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DISCUSSION PAPER

**COGNITION AND AGEING IN THE SURVEY OF
HEALTH, AGEING AND RETIREMENT IN EUROPE
HARMONISED COGNITIVE ASSESSMENT PROTOCOL
(SHARE-HCAP)**

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**Cohort Profile Update: Cognition and Aging in The Survey of Health, Ageing and Retirement in
Europe Harmonised Cognitive Assessment Protocol (SHARE-HCAP)**

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Key Features

- The Survey of Health, Aging and Retirement in Europe (SHARE) is a cross-national longitudinal survey of people aged 50 years and over that is modelled closely after its sister studies HRS in the USA and ELSA in the UK. It follows respondents every two years since 2004.
- SHARE-HCAP is a supplemental dataset that provides a large battery of neuropsychological tests that complement the cognitive measures in SHARE. The aim of SHARE-HCAP is to investigate the prevalence and determinants of cognitive impairment and dementia in Europe.
- The tests cover multiple domains of cognition and informant interviews, which are harmonised with other HCAP sister studies around the world, including studies in the US, UK, India, China and South Africa.
- SHARE-HCAP respondents are a subsample of the SHARE cohort study and include 2685 individuals that are 65 years and over.
- For collaboration and data access: share-eric.eu/data.

The original cohort

The Survey of Health, Ageing and Retirement in Europe (SHARE) is a harmonised and multi-national population-based panel study of micro data on health, social and economic factors. [1] The aim of SHARE is to provide evidence of the rapid ageing process in Europe at individual and population levels. Since 2004, SHARE has conducted interviews every two years with more than 140 000 respondents aged 50 years and over plus their partners in 27 European countries and Israel, covering 39 languages. Nine waves of data have been completed and made available to the scientific community. Data collection of the tenth wave has been completed in Fall 2025. Throughout the waves of data collection, countries were added and refreshment samples were drawn to increase net sample size and compensate for attrition in the longitudinal sample. Retrospective life histories regarding childhood circumstances, partners, children, accommodation, employment, socio-economic and health conditions are collected in SHARELIFE. The data were collected in wave three and wave seven in all 28 countries in a highly structured manner that enhances working with the data in combination with other SHARE datasets. In wave 6 (2015), SHARE collected blood-based biomarkers as additional objective measures of health in eleven European countries and Israel.[2,3]

SHARE is a longitudinal survey infrastructure by and for researchers from various disciplines and works closely with a national team in each of the countries throughout the data generating process. It allows for cross-national and cross-cultural comparative research as every step in the survey life cycle, from sampling to data processing, is ex-ante harmonised across the countries. Additionally, it is harmonised to the US Health and Retirement Study (HRS)[4] and its International Family of Studies, which is a growing network of longitudinal aging studies around the world.

SHARE data is available free of charge to the scientific community, www.share-eric.eu, and is used by researchers and policy makers throughout the world.

What is the reason for new data collection?

The rising dementia prevalence is a critical health and economic concern, particularly in rapidly ageing European populations. Although dementia has no cure, prevention through the identification of risk factors is increasingly emphasized.[5,6] The societal burden is substantial, with high care and significant impacts on families and the social welfare systems.[7] SHARE-HCAP was launched to have more detailed and harmonised assessments of cognitive impairment in Europe.

SHARE-HCAP enhances the SHARE study with in-depth assessments modelled after the Harmonised Cognitive Assessment Protocol (HCAP), a neuropsychological battery initiated by the HRS[8] and implemented by studies across the globe like English Longitudinal Study of Ageing (ELSA)[9,10], Mexican Health and Aging Study (MHAS)[11,12], Health and Aging in Africa (HAALSI)[13,14] and China Health and Retirement Longitudinal Study (CHARLS)[15]. Researchers can better identify cognitive impairment through SHARE-HCAP while exploring health and socio-economic influences on cognitive aging. Its harmonization with other HCAP studies facilitates cross-national and longitudinal comparisons, offering insights into how policy contexts and life conditions shape cognitive aging across Europe.

What will be the new areas of research?

SHARE-HCAP study fills a significant gap as no other harmonised, population-based data on cognitive functioning exists across Europe, making it invaluable for comparative analysis within Europe and across other ageing studies across the globe.

Contributing to a growing body of research on the classification of cognitive functioning, SHARE-HCAP provides a framework to determine prevalence of cognitive impairment comparatively within Europe and across other HCAP studies.[16–19] The classification approach is a powerful instrument to capture cognitive functioning across large groups of people within a cross-national, longitudinal framework and helps identify risk factors across diverse populations.

The harmonised design of SHARE-HCAP allows researchers to examine how systemic factors such as healthcare, education, and social support interact with modifiable risk and protective factors to shape cognitive ageing. The inclusion of blood-based biomarkers and life course data enhances the capacity to explore mechanisms underlying cognitive decline.

Furthermore, its diverse population opens new avenues to evaluate cross-cultural validity of cognitive assessment [20] and provides a platform for evaluating cross-cultural validity of assessments.

Who is in the cohort?

Five countries have been selected to represent a variety of regions and cultures in Europe: Czechia, Denmark, France, Germany and Italy. To determine the eligibility for participation in the SHARE-HCAP study a multi-step procedure was developed where the goal was to have sufficient representation across the cognition continuum.

In the first step, potential respondents were selected from the SHARE parent study during Wave 9 (2021-2022) if they were aged 65 years and over at the start of fieldwork (i.e. born before January 1st, 1957) and have completed at least one SHARE interview in the three previous waves to ensure that there is recent baseline information available. Individuals residing in care or nursing homes were eligible, provided they had the capacity to give informed consent.

In the second step, a selection of respondents was made that were hypothesized to be at greater risk of cognitive impairment based on prior performance on the word recall test in the SHARE parent study and/or a previously reported doctor's diagnosis of Alzheimer's disease or related dementia (ADRD) from any of the waves. Like the approach taken in ELSA-HCAP, respondents were categorized into three groups. To account for cross-country variation in word recall performance, country-specific percentiles were used to classify respondents: 1) severe cognitive impairment (SCI, score below the 10th percentile and/or a reported ADRD diagnosis); 2) mild cognitive impairment

(MCI, score is between the 10th and 25th percentile and no reported ADRD diagnosis and 3) normative cognition (score is above 25th percentile and no reported ADRD diagnosis).

Third step was to oversample respondents that had been identified as at higher risk of MCI or SCI. Respondents in groups 2) and 3) were fully included, while only a small share of group 1) was fielded at fieldwork start to meet country-specific sample size targets. Further, in households with more than one eligible respondent, the individual at higher risk of cognitive impairment was selected to participate. If both were equally at risk, one was randomly selected.

Respondents were also invited to nominate up to three people that are close to them (e.g. partner, family) who would be able to provide information on the respondent's cognitive functioning and everyday activities; so-called Family and Friends interview (F&F).

Fieldwork and response rates

The fieldwork for SHARE-HCAP[21] took place between May and November 2022, which overlapped with the data collection period of wave 9[22] of SHARE (October 2021 - August 2022). A total of 2685 individuals participated in the study, with 500 or more respondents per country (see Table 1). Most respondents were either in the MCI or normative cognition group at selection. Italy stands out as having most respondents in the MCI group.

The response rate in the overall SHARE-HCAP sample varies between 70.2% in Czechia and 87.6% in Italy (difference: P-value <0.001, 95% CI: 13.2, 21.7). Across other countries, pairwise differences are much smaller.

Table 1 reports differences in response rates across the participating countries and cognition groups at selection for participation. Overall, respondents that were classified as SCI have about 5% lower response probability (P-value = 0.02, 95% confidence interval (CI): -8.7, -0.6) compared to the normative group, while the difference between MCI and normative is negligible (P-value = 0.48, 95% CI: -4.2, 2.0). At the country level, Czechia's respondents in the SCI group have about 10.0% lower response probability (P-value = 0.04, 95% CI: -19.6, -0.5) compared to the normative group, whereas no substantial differences were found across the cognition groups in the other SHARE-HCAP

countries (P-values > 0.05, 95% CIs include 0). After adjusting for covariates like sex and age, the difference in Czechia drops to 0.3% (P-value = 0.94, 95% CI: -7.6, 8.2) and the remaining estimates become smaller and less precise (Supplementary Table S2, P-values > 0.05, 95% CIs include 0).

Table 2 presents SHARE-HCAP response rates across cognition groups and sociodemographic characteristics. Estimates from probit models show that respondents classified as SCI have a lower response probability, across sex, education and residence type (P-value < 0.05, 95% CIs not including 0). Response probabilities for the MCI group were comparable to the normative group (P-values > 0.05, 95% CIs include 0). After adjusting for covariates, the differences in response probability across cognition groups were attenuated (Supplementary Table S3).

A total of 2281 individuals have participated in the Family & Friend (F&F) interviews, which is an overall response rate of 85.0% (see Table 3). Of these interviews, 407 interviews were conducted in Czechia, 459 in Denmark, 409 in France, 469 in Germany, and 537 in Italy. In 45 cases, only an F&F interview was completed as respondents could not participate due to cognitive health reasons. Response rates range between 75.8% in France and 96.6% in Italy when excluding unmatched F&F interviews (P-value < 0.001, 95% CI: -24.8, -16.9).

About two-thirds of F&F interviewees were female and majority of interviewees is 65 years or over. Spouses, partners or children most often completed F&F interviews, likely due to their proximity during the respondent's face-to-face interview.

Table 4 compares the SHARE-HCAP sample with the same country subsample from wave 9 (N = 9 956) and includes independent t-test results of differences across the samples. People aged 75 years and over, individuals with low or high education, nursing home residents, individuals with ADL or IADL difficulties are more likely to participate in SHARE-HCAP ($|t\text{-statistic}| \geq 2.15$, P-values ≤ 0.03).

Weights

The calibrated cross-sectional weights for SHARE-HCAP were derived using a two-stage procedure that modelled country-specific response processes. This procedure accounted for design weights, prior participation patterns in SHARE, and SHARE-HCAP stratification variables (i.e. cognitive status

at selection and one individual per household). The resulting calibrated weights were constructed to satisfy known population margins.[23]

What has been measured?

Respondent interview

Table 5 presents the SHARE-HCAP respondent battery in order of administration. This multidomain neuropsychological test battery, adapted for the European context, enables cross-study calibration with HRS and its sister studies. The adaptation process for the five countries included consultations with the SHARE-HCAP Advisory Board of experts, local cognition experts and native speakers to ensure cultural relevance.

Many of the tests were new to SHARE: Mini-Mental State Examination (MMSE), Consortium to Establish a Registry for Alzheimer’s Disease (CERAD: word recall and constructional praxis), HRS Telephone Interview for Cognitive Status (TICS), Symbol Cancellation, Brief Community Screening Instrument for Dementia (CSI-D), East Boston Memory test (‘Brave Man story’), Wechsler Memory Scale Logical Memory (WMS-IV), Symbol Digit Modalities Test (SDMT), Raven’s Standard Progressive Matrices Test (Raven’s) and Trail Making Test part A and B (TMT). Given the influence of health cognitive performance, the protocol includes ADL, self-reported health conditions and depressive symptoms (EURO-D scale). More details are in Supplementary Table S1.

Family and Friend interview

SHARE-HCAP included an F&F interview with someone else who is familiar with the respondent (Table 5) to complement cognitive assessments. The protocol captures changes in general and cognitive health and changes in functional abilities through measures such as ADLs, IADLs and health conditions, which overlap with measures in the respondent interview and SHARE parent study. New measures included are: Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE), Blessed Dementia Rating Scale, HRS activities, Community Screening Instrument for Dementia (CSI-

D) Cognitive Activities Questionnaire and the 10/66 Dementia Research Group Informant Questionnaire.

What has it found? Key findings and publications

Between 2020 and 2024, over 200 peer-reviewed publications have used SHARE cognition data (see <https://share-eric.eu/publications>). SHARE-HCAP studies have looked at dementia prevalence, education and cognitive ageing, and psychometric properties of the SHARE-HCAP battery.[24–26]

A key contribution of SHARE-HCAP is to validate cognition measures in the SHARE parent study, enabling enhanced estimates of MCI and dementia prevalence. In the most harmonised and comprehensive cross-national assessments of cognition in Europe to date, Börsch-Supan et al.[24] find higher dementia prevalence rates in the Mediterranean and Southeastern European countries and a much larger variation of cognitive impairment across Europe and Israel than previously known. Dementia prevalence ranges from 4.5% in Switzerland to 22.7% in Spain, MCI prevalence from 17.2% in Sweden to 31.1% in Portugal. Most of this variation is explained by early-life education and other risk factors such as age and comorbidities.

SHARE-HCAP also advances methodological research on cross-national harmonisation of cognitive assessments, enabling integration with other HCAP studies worldwide [27–30], which includes a publication that outlines recommended best practices from HCAP studies for harmonizable cognitive data collection.[31]

SHARE-HCAP offers a resource to study risk and protective factors. As an example, Liao et al.[32] use data from SHARE-HCAP and CHARLS-HCAP and reveal culturally distinct associations between sleep patterns and cognitive performance in older adults across Europe and China.

What are the main strengths and weaknesses?

A key strength of SHARE-HCAP is the ex-ante harmonisation of in-depth cognitive measures within a cross-national setting, which is closely aligned with HCAP sister studies. In addition, SHARE-HCAP is harmonized with its parent study, which enables researchers to link rich longitudinal data on socioeconomic status, health, and life history with in-depth cognitive assessments. This integration allows for both cross-national comparability and longitudinal tracking of themes around cognitive aging across a diverse European landscape. SHARE-HCAP offers an unparalleled resource for studying dementia prevalence and cognitive trajectories making it a cornerstone for evidence-based policy and ageing research in Europe. These data are supplemented with blood-based biomarker data collected in SHARE, which allows linkage to indicators such as cholesterol levels and inflammatory markers.[3]

One limitation of the SHARE-HCAP sample is the coverage of only five countries in Europe. As shown in Börsch-Supan et al.[24], the linkage with the SHARE parent study makes it possible to validate its cognition measures to have a refined measure of cognition for all European countries.

Another challenge is the limited sample size per country, which can affect statistical power to conduct stratified analyses. However, we see similar variability in wave 9 and SHARE-HCAP across the much-used demographic characteristics of age, sex, education and functional abilities (see Table 4).

The ambition is to follow-up respondents of SHARE-HCAP to obtain trajectories of cognitive ageing, which will strengthen the evidence base for research on cognitive decline, dementia and their associated risk factors.

Can I get hold of the data? Where can I find out more?

SHARE-HCAP and SHARE data are publicly available through the SHARE Research Data Center to registered users for scientific use (<https://share-eric.eu/data/data-access>). Contact Salima Douhou (hcap@mea-share.eu) for the SHARE-HCAP study.

Ethics approval

Written informed consent was obtained from all individuals and the SHARE and SHARE-HCAP protocols were approved by the Ethics Committee of the Max Planck Institute in Germany. These studies have been performed in accordance with the Declaration of Helsinki.

Author contributions

A.B.S. designed the SHARE parent study and did the funding acquisition. A.B.S. and S.D. designed and oversaw the SHARE-HCAP study. S.D., M.B., Y.P. and M.C.O. contributed to the fieldwork implementation and its documentation. M.B. and A.B. designed and implemented the sampling strategy for SHARE-HCAP. G.D.L. designed and implemented the weighting strategy for SHARE-HCAP and SHARE. S.D. wrote the original draft with all co-authors providing review and editing. All authors had full access to the data in the study, verified the data and approved the final version of the manuscript.

Supplementary data

Supplementary data are available at IJE online.

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Conflict of interest

None declared.

References

1. Börsch-Supan A, Brandt M, Hunkler C *et al.* Data resource profile: The survey of health, ageing and retirement in europe (share). *Int J Epidemiol* 2013;**42**:992–1001.
2. Deza-Lougovski YI, Weiss LM, Horton HM *et al.* Circulating apoE4 protein levels from dried blood spots predict cognitive function in a large population-based survey setting. *Alzheimer's & Dementia* 2024;**20**:7613–23.
3. Börsch-Supan M, Andersen-Ranberg K, Borbye-Lorenzen N *et al.* *Biomarkers in SHARE: Documentation of Implementation, Collection, and Analysis of Dried Blood Spot (DBS) Samples 2015 – 2023*. Cambridge, MA, 2024.
4. Sonnega A, Faul JD, Ofstedal MB *et al.* Cohort Profile: the Health and Retirement Study (HRS). *Int J Epidemiol* 2014;**43**:576–85.
5. Livingston G, Huntley J, Liu KY *et al.* Dementia prevention, intervention, and care: 2024 report of the Lancet standing Commission. *The Lancet* 2024;**404**:572–628.
6. Mostert CM, Udeh-Momoh C, Winkler AS *et al.* Broadening dementia risk models: building on the 2024 Lancet Commission report for a more inclusive global framework. *EBioMedicine* 2025;**120**:105950.
7. Winblad B, Amouyel P, Andrieu S *et al.* Defeating Alzheimer's disease and other dementias: a priority for European science and society. *Lancet Neurol* 2016;**15**:455–532.
8. Langa KM, Ryan LH, McCammon RJ *et al.* The Health and Retirement Study Harmonized Cognitive Assessment Protocol Project: Study Design and Methods. *Neuroepidemiology* 2020;**54**:64–74.
9. Steptoe A, Breeze E, Banks J *et al.* Cohort Profile: The English Longitudinal Study of Ageing. *Int J Epidemiol* 2013;**42**:1640–8.
10. Cadar D, Abell J, Matthews FE *et al.* Cohort Profile Update: The Harmonised Cognitive Assessment Protocol Sub-study of the English Longitudinal Study of Ageing (ELSA-HCAP). *Int J Epidemiol* 2021;**50**:725–726i.
11. Wong R, Michaels-Obregon A, Palloni A. Cohort Profile: The Mexican Health and Aging Study (MHAS). *Int J Epidemiol* 2017;**46**:e2–e2.
12. Mejia-Arango S, Nevarez R, Michaels-Obregon A *et al.* The Mexican Cognitive Aging Ancillary Study (Mex-Cog): Study Design and Methods. *Arch Gerontol Geriatr* 2020;**91**:104210.
13. Gómez-Olivé FX, Montana L, Wagner RG *et al.* Cohort Profile: Health and Ageing in Africa: A Longitudinal Study of an INDEPTH Community in South Africa (HAALSI). *Int J Epidemiol* 2018;**47**:689–690j.
14. Bassil DT, Farrell MT, Wagner RG *et al.* Cohort Profile Update: Cognition and dementia in the Health and Aging in Africa Longitudinal Study of an INDEPTH community in South Africa (HAALSI dementia). *Int J Epidemiol* 2022;**51**:e217–26.
15. Zhao Y, Hu Y, Smith JP *et al.* Cohort Profile: The China Health and Retirement Longitudinal Study (CHARLS). *Int J Epidemiol* 2014;**43**:61–8.
16. Manly JJ, Jones RN, Langa KM *et al.* Estimating the Prevalence of Dementia and Mild Cognitive Impairment in the US. *JAMA Neurol* 2022;**79**:1242.

17. Farrell MT, Bassil DT, Guo M *et al.* Estimating dementia prevalence using remote diagnoses and algorithmic modelling: a population-based study of a rural region in South Africa. *Lancet Glob Health* 2024;**12**:2003–11.
18. Chen H, Huang Y, Lv X *et al.* Prevalence of dementia and the attributable contributions of modifiable risk factors in China. *Gen Psychiatr* 2023;**36**:e101044.
19. Gross AL, Nichols E, Angrisani M *et al.* Prevalence of DSM-5 mild and major neurocognitive disorder in India: Results from the LASI-DAD. *PLoS One* 2024;**19**:e0297220.
20. International Test Commission. ITC Guidelines for Translating and Adapting Tests (Second Edition). 2017:<http://www.intestcom.org/>.
21. SHARE-ERIC. Survey of Health, Ageing and Retirement in Europe (SHARE) SHARE-HCAP1. 2025, DOI: DOI:10.6103/SHARE.HCAP1.100.
22. SHARE-ERIC. Survey of Health, Ageing and Retirement in Europe (SHARE) Wave 9. 2024.
23. Douhou S, Otero MC, Pettinicchi Y *et al.* Cognition and Ageing: Introducing SHARE-HCAP. In: Bergmann M, Wagner M, Börsch-Supan A (eds.). *SHARE Wave 9 Methodology: From the SHARE Corona Survey 2 to the SHARE Main Wave 9 Interview*. Munich: SHARE-ERIC, 2024, 171–4.
24. Börsch-Supan A, Douhou S, Otero MC *et al.* Harmonized prevalence estimates of dementia in Europe vary strongly with childhood education. *Sci Rep* 2025;**15**:14024.
25. Fjell AM, Rogeberg O, Sørensen Ø *et al.* Reevaluating the role of education on cognitive decline and brain aging in longitudinal cohorts across 33 Western countries. *Nat Med* 2025;**31**:2967–76.
26. Otero M, Fernández I, Douhou S *et al.* Psychometric properties of the Survey of Health Aging and Retirement in Europe, Harmonized Cognitive Assessment Protocol (SHARE-HCAP). 2025, DOI: 10.31234/osf.io/qr3yc_v1.
27. Gross AL, Li C, Briceño EM *et al.* Harmonisation of later-life cognitive function across national contexts: results from the Harmonized Cognitive Assessment Protocols. *Lancet Healthy Longev* 2023;**4**:e573–83.
28. Kobayashi LC, Jones RN, Briceño EM *et al.* Cross-national comparisons of later-life cognitive function using data from the Harmonized Cognitive Assessment Protocol (HCAP): Considerations and recommended best practices. *Alzheimer's & Dementia* 2024;**20**:2273–81.
29. Nichols E, Jones RN, Gross AL *et al.* Development and assessment of analytic methods to improve the measurement of cognition in longitudinal studies of aging through the use of substudies with comprehensive neuropsychological testing. *Alzheimer's & Dementia* 2024;**20**:7024–36.
30. Nichols E, Ng DK, Hayat S *et al.* Differences in the measurement of cognition for the assessment of dementia across geographic contexts: Recommendations for cross-national research. *Alzheimer's & Dementia* 2023;**19**:1009–19.
31. Briceño E, Bassil D, Khobragade P *et al.* Recommended best practices for construct-centered adaptation of the Harmonized Cognitive Assessment Protocol. *Journal of Gerontology: Social Sciences* 2025;**in press**.
32. Liao J, Shi Y, Li Y *et al.* Cognitive-friendly sleep patterns in older Adults: A cross-regional HCAP study. *Sleep Med* 2025;**134**:106684.

Table 1: Response rates and marginal effects in SHARE-HCAP study, per country and cognition group at selection (eligible and completed interviews)

Cognition group per country, response rates & average marginal effects																			
Country	1: Severe cognitive impairment (SCI)						2: Mild cognitive impairment (MCI)						3: Normative cognition			Overall sample			
	eligible <i>n</i>	particip <i>n</i>	%	AME ¹	p- value	95% CI	eligible <i>n</i>	particip <i>n</i>	%	AME ¹	p- value	95% CI	eligible <i>n</i>	particip <i>n</i>	%	eligible <i>n</i>	particip <i>n</i>	%	
Czechia	136	84	61.8	-10.02	0.04	-19.57 -0.48	259	188	72.6	0.80	0.83	-6.54 8.14	319	229	71.8	714	501	70.2	
Denmark	85	62	72.9	-6.49	0.21	-16.54 3.56	112	90	80.4	0.92	0.82	-7.20 9.05	530	421	79.4	727	573	78.8	
France	80	63	78.8	-3.43	0.49	-13.14 6.28	176	133	75.6	-6.61	0.08	-13.97 0.75	404	332	82.2	660	528	80.0	
Germany	121	97	80.2	-1.81	0.66	-9.84 6.22	158	118	74.7	-7.29	0.06	-15.04 0.45	405	332	82.0	684	547	80.0	
Italy	129	110	85.3	-5.01	0.21	-12.80 2.79	339	296	87.3	-2.96	0.33	-8.96 3.03	144	130	90.3	612	536	87.6	
<i>Total</i>	<i>551</i>	<i>416</i>	<i>75.5</i>	<i>-4.63</i>	<i>0.02</i>	<i>-8.67 -0.60</i>	<i>1044</i>	<i>825</i>	<i>79.0</i>	<i>-1.11</i>	<i>0.48</i>	<i>-4.19 1.97</i>	<i>1802</i>	<i>1444</i>	<i>80.1</i>	<i>3397</i>	<i>2685</i>	<i>79.0</i>	

¹Average marginal effects, measuring change in response probabilities of a cognition group (SCI or MCI) relative to the normative group.

Table 2: Response rates in SHARE-HCAP study across demographic characteristics and cognitive status at selection (eligible and completed interviews)

Cognition groups & demographic characteristics, response rates																		
Demographic characteristics	1: Severe cognitive impairment							2: Mild cognitive impairment						3: Normative cognition				
	eligible	particip	n	%	AME ¹	p-value	95% CI	eligible	particip	n	%	AME ¹	p-value	95% CI	eligible	particip	n	%
	n	n						n	n						n	n		
Sex	Female	304	220	72.4	-7.23	0.01	-12.82	-1.63	543	419	77.2	-2.43	0.27	-6.73	1.87	1034	823	79.6
	Male	247	196	79.4	-1.51	0.61	-7.27	4.26	501	406	81.0	0.18	0.94	-4.24	4.60	768	621	80.9
Age	65-74	111	82	73.9	-7.23	0.10	-15.74	1.28	363	289	79.6	-1.49	0.54	-6.26	3.28	1053	854	81.1
	75-84	242	190	78.5	0.08	0.98	-6.09	6.25	483	391	81.0	2.52	0.31	-2.34	7.37	575	451	78.4
	85+	198	144	72.7	-7.16	0.10	-15.76	1.44	198	145	73.2	-6.65	0.13	-15.23	1.92	174	139	79.9
Education	Low	296	217	73.3	-7.68	0.02	-14.00	-1.35	546	436	79.9	-1.13	0.66	-6.23	3.96	405	328	81.0
	Medium	187	148	79.1	-0.67	0.84	-7.16	5.83	343	268	78.1	-1.68	0.53	-6.91	3.56	748	597	79.8
	High	67	50	74.6	-5.22	0.35	-16.09	5.65	153	121	79.1	-0.76	0.83	-7.91	6.39	645	515	79.8
Residence	Community	526	396	75.3	-4.77	0.02	-8.90	-0.64	1020	809	79.3	-0.74	0.64	-3.84	2.36	1780	1425	80.1
	Nursing home	25	20	80.0	-6.36	0.56	-27.61	14.88	24	16	66.7	-19.70	0.10	-43.39	4.00	22	19	86.4
Wave 9 interview	Self	478	391	81.8	-0.44	0.82	-4.34	3.46	970	800	82.5	0.23	0.88	-2.76	3.22	1740	1431	82.2
	Proxy ²	35	23	65.7	na	na	na	na	28	16	57.1	na	na	na	na	3	3	100.0
ADL difficulties	None	349	284	81.4	-0.90	0.69	-5.41	3.60	802	664	82.8	0.52	0.75	-2.72	3.75	1546	1272	82.3
	>=1	162	128	79.0	-3.55	0.40	-11.78	4.68	194	150	77.3	-5.24	0.20	-13.19	2.70	195	161	82.6
IADL difficulties	None	247	206	83.4	0.51	0.84	-4.51	5.53	685	566	82.6	-0.26	0.88	-3.69	3.17	1467	1216	82.9
	>=1	264	206	78.0	-1.17	0.74	-8.10	5.76	311	248	79.7	0.55	0.87	-6.02	7.11	274	217	79.2

na = not available.

¹Average marginal effects, measuring change in response probabilities of a cognition group (SCI or MCI) relative to the normative group).

²Interaction between proxy interview and SCI and MCI (relative to normative group) could not be estimated because of sparse data.

Table 3: Demographic characteristics and response rates of SHARE-HCAP Family and friend (F&F) interviews

Demographic characteristics		F&F interviews	
		N = 2281	
		<i>n</i>	%
Sex	Female	1532	67.3
	Male	744	32.7
Age	<55	467	20.6
	55-64	451	19.9
	65-74	749	33.0
	75-84	507	22.3
	85+	95	4.2
	Interview mode	Face-to-face	1296
	Telephone	973	42.9
Relation to respondent	Spouse/partner	1230	54.1
	Child	613	26.9
	Grandchild	22	1.0
	Sibling	69	3.0
	Parent	17	0.7
	Friend	171	7.5
	Guardian	1	0.0
	Neighbour	42	1.8
	Other	110	4.8
	Matched F&F interviews ¹	Czechia	405
Denmark		456	79.6
France		400	75.8
Germany		457	83.5
Italy		518	96.6
F&F-only interviews		Czechia	2
	Denmark	3	
	France	9	
	Germany	12	
	Italy	19	

¹ These are the interviews that can be matched with a respondent interview. Response rates are calculated as the number of F&F interviews divided over the total number of respondent interviews for a specific country.

Table 4: Demographic characteristics of SHARE parent and SHARE-HCAP sample

Sample composition, SHARE-HCAP vs SHARE wave 9							
		<i>SHARE-HCAP</i> <i>N = 2685</i>				<i>SHARE wave 9</i> <i>N = 9956</i>	
Demographic characteristics		<i>n</i>	<i>%</i>	<i>t-test</i>	<i>p-value</i>	<i>n</i>	<i>%</i>
Sex	Female	1462	54.5	-1.02	0.31	5531	55.6
	Male	1223	45.5	1.02	0.31	4425	44.4
Age	65-74	1225	45.6	4.87	0.00	5069	50.9
	75-84	1032	38.4	-2.26	0.02	3591	36.1
	85+	428	15.9	-3.92	0.00	1296	13.0
Education	Low	977	36.5	-2.15	0.03	3397	34.2
	Medium	1017	37.9	3.57	0.00	4145	41.8
	High	686	25.6	-1.70	0.09	2383	24.0
Residence	Community	2630	98.0	4.14	0.00	9852	99.0
	Nursing home	55	2.0	-4.14	0.00	104	1.0
Wave 9	Self	2622	98.4	-1.97	0.05	8971	97.8
	Proxy	42	1.6	1.97	0.05	201	2.2
ADL difficulties	none	2220	83.5	4.41	0.00	7966	86.9
	>=1	439	16.5	-4.41	0.00	1206	13.1
IADL difficulties	none	1988	74.8	5.35	0.00	7301	79.6
	>=1	671	25.2	-5.35	0.00	1871	20.4
Country	Czechia	501	18.7	6.43	0.00	2445	24.6
	Denmark	573	21.3	-14.41	0.00	1081	10.9
	France	528	19.7	-4.21	0.00	1616	16.2
	Germany	547	20.4	2.70	0.01	2272	22.8
	Italy	536	20.0	5.98	0.00	2542	25.5

¹ T-test statistic of differences in response rates between SHARE-HCAP and wave 9 respondents.

Table 5: SHARE-HCAP respondent and F&F battery

Domain ¹	SHARE-HCAP respondent tests	SHARE parent study	HCAP sister studies
Orientation, memory (immediate and delayed), visuospatial skills, attention/speed, language fluency	MMSE	X	✓
Memory (immediate), orientation, language fluency	HRS-TICS (3 items: Object naming; naming president)	X	✓
Memory (immediate, delayed and recognition)	CERAD Word List – Recall: Immediate and delayed, Recognition	X	✓
Language fluency	Semantic Fluency (Animal Naming)	✓	✓
Attention/speed, visuospatial	Symbol cancellation	X	✓
Attention/speed	Timed Backward Counting Task	✓	✓
Orientation, executive functioning, language fluency	Community Screening Instrument for Dementia (CSID; 4 items)	X	✓
Memory (immediate, delayed and recognition)	Logical memory (story recall) – immediate, delayed and recognition	X	✓
Memory (immediate and delayed), visuospatial skills	CERAD Constructional Praxis – immediate and delayed	X	✓
Executive functioning, attention/speed	Symbol Digit Modalities Test (SDMT)	X	✓
Executive functioning	HRS Number Series	X	✓
Executive functioning	Raven’s Standard Progressive Matrices	X	✓
Executive functioning, attention/speed	Trail Making Test (Part A and Part B)	X	✓
	SHARE-HCAP F&F interview	SHARE parent study	HCAP sister studies
Informant report	Jorm Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE)	X	✓
Informant report	Blessed Dementia Rating Scale	X	✓
Informant report	HRS Activities	X	✓
Informant report	10/66 Dementia Research Group Informant Questionnaire	X	✓
Informant report	CSI-D Cognitive Activities	X	✓

¹ Some tests have additional domains as they have been assigned in the indicator/domain overview for the factor analyses. EURO-D scale is specific to SHARE’s European context. A commonly used depression scale by sister studies is CES-D.

Supplementary Table S1: SHARE-HCAP Cognitive tests and F&F items

Respondent tests of SHARE-HCAP
Mini Mental State Examination (MMSE)[1,2]
HRS TICS (3 items: Object naming; naming president)[3]
CERAD Word List – Recall: Immediate and delayed, Recognition[4-6]
Semantic Fluency (Animal Naming)[4,7-9]
Symbol cancellation test[10]
Timed Backward Counting Task[11]
Brief Community Screening Instrument for Dementia (CSI-D; 4 items)[12]
Story recall – immediate, delayed and recognition[13,14]
CERAD Constructional Praxis – immediate and delayed[1,15]
Symbol Digit Modalities Test (SDMT)[16]
HRS Number Series[17]
Raven’s Standard Progressive Matrices[18-20]
Trail Making Test (Part A and Part B)[21,22]
SHARE-HCAP informant report
Background information
Jorm Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE)[23]
Blessed Dementia Rating Scale[24]
HRS Activities
10/66 Dementia Research Group Informant Questionnaire (4 items)[25]
CSI-D Cognitive Activities[26]

Supplementary Table S2: Predicted response probabilities in SHARE-HCAP study, per country and cognition group at selection

Cognition groups, predicted response probabilities												
Country	1: SCI					2: MCI					3: Normative	Overall sample
	Predicted ¹ %	AME ²	p-value	95% CI		Predicted ¹ %	AME ²	p-value	95% CI		Predicted ¹ %	Predicted ¹ %
Czechia	69.3	0.31	0.94	-7.55	8.18	72.0	2.97	0.34	-3.09	9.04	69.0	70.2
Denmark	74.7	-4.52	0.40	-15.05	6.02	80.2	0.98	0.81	-7.18	9.14	79.2	78.8
France	78.6	-3.61	0.52	-14.47	7.26	75.2	-7.02	0.08	-14.98	0.94	82.2	79.9
Germany	82.4	1.74	0.69	-6.85	10.34	76.1	-4.55	0.25	-12.32	3.22	80.7	79.9
Italy	87.6	-1.33	0.75	-9.57	6.92	87.1	-1.84	0.59	-8.51	4.83	88.9	87.6
<i>Total</i>	<i>78.5</i>	<i>-0.69</i>	<i>0.74</i>	<i>-4.75</i>	<i>3.37</i>	<i>79.1</i>	<i>-0.08</i>	<i>0.96</i>	<i>-3.22</i>	<i>3.05</i>	<i>79.2</i>	<i>79.0</i>

¹Predicted percentages are adjusted response probabilities estimated from a probit model, which includes country dummies, cognition group, age, sex, education, residence type, proxy interview, ADLs, IADLs.

² Average marginal effects, measuring change in response probabilities of a cognition group (SCI or MCI) relative to the normative group.

Supplementary Table S3: Adjusted response probabilities in SHARE-HCAP study across demographic characteristics and cognitive status at selection

Cognition grouping & demographic characteristics, adjusted response probabilities												
Demographic characteristics		1: SCI				2: MCI				3: Normative		
		Predicted ¹ %	AME ²	p-value	95% CI	Predicted ¹ %	AME ²	p-value	95% CI	Predicted ¹ %		
Sex	Female	77.0	-1.56	0.46	-5.70	2.57	76.5	-2.03	0.23	-5.34	1.28	78.5
	Male	80.0	-1.50	0.46	-5.47	2.47	79.6	-1.95	0.23	-5.12	1.22	81.5
Age	65-74	79.3	-1.52	0.46	-5.58	2.53	78.8	-1.98	0.23	-5.23	1.27	80.8
	75-84	78.8	-1.52	0.46	-5.52	2.49	78.4	-1.97	0.23	-5.17	1.23	80.4
	85+	74.7	-1.60	0.45	-5.80	2.60	74.2	-2.08	0.23	-5.44	1.28	76.3
Education	Low	78.3	-1.49	0.46	-5.39	2.42	77.9	-1.93	0.22	-5.04	1.18	79.8
	Medium	78.4	-1.54	0.46	-5.61	2.53	78.0	-2.00	0.23	-5.26	1.27	80.0
	High	78.2	-1.60	0.46	-5.87	2.66	77.7	-2.08	0.23	-5.51	1.35	79.8
Residence	Community	78.4	-1.53	0.46	-5.58	2.52	77.9	-1.99	0.23	-5.23	1.25	79.9
	Nursing home	77.5	-1.70	0.46	-6.19	2.78	77.0	-2.21	0.23	-5.82	1.40	79.2
Wave 9 interview	Self	78.6	-1.52	0.46	-5.55	2.51	78.2	-1.98	0.23	-5.20	1.25	80.1
	Proxy	64.1	-2.17	0.45	-7.81	3.48	63.4	-2.80	0.22	-7.31	1.71	66.2
ADL difficulties	None	78.2	-1.52	0.46	-5.54	2.50	77.7	-1.97	0.23	-5.19	1.25	79.7
	>=1	79.2	-1.62	0.46	-5.88	2.64	78.7	-2.10	0.23	-5.52	1.31	80.9
IADL difficulties	None	78.3	-1.49	0.46	-5.46	2.47	77.8	-1.94	0.23	-5.11	1.23	79.7
	>=1	78.6	-1.66	0.45	-6.00	2.69	78.1	-2.15	0.23	-5.63	1.33	80.3

¹ Predicted percentages are adjusted response probabilities estimated from a probit model, which includes country dummies, cognition group, age, sex, education, residence type, proxy interview, ADLs, IADLs.

² Average marginal effects, measuring change in response probabilities of a cognition group (SCI or MCI) relative to the normative group).

References Supplementary

1. Folstein, M.F., Folstein, S.E. & McHugh, P.R. Mini-mental state. A practical method for grading the cognitive state of patients for the clinician. *J. Psychiatr. Res.* **12**, 189-198 (1975).
2. Crum, R.M. Population-Based Norms for the Mini-Mental State Examination by Age and Educational Level. *JAMA* **269**, 2386-2391 (1993).
3. Brandt, J., Spencer, M. & Folstein, M. The telephone interview for cognitive status. *Neuropsychiatry Neuropsychol. Behav. Neurol.* **1**,111-117 (1988).
4. Morris, J.C. et al. The Consortium to Establish a Registry for Alzheimer's Disease (CERAD). Part I. Clinical and neuropsychological assessment of Alzheimer's disease. *Neurology* **39**, 1159-1165 (1989).
5. Ofstedal, M.B., Fisher, G.G. & Herzog, A.R. *Documentation of Cognitive Functioning Measures in the Health and Retirement Study* (Institute for Social Research, University of Michigan, 2005).
6. McArdle, J.J., Fisher, G.G. & Kadlec, K.M. Latent variable analyses of age trends of cognition in the Health and Retirement Study, 1992-2004. *Psychol Aging* **22**, 525-545 (2007).
7. Goodglass, H., Kaplan, E. & Barresi, B. *The Assessment of Aphasia and Related Disorders*. (Lippincott Williams & Wilkins, 2001).
8. Kertesz, A. *Western Aphasia Battery*. (The Psychological Corporation, 1982).
9. Thurstone, L.L. *Primary Mental Abilities*. (University of Chicago Press, 1938).
10. Lowery, N., Ragland, D., Gur, R.C., Gur, R.E. & Moberg, P.J. Normative Data for the Symbol Cancellation Test in Young Healthy Adults. *Appl Neuropsychol.* **11**, 216-219 (2004).
11. Agrigoroaei, S. & Lachman, M.E. Cognitive Functioning in Midlife and Old Age: Combined Effects of Psychosocial and Behavioral Factors. *J. Gerontol. B Psychol. Sci. Soc. Sci.* **66B**, i130-i140 (2011).
12. Prince, M. et al. A brief dementia screener suitable for use by non-specialists in resource poor settings—the cross-cultural derivation and validation of the brief Community Screening Instrument for Dementia. *Int. J. Geriatr. Psychiatry* **26**, 899-907 (2011).
13. Wechsler, D. *Wechsler Memory Scale-Revised*. (The Psychological Corporation, 1987).
14. Scherr, P.A. et al. Correlates of Cognitive Function in an Elderly Community Population. *Am J Epidemiol.* **128**,1084-1101 (1988).
15. Rosen, W.G., Mohs, R.C. & Davis, K.L. A new rating scale for Alzheimer's disease. *Am. J. Psychiatry* **141**, 1356-1364 (1984).
16. Smith, A. *Symbol Digit Modalities Test*. (Western Psychological Services, 1982).
17. Fisher, G.G., McArdle, J.J., McCammon, R.J., Sonnega, A. & Weir, D.R. *New Measures of Fluid Intelligence in the HRS* (Institute for Social Research, University of Michigan, 2013).
18. Raven, J. The Raven's Progressive Matrices: Change and Stability over Culture and Time. *Cogn. Psychol.* **41**,1-48 (2000).
19. Raven, J. The Raven Progressive Matrices: A Review of National Norming Studies and Ethnic and Socioeconomic Variation Within the United States. *J. Educ. Meas.* **26**, 1-16 (1989).
20. Raven, J. *Manual for Raven's Progressive Matrices and Vocabulary Scales*. Research Supplement No. 1: The 1979 British Standardisation of the Standard Progressive Matrices and Mill Hill Vocabulary Scales, Together with Comparative Data from Earlier Studies in the UK, US, Canada, Germany, and Ireland. (Oxford Psychologists Press, The Psychological Corporation, 1981).
21. Reitan, R.M. *Trail Making Test: Manual for Administration and Scoring*. (Reitan Neuropsychology Laboratory, 1992).
22. Ricker, J.H. & Axelrod, B.N. Analysis of an Oral Paradigm for the Trail Making Test. *Assessment* **1**, 47-51 (1994).
23. Jorm, A.F. A short form of the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE): development and cross-validation. *Psychol Med.* **24**, 145-153 (1994).

24. Blessed, G., Tomlinson, B.E. & Roth, M. The Association Between Quantitative Measures of Dementia and of Senile Change in the Cerebral Grey Matter of Elderly Subjects. *Br. J. Psychiatry* **114**, 797-811 (1968).
25. Prince, M. et al. The protocols for the 10/66 dementia research group population-based research programme. *BMC Public Health* **7**, 165 (2007).
26. Hall, K.S. et al. The development of a dementia screening interview in two distinct languages. *Int. J. Methods Psychiatr. Res.* **3**, 1-28 (1993).