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Patterns and Factors of Intrinsic Capacity Impairment in Older Adults with Chronic Diseases: A Latent Class Analysis

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Background: Due to the increase in life expectancy, the prevalence of older adults with chronic diseases is gradually increasing. Intrinsic capacity (IC) is an important indicator for assessing the physical condition of older adults. Older adults often experience a decline in IC before serious illness develops. Early screening for IC decline and timely interventions are essential. The goal of this study was to explore the patterns of IC impairment and their influencing factors in older adults with chronic diseases, and to provide a reference for the development of interventions to enhance their IC.

Methods: We conducted a cross-sectional study of 8427 older adults (≥60 years) in Zunyi City, China. A composite score for IC, covering the cognitive, sensory, locomotion, vitality, and psychological domains, was calculated using a weighting method. Data were collected on demographics, chronic conditions, and a battery of standardized assessments. These included measures of functional capacity (BADL, IADL), cognitive status (CMMS), physical performance (SPPB), nutritional risk (MNA-SF), depressive symptoms (GDS-15), and sensory function (vision, hearing).

Results: Overall, 87.56% of participants showed IC impairment. Latent class analysis identified three distinct patterns of IC impairment: a "Higher IC group", a "Cognitive-locomotion domain-impaired mid-IC group", and a "Locomotion-impaired predominantly low-IC group", which comprised 23.2%, 59.96%, and 16.84% of the sample, respectively; age, BMI, BADL, IADL, sex, educational level, marital status, type of medical insurance, average household monthly income, drinking, annual physical examination, socialization, and exercise were all influential factors in the patterns of IC ($P<0.05$).

Conclusion: The impairment of IC in older adults is group heterogeneous and affected by different factors; using IC as a multicategorical variable is beneficial to refine the patterns of IC impairment; healthcare professionals should carry out early targeted interventions for different patterns of older adults to enhance their IC and promote healthy aging.

Keywords: older adults, intrinsic capacity, chronic diseases, latent class analysis

Introduction

As the population ages, the number of older adults with disabilities is increasing, one of the reasons for this phenomenon being the high prevalence of chronic diseases among older adults.[1] Currently, the prevalence of chronic diseases among older adults in China is 81.1%[2] and continues to rise. Chronic diseases are a major cause of death and disease burden.[3]

In 2015, the World Health Organization (WHO) introduced the concept of "healthy ageing" and, for the first time, proposed the notion of Intrinsic Capacity (IC). IC refers to the aggregate of older adults' physical and mental capacities that determine their ability to combine with environmental factors and their interactions.[4] Subsequently, WHO identified five core components of IC: cognition, sensory, motor, vitality, and psychological, which comprehensively reflect the functional status of older adults, highlight the importance of slowing IC decline[5] and recommend that screening for decline in IC be used as a foundation for assessing the health-related needs of older adults, and then interventions based on the results of the assessments.[6]

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WHO has proposed that older adults often show declining IC before impending serious illness,[4] and that it is particularly important to have early IC screening and timely intervention in older patients. IC shifts the focus from disease-centered measures of health to maintaining functional performance for healthy ageing, and has been proposed as an indicator for monitoring and evaluating the progress and impact of the "United Nations Decade of Collaborative Action on Healthy Ageing" (UNDHA).[7] Early assessment of IC is therefore of significant value for advancing healthy ageing and enhancing longevity.

Although the concept of IC is gaining traction in general geriatric research, its application to specific high-risk subgroups remains limited. In particular, there is a scarcity of evidence characterizing IC impairment specifically among older adults with chronic diseases. This is a critical gap because this population bears a dual burden: the management of multiple long-term conditions and a heightened risk of accelerated functional decline.[2,8,9] Understanding the distinct patterns of IC decline in this vulnerable group is essential to move beyond a generalized approach to geriatric care.

Therefore, our study focuses specifically on older adults with chronic conditions. Identifying specific typologies of IC impairment in this population has direct practical importance.[2] For clinicians, such insights can inform the development of targeted screening protocols and personalized care plans that address the most vulnerable IC domains. For policy-makers, elucidating these patterns is crucial for the efficient allocation of healthcare resources and for designing effective public health strategies aimed at preserving function and independence in this growing demographic.

Latent Class Analysis (LCA) is a statistical method that identifies subgroups of individuals with shared characteristics by analyzing patterns of scores across multiple variables among study participants.[10] This approach is particularly useful for deriving distinct patterns of IC decline in older adults. Compared to traditional clustering methods, LCA have several advantages, including providing classification, determination of the optimal number of latent classes, and a lower misclassification rate. In order to gain insight into the impact of chronic diseases on the typology of IC, this study used LCA to identify latent classes and influencing factors of IC in older adults with chronic diseases. The findings aim to provide a reference for developing targeted clinical interventions.

Materials and Methods

Participants

The study used a convenience sampling method to select older adults aged 60 years and older from seven medical institutions, three communities, and five nursing homes in Zunyi City, Guizhou Province, between October 2022 and September 2023 as study subjects. The inclusion criteria for the study subjects were as follows: (1) age ≥60 years; (2) voluntary participation in this study and provision of informed consent. The exclusion criteria were as follows: (1) suffering from acute critical illness (including shock, respiratory failure, acute heart failure, acute myocardial infarction, stroke) and unable to cooperate with the investigation; (2) acute exacerbation of a chronic disease or advanced stage of the disease (expected survival <3 months). This study was approved by the Ethics Review Committee of the Affiliated Hospital of Zunyi Medical University (approval number: KLL2022-814).

Assessment of IC

IC was assessed through five domains,[6] and scoring was weighted for each domain with reference to the IC composite scoring method:[11] 0 for severe impairment, 1 for mild-moderate impairment, and 2 for normal. The total score is 10, with 0–4 indicating severe impairment of IC, 5–8 indicating mild-moderate impairment of IC, and 9–10 indicating normal IC. In this study, the following scales were selected by considering the reliability of the scales, the level of understanding of older adults, and the convenience of follow-up:

Vitality: The vitality domain was assessed using the Short-Form Mini-Nutritional Assessment (MNA-SF), developed by Rubenstein et al[12] with a Cronbach's alpha coefficient of 0.703. The scale consists of 6 entries with a total score of 0–14. According to the weighted scores, a score of 0–7 on the MNA-SF is recorded as 0 in the vitality domain; a score of 7–11 is recorded as 1 in the vitality domain; and a score of 12–14 is recorded as 2 in the vitality domain.

Psychological: The Geriatric Depression Scale-15 (GDS-15) was used to assess the psychological functioning of older adults, which was designed for the characteristics of older adults on the basis of the Geriatric Depression Scale.[13]

The Cronbach's alpha coefficient is 0.78. It consists of 15 items with a total of 15 points, and the higher the score, the more pronounced the depressive symptoms. According to the weighted scoring, a score of 0–4 on the GDS-15 is scored as 0 in the psychological domains; a score of 5–9 is scored as 1 in the psychological domains; and a score of 10–15 is scored as 2 in the psychological domains.

Locomotion: This was evaluated using the Short Physical Performance Battery (SPPB), developed by Guralnik et al[14] with a Cronbach's alpha coefficient of 0.76. It consists of 3 dimensions: "Balance", "4-metre walking speed" and "Chair rise test", with a total score of 12 points, according to the weighted scoring, 0–2 points for SPPB. According to the weighted scoring, if SPPB scores 0–2 points, 0 points will be recorded in the locomotion domain; if it scores 3–9 points, 1 point will be recorded in the locomotion domain; if it scores 10–12 points, 2 points will be recorded in the locomotion domain.

Cognitive: The Chinese Mini-Mental Status (CMMS)[15] was employed to assess cognitive function. This 30-item instrument yields a total score of 30 points, evaluating the following domains: time orientation (5 points), spatial orientation (5 points), immediate memory (3 points), attention and calculation (5 points), delayed recall (3 points), language ability (8 points), and visuospatial skills (1 point). Higher total scores indicate better cognitive performance. According to the weighted scores, a CMMS score of 0–9 was assessed as severe cognitive impairment, with 0 points scored in the cognitive domain; a score of 10–26 was assessed as mild cognitive impairment, with 1 point scored in the cognitive domain; and a score of 27–30 was assessed as normal cognitive functioning, with 2 points scored in the cognitive domain.

Sensory: The assessment of vision and hearing in the sensory domains is in the form of a self-report, using two self-report questions (if glasses/hearing aids are normally worn, then the time of wearing them will be taken as the time of wearing them):[16] Question 1: Respondents are asked to answer the question "Do you have any loss of vision (hearing) that interferes with daily life, based on their daily level of vision and hearing?" The options were set to "yes" and "no", and participants who answered "yes" were considered to have visual ("hearing") difficulties. On a weighted scale, the sensory domains were scored as 0 if both vision and hearing were impaired, 1 if either vision or hearing were impaired, and 2 if both vision and hearing were normal.

Assessment of ADL

ADL was assessed through the Basic Activities of Daily Living (BADL) and Instrumental Activities of Daily Living (IADL). The Barthel Index was used to assess BADL. The Barthel Index consists of 10 entries with scores ranging from 0 to 100, with 0 to 40 representing heavy dependence, 45 to 60 representing moderate dependence, 65 to 95 representing mild dependence, and 100 representing complete independent. The higher the total score, the better their BADL. The IADL scale was used to assess the IADL. The IADL scale consists of 8 entries with a score range of 0 to 24, with a higher score representing a better IADL.

Assessment of Multimorbidity

The nine chronic diseases encompassed hypertension, diabetes, coronary heart disease, cerebrovascular disease, Chronic Obstructive Pulmonary Disease (COPD), cataract, degenerative osteoarthropathy, chronic bronchitis, and hyperlipidemia. Older adults with two or more of the above chronic conditions were classified as multimorbidity respondents, while respondents with only one or none of the chronic conditions were categorized as non-multimorbidity respondents. The information on chronic diseases was collected through self-reports, based on diagnostic evidence from medical records or physician prescriptions, and further validated by the interviewer during data collection.

General Information Survey

This general information survey covers demographic data and health-related characteristics, including sex, age, body mass index (BMI), educational level, marital status, number of children, place of residence (rural/urban), mode of residence (living alone/not living alone), type of health insurance, average household monthly income, drinking, smoking, participation in annual physical examinations, and participation in social activities, exercise.

Data Collection

Participants were recruited from medical institutions, communities, and nursing homes. After providing written informed consent, each participant underwent a face-to-face assessment conducted by trained nurses. All nurses received systematic training on survey terminology and assessment tools to ensure inter-rater reliability. Using standardized instructions, the assessors completed the questionnaires based on participants' responses. The completeness of questionnaires was reviewed on-site. All data were cross-checked by two researchers to eliminate questionnaires with logical inconsistencies, thereby ensuring the validity of the collected data. All collected data were anonymized and stored securely on password-protected servers, with access restricted to the research team, to ensure confidentiality.

Management of Missing Data

To ensure data accuracy, prevent overall bias caused by excessively large or small variable values, and avoid data entry errors, it was necessary to detect outliers in continuous variables. In this study, potential outliers were identified using the box plot method. Each flagged value was re-checked against its original data source. If the original data were unavailable or the value was confirmed to be an outlier, it was replaced with "null" to represent missing data. Records containing missing values were excluded from the final analysis.

Statistical Analysis

SPSS 29.0 (IBM Inc., Armonk, NY, United States) was used for statistical analysis. Quantitative data were expressed as frequencies and percentages (%), and Z-tests and chi-square tests were used to compare differences between groups. Means ± standard deviation ($\bar{X} \pm S$) were used for measures that conformed to normal distribution, and median with interquartile spacing *[M (P25, P75)]* for measures that did not conform to normal distribution.

The selection of covariates was informed by the World Health Organization's conceptual framework for healthy ageing, which highlights the roles of IC, health behaviors, and environmental influences. Variables were excluded if they demonstrated limited theoretical or empirical association with IC (eg, occupation, which exhibited restricted variability in this largely retired population) or if data completeness or reliability were concerns (eg, detailed dietary records). We chose sex, age, BMI, BADL, IADL, educational level, marital status, number of children, place of residence (rural/urban), mode of residence (living alone/not living alone), type of health insurance, average household monthly income, drinking, smoking, whether or not they have annual medical check-ups, participation in social activities, exercise, and whether or not they have multimorbidity as covariates, with age, BMI, BADL and IADL as continuous variables. $P<0.05$ was considered statistically significant. Multivariate logistic regression analysis was used to identify the potential influences of different subgroups of older adults with chronic diseases. Given the exploratory objective of identifying a broad set of potential factors associated with the latent classes, we prioritized the reduction of Type II errors (false negatives) over strict control for multiple comparisons in the multivariable logistic regression. Therefore, formal adjustments (eg, Bonferroni) were not applied. The results are interpreted with a focus on the magnitude and direction of the odds ratios (ORs) and their 95% confidence intervals (CIs), in addition to p-values, to provide a more nuanced understanding of the associations.[17] Correlations between different chronic diseases and various domains of IC were analyzed using Spearman correlation analysis.

Mplus version 8.3 (Muthen & Muthen, Los Angeles, CA, USA) was employed to conduct LCA. Models with one to four latent classes were estimated separately. Model fit was assessed using several indices: the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and adjusted BIC (aBIC), each derived from the log-likelihood (LL). Lower values of AIC, BIC, and aBIC indicate superior model fit. Classification accuracy was evaluated using entropy, which ranges from 0 to 1; values closer to 1 reflect better classification, with an entropy above 0.8 generally considered acceptable (corresponding to over 90% classification accuracy). To compare nested models, the Lo–Mendell–Rubin likelihood ratio test (LMR) and the bootstrap likelihood ratio test (BLRT) were utilized. A significant result ($P < 0.05$) for both tests suggests that the k-class model provides a better fit than the (k-1)-class model, where k denotes the number of latent classes.

R 4.4.3 (R Foundation, Vienna, Austria) was used to draw stacked plots of distributional probabilities of latent classes models and heat maps of correlations between different chronic diseases and various domains of IC. Correlations were classified as strong, moderate, weak and no correlation through the correlation coefficient (ρ), with three thresholds of 0.8, 0.5 and 0.3, respectively.

Results

Sample Characteristics

A total of 8,427 older adults with a mean age of 71.69 (±7.05) years were included in the study. The sample was nearly balanced in gender (50.85% male) and predominantly had an educational level of elementary school or below (65.31%). The majority of participants were married (83.45%), lived with others (94.05%), had health insurance coverage (97.94%), and nearly half (46.62%) reported a monthly household income of less than 2,000 yuan. Regarding IC, the majority (62.76%) were categorized as having mild-moderate impairment. The detailed sociodemographic and health characteristics of the participants are presented in Table 1.

Latent Class Analysis for IC of Older Adults

The five domains of IC were used as exogenous variables to fit the number of latent classes from 1 to 4 stepwise. The values of AIC, BIC, and aBIC were lower when three classes were retained, with entropy values >0.8, indicating that the model had high accuracy. Both LMR and BLRT were significant ($P < 0.001$), and the class probabilities of each class were 23.2%, 59.96%, and 16.84%, respectively, which verified the reliability of the categorization. Considering the model fit indices and category interpretability, the three-class model was selected as the optimal solution for this study (Table 2). The high diagonal values in the classification accuracy matrix (all >0.8, Table 3) indicated stable class assignment.

After categorization, the distribution of IC level in each class is shown in Table 4. Combining Figure 1 and Table 4, it can be seen that the IC impairment rate of older adults in Class 1 is lower than that of the other two groups, and only a small number of older adults are impaired in locomotion domains, which is called the "Higher IC level group", accounting for 23.2% (1,955 cases); very few older adults in Class 2 had normal cognitive domains and were severe impairments in the locomotion domain, named the "Cognitive- locomotion domain-impaired mid-IC group", which accounted for 59.96% (5053 cases); older adults in Class 3 had moderate to high levels of impairment in all domains, particularly in the locomotion domain, and were named the "Locomotion-impaired predominantly low-IC group", accounting for 16.84% of the cases (1,419 cases).

Comparison of Characteristics of Three Latent Classes of IC Levels Among Older Adults

The results of univariate analysis showed that sex, age, BMI, literacy, marital status, number of children, place of residence (rural/urban), mode of residence (living alone/not living alone), type of health insurance, average household monthly income, drinking, smoking, whether or not they had annual physical examination, participation in social activities, exercise, and whether or not they had chronic disease latent classes were all statistically significant ($P<0.05$), see Table 5.

Multivariate Logistic Regression of Influences on Three Latent Classes

The results of the multinomial logistic regression analysis with different latent classes as dependent variables and variables that were statistically significant in the univariate analysis as independent variables are shown in Table 6.

Compared to Class 1, Class 2 was associated with slightly younger age (OR = 0.989, 95% CI: 0.978–0.999), lower IADL scores (OR = 0.836, 95% CI: 0.818–0.855), and a higher likelihood of regular exercise (OR = 1.806, 95% CI: 1.515–2.152). In terms of chronic conditions, individuals with hypertension (OR = 1.278, 95% CI: 1.087–1.502) or coronary heart disease (OR = 1.471, 95% CI: 1.216–1.779) were more likely to be in Class 2, whereas those with chronic bronchitis (OR = 0.718, 95% CI: 0.561–0.918) or hyperlipidemia (OR = 0.704, 95% CI: 0.566–0.876) were more likely

Table 1 Baseline Characteristics of Older Adults with Different IC Levels

Variables	Total (n=8427)	IC Level		
		Severe Impairment (n=2090)	Mild to Moderate Impairment (n=5289)	Normal (n=1048)
BMI	22.93 (20.81, 24.97)	21.95 (19.51, 24.16)	23.13 (21.09, 24.98)	23.84 (21.78, 25.71)
Age	71.69 (66.00, 76.00)	74.69 (69.00, 80.00)	71.02 (66.00, 76.00)	69.05 (64.00, 73.00)
BADL	90.74 (90.00, 100.00)	77.43 (65.00, 95.00)	94.53 (95.00, 100.00)	98.19 (100.00, 100.00)
IADL	17.94 (16.00, 22.00)	13.05 (8.00, 18.00)	19.14 (17.00, 22.00)	21.62 (21.00, 23.00)
Sex, n (%)				
Male	4285 (50.85)	1006 (48.13)	2705 (51.14)	574 (54.77)
Female	4142 (49.15)	1084 (51.87)	2584 (48.86)	474 (45.23)
Educational level, n (%)				
Primary school and below	5504 (65.31)	1604 (76.75)	3409 (64.45)	491 (46.85)
Middle school	1727 (20.49)	320 (15.31)	1105 (20.89)	302 (28.82)
High school/technical high school	900 (10.68)	130 (6.22)	588 (11.12)	182 (17.37)
Junior college and above	296 (3.51)	36 (1.72)	187 (3.54)	73 (6.97)
Marital status, n (%)				
Married	7032 (83.45)	1599 (76.51)	4516 (85.38)	917 (87.50)
Other (separated/divorced/widowed/ unmarried)	1395 (16.55)	491 (23.49)	773 (14.62)	131 (12.50)
Number of children, n (%)				
No	86 (1.02)	19 (0.91)	55 (1.04)	12 (1.15)
One	1182 (14.03)	171 (8.18)	759 (14.35)	252 (24.05)
Two	2828 (33.56)	581 (27.80)	1836 (34.71)	411 (39.22)
Three and above	4331 (51.39)	1319 (63.11)	2639 (49.90)	373 (35.59)
Residence, n (%)				
Urban	4699 (55.76)	954 (45.65)	3003 (56.78)	742 (70.80)
Rural	3728 (44.24)	1136 (54.35)	2286 (43.22)	306 (29.20)
Mode of residence, n (%)				
Not living alone	7926 (94.05)	1935 (92.58)	4995 (94.44)	996 (95.04)
Living alone	501 (5.95)	155 (7.42)	294 (5.56)	52 (4.96)
Type of medical insurance, n (%)				
Insurance	8253 (97.94)	2049 (98.04)	5173 (97.81)	1031 (98.38)
Self-funded	174 (2.06)	41 (1.96)	116 (2.19)	17 (1.62)
Average household monthly income (1 yuan = 0.139 USD), n (%)				
≥ 2000 yuan	4498 (53.38)	957 (45.79)	2863 (54.13)	678 (64.69)
< 2000 yuan	3929 (46.62)	1133 (54.21)	2426 (45.87)	370 (35.31)
Drinking, n (%)				
Nondrinker	7422 (88.07)	1868 (89.38)	4664 (88.18)	890 (84.92)
Drinker	1005 (11.93)	222 (10.62)	625 (11.82)	158 (15.08)
Smoking, n (%)				
Nonsmoker	6988 (82.92)	1746 (83.54)	4398 (83.15)	844 (80.53)
Smoker	1439 (17.08)	344 (16.46)	891 (16.85)	204 (19.47)
Annual physical examination, n (%)				
Yes	4624 (54.87)	969 (46.36)	2993 (56.59)	662 (63.17)
No	3803 (45.13)	1121 (53.64)	2296 (43.41)	386 (36.83)
Socialization, n (%)				
Yes	5104 (60.57)	999 (47.80)	3300 (62.39)	805 (76.81)
No	3323 (39.43)	1091 (52.20)	1989 (37.61)	243 (23.19)

(*Continued*)

Table 1 (Continued).

Variables	Total (n=8427)	IC Level		
		Severe Impairment (n=2090)	Mild to Moderate Impairment (n=5289)	Normal (n=1048)
Exercise, n (%)				
Yes	6455 (76.60)	1308 (62.58)	4243 (80.22)	904 (86.26)
No	1972 (23.40)	782 (37.42)	1046 (19.78)	144 (13.74)
Hypertension, n (%)				
No	3168 (37.59)	842 (40.29)	1909 (36.09)	417 (39.79)
Yes	5259 (62.41)	1248 (59.71)	3380 (63.91)	631 (60.21)
Diabetes, n (%)				
No	6450 (76.54)	1665 (79.67)	3971 (75.08)	814 (77.67)
Yes	1977 (23.46)	425 (20.33)	1318 (24.92)	234 (22.33)
Coronary heart disease, n (%)				
No	6897 (81.84)	1646 (78.76)	4321 (81.70)	930 (88.74)
Yes	1530 (18.16)	444 (21.24)	968 (18.30)	118 (11.26)
Cerebrovascular disease, n (%)				
No	7218 (85.65)	1638 (78.37)	4625 (87.45)	955 (91.13)
Yes	1209 (14.35)	452 (21.63)	664 (12.55)	93 (8.87)
COPD, n (%)				
No	7724 (91.66)	1833 (87.70)	4909 (92.82)	982 (93.70)
Yes	703 (8.34)	257 (12.30)	380 (7.18)	66 (6.30)
Cataracts, n (%)				
No	7942 (94.24)	1876 (89.76)	5045 (95.39)	1021 (97.42)
Yes	485 (5.76)	214 (10.24)	244 (4.61)	27 (2.58)
Degenerative osteoarthropathy, n (%)				
No	7497 (88.96)	1770 (84.69)	4754 (89.88)	973 (92.84)
Yes	930 (11.04)	320 (15.31)	535 (10.12)	75 (7.16)
Chronic bronchitis, n (%)				
No	7725 (91.67)	1825 (87.32)	4945 (93.50)	955 (91.13)
Yes	702 (8.33)	265 (12.68)	344 (6.50)	93 (8.87)
Hyperlipidemia, n (%)				
No	7720 (91.61)	1942 (92.92)	4869 (92.06)	909 (86.74)
Yes	707 (8.39)	148 (7.08)	420 (7.94)	139 (13.26)
Presence of multimorbidity, n (%)				
No	4436 (52.64)	874 (41.82)	2890 (54.64)	672 (64.12)
Yes	3991 (47.36)	1216 (58.18)	2399 (45.36)	376 (35.88)

Notes: Non-normal continuous variables are described by the median and interquartile range, M (Q1, Q3): Age, BMI, BADL, IADL.
Abbreviations: IC, Intrinsic capacity; BMI, Body mass index; IADL, Instrumental activities of daily living; BADL, Basic Activities of Daily Living; COPD, Chronic Obstructive Pulmonary Disease.

Table 2 Fit Indices of Latent Class Analysis for Intrinsic Capacity of Older Adults

Model	LL	AIC	BIC	aBIC	Entropy	*P*		Classification Probability
						LMR	BLRT	
1	−34,613.946	69,247.893	69,318.285	69,286.507	–	–	–	1
2	−33,579.647	67,201.294	67,349.117	67,282.383	0.621	<0.001	<0.001	0.77418/0.22582
3	**−33,373.486**	**66,810.972**	**67,036.226**	**66,934.536**	**0.801**	**<0.001**	**<0.001**	**0.23199/0.59962/0.16839**
4	−33,291.084	66,668.168	66,970.853	66,834.207	0.544	0.0329	<0.001	0.29583/0.52059/0.05530/0.12828

Notes: *P*<0.05: statistically significant. Bold text indicates that this model has the best fit.
Abbreviations: LL, loglikelihood; AIC, Akaike Information Criterion; BIC, Bayesian Information Criterion; aBIC, adjusted Bayesian Information Criterion; LMR, likelihood Ratio; BLRT, Bootstrap likelihood Ratio Test.

Table 3 The Probability of Correct Classification for Each Category

Latent Class	1	2	3
1	0.973	<0.001	0.027
2	<0.001	0.914	0.086
3	0.018	0.162	0.82

Table 4 Distribution of IC Level Among Classes After Classification

Variables	Total (n = 8427)	Class 1 (n = 1955)	Class 2 (n = 5053)	Class 3 (n = 1419)
IC Level				
Severe impairment (n=2090)	2090 (24.80)	11 (0.56)	668 (13.22)	1411 (99.44)
Mild to moderate impairment (n=5289)	5289 (62.76)	1172 (59.95)	4109 (81.32)	8 (0.56)
Normal (n=1048)	1048 (12.44)	772 (39.49)	276 (5.46)	0 (0.00)

Abbreviation: IC, Intrinsic capacity.

to be in Class 1. Furthermore, several factors were protective against being in Class 2 relative to Class 1, including higher educational attainment (eg, college and above: OR = 0.22, 95% CI: 0.162–0.299), being male (OR = 0.632, 95% CI: 0.552–0.725), being married (OR = 0.749, 95% CI: 0.604–0.928), having insurance (OR = 0.572, 95% CI: 0.355–0.922), a monthly household income ≥2000 yuan (OR = 0.628, 95% CI: 0.546–0.723), being a drinker (OR = 0.767, 95% CI: 0.632–0.93), and participating in social activities (OR = 0.664, 95% CI: 0.573–0.77).

When comparing Class 3 to Class 1, Class 3 was characterized by lower BMI (OR = 0.859, 95% CI: 0.833–0.886), BADL (OR = 0.98, 95% CI: 0.974–0.987), and IADL scores (OR = 0.742, 95% CI: 0.724–0.761). The protective effects of these socioeconomic factors (higher education, male gender, being married, higher income, and social participation) for membership in Class 1 were also consistently observed when Class 3 was the comparator. Regular exercise, however, was associated with a higher likelihood of being in Class 3 versus Class 1 (OR = 1.371, 95% CI: 1.087–1.728). Specific chronic conditions increasing the risk for Class 3 membership included cerebrovascular disease (OR = 1.402, 95% CI:

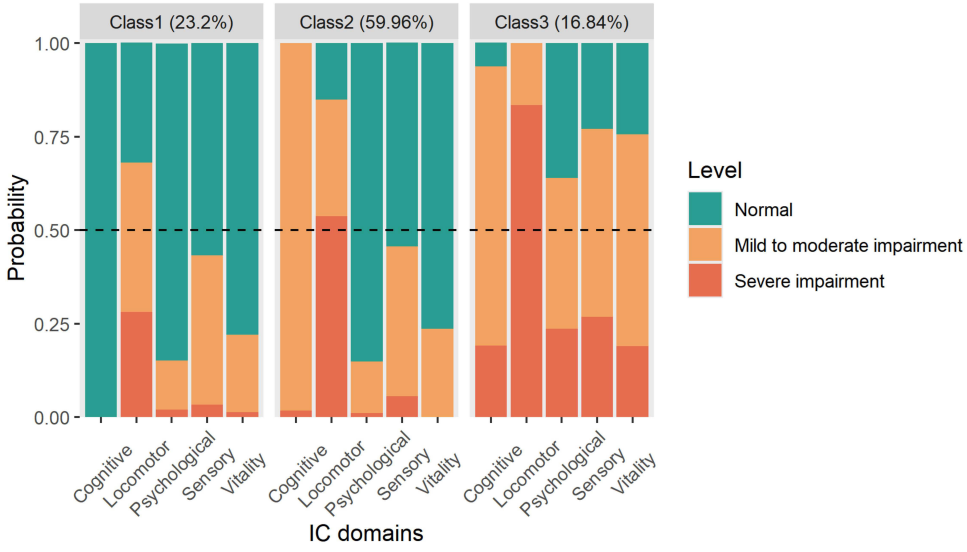

Figure 1 Stacked conditional probability distributions for three latent classes of IC levels in older adults.
Notes: *P<0.01, **P<0.05.
Abbreviations: IC, Intrinsic capacity.

Table 5 Comparison of Characteristics of Three Latent Classes of IC Levels Among Older Adults

Variables	Total (n = 8427)	Class 1 (n = 1955)	Class 2 (n = 5053)	Class 3 (n = 1419)	Z/χ^2	*P*
BMI	22.893 (20.812, 24.974)	23.255 (21.348, 25.236)	23.111 (21.094, 25.100)	21.259 (19.147, 23.828)	311.564	<0.001
Age	71.000 (66.000, 76.000)	68.000 (64.000, 74.000)	71.000 (67.000, 76.000)	75.000 (69.000, 80.000)	507.708	<0.001
BADL	100.000 (90.000, 100.000)	100.000 (100.000, 100.000)	100.000 (95.000, 100.000)	80.000 (55.000, 95.000)	1643.495	<0.001
IADL	20.000 (16.000, 22.000)	22.000 (20.000, 23.000)	19.000 (16.000, 22.000)	12.000 (7.000, 17.000)	2133.757	<0.001
Sex					166.502	<0.001
Female	4142 (49.152)	711 (36.368)	2683 (53.097)	748 (52.713)		
Male	4285 (50.848)	1244 (63.632)	2370 (46.903)	671 (47.287)		
Educational level					1043.24	<0.001
Primary school and below	5504 (65.314)	740 (37.852)	3647 (72.175)	1117 (78.717)		
Middle school	1727 (20.494)	579 (29.616)	945 (18.702)	203 (14.306)		
High school/technical high school	900 (10.680)	450 (23.018)	374 (7.402)	76 (5.356)		
Junior college and above	296 (3.513)	186 (9.514)	87 (1.722)	23 (1.621)		
Marital status					121.065	<0.001
Other (separated/divorced/widowed/unmarried)	1395 (16.554)	182 (9.309)	886 (17.534)	327 (23.044)		
Married	7032 (83.446)	1773 (90.691)	4167 (82.466)	1092 (76.956)		
Number of children					651.163	<0.001
No	86 (1.021)	24 (1.228)	50 (0.990)	12 (0.846)		
One	1182 (14.026)	571 (29.207)	496 (9.816)	115 (8.104)		
Two	2828 (33.559)	736 (37.647)	1705 (33.742)	387 (27.273)		
Three and above	4331 (51.394)	624 (31.918)	2802 (55.452)	905 (63.777)		
Residence					277.143	<0.001
Rural	3728 (44.239)	582 (29.770)	2327 (46.052)	819 (57.717)		
Urban	4699 (55.761)	1373 (70.230)	2726 (53.948)	600 (42.283)		
Mode of residence					7.02	0.030
Living alone	501 (5.945)	92 (4.706)	318 (6.293)	91 (6.413)		
Not living alone	7926 (94.055)	1863 (95.294)	4735 (93.707)	1328 (93.587)		
Type of medical insurance					10.687	0.005
Insurance	8253 (97.935)	1932 (98.824)	4931 (97.586)	1390 (97.956)		
Self-funded	174 (2.065)	23 (1.176)	122 (2.414)	29 (2.044)		
Average household monthly income (1 yuan = 0.139 USD)					428.268	<0.001
≥ 2000 yuan	4498 (53.376)	1442 (73.760)	2416 (47.813)	640 (45.102)		
< 2000 yuan	3929 (46.624)	513 (26.240)	2637 (52.187)	779 (54.898)		

(*Continued*)

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Table 5 (Continued).

Variables	Total (n = 8427)	Class 1 (n = 1955)	Class 2 (n = 5053)	Class 3 (n = 1419)	Z/χ^2	*P*
Drinking					85.127	<0.001
Nondrinker	7422 (88.074)	1606 (82.148)	4539 (89.828)	1277 (89.993)		
Drinker	1005 (11.926)	349 (17.852)	514 (10.172)	142 (10.007)		
Smoking					43.985	<0.001
Nonsmoker	6988 (82.924)	1525 (78.005)	4274 (84.583)	1189 (83.791)		
Smoker	1439 (17.076)	430 (21.995)	779 (15.417)	230 (16.209)		
Annual physical examination					161.407	<0.001
Yes	4624 (54.871)	1243 (63.581)	2791 (55.235)	590 (41.579)		
No	3803 (45.129)	712 (36.419)	2262 (44.765)	829 (58.421)		
Socialization					317.711	<0.001
Yes	5104 (60.567)	1463 (74.834)	3006 (59.489)	635 (44.750)		
No	3323 (39.433)	492 (25.166)	2047 (40.511)	784 (55.250)		
Exercise					361.623	<0.001
Yes	6455 (76.599)	1607 (82.199)	4036 (79.873)	812 (57.223)		
No	1972 (23.401)	348 (17.801)	1017 (20.127)	607 (42.777)		
Hypertension					30.466	<0.001
No	3168 (37.593)	791 (40.460)	1781 (35.246)	596 (42.001)		
Yes	5259 (62.407)	1164 (59.540)	3272 (64.754)	823 (57.999)		
Diabetes					14.724	<0.001
No	6450 (76.540)	1455 (74.425)	3859 (76.370)	1136 (80.056)		
Yes	1977 (23.460)	500 (25.575)	1194 (23.630)	283 (19.944)		
Coronary heart disease					36.053	<0.001
No	6897 (81.844)	1689 (86.394)	4076 (80.665)	1132 (79.774)		
Yes	1530 (18.156)	266 (13.606)	977 (19.335)	287 (20.226)		
Cerebrovascular disease					76.011	<0.001
No	7218 (85.653)	1749 (89.463)	4349 (86.068)	1120 (78.929)		
Yes	1209 (14.347)	206 (10.537)	704 (13.932)	299 (21.071)		
COPD					42.343	<0.001
No	7724 (91.658)	1822 (93.197)	4662 (92.262)	1240 (87.385)		
Yes	703 (8.342)	133 (6.803)	391 (7.738)	179 (12.615)		
Cataracts					52.108	<0.001
No	7942 (94.245)	1876 (95.959)	4784 (94.676)	1282 (90.345)		
Yes	485 (5.755)	79 (4.041)	269 (5.324)	137 (9.655)		

Degenerative osteoarthropathy					47.235	<0.001
No	7497 (88.964)	1797 (91.918)	4502 (89.096)	1198 (84.426)		
Yes	930 (11.036)	158 (8.082)	551 (10.904)	221 (15.574)		
Chronic bronchitis					71.191	<0.001
No	7725 (91.670)	1793 (91.714)	4709 (93.192)	1223 (86.187)		
Yes	702 (8.330)	162 (8.286)	344 (6.808)	196 (13.813)		
Hyperlipidemia					29.263	<0.001
No	7720 (91.610)	1733 (88.645)	4671 (92.440)	1316 (92.741)		
Yes	707 (8.390)	222 (11.355)	382 (7.560)	103 (7.259)		
Presence of multimorbidity					104.127	<0.001
No	4436 (52.640)	1174 (60.051)	2662 (52.682)	600 (42.283)		
Yes	3991 (47.360)	781 (39.949)	2391 (47.318)	819 (57.717)		

Notes: χ^2: chi-square test. $P<0.05$: statistically significant. Non-normal continuous variables are described by the median and interquartile range, M (Q1, Q3): Age, BMI, BADL, IADL.
Abbreviations: IC, Intrinsic capacity; BMI, Body mass index; IADL, Instrumental activities of daily living; BADL, Basic Activities of Daily Living; COPD, Chronic Obstructive Pulmonary Disease.

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Table 6 Multivariate Logistic Regression Modeling of Factors Influencing the Three Latent Classes

Variables	Class 2 vs Class 1[a]		Class 3 vs Class 1[a]		Class 3 vs Class 2[a]	
	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
Age	**0.989 (0.978, 0.999)**	**0.030**	0.999 (0.985, 1.014)	0.923	1.011 (0.999, 1.023)	0.065
BMI	1.002 (0.981, 1.023)	0.864	**0.859 (0.833, 0.886)**	**<0.001**	**0.857 (0.837, 0.879)**	**<0.001**
BADL	1.004 (0.998, 1.011)	0.208	**0.98 (0.974, 0.987)**	**<0.001**	**0.976 (0.972, 0.98)**	**<0.001**
IADL	**0.836 (0.818, 0.855)**	**<0.001**	**0.742 (0.724, 0.761)**	**<0.001**	**0.888 (0.874, 0.902)**	**<0.001**
Sex						
Female	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Male	**0.632 (0.552, 0.725)**	**<0.001**	**0.56 (0.46, 0.682)**	**<0.001**	0.886 (0.754, 1.04)	0.139
Educational level						
Elementary school and below	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Middle school	**0.513 (0.441, 0.597)**	**<0.001**	**0.503 (0.396, 0.639)**	**<0.001**	0.98 (0.795, 1.208)	0.848
High school/technical high school	**0.322 (0.266, 0.391)**	**<0.001**	**0.254 (0.178, 0.364)**	**<0.001**	0.789 (0.567, 1.1)	0.162
College and above	**0.22 (0.162, 0.299)**	**<0.001**	**0.217 (0.118, 0.396)**	**<0.001**	0.983 (0.548, 1.764)	0.953
Marital status						
Other (separated/divorced/widowed/unmarried)	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Married	**0.749 (0.604, 0.928)**	**0.008**	**0.591 (0.451, 0.773)**	**<0.001**	**0.789 (0.652, 0.955)**	**0.015**
Number of children						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
One	0.831 (0.474, 1.459)	0.520	1.622 (0.646, 4.073)	0.304	1.951 (0.878, 4.334)	0.101
Two	1.264 (0.728, 2.194)	0.406	1.831 (0.748, 4.482)	0.186	1.449 (0.67, 3.13)	0.346
Three and above	1.592 (0.916, 2.764)	0.099	2.268 (0.931, 5.528)	0.072	1.425 (0.664, 3.059)	0.363
Residence						
Rural	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Urban	0.97 (0.836, 1.127)	0.694	0.885 (0.718, 1.09)	0.251	0.912 (0.772, 1.077)	0.276
Mode of residence						
Living alone	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Not living alone	1.059 (0.787, 1.425)	0.705	1.029 (0.693, 1.528)	0.888	0.972 (0.716, 1.318)	0.853
Type of medical insurance						
Self-funded	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Insurance	**0.572 (0.355, 0.922)**	**0.022**	0.623 (0.327, 1.188)	0.151	1.089 (0.669, 1.773)	0.731
Average household monthly income (1 yuan = 0.139 USD)						
< 2000 yuan	1.00 (reference)		1.00 (reference)		1.00 (reference)	
≥ 2000 yuan	**0.628 (0.546, 0.723)**	**<0.001**	**0.622 (0.51, 0.758)**	**<0.001**	0.99 (0.846, 1.159)	0.900
Drinking						
Nondrinker	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Drinker	**0.767 (0.632, 0.93)**	**0.007**	0.948 (0.705, 1.276)	0.726	1.237 (0.957, 1.598)	0.104
Smoking						
Nonsmoker	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Smoker	0.973 (0.814, 1.163)	0.764	1.136 (0.87, 1.484)	0.348	1.168 (0.931, 1.464)	0.179

Annual physical examination						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	1.101 (0.961, 1.263)	0.166	0.87 (0.716, 1.056)	0.159	**0.79 (0.675, 0.923)**	**0.003**
Socialization						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	**0.664 (0.573, 0.77)**	**<0.001**	**0.682 (0.554, 0.84)**	**<0.001**	1.027 (0.87, 1.213)	0.754
Exercise						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	**1.806 (1.515, 2.152)**	**<0.001**	**1.371 (1.087, 1.728)**	**0.008**	**0.759 (0.635, 0.907)**	**0.002**
Hypertension						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	**1.278 (1.087, 1.502)**	**0.003**	1.049 (0.839, 1.312)	0.673	**0.821 (0.687, 0.981)**	**0.030**
Diabetes						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	1.043 (0.879, 1.237)	0.633	0.947 (0.742, 1.209)	0.662	0.908 (0.746, 1.106)	0.340
Coronary heart disease						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	**1.471 (1.216, 1.779)**	**<0.001**	1.222 (0.946, 1.579)	0.125	0.831 (0.683, 1.011)	0.065
Cerebrovascular disease						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	1.199 (0.973, 1.477)	0.088	**1.402 (1.068, 1.842)**	**0.015**	1.17 (0.952, 1.437)	0.135
COPD						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	1.266 (0.979, 1.637)	0.073	1.311 (0.94, 1.83)	0.111	1.036 (0.803, 1.336)	0.785
Cataracts						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	0.969 (0.719, 1.305)	0.834	**1.642 (1.137, 2.372)**	**0.008**	**1.696 (1.297, 2.216)**	**<0.001**
Degenerative osteoarthropathy						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	1.154 (0.916, 1.454)	0.225	1.338 (0.994, 1.801)	0.055	1.16 (0.928, 1.449)	0.193
Chronic bronchitis						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	**0.718 (0.561, 0.918)**	**0.008**	1.314 (0.961, 1.795)	0.087	**1.83 (1.435, 2.334)**	**<0.001**
Hyperlipidemia						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	**0.704 (0.566, 0.876)**	**0.002**	0.841 (0.607, 1.164)	0.296	1.194 (0.906, 1.573)	0.208
Presence of multimorbidity						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	1.129 (0.934, 1.364)	0.211	**1.588 (1.223, 2.062)**	**0.001**	**1.407 (1.143, 1.733)**	**0.001**

Notes: *P*<0.05: statistically significant. [a]The reference category. Bold text indicates statistical significance. Non-normal continuous variables are described by the median and interquartile range, M (Q1, Q3): Age, BMI, BADL, IADL.
Abbreviations: IC, Intrinsic capacity; BMI, Body mass index; IADL, Instrumental activities of daily living; BADL, Basic Activities of Daily Living; COPD, Chronic Obstructive Pulmonary Disease.

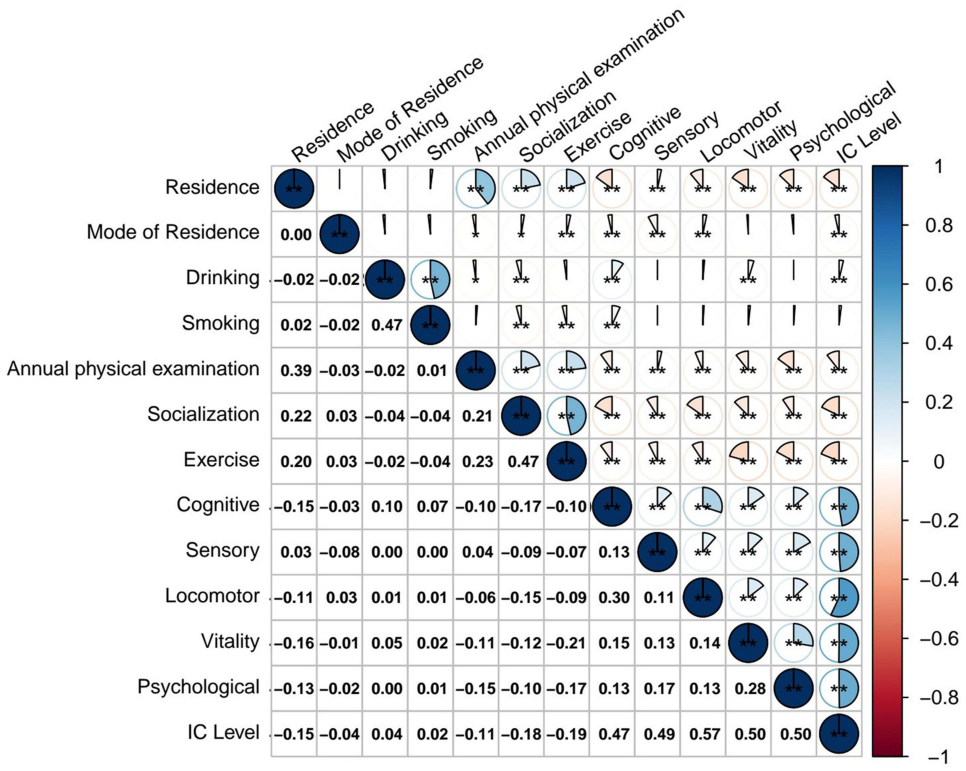

Figure 2 The Spearman correlation between lifestyle and the domains of IC. (All other covariates have been adjusted).
Notes: *P<0.01, **P<0.05.
Abbreviations: IC, Intrinsic capacity.

1.068–1.842) and cataracts (OR = 1.642, 95% CI: 1.137–2.372). Critically, older adults with multimorbidity were at significantly greater risk of belonging to Class 3 than Class 1 (OR = 1.588, 95% CI: 1.223–2.062).

Finally, in the direct comparison between Class 2 and Class 3, Class 2 had lower levels of BMI (OR = 0.857, 95% CI: 0.837–0.879), BADL (OR = 0.976, 95% CI: 0.972–0.98), and IADL (OR = 0.742, 95% CI: 0.724–0.761). Being married (OR = 0.789, 95% CI: 0.652–0.955), having annual physical examinations (OR = 0.79, 95% CI: 0.675–0.923), and exercising regularly (OR = 0.759, 95% CI: 0.635–0.907) were associated with a higher probability of being in Class 2 relative to Class 3. Regarding chronic diseases, hypertension increased the likelihood of being in Class 2 (OR = 0.821, 95% CI: 0.687–0.981), whereas cataracts (OR = 1.696, 95% CI: 1.297–2.216), chronic bronchitis (OR = 1.83, 95% CI: 1.435–2.334), and the presence of multimorbidity (OR = 1.407, 95% CI: 1.143–1.733) posed a greater risk for Class 3 membership.

Figure 2 shows the Spearman correlation between lifestyle and the domains of IC, and Figure 3 shows the Spearman correlation between chronic diseases and the domains of IC.

Discussion

This study represents a pioneering effort to delineate the latent class structure of IC among older adults with chronic diseases, moving beyond the conventional dichotomous classification of IC impairment. By employing a multi-categorical LCA, we identified three distinct subgroups: a “Higher IC group” (23.2%), a “Cognitive-Locomotion Domain-Impaired Mid-IC group” (59.96%), and a “Locomotion-Impaired Predominantly Low-IC group” (16.84%). These subgroups reflect group heterogeneity in IC levelamong older adults with chronic diseases, and this group heterogeneity reflects multidimensional differences in physical, psychological, and social functioning among the older population.

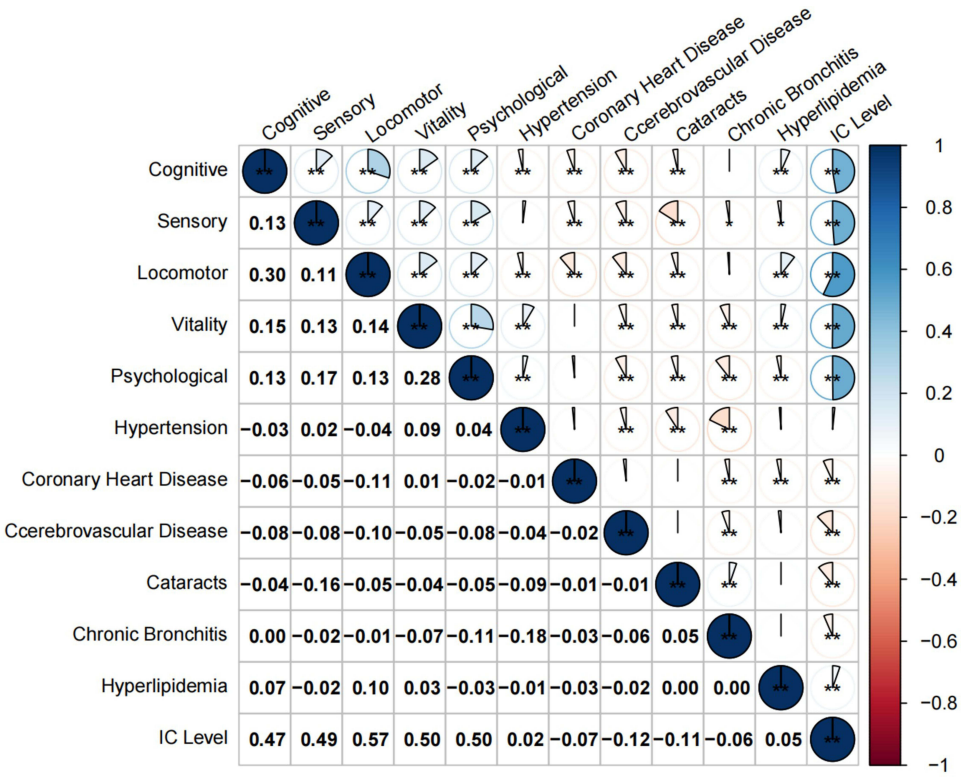

Figure 3 The Spearman correlation between chronic diseases and the domains of IC. (All other covariates have been adjusted).
Abbreviations: IC, Intrinsic capacity; COPD, Chronic Obstructive Pulmonary Disease.

High Prevalence and Comparative Context of IC Impairment

The prevalence of IC decline in older adults with chronic diseases in this study was 87.56%. Linlin et al[18] found that the rate of IC decline in older adults over 80 years old was 86.9%, which is not much different from the results of the present study, and both of them belong to the high level, which may be that older adults and older adults with chronic diseases are the focus of IC decline. A study by Zhu et al[19] on IC impairment in 237 hospitalized older adults yielded an IC decline rate of 69.6%, which is lower than the results of the present study, probably because of its small sample size and the fact that the information was collected in only one older adults hospital. Merchant et al[20] reported an exceptionally high rate (96.1%) in a community-based sample selected for fall risk. This elevated figure likely reflects the strong, bidirectional relationship between IC decline and fall risk, compounded by their study's limited sample size. The variability across these studies highlights the influence of sample characteristics and setting on IC prevalence estimates. Critically, our high prevalence rate underscores the urgent need to integrate IC assessments into the routine management of older adults with chronic conditions.

Factors Associated with IC Latent Class Membership

Our analysis identified numerous sociodemographic, lifestyle, and clinical factors associated with class membership. A nuanced interpretation of these findings is warranted.

In the results of this study, older adults were slightly more likely to be in the "Higher IC group". A study has shown that older adults have a greater risk of IC decline,[19] which is somewhat different from the results of the present study. The reason for this may be that the mean ages of the "Higher IC group" and the "middle IC group with cognitive-locomotion impairments" are 68 and 71, and the difference in age distribution between the two groups was not obvious, with an OR value of 0.989. A comparison of the results of two studies on the normalization of IC in older adults aged 80 years or older has revealed a significant gap between the two,[18] but this difference in results does not diminish the credibility of

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the studies; on the contrary, it further emphasizes the wide availability of the current definition of IC and the significant group heterogeneity it provokes.[18]

A higher BMI emerged as a protective factor against IC impairment. This seemingly counterintuitive finding may be partly attributed to the assessment methodology for the nutritional domain within IC, where a higher BMI can contribute to a better score on tools like the MNA-SF. Furthermore, being underweight is a known risk factor for cognitive impairment,[21] and older adults with a higher BMI may have better overall functional and psychological status.[22,23] However, this observation necessitates cautious interpretation, as a high BMI is also a risk factor for conditions like hyperlipidemia;[24] thus, its relationship with IC is likely complex and non-linear.

The results of the present study[19] showed that older adults with high levels of IC had higher BADL and IADL scores, similar to the results of previous studies, and it was found that most of the decline in IC in older adults with chronic diseases was due to their impaired locomotion domains, and that the SPPB, a global measure of physical functioning used in locomotion domain assessment, was strongly correlated with the decline in BADL and the decline in IADL.[25]

Consistent with existing literature,[18] we found that men were generally less likely to experience IC impairment than women. This disparity may be driven by sociocultural factors, where historically lower educational attainment and economic status among women, combined with greater caregiver burdens and role stress, can negatively impact physical and mental health.[26] This is evidenced by their higher incidence of cognitive disorders, depression, and functional disabilities.[27–29]

Higher educational level was a strong protective factor for IC. This is plausibly mediated through greater health literacy, better cognitive reserve, enhanced self-management skills, and greater adaptability, such as engaging in mentally stimulating activities that can slow cognitive decline.[30] Extensive research supports the protective effect of education on psychological and cognitive function in later life,[31] as well as a lower risk of chronic diseases,[32,33] ultimately optimizing IC levels.

Marital status serves as a protective factor for IC in older adults. After the older adults have retired and separated from their children, the spouse can not only take care of most of the socialization needs, but also share some of the financial pressure, and the spouse of an older adult with a chronic disease is able to provide some day-to-day care for him or her.[34,35] At the same time, it has been shown that older adults with 21–30 years of marriage are less likely to have multimorbidity than those with less than 10 years of marriage,[36] thereby protecting older adults IC levels, consistent with our findings (multimorbidity aggravates IC impairment). Older adults with higher average household monthly income have relatively higher levels of IC.

Older adults with higher income levels usually have sufficient funds to maintain healthy living conditions and access to excellent healthcare resources. Older adults with insurance will have a higher level of IC. In addition to being more likely to have insurance with a high level of education and economic status,[37] these older adults will have a greater willingness to seek medical care and a greater awareness of chronic disease management.[38]

In terms of lifestyle, older adults who still drink are more likely to be in the "Higher IC group" than the "Cognitive-locomotion domain-impaired mid-IC group". Studies have shown that light or moderate drinking (less than 8 drinks per week for women and less than 15 drinks per week for men) contributes to improved cognitive performance in middle-aged and older adults,[39] while moderate drinking is a protective factor against depression in older adults.[40]

Older adults who underwent annual physical examinations had higher IC levels, underscoring the value of regular health monitoring for early detection and chronic disease management, which is linked to a slower decline in BADL.[41] Social engagement was a consistent protective factor, likely by enriching life, protecting cognitive function, improving sleep quality,[42] and reducing negative emotions.[43]

The effect of exercise on IC level was not statistically significant in our primary analysis, particularly for the "Mid-IC group." The evidence on the cognitive benefits of physical activity in older adults remains mixed, with some intervention studies, including an 18-month trial, showing no significant cognitive improvement.[44] The relationship is likely highly dependent on the type, intensity, and duration of exercise, warranting future research with more detailed exercise characterization.[45,46]

The Factors of Chronic Disease in Older Adults in Different Latent Classes

The chronic disease profiles varied significantly across latent classes. Older adults with hypertension and coronary heart disease were more likely to belong to the "Mid-IC group." These cardiovascular conditions are known to promote systemic inflammation,[47] exacerbate cognitive impairment, and increase the risk of depression and Alzheimer's dementia.[48] Coronary heart disease can even lead to asymptomatic brain damage and β-amyloid deposition, which can lead to cognitive impairment.

Older adults with cataracts are found in the "Locomotion-impaired predominantly low-IC group", which shows that cataracts are very detrimental to the IC level of older adults. On the one hand, vision level, one of the domains of the IC, itself affects IC scores; on the other hand, several studies[49,50] have shown that when older adults vision declines, it is accompanied by a decline in well-being, anxiety, and irritability, which can lead to an increased risk of depression in older adults.

The distribution of chronic bronchitis was bipolar, concentrated in both the "High IC" and "Low IC" groups. This heterogeneity might be explained by confounding factors; for instance, an extroverted personality (a potential proxy for social engagement, a known IC protector[51]) may be a risk factor for chronic bronchitis. Conversely, when chronic bronchitis progresses to COPD,[52] it can trigger chronic inflammation, accelerate senescence, and significantly increase mortality risk.[53] This dual potential underscores the need for more research on the specific impact of chronic bronchitis on IC. There are fewer relevant studies exploring the relationship between chronic bronchitis and various domains of IC, and the results of this study are informative about the impact of chronic bronchitis on IC in older adults.

As anticipated, multimorbidity was profoundly detrimental, with affected individuals predominantly located in the "Low-IC group." The coexistence of multiple chronic diseases creates synergistic negative effects, accelerating physical and cognitive decline[27,54] and increasing the risk of future depressive symptoms.[55]

Clinical Implications

This study reinforces the importance of education—not only formal schooling but also lifelong learning through initiatives such as "senior citizens" universities."[32] It also highlights gaps in health insurance utilization and underscores the need for expanded coverage and reimbursement policies.[9,37]

The three latent classes identified in this study provide a potentially practical framework for IC care strategies for older adults, and precise typing could be used in the future to guide individualized interventions for older adults with chronic conditions. The "Higher IC group" can maintain existing health behaviors and strengthen chronic disease self-management education to prevent the decline of IC; the "Cognitive- locomotion domain-impaired mid-IC group" should formulate an individualized exercise rehabilitation program, combined with respiratory exercise to slow down the decline of cardiorespiratory function; the "Locomotion-impaired predominantly low-IC group" needs early screening for cognitive function.

The results of this study support the inclusion of IC assessment in chronic disease management guidelines and the development of standardized assessment tools for IC subgroups. In addition, health education for older adults in the community needs to be strengthened to promote healthy lifestyles and reduce the risk of multimorbidity. In this study, older adults with chronic diseases suffered the most severe impairment in the area of locomotion, followed by cognition and sensory function, which should be given corresponding attention.

Advantages and Limitations

This study advances the field by moving beyond the prior dichotomous treatment of IC and employing, for the first time, a multi-categorical LCA to model IC in older adults with chronic diseases. The use of stacked plots provides an intuitive visualization of the distinct IC domain profiles across the identified subgroups, enhancing the interpretability of the complex latent structure. As the first study to specifically explore IC status and its heterogeneity in a chronic disease population aged 60 years and above, it lays a crucial foundation for developing targeted care and personalized intervention strategies. Furthermore, the distinct patterns of influencing factors associated with each latent class offer a valuable reference for clarifying the impact of certain controversial factors on older adults health. Collectively, these findings provide new perspectives on the needs and challenges faced by this growing demographic.

However, there are some limitations in this study. First, the combinations of multimorbidity are complex and diverse, and the study did not explore the effects of different combinations of chronic diseases on IC and the mechanisms of chronic diseases on various domains of IC. Second, this study was conducted in Guizhou province of China, and the samples may exhibit geographic-specific characteristics, which could limit its generalizability. Therefore, future research could consider conducting multicenter IC assessment across the nationwide for further typing of the level of IC.

Conclusion

In conclusion, this study is the first to use IC level as a multi-categorical factor in LCA of older adults with chronic diseases. Three subgroups were identified and visualized with stacked plots: higher IC, cognitive–locomotion impaired mid-IC, and locomotion-impaired low-IC. Meanwhile, factors influencing latent classes of IC, including sociodemographic, functional, and lifestyle factors, were identified, and the correlations among them were explored.

Ethics Approval and Consent to Participate

This study was reviewed by the Ethical Review Committee of the Affiliated Hospital of Zunyi Medical College (KLL2022-814). The study was conducted in accordance with the principles of the Declaration of Helsinki. All the participants provided signed informed consent at the time of participation.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare no competing interests in this work.

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