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Original Research

Association of objective and subjective socioeconomic status with intrinsic capacity deficits among community-dwelling middle-aged and older adults in China: A cross-sectional study

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ABSTRACT

Background: Intrinsic capacity (IC), representing an individual's full range of physical and mental abilities, is influenced by objective socioeconomic status (SES); however, the impact of subjective SES remains unclear.
Objectives: This study aims to assess IC and investigate the relationship between SES and IC deficits, with a particular focus on the role of subjective SES.
Design: Cross-sectional study
Setting: 45 communities in two provinces in China
Participants: Community-dwelling middle-aged and older adults aged 50 and above
Measurements: IC was assessed following the Integrated Care for Older People guideline. SES was measured through objective SES (education and occupation) and subjective SES (measured by MacArthur Scale). Ordinal logistic regression models were performed to estimate the association between SES and IC.
Results: Among 3,058 participants (61.3 ± 8.05 years, 54.8 % women), 2,333 (76.3 %) showed deficits in at least one IC subdomain, particularly sensory (63.5 %), vitality (25.8 %) and cognition (18.4 %). A dose-response association was observed between SES and IC deficits. Individuals with high subjective SES (OR: 0.72, 0.60–0.87), high education (OR: 0.54, 0.38–0.75), and high occupation (OR: 0.64 0.50–0.81) exhibited lower IC deficits risk compared with counterparts. Individuals with high education and middle subjective SES or high occupation and middle subjective SES had 67 % (OR: 0.33, 0.18–0.60) and 49 % (OR: 0.51, 0.35–0.74) lower risk than those with low SES.
Conclusions: These findings suggest that individuals with low SES may be more vulnerable to IC deficits. Addressing social inequalities in the early assessment of IC is crucial for reducing health disparities and promoting healthy ageing.

1. Background

Intrinsic capacity (IC) represents the composite of an individual's physical and mental abilities across their lifetime and is central to the integrated care model for healthy ageing [1,2]. Evidence shows that IC deficits strongly predict adverse outcomes, such as falls, care dependency, disability, and mortality [3]. A systematic review estimated the global detection rate of IC deficits at 72.0 %, with 70.3 % in China, though variations in measurement tools contribute to high heterogeneity in prevalence across populations [4]. The development of the Integrated Care for Older People (ICOPE) guideline has provided a valid and comprehensive assessment of IC and suggested assessing IC deficits from five subdomains, including cognition, locomotion, psychology, vitality, and sensory function (vision and hearing) [2,5]. With the availability of

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these tools, early assessment, and identification of IC among the middle-aged population are critical for designing public health interventions to promote healthy ageing [6].

Among a series of potential factors that may be associated with IC deficits, socioeconomic status (SES) has gained increasing attention. SES has been widely considered as 'the rooted cause of causes', with ability to shape health outcomes through multiple pathways, including material conditions, psychosocial environments, behavioral factors, and access to care [7]. Most previous studies have focused on objective SES, such as education level, occupation, and household wealth and consistent findings have demonstrated that lower objective SES is associated with an earlier onset of IC deficits and more rapid disease progression [8–10].

However, subjective SES, another dimension of SES, has been insufficiently studied. Subjective SES reflects individuals' self-assessments of their perceived SES [11] and may capture additional aspects of socioeconomic status that are not fully reflected by objective measures [12]. Studies show that subjective SES is independently associated with health outcomes, including self-rated health, mental health, and mortality, regardless of objective SES [13–15]. Evidence from the English Longitudinal Study of Ageing suggests that social comparisons within subjective SES may impact health through the mechanism of relative deprivationa - negative psychological state arising from perceived disadvantages in education, social status, or wealth compared to others [16,17]. This mechanism may contribute to frailty in older adults [16]. While it is plausible to hypothesize that subjective SES influences IC, evidence on the association between subjective SES and IC deficits remains inconclusive.

Therefore, this study aims to assess IC among community-dwelling middle-aged and older adults in selected settings in China, describe the detection rate of deficits in IC and its subdomains across populations, and to investigate the associations between SES and IC deficits, with a particular focus on subjective SES.

2. Methods

2.1. Study design and participants

This cross-sectional study surveyed individuals aged 50 and above in multiple communities in China from July to September 2023. We employed a multi-stage purposive sampling approach, selecting 45 communities in Fangshan District, Beijing (urban) and Wuyuan County, Jiangxi Province (rural). Community-dwelling adults were informed about the project by community administrative officers and invited to participate if they visited the study sites on specified days. Inclusion criteria were:(1) age ≥ 50 years; (2) permanent residents in the area (residing at least 6 months annually); and (3) willingness to participate with written informed consent. Individuals with serious disabilities or cognitive impairments that could affect participation were excluded.

This study was received approval from the Ethics Committee of Chinese Academy of Medical Sciences & Peking Union Medical College (CAMS&PUMC-IEC-2022–076).

2.2. Assessment of socioeconomic status

Subjective SES alongside objective SES was utilized to holistically evaluate the SES among participants. We employed the MacArthur Scale, a valid and commonly used scale for assessment of subjective SES [18]. Participants were provided with a figure of the ladder and self-indicated their perceived position on this ladder, reflecting their perceived socioeconomic status. Subsequently, we derived scores ranging from 0 to 10 based on respondents' markings [19]. Participants were further divided into three groups based on the tertiles of MacArthur scores.

We utilized education and occupation as indicators of objective SES, each divided into three categories. According to previous studies [20], education was classified as: primary education and below (low), secondary and high school (middle), and college and above (high). Occupation, encompassing the current or pre-retirement status of participants, was categorized into three groups: unskilled (low), including homemakers and individuals engaged in flexible employment; skilled (middle), including clerical staff, personnel in social production and service industries, workers in agriculture, forestry, animal husbandry, and fisheries, and production and transportation workers; professional or managerial (high), including senior officials, managers, professionals, and technicians.

2.3. Assessment of intrinsic capacity

IC was assessed according the WHO ICOPE in-depth assessment tool covering five subdomains [5], including cognition (measured by Mini-Mental State Examination) [21], locomotion (measured by Short Physical Performance Battery test) [22], vitality (measured by Mini Nutritional Assessment short form) [23], psychology (measured by Patient Health Questionnaire-9) [24] and sensory (vision was measured by WHO simple eye chart; hearing was measured by 'hearWHO' application) [5]. The detailed measurement and scoring methods for the IC subdomains can be found in **Supplementary Table 1**. Following previous studies [25], each subdomain was assigned a score ranging from 0 to 2 (i.e., 0 = severe impairment; 1 = mild impairment; 2 = intact). This resulted in an overall IC composite score ranging from 0 to 10, with higher scores representing greater IC. Further, participants were divided into three groups based on the tertiles of IC scores: high and stable capacity, declining capacity, and significant loss of capacity. Additionally, severe or mild impairment in subdomains was considered to indicate deficits in subdomains. IC deficits was defined as the presence of either declining capacity or significant loss of capacity.

2.4. Assessment of covariates

A series of covariates were considered. Age (50–59, 60–69, 70+), gender (male vs. female) and marital status (married, divorced or widowed and unmarried) were recorded. Following previous studies, smoking (current smoker vs. non-smoker or past smoker) [26], alcohol use (frequent use defined as consuming alcohol more than once a month vs. non-frequent use) [26] and physical activity (physically active with energy expenditure from self-reported leisure-time physical activities exceed 600 Metabolic Equivalent of Task minutes per week vs. physically inactive) [27], diet (sufficient, defined as consuming at least 300g of vegetables and 200g of fruit daily vs. insufficient) [28] were dichotomized. In addition, the self-reported number of chronic conditions from a list of 39 common chronic diseases (categories as 0, 1, 2 and 3+ chronic diseases), and enrollment of health insurance (yes vs. no) were also considered.

2.5. Data collection

Data collection was conducted in each community, where participants were asked to visit survey sites on designated days. After obtaining written informed consent, standardized questionnaires and physical examinations were conducted sequentially. Trained data collectors performed face-to-face interviews using tablets with an embedded survey system, and all physical examination records were entered directly into the system after measurements.

2.6. Data analysis

Continuous variables were summarized as means and standard deviations, while categorical variables were presented as frequencies and percentages. We assessed the relationship between variables and subjective SES using chi-square tests for categorical variables, Kruskal-Wallis

Table 1
Characteristics of participants (n = 3058).

Characteristics	Subjective socioeconomic status			Total (N = 3058)
	Low (N = 1386)	Middle (N = 1048)	High (N = 624)	
Age				
50–59	670 (48.3 %)	520 (49.6 %)	283 (45.4 %)	1473 (48.2 %)
60–69	478 (34.5 %)	340 (32.4 %)	245 (39.3 %)	1063 (34.8 %)
70+	238 (17.2 %)	188 (17.9 %)	96 (15.4 %)	522 (17.1 %)
Sex				
Male	624 (45.0 %)	469 (44.8 %)	288 (46.2 %)	1381 (45.2 %)
Female	762 (55.0 %)	579 (55.2 %)	336 (53.8 %)	1677 (54.8 %)
Marital status				
Married	1193 (86.1 %)	926 (88.4 %)	558 (89.4 %)	2677 (87.5 %)
Divorced or widowed	179 (12.9 %)	118 (11.3 %)	64 (10.3 %)	361 (11.8 %)
Unmarried	14 (1.0 %)	4 (0.4 %)	2 (0.3 %)	20 (0.7 %)
Education				
Primary school and below	682 (49.2 %)	411 (39.2 %)	221 (35.4 %)	1314 (43.0 %)
Secondary and high school	659 (47.5 %)	597 (57.0 %)	350 (56.1 %)	1606 (52.5 %)
College and above	45 (3.2 %)	40 (3.8 %)	53 (8.5 %)	138 (4.5 %)
Occupation[a]				
Unskilled	482 (34.8 %)	331 (31.6 %)	155 (24.8 %)	968 (31.7 %)
Skilled	795 (57.4 %)	595 (56.8 %)	345 (55.3 %)	1735 (56.7 %)
Professional or managerial	109 (7.9 %)	122 (11.6 %)	124 (19.9 %)	355 (11.6 %)
Smoking				
Non-smoker or past smoker	856 (61.8 %)	642 (61.3 %)	400 (64.1 %)	1898 (62.1 %)
Current smoker	530 (38.2 %)	406 (38.7 %)	224 (35.9 %)	1160 (37.9 %)
Alcohol use				
Non-frequent	985 (71.1 %)	738 (70.4 %)	435 (69.7 %)	2158 (70.6 %)
Frequent	401 (28.9 %)	310 (29.6 %)	189 (30.3 %)	900 (29.4 %)
Physical activity				
Inactive	700 (50.5 %)	493 (47.0 %)	240 (38.5 %)	1433 (46.9 %)
Active	686 (49.5 %)	555 (53.0 %)	384 (61.5 %)	1625 (53.1 %)
Diet (vegetable and fruit intake)				
Insufficient	1293 (93.3 %)	962 (91.8 %)	548 (87.8 %)	2803 (91.7 %)
Sufficient	93 (6.7 %)	86 (8.2 %)	76 (12.2 %)	255 (8.3 %)
Health insurance				
No	20 (1.4 %)	9 (0.9 %)	1 (0.2 %)	30 (1.0 %)
Yes	1366 (98.6 %)	1039 (99.1 %)	623 (99.8 %)	3028 (99.0 %)
Number of major chronic diseases				
0	319 (23.0 %)	272 (26.0 %)	147 (23.6 %)	738 (24.1 %)
1	406 (29.3 %)	309 (29.5 %)	185 (29.6 %)	900 (29.4 %)
2	305 (22.0 %)	223 (21.3 %)	128 (20.5 %)	656 (21.5 %)
3+	356 (25.7 %)	244 (23.3 %)	164 (26.3 %)	764 (25.0 %)

Notes: Data were expressed as mean (standard deviation) or n (%). a: Occupation encompasses the current or pre-retirement status of participant.

tests for ordinal variables, and one-way ANOVA for normally distributed continuous variables. Additionally, ordinal logistic regression was used to examine the association between SES and IC deficits, adjusting for age, gender, marital status, smoking, alcohol use, physical activity, diet, health insurance, and the number of chronic diseases in the multivariable model.

We further explored the relationships between individual subdomains and SES to determine if the association between IC and SES is driven by specific subdomains. To evaluate the independent and combined associations of subjective and objective SES with IC deficits, we classified individuals into nine groups based on three levels of both subjective and objective SES (low, middle, high), using the estimated risk ratio for participants with both low subjective and objective SES as the reference group.

We conducted sensitivity analyses to ensure the robustness of our findings. First, we reclassified the participants based on the number of IC subdomains with deficits, categorizing them into three groups: no deficits, deficits in one or two subdomains, and deficits in three or more subdomains. Second, we repeated the analysis using the continuous scores for subjective SES to determine whether the results were consistent with those of the primary analysis. Furthermore, we conducted stratified analyses based on age and gender. The statistical analysis was performed using Stata 17·0 [29].

3. Results

A total of 3236 participants aged 50 and older were recruited for the study, with 3058 having complete data for analysis. The average age was 61.3 years (SD = 8.05), and 1677 (54.8 %) were female. About 43.0 % had primary education and below, and 88.4 % were categorized as unskilled or skilled labor. Regarding lifestyle factors, the majority of participants had never smoked or were past smoker (1898, 62.1 %), consumed alcohol less than once a month (2158, 70.6 %), were physically active (1625, 53.1 %), and had insufficient fruit or vegetable intake according to the Chinese Dietary Guidelines (2803, 91.7 %). Approximately 45.3 % of participants perceived their subjective SES as low, while only 20.4 % rated it as high. Individuals with primary education and below, unskilled occupations, physical inactivity, and insufficient fruit or vegetable intake were more likely to rate their subjective SES as low ($P < 0.001$) (Table 1).

About 38.1 % ($n = 1166$) of participants showed significant loss of capacity (Table 2), which was higher among females (40.8 %) compared with males (34.8 %, $P < 0.05$) (**Supplementary Table 2**). The detection rates of deficits in subdomains were highest in sensory (63.5 %), followed by vitality (25.8 %), cognition (18.4 %), psychology (15.3 %), and locomotion (11.5 %). Of these participants, 725 (23.7 %) showed no deficits in any subdomain, and they were more likely to perceive

Table 2
The detection rates of intrinsic capacity deficits (n = 3058).

	Subjective socioeconomic status			Total (N = 3058)
	Low (N = 1386)	Middle (N = 1048)	High (N = 624)	
Intrinsic capacity				
High and stable capacity	309 (22.3 %)	253 (24.1 %)	163 (26.1 %)	725 (23.7 %)
Declining capacity	478 (34.5 %)	439 (41.9 %)	250 (40.1 %)	1167 (38.2 %)
Significant loss of capacity	599 (43.2 %)	356 (34.0 %)	211 (33.8 %)	1166 (38.1 %)
Cognition				
Intact	1091 (78.7 %)	875 (83.5 %)	530 (84.9 %)	2496 (81.6 %)
Deficit[a]	295 (21.3 %)	173 (16.5 %)	94 (15.1 %)	562 (18.4 %)
Locomotion				
Intact	1201 (86.7 %)	958 (91.4 %)	546 (87.5 %)	2705 (88.5 %)
Deficit[a]	185 (13.3 %)	90 (8.6 %)	78 (12.5 %)	353 (11.5 %)
Psychology				
Intact	1145 (82.6 %)	910 (86.8 %)	536 (85.9 %)	2591 (84.7 %)
Deficit[a]	241 (17.4 %)	138 (13.2 %)	88 (14.1 %)	467 (15.3 %)
Vitality				
Intact	997 (71.9 %)	791 (75.5 %)	481 (77.1 %)	2269 (74.2 %)
Deficit[a]	389 (28.1 %)	257 (24.5 %)	143 (22.9 %)	789 (25.8 %)
Sensory				
Intact	484 (34.9 %)	396 (37.8 %)	235 (37.7 %)	1115 (36.5 %)
Deficit[a]	902 (65.1 %)	652 (62.2 %)	389 (62.3 %)	1943 (63.5 %)

Notes: Data were expressed as mean (standard deviation) or n (%). a: Severe or mild impairment was considered to indicate deficit.

Table 3
Ordinal logistic regression for socioeconomic status with intrinsic capacity deficits.

	Model 1		Model 2		Model 3	
	OR (95 % CI)	p-value	OR (95 % CI)	p-value	OR (95 % CI)	p-value
Education						
Primary school and below	1.0 (Ref)		1.0 (Ref)		1.0 (Ref)	
Secondary and high school	0.59 (0.51–0.68)	<0.001	0.62 (0.53–0.72)	<0.001	0.62 (0.53–0.72)	<0.001
College and above	0.48 (0.34–0.67)	<0.001	0.54 (0.38–0.75)	<0.001	0.54 (0.38–0.75)	<0.001
p for trend	<0.001		<0.001		<0.001	
Occupation						
Unskilled	1.0 (Ref)		1.0 (Ref)		1.0 (Ref)	
Skilled	0.86 (0.74–1.00)	0.056	0.86 (0.73–1.00)	0.046	0.85 (0.73–0.99)	0.038
Professional or managerial	0.60 (0.48–0.76)	<0.001	0.64 (0.51–0.82)	<0.001	0.64 (0.50–0.81)	<0.001
p for trend	<0.001		<0.001		<0.001	
Subjective socioeconomic status						
Low	1.0 (Ref)		1.0 (Ref)		1.0 (Ref)	
Middle	0.75 (0.64–0.87)	<0.001	0.75 (0.65–0.89)	<0.001	0.76 (0.65–0.88)	<0.001
High	0.69 (0.57–0.82)	<0.001	0.72 (0.60–0.87)	<0.001	0.72 (0.60–0.87)	<0.001
p for trend	<0.001		<0.001		<0.001	

Notes: Model 1: adjusted by age, gender, marital status. Model 2: adjusted by age, gender, marital status, lifestyle factors. Model 3: adjusted by age, gender, marital status, lifestyle factors, health insurance, number of major chronic diseases. Abbreviations: OR = odds ratio. CI = confidence interval.

themselves as high subjective SES. In total, 1837 (60.1 %) experienced deficits in 1–2 subdomains, and 496 (16.2 %) exhibited deficits in three or more subdomains **(Supplementary Table 3)**. Individuals who ranked their subjective SES as low reported a detection rate of IC deficits at 77.7 %. These individuals were also more likely to experience deficits in cognition (21.3 %), locomotion (13.3 %), psychology (17.4 %), and vitality (28.1 %) subdomains ($P < 0.05$) (Table 2).

The multilevel ordinal regression models indicated that individuals with lower objective and subjective SES were more likely to exhibit IC deficits compared to those with higher SES ($P < 0.05$) (Table 3). A dose-response relationship was observed between subjective SES and detection rates of IC deficits, with individuals having middle or high subjective SES showing a 25 % (OR: 0.75, 95 % CI: 0.64–0.87) and 31 % (OR: 0.69, 95 % CI: 0.57–0.82) lower risk of deficits, respectively, compared to those with low subjective SES (p-for-trend<0.001). After adjusting for all covariates, the ORs in the fully adjusted model were 0.76 (95 % CI: 0.65–0.88) and 0.72 (95 % CI: 0.60–0.87). A similar trend was noted for education and occupation (p-for-trend<0.001). In the fully adjusted model, individuals with college and above education had a 46 % (OR: 0.54, 95 % CI: 0.38–0.75) lower risk of IC deficits compared to those with primary school and below, while participants in professional or managerial roles exhibited a 36 % (OR: 0.64, 95 % CI: 0.50–0.81) lower risk than those in unskilled occupations.

In the stratified analysis by age and gender, the association between SES and IC deficits persisted for most outcomes, except among older adults aged 70 and above, where the sample size was relatively small (**Supplementary Table 4**). This association was more pronounced in females, showing a larger effect size than in males (**Supplementary Table 5**). Sensitivity analyses yielded consistent findings when participants were reclassified based on the number of IC subdomains with deficits (**Supplementary Table 6**) and when subjective SES scores were treated as continuous variables (**Supplementary Table 7**).

Among the associations between SES and IC subdomains deficits, the strongest was with cognition deficits (Table 4), where education level had the greatest impact. Individuals with a college and above education had a significantly lower risk of cognition deficits (OR: 0.20, 95 % CI: 0.08–0.51) compared to those with primary school and below. Participants in professional or managerial occupations also showed a 56 %

Table 4
Ordinal logistic regression for socioeconomic status with deficits in intrinsic capacity subdomains (fully adjusted model).

	Cognition		Locomotion		Psychology		Vitality		Sensory	
	OR (95 % CI)	p-value	OR (95 % CI)	p-value	OR (95 % CI)	p-value	OR (95 % CI)	p-value	OR (95 % CI)	p-value
Education										
Primary school and below	1.0 (Ref)		1.0 (Ref)		1.0 (Ref)		1.0 (Ref)		1.0 (Ref)	
Secondary and high school	0.81 (0.66–1.00)	0.048	0.49 (0.37–0.64)	<0.001	1.13 (0.90–1.41)	0.289	0.88 (0.74–1.06)	0.181	0.45 (0.37–0.53)	<0.001
College and above	0.20 (0.08–0.51)	0.001	0.53 (0.23–1.21)	0.130	0.85 (0.48–1.51)	0.585	0.83 (0.54–1.30)	0.423	0.47 (0.32–0.70)	<0.001
p for trend	0.001		<0.001		0.619		0.164		<0.001	
Occupation										
Unskilled	1.0 (Ref)		1.0 (Ref)		1.0 (Ref)		1.0 (Ref)		1.0 (Ref)	
Skilled	0.89 (0.73–1.09)	0.272	0.89 (0.69–1.16)	0.389	1.00 (0.81–1.25)	0.971	0.81 (0.67–0.97)	0.019	0.89 (0.74–1.07)	0.212
Professional or managerial	0.44 (0.29–0.66)	<0.001	0.64 (0.39–1.04)	0.070	0.74 (0.50–1.10)	0.132	0.30 (0.60–1.07)	0.133	0.73 (0.55–0.96)	0.025
p for trend	0.001		0.087		0.286		0.034		0.028	
Subjective socioeconomic status										
Low	1.0 (Ref)		1.0 (Ref)		1.0 (Ref)		1.0 (Ref)		1.0 (Ref)	
Middle	0.75 (0.60–0.92)	0.007	0.59 (0.44–0.79)	<0.001	0.74 (0.59–0.94)	0.012	0.85 (0.70–1.02)	0.076	0.89 (0.74–1.06)	0.186
High	0.69 (0.53–0.89)	0.005	1.02 (0.75–1.40)	0.886	0.80 (0.61–1.05)	0.105	0.77 (0.62–0.97)	0.026	0.89 (0.72–1.11)	0.299
p for trend	0.001		0.407		0.035		0.015		0.215	

Notes: Adjusted by age, gender, marital status, lifestyle factors, health insurance, number of major chronic diseases. The subdomains of intrinsic capacity were analyzed as binary categorical variables (intact and deficit). Abbreviations: OR = odds ratio. CI = confidence interval.

lower risk (OR: 0.44, 95 % CI: 0.29–0.66) than those in unskilled jobs. Additionally, high and middle subjective SES were linked to reduced odds of cognition deficits (OR: 0.69, 95 % CI: 0.53–0.89; OR: 0.75, 95 % CI: 0.60–0.92, respectively) compared to low subjective SES.

The joint association of objective and subjective SES with IC deficits was reported in Fig. 1. Within each category of education or occupation, we observed a higher risk of IC deficits for individuals with low subjective SES compared with their counterparts. Participants with high education (college and above) or high occupation (professional or managerial) and middle subjective SES had a significantly lower risk of IC deficits, with reductions of 67 % (OR: 0.33, 0.18–0.60) and 49 % (OR: 0.51, 0.35–0.74), respectively, compared to those with low SES.

4. Discussion

This study assessed IC among community-dwelling adults aged 50 and older in China and found that 76.3 % had deficits in at least one IC subdomain. The sensory (63.5 %), vitality (25.8 %), and cognition (18.4 %) subdomains were most susceptible to deficits. Individuals with lower subjective and objective SES were more likely to experience IC deficits, especially in cognition subdomain. These findings underscore the need for early IC assessment and the importance of addressing social determinants to reduce health disparities.

Our study is one of a few studies that utilized ICOPE tools for an in-depth assessment of IC among middle-aged and older adults in China. In comparison to an existing review that encompassed 56 studies globally [4], our study reported a slightly higher detection rate of IC deficits. Specifically, the detection rate of sensory deficits was markedly higher than the global average. By employing ICOPE-recommended tools such as the 'hearWHO' application and the WHO simple eye chart for sensory assessments [5], rather than relying on self-reported data, we leveraged a methodological advantage that enabled us to detect subtle vision and hearing deficits with greater precision. Compared to the review where the average age of study participants was 74.2 years [4], our study focused on a relatively younger population and recruited individuals who were aged 50–60 years old. Notably, about 62.5 % individuals aged 50–60 years old reported IC deficits in our study, which highlights the needs of early assessment to capture the critical window for early intervention.

Consistent with previous studies [8,9,30], our study demonstrates that objective SES is associated with IC deficits. We observed that education and occupation have similar impacts on IC, with education emerging as a more powerful associated factor in most subdomains of IC, particularly in the cognition. Education, acquired early in life, fundamentally influences IC through its impact on occupation, household wealth, and social interactions [31,32]. Additionally, individuals with higher objective SES are more likely to prioritize healthy lifestyles and early disease diagnosis [33], potentially exacerbating the socioeconomic disparities in IC deficits. These findings underscore the importance of providing health management education and economic support to middle-aged and older adults, particularly those in lower socioeconomic positions.

An important yet previously unexplored issue is how subjective SES affects IC. Our findings reveal a significant negative correlation between subjective SES and IC deficits, which is independent from the impact of objective SES. In the joint analysis of subjective and objective SES on IC, we consistently found that higher subjective SES was associated with a lower risk of IC deficits, a pattern that remained stable across different educational and occupational backgrounds. This aligns with the longitudinal evidence demonstrating that subjective SES predicted a milder frailty trajectory, even after adjusting for demographics, objective SES, and health behaviors [16]. The consistency across studies indicated that an individual's subjective perception of SES often reflects their family resources and access to social support, potentially encompassing a broader range of SES than traditional objective SES [12,34]. Therefore, subjective SES warrants particular attention, and it is a dynamic assessment

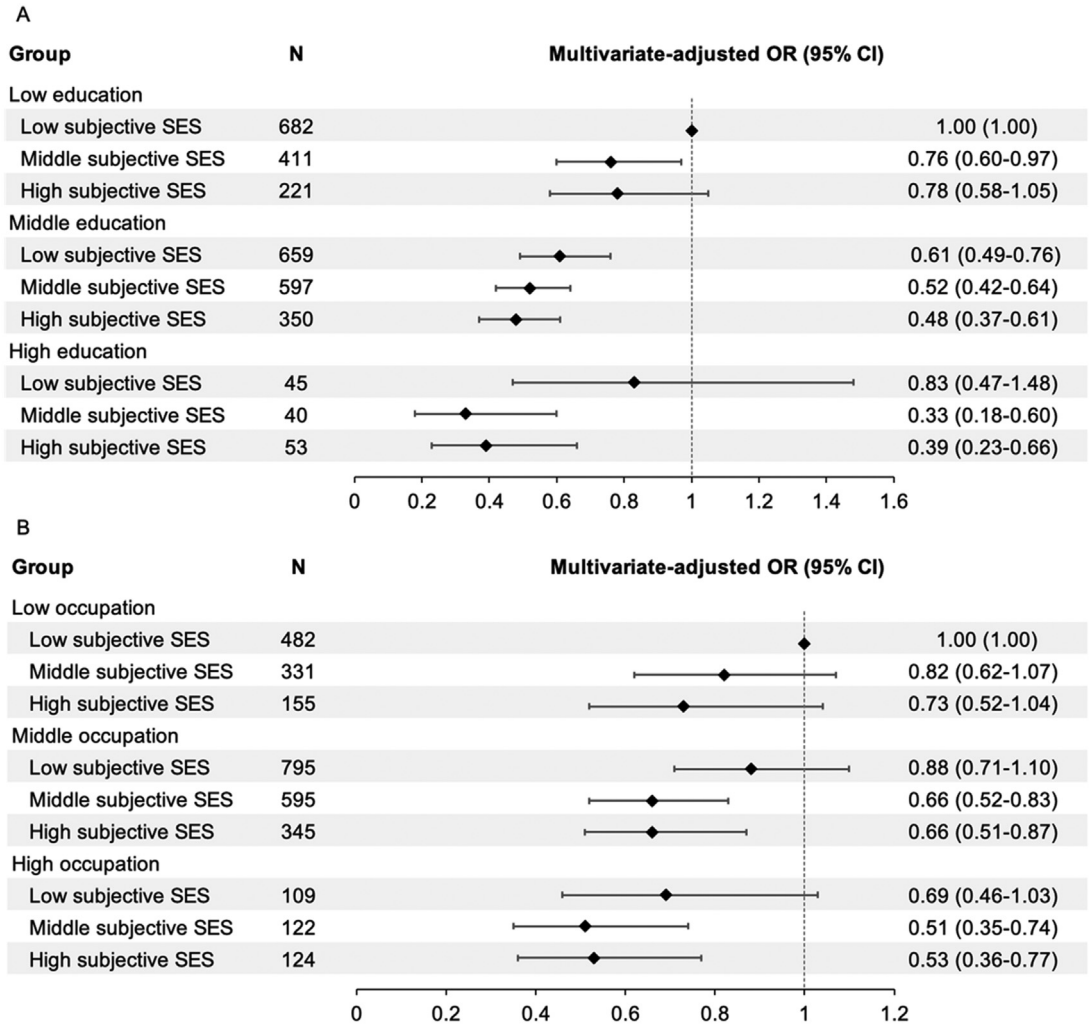

Fig. 1. Joint analysis for intrinsic capacity according to subjective and objective socioeconomic status.
Notes: (A): Joint analysis for intrinsic capacity according to subjective socioeconomic status and education. (B): Joint analysis for intrinsic capacity according to subjective socioeconomic status and occupation.
Each participant was categorized according to objective and subjective socioeconomic status, resulting in 9 distinct groups. Using this combined variable as exposure, its association with intrinsic capacity deficits was assessed, with reference group being participants in low objective socioeconomic status and low subjective socioeconomic status. Results were from ordinal logistic regression model and adjusted for age, gender, marital status, lifestyle factors (smoking, alcohol use, physical activity, and diet), health insurance, disease number. Abbreviations: OR = odds ratio. CI = confidence interval.

indicator that is more likely to change in older adults due to factors such as retirement and gradual withdrawal from the labor market [35].

Our study also prompts several implications regarding the implementation of IC assessment and interventions. Firstly, our study is one of the a few studies that assessed IC among middle-aged adults. The high detection rate of IC deficits among this group highlights the importance of early screening and monitoring, especially in the sensory, vitality, and cognitive subdomains. These proactive measures are essential for developing personalized care strategies. In addition, the association of SES and IC deficits observed in our study implied the crucial needs of accounting for various social determinants when developing intervention strategies for IC. Prioritizing individuals with limited social resources, increasing screening and care services for socially vulnerable groups, ensuring equitable distribution of resources, and adopting a life course approach that emphasizes early health education to address the low SES on health can help mitigate the adverse effects of socioeconomic disparities on health, thereby promoting healthy ageing [36].

Our study has several strengths. Our study represents an innovative effort to explore the relationship between subjective SES and IC. Secondly, Utilizing the ICOPE guidelines, we employed validated scales along with digital self-assessment applications to evaluate IC. This methodological advantage holds significant potential for future study [37]. Thirdly, our focus on individuals aged 50 and above provides valuable insights for the early assessment and intervention of IC.

Our study also bears several limitations and the interpretation of the study findings should be cautious. Firstly, due to the unavailable of data, some major objective SES factors, such as living environment, household wealth, were not considered. However, existing studies suggest that education and occupation are robust indicators of objective SES [38,39]. Secondly, the cross-sectional nature of this study prevents us from determining the longitudinal effects of SES on IC. Future studies should further explore the causal relationship between SES and IC. Thirdly, due to the feasibility of study, we conducted purposive sampling and recruit voluntary participants based on age and gender distribution, which may introduce selection bias, potentially excluding individuals with poorer health. This limitation could lead to an underestimation of IC deficits detection rates. Despite this, our study still reported relatively high detection rates, underscoring the importance of healthcare providers focusing

on IC. Additionally, as our study was conducted with participants from specific communities in China, further studies are needed to determine the generalizability of our findings to other populations.

5. Conclusion

IC deficits are highly prevalent among middle-aged and older adults in China, with a strong correlation between both objective and subjective SES and IC deficits, particularly in the cognition subdomain. Policymakers and healthcare professionals should prioritize early assessment and ongoing monitoring of IC while tackling underlying social inequalities to mitigate health disparities and foster healthy ageing.

Declaration

Ethics approval and consent to participate

This study was received approval from the Ethics Committee of Chinese Academy of Medical Sciences & Peking Union Medical College (CAMS&PUMC-IEC-2022–076).

All participants were provided with detailed information regarding the study's purpose, procedures, potential risks, and benefits in advance, and they signed a written informed consent form.

Consent for publication

Not applicable.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declaration of competing interest

The authors have no conflicts of interest to declare.

CRediT authorship contribution statement

Fangqin Tan: Writing – original draft, Visualization, Methodology, Formal analysis, Data curation. **Xiaoxia Wei:** Validation, Investigation, Data curation. **Ji Zhang:** Writing – review & editing, Methodology. **Yihao Zhao:** Writing – review & editing, Methodology. **Yue Zhang:** Writing – review & editing, Investigation. **Haiying Gong:** Writing – review & editing, Investigation. **Jean-Pierre Michel:** Writing – review & editing, Methodology. **Enying Gong:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization. **Ruitai Shao:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.tjfa.2025.100036.

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