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Intrinsic capacity and its association with predictors among Chinese empty nest older adults in communities: a latent class analysis

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Abstract

Objectives This study aimed to examine Intrinsic Capacity (IC) subgroups and the association of IC subgroups with IC predictors in Chinese urban empty nesters.

Methods A convenient sample of 385 older adults aged 60 and above in Community Health Service Center was recruited from Hei Longjiang Province, China, between June 2023 and December 2023. Latent class Analysis (LCA) was conducted to explore IC subgroups using the sensory, cognition, locomotion, psychological, and vitality domains of IC as input variables. Multinomial logistic regression was performed to explore the association between latent subgroups and the IC predictors.

Results We identified three IC subgroups: "Low IC level—Low locomotion domain"(33.5%), "Medium IC level—Low sensory domain" (16.9%) and "High IC level" (49.6%). Being young, married, without multimorbidity, receiving visits from children ≥ 1 time per week, a low score of self-neglect, a high score of social networking, and a low score of loneliness were closely correlated to the "High IC level" subgroup of empty-nest older adults in communities.

Conclusion The potential subgroups of the IC of empty-nest older adults in communities can be identified through five IC domains. The older empty-nesters should pay extra attention to their critical IC predictors. Community medical staff and other workers should provide intervention measures for different subgroups of older adults to improve their IC in an effective and individualized manner.

Keywords Older adults, Intrinsic capacity, Health ecology model, Influencing factors, Latent class analysis

Background

In today's world, aging has become an increasingly serious public issue, and public healthcare is facing major challenges [1]. China has now become one of the countries with the severest aging population. According to the seventh national census data, as of 2020, there are at least 145 million empty-nest older adults in China, accounting for 55.68% of the total older population [2]. Studies have shown that compared to non-empty-nest older people, empty-nest older adults are more prone to problems such as falls, cognitive decline, and depression [3–5]. Their

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functional status is far inferior to that of non-empty-nest older adults, and their disability and mortality rates are also higher, not to mention the increasing phenomenon of dying alone [6, 7]. Therefore, the need for empty-nest older adults to maintain and improve their functional abilities has become particularly urgent. How to effectively enhance and improve their functional abilities has become a key challenge for empty-nest older adults.

Intrinsic capacity (IC) represents the sum of the mental and physical capabilities that older individuals can utilize at any given time. As a multidimensional construct, IC comprises sensory, cognition, locomotion, psychological, and vitality domains, which interact and influence each other, forming the foundation for the functioning of the older adults [8]. The risk of IC damage and various adverse outcomes are closely related. For example, a longitudinal aging study analysis has indicated that higher IC is associated with reduced risk of falls [9]. Other studies have found that a decrease in IC is associated with a decrease in quality of life, an increased risk of disability [10], an increased risk of hospitalization [11], an increased incidence of frailty [12], and an increased mortality rate [13], consistent with cohort studies from Hong Kong [14]. It can be seen that improving IC is crucial for the health and life of the older adults, and how to maintain and improve IC in the older adults has become an increasingly important factor in nursing practices.

Due to the multidimensional structure described above, IC may be influenced by multiple factors. Most existing literatures have focused on the influencing factors of IC among older adults in the community, confirming that, among others, personal factors, disease conditions, lifestyle habits are closely related to IC [14–17]. Although these studies have gradually enriched the understanding of the influencing factors of IC in older adults in the community, the selection of influencing factors in a single study is not comprehensive enough, and there are still certain theoretical shortcomings. More importantly, the exploration of the influencing factors of IC in empty nest older adults is relatively rare. This study attempts to explore the influencing factors of IC in empty-nest older adults in a more comprehensive and multidimensional manner through the health ecology model. The health ecology model consists of five layers from the inside to the outside, namely personal traits layer, psychological behavior layer, interpersonal network layer, work and living conditions layer, and policy environment layer [18]. The factors contained in these five layers interact with each other and jointly affect human health. The health ecology model takes into account both remote and proximal factors influencing human health, and is a comprehensive thinking model that guides public health events.

Previous researchers have primarily focused on the relationship between IC scores of the older adults and individual variables. Unfortunately, they mostly employ traditional variable-centered regression analysis methods, ignoring the multi-dimensional structure and sample heterogeneity of IC, which may hamper precise and personalized intervention programs [19, 20]. Fortunately, latent class analysis (LCA) can identify and describe the underlying subgroups within the overall sample, thereby classifying the samples with potential heterogeneity into more meaningful subgroups [21, 22]. Additionally, this method allows for the identification of the most in-need population and the determination of intervention targets within the five domains of IC. Therefore, statistical methods of LCA can be used to identify potential subgroups of empty-nest older individuals, in order to gain a deeper understanding of the differences in influential factors among these subgroups.

Overall, the current research on the factors influencing the IC of empty-nest older adults in Chinese communities lacks comprehensive and in-depth exploration. To the best of our knowledge, there has been no research that applies the LCA method to the exploration of the IC of empty-nest older adults in Chinese communities. Therefore, our understanding of the potential subgroups of IC among empty nesters is extremely limited, which greatly hinders the provision of personalized and differentiated care services for this population. This study aims to use latent class analysis (LCA) to explore the underlying subgroups of community-dwelling empty nesters and to construct the health ecology model to comprehensively and systematically assess the influential factors of the IC of these individuals. These factors include personal characteristics (such as age, gender and multimorbidity), psychological behaviors (such as smoking, drinking, self-neglect, loneliness), interpersonal networks (marital status, social networks, frequency of visits from children), work and living conditions (educational level, monthly income), and policy environment (type of medical insurance). Therefore, this study is expected to provide scientific evidence for healthcare professionals and community workers to develop multifaceted and personalized intervention measures, in order to effectively prevent or delay the decline of IC in community-dwelling older adults, thereby improving their functional status, reducing the occurrence of adverse events, and enhancing their quality of life.

Methods

Design

We employed convenient sampling method in the cross-sectional study, to investigate community-dwelling

empty-nest older adults from DaQing City, Heilongjiang Province of China.

Participants

Two trained nursing graduates used a structured questionnaire to conduct face-to-face interviews and objective data measurements to investigate the IC status and influencing factors of community empty-nest older adults from June 2023 to December 2023.

All participants were ≥ 60 years old, had been living in the community for more than 6 months (excluding empty nest older adults who had just moved into the community and were not stable residents), did not live with their children, had no mental illness, and agreed to participate in this survey. If participants had any impairment or limitation in the ability to understand, express, or exchange information that significantly affected an individual's ability to participate in the study or to comprehend and follow study instructions; or had any medical condition that was severe, life-threatening, or rapidly progressing and required immediate medical attention or had a high likelihood of resulting in death, they were excluded. The exclusion criteria might include, but was not limited to, older individuals with related diseases that resulted in a life expectancy of less than 6 months, and older adults who were in the acute onset of the disease and were unable to complete the study. The study had been approved by the Ethics Committee of Harbin Medical University (HMUDQ20240717004), and informed consent forms were signed by the participants and/or their legal representatives after receiving relevant information, thereby strictly safeguarding the voluntary, anonymous, and confidential nature of the research.

The sample size was calculated based on the Kendall model, which estimates the sample size to be 5–10 times the number of variables [23]. In this study, there were 16 variables, so the estimated sample size was 80–160 cases. The probability of IC reduction in empty-nest older adults is about 70% [24], and given the possibility of invalid responses, the sample size was increased by 20%, resulting in a final sample size of 137–274 cases. In total, 400 people were investigated, 15 of whom were excluded due to data loss or invalidity, and 385 people were included in the final analysis (response rate 96.25%).

Measurement outcomes

General information about the participants

Population statistics collected from participants included age, gender, marital status, educational level, monthly income, type of medical insurance, frequency of visits form children, smoking history, drinking history, and multimorbidity. Specifically, the chronic diseases included self-reported cardiovascular disease, cerebrovascular disease, respiratory system disease, digestive system disease, liver disease, kidney disease, musculoskeletal disease, cancer, and other conditions. The WHO, in 2008, defined multimorbidity as the presence of two or more chronic conditions within an individual [25]. The multimorbidity were divided into two categories: one or fewer chronic diseases, and two or more chronic diseases.

Intrinsic capacity

The evaluation of IC was based on the WHO Integrated Care for Older People guideline [26]. This structured questionnaire has been applied [27]. Assessment of IC involved evaluation in sensory, cognition, locomotion, psychological, and vitality domains. For locomotion domain, the Short Physical Performance Battery test (SPPB) was used for assessment [28], including chair stand, gait speed, and balance tests, and a total score of ≤ 9 out of 12 (top score of 4 for each) signals a drop in physical function. In the sensory domain, we assessed visual function by asking if there were any difficulties with near or distant vision, and evaluated auditory function by asking if there was any hearing loss. If the response to either question was "Yes", then sensory function was considered to be impaired. Cognition domain: The Mini-Mental State Examination (MMSE) [29], with a total score of 30, was used to evaluate cognitive function impairment based on the educational level of the respondent. Scores are as follows: illiterate, ≤ 17; primary education, ≤ 20; secondary education, including technical schools, ≤ 22; university education, including community colleges, ≤ 23. Psychological domain: The Geriatric Depression Scale 15-item (GDS-15) [30], with a total score of 15, was used to assess depression status in the older adults. A score greater than 5 indicates a state of depression, reflecting poor psychological functioning. Vitality domain: The Mini-Nutritional Assessment Short-Form (MNA-SF) [31], with a total score of 14, was used to assess nutritional status and vitality. A score of 12–14 represents normal nutrition and vitality, while a score ≤ 11 indicates a decline in these areas. For every domain where the function of the IC is impaired, one point is assigned, with normal function earning 0 points. The total score ranges from 0 to 5, with higher scores representing a worse overall performance of the IC [27].

Self-neglect

We employed the Chinese culture-based Scale of Elderly Self-Neglect (SESN), which was designed to assess the level of self-neglect among the older adults in the Chinese context [32]. The scale includes five dimensions: medical care and health protection (3 items), environmental and personal hygiene (3 items), psychological

health (3 items), safety (3 items), and social interaction (2 items). Each item is rated on a four-level scoring system (0 = no occurrence, 1 = mild impact, 2 = moderate impact, 3 = severe impact), with a total possible range of 0 to 42 points. The higher the overall score, the greater the level of self-neglect. In this study, the Cronbach's α of the scale was 0.731.

Loneliness

The Loneliness Self-Assessment Questionnaire (UCLA Loneliness Scale, ULS-6) is a six-item questionnaire developed by Chinese scholars based on the original 20-item version of the scale [33]. It is used to measure the feeling of loneliness, where each item is scored from 1 to 4, and the total score ranges from 6 to 24. The higher the score, the stronger the feeling of loneliness. The scale has good reliability and validity in China. The Cronbach's α of the scale is 0.902.

Social network

The Lubben Social Network Scale-6 (LSNS-6), developed by Lubben and colleagues based on the original social network scale [34], is a simplified, six-item tool that assesses the closeness of family and friend relationships. The first three questions pertain to the family dimension, measuring the level of intimacy between relatives, while the last three questions relate to the friend dimension, assessing the degree of closeness between friends. The scores are calculated on a scale of 0 to 5 points, where "0" means no one, and "5" means nine or more people. The overall score for social isolation ranges from 0 to 30 points. Therefore, an overall social isolation score of 12 points or less signifies that a person is truly isolated [35], and a score of 6 points or less on both the family and friend dimensions indicates that they are isolated as well. In this study, the Cronbach's α for the LSNS-6 was 0.899.

Statistical analysis

SPSS 27.0 was utilized for descriptive statistics, single-factor analysis, and multi-factor analysis. Mplus 7.4 software was employed for latent class analysis to identify IC subgroups based on the sensory, cognition, locomotion, psychological, and vitality domains. We also used a variety of model fit indices to determine the optimal number of potential subgroups, including the Akaike Information Criterion (AIC), the Bayesian Information Criterion (BIC), the sample size-adjusted BIC (aBIC), the likelihood ratio test for independence (LMRT), the bootstrap likelihood ratio test (BLRT), and entropy. The lower the values of AIC, BIC, and aBIC, the better the model fitted the data. LMRT and BLRT were used to compare the model fit between two adjacent models, and a p value less than 0.05 indicated that the k-class model had a better data fit than the k-1 class model. Entropy was used to assess classification quality, and a value close to 1 indicated good class differentiation [36]. Furthermore, the posterior probability of classes was used to validate the classification, where an entropy value of 0.80 or higher represented good distinguishability [37].

After determining the groups, each potential subgroup was named to better describe their characteristics and distinguish them from other potential subgroups. Then, a normality test was performed on the scores of IC. If the data followed a normal distribution, one-way ANOVA was used to analyze the differences in the IC scores among different types of empty-nest older adults. Otherwise, a non-parametric test (Kruskal–Wallis test) was used to analyze the differences. For qualitative data, chi-square test was used to compare the differences between potential subgroups. For quantitative data, if they followed a normal distribution, ANOVA was adopted to compare the differences between groups; otherwise, non-parametric tests were used to compare the differences between groups. Significant variables were included in a multinomial logistic regression to explore the relationship between predictive factors and classes. A p-value less than 0.05 indicated a statistically significant difference.

Results

Descriptive statistics

The survey data of 385 empty-nester older adults were analyzed (Table S1), with a mean (SD) age of 71.27 (6.27) years (range: 60–91 years), including 219 female participants (56.9%) and 166 male participants (43.1%). The majority of these empty nesters were married (302, 78.4%). More than half of the residents (51.9%) had an elementary school or below education; 59.7% reported having a monthly pension income of ≤ 3,000 Chinese yuan, and 80.8% of residents had child visits per week. Among the older population, 86.0% participants were covered by urban medical insurance, while 14.0% were covered by rural medical insurance. Additionally, 13.8% of the older population smoked, 13.8% drank, 8.3% had quit smoking, and 8.6% had stopped drinking.

The median numbers (QL, QU) of social network score, loneliness score and self-neglect score were 15 (10,18), 8 (6,13) and 6 (4,9), respectively. The prevalence of multimorbidity among the older adults was 61.6%. Among the participants, 117 people (30.4%) had normal IC domain codes; 91 people (23.6%), 94 people (24.4%), 53 people (13.8%), 23 people (6%) and 7 people (1.8%), had one, two, three, four and five domains of decline, respectively. There were different levels of decline in each IC domain. The most common decline was found in the locomotion domain, with 156 people (40.5%), followed by the sensory

domain (35.8%), the psychological domain (31.4%), the vitality domain (25.2%), and finally the cognitive domain (13.8%).

Latent class analysis of IC

The fit statistics results for the 1–4 potential class models are shown in Table 1. With the increase of potential subgroups, the values of AIC, BIC, and aBIC gradually decreased and then increased, and the *p* values of LMRT and BLRT for the 4-class models were all greater than 0.05, so the 4-class model was rejected. The AIC, BIC, and aBIC values of the 2-class and 3-class models were all relatively small, and the *p* values for LMRT and BLRT were both less than 0.05. Notably, the entropy value of the 3-class model was larger, exceeding 0.8, which indicated good distinguishability and reliable classification, and the 3-class model emerged a new class with clinically relevant patterns of item-response probabilities when compared with the 2-class solution. Therefore, we selected the 3-class model for the following analysis.

The characteristics of the 3-class model are illustrated in Fig. 1. The first class comprised 129 (33.5%) older adults. They were characterized by the decline in all domains, low level of intrinsic capacity, and the most serious decline in locomotion domain, so they were named as the "Low IC level—Low locomotion domain" class. The second class was composed of 65 older adults (16.9%). They had a medium level of intrinsic capacity and a prominent decline in the sensory domain, so they were named as the "Medium IC level—Low sensory domain" class. The third class had the largest number of 191 (49.6%). As their overall health was good, these people were referred to as the "High IC level" class.

The nonparametric tests indicated that the IC scores of the three classes were significantly different ($p < 0.05$). The median of the first IC was 3 points, and the quartiles were (2, 3). The median of the second IC is 2 points, and the quartiles are (1, 2). The median of the third IC is 0 point, and the quartiles are (0, 1). Therefore, it supported the explainability of LCA classification.

Table 1 Model fit results of latent classes for IC ($n = 385$)

Number of class	AIC	BIC	aBIC	LMRT(*p*)	BLRT(*p*)	Entropy	Class proportion (%)
1	2254.725	2274.491	2258.627	—	—	—	1.000
2	2109.459	2152.945	2118.043	< 0.001	< 0.001	0.772	0.306 0.694
3	2091.759	2158.964	2105.025	< 0.001	< 0.001	0.832	0.335 0.169 0.496
4	2099.311	2190.236	2117.260	0.675	1.000	0.766	0.138 0.135 0.374 0.353

Class proportions indicated the proportion of each class in each classification model

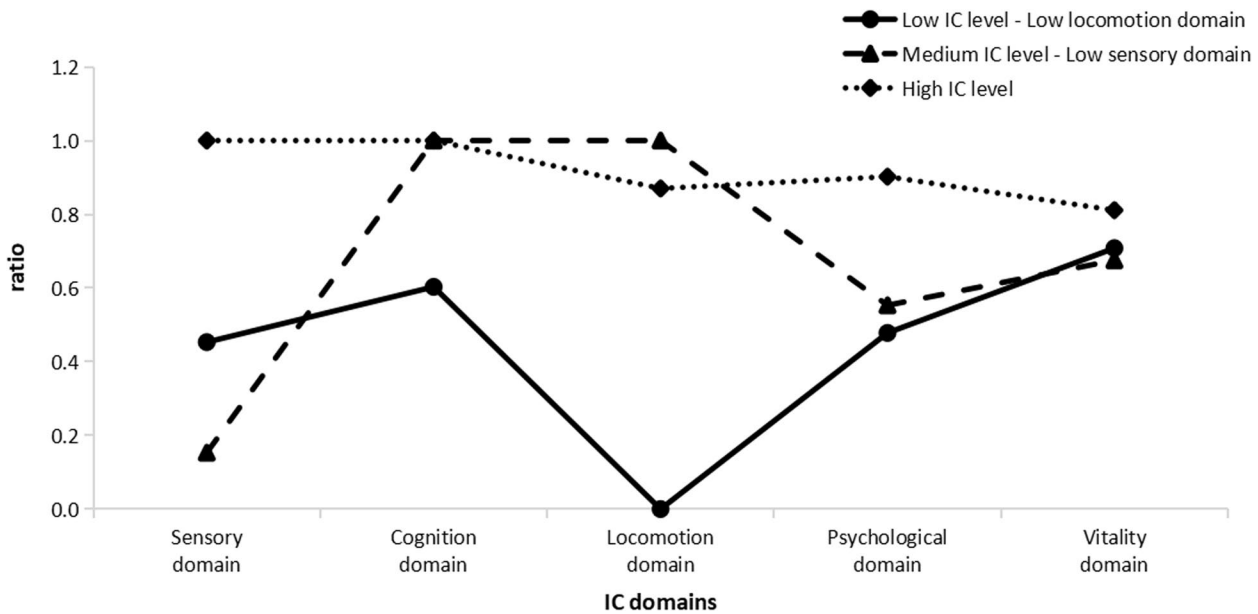


Fig. 1 Distribution of three classes of intrinsic capacity (IC). Note: The vertical ordinate represents the probability of non-damage of each domain. The horizontal ordinate represents the domains of intrinsic capacity

Comparison of predictors in each latent class

Table 2 is provided to promote understanding of the differences in population statistics and other predictive factors between the older adults of different classes. Among these variables, age, marital status, educational level, monthly income, type of medical insurance, frequency of visits by children, multimorbidity, self-neglect, loneliness, and social networks differed significantly between the three IC categories ($p < 0.05$). Interestingly, there were no significant differences in gender, smoking, and drinking ($p > 0.05$).

Multinomial logistic regression results

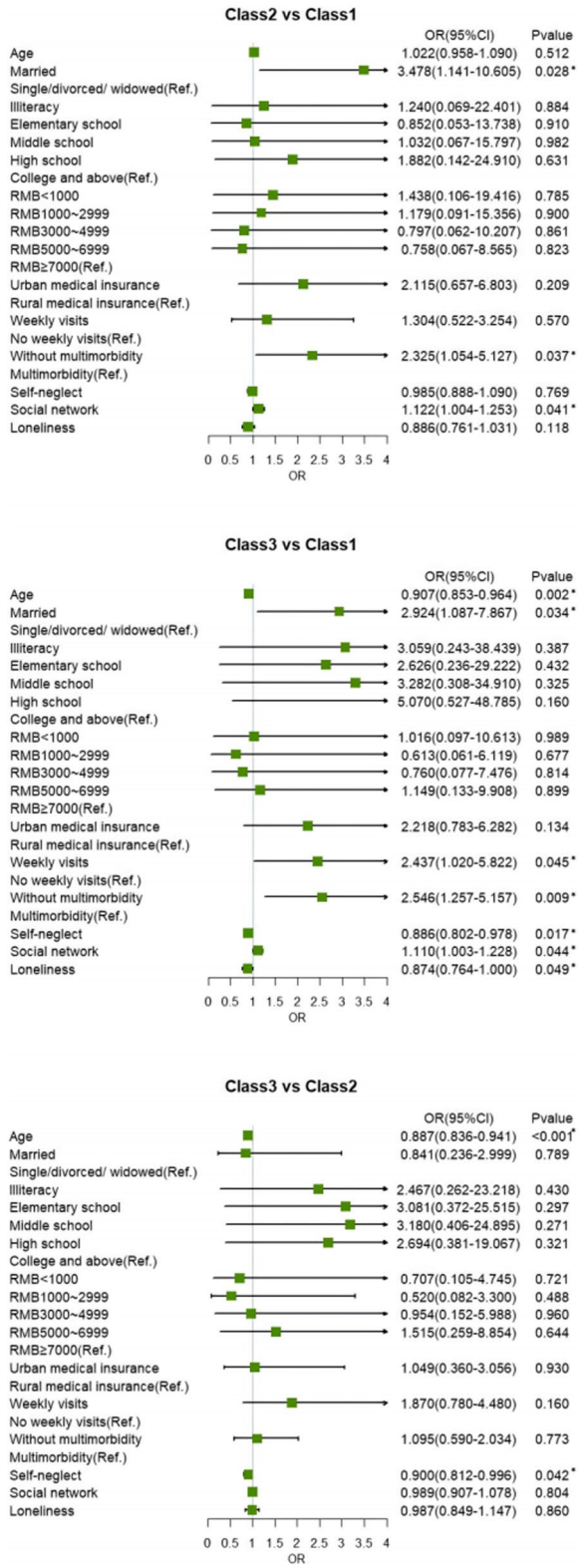
Multinomial logistic regression was used to test the correlation between IC and its predictive factors. Only those variables related to the IC subgroups served as independent variables in the logistic regression analysis.

Firstly, we compared class 1 (the group with the lowest overall IC and poor performance in the locomotion, psychological, and cognition domains) with the other two classes. The probability of older adults with higher ages joining class 3 was reduced (OR 0.907, 95%CI 0.853–0.964); married seniors were more likely to join class 2 (OR 3.478, 95%CI 1.141–10.605) and class 3 (OR 2.924, 95%CI 1.087–7.867) than their widowed, unmarried, and divorced peers. Senior citizens who are visited by their

Table 2 Classes of IC in predictors among Chinese empty nest older adults ($n = 385$)

Variables		Class 1 n(%)/M(QL,QU) 129(33.5)	Class 2 n(%)/M(QL,QU) 65(16.9)	Class 3 n(%)/M(QL,QU) 191(49.6)	X^2/z	p
Age(years)		73(70,79)[a]	72(68,77)[a]	68(65,73)[a]	57.075	< 0.001*
Gender	Male	50(38.8)	31(47.7)	85(44.5)	1.703	0.427
	Female	79(61.2)	34(52.3)	106(55.5)		
Marital status	Married	62(48.1)	59(90.8)	181(94.8)	106.337	< 0.001*
	Single/divorced/ widowed	67(51.9)	6(9.2)	10(5.2)		
Educational level	Illiteracy	31(24.0)	11(16.9)	19(9.9)	22.456	0.004*
	Elementary school	52(40.3)	25(38.5)	62(32.5)		
	Middle school	33(25.6)	18(27.7)	62(32.5)		
	High school	9(7.0)	8(12.3)	38(19.9)		
	College and above	4(3.1)	3(4.6)	10(5.2)		
Monthly income(RMB)	< 1000	48(37.2)	20(30.8)	44(23.0)	20.671	0.008*
	1000 ~ 2999	46(35.7)	23(35.3)	49(25.7)		
	3000 ~ 4999	17(13.2)	10(15.4)	48(25.1)		
	5000 ~ 6999	13(10.1)	8(12.3)	36(18.9)		
	≥ 7000	5(3.8)	4(6.2)	14(7.3)		
Medical insurance type	Urban medical insurance	100(77.5)	57(87.7)	174(91.1)	11.967	0.003*
	Rural medical insurance	29(22.5)	8(12.3)	17(8.9)		
Has child visits per week	Yes	87(67.4)	54(83.1)	170(89.0)	23.325	< 0.001*
	No	42(32.6)	11(16.9)	21(11.0)		
Smoking	Yes	21(16.3)	5(7.7)	27(14.1)	6.104	0.192
	No	93(72.1)	56(86.2)	151(79.1)		
	Quit smoking	15(11.6)	4(6.1)	13(6.8)		
Drinking	Yes	15(11.6)	6(9.2)	32(16.7)	6.817	0.146
	No	98(76.0)	53(81.6)	148(77.5)		
	Stop drinking	16(12.4)	6(9.2)	11(5.8)		
Multimorbidity	No	23(17.8)	30(46.2)	95(49.7)	35.094	< 0.001*
	Yes	106(82.2)	35(53.8)	96(50.3)		
Self-neglect		10(6,13)[a]	6(4,8)[a]	5(3,7)[a]	45.747	< 0.001*
Social network		9(8,13)[a]	17(12,19)[a]	17(14,20)[a]	107.606	< 0.001*
Loneliness		15(10,17)[a]	8(7,11)[a]	7(6,9)[a]	93.009	< 0.001*

[a] represents the median and lower and upper quartiles: M (QL, QU). * represents $p < 0.05$



◀ **Fig. 2** Multinomial logistic regression of different latent classes of IC among Chinese urban empty nesters. Note: The analysis includes three parts. The first part compares the results of the "Medium IC level—Low sensory domain" group with the "Low IC level—Low locomotion domains" group. The second part compares the results of the "High IC level" group with the "Low IC level—Low locomotion domains" group. The third part compares the results of the "High IC level" group with the "Medium IC level—Low sensory domain" group. OR = odds ratio. If an odds ratio > 1, the probability that the membership is classified into a particular class will increase along with an increase in each unit of the predictor variable, and vice versa

children at least once a week were more frequently found in class 3 (OR 2.437, 95% CI 1.020–5.822); those without multimorbidity are more prevalent in the class 2 (OR 2.325, 95% CI 1.054–5.127) and class 3 (OR 2.546, 95% CI 1.257–5.157). Older individuals with low self-neglect scores were more likely to be found in class 3 (OR 0.886, 95%CI 0.802–0.978). Empty-nest older adults with high scores of loneliness were less likely to be in class 3 (OR 0.874, 95%CI 0.764–1.000). Empty-nest older adults with high social network scores were more likely to be in class 2 (OR 1.122, 95%CI 1.004–1.253) and class 3 (OR 1.110, 95%CI 1.003–1.228) (Fig. 2 and Table S2).

Secondly, a comparison between class 2 and class 3 revealed that the older empty-nesters were more likely to fall into class 2 (OR 0.887, 95%CI 0.836–0.941); while older individuals with lower scores on self-neglect were more likely to be in class 3 (OR 0.900, 95%CI 0.812–0.996) (Fig. 2 and Table S3).

Discussion

To the best of our knowledge, this study seemed to be the first attempt to use Latent Class Analysis to identify the heterogeneity of IC among empty-nest older in Chinese communities. Our research identified three different types of IC, named "Low IC Level—Low locomotion", "Medium IC Level—Low sensory domain", and "High IC Level". Among the three identified classes, the "High IC level" class accounted for 49.6% of the total (the largest proportion). Its characteristic was that all domains of IC (such as locomotion, sensory, cognition, psychological and vitality) were relatively good. The second largest class was "Low IC Level—Low locomotion", accounting for 33.5%, with the characteristic of poor performance in all IC domains, with the locomotion domain affected the most. The remaining class "Medium IC level—Low sensory domain" accounted for 16.9%. This class was characterized by moderate overall IC, but with more severe impairments in the sensory and vitality domains when compared to the other classes. These results demonstrated disparities in the status of the five domains of

IC among empty-nest older individuals in communities. Specifically, there were significant differences in the sensory and locomotion domains among the three classes, while the vitality domain showed less differences. Therefore, precise interventions should be provided for community-dwelling empty nesters in different states of IC. Among these classes, the "Low IC Level—Low locomotion" class with severe IC decline required the most attention. This suggested that when developing interventions for IC, we should pay close attention to those targeting the locomotion domain.

We also found that the IC of empty-nest older adults in the community was influenced by factors in multiple layers of the health ecology model. At the individual trait layer, we found that multimorbidity and age affected the IC of empty-nest older adults in the community. Older empty nesters with multimorbidity were more likely to fall into the "Low IC Level—Low locomotion" class. This could be due to their weaker ability to maintain homeostasis and physiological balance compared to counterparts without multimorbidity, leading to an increased risk of adverse drug events and ultimately resulting in a decrease in IC. Several studies have shown that multimorbidity can affect the health trajectory of older adults. For example, Wang et al. [37] found that the more chronic diseases an individual has, the more likely they are to experience a worse trajectory of healthy aging. The trajectory of IC in older adults with a high number of chronic diseases (severe multimorbidity) shows a significant decrease [14]. Therefore, empty-nest older adults in communities with multimorbidity are more likely to experience a decrease in IC. Age was one of the influencing factors of IC among empty nest older adults in the community according to our analysis. Older adults in the classes of "Low IC Level—Low locomotion" and "Medium IC Level—Low sensory domain" were generally older, while those in the "High IC Level" class were mostly younger.Aging is a risk factor for the decline of IC, and older adults are more likely to experience an increase the damaged area of IC [38–40]. The reason may be that as age increases, the functions of tissues and organs in the body decline, leading to a decrease in physical functions and psychological abilities, ultimately causing IC damage.

In the psychological behavioral layer, we found that self-neglect and loneliness were the influencing factors of IC among empty nest older adults in the community. The self-neglect of older adults refers to their refusal or failure to provide himself/herself with essential self-care tasks, including keeping up personal hygiene, searching for medical assistance when necessary, and maintaining a socially accepted standard of health [41]. Community empty nest older adults with high self-neglect scores were more likely to fall into "Low IC Level—Low locomotion" class. In contrast, the lower the self-neglect scores, the fewer IC domains were damaged for the empty-nesters. Previous studies have explored the relationship between self-neglect and various health outcomes. Ramsey-Klawsnik et al. mentioned that self-neglect is a form of abuse that can cause health and safety issues in older adults, leading to adverse health outcomes and even death [42]. The more severe the self-neglect, the more likely empty nest older adults are to experience delayed medical treatment, poor hygiene conditions, and mental health damage, which may lead to reduced food intake, depression, and poor social interaction [43, 44], affecting all functional domains of empty nest older adults. It is worrying that the phenomenon of self-neglect among empty nest older adults is widespread and the situation is not optimistic [45]. Therefore, for older adults who experience self-neglect, we should promptly identify and intervene to avoid adverse outcomes such as decreased IC of empty nest older adults in the community.

Empty nest older adults with high levels of loneliness were more likely to appear in the "Low IC Level—Low locomotion" class. The higher the level of loneliness, the worse the overall IC level. Some studies have found that the cumulative burden of loneliness can affect the health of the older adults, speed up disease progress, and increase the incidence rate of cardiovascular diseases in one year [46]. Moreover, loneliness plays a mediating role between older adults living alone and depression [47]. Loneliness can lead to poor mental quality of life [48] and have adverse effects on cognition in older adults [49]. Therefore, we speculate that the impact of loneliness on IC may be related to factors such as depression and cognitive decline caused by loneliness. Timely intervention should be applied to empty nest older adults with feelings of loneliness to maintain and enhance their IC levels. In the exploration of the behavioral psychology of empty nest older adults, we did not find that smoking and drinking had significant effect on the different classes of IC in empty nest older adults. Perhaps the impact of smoking and drinking on IC is related to their time length and quantity. Future research can delve into the relationship between the duration and quantity of smoking and drinking and IC in empty nest older individuals, further revealing the dose–response relationship between adverse health behaviors such as smoking and drinking and IC.

In the interpersonal network layer, we found that marital status, frequency of child visits, and social networks were the influencing factors of IC among empty nest older adults in the community. Community empty nest older adults with marital status of Single/divorced/widowed were more likely to appear in the "Low IC

Level—Low locomotion" class..Empty nest older adults with high frequency of child visits were more likely to appear in the "High IC Level" class. This may be influenced by China's "filial piety" culture, where older adults prefer a family-centered support and care model, making them more dependent on the care and support of their children and spouses. Therefore, when older adults lose these supports, they were more likely to experience functional decline. Other studies have also shown that marital status is an important influencing factor for self-rated health and depression among older adults [50], and older adults living alone are often more prone to self-rated poor health [50] and poor mental health [51]. These studies also provide strong support for our results. Community-dwelling nest older adults are characterized by their children leaving home and their family size shrinking. This study found that a decrease in the frequency of children's visits and care could lead to a decrease in IC. The attention of children to their parents is of great significance for empty nest older adults. At the same time, the importance of spouses as an important source of family support is particularly prominent. In the future, based on the analysis of the interdependence between the subject and object of empty nest older couples, we can explore the impact of binary coping strategies on their IC, and further reveal the role of marital relationships in the health of the older adults.

The social network score levels of the three classes of empty nest older individuals were different. The older individuals in the "Low IC Level—Low locomotion" class have the lowest overall social network score, followed by the "Medium IC level—Low sensory domain" class, and the "High IC Level" class has the highest social network score. The Society Convoy Model can explain this phenomenon, where social networks composed of family, friends, and other individuals can provide various forms of social support, thus playing the role of "escorts" to help individuals cope with difficult and stressful situations [52]. Empty nest older adults can improve their thinking and cognitive abilities through rich social networks and social participation, reduce neurodegenerative diseases, and improve their health status [53]. The more social networks there are, the more beneficial it is to maintain the social integration of empty nest older adults and reduce the occurrence of mental health problems, such as depression [54, 55]. A study has found that increasing social networks can help prevent loss of appetite in older adults [56]. The above studies all indicate that increasing social networks may delay cognitive decline, and reduce the occurrence of psychological problems and appetite loss in older adults, thereby delaying the decline of IC.

This study explored the IC of community empty nest older adults, and identified potential classes of IC through LCA, which can clearly understand the heterogeneity of their IC. The use of health ecology model facilitate comprehensively and fully exploring the influencing factors of IC in different classes of empty nest older adults in communities, providing evidence support for subsequent personalized interventions. At the same time, this study also has certain limitations. Firstly, this study adopted a cross-sectional design, and the results cannot represent causal associations, which may be revealed by further longitudinal studies. Secondly, all participants were empty nest older adults in Daqing community, and these data cannot represent the entire older population in China. However, due to the migration of labor force and severe empty nest phenomenon in the region, our respondents served as a representative sample for the Northeast region with severe empty nest phenomenon. Thirdly, investigations related to multimorbidity were limited to whether there were multimorbidity, and the severity of the disease was not considered. In the future, when exploring the relationship between multimorbidity and IC, the severity of the disease can be included to shed more light on this issue. Fourth, this study has not yet found the specific impact of factors at the work and living conditions layer and policy environment layer on the IC of empty nest older adults. Due to the impact of convenience sampling, the population included in this study shows no significant variations in terms of monthly income, educational level, and other aspects. In the future, we can focus on exploring the relationship between IC and these two layers of factors.

Conclusion

This study utilized latent class analysis (LCA) to investigate three distinct classes of IC among community empty-nest older adults: the "Low IC level—Low locomotion domain" class, the "Medium IC level—Low sensory domain" class, and the "High IC level" class. Among these community empty-nest older adults, we have identified that age, marital status, receiving visits from children, multimorbidity, social network, loneliness, and self-neglect are factors correlated with IC. Our research findings may assist community medical staff and workers in focusing on the community empty-nest older adults with declining IC, and provide robust evidence to support the formulation of precise intervention programs tailored to their needs. The older empty-nesters may want to actively strengthen their social network, and reduce their self-neglect and loneliness, thereby improving IC scores and improving their functional abilities.

Abbreviations

IC Intrinsic capacity
LCA Latent class analysis

Supplementary Information

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Supplementary Material 1.

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An unauthorized version of the Chinese MMSE was used by the study team without permission, however this has now been rectified with PAR. The MMSE is a copyrighted instrument and may not be used or reproduced in whole or in part, in any form or language, or by any means without written permission of PAR (https://www.parinc.com).

Clinical trial number
Not applicable.

Authors' contributions
W.G. and L.M. collaboratively authored and revised this paper, sharing the role of first author. Y.L. serving as the corresponding author, made substantial contributions to the conception and design of this paper, and assumes scientific and legal responsibility for its content. All remaining authors contributed to the data collection for this paper.

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Data availability
The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was conducted in accordance with the Declaration of Helsinki and approved by the ethic committee of Harbin Medical University (HMUDQ20240717004), informed consent was obtained from all subjects and/or their legal guardians.

Competing interests
The authors declare no competing interests.

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