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Development and psychometric evaluation of the Intrinsic Capacity Assessment Scale for Older Patients with Stroke: a mixed-methods study

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Abstract

Background

Intrinsic capacity is a core indicator of healthy aging; however, assessment tools specifically designed for older Chinese patients with stroke remain lacking. This study aimed to develop a culturally appropriate intrinsic capacity assessment scale for older patients with stroke and to evaluate its psychometric properties.

Methods

The item pool was developed through a literature review and descriptive qualitative semi-structured interviews. Two rounds of Delphi consultation were conducted to refine the items. A cross-sectional survey was carried out between January and May 2024 among older inpatients with stroke at a tertiary general hospital in China. Item screening was performed using response distribution, critical ratio, item-total correlation, and exploratory factor analysis (EFA). Psychometric properties were evaluated using Cronbach's α, split-half reliability, test-retest reliability, the content validity index (CVI), EFA, and confirmatory factor analysis (CFA).

Results

The initial scale contained 24 items across five dimensions. After the first round of Delphi consultation, one item was deleted, 16 items were revised, and eight items were added, yielding 31 items; after the second round, one item was deleted and two items were revised, yielding 30 items for psychometric testing. The expert authority coefficients were 0.90 and 0.93, respectively, with significant Kendall's W values ($P < 0.05$). A total of 623 questionnaires were distributed, and 617 valid questionnaires were returned (effective response rate, 99.03%). One item was deleted after EFA, yielding a final 29-item scale with five dimensions. Five factors were extracted, explaining 71.08% of the total variance. CFA showed acceptable model fit (χ^2/df = 2.472, RMSEA = 0.065, NFI = 0.886, IFI = 0.930, TLI = 0.915, CFI = 0.929). The overall Cronbach's α was 0.961 (range across dimensions, 0.873–0.946); total split-half reliability was 0.877, total test-retest reliability was 0.949, the S-CVI was 0.977, and item-level CVI values ranged from 0.83 to 1.00.

Conclusions

The scale demonstrated satisfactory reliability and validity and is suitable for the Chinese cultural and clinical context. It can be used to assess intrinsic capacity in older patients with stroke in clinical practice, although further multicenter validation is needed.

Background

As people age, physiological function declines and the risk of chronic disease increases. After age 60, the main contributors to disability and death are age-related sensory decline (such as hearing and vision loss) and loss of mobility, as well as the cumulative effects of non-communicable diseases, including cardiovascular and cerebrovascular disease, chronic respiratory disease, cancer, and dementia [1, 2]. Stroke is an age-related disease, and the incidence of stroke increases several-fold with advancing age. With socioeconomic development in China, life expectancy has risen and population aging has accelerated; older adults are now the group most affected by stroke [3]. According to data from the China Health and Retirement Longitudinal Study, the prevalence of comorbidity among Chinese adults aged 60 years or older is 65.6% [4]. Stroke stands out among these comorbid conditions: more than 60% of first-ever strokes occur in people aged 60 years or older [5], and mortality is higher than in younger patients [6]. With the high incidence and high rates of mortality and disability in China [7], stroke threatens the health and quality of life of older adults and places a heavy medical burden on patients' families and society.

WHO has incorporated the physical and mental functioning of older adults into the concept of intrinsic capacity and recommends assessing five domains together: activity function, sensory function, cognition function, psychological state, and vitality state [8]. This approach permits comprehensive assessment of intrinsic capacity and rapid screening of functional status in older adults [9]. On this basis, Cesari et al. [10] developed an intrinsic capacity model with five core domains: cognition, psychological function, sensory function, vitality, and locomotion. Beard et al. [11] validated the model and confirmed that intrinsic capacity is valuable for assessing and predicting adverse outcomes such as disability and death. Belloni et al. [12] argued that intrinsic capacity focuses on the functional ability that older adults currently retain and, compared with frailty, has a more positive connotation. Effective assessment and improvement of intrinsic capacity are thus important for promoting healthy aging.

Intrinsic capacity impairment is common among older adults with chronic diseases; 70.18% had impairment in at least one domain and 52.78% had multidomain impairment [13]. Moreover, the decline in intrinsic capacity may be more pronounced in stroke patients. Impaired intrinsic capacity directly reduces functional ability in patients with stroke. Zhu et al. [14]showed that among hospitalized older adults, stroke was associated with a higher likelihood of belonging to the low intrinsic capacity class. Lu et al. [15] followed intrinsic capacity trajectories in older patients with stroke and found that 42.02% showed a persistent decline, whereas 49.84% remained at a persistently low level. These findings suggest that intrinsic capacity is often unsatisfactory in older patients with stroke and frequently results in adverse health outcomes. Assessment and intervention are therefore particularly important for this population.

However, existing intrinsic capacity assessment instruments were designed for the general older population. Such instruments are broadly applicable but insufficiently specific to older patients with stroke, and an instrument that captures stroke-specific characteristics is still lacking. The Integrated

Care for Older People (ICOPE) screening instrument, for example, contains six indicators, each rated as impaired or not; higher scores indicate better intrinsic capacity [16]. This instrument is simple and quick, can identify declines in intrinsic capacity and suggest targets for intervention, and has shown good reliability and validity in several studies [17, 18]. Nevertheless, the ICOPE instrument is designed only for initial screening, and the assessment within each domain is brief. The content and assessment methods need to be expanded to capture intrinsic capacity more comprehensively.

Therefore, a reliable and valid intrinsic capacity assessment scale should be developed for older patients with stroke, taking into account the characteristics of the disease. Such a scale would provide clinicians with a scientific and dependable instrument for assessing intrinsic capacity, help clarify patients' current status and specific problems, and offer a basis for clinical intervention. In this study, we followed standard scale development procedures and used the healthy aging conceptual framework as the theoretical basis. A literature review, a descriptive qualitative study, and group discussions were conducted to determine item content and construct an item pool. Two rounds of Delphi evaluation were then performed to improve the scientific basis and feasibility of the items and to produce an initial scale. Finally, a cross-sectional survey was used to refine and optimize the items and to evaluate the reliability and validity of the scale, resulting in the intrinsic capacity assessment scale for older patients with stroke.

Methods

Study design

This was a mixed-methods study comprising a scale development phase (literature review, qualitative interviews, and Delphi consultation) followed by a cross-sectional psychometric validation study. The study was reported in accordance with the COSMIN checklist for studies on measurement properties.

Purpose of scale development

Previous studies on intrinsic capacity in older adults have identified a lack of specialized assessment tools for this population. A literature search identified no existing tool that can be directly applied to patients with stroke. Therefore, we developed this scale to assess intrinsic capacity in older patients with stroke and to support studies in this field.

Establishment of item pool

The item pool was developed around five dimensions: activity function, sensory function, cognitive function, psychological state, and vitality state. These dimensions were derived from the concept of intrinsic capacity proposed by the World Health Organization (WHO), which defines intrinsic capacity through these five domains. The item pool was developed mainly through a literature review and a

qualitative study. In addition, internationally recognized instruments covering these five dimensions were reviewed, including the ADL [19, 20], IADL [21], MMSE [22], HADS [23], and WHOQOL-100 [24].

Literature analysis

We conducted a comprehensive search of previously published relevant literature, screened and analyzed the retrieved studies, and extracted the main content to form the item pool. The CNKI, Wanfang, VIP, Web of Science, PubMed, MEDLINE, and Cochrane Library databases were searched from inception to September 2023. The following terms were used: "stroke" / "apoplexy" / "cerebrovascular disease" / "cerebral infarction" / "cerebral hemorrhage" / "cerebral embolism", "intrinsic capacity", "activity function", "sensory function", "cognitive ability", "psychology", "vitality", "society", and "environment".

Qualitative study

Purposive sampling was used between August and September 2023 in the neurology, neurosurgery, and rehabilitation departments of one tertiary hospital in Wuhu, Anhui province, China. The inclusion criteria were: age 60 years or older; diagnosis of stroke by CT or MRI (or a history of stroke) according to the Chinese diagnostic criteria for cerebrovascular disease [25]; consciousness with stable vital signs; ability to communicate verbally; and willingness to provide informed consent. The exclusion criteria were: language comprehension impairment; severe visual or auditory impairment; mental illness; severe organic disease; or inability to cooperate because of physical weakness or intolerance. Sample size was determined by information saturation, and 10 patients were enrolled.

Based on the ICF theoretical framework [26] and this study objectives, a preliminary interview guide was developed through a literature review, group discussions and consultation with relevant experts. Before the formal interviews, pilot interviews were conducted with two participants using the preliminary guide, and the guide was revised on the basis of the pilot results. The final interview guide is provided in Additional file 1: Table S1.

A researcher trained in interview methods conducted semi-structured face-to-face interviews with each participant. Before each interview, the interviewer explained the purpose, methods, and expected content of the study and assured participants of anonymity and confidentiality. After obtaining informed consent, in-depth interviews were conducted according to the interview guide developed by the research group. The interviewer also observed and recorded the participant's tone, emotions, and movements. Each interview lasted 30 to 40 minutes and continued until no new information emerged and data saturation was reached. The interviews were transcribed verbatim and analyzed using content analysis [27]; the findings were used to supplement the scale items. An initial item pool of 24 items across five dimensions was thus formed.

Determination of the scale response format

The research team determined the response format for the scale. Because the Likert scale is widely used in instrument development, most existing scales use a 5-point response format, such as WHOQOL-100 [24], SS-QOL [28], etc.. With reference to the scoring formats of previously published scales, this study used a 5-point Likert response format to facilitate application and statistical analysis. The scale was designed primarily for patient self-assessment.

Delphi consultation

The Delphi consultation was conducted between October and November 2023, and experts were recruited nationwide. The inclusion criteria were: working in a tertiary general hospital or a general institution of higher education; specialization in chronic disease management, geriatric care, or rehabilitation therapy with at least 10 years of experience; a bachelor's degree or higher; an associate senior professional title or higher; and willingness to participate and complete all rounds of consultation.

The consultation questionnaire included an introduction to the study; ratings of item importance and operability (5-point Likert scale: 1 = strongly not recommended, 2 = not recommended, 3 = acceptable, 4 = recommended, 5 = strongly recommended); experts' general information; and a self-assessment of expert authority. Items with a mean importance score of 3.50 or higher, a coefficient of variation (Cv) of 0.25 or lower, and a proportion of full scores of 0.20 or higher were retained [29]. After each round, the study group discussed the experts' suggestions and added, deleted, or modified items accordingly. The Delphi results were evaluated using the expert positive coefficient, the authority coefficient (Cr), and the coordination coefficient [30]. The Ca denotes the judgment coefficient, reflecting the basis of the experts' judgments, and the Cs denotes the familiarity coefficient, reflecting the experts' self-assessed familiarity with the topic [31].

Psychometric testing of the scale

Participants

Convenience sampling was used between January and May 2024 in the same departments. The inclusion criteria were: age 60 years or older; diagnosis of stroke by CT or MRI according to the Chinese diagnostic criteria for cerebrovascular disease [25]; adequate cognitive and communication ability to complete the survey; consciousness without a history of mental illness; and voluntary participation with signed informed consent. The exclusion criteria were: sequelae of other brain diseases (e.g., tumor, traumatic brain injury, or cerebral parasitosis); severe auditory or visual impairment; or unstable condition, physical weakness, intolerance, or other reasons preventing cooperation.

Sample size

On the basis of scale development principles and the commonly used rule of thumb [32, 33], the required sample size should be at least 5 to 10 times the number of items, with an additional 10% allowance for

invalid responses. For the 24-item initial scale, the estimated sample size was 132 to 264. The final sample of 617 participants exceeded this requirement and allowed the sample to be randomly split for exploratory factor analysis (EFA) and confirmatory factor analysis (CFA).

Instruments

A self-designed general demographic questionnaire was used to collect information on sex, age, educational level, disease type, occupation, marital status, and other characteristics.

The intrinsic capacity assessment scale for older patients with stroke, comprising five dimensions and 30 items, was used for psychometric testing. Each item uses a 5-point Likert response format, and the five response options are scored sequentially from 1 to 5 (A = 1 ~ E = 5). Total scores range from 30 to 150, with higher scores indicating a higher level of intrinsic capacity. Subscale scores can be obtained by summing the items within each dimension.

Data collection

Questionnaires were completed on site in a centralized setting to improve the authenticity and accuracy of the responses. Unified on-site guidance was provided for questionnaire completion, and anonymous questionnaires were collected immediately after completion to ensure data quality. Unclear, incomplete, or ambiguous responses were checked and clarified on site.

Statistical analysis

Excel was used for double data entry; SPSS 22.0 was used for descriptive statistics, item analysis, reliability analysis, and EFA; AMOS 22.0 was used for CFA. The expert positive coefficient was represented by the questionnaire response rate; expert authority was calculated as Cr = (Ca + Cs) / 2; Kendall's W and Cv were used to assess the degree of expert coordination. Cronbach's α, split-half reliability, and test-retest reliability were used to assess reliability, and the content validity index (CVI), EFA, and CFA were used to assess validity. $P < 0.05$ was considered statistically significant.

Results

Scale development and item pool

A total of 1,390 publications were retrieved, and 20 studies were finally included after screening. The 10 interviewed patients had ischemic or hemorrhagic stroke and were aged 60 to 75 years, with a mean age of 69.10 years (see Additional file 1: Table S2). Based on the ICF coding framework, interview themes were categorized into fear of disease outcomes, stigma, low adherence, numbness or sensory loss, focal or generalized pain, impaired communication ability, self-care deficits, and other domains; these findings supplemented the scale items and contributed to the initial 24-item, five-dimension scale. ICF codes and themes identified was displayed in Additional file 1: Table S3. The sources of the items are presented in Table 1.

Table 1
Initial item pool and sources of evidence

Dimension	Item	Literature analysis	Qualitative study	Refer to relevant scales
Activity function	Item 1	P		ADL
	Item 2	P		IADL
Sensory function	Item 3	P		
	Item 4	P		
	Item 5		P	
	Item 6	P		
	Item 7	P		
Cognitive function	Item 8	P		
	Item 9	P		
	Item 10	P		MMSE
	Item 11	P		MMSE
	Item 12	P		MMSE
	Item 13		P	
Psychological state	Item 14	P		HADS
	Item 15	P		HADS
	Item 16	P		
	Item 17		P	
	Item 18		P	
	Item 19		P	
Vitality state	Item 20	P		
	Item 21	P		WHOQOL-100
	Item 22	P		WHOQOL-100
	Item 23	P		
	Item 24		P	

Delphi consultation

Fifteen experts from six provinces or municipalities were invited, and 13 completed both rounds of consultation. The experts were aged 37 to 62 years, with a mean age of 45.90 years; more than 70% held

a master's or doctoral degree and an associate senior or senior professional title. Their mean length of work experience was 22.50 years in geriatric nursing, chronic disease management, and related fields (see Additional file 1: Table S4). After the first round, one item was deleted, 16 items were revised, and eight items were added, yielding 31 items; after the second round, one item was deleted and two items were revised, yielding 30 items for psychometric testing. The detailed item modification process across the two rounds is presented in Additional file 1: Table S5.

The questionnaire response rates were 86.7% in the first round and 100% in the second round. The Cs of experts were 0.81 and 0.86, the Ca of expers were 0.98 and 0.99, and the Cr of expers were 0.90 and 0.93 in the two rounds, respectively. Kendall's W was 0.128 in round 1 and 0.137 in round 2 (both $P < 0.05$); the coefficients of variation for the items ranged from 0 to 0.22 and from 0.06 to 0.22, respectively (see Additional file 1: Table S6 and Table S7).

Participants

A total of 623 questionnaires were distributed, and 617 valid questionnaires were returned (effective response rate, 99.03%). Participants were aged 60 to 94 years, with a mean age of 70.77 years. The sample was randomly divided into 308 participants for EFA and 309 for CFA.

Item screening

For ease of analysis, items were coded Aa1 to Ae5. In the item distribution analysis, no response option was selected by more than 80% of participants, so all items were retained. The critical ratio test showed that t values ranged from 10.234 to 24.189; all were greater than 3.00 ($P < 0.001$), so no item was deleted. Item-total correlation analysis showed that correlations between each item and the total scale score ranged from 0.510 to 0.801; all were greater than 0.40 ($P < 0.001$), so all items were retained. One item was eliminated after EFA because it did not load on its assigned dimension; the final scale contained five dimensions and 29 items.

Validity analysis

Content validity

Six experts (two in geriatric nursing, three in chronic disease management, and one in scale development statistics) rated item relevance using a 4-point scale. The overall S-CVI was 0.977, and item-level CVI values ranged from 0.83 to 1.00 (Table 2).

Table 2
Content validity rates of scale items

Items	Number of rated 3 or 4	I-CVI	Pc	K*	Items	Number of rated 3 or 4	I-CVI	Pc	K*
Aa1	6	1.00	0.016	1.00	Ac7	6	1.00	0.016	1.00
Aa2	6	1.00	0.016	1.00	Ac8	5	0.83	0.094	0.81
Aa3	6	1.00	0.016	1.00	Ad1	6	1.00	0.016	1.00
Aa4	5	0.83	0.094	0.81	Ad2	6	1.00	0.016	1.00
Ab1	6	1.00	0.016	1.00	Ad3	6	1.00	0.016	1.00
Ab2	6	1.00	0.016	1.00	Ad4	6	1.00	0.016	1.00
Ab3	6	1.00	0.016	1.00	Ad5	6	1.00	0.016	1.00
Ab4	6	1.00	0.016	1.00	Ad6	6	1.00	0.016	1.00
Ab5	6	1.00	0.016	1.00	Ad7	6	1.00	0.016	1.00
Ac1	6	1.00	0.016	1.00	Ad8	5	0.83	0.094	0.81
Ac2	6	1.00	0.016	1.00	Ae1	6	1.00	0.016	1.00
Ac3	6	1.00	0.016	1.00	Ae2	6	1.00	0.016	1.00
Ac4	6	1.00	0.016	1.00	Ae3	6	1.00	0.016	1.00
Ac5	6	1.00	0.016	1.00	Ae4	6	1.00	0.016	1.00
Ac6	6	1.00	0.016	1.00	Ae5	5	0.83	0.094	0.81

Pc: probability of chance agreement; K*: adjusted kappa coefficient.

Construct validity

The Kaiser-Meyer-Olkin value was 0.942, and Bartlett's test of sphericity was significant ($P < 0.001$), indicating that the data were suitable for EFA. Five factors with eigenvalues greater than 1 (14.183, 2.872, 1.771, 1.357, and 1.142) were extracted using principal axis factoring with varimax rotation; the cumulative variance explained was 71.08%.

After factor analysis, all 30 items had loadings above 0.40 (range, 0.412 to 0.818). Ad8 was deleted because it loaded on a factor inconsistent with its assigned dimension. Aa1 and Aa4, although loading above 0.40 on two factors, were retained after group discussion because of their clinical and practical importance. The final scale therefore comprised 29 items across five dimensions. In the orthogonally rotated loading matrix, Ac1 to Ac8, Ad1 to Ad7, Ab1 to Ab5, Ae1 to Ae5, and Aa1 to Aa4 loaded on factors 1 to 5, comprising 8, 7, 5, 5, and 4 items, respectively (Table 3).

Table 3
Factor loading matrix and communalities after item deletion

Items	Factors					Communality
	1	2	3	4	5	
Ac5	0.818					0.741
Ac3	0.794					0.784
Ac6	0.792					0.759
Ac7	0.766					0.808
Ac4	0.720					0.734
Ac1	0.698					0.711
Ac2	0.688					0.720
Ac8	0.614					0.790
Ad6		0.757				0.627
Aa3					0.701	0.734
Aa4					0.652	0.631
Ad5		0.755				0.599
Ad7		0.749				0.596
Ad4		0.734				0.655
Ad3		0.588				0.645
Ad2		0.574				0.669
Ad1		0.567				0.725
Ab2			0.780			0.669
Ab5			0.774			0.701
Ab3			0.773			0.708
Ab4			0.769			0.700
Ab1			0.726			0.678
Ae3				0.795		0.564
Ae4				0.774		0.598
Ae5				0.710		0.565
Ae2				0.679		0.682

Items	Factors					Communality
	1	2	3	4	5	
Ae1				0.412		0.666
Aa1					0.739	0.721
Aa2					0.734	0.711

CFA was used to test the factor structure identified by EFA. The initial model was estimated using maximum likelihood estimation, which yielded suboptimal fit indices. The model was therefore refined by adding residual covariances based on modification indices and the expected decrease in the chi-square value (Fig. 1). The final revised model showed acceptable goodness of fit (Table 4).

For convergent validity, the average variance extracted (AVE) for each latent variable ranged from 0.548 to 0.688, and composite reliability (CR) ranged from 0.874 to 0.945 (see Additional file 1: Table S8). For discriminant validity, the five dimensions were significantly correlated ($P < 0.01$), and the absolute correlation coefficients between dimensions were lower than the square root of the corresponding AVE (see Additional file 1: Table S9).

Table 4
Model Fit Indices of CFA

Model fit index	Value
χ^2	881.045
df	363
χ^2/df	2.472
CFI	0.929
NFI	0.886
TLI	0.915
IFI	0.930
RMSEA	0.065

CFI: comparative fit index; NFI: normed fit index; TLI: Tucker-Lewis index; IFI: incremental fit index; RMSEA: root mean square error of approximation; chi-square/df: chi-square to degrees-of-freedom ratio; df: degrees of freedom.

A1: activity function; A2: sensory function; A3: cognitive function; A4: psychological state; A5: vitality state. Items were renamed according to their order after exploratory factor analysis.

Reliability analysis

The Cronbach's *α* was 0.961 for the total scale and ranged from 0.873 to 0.946 across the five dimensions. Split-half reliability was 0.877 for the total scale and ranged from 0.813 to 0.919 across dimensions. Test-retest reliability was assessed in 20 patients who completed the scale twice, one week apart; the total-scale coefficient was 0.949, and dimension coefficients ranged from 0.821 to 0.943. All indices met conventional reliability criteria (Table 5).

Table 5
Reliability of the scale

Dimension	Cronbach's *α*	Split-half reliability	Test-retest reliability	*P* value
Activity function	0.890	0.813	0.821	< 0.001
Sensory function	0.922	0.879	0.886	< 0.001
Cognitive function	0.946	0.919	0.877	< 0.001
Psychological state	0.894	0.860	0.943	< 0.001
Vitality state	0.873	0.835	0.823	< 0.001
Total scale	0.961	0.877	0.949	< 0.001

Test-retest reliability values are Pearson correlation coefficients between the two assessments, and *P* values refer to these correlations. Split-half reliability was calculated using the Guttman method.

Discussion

In this study, we developed the intrinsic capacity assessment scale for older patients with stroke and evaluated its psychometric properties in 617 older inpatients with stroke. The final 29-item scale covers five dimensions (activity function, sensory function, cognitive function, psychological state, and vitality state) and showed satisfactory reliability and validity. Its development followed a systematic, multi-stage process based on the WHO healthy ageing framework: a literature review and appraisal of existing instruments generated the initial item pool; Semi-structured interviews with patients captured their experiences and added items to the scale; two Delphi rounds refined the items; and statistical screening with reliability and validity testing yielded the final scale. This process aligns with accepted standards for instrument development and supports the scale's content validity and comprehensiveness.

The main strength of the scale is its specificity for older patients with stroke, rather than being a generic measure of intrinsic capacity in older adults. For the activity dimension, basic and instrumental activities of daily living were included; both are well-established indicators of independent functioning after stroke. For the sensory dimension, items on taste, smell, and superficial and deep sensation were added beyond the vision and hearing assessments recommended by the WHO, because stroke often impairs several sensory modalities simultaneously and these impairments can interact to affect cognition and overall quality of life [34]. For the psychological dimension, post-stroke comorbid anxiety and depression (PSCAD) was incorporated. PSCAD is common after stroke, with an estimated prevalence of 27.81% to

40.69% [35, 36]; the two conditions often develop sequentially and exacerbate each other, so assessing them together is more clinically useful than measuring a single mood state. In the vitality dimension, sleep and chronic pain were assessed, and appetite was included as an indicator of nutritional status. Energy intake is essential for maintaining physiological balance, and energy expenditure and metabolism are important determinants of functioning in aging and disease [37]. Chronic pain, a frequent complication after stroke, can deplete energy through multiple pathways and thereby reduce vitality. Including these stroke-related manifestations makes the scale more responsive to the functional problems that characterize this patient group.

The WHO ICOPE screening tool assesses the five domains with brief questions and is well suited to community screening [38], but it provides limited detail within each domain because it was designed for screening rather than detailed assessment [10]. Validation studies have mostly involved community-dwelling older adults and used different comparator measures, so findings are difficult to compare and performance in hospital or stroke populations remains uncertain [39, 40]. Others have combined the five domains into a single score or developed age- and sex-specific reference values (centiles), which are associated with frailty, multimorbidity, and functional limitations [41, 42]; however, these measures are generic and do not capture stroke-specific problems such as communication impairment, post-stroke anxiety and depression, sensory changes, sleep disturbance, pain, or poor nutrition. Besides, threshold scores for classifying impaired intrinsic capacity have been proposed for Chinese older adults [43], but no stroke-specific instrument has been available. This scale addresses this gap by providing dimension-level scores from 29 items across five domains and covering stroke-related content that generic instruments assess only briefly. It is therefore complementary to ICOPE, which is suitable for initial screening, whereas our scale supports more detailed assessment.

In developing the scale, items were screened using complementary methods rather than a single statistical test: experts' importance ratings and full-score proportions assessed content relevance and homogeneity [44]; response distribution and critical ratio analyses examined item use and discrimination; and item–total correlations assessed convergence on a common construct. Although no items were deleted, these analyses confirmed that the items were relevant, well distributed, discriminative, and internally consistent, supporting their retention. Items "Aa1" and "Aa4" cross-loaded on two factors in the EFA but were retained because item "Aa1" measures basic activities of daily living, whereas item "Aa4" captures higher-level physical activity requiring social participation; both are conceptually relevant to intrinsic capacity in older patients with stroke. One item was subsequently removed because it loaded on an unintended dimension. The remaining items passed all checks, indicating that the preceding qualitative interviews and Delphi rounds had produced well-defined items; the stagewise screening therefore confirmed rather than reshaped the scale and avoided discarding meaningful items because of a single anomalous result.

Reliability analysis showed that Cronbach's α was 0.961 for the overall scale and ranged from 0.873 to 0.946 across dimensions, indicating that the items were closely related and that scale scores were highly stable [45]. In this study, reliability was evaluated in two respects: internal consistency, which

indicates whether items within the scale measure the same underlying construct, and temporal stability, which indicates whether scores remain reproducible when the scale is administered again [46]. All coefficients for the overall scale and its dimensions exceeded 0.70, and the overall coefficients were higher than those for individual dimensions. This is expected because reliability generally increases with the number of items. The test-retest result obtained over a one-week interval also suggests that the scale captures relatively stable aspects of intrinsic capacity rather than momentary states, an important property for a measure intended to monitor patients during rehabilitation [47]. Together, these results indicate that the scale produces consistent and reproducible scores, a prerequisite for its use in repeated clinical assessment.

We evaluated validity from several perspectives to verify that the scale measures the construct it was designed to measure. The high content validity (S-CVI, 0.977) indicates that experts considered the scale suitable for measuring intrinsic capacity in this population [48] and that the items reflect the intended construct. EFA identified five factors that explained 71.08% of the total variance, supporting construct validity [49, 50]. CFA showed that the model fit indices were within acceptable ranges, indicating reasonable agreement between the hypothesized framework and the observed data [51]. Factor loadings for the items corresponding to each dimension ranged from 0.412 to 0.818, with most loadings greater than 0.50, further supporting the construct validity of the scale. In addition, convergent validity was supported (AVE > 0.50; CR > 0.70) and discriminant validity was supported by the Fornell-Larcker criterion [33]. These findings indicate that the items are strongly related and collectively reflect intrinsic capacity in older patients with stroke, and that the scale can distinguish patients with higher and lower levels of intrinsic capacity. Overall, these results support the interpretation of scale scores as measures of intrinsic capacity in older patients with stroke.

Limitations

Several limitations should be acknowledged. First, participants were recruited by convenience sampling from a single tertiary hospital in China, which may limit the representativeness of the sample and the generalizability of the findings. Second, the scale was developed and validated in a Chinese cultural and clinical context; its applicability to older patients with stroke in other countries or cultural settings is unknown and would require cross-cultural adaptation and validation. Third, the scale was not compared with established measures such as the ICOPE screening tool, frailty instruments, so criterion validity remains to be established. Fourth, test-retest reliability was assessed in only 20 patients over a one-week interval, so the short interval may be influenced by memory effects and does not capture longer-term changes during recovery. Therefore, subsequent multi-center research across different regions is needed to further verify the stability of the scale.

Conclusions

The Intrinsic Capacity Assessment Scale for Older Patients with Stroke developed in this study demonstrated satisfactory reliability and validity. Aligned with the WHO healthy ageing framework, the

scale incorporates stroke-specific characteristics and therefore has adequate specificity. Overall, the scale has well-designed items and appropriate measurement properties, making it suitable for assessing intrinsic capacity in older patients with stroke.

Abbreviations

ADL: activities of daily living; AVE: average variance extracted; Ca: judgment coefficient; CFA: confirmatory factor analysis; CFI: comparative fit index; COSMIN: COnsensus-based Standards for the selection of health Measurement INstruments; CR: composite reliability; Cr: authority coefficient; Cs: familiarity coefficient; CT: computed tomography; Cv: coefficient of variation; CVI: content validity index; df: degrees of freedom; EFA: exploratory factor analysis; HADS: Hospital Anxiety and Depression Scale; I-CVI: item-level content validity index; IADL: instrumental activities of daily living; ICF: International Classification of Functioning, Disability and Health; ICOPE: Integrated Care for Older People; IFI: incremental fit index; KMO: Kaiser-Meyer-Olkin; MMSE: Mini-Mental State Examination; MRI: magnetic resonance imaging; NFI: normed fit index; Pc: probability of chance agreement; PSCAD: post-stroke comorbid anxiety and depression; RMSEA: root mean square error of approximation; S-CVI: scale-level content validity index; TLI: Tucker-Lewis index; WHO: World Health Organization; WHOQOL-100: World Health Organization Quality of Life Assessment (100 items).

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the Ethics Committee of the First Affiliated Hospital of Wannan Medical College. All participants provided written informed consent before the investigation. All research procedures complied with the Declaration of Helsinki (1964) and its subsequent amendments.

Consent for publication

Not applicable.

Clinical trial number

Not applicable.

Availability of data and materials

The original dataset is available from the corresponding author upon reasonable request.

Competing interests

The authors declare no competing interests.

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Authors' contributions

W.Z.: Conception, design of the study, literature search, writing-original draft

A.W.: Methodology, manuscript revision;

K.L.: Questionnaire survey and data collection

H.X.: Data curation, data analysis and data interpretation

Y.T.: Project administration, and funding acquisition.

L.Y.: Supervision, writing-review & editing.

All authors reviewed the manuscript.

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Figures

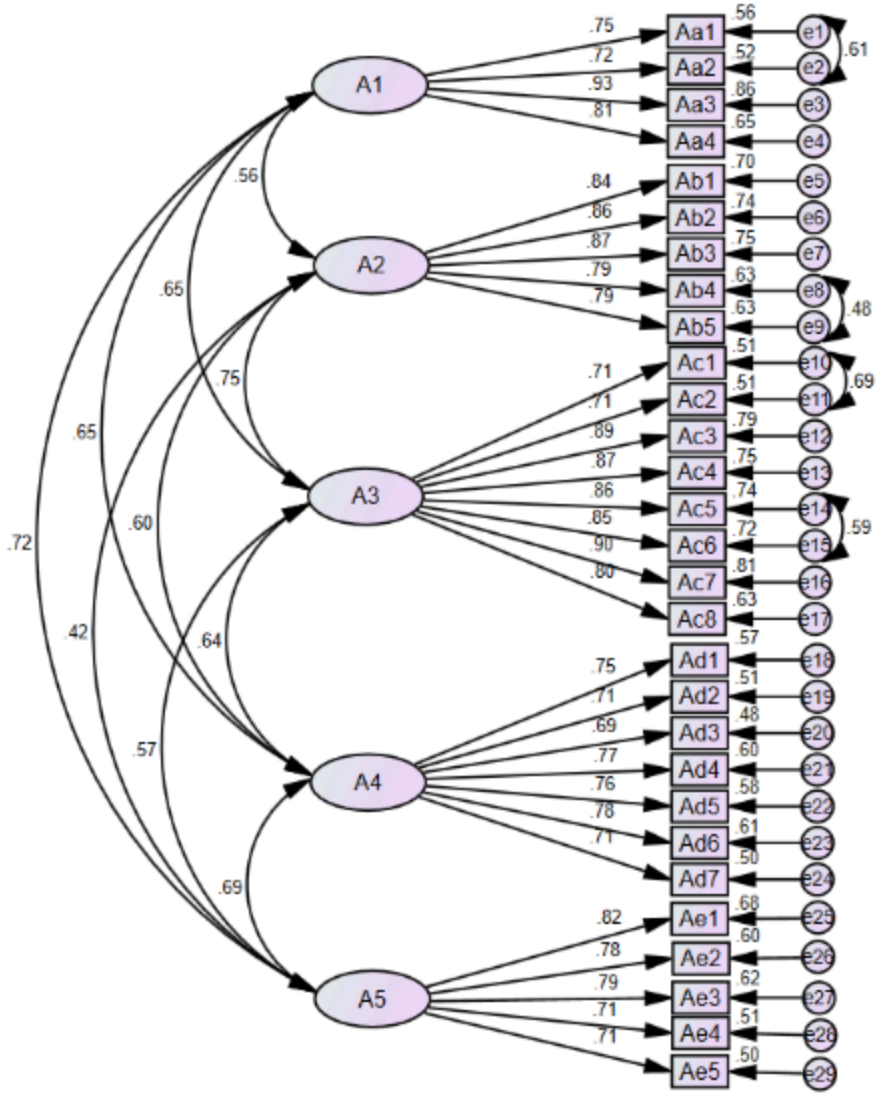


Figure 1

CFA path diagram for the intrinsic capacity model

A1: activity function; A2: sensory function; A3: cognitive function; A4: psychological state; A5: vitality state. Items were renamed according to their order after exploratory factor analysis.

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