Dwelling Indonesian Older Adults: Evidence from Exploratory and Confirmatory Factor Analysis

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ABSTRACT

Background: Despite the widespread use of functional independence measures in geriatric assessment, evidence regarding their underlying factor structure among Indonesian older adults remains limited. Therefore, this study aimed to identify and validate the factor structure of functional independence among Indonesian older adults using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA).
Methods: The measurement items were derived from the 2023 Indonesian Health Survey (SKI 2023) dataset. These items were adapted from domains of the Barthel Index and were intended to assess functional independence among 95,552 older adults. EFA was initially conducted using the principal-factor method with varimax rotation. Factors with eigenvalues greater than 1.0 were retained, and items with factor loadings of at least 0.40 were considered acceptable. Subsequently, CFA was performed to assess the construct validity of the identified factor structure.
Results: The EFA results identified a two-factor structure consisting of 10 indicators, explaining 74.55% of the total variance. Factor 1, Basic Activities of Daily Living (ADL), comprised eight indicators and accounted for 52.59% of the variance. Factor 2, Continence Control, comprised two indicators and accounted for 21.96% of the variance. CFA demonstrated an acceptable model fit (RMSEA= 0.070, CFI= 0.975, TLI= 0.967, SRMR= 0.019, and CD= 98.7%), with Cronbach's alpha values= 0.92.
Conclusion: The two-factor model supports the conceptualization of functional independence as a multidimensional construct comprising both basic activities of daily living and continence control. The validated instrument may be useful for geriatric assessment, public health surveillance, and community-based services aimed at identifying older adults at risk of functional decline.

Keywords: ***Exploratory Factor Analysis; Functional Independence; Older People***

INTRODUCTION

Indonesia has experienced a rapid increase in its older adult population over the past decade. Since 2021, older adults have accounted for more than 10% of the total population, marking the country's transition into an ageing society.[1] While increased longevity reflects improvements in population health, it also presents important public health challenges.

Ageing is commonly accompanied by a higher burden of chronic diseases, physical limitations, disability, and mental health problems, which may compromise an individual's ability to perform activities of daily living independently.[2],[3]

Functional independence is a key indicator of healthy ageing because it reflects an older adult's capacity to maintain autonomy and participate in community life.[4] Declines in functional independence have been associated with increased healthcare utilization, reduced quality of life, greater caregiver burden,

and higher risks of institutionalization and mortality. Therefore, assessing functional independence is essential for identifying older adults who may require rehabilitation, supportive care, or community-based services.[5] Functional assessment can also support clinical decision-making, monitor changes in health status over time, evaluate intervention outcomes, and inform health and social care planning.

Given the growing older population in Indonesia, reliable and valid measures of functional independence are needed to support clinical practice, public health surveillance, and healthy ageing policies. Functional assessment is particularly important for identifying older adults who may require additional healthcare, rehabilitation, or social support services.[6]

The Barthel Index was originally developed to assess activities of daily living (ADL) among patients recovering from stroke, particularly younger adults.[7][8] Over time, however, its application has expanded considerably and it is now widely used as a measure of functional independence in geriatric assessment.[9] Previous studies have reported satisfactory psychometric properties of the Barthel Index among older populations in various settings. Nevertheless, evidence regarding the psychometric performance of ADL measures derived from large-scale population surveys in Indonesia remains limited. Although a previous Indonesian study using a similar national survey dataset examined the association between functional limitations and depression among older adults[10], the measurement properties and underlying factor structure of the functional independence instrument were not evaluated. Therefore, further validation is needed to establish the construct validity and reliability of this instrument among Indonesian older adults.

Exploratory Factor Analysis (EFA) is widely used to evaluate the underlying structure of measurement instruments and identify latent dimensions that explain the relationships among observed variables.[11][12][13] Previous studies have applied EFA to assess physical functioning among older adults in several countries, including China[14], Spain[15], and the United Kingdom[16]. However, evidence regarding the psychometric properties of functional independence measures among Indonesian older adults remains limited. Therefore, this study aimed to evaluate the factor structure and reliability of a functional independence instrument among Indonesian older adults using exploratory and confirmatory factor analyses.

METHODS

Study design

A cross-sectional study was conducted to evaluate the dimensionality and psychometric properties of a questionnaire designed to measure the construct of functional independence among older adults, based on data obtained from the 2023 Indonesian Health Survey (SKI 2023). Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were performed to evaluate the questionnaire's factor structure.

Sample size

The initial dataset included 877,531 participants aged from less than 1 year to 112 years. As this study focused on older adults, participants younger than 60 years were excluded. Individuals with incomplete data on the variables of interest were also excluded, resulting in 97,339 eligible participants. Subsequently, 1,787 participants (1.87%) with missing data on the outcome variables (depression) were excluded.

The distribution of participants with missing data was relatively balanced across key demographic characteristics, including sex and place of residence, indicating that the missingness was not concentrated within any particular demographic group. Although the mechanism of missingness was not

formally assessed, the observed pattern suggests no obvious demographic imbalance in the excluded observations.

A total of 95,552 older adults were included in this study. The sample size was considered more than adequate for exploratory factor analysis (EFA). First, based on the commonly recommended item-to-response ratio of at least 10 participants per item, a minimum sample of 100 participants would have been required for the 10-item instrument.[17] Second, according to the recommendations of Mundfrom et al.,[18] sample sizes ranging from 100 to more than 1,000 participants are generally sufficient for factor analysis, depending on the characteristics of the data and factor structure. The available sample substantially exceeded established recommendations, providing a robust basis for evaluating the factor structure of the instrument.

Statistical analyses

Descriptive statistics

Descriptive analysis was conducted to summarize the characteristics of the study population. Categorical variables were presented as frequencies (n) and percentages (%), while continous variables were summarized using means and standard deviations (SD). We performed all the statistical analyses using STATA statistical software version 17.

Checking the assumptions of EFA

The functional independence instrument used in this study was derived from questions available in the 2023 Indonesian Health Survey (SKI 2023) questionnaire. Specifically, the instrument was based on a module designed to assess physical and mental disability among household members aged 60 years and older and comprised 10 items. These items were adapted from domains included in the Barthel Index.

Prior to EFA, the factorability of the correlation matrix was assessed using Bartlett's test of sphericity and the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy. A significant Bartlett's test indicated that the correlation matrix was suitable for factor analysis, while KMO values greater than 0.50 were considered evidence of adequate sampling adequacy.[19][20]

Examining the construct validity: exploratory factor analysis

This study employed exploratory factor analysis (EFA) using principal component factor (PCF) extraction with varimax rotation to examine the underlying factor structure of the functional independence instrument.[21]

PCF was used to identify latent dimensions underlying the observed items, while varimax rotation was applied to achieve a simpler and more interpretable factor structure by maximizing the variance of factor loadings across items.[15][22]

Two criteria were used to determine the number of factors to retain. First, the Kaiser criterion was applied, whereby factors with eigenvalues greater than 1.0 were retained.[23] Second, visual inspection of the scree plot was performed, and factors above the point of inflection (elbow) were retained.[24] The final factor solution was determined based on the consistency of these two approaches.

Confirmatory factor analysis (CFA)

Confirmatory factor analysis (CFA) was performed to test the measurement model identified through exploratory factor analysis.[25] CFA evaluates the extent to which observed indicators represent their underlying latent constructs and provides statistical indices to assess model fit. Model fit was evaluated using the comparative fit index (CFI), Tucker–Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR).[26]

Reliability test

Following EFA and CFA, the reliability of the instrument was assessed using item-level and scale-level reliability statistics. Internal consistency was evaluated using Cronbach's alpha (α), while item

reliability was evaluated using item-rest correlations.[27] Cronbach's alpha values of 0.70 or higher were considered acceptable for research purposes, whereas item-rest correlations greater than 0.20 were considered indicative of adequate item discrimination.

Ethics approval

This study was approved by the Health Research Ethics Committee of Faculty of Health Science, Universitas Muhammadiyah Surakarta, Indonesia (Approval Number: 2001/KEPK-FIK/II/2026).

RESULTS

Descriptive analysis

A total of 95,552 older adults aged 60 years and above were included in the study. The sample was relatively balanced by sex, comprising 51% females and 49% males. Participants had a mean age of 67.53 years (SD = 6.59), indicating that most respondents were in the younger-old age group. More than half of the participants resided in urban areas (54.02%), while 45.98% lived in rural areas. Geographically, the largest proportion of respondents were from Java and Bali (36.90%), followed by Sumatera (28.19%), Kalimantan and Sulawesi (22.53%), and Nusa Tenggara, Maluku, & Papua (12.39%). These characteristics suggest that the study included a large and geographically diverse sample of Indonesian older adults from both urban and rural settings (Table 1).

Table 1. Sample characteristics

Sample Characteristics	n	%
Age (years old)	Mean= 67.53; SD= 6.59; min.= 60; max.= 112	
Sex		
Female	48,735	51.00%
Male	46,817	49.00%
Place of residence		
Rural	43,939	45.98%
Urban	51,613	54.02%
Province of living		
Sumatera	26,936	28.19%
Java-Bali	35,255	36.90%
Kalimantan-Sulawesi	21,525	22.53%
Nusa Tenggara-Maluku-Papua	11,836	12.39%

Exploratory factor analysis (EFA) results

The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was 0.94, indicating excellent suitability for exploratory factor analysis. Results from the rotated factor solution, eigenvalue criterion, and scree plot (**Figure 1**) consistently supported the retention of two factors. Therefore, a two-factor solution was retained as the most parsimonious and interpretable model (**Tables 2 and 3**).

Table 2. Exploratory factor analysis of functional independence items among Indonesian older adults (N = 95,552)

Item	Description	Factor 1	Factor 2	Uniqueness
Item1	Grooming	0.816	0.220	0.286
Item2	Toilet use	0.837	0.295	0.213
Item3	Feeding	0.760	0.330	0.313
Item4	Transfer	0.803	0.311	0.259
Item5	Mobility/Walking	0.804	0.281	0.275
Item6	Dressing	0.850	0.284	0.196
Item7	Stairs	0.722	0.252	0.415

Item	Description	Factor 1	Factor 2	Uniqueness
Item8	Bathing	0.815	0.180	0.303
Item9	Bowel control	0.226	0.900	0.139
Item10	Bladder control	0.252	0.889	0.146

Table 3. Factor Retention Statistics

Indicator	Value
Bartlett's test of sphericity (p)	<0.001
Kaiser-Meyer-Olkin (KMO)	0.94
Number of retained factors	2
Eigenvalue Factor 1	6.37
Eigenvalue Factor 2	1.09
Variance explained by Factor 1	52.59%
Variance explained by Factor 2	21.96%
Total variance explained	74.55%

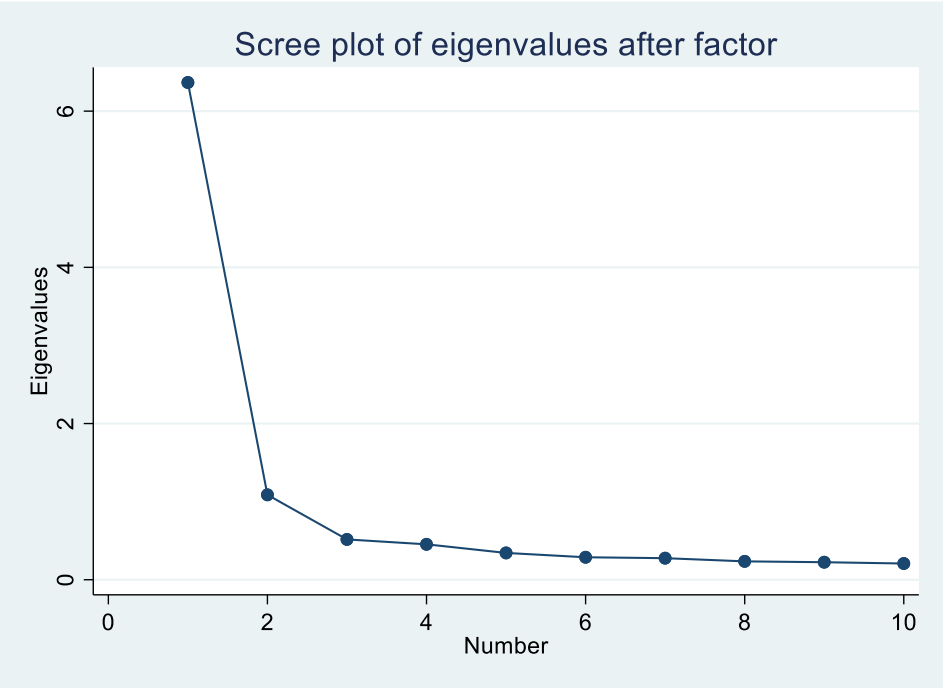

Figure 1. Scree Plot Supporting the Retention of Two Factors for the Functional Independence Instrument

Factor 1: Basic Activities of Daily Living (ADL).

Items 1–8 were grouped under the Basic Activities of Daily Living (ADL) factor. These items assess an individual's ability to independently perform essential self-care and daily functional tasks, including activities such as bathing, dressing, eating, transferring, mobility, and personal hygiene. Higher scores indicate greater functional independence in performing basic daily activities.

Factor 2: Continence Control.

Items 9 and 10 were grouped under the Continence Control factor. These items assess an individual's ability to maintain bowel and urinary continence and to control elimination functions independently. Higher scores indicate better continence control and greater independence in managing bladder and bowel functions.

Confirmatory factor analysis (CFA) results

Two competing measurement models were evaluated using confirmatory factor analysis. The first model (**Figure 2**) specified a single latent factor underlying all 10 functional independence items, whereas the second model (**Figure 3**) specified two correlated latent factors. In the two-factor model, items related to basic activities of daily living (items 1–8) loaded on the first factor, while the continence-related items (items 9–10) loaded on the second factor.

Although both factors reflected aspects of functional independence, the superior fit of the two-factor model suggests that continence control constitutes a distinct domain rather than simply another component of basic ADL. Therefore, functional independence among Indonesian older adults appears to be best conceptualized as a multidimensional construct consisting of basic ADL and continence control dimensions.

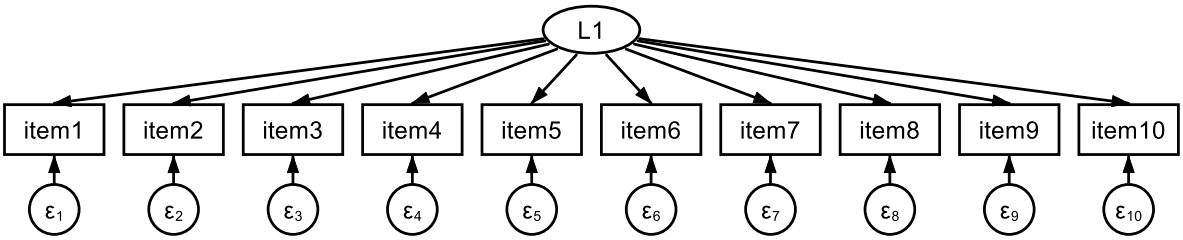

Figure 2. Single-Factor Measurement Model for the 10-Item Functional Independence Instrument

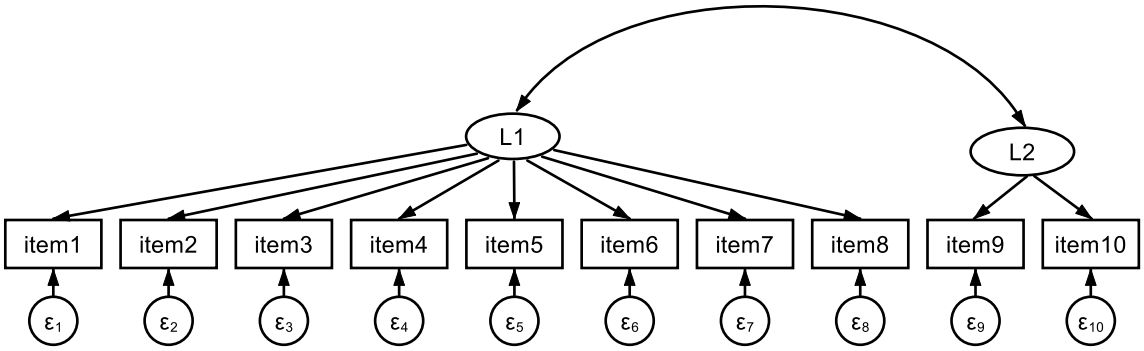

Figure 3. Two-Factor Confirmatory Factor Analysis Model Consisting of Basic Activities of Daily Living and Continence Control Dimensions

Table 4. Comparison of Standardized Factor Loadings Between the Single-Factor and Two-Factor Confirmatory Factor Analysis Models of Functional Independence

Item	Domain	Single-Factor Analysis			Two-Factor Analysis		
		Standardized Loading (β)	95% CI	p	Standardized Loading (β)	95% CI	p
Item 1	Basic ADL	0.81	0.81 to 0.81	<0.001	0.81	0.81 to 0.82	<0.001
Item 2	Basic ADL	0.87	0.87 to 0.87	<0.001	0.87	0.87 to 0.87	<0.001
Item 3	Basic ADL	0.81	0.81 to 0.81	<0.001	0.81	0.81 to 0.81	<0.001
Item 4	Basic ADL	0.84	0.83 to 0.84	<0.001	0.84	0.84 to 0.84	<0.001
Item 5	Basic ADL	0.83	0.82 to	<0.001	0.83	0.83 to	<0.001

Item	Domain	Single-Factor Analysis			Two-Factor Analysis		
		Standardized Loading (β)	95% CI	p	Standardized Loading (β)	95% CI	p
Item 6	Basic ADL	0.88	0.83 0.88 to 0.88	<0.001	0.89	0.84 0.88 to 0.89	<0.001
Item 7	Basic ADL	0.73	0.72 to 0.73	<0.001	0.73	0.73 to 0.73	<0.001
Item 8	Basic ADL	0.79	0.79 to 0.79	<0.001	0.79	0.79 to 0.80	<0.001
Item 9	Continence Control	0.54	0.53 to 0.54	<0.001	0.83	0.83 to 0.84	<0.001
Item 10	Continence Control	0.55	0.55 to 0.56	<0.001	0.86	0.86 to 0.87	<0.001
Covariance basic ADL ←→ continence control		N/A	N/A	N/A	0.62	0.61 to 0.62	<0.001

Goodness of fit indices of CFA

The single-factor model (**Figure 2**) demonstrated a suboptimal fit to the data, as indicated by a high RMSEA (0.13), a TLI below the recommended threshold (0.880), and an SRMR above the recommended cutoff (0.06) (**Table 5**). Although the CFI (0.91) exceeded the minimum acceptable value of 0.90, the overall fit indices suggested that a unidimensional representation of functional independence did not adequately capture the underlying structure of the instrument.

In contrast, the two-factor model (**Figure 3**) demonstrated substantially better model fit across all indices. The RMSEA decreased from 0.13 to 0.07, indicating acceptable approximation error, while the CFI and TLI increased to 0.98 and 0.97, respectively, exceeding recommended thresholds. The SRMR also improved markedly from 0.06 to 0.02, indicating excellent fit. Furthermore, the coefficient of determination increased from 94.5% to 98.7%, suggesting that the two-factor model explained a greater proportion of variance in the observed indicators.

These results support the two-factor structure (**Figure 3**) identified in the exploratory factor analysis. The results suggest that functional independence among Indonesian older adults is better represented by two correlated dimensions—Basic Activities of Daily Living (ADL) and Continence Control—rather than a single underlying factor.

Table 5. Comparison of confirmatory factor analysis results for the single and two-factor model of functional independence in older people

Fit Index	Model 1: single-CFA	Model 2: 2-CFA	Recommended Value
χ^2	67,497.08	15,856.04	Lower is better
p	<0.001	<0.001	< 0.050
df	30	31	≥1
RMSEA	0.14	0.08	< 0.080
CFI	0.91	0.97	> 0.90
TLI	0.88	0.96	> 0.90
SRMR	0.06	0.02	< 0.050
CD	94.9%	98.8%	Close to 1

Internal consistency

Item-rest correlations ranged from 0.57 to 0.83, indicating that all items demonstrated adequate discrimination and contributed meaningfully to the overall scale. The instrument showed excellent internal consistency, with an overall Cronbach's alpha (α) of 0.92 (**Table 6**).

Table 6. Internal Consistency Reliability of the Functional Independence Scale (N= 95,552)

Item	Description	Item-test Correlation	Item-rest Correlation	Cronbach's α if Item Deleted
Factor1 (basic ADL)				
Item1	Grooming	0.79	0.76	0.92
Item2	Toilet use	0.86	0.83	0.91
Item3	Feeding	0.81	0.77	0.91
Item4	Transfer	0.87	0.81	0.91
Item5	Mobility/Walking	0.86	0.80	0.91
Item6	Dressing	0.87	0.83	0.91
Item7	Stairs	0.78	0.70	0.92
Item8	Bathing	0.77	0.74	0.92
Factor2 (continence control)				
Item9	Bowel control	0.650	0.57	0.92
Item10	Bladder control	0.669	0.58	0.92
Reliability Statistic Value				
Number of items: 10				
Cronbach's Alpha: 0.92				

DISCUSSION

The present study identified a two-factor structure of functional independence consisting of Basic Activities of Daily Living (ADL) and Continence Control dimensions. The model demonstrated satisfactory construct validity and excellent internal consistency, supporting the multidimensional nature of functional independence among Indonesian older adults.

The first factor, Basic Activities of Daily Living (ADL), comprised feeding, dressing, bathing, toileting, grooming, mobility, transfers, and stair climbing. These activities represent fundamental self-care and mobility functions that are essential for maintaining independence in later life.[28] Performance of these tasks depends on a combination of muscle strength, balance, mobility, coordination, and postural control. However, these physical capacities tend to decline with advancing age due to age-related changes in the musculoskeletal and neuromuscular systems, including reductions in muscle mass, muscle strength, and motor function.[29] Consequently, older adults may experience increasing difficulty performing daily activities independently, placing them at greater risk of functional decline, disability, and dependence on caregivers. The clustering of these items into a single factor suggests that they reflect a common underlying dimension of physical functioning and self-care capacity among community-dwelling older adults.

In contrast, bowel and bladder control emerged as a separate Continence Control factor, indicating that continence represents a distinct domain of functional independence that is not fully captured by traditional ADL measures. This finding is consistent with previous evidence suggesting that the Barthel Index has limited sensitivity for identifying urinary incontinence among patients with stroke.[30] The emergence of a distinct Continence Control factor suggests that

bowel and bladder function may represent a separate dimension of functional independence that is not fully reflected by traditional ADL tasks. Unlike activities such as feeding, dressing, or bathing, continence is associated with a range of physiological and health-related factors, including neurological function, pelvic floor integrity, cognitive status, and chronic disease burden.[31] Age-related changes in these systems may be accompanied by difficulties in maintaining bladder and bowel control, even among older adults who remain relatively independent in other daily activities.[32] This finding may explain why the continence-related items clustered separately from the basic ADL items in the present study.

The identification of Continence Control as an independent construct also has important implications for functional assessment. Previous studies have shown that urinary and fecal incontinence are associated with poorer quality of life, reduced social participation, psychological distress, and increased care needs among older adults.[33][34] Therefore, evaluating continence alongside traditional ADL measures may provide a more comprehensive assessment of functional independence and help identify older adults with care needs that may otherwise remain undetected.

The validated two-factor structure also has important implications for future research. Basic ADL and Continence Control may be analyzed as separate dimensions to determine whether they have different determinants, trajectories, or associations with health outcomes. In addition, these two latent constructs can be incorporated into structural equation modeling (SEM) to investigate their relationships with physical health, mental health, quality of life, disability, healthcare utilization, and healthy aging.

CONCLUSION

Our study suggests that functional independence among older adults should be assessed across both basic daily functioning and continence control domains. Evaluating these dimensions separately may help healthcare practitioners identify specific support needs, detect early functional decline, and guide appropriate rehabilitation, caregiving, and community-based interventions to support independent living among older adults.

Study implication

The identification of two distinct dimensions of functional independence—Basic Activities of Daily Living (ADL) and Continence Control—has important implications for healthcare practice. The findings suggest that healthcare practitioners should assess both domains rather than relying solely on an overall measure of functional independence. Older adults may remain independent in daily activities while experiencing bladder or bowel control difficulties that require specific management strategies. As continence control emerged as a separate dimension, changes in bladder or bowel function may warrant particular attention as potential indicators of declining health and independence. Among community-dwelling older adults, assessment of both dimensions may facilitate the early identification of individuals who could benefit from rehabilitation, home-based care, caregiver support, or other community services aimed at maintaining functional independence and quality of life.

Study limitation

Several limitations in our study should be acknowledged. First, the cross-sectional design and the absence of repeated measurements prevented evaluation of the temporal stability and test–retest reliability of the instrument. Consequently, it remains uncertain whether the identified factor structure would be maintained over time. Second, although the instrument demonstrated satisfactory construct validity and internal consistency, its ability to predict future health out-

comes, such as disability, hospitalization, or healthcare utilization, was not examined.

Third, the instrument was derived from items available in a secondary national survey, which may not have fully captured the broad spectrum of functional independence among older adults. In addition, functional independence was assessed using self-reported information and was therefore subject to potential recall and reporting biases, while objective performance-based measures were unavailable for comparison.

Fourth, the same dataset was used for both exploratory and confirmatory factor analyses without random sample splitting. Although the large sample size provided stable parameter estimates and the CFA demonstrated satisfactory model fit, the absence of an independent validation sample may limit the generalizability of the identified factor structure. The absence of Parallel Analysis was found, which is considered a more robust approach for determining the optimal number of factors in exploratory factor analysis. Factor retention was based on eigenvalues greater than one, scree plot inspection, theoretical interpretability, and subsequent CFA. While these complementary methods supported a stable and interpretable two-factor solution with satisfactory model fit, future studies should employ Parallel Analysis to further confirm the dimensional structure of the instrument. Finally, the consistency of the factor structure across demographic subgroups, including sex, age, and place of residence, was not evaluated. Further research using longitudinal and clinical datasets is warranted to examine the stability, predictive performance, and cross-group applicability of the instrument.

Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available but are available from the corresponding author on reasonable request.

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Conflict of interest

All authors declare that there are no conflicts of interest, including any financial or institutional relationships with the funders, that could have influenced the design, implementation, analysis, or reporting of the study.

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