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Original Investigation | Geriatrics

Intrinsic Capacity Across 15 Countries in the Survey of Health, Aging, and Retirement in Europe

Meimei Chen, MRes; Katja Hanewald, PhD; Yafei Si, PhD; Yuanyuan Gu, PhD; John R. Beard, MBBS, PhD

Abstract

IMPORTANCE Intrinsic capacity (IC) is a core component of the World Health Organization's healthy aging framework. Yet, despite multiple validations of IC across various settings, there is still a lack of longitudinal cross-national analysis.

OBJECTIVE To validate the IC construct, describe variance between key demographic groups, and create population centile curves across 15 countries using data from the Survey of Health, Aging, and Retirement in Europe (SHARE).

DESIGN, SETTING, AND PARTICIPANTS In this population-based multicenter cohort study, data from SHARE wave 5 (January to November 30, 2013) were analyzed, and subsequent care dependence in wave 6 (January to November 30, 2015) was determined. Adults 50 years and older from SHARE wave 5 with at least 1 available measure and follow-up data in SHARE wave 6 were included. Data analyses were conducted between December 11, 2022, and June 7, 2024.

EXPOSURE SHARE waves 5 and 6.

MAIN OUTCOMES AND MEASURES Changes in activities of daily living (ADL) and instrumental activities of daily living (IADL). Methods included structural equation modeling, bifactor analysis, and path analysis. Construct validity was tested through multiple linear regression and validity of estimates through mediation analysis. Centile curves were established using the generalized additive models for location, scale, and shape.

RESULTS The sample included 64 872 eligible participants aged 50 to 104 years, with a mean (SD) age of 67.24 (10.01) years, of whom 35 976 (55.46%) were women. The bifactor confirmatory factor analysis model achieved good fit (comparative fit index, 0.986; Tucker-Lewis index, 0.981), suggesting an IC structure consisting of 1 general factor and 5 subdomains. Mediation analysis indicated that IC was associated with subsequent declining performance in ADL (standard coefficient [SD], −0.213 [0.002]; $P < .001$) and IADL (standard coefficient [SD], −0.209 [0.002]; $P < .001$) after adjusting for age, gender, educational attainment, socioeconomic status, and country. Socioeconomic status was associated with IC both within and between countries. Centile curves for IC by gender and country (5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles) were constructed.

CONCLUSIONS AND RELEVANCE Results of this cohort study of older adults suggest that IC was a valid and reliable measure that effectively captured individual-level aspects of functional ability. The centile curves developed during the study suggest that IC has the potential to serve as a benchmark for health status in older populations.

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Key Points

Question Is the intrinsic capacity (IC) concept of the World Health Organization a reliable and valid measure of older adults' health and functional status across multiple countries?

Findings This cohort study of 64 872 adults 50 years and older confirmed that IC exhibits construct validity and is associated with subsequent declines in activities of daily living and instrumental activities of daily living. The study highlighted gender differences in IC and individual- and country-level economic factors and provided centile curves.

Meaning These findings suggest that IC is a valid and reliable measure that effectively captures the individual-level attributes that contribute to the functional ability of older adults, offering a benchmark for monitoring population health.

+ Invited Commentary

+ Supplemental content

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Introduction

The world is experiencing a demographic shift, with an increasing percentage of older adults in almost every population. By 2050, approximately 25% of people in regions such as Europe, Australia and New Zealand, East Asia, and North America will be older than 65 years.[1] A better understanding of the health of this growing population segment is crucial. In the 2015 World Report on Aging and Health, the World Health Organization (WHO) proposed a framework for healthy aging focused on the development and preservation of older adults' functional ability.[2,3] It describes functional ability as being determined by an individual's intrinsic capacity (IC), the environments they inhabit, and the interactions between these elements. The report defined IC as "the composite of all the physical and mental capacities that an individual can draw on."[2]

Since the publication of the World Report, the concept of IC has gained substantial attention among clinicians and researchers as a useful measure for understanding an older adult's health status. The WHO Integrated Care for Older People program has used IC as the entry point for care pathways.[4]

A number of studies have proposed a structure for IC that includes a summary domain and 5 subdomains: psychological, sensory, cognitive, locomotor, and vitality.[4-8] This structure has utility in estimating a range of outcomes, including declines in activities of daily living (ADL) and instrumental activities of daily living (IADL),[6,7] mortality,[9-11] disease,[12] and care dependence,[10] even after adjustment for age, demographic characteristics, and multimorbidity. However, while 1 multicountry study used a predetermined structure to assess the prognostic power of IC in low-income and middle-income countries,[10] to our knowledge, no study has yet statistically validated the IC construct and its predictive validity using a cross-national dataset.

In the present study, we determine and validate the structure of IC using data from the Survey of Health, Aging, and Retirement in Europe (SHARE). Our analysis is based on participants from 15 countries in SHARE wave 5 (January 1 to November 30, 2013). We first examine the structure and validity of the IC construct and then conduct a cross-national comparison of IC and subdomain scores, stratified by age, gender, country, and socioeconomic status. Last, we derive populational centile curves for IC and its subdomains, stratified by gender and country.

These are, to our knowledge, the first international level centile curves for IC, although similar efforts have been made at the national level in France.[13] Centile curves have long been used in public health, such as for child growth charts, which monitor children's height, weight, body mass index, and other related biomarkers against age.[14-16] These centile curves enable clinicians to make decisions by comparing an individual's health trajectory against population norms rather than simply reacting after a condition becomes apparent. Our aim is to foster the development of normative curves of IC that might enable clinicians and researchers to consider trajectories of health in older adults in much the same way as pediatricians monitor development in early life.

Methods

Data

SHARE is a cross-national multidisciplinary dataset offering individual-level data on health, socioeconomic, and demographic variables for individuals 50 years and older in 29 countries. Since its 2004 inception, SHARE has released 9 data waves. We used wave 5 (2013) as our baseline, as it provides the most recent and comprehensive measures for constructing IC and its 5 subdomains,[6,7] and wave 6 (January 1 to November 30, 2015) as the follow-up. Both waves were approved by the Ethics Council of the Max Planck Society, and SHARE obtained oral consent from all participants.

We selected participants 50 years and older from SHARE wave 5 (2013) with complete age, country, and gender information, at least 1 indicator of IC, and full ADL and IADL data in both waves 5 and 6 (2015). Those with proxy-completed questionnaires, living in care homes, or with cognitive-affecting diseases were included in the baseline analysis. Spouses younger than 50 years were

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excluded. The final sample consisted of 64 872 participants from 15 countries (35 976 women and 28 896 men). A flowchart of the study inclusion criteria is available in eFigure 1 in Supplement 1.

The countries represented in the sample include Austria (n = 4196), Belgium (n = 5532), the Czech Republic (n = 5521), Denmark (n = 4055), Estonia (n = 5677), France (n = 4414), Germany (n = 5593), Israel (n = 2548), Italy (n = 4653), Luxembourg (n = 1585), the Netherlands (n = 4117), Slovenia (n = 2916), Spain (n = 6563), Sweden (n = 4507), and Switzerland (n = 2995). This study follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline for observational studies.

Measures

Intrinsic Capacity

Building on prior research,[6-8] we selected measures collected in SHARE that have the potential to provide information on IC based on 2 criteria. First, the measure should be associated with at least 1 aspect of capacity based on previous literature.[6-8] Second, the measure can differentiate between high and low levels of capacity as well as detect changes in capacity within and between individuals over time.

The measures in SHARE were collected by trained interviewers and were identical in each country. The trained interviewers assessed verbal fluency, math ability, immediate and delayed memory, chair-stand test, and grip strength. Computer-assisted personal interviews determined mental health status using the EURO-D measure,[17] and participants reported hearing and visual abilities, sleep quality, weight, weight loss, height, mobility, memory status, and concentration ability. Details are found in eAppendix 1 in Supplement 2.

Covariates

We extracted sociodemographic and health-related covariates from SHARE wave 5, which were identified as potential confounders in previous studies.[6,7] Our analysis included age, gender (1, men; 0, women), educational attainment (0, primary school or lower; 1, middle and high school; 2, bachelor's degree or higher), multimorbidity, and socioeconomic status.[18] Socioeconomic status was determined by the quartiles of annual per capita household income within the respective country of each individual (0, first quartile; 1, second quartile; 2, third quartile; 3, fourth quartile). Multimorbidity was self-reported for 20 physician-diagnosed chronic conditions (listed in eAppendix 1 in Supplement 1) and categorized as none, 1 to 2, or 3 or more chronic conditions. eTable 1 in Supplement 1 details covariate distribution by country.

Measures of Outcome

Declining performance in ADL and IADL, based on self-reported limitations, was chosen as the outcome of interest since it provides a comprehensive measure of severe disability and loss of independence that is of clinical relevance and different from the items selected to construct IC.[6,7] The 6 ADLs include dressing, walking across a room, bathing or showering, eating, getting in or out of bed, and using the toilet. The 7 IADLs include using a map, performing household chores or gardening, preparing a hot meal, shopping for groceries, making telephone calls, managing money, and taking medications.[17] Declining performance in ADL and IADL is analyzed separately and is defined as participants developing at least 1 limitation in these activities between wave 5 (baseline) and wave 6 (follow-up). More details are available in eAppendix 2 in Supplement 1.

Statistical Analysis

Validation

The methodology for assessing the validity of IC was conducted within the structural equation modeling (SEM) framework, similar to the approaches adopted by Beard and colleagues.[6,7] The techniques used include confirmatory factor analysis (CFA), exploratory SEM (ESEM) framework, bifactor CFA, bifactor ESEM, and path analysis.

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To evaluate the goodness-of-fit of these models, we used a range of statistical measures. These included the absolute fit index χ^2 test, the approximate fit index root means square error of approximation (RMSEA), and the incremental fit indices, including the comparative fit index (CFI) and the Tucker-Lewis index (TLI). The weighted least square mean and variance-adjusted estimator, with robust standard errors and adjusted mean and variance, was used to assess the ESEM, CFA, and bifactor models. We assumed the missing data mechanism to be missing at random and applied pairwise deletion to handle missing data.

The construct validity was tested using linear regression, and the predictive validity was evaluated using mediation analysis.[19] Data analyses were conducted between December 11, 2022, and June 7, 2024. More details on the methods are available in eAppendix 2 in Supplement 1.

Cross-Country Comparisons

We weighted and rescaled the standardized IC scores obtained from the CFA model for cross-country comparison. These scores were weighted using calibrated weights provided by SHARE to ensure the survey data were representative of the general population in the studied countries. After weighting, the scores were rescaled to a range of 0 to 100 to make them more intuitive for general readers. In this scale, 0 represents the lowest capacity among all participants, and 100 represents the highest capacity.

Centile Curves

To construct the centile curves, we adopted the generalized additive models for location, scale, and shape (GAMLSS) method,[20] which is used by the WHO to construct child growth charts.[21,22] GAMLSS was chosen because it models the mean (location), the variance (scale), and skewness or kurtosis (shape), allowing for a flexible fitting of the data.[23] We selected the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles to better capture the distribution of IC scores in older adults. The statistical analyses were performed with R, version 4.2.2 (R Program for Statistical Computing).

Results

Validation

Bifactor ESEM, CFA, and Model Fit

The sample included 64 872 eligible participants aged 50 to 104 years, with a mean (SD) age of 67.24 (10.01) years, of whom 35 976 (55.46%) were women and 28 896 (44.54%) were men. The model fit statistics are presented in eTable 2 in Supplement 1. The 5-factor ESEM models fit well (RMSEA, 0.031; 90% CI, 0.030-0.032; CFI, 0.996; TLI, 0.991), supporting IC as a multidimensional construct. The bifactor ESEM model showed better fit (RMSEA, 0.033; 90% CI, 0.032-0.034; CFI, 0.997; TLI, 0.990), suggesting a general factor (the IC) with 5 subfactors: cognitive, sensory, vitality, locomotor, and psychological. The bifactor CFA model also fit well (RMSEA, 0.044; 90% CI, 0.043-0.045; CFI, 0.986; TLI, 0.981). We observed that most factor loadings on IC were greater than 0.3, indicating that the items contribute meaningfully to the factor (**Figure 1**).

Construct Validity

The regression analysis indicated an association between lower IC scores and factors such as higher age (eg, >80 years coefficient, −0.899; 95% CI, −0.911 to −0.867; $P < .001$), being a woman (coefficient, −0.087; 95% CI, −0.099 to −0.074; $P < .001$), lower levels of educational attainment (eg, intermediate level coefficient, 0.268; 95% CI, 0.252-0.283; $P < .001$) and income (eg, second quartile coefficient, 0.138; 95% CI, 0.121-0.156; $P < .001$), and a higher number of chronic diseases (eg, ≥3 coefficient, −0.770; 95% CI, −0.789 to −0.751; $P < .001$) (eTable 2 in Supplement 1). These findings were statistically significant after accounting for country, suggesting that each of these covariates contributed independently to the variations in IC. Considering that existing literature has

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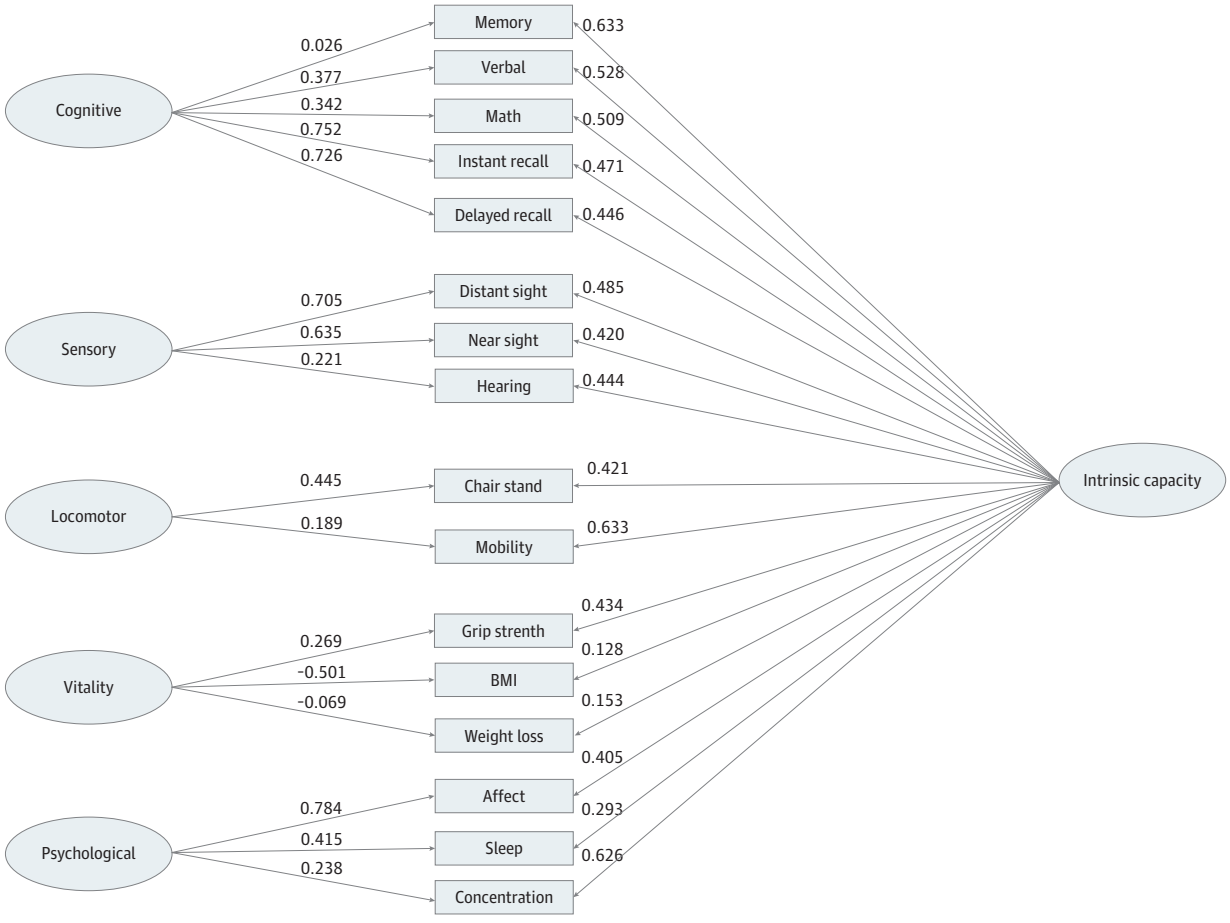
established the association of these covariates with the health status of older adults, the present findings support the construct validity of IC.

The association between subdomains and covariates (eTable 2 in Supplement 1) showed that women had lower subdomain scores, except in cognitive capacity, where they scored higher (coefficient, 0.210; 95% CI, 0.192-0.228; $P < .001$). Increasing age was associated with lower scores in all subdomains, except for the psychological domain, which was higher in the group aged 60 to 69 years (coefficient, 0.071; 95% CI, 0.045-0.096; $P < .001$) than in the reference group aged 50 to 59 years. Higher educational and income levels were associated with higher subdomain scores, although the psychological score increase from the second-highest to highest income quartiles was small (coefficient, 0.214 [95% CI, 0.186-0.242] and 0.219 [95% CI, 0.189-0.248]). IC and subdomain scores significantly declined with more chronic diseases (coefficient, −0.770; 95% CI, −0.789 to −0.751; $P < .001$).

Pathway to Care Dependence

To identify participants with declining performance, we selected those without ADL or IADL limitations in wave 5 (2013) who developed at least 1 limitation by wave 6 (2015). Among 64 872 participants, 41 641 had no ADL limitations and complete ADL scores across waves, while 39 171 had no IADL limitations in wave 5 and complete IADL scores in wave 6. These subsets were included in the analysis. We also compared the characteristics of those lost to follow-up with those included in

Figure 1. Factor Loadings of the Bifactor Confirmatory Factor Analysis Model



The bifactor confirmatory factor analysis model shows the association between intrinsic capacity and its subdomains: cognitive, sensory, locomotor, vitality, and psychological. Each domain is represented by specific measurable attributes (eg, memory, hearing, mobility), with factor loadings describing their association with intrinsic capacity. Definitions for cognitive, sensory, locomotor, vitality, and psychological domains are given in eAppendix 1 in Supplement 1. BMI indicates body mass index.

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the final analysis for both ADL and IADL (eTable 3 in Supplement 1). Although characteristics between groups were similar, participants lost to follow-up had lower levels of educational attainment.

We first conducted a simple mediation analysis to examine the direct effect estimates of IC on ADL and IADL decline and the indirect effect estimates mediated by multimorbidity, controlling for personal characteristics (age, gender, educational attainment, income, and country). IC strongly predicted ADL and IADL decline, with dominant direct effects (standardized coefficients: −0.148 [95% CI, −0.157 to −0.140; $P < .001$] and −0.231 [95% CI, −0.246 to −0.220; $P < .001$], respectively) and minimal indirect effects via multimorbidity, accounting for only 4.5% of ADL variance (standardized coefficient, −0.007; 95% CI, −0.009 to 0.000; $P < .001$) and 2.9% of IADL variance (standardized coefficient, −0.007; 95% CI, −0.010 to 0.000; $P < .001$) (eTable 4 in Supplement 1).

Next, we applied a multilevel serial multiple mediation model to examine how wave 5 personal characteristics were associated with ADL and IADL decline in wave 6, controlling for country effects (eFigures 2 and 3 in Supplement 1). Declines in ADL and IADL were associated with both multimorbidity (standardized coefficient for ADL, 0.039 [SE, 0.002]; standardized coefficient for IADL, 0.041 [SE, 0.002]) and IC (standardized coefficient for ADL, −0.213 [SE, 0.002]; standardized coefficient for IADL, −0.209 [SE, 0.002]). IC also showed associations with age (standardized coefficient for ADL, 0.056 [SE, 0.000]; standardized coefficient for IADL, 0.050 [SE, 0.000]), gender (standardized coefficient for ADL, 0.016 [SE, 0.001]; standardized coefficient for IADL, 0.011 [SE, 0.001]), educational attainment (standardized coefficient for ADL, −0.049 [SE, 0.001]; standardized coefficient for IADL, −0.047 [SE, 0.001]), and income (standardized coefficient for ADL, −0.016 [SE, 0.000]; standardized coefficient for IADL, −0.015 [SE, 0.000]).

The pathways between personal characteristics and ADL and IADL, controlling for country effects and mediated by IC and multimorbidity, are detailed in eTable 5 in Supplement 1. Increased age and being a woman were associated with more chronic diseases, lower IC scores, and greater ADL and IADL decline. Conversely, higher educational attainment and income were associated with higher IC scores, fewer chronic diseases, and better ADL and IADL maintenance. The analysis also indicated that IC predominantly mediated effect estimates of gender, income, and educational attainment with on ADL and income and educational attainment on IADL.

Analysis of IC Values

Mean IC Scores Across 15 Countries

The analysis of this validated model, adjusted using the SHARE calibrated survey weights for national representativeness, is presented in **Figure 2**. A line plot displays mean IC and subdomain scores by gender across ages, with 95% CIs. On average, men scored higher on IC, with the largest gender differences in the psychological subdomain (mean [SD], 63.12 [19.63] vs 57.35 [19.90]) and locomotor subdomain (mean [SD], 65.30 [19.12] vs 58.52 [22.59]). Men also had a slight advantage in the vitality domain (mean [SD], 59.82 [18.53] vs 57.63 [20.62]) and the sensory domain (mean [SD], 58.22 [18.34] vs 56.75 [18.73]). In contrast, women younger than 70 years scored higher in the cognitive subdomain (mean [SD], 62.93 [16.92] vs 60.43 [16.44]), but scores converged between genders after this age (mean value [SD], 47.24 [18.50] for women vs 47.41 [17.32] for men).

Cross-Country Variations

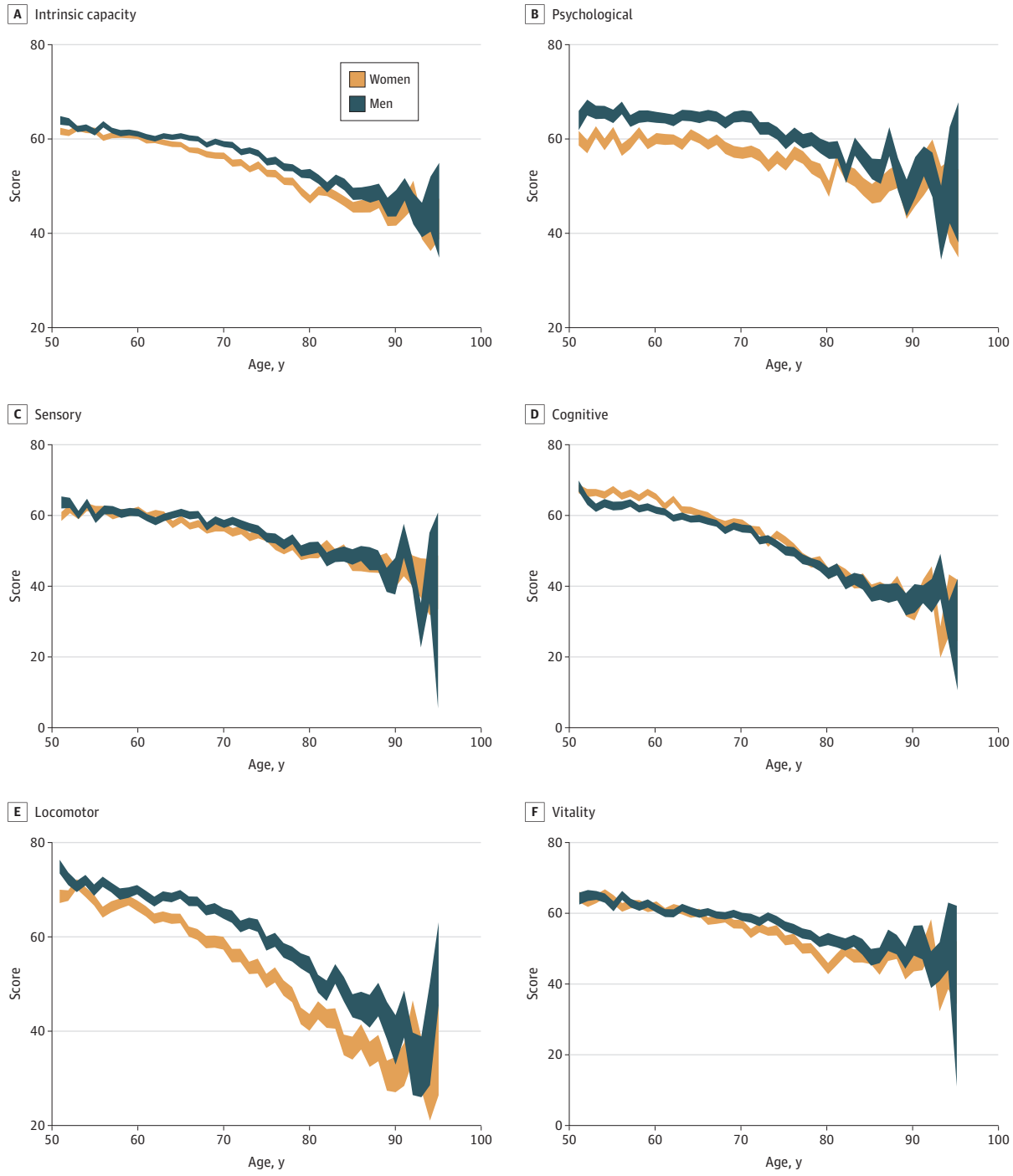
The mean values and SDs for IC and its subdomains, categorized by gender and country, are shown in eTable 6 in Supplement 1. Men generally had higher IC scores than women across all countries, though the gender gap varied. It was narrower in countries such as Sweden (eg, IC value [SD], 60.56 [10.78] for women vs 62.09 [9.90] for men) and Denmark (eg, IC value [SD], 63.45 [11.00] for women vs 65.05 [9.73] for men) but more pronounced in Spain (eg, IC value [SD], 53.54 [11.77] for women vs 56.15 [10.70] for men) and Italy (eg, IC value [SD], 52.79 [11.81] for women vs 56.37 [10.54] for men).

Figure 3 illustrates IC and subdomain scores by age across countries for women, and eFigure 7 in Supplement 1 illustrates IC and subdomain scores by age across countries for men. Countries are

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ordered by 2013 gross domestic product (GDP) per capita presenting higher and lower GDP per capita[24] as well as overall mean. Higher GDP per capita was generally associated with higher IC and subdomain scores (eg, Switzerland, mean [SD], 62.84 [9.84]; Denmark, 64.22 [10.44]; Slovenia, 57.47 [11.00]; and Estonia, 55.85 [10.87]).

Figure 2. Gender Differences in Intrinsic Capacity and Cognitive, Sensory, Locomotor, Vitality, and Psychological Subdomains



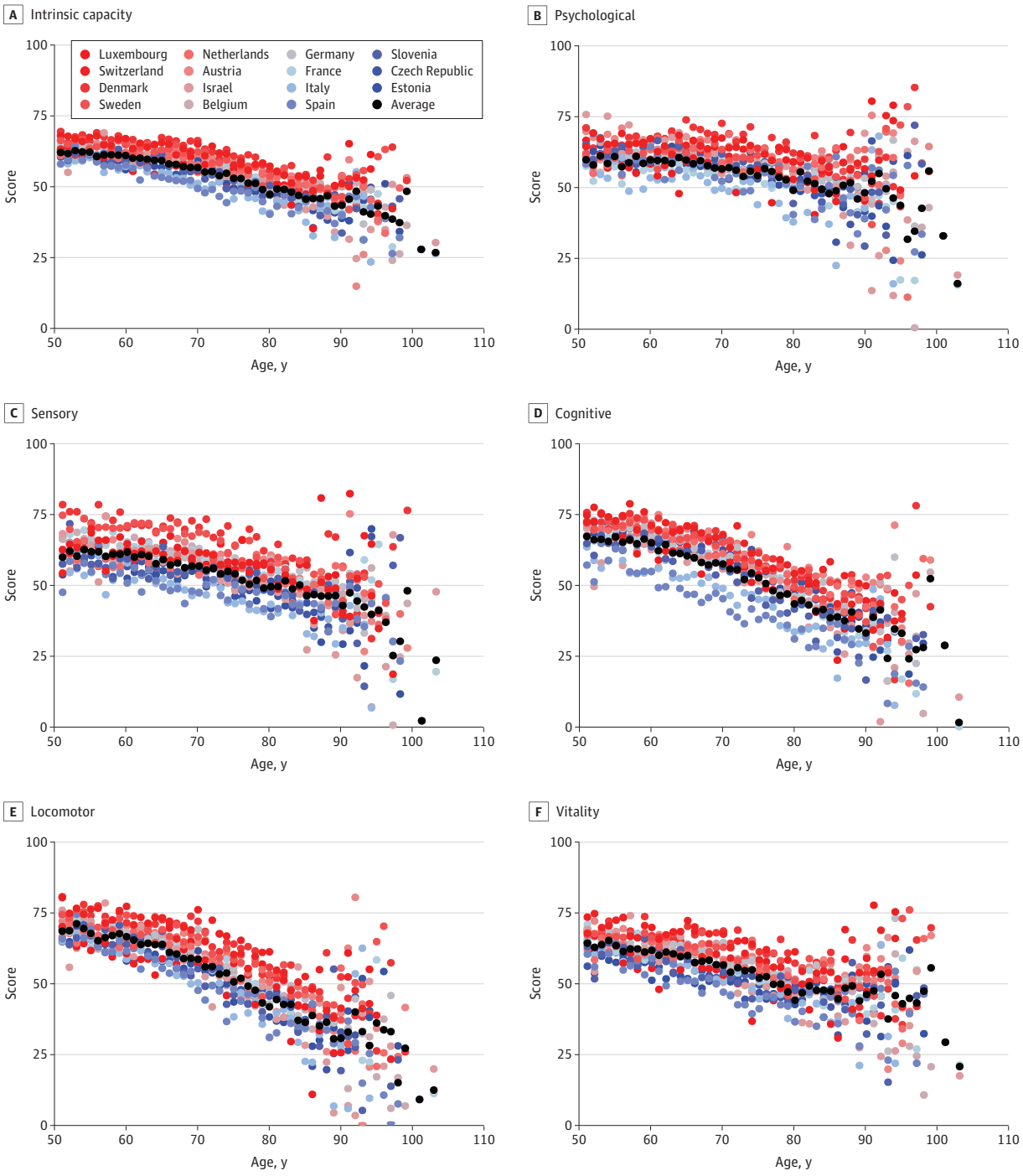
At each age, the mean value of the intrinsic capacity is assumed to follow a normal distribution when the number of participants is greater than 30, and a *t* distribution when the number of participants is 30 or fewer. Because of insufficient sample size, participants older than 95 years were omitted.

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IC and Socioeconomic Status

To examine relative socioeconomic status within each country, we divided individuals into 4 groups based on family per capita income using a quartile-based approach. **Figure 4** presents a scatterplot of

Figure 3. Intrinsic Capacity and Subdomain Scores Across Different Countries for Women



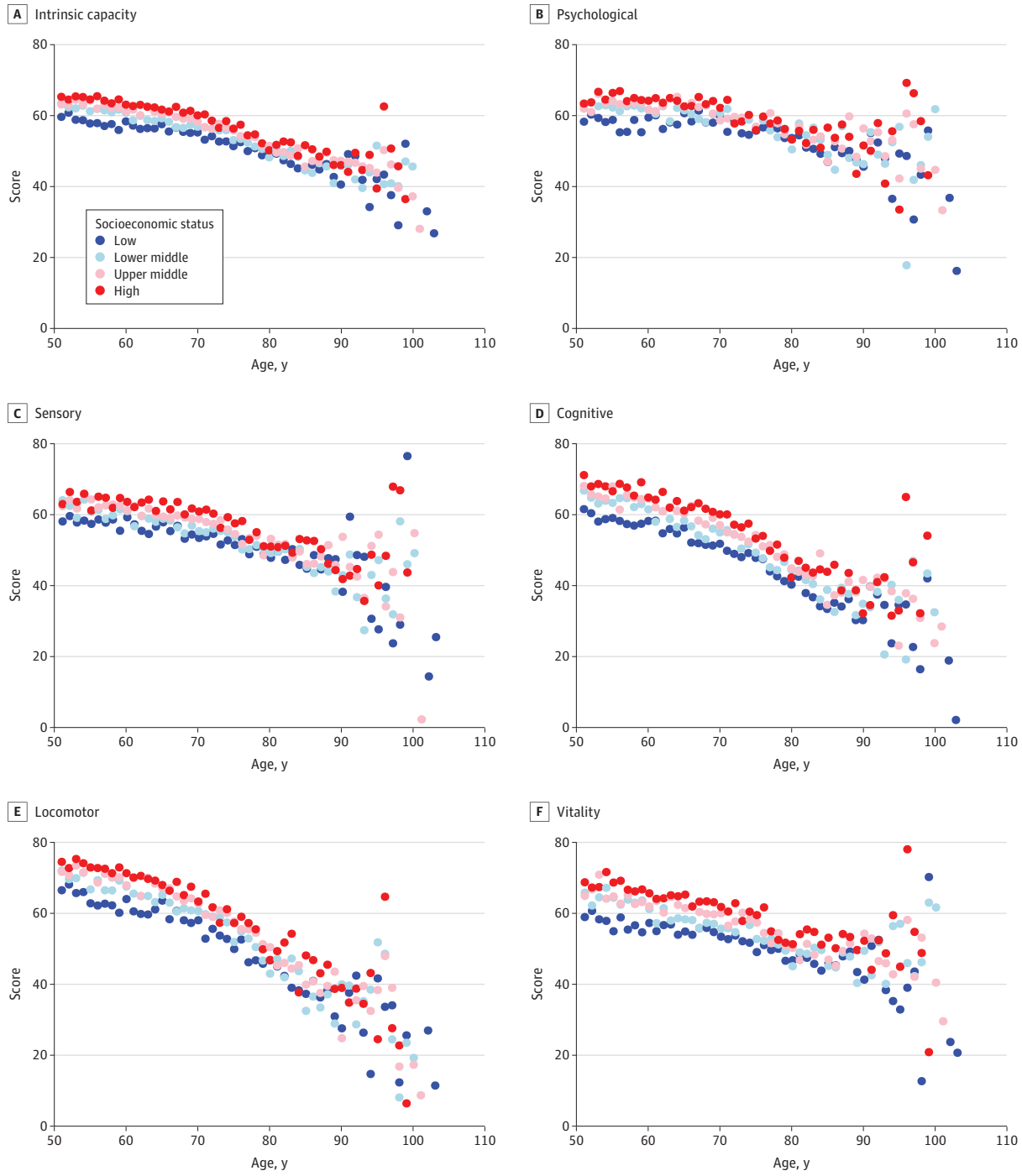
Each point represents the mean score for IC or its subdomains for participants of a certain age across different countries. Black points indicate the overall mean values across all the countries. Countries are ordered by 2013 gross domestic product (GDP) per capita: those with a higher GDP per capita are depicted in red, while those with a lower GDP per capita are depicted in blue. GDP per capita data for the studied countries were retrieved from World Bank Group.[24]

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mean IC and subdomain scores by age and socioeconomic status, showing that higher status was associated with higher scores across all subdomains.

When analyzed by gender, women aged 50 to 70 years with higher socioeconomic status had higher IC and subdomain scores, but this advantage was not found after 70 years of age (eFigure 4 in Supplement 1). Men showed a similar pattern, though those in the highest socioeconomic group maintained their advantage until 80 years of age. Across all ages, individuals in the lowest

Figure 4. Intrinsic Capacity and Cognitive, Sensory, Locomotor, Vitality, and Psychological Subdomain Scores for Different Socioeconomic Status Groups



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socioeconomic group consistently had the lowest IC and subdomain scores. Mean scores by age and socioeconomic status for both genders are detailed in eTable 7 in Supplement 1.

Centile Curves

Next, we generated population-level centile curves for IC. **Figure 5** displays the smoothed centile curves for IC, while subdomain-specific curves are shown in eFigure 5 in Supplement 1. The results indicate a general decline in IC and its subdomains with age, accelerating after 70 years of age. However, unlike other subdomains, psychological scores increased between 60 and 70 years of age for both genders. Given the substantial cross-country variation in IC, we also constructed country-specific centile curves, which showed broadly similar age-related patterns but varying absolute levels across countries (eFigure 6 in Supplement 1).

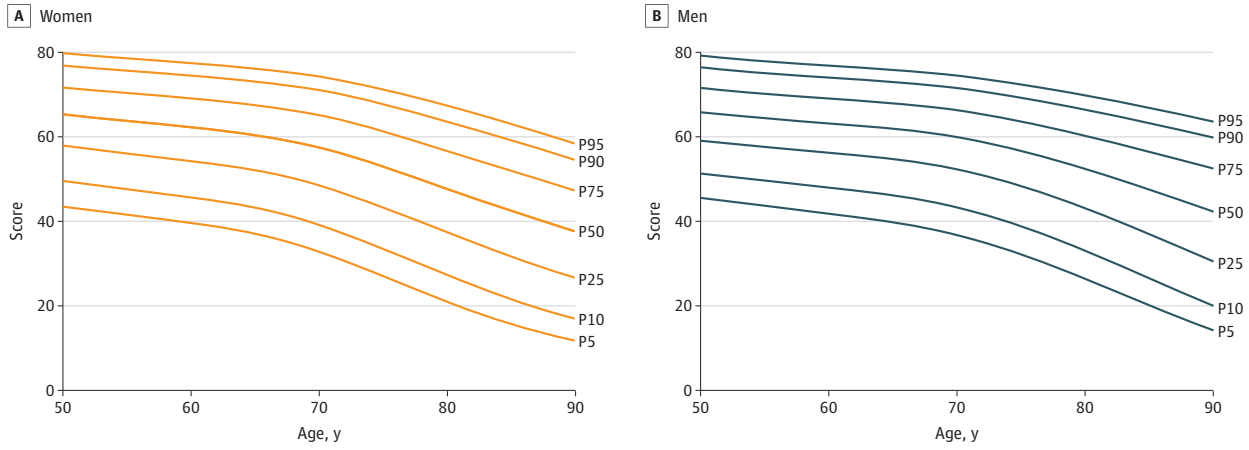
Discussion

In these representative cohorts of individuals 50 years and older from a diverse set of 15 countries in SHARE, we identified a structure for IC consisting of a general factor and 5 subdomains, which aligns with both theoretical frameworks and prior research in other settings.[6-8] The structure of 1 general factor and 5 subdomains showed good construct and predictive validity, and the robustness of this approach is reinforced by the cross-country nature of our analysis.

Our longitudinal analysis confirmed the IC power to estimate declines in ADL and IADL, even after adjusting for demographic variables (age, gender, educational attainment, income, and country) and multimorbidity. This suggests that IC provides unique insights into an individual's health and functional status beyond traditional measures such as chronological age or the presence of diseases. While more work in clinical settings is needed, tracking IC trajectories in older adults, or even from an earlier age, might help to identify those at risk of future functional decline.

Our findings reveal significant gender differences in IC and its subdomains (Figure 2). Men generally had higher IC scores than women across all age groups, with the gap widening as age increased. Within subdomains, men had higher vitality, psychological, and locomotor capacities than women. In contrast, women had higher scores on the cognitive domain than men until 70 years of age, after which the 2 genders showed similar levels (Figure 2). Patterns of sensory capacity were less clear. These findings are all generally consistent with previous research on individual outcomes[25-29]; however, our analysis allows each outcome to be understood in a broader functional context.

Figure 5. Intrinsic Capacity Across 15 Countries



Smoothed centile curves for intrinsic capacity P5 indicates 5th percentile; P10, 10th; P25, 25th; P50, 50th; P75, 75th; P90, 90th; and P95, 95th.

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Stratification by country shows regional variations in these gender differences, with Southern European countries such as Spain and Italy displaying more pronounced differences than other regions (eTable 6 in Supplement 1). This finding aligns with those of previous studies on cognitive function across European countries.[28] Individuals from countries with higher GDP per capita generally had higher IC scores across both genders, while, at an individual level, participants from the lowest socioeconomic status group had the lowest scores in all domains. This pattern is also consistent with previous research and highlights the importance of socioeconomic context in shaping the health of older adults.[30,31]

The centile curves for IC and its subdomains show a natural progression of IC across different ages, with a clear pattern of declining functioning with age. A similar pattern was observed in a French study conducted with participants aged between 20 and 102 years.[13] However, we found that older adults experience accelerated declines in IC after the early 70s in women or the mid-70s in men. This contrasts with the French study, where the centile curves demonstrated a more gradual decline across all age groups.[13] A key factor in this difference may be the observed increase in psychological subdomain scores after traditional retirement ages in our cohort.

Centile curves of IC and its subdomains have multiple potential uses. These include routine clinical assessment, where they might be used to identify individuals whose trajectories are veering away from the population norm and who may require further assessment. This is similar to the approach already taken by pediatricians to monitor child development. At a population level, the centile curves can also help compare and benchmark IC and subdomain levels against those of different settings.

Strengths and Limitations

One strength of our study lies in the use of the SHARE dataset, which is large, representative, and longitudinal. The cross-national nature of SHARE allows consideration of the broader contextual factors that might affect our findings. However, since SHARE is not specifically designed to measure older adults' IC and its subdomains, our study was limited to the measures available in the dataset. Consequently, we could not account for all possible factors that might be considered components of an individual's IC. This limitation is also common in other studies, leading to inconsistencies in how IC and its subdomains have been measured. Furthermore, some items used to construct IC are self-reported, which may introduce bias into the results. Additionally, individuals who agree to participate in longitudinal studies such as SHARE may be healthier than the general population. Moreover, differences in characteristics between those included in the final mediation analysis and those lost to follow-up may introduce attrition bias, as we found that participants with lower educational levels were more likely to drop out (eTable 3 in Supplement 1). SHARE targets adults 50 years and older, so our findings may not be generalizable to younger populations, notably premenopausal women. The accelerated decline of cognitive capacity in women, but not men, after 60 years of age suggests that the impact of menopause on women's IC scores and trajectories could be an important avenue for future research. Our data selection was also constrained by the availability of measures across different SHARE waves. We selected wave 5 as it is the most recent wave that provides all the necessary measurements to construct all 5 subdomains of IC.

Last, our findings may not be generalizable to end-of-life situations or to individuals experiencing sudden functional decline due to catastrophic events such as accidents, trauma, or rapidly progressing diseases such as aggressive cancers. Additionally, IC scores may be affected by secular trends, varying across both countries and decades due to factors such as advancements in health care, economic fluctuations, and global events such as pandemics. Cultural factors may also contribute to variations in IC scores, particularly for self-reported measures such as sleep quality, which can be shaped by societal structures and individual perceptions. Future research could explore secular trends and cultural differences using longitudinal data from early and recent waves of SHARE to better understand how IC scores evolve over time.

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Conclusions

To our knowledge, this cohort study is one of the largest and most comprehensive efforts to validate and operationalize the concept of IC. Our results have the potential to guide future research in exploring the heterogeneity of IC and its subdomains among different populations, as well as to provide tools for practical applications.

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REFERENCES

1. United Nations Population Division. *World Population Prospects 2022: Summary of Results*. United Nations; 2022. Accessed December 12, 2023. https://www.un.org/development/desa/pd/content/World-Population-Prospects-2022

2. World Health Organization. World report on ageing and health. 2015. Accessed December 16, 2023. https://iris.who.int/handle/10665/186463 (accessed Dec 16, 2023).

3. Beard JR, Officer A, de Carvalho IA, et al. The world report on ageing and health: a policy framework for healthy ageing. *Lancet*. 2016;387(10033):2145-2154. doi:10.1016/S0140-6736(15)00516-4

4. World Health Organization. Integrated care for older people (ICOPE): guidance for person-centred assessment and pathways in primary care. 2019. Accessed March 24, 2025. https://apps.who.int/iris/handle/10665/326843

5. Cesari M, Araujo de Carvalho I, Amuthavalli Thiyagarajan J, et al. Evidence for the domains supporting the construct of intrinsic capacity. *J Gerontol A Biol Sci Med Sci*. 2018;73(12):1653-1660. doi:10.1093/gerona/gly011

6. Beard JR, Jotheeswaran AT, Cesari M, Araujo de Carvalho I. The structure and predictive value of intrinsic capacity in a longitudinal study of ageing. *BMJ Open*. 2019;9(11):e026119. doi:10.1136/bmjopen-2018-026119

7. Beard JR, Si Y, Liu Z, Chenoweth L, Hanewald K. Intrinsic capacity: validation of a new who concept for healthy aging in a longitudinal Chinese study. *J Gerontol A Biol Sci Med Sci*. 2022;77(1):94-100. doi:10.1093/gerona/glab226

8. Beard JR, Hanewald K, Si Y, Amuthavalli Thiyagarajan J, Moreno-Agostino D. Cohort trends in intrinsic capacity in England and China. *Nat Aging*. 2025;5(1):87-98. doi:10.1038/s43587-024-00741-w

9. Stolz E, Mayerl H, Freidl W, Roller-Wirnsberger R, Gill TM. Intrinsic capacity predicts negative health outcomes in older adults. *J Gerontol A Biol Sci Med Sci*. 2022;77(1):101-105. doi:10.1093/gerona/glab279

10. Prince MJ, Acosta D, Guerra M, et al. Intrinsic capacity and its associations with incident dependence and mortality in 10/66 Dementia Research Group studies in Latin America, India, and China: a population-based cohort study. *PLoS Med*. 2021;18(9):e1003097. doi:10.1371/journal.pmed.1003097

11. Locquet M, Sanchez-Rodriguez D, Bruyère O, et al. Intrinsic capacity defined using four domains and mortality risk: a 5-year follow-up of the SarcoPhAge cohort. *J Nutr Health Aging*. 2022;26(1):23-29. doi:10.1007/s12603-021-1702-7

12. Ramírez-Vélez R, Iriarte-Fernández M, Santafé G, et al. Association of intrinsic capacity with incidence and mortality of cardiovascular disease: prospective study in UK Biobank. *J Cachexia Sarcopenia Muscle*. 2023;14(5):2054-2063. doi:10.1002/jcsm.13283

13. Lu WH, Rolland Y, Guyonnet S, de Souto Barreto P, Vellas B. Reference centiles for intrinsic capacity throughout adulthood and their association with clinical outcomes: a cross-sectional analysis from the INSPIRE-T cohort. *Nat Aging*. 2023;3(12):1521-1528. doi:10.1038/s43587-023-00522-x

14. Cole TJ, Freeman JV, Preece MA. Body mass index reference curves for the UK, 1990. *Arch Dis Child*. 1995;73(1):25-29. doi:10.1136/adc.73.1.25

15. Kuczmarski RJ, Ogden CL, Guo SS, et al. 2000 CDC growth charts for the United States: methods and development. National Center for Health Statistics. Vital Health Stat. 2000. Accessed October 23, 2023. https://www.cdc.gov/nchs/data/series/sr_11/sr11_246.pdf

16. De Onis M; WHO Multicentre Growth Reference Study Group. WHO Child Growth Standards based on length/height, weight and age. *Acta Paediatr Suppl*. 2006;450:76-85.

17. Börsch-Supan A, Brandt M, Hunkler C, et al; SHARE Central Coordination Team. Data resource profile: the Survey of Health, Ageing and Retirement in Europe (SHARE). *Int J Epidemiol*. 2013;42(4):992-1001. doi:10.1093/ije/dyt088

18. Connolly D, Garvey J, McKee G. Factors associated with ADL/IADL disability in community dwelling older adults in the Irish Longitudinal Study on Ageing (TILDA). *Disabil Rehabil*. 2017;39(8):809-816. doi:10.3109/09638288.2016.1161848

19. Preacher KJ, Zyphur MJ, Zhang Z. A general multilevel SEM framework for assessing multilevel mediation. *Psychol Methods*. 2010;15(3):209-233. doi:10.1037/a0020141

20. Rigby RA, Stasinopoulos DM. Generalized additive models for location, scale and shape. *J R Stat Soc Ser C Appl Stat*. 2005;54:507-554. doi:10.1111/j.1467-9876.2005.00510.x

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21. de Onis M, Garza C, Victora CG, Onyango AW, Frongillo EA, Martines J. The WHO Multicentre Growth Reference Study: planning, study design, and methodology. *Food Nutr Bull*. 2004;25(1)(suppl):S15-S26. doi:10.1177/15648265040251S104

22. Borghi E, de Onis M, Garza C, et al; WHO Multicentre Growth Reference Study Group. Construction of the World Health Organization child growth standards: selection of methods for attained growth curves. *Stat Med*. 2006;25(2):247-265. doi:10.1002/sim.2227

23. Stasinopoulos MD, Rigby RA, Heller GZ, Voudouris V, Bastiani FD. *Flexible Regression and Smoothing: Using GAMLSS in R*. CRC Press; 2017. doi:10.1201/b21973

24. World Bank Group. GDP per capita (current US$). Accessed July 18, 2023. https://data.worldbank.org/indicator/NY.GDP.PCAP.CD

25. Boyd A, Van de Velde S, Vilagut G, et al; EU-WMH Investigators. Gender differences in mental disorders and suicidality in Europe: results from a large cross-sectional population-based study. *J Affect Disord*. 2015;173:245-254. doi:10.1016/j.jad.2014.11.002

26. Leopold L, Engelhardt H. Education and physical health trajectories in old age: evidence from the Survey of Health, Ageing and Retirement in Europe (SHARE). *Int J Public Health*. 2013;58(1):23-31. doi:10.1007/s00038-013-0453-6

27. Bonsang E, Skirbekk V, Staudinger UM. As you sow, so shall you reap: gender-role attitudes and late-life cognition. *Psychol Sci*. 2017;28(9):1201-1213. doi:10.1177/0956797617708634

28. Ahrenfeldt LJ, Scheel-Hincke LL, Kjærgaard S, Möller S, Christensen K, Lindahl-Jacobsen R. Gender differences in cognitive function and grip strength: a cross-national comparison of four European regions. *Eur J Public Health*. 2019;29(4):667-674. doi:10.1093/eurpub/cky266

29. Hansen RS, Scheel-Hincke LL, Jeune B, Ahrenfeldt LJ. Sex differences in vision and hearing impairments across age and European regions: findings from SHARE. *Wien Klin Wochenschr*. 2024;136(1-2):55-63. doi:10.1007/s00508-023-02223-2

30. Crimmins EM, Kim JK, Seeman TE. Poverty and biological risk: the earlier "aging" of the poor. *J Gerontol A Biol Sci Med Sci*. 2009;64(2):286-292. doi:10.1093/gerona/gln010

31. Kumar K, Shukla A, Singh A, Ram F, Kowal P. Association between wealth and health among older adults in rural China and India. *J Econ Ageing*. 2016;7:43-52. doi:10.1016/j.jeoa.2016.02.002

SUPPLEMENT 1.

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SUPPLEMENT 2.

Data Sharing Statement

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