MAX PLANCK INSTITUTE
FOR DEMOGRAPHIC RESEARCH

Konrad-Zuse-Strasse 1 · D-18057 Rostock · Germany · Tel +49 (0) 3 81 20 81 - 0 · Fax +49 (0) 3 81 20 81 - 202 · www.demogr.mpg.de

MPIDR Working Paper WP 2023-044 I November 2023
https://doi.org/10.4054/MPIDR-WP-2023-044

Trends in cognitive impairment among older adults in the USA and Europe, 1996-2018

Mikko Myrskylä I myrskyla@demogr.mpg.de
Jo Mhairi Hale I hale@demogr.mpg.de
Daniel C. Schneider I schneider@demogr.mpg.de
Neil K. Mehta

Trends in cognitive impairment among older adults in the USA and Europe, 1996-2018

Mikko Myrskylä, PhD (1, 2, 3); Jo Mhairi Hale, PhD (1, 4); Daniel C. Schneider, PhD (1);

Neil K. Mehta, PhD (5, 6)

1. Max Planck Institute for Demographic Research, Rostock, Germany
2. Population Research Unit, University of Helsinki, Helsinki, Finland
3. Max Planck – University of Helsinki Center for Social Inequalities in Population Health, Rostock, Germany and Helsinki, Finland
4. School of Geography and Sustainable Development, University of St Andrews, St Andrews, Scotland
5. Department of Epidemiology, School of Public and Population Health, University of Texas Medical Branch Galveston, 301 University Blvd, Galveston, TX 77555, USA
6. Sealy Center on Aging, University of Texas Medical Branch Galveston, 301 University Blvd, Galveston, TX 77555, USA

Corresponding author: Mikko Myrskylä, myrskyla@demogr.mpg.de

Word count: 3,910

Number of tables: 3

Number of Figures: 2

Abstract

Background Single-country studies document varying time trends in cognitive impairment. Comparative analyses across several countries are limited.

Methods We use data for a total of 13 countries from three large representative surveys (USA: HRS; England: ELSA; 11 European countries: SHARE), across years 1996-2018, and ages 50 and above. Cognitive function is based on the modified Telephone Interview for Cognitive Status. We use linear regression to study trends in average test scores and logistic regression for cognitive impairment. We analyze trend heterogeneity by gender, age, and education and explore mechanisms by adjusting for migration background, education, health and health behaviors, and partnership status.

Results The age-adjusted 10-year change in average score is 0.23 standard deviations (SD) (95% confidence interval (CI) 0.21, 0.24) for SHARE countries; 0.08 (95% CI 0.05, 0.10) in England; and -0.02 (95% CI -0.03, -0.01) in the USA The 10-year change in odds ratio for cognitive impairment is 0.63 (95% CI 0.61, 0.66) for SHARE; 0.93 (95% CI 0.85, 1.02) in England; and 1.05 (95% CI 1.02, 1.09) in the USA. The trends are largely similar across gender, education, and age subgroups. Regional differences in trends remain after adjustment for potential mechanisms.

Conclusions Time trends in cognitive function and impairment vary across countries. European countries have experienced improvement over the last twenty years, whereas the USA time trend is worsening or stagnating both in mean scores and in indicators for impairment. Uncovering the causes for this “American exceptionalism” should be both a research and public health priority.

Keywords: Cognitive impairment, dementia, trends, comparative analysis

Introduction

Cognitive impairment is a key health challenge of aging populations. Globally, over 55 million individuals are estimated to have dementia; this number is expected to triple by 2050 (1). Already now Alzheimer's disease and related dementias (ADRD) are the leading cause of death in the UK, the sixth leading cause of death in the US, and the seventh globally (2). Cognitive impairment, including ADRD, impacts not only the individuals directly affected, but also places a substantial burden on families, caregivers, and health care systems.

There is no cure or efficacious treatment for Alzheimer's disease, which is the most common cause of dementia. Thus, monitoring population-level trends in cognitive impairment is of major importance when anticipating the aggregate burden of cognitive impairment. Cognitive impairment is strongly age dependent. For example, the 2019 global prevalence of dementia is estimated to be 3% at ages 70 to 74 (3-4% in the UK, Western Europe, and US), doubling by ages 75-79, then increasing to 25% for those 85+ (UK 22%, Western Europe 25%, US 31%) (1). A key predictor of the burden of cognitive impairment at the population level therefore is the population age structure.

However, age-specific incidence of dementia may vary over time and place. In reviews of studies conducted in Sweden, Spain, England, the Netherlands, France, the USA, Japan, and Nigeria, evidence indicates prevalence or incidence of cognitive impairment declined over recent decades (3,4), suggesting that the impact of population ageing on cognitive impairment is not deterministic, and can perhaps even be mitigated. However, other studies document opposite or stable trends (5–8). Within countries, time trends in cognitive impairment also may vary across sub-populations, for example by race/ethnicity or level of education (8,9).

The existing evidence on the variation in time trends of cognitive impairment comes primarily from single-country studies (3,4). One exception is that Wolters and colleagues analyze data from smaller, population-based samples from several cities across the USA, England and Europe; they find declining trends, but highlight the need for additional work on geographically and ethnically diverse samples (10). Comparative, cross-country analyses of the time trends from a large number of countries are limited. Documenting the cross-country variation, including within-population heterogeneity, is important for two key reasons. First, the time trends are crucial for anticipating the burden of dementia. Second, analysis of the sources of the variation may help to improve our understanding of both risk and protective factors for cognitive impairment. Identifying modifiable risk factors is a primary focus for this incurable disease (11).

We use three different data sources that cover in total 13 countries to estimate the time trends in cognitive impairment. We analyze within-country heterogeneity in time trends in sub-populations defined by gender, age, and education. To explore mechanisms, we adjust our estimates for potential protective and risk factors, including education, health and health behaviors, partnership status, and migration background. Our results are based on publicly available datasets and replication code is posted at https://osf.io/pw8zg/?view_only=cee2bd9cd14449139246b3ba5119f344.

Data and methods

Study Population

We use the Health and Retirement Study (HRS) from the United States (12), the English Longitudinal Study of Ageing (ELSA) (13) and the Survey of Health, Ageing in Europe (SHARE)

(14). These sibling studies are all nationally-representative panel surveys that collect information of residents over age 50 on demographic factors, educational attainment, socioeconomic characteristics, and health and wellbeing, including cognitive function. We use data from the harmonized project Gateway to Global Aging Data (g2aging.org) (15); and for the HRS, we additionally use the HRS tracker file and RAND HRS longitudinal file for proxy responses, interview mode, and additional demographic information. The exact data sources and instructions on how to obtain the data can be found in the replication script.

We restrict the analysis to survey waves in which a harmonized set of cognitive function measures were available (HRS 1996-2018, ELSA 2002-2018, SHARE 2004-2019, but not 2009). We retain only those 11 SHARE countries that cover the span from wave 1 (2004) to wave 8 (2019): Austria, Belgium, Denmark, France, Germany, Greece, Israel, Italy, Spain, Sweden, and Switzerland and refer to this aggregate as "SHARE-11". For easier presentation of results, we label wave years as even-numbered years (1996-2018), even though SHARE field times largely fell on odd-numbered years (2007-2019).

Measures

Cognitive function is defined based on measures from the modified Telephone Interview for Cognitive Status (TICS-M) that reflect neurophysiological health and that are consistent across all three surveys and the widest time range: immediate (0-10 points) and delayed word recall (0-10 points). The range is 0-20; higher scores indicate better cognitive function. For the HRS, we use the University of Michigan Survey Research Center's imputed TICS-M values (16). ELSA and SHARE do not release standard imputation files, but we address this inconsistency in robustness checks.

We model cognition in two ways. The first is linearly based on the actual score (0-20) and the second based on a dichotomous indicator of cognitive impairment. With respect tot the latter, there are no standard cut-points to indicate cognitive impairment that would be applicable to all three datasets. The validated cut-points for mild cognitive impairment and dementia in the HRS are based on a broader set of cognition measures than our harmonized 20-point score (17). For the purposes of this study, we define cognitive impairment as the score being 1.5 or more standard deviations (SD) below the average score of the country-specific population aged 50-69 calculated over all waves of the samples.

The threshold 1.5SD is consistent with advice on cognitive impairment from the International Working Group on Mild Cognitive Impairment (MCI)(18) and produces a prevalence of cognitive impairment in HRS that is close to that of the prevalence previously validated using the Aging, Demographics, and Memory Study (ADAMS), which uses comprehensive neuropsychological examinations to provide a diagnosis of cognitive impairment on a subset of the HRS sample (17). Although the underlying cognitive score represented by the 1.5SD threshold will vary across countries, our focus is on comparing country-specific time trends versus comparing countries' prevalences. We also present results based on alternative thresholds (1.3SD, 1.7SD, and 2.0SD).

In supplementary analyses for the USA, we construct a measure from proxy interviews to indicate categories of cognitive impairment when respondents do not complete the TICS-M. SHARE and ELSA (initially only about 2-3% proxy compared to 12% in the HRS (19)) do not have analogous measures.

We control for age at interview (5-year categories), self-reported gender (woman/man), educational attainment (less than upper secondary education, upper secondary education or vocational training, or tertiary education), migration background (binary, yes for being born in another country), and partnership status (partnered/not). About 10% of respondents in ELSA do not have their education level recorded. These subjects are excluded from the analysis.

We use eight health measures based on whether the respondent has ever been diagnosed with a certain condition. Four of these (diabetes, high blood pressure, heart problems, stroke) are related to the cardiovascular system, which is associated with cognitive health (20); the others are arthritis, cancer, lung disease, and psychological problems. We control for body mass index (BMI, kg/m^2 categorized into <18.5, 18.5-24.9, 25-29.9, 30 or above), smoking (never smoker, former smoker, current smoker) and physical exercise (exercise more than once per week or not). We control for number of previous cognitive function tests (categories 0, 1, 2-3, 4-6, 7+) in order to mitigate panel conditioning effects (21).

Due to missingness related to questions not being asked in all SHARE waves, the following carry-forward or carry-backward operations were applied: Ever diagnosed with psychological problems was carried backward from wave 2 to wave 1; exercise frequency was carried forward from wave 6 to waves 7; and about half of the observations for smoking behavior of waves 5 and 6 were carried forward to waves 6-8.

Statistical models

For the continuous average score, we use linear regression whose time trend coefficients are standardized by the standard deviation of the dependent variable. We employ four different model

specifications (M1-M4), where each model is fit separately for country-specific data and for SHARE-11. M1 regresses cognitive score on calendar year and includes controls for age, gender, and number of prior tests. Additionally, for the USA, due to sampling specifics of the HRS, we include race/ethnicity, interview mode (telephone v. face-to-face) and the interaction between interview mode and gender. M1 is our key model that documents the time trends.

In M2 we add education to M1 to study whether the time trends are driven by changing educational composition. M3 adds health behaviors, underlying health conditions, partnership status, and migration background to M1. This allows us to analyze whether the time trends are driven by changes in the prevalence of these risk factors. Finally, M4 comprises the full set of controls.

To explore within-country heterogeneity, we estimate model M1 by gender, age (50-64, 65-74, 75+), and education, separately for each country and also for SHARE-11.

For binary measure of cognitive impairment, we use logistic regression and four models M1-M4 with the same covariate specifications as for continuous score.

Results

Descriptives

Our sample consists of 37,302 individuals for the HRS, 68,527 for SHARE, and 11,124 subjects for ELSA. Mean age is 67 years in each of the data sets and increasing across waves, and 54-59% are women (Table 1). Cognitive function score (range 0-20) is 10.0 in the first and 9.8 in the last wave pair for the US. For ELSA, the numbers for the first and last wave pairs are 9.9 and 10.6, and for

SHARE-11, 8.4 and 9.2, suggesting differing trends between the US and other countries. For cognitive impairment all three study populations exhibit declining unadjusted trends.

Level of education increases across all three data sets. The HRS population is less often partnered and exercises less than the ELSA and SHARE populations. Prevalence of obesity increases in HRS and SHARE, but the increase is more pronounced in HRS. The fraction of current smokers declines in each of the data sets, but this decline is slower in HRS and SHARE than in ELSA. Diabetes, high blood pressure, heart problems, and stroke, which are all risk factors for cognitive impairment, are either at a higher level in HRS or their prevalence increases faster than in ELSA and SHARE (with the exception of heart problems, which are higher in ELSA). For most other health conditions, the prevalence is highest in the HRS. These differences highlight the importance of taking these risk factors into consideration in a comparative analysis of trends in cognitive impairment.

[Table 1]

Time trends in average cognitive function

Figure 1 shows time trends in average cognitive score, based on descriptive model M1 and using wave pairs as the time indicator. Table 2 shows time trend coefficients for average score based on models M1, M2, M3, and M4, using continuous time specification. The coefficients are scaled to represent standard deviation change in average score per 10-year change in time. Appendix Tables 2A-2C document the full model results, demonstrating that the coefficients for the control variables are largely in the expected direction.

[Figure 1]

Table 2, model M1 shows that in almost all countries, the time trend is positive, but varies in magnitude. Across the SHARE countries, the time trend coefficient is 0.23 (95% CI 0.21, 0.24). Austria (0.44), Spain (0.40), and Israel (0.38) have the most positive trend, and Denmark (0.07) and Sweden (0.08) the least. ELSA is similar to the worst-performing SHARE countries, with a positive time trend of 0.08 (95% CI 0.05, 0.10). The US is an outlier with a negative trend of -0.02 (95% CI -0.03, -0.01). The US's divergence from the other countries' positive trend is also clear in Figure 1.

[Table 2]

Model 2 (Table 2) introduces controls for education. As a result, the estimated time trends become less positive (SHARE), flat (ELSA), or more negative (HRS), indicating that part of the positive trends may be attributable to the expansion of education.

Model 3 introduces controls for migration background, partnership status, health behaviors, and health. On average across the countries, the coefficients in Model 3 when compared to Model 1 are slightly more positive (SHARE), flat (ELSA), or less negative (HRS). This suggests that the improvement in cognitive scores would have been even stronger if the distribution of the risk factors had not changed. The country rankings based on Model 3, however, are similar to those in Model 1.

Model 4 jointly controls for education, migration background, partnership status, health behaviors, and health. The results of this model are also qualitatively consistent with the descriptive Model 1:

the USA has a clear negative trend, followed by Sweden, England, and Denmark with estimated trends negative or close to zero. For the other countries, the trends are positive, including for SHARE-11 as an aggregate.

[Figure 2]

Figure 2 shows time trends in average cognitive score, based on descriptive model M1 and estimated separately by gender, age groups, and education. For all but one of the sub-populations, the USA has the worst trajectory. In general, results by gender, education, or age do not reveal large systematic differences in the time trajectories within these sub-populations. However, England's oldest group fares slightly worse than their USA counterparts, and substantially worse than their younger counterparts. England also stands out as having negative trends for those in the lowest education group, compared with their higher educated counterparts.

Table 3 shows the odds ratios for the time trend in cognitive impairment based on a logistic regression model (M1) and using a variety of thresholds for cognitive impairment. The qualitative pattern that emerges is similar to what we observe when modeling average time trend with a linear regression. In most countries, we find decreasing odds of cognitive impairment. Across the SHARE-11, the odds ratio for cognitive impairment over a 10-year time period is 0.63. For Denmark, the odds ratio does not significantly differ from one, but there is no clear evidence of increased odds of cognitive impairment for any of the countries, except for the USA (odds ratio 1.05). Using differential thresholds (1.3SD, 1.7SD, or 2SD) does not change the picture: SHARE countries and

England on average always have decreasing odds, and the USA increasing odds of cognitive impairment. Appendix Figure 3 illustrates the patterns using the 1.5SD threshold.

[Table 3]

Robustness checks

We ran additional logistic regressions based on the covariate lists of models M2-M4 of Table 2 (Appendix Table 4). We cross-checked both linear and logistic regressions against specifications that do not include practice effects as a control (Appendix Tables 5 and 6). For linear models, we specified age as continuous quadratic instead of linear (Appendix Table 7) and applied a binary variable for the first test occasion as the measure for practice effects (Appendix Table 8). None of these modifications produced results or results patterns that are substantially different from our key results.

There may be substantially different attrition across the surveys, and differential pursuit of self-interviews and the use of proxy respondents to estimate cognitive impairment (22). Thus, the accumulated number of tests may vary across countries in ways that are correlated with cognitive health. Therefore, we estimated models based only on first-time interviews in which neither selective attrition nor practice effects play a role (Appendix Table 9). The results are qualitatively consistent with our main results, despite the large reduction in sample size. The inclusion of proxy respondents in the HRS (Appendix Table 10) indicates an even worsening time trend, and so does the exclusion of imputed word recall scores in the HRS (Appendix Table 11).

Since the availability of body mass index in ELSA reduces the available common sample for models M1-M4 in a non-negligible way, we compared results for models M1 and M2 based on a sample that does not have this data restriction (Appendix Table 12). Results do not change in a substantial way.

Discussion

Most countries experience improving trends in cognitive function. However, the trend for the USA stands out in the international comparison. While the other 12 countries experience improvements in average cognitive scores and declines in cognitive impairment – or at worst stagnation, such as England, Denmark and Sweden – for the USA, the time trend is worsening across most model specifications. This is a surprising and important contrast to the earlier papers that found an improving trend starting from the 2000s (23,24).

Our finding on the exceptional trends in health in the USA are not unique to cognitive function. Prior research has documented alarming trends for subsets of the USA population for physical health outcomes. In a landmark paper on mortality, Case and Deaton (25) showed that whereas most peer-countries have experienced declines in mortality, for the USA mortality for white men aged 45-54 increased over the years 1999-2013. Since then, several alarming reports have contributed to the picture of American exceptionalism. The adverse trends in mortality are not isolated to one sub-population but are affecting the USA population more broadly, and since 2010, they have led to stagnating and in some years even decreasing life expectancy (26), even before the impact of the Covid-19. This end-of-progress against mortality is attributable to a multitude of forces, including

rapidly increasing mortality from drug-related causes (27) and stagnation of progress in cardiovascular disease mortality (28).

Cardiometabolic conditions–obesity, diabetes, hypertension, heart disease, heart attacks, and stroke–may be key in understanding the USA's divergence from improving cognitive trends, as they amplify the risk of Alzheimer's disease and related dementias (ADRD) (20). The USA has higher prevalence of obesity and cardiometabolic health conditions than the comparison countries, which may explain some of the adverse trends and offset the positive force of increasing educational distribution. We controlled for a large set of these risk factors, but that did not meaningfully change the country rankings. However, the measures that were available in this study were perhaps too crude to fully account for the adverse cardiometabolic health profile that differentiates the USA from peer countries. For example, prior research on obesity as a risk factor for physical health outcomes suggests that exposure to obesity over the life course would be preferred over BMI at survey (29), the measure that was available for this study.

Despite the USA's poor performance, the generally improving trend in all the other countries is positive news. Models 2 and 4 (Tables 2 and 3) suggest that education is a primary factor, which is expected, as a substantial body of research documents the positive association between education and cognitive reserve (30). However, education is not the sole explanation. Between-country differences in both trends and social and contextual factors could be further exploited to help identify other mechanisms that may vary, such as increased access to nutrition and health care.

These remaining questions point to some of the limitations of the study. While considerable effort has been invested in harmonizing these three sister studies (15) and measuring cognitive function consistently across countries and across time, it is likely there remain some inconsistencies. Because we are analyzing within-country time trends, the between-country variation is less problematic than measurement changes across time. For example, the HRS made more of an effort across waves to have respondents complete the TICS, which would bias the USA cognitive function scores downward compared to the other surveys (22). We, therefore, ran additional robustness tests to analyze the potential role of panel conditioning and attrition. However, it is likely there are differences for which we cannot account. Further, more refined measures on cardiometabolic risk factors, preferably over the life course, would be useful when exploring the mechanisms behind the country-to-country variation; unfortunately, these are not available across the data sets.

Strengths of this paper include the use of three high quality, population-based panel surveys, all of which use consistent measurement of cognitive function – immediate and delayed recall – that is understood to identify neurophysiological decline, as well as harmonized education, demographic, behavioral, and health measures (15). We start by using linear regression models to analyze the average cognitive function score, exploring time as both categorical and continuous. To also investigate whether trends differ in the tail of the distribution, we then use logistic regression models with a categorized measure of cognitive function and explore four different thresholds for impairment. We conduct several robustness checks to ensure that trends were not confounded by panel conditioning, attrition, or proxy responses.

This study contributes a novel comparative analysis of trends in cognitive impairment across the USA, England, and eleven SHARE countries. There are several implications from our findings. First, like others (3,4), we find primarily improving trends showing declining cognitive impairment and that trends in increasing educational attainment act as a possible mechanism. Second, the USA's divergence from those trends in England and SHARE-11 is alarming. The main goal of our analysis was to document the cross-country variation in trends in cognitive function, and as secondary goal explore the potential reasons. Despite a large number of potential mechanisms, we were not able to explain the exceptionally worsening trends in the USA, which are, however, not necessarily surprising considering comparably negative trends in outcomes such as life expectancy. Nevertheless, uncovering the causes for this case of "American exceptionalism" should be both a research and public health priority.

Funding

This work was supported the Strategic Research Council (SRC), FLUX consortium, decision numbers 345130 and 345131, to MM; by the National Institute on Aging (R01AG075208) , to MM; by grants to the Max Planck – University of Helsinki Center from the Max Planck Society, Jane and Aatos Erkko Foundation, Faculty of Social Sciences at the University of Helsinki, and Cities of Helsinki, Vantaa and Espoo; and the European Union (ERC Synergy, BIOSFER, 101071773), to MM. Views and opinions expressed are, however, those of the authors only and do not necessarily reflect those of the European Union or the European Research Council. Neither the European Union nor the granting authority can be held responsible for them.

Conflict of Interest

All authors declared no conflict of interest.

Author Contributions

All authors conceptualized the paper and contributed to the methodology. D.C.S. conducted data curation and formal analysis. The authors wrote the original draft, reviewed it, and edited it together.

References

1. Nichols E, Steinmetz JD, Vollset SE, et al. Estimation of the global prevalence of dementia in 2019 and forecasted prevalence in 2050: an analysis for the Global Burden of Disease Study 2019. *Lancet Public Health*. 2022;7(2):e105-e125. doi: https://doi.org/10.1016/S2468-2667(21)00249-8.

2. Nichols E, Szoeke CEI, Vollset SE, et al. Global, regional, and national burden of Alzheimer's disease and other dementias, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet Neurol*. 2019;18(1):88-106. doi:https://doi.org/10.1016/S1474-4422(18)30403-4

3. Wu YT, Beiser AS, Breteler MMB, et al. The changing prevalence and incidence of dementia over time-current evidence. *Nat Rev Neurol*. 2017;13(6):327-339. doi:10.1038/nrneurol.2017.63

4. Larson EB, Yaffe K, Langa KM. New Insights into the Dementia Epidemic. *New England Journal of Medicine*. 2013;369(24):2275-2277. doi:10.1016/j.dcn.2011.01.002.The

5. van Bussel EF, Richard E, Arts DL, et al. Dementia incidence trend over 1992-2014 in the Netherlands: Analysis of primary care data. *PLoS Med*. 2017;14(3):1-13. doi:10.1371/journal.pmed.1002235

6. Hale JM, Schneider DC, Gampe J, Mehta NK, Myrskylä M. Trends in the Risk of Cognitive Impairment in the United States. *Epidemiology*. 2020;31(5):745-754. doi:10.1097/EDE.0000000000001219

7. Parker MG, Ahacic K, Thorslund M. Health changes among Swedish oldest old: Prevalence rates from 1992 and 2002 show increasing health problems. *Journals of Gerontology - Series A Biological Sciences and Medical Sciences*. 2005;60(10):1351-1355. doi:10.1093/gerona/60.10.1351

8. Power MC, Bennett EE, Turner RW, et al. Trends in Relative Incidence and Prevalence of Dementia Across Non-Hispanic Black and White Individuals in the United States, 2000-2016. *JAMA Neurol*. 2020;20052:1-10. doi:10.1001/jamaneurol.2020.4471

9. Hale JM, Schneider DC, Mehta NK, Myrskylä M. Cognitive impairment in the U.S.: Lifetime risk, age at onset, and years impaired. *SSM Popul Health.* 2020;11. doi:10.1016/j.ssmph.2020.100577

10. Wolters F, Chibnik L, Waziry R, et al. *27-Year Time Trends in Dementia Incidence in Europe and the US: The Alzheimer Cohorts Consortium*. Vol 0.; 2020. doi:10.1212/WNL.0000000000010022

11. Livingston G, Huntley J, Sommerlad A, et al. Dementia prevention, intervention, and care: 2020 report of the Lancet Commission. *The Lancet*. 2020;396(10248):413-446. doi:10.1016/S0140-6736(20)30367-6/ATTACHMENT/CEE43A30-904B-4A45-A4E5-AFE48804398D/MMC1.PDF

12. Health and Retirement Study, (Version Q) Public Use Dataset. Published online 2022. hrsonline.isr.umich.edu

13. Banks J, Batty GD, Breedvelt J, et al. English longitudinal study of ageing: waves 0-9, 1998-2019. Published online 2022.

14. Börsch-Supan A. Survey of Health, Ageing and Retirement in Europe (SHARE). Published online 2022.

15. Gateway to Global Aging Data. *Program on Global Aging, Health & Policy*. Published online 2023. Accessed August 3, 2023. https://g2aging.org/

16. McCammon RJ, Fisher GG, Hassan H, Faul JD, Rodgers WL, Weir DR. Health and Retirement Study Imputation of Cognitive Functioning Measures. Published online 2019.

17. Crimmins EM, Kim JK, Langa KM, Weir DR. Assessment of cognition using surveys and neuropsychological assessment: The Health and Retirement Study and the Aging, Demographics, and Memory Study. *Journals of Gerontology Series B: Psychological Sciences & Social Sciences*. 2011;66B(supp_1):i162-i171. doi:10.1093/geronb/gbr048

18. Dunne RA, Aarsland D, O'Brien JT, et al. Mild cognitive impairment: the Manchester consensus. *Age and Ageing*. 2021;50(1):72-80. doi: https://doi.org/10.1093/ageing/afaa228

19. Langa KM, Llewellyn DJ, Lang IA, et al. Cognitive health among older adults in the United States and in England. *BMC Geriatr*. 2009;9(1):1-11. doi: https://doi.org/10.1186/1471-2318-9-23

20. Omura JD, McGuire LC, Patel R, et al. Modifiable risk factors for Alzheimer disease and related dementias among adults aged≥ 45 years—United States, 2019. *Morbidity and Mortality Weekly Report*. 2022;71(20):680.

21. Goldberg TE, Harvey PD, Wesnes KA, Snyder PJ, Schneider LS. Practice effects due to serial cognitive assessment: Implications for preclinical Alzheimer's disease randomized controlled trials. *Alzheimer's and Dementia: Diagnosis, Assessment and Disease Monitoring*. 2015;1(1):103-111. doi:10.1016/j.dadm.2014.11.003

22. Weir DR, Faul JD, Langa KM. Proxy interviews and bias in the distribution of cognitive abilities due to non-response in longitudinal studies: a comparison of HRS and ELSA. *Longit Life Course Stud*. 2014;2(2):170-184. doi:10.14301/llcs.v2i2.116.Proxy

23. Langa KM, Larson EB, Crimmins EM, et al. A comparison of the prevalence of dementia in the United States in 2000 and 2012. *JAMA Intern Med*. 2017;177(1):51-58. doi:10.1001/jamainternmed.2016.6807

24. Crimmins EM, Farina M, Zhang Y, Kim JK, Hayward MD. O4-07-01: Trends in Dementia Prevalence, Incidence and Mortality in the United States. *Alzheimer's & Dementia*. 2019;15:P1248-P1249. doi:10.1016/j.jalz.2019.06.4776

25. Case A, Deaton A. Rising morbidity and mortality in midlife among white non-Hispanic Americans in the 21st century. *Proceedings of the National Academy of Sciences*. 2015;112(49):15078-15083. doi:10.1073/pnas.1518393112

26. Ho JY, Hendi AS. Recent trends in life expectancy across high income countries: Retrospective observational study. *BMJ (Online)*. 2018;362. doi:10.1136/bmj.k2562

27. Barbieri M. The contribution of drug-related deaths to the US disadvantage in mortality (International Journal of Epidemiology (2018) DOI: 10.1093/ije/dyy288). *Int J Epidemiol*. 2019;48(3):1026. doi:10.1093/IJE/DYZ067

28. Mehta NK, Abrams LR, Myrskylä M. US life expectancy stalls due to cardiovascular disease, not drug deaths. *Proceedings of the National Academy of Sciences*. 2020;117(13):6998-7000. doi:10.1073/PNAS.1920391117

29. Preston SH, Mehta NK, Stokes A. Modeling Obesity Histories in Cohort Analyses of Health and Mortality. *Epidemiology*. 2013;24(1):158-166. doi:10.1097/EDE.0B013E3182770217

30. Stern Y. Cognitive reserve in ageing and Alzheimer's disease. *Lancet Neurol*. 2012;11(11):1006-1012. doi:10.1016/S1474-4422(12)70191-6

Tables and Figures

List of Tables:

List of Figures:

Table 1. Descriptive characteristics of the analytical sample

	HRS				ELSA				SHARE		
	1996-1998	2004-2006	2016-2018	All years	2000-2002	2004-2006	2016-2018	All years	2004-2006	2016-2018	All years
Age (years, mean)	66	68	67	67	64	66	71	67	65	70	67
Women	59	59	58	59	53	54	55	54	55	56	55
Cognitive score (mean; range 0-20)	10.0	9.7	9.8	9.8	9.9	10.2	10.6	10.4	8.4	9.2	9.1
Cognitive impairment* (1.5 SD)	13.2	12.5	11.1	12.3	16.4	15.0	14.3	14.3	16.1	13.0	13.9
Number of prior tests (mean)	1.4	4.4	6.4	4.5	1.0	2.4	7.0	4.0	1.4	4.2	2.6
Educational attainment											
Less than upper secondary	28	21	17	21	41	38	26	33	49	38	42
Upper sec. / vocat. training	55	58	59	58	45	47	53	49	31	36	34
Tertiary education	17	21	24	21	14	15	21	18	20	26	24
Born in foreign country	9	10	16	12	6	6	9	8	11	9	10
Partnered	67	64	59	63	72	70	68	70	75	73	75
Smoking											
Never	41	43	46	43	36	37	37	37	54	55	54
Former	42	43	40	42	47	48	54	50	28	30	29
Current	17	14	14	15	17	15	9	13	18	15	17
Exercises >=1/week	44	54	49	48	61	62	62	62	70	68	69
Obesity											
Normal (BMI >=18.5, <25)	38	35	28	33	27	27	27	27	39	40	40
Overweight (BMI >=25, <30)	40	40	38	40	43	43	43	42	43	42	42
Obese (BMI >=30)	22	25	34	27	30	30	30	30	18	19	18
Ever diagnosed health conditions											
Diabetes	13	18	28	20	6	8	13	10	11	17	14
High blood pressure	43	53	62	54	35	41	47	42	37	55	45
Heart problems	20	23	24	22	14	17	26	19	14	20	16
Stroke	6	8	9	8	3	4	6	4	4	8	6
Arthritis	48	56	58	55	29	34	44	37	24	45	35
Cancer	10	13	15	13	5	7	15	10	6	13	9
Lung disease	7	8	11	9	5	6	8	6	6	11	9
Psychological problems	9	14	21	15	7	8	12	10	9	17	13
Person-waves	34,273	34,155	33,555	205,729	7,239	14,312	11,738	64,735	44,029	56,527	217,291

Notes: HRS, 1996–2018, (Number of Persons 37,302); ELSA, 2002–2018, (Number of Persons 11,124); SHARE, 2004–2018, (Number of Persons 117,133). Values tabulated are percentages if not otherwise noted. For each data set the first two waves and the last two waves as well as the total across all waves are shown; in addition, the 2004-2006 waves that are available for each data set are shown. The waves not shown in Table 1 were included in the analysis and are shown in Appendix Tables 1A-1C.

Table 2. Linear time trend coefficients for continuous score, models M1-M4

			M1 - descriptive		M2 - education		M3 - health, demographic		M4 - full adjustment	
		N	b	95% CI	b	95% CI	b	95% CI	b	95% CI
Survey	HRS	205,084	-0.02	[-0.03, -0.01]	-0.07	[-0.08, -0.07]	0.00	[-0.01, 0.01]	-0.05	[-0.06, -0.05]
	ELSA	64,735	0.08	[0.05, 0.10]	0.00	[-0.03, 0.02]	0.08	[0.06, 0.11]	0.01	[-0.01, 0.04]
	SHARE	217,291	0.23	[0.21, 0.24]	0.15	[0.13, 0.16]	0.25	[0.23, 0.26]	0.17	[0.15, 0.18]
SHARE Countries	Austria	17,895	0.44	[0.38, 0.49]	0.34	[0.29, 0.39]	0.39	[0.34, 0.44]	0.31	[0.27, 0.36]
	Belgium	27,975	0.33	[0.3, 0.36]	0.24	[0.21, 0.27]	0.37	[0.34, 0.4]	0.27	[0.24, 0.3]
	Denmark	18,462	0.07	[0.03, 0.11]	0.03	[0, 0.07]	0.05	[0.01, 0.09]	0.02	[-0.02, 0.06]
	France	23,335	0.28	[0.24, 0.32]	0.25	[0.21, 0.29]	0.28	[0.24, 0.32]	0.24	[0.21, 0.28]
	Germany	21,571	0.18	[0.15, 0.22]	0.16	[0.13, 0.2]	0.21	[0.17, 0.25]	0.18	[0.15, 0.22]
	Greece	15,731	0.32	[0.29, 0.36]	0.29	[0.25, 0.32]	0.36	[0.33, 0.39]	0.32	[0.29, 0.35]
	Israel	9,869	0.38	[0.3, 0.45]	0.19	[0.12, 0.26]	0.40	[0.33, 0.47]	0.23	[0.16, 0.3]
	Italy	23,268	0.30	[0.27, 0.33]	0.25	[0.21, 0.28]	0.30	[0.26, 0.33]	0.26	[0.23, 0.29]
	Spain	23,835	0.40	[0.36, 0.44]	0.33	[0.3, 0.37]	0.38	[0.35, 0.42]	0.33	[0.3, 0.37]
	Sweden	19,904	0.08	[0.04, 0.12]	-0.01	[-0.05, 0.02]	0.07	[0.03, 0.1]	-0.02	[-0.05, 0.02]
	Switzerland	15,446	0.33	[0.28, 0.39]	0.14	[0.08, 0.2]	0.37	[0.31, 0.42]	0.18	[0.12, 0.24]

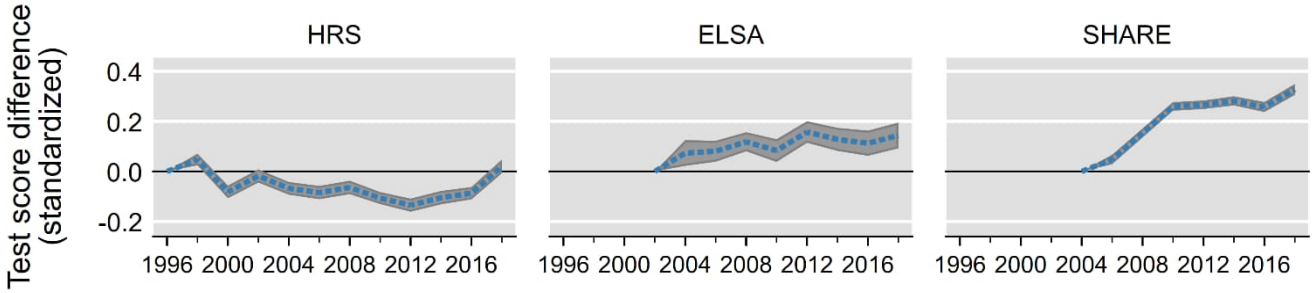
Notes: Based on survey/country-specific linear regressions on quasi-continuous cognitive score 0-20. M1 regresses cognitive score on calendar year and includes controls for age, gender, number of tests taken, and for the U.S., race/ethnicity and interview mode. M2 adds education to M1. M3 adds demographic variables (migration, partnership), behaviors, and underlying health conditions to M1. M4 adds education to model M3. Coefficients shown are for linear time (unit: 10 years), standardized by dividing through the standard deviation of the dependent variable.

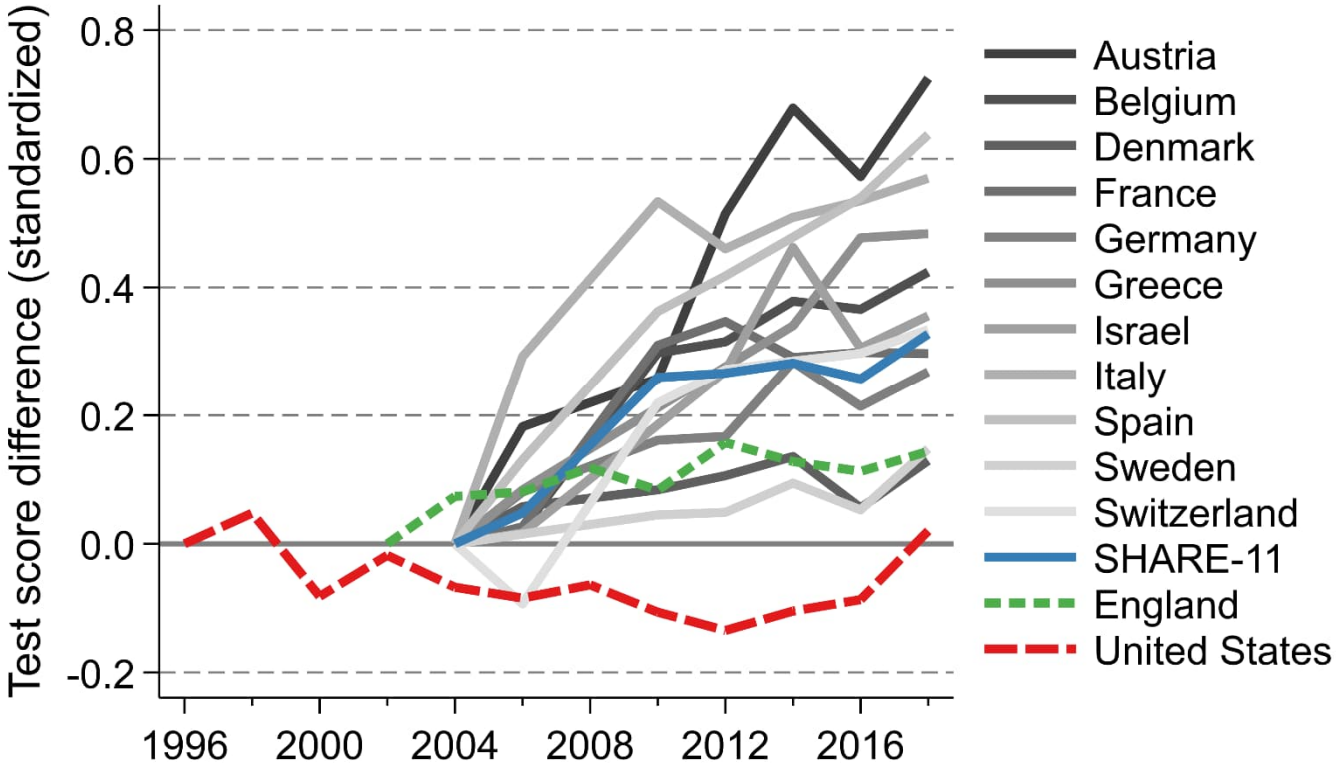
Table 3. Odds ratios from logistic regression for 10-year change in cognitive score for varying thresholds of impairment

			Main		Alternatives					
			1.5 SD		1.3 SD		1.7 SD		2.0 SD	
		N	b	95% CI	b	95% CI	b	95% CI	b	95% CI
Survey	HRS	205,084	1.06	[1.02, 1.09]	1.05	[1.02, 1.08]	1.04	[1, 1.08]	1.05	[0.99, 1.1]
	ELSA	64,735	0.93	[0.85, 1.02]	0.88	[0.82, 0.96]	0.91	[0.81, 1.01]	0.92	[0.81, 1.04]
	SHARE	217,291	0.63	[0.61, 0.66]	0.62	[0.6, 0.64]	0.66	[0.63, 0.69]	0.74	[0.7, 0.78]
SHARE Countries	Austria	17,891	0.46	[0.39, 0.55]	0.48	[0.41, 0.56]	0.51	[0.41, 0.62]	0.54	[0.42, 0.69]
	Belgium	27,970	0.56	[0.5, 0.63]	0.54	[0.49, 0.59]	0.55	[0.49, 0.63]	0.61	[0.52, 0.71]
	Denmark	18,462	1.00	[0.87, 1.15]	0.95	[0.84, 1.07]	0.90	[0.77, 1.06]	0.92	[0.76, 1.12]
	France	23,330	0.71	[0.62, 0.81]	0.71	[0.62, 0.81]	0.70	[0.6, 0.81]	0.68	[0.57, 0.81]
	Germany	21,570	0.86	[0.75, 0.98]	0.81	[0.72, 0.91]	0.86	[0.75, 0.98]	0.88	[0.75, 1.03]
	Greece	15,731	0.65	[0.58, 0.74]	0.61	[0.55, 0.67]	0.65	[0.58, 0.74]	0.73	[0.63, 0.85]
	Israel	9,864	0.52	[0.39, 0.67]	0.45	[0.36, 0.57]	0.52	[0.39, 0.67]	0.67	[0.49, 0.92]
	Italy	23,268	0.57	[0.5, 0.65]	0.51	[0.46, 0.57]	0.57	[0.5, 0.65]	0.67	[0.57, 0.78]
	Spain	23,835	0.49	[0.44, 0.55]	0.49	[0.44, 0.55]	0.58	[0.5, 0.66]	0.87	[0.73, 1.04]
	Sweden	19,901	0.86	[0.76, 0.99]	0.86	[0.77, 0.96]	0.86	[0.76, 0.99]	0.98	[0.84, 1.14]
	Switzerland	15,445	0.58	[0.48, 0.71]	0.54	[0.46, 0.64]	0.59	[0.46, 0.74]	0.68	[0.51, 0.91]

Notes: Based on survey/country-specific logistic regressions on binary impairment, defined by scores that are 1.3, 1.5, 1.7, and 2 standard deviations below the mean for ages 50-69. The main results discussed in the paper use 1.5 standard deviations to define the impairment threshold. Alternative definitions employ 1.3, 1.7, and 2 standard deviations. Odds ratios shown are for linear time (unit: 10 years). The underlying model M1 adjusts for age, gender, number of tests taken, and for the U.S., race/ethnicity and interview mode.

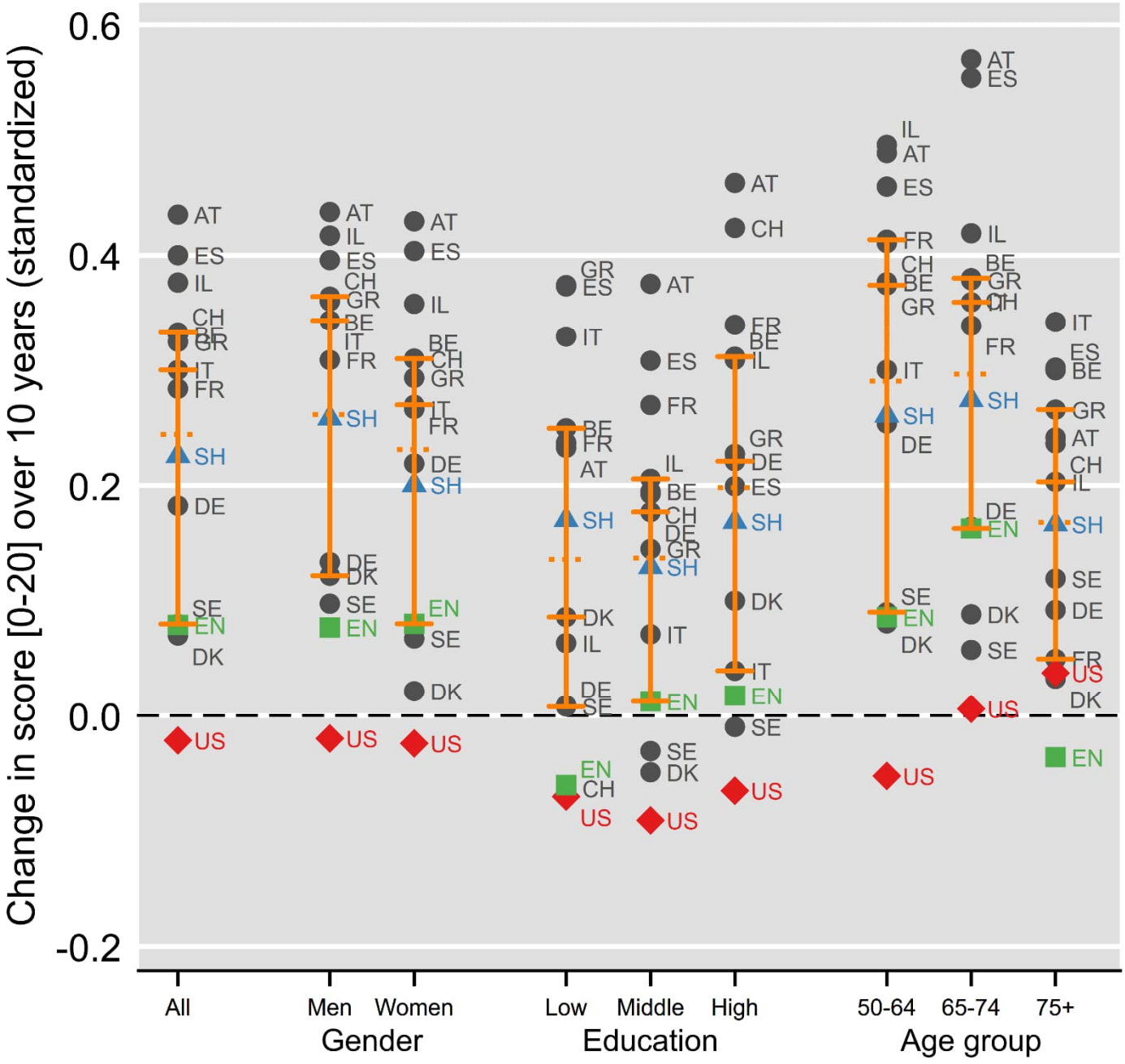
Figure 1. Change in continuous score over survey waves (model M1)





Notes: Based on survey/country-specific linear regressions on quasi-continuous cognitive score 0-20. Each line depicts regression coefficient values of survey wave year indicators, standardized by dividing through the standard deviation of the dependent variable, so values are the difference in terms of standard deviations of cognitive score relative to the first survey year in the sample (HRS: 1996; ELSA: 2002; SHARE: 2004). The underlying model M1 adjusts for age, gender, number of tests taken, and for the U.S., race/ethnicity and interview mode.

Figure 2. Change in continuous cognitive score over 10 years, by subsamples of gender, education, and age group



Notes: Based on survey/country-specific linear regressions on quasi-continuous cognitive score 0-20 for the full sample and for subpopulations. Markers are regression coefficients for linear time (unit: 10 years), standardized by dividing through the standard deviation of the dependent variable, and map as follows: Black circles - individual SHARE countries; blue triangles - SHARE-11; green squares - ELSA/England; red diamonds - HRS/United States. Vertical orange lines connect 25% and 75% percentiles, calculated over all countries except SHARE-11. The median and mean are also shown, using markers of orange horizontal solid and dotted lines, respectively. The underlying model M1 adjusts for age, gender, number of tests taken, and for the U.S., race/ethnicity and interview mode. Values depicted along with 95% confidence intervals are tabulated in Appendix Tables 3A and 3B.

Supplemental Material (Appendix)

List of Appendix Tables and Appendix Figures

Appendix Tables

Appendix Table 1A. Descriptive statistics by wave-pair for all waves: HRS

	1996-98	2000-02	2004-06	2008-10	2012-14	2016-18	All years
Age (years, mean)	66	68	68	67	68	67	67
Women	59	60	59	59	59	58	59
Cognitive function score (mean; range 0-20)	10.0	9.9	9.7	9.6	9.6	9.8	9.8
Cognitive impairment (1.5 SD)	13.2	12.3	12.5	12.4	12.5	11.1	12.3
Number of prior tests (mean)	1.4	3.1	4.4	5.3	6.2	6.4	4.5
Educational attainment							
Less than upper secondary	28	24	21	20	18	17	21
Upper secondary / vocational training	55	57	58	58	59	59	58
Tertiary education	17	19	21	22	23	24	21
Obesity							
Normal (BMI >=18.5, <25)	38	36	35	32	30	28	33
Overweight (BMI >=25, <30)	40	41	40	40	39	38	40
Obese (BMI >=30)	22	23	25	28	31	34	27
Smoking							
Never	41	41	43	43	44	46	43
Former	42	44	43	43	42	40	42
Current	17	14	14	14	14	14	15
Ever diagnosed health conditions							
Diabetes	13	15	18	21	24	28	20
High blood pressure	43	48	53	57	61	62	54
Heart problems	20	22	23	23	24	24	22
Stroke	6	7	8	8	8	9	8
Arthritis	48	54	56	57	58	58	55
Cancer	10	12	13	14	15	15	13
Lung disease	7	7	8	9	10	11	9
Psychological problems	9	11	14	16	18	21	15
Partnered	67	65	64	63	62	59	63
Exercises >=1/week	44	42	54	50	48	49	48
Low childhood SES	33	32	31	31	30	29	31
Low childhood self-rated health	7	6	6	7	7	7	7
Born in foreign country	9	9	10	12	14	16	12
Person-waves	34,273	32,676	34,155	35,303	35,767	33,555	205,729

Notes: Descriptive statistics for all wave-pairs of the HRS. Notes from Table 1 apply.

Appendix Table 1B. Descriptive statistics by wave-pair for all waves: ELSA

	1996-98	2000-02	2004-06	2008-10	2012-14	2016-18	Total
Age (years, mean)	-	64	66	66	68	71	67
Women	-	53	54	54	54	55	54
Cognitive function score (mean; range 0-20)	-	9.9	10.2	10.5	10.6	10.6	10.4
Cognitive impairment (1.5 SD)	-	16.4	15.0	13.7	13.2	14.3	14.3
Number of prior tests (mean)	-	1.0	2.4	3.5	5.1	7.0	4.0
Educational attainment							
Less than upper secondary	-	41	38	33	29	26	33
Upper secondary / vocational training	-	45	47	49	51	53	49
Tertiary education	-	14	15	18	20	21	18
Obesity							
Normal (BMI >=18.5, <25)	-	27	27	27	27	27	27
Overweight (BMI >=25, <30)	-	43	43	42	42	43	42
Obese (BMI >=30)	-	30	30	31	31	30	30
Smoking							
Never	-	36	37	39	37	37	37
Former	-	47	48	48	52	54	50
Current	-	17	15	13	11	9	13
Ever diagnosed health conditions							
Diabetes	-	6	8	10	11	13	10
High blood pressure	-	35	41	41	43	47	42
Heart problems	-	14	17	17	20	26	19
Stroke	-	3	4	4	5	6	4
Arthritis	-	29	34	36	39	44	37
Cancer	-	5	7	9	12	15	10
Lung disease	-	5	6	6	7	8	6
Psychological problems	-	7	8	9	11	12	10
Partnered	-	72	70	71	70	68	70
Exercises >=1/week	-	61	62	61	62	62	62
Low childhood SES	-	7	7	7	7	8	7
Low childhood self-rated health	-	12	12	12	12	11	12
Born in foreign country	-	6	6	8	9	9	8
Person-waves	-	7,239	14,312	16,343	15,103	11,738	64,735

Notes: Descriptive statistics for all wave-pairs of ELSA. Notes from Table 1 apply.

Appendix Table 1C. Descriptive statistics by wave-pair for all waves: SHARE-11

	1996-98	2000-02	2004-06	2008-10	2012-14	2016-18	All years
Age (years, mean)	-	-	65	66	67	70	67
Women	-	-	55	55	55	56	55
Cognitive function score (mean; range 0-20)	-	-	8.4	9.2	9.3	9.2	9.1
Cognitive impairment (1.5 SD)	-	-	16.1	14.5	13.0	13.0	13.9
Number of prior tests (mean)	-	-	1.4	1.8	2.5	4.2	2.6
Educational attainment							
Less than upper secondary	-	-	49	42	40	38	42
Upper secondary / vocational training	-	-	31	36	35	36	34
Tertiary education	-	-	20	22	25	26	24
Obesity							
Normal (BMI >=18.5, <25)	-	-	39	41	40	40	40
Overweight (BMI >=25, <30)	-	-	43	41	42	42	42
Obese (BMI >=30)	-	-	18	18	19	19	18
Smoking							
Never	-	-	54	52	53	55	54
Former	-	-	28	30	29	30	29
Current	-	-	18	18	17	15	17
Ever diagnosed health conditions							
Diabetes	-	-	11	12	15	17	14
High blood pressure	-	-	37	40	46	55	45
Heart problems	-	-	14	14	16	20	16
Stroke	-	-	4	5	6	8	6
Arthritis	-	-	24	30	35	45	35
Cancer	-	-	6	8	10	13	9
Lung disease	-	-	6	8	9	11	9
Psychological problems	-	-	9	11	13	17	13
Partnered	-	-	75	75	76	73	75
Exercises >=1/week	-	-	70	69	69	68	69
Low childhood SES	-	-	15	12	9	9	11
Low childhood self-rated health	-	-	8	10	9	9	9
Born in foreign country	-	-	11	9	10	9	10
Person-waves	-	-	44,029	30,914	85,821	56,527	217,291

Notes: Descriptive statistics for all wave-pairs of SHARE. Notes from Table 1 apply.

Appendix Table 2A. Full regression results of models M1-M4 for the HRS

	M1 - descriptive		M2 - education		M3 - health, demographic		M4 - full adjustment	
Linear time trend (unit: 10 years)	-0.08	[-0.11,-0.05]	-0.27	[-0.30,-0.24]	-0.00	[-0.03,0.02]	-0.20	[-0.23,-0.17]
Demographic								
Male	-0.82	[-0.86,-0.78]	-0.90	[-0.93,-0.86]	-0.93	[-0.98,-0.89]	-0.99	[-1.03,-0.95]
Partnered					0.26	[0.23,0.29]	0.19	[0.16,0.22]
Foreign born					-0.24	[-0.29,-0.19]	-0.13	[-0.17,-0.08]
Age group (ref: 50-54)								
55-59	-0.28	[-0.34,-0.23]	-0.21	[-0.26,-0.15]	-0.20	[-0.25,-0.14]	-0.15	[-0.21,-0.10]
60-64	-0.72	[-0.78,-0.66]	-0.55	[-0.61,-0.49]	-0.59	[-0.64,-0.53]	-0.46	[-0.52,-0.40]
65-69	-1.33	[-1.39,-1.26]	-1.07	[-1.13,-1.01]	-1.16	[-1.22,-1.09]	-0.96	[-1.02,-0.89]
70-74	-2.15	[-2.21,-2.08]	-1.80	[-1.86,-1.74]	-1.95	[-2.02,-1.89]	-1.67	[-1.73,-1.61]
75-79	-3.03	[-3.10,-2.96]	-2.62	[-2.68,-2.55]	-2.78	[-2.85,-2.71]	-2.45	[-2.51,-2.38]
80-84	-3.98	[-4.05,-3.90]	-3.51	[-3.58,-3.44]	-3.67	[-3.74,-3.59]	-3.28	[-3.36,-3.21]
85-89	-5.03	[-5.11,-4.94]	-4.49	[-4.58,-4.41]	-4.66	[-4.75,-4.57]	-4.22	[-4.31,-4.14]
90-94	-6.00	[-6.13,-5.88]	-5.43	[-5.54,-5.31]	-5.60	[-5.72,-5.48]	-5.12	[-5.24,-5.00]
95-99	-6.95	[-7.19,-6.71]	-6.41	[-6.64,-6.18]	-6.53	[-6.77,-6.30]	-6.09	[-6.32,-5.86]
100+	-8.36	[-9.11,-7.62]	-7.64	[-8.36,-6.92]	-7.97	[-8.71,-7.23]	-7.32	[-8.03,-6.61]
Education (ref: < upper sec.)								
Upp sec./voc. train.			1.61	[1.58,1.65]			1.48	[1.44,1.52]
Tertiary Education			2.90	[2.85,2.94]			2.64	[2.60,2.69]
Test #								
2	0.18	[0.13,0.23]	0.18	[0.13,0.22]	0.20	[0.15,0.25]	0.19	[0.15,0.24]
3-4	0.23	[0.18,0.28]	0.21	[0.16,0.26]	0.25	[0.20,0.29]	0.23	[0.18,0.27]
5-7	0.55	[0.50,0.60]	0.50	[0.45,0.55]	0.53	[0.48,0.58]	0.49	[0.44,0.54]
8+	0.93	[0.86,1.00]	0.86	[0.79,0.92]	0.94	[0.88,1.01]	0.87	[0.81,0.94]
Obesity (ref.: Normal)								
Underweight					-0.19	[-0.32,-0.05]	-0.11	[-0.25,0.02]
Overweight					-0.00	[-0.04,0.03]	0.08	[0.05,0.12]
Obese					-0.01	[-0.05,0.03]	0.11	[0.07,0.15]
Behaviors								
Former smoker					-0.06	[-0.09,-0.03]	0.00	[-0.03,0.03]
Current smoker					-0.50	[-0.55,-0.46]	-0.18	[-0.23,-0.14]
Exercises >1/week					0.55	[0.52,0.57]	0.43	[0.40,0.46]
Health: ever diagnosed with:								
Diabetes					-0.36	[-0.40,-0.32]	-0.28	[-0.32,-0.24]
High blood pressure					-0.14	[-0.17,-0.11]	-0.10	[-0.12,-0.07]
Heart problems					-0.13	[-0.17,-0.10]	-0.10	[-0.13,-0.06]
Stroke					-0.73	[-0.79,-0.68]	-0.67	[-0.72,-0.62]
Arthritis					-0.16	[-0.19,-0.13]	-0.06	[-0.09,-0.03]
Cancer					0.15	[0.11,0.19]	0.07	[0.03,0.11]
Lung disease					-0.23	[-0.28,-0.18]	-0.08	[-0.13,-0.03]
Psychological problems					-0.63	[-0.67,-0.59]	-0.57	[-0.61,-0.53]
Constant	11.69	[11.63,11.74]	9.96	[9.90,10.02]	11.58	[11.52,11.65]	9.88	[9.81,9.96]
N	205,084		205,084		203,400		203,400	

Notes: Full results for models M1-M4 using HRS data. Standardized time coefficients of these models have been shown in Table 2. The numbers are based on linear regressions on quasi-continuous cognitive score 0-20. M1 regresses cognitive score on calendar year and includes controls for age, gender, number of tests taken, and (not shown) race/ethnicity and interview mode. M2 adds education. M3 adds demographic variables (migration, partnership), behaviors, and underlying health conditions to M1. M4 adds education to model M3. Time coefficients in this table are not standardized.

Appendix Table 2B. Full regression results of models M1-M4 for ELSA

	M1 - descriptive		M2 - education		M3 - health, demographic		M4 - full adjustment	
Linear time trend (unit: 10 years)	0.29	[0.20,0.38]	-0.02	[-0.10,0.07]	0.30	[0.21,0.39]	0.05	[-0.03,0.14]
Demographic								
Male	-0.69	[-0.74,-0.64]	-0.99	[-1.04,-0.94]	-0.76	[-0.81,-0.71]	-1.02	[-1.07,-0.97]
Partnered					0.20	[0.14,0.26]	0.11	[0.05,0.17]
Foreign born					-0.62	[-0.71,-0.52]	-0.77	[-0.86,-0.68]
Age group (ref: 50-54)								
55-59	-0.42	[-0.53,-0.31]	-0.28	[-0.39,-0.17]	-0.38	[-0.49,-0.28]	-0.27	[-0.38,-0.17]
60-64	-0.89	[-1.01,-0.78]	-0.60	[-0.70,-0.49]	-0.84	[-0.95,-0.73]	-0.59	[-0.70,-0.49]
65-69	-1.66	[-1.77,-1.55]	-1.19	[-1.30,-1.08]	-1.58	[-1.69,-1.46]	-1.18	[-1.29,-1.07]
70-74	-2.61	[-2.72,-2.49]	-1.96	[-2.08,-1.85]	-2.45	[-2.57,-2.34]	-1.92	[-2.03,-1.80]
75-79	-3.60	[-3.72,-3.48]	-2.81	[-2.93,-2.69]	-3.36	[-3.48,-3.23]	-2.72	[-2.84,-2.60]
80-84	-4.74	[-4.88,-4.61]	-3.85	[-3.98,-3.72]	-4.37	[-4.51,-4.23]	-3.67	[-3.81,-3.54]
85-89	-6.06	[-6.23,-5.89]	-5.10	[-5.26,-4.93]	-5.59	[-5.77,-5.42]	-4.85	[-5.02,-4.68]
90-94	-7.33	[-7.58,-7.08]	-6.26	[-6.50,-6.02]	-6.73	[-6.98,-6.48]	-5.92	[-6.16,-5.68]
95-99								
100+								
Education (ref: < upper sec.)								
Upp sec./voc. train.			1.69	[1.63,1.74]			1.53	[1.47,1.59]
Tertiary Education			2.84	[2.77,2.91]			2.62	[2.54,2.69]
Test #								
2	0.37	[0.28,0.46]	0.37	[0.28,0.45]	0.36	[0.27,0.45]	0.36	[0.28,0.45]
3-4	0.73	[0.63,0.82]	0.69	[0.60,0.78]	0.72	[0.63,0.82]	0.68	[0.59,0.77]
5-7	1.13	[1.01,1.25]	1.05	[0.94,1.17]	1.12	[1.00,1.24]	1.03	[0.91,1.14]
8+	1.53	[1.37,1.70]	1.39	[1.23,1.55]	1.48	[1.32,1.65]	1.34	[1.18,1.49]
Obesity (ref.: Normal)								
Underweight					-0.49	[-0.79,-0.19]	-0.66	[-0.95,-0.37]
Overweight					-0.09	[-0.15,-0.03]	0.01	[-0.05,0.07]
Obese					-0.33	[-0.40,-0.27]	-0.11	[-0.18,-0.05]
Behaviors								
Former smoker					-0.09	[-0.14,-0.03]	-0.01	[-0.07,0.04]
Current smoker					-0.72	[-0.80,-0.64]	-0.31	[-0.40,-0.23]
Exercises >1/week					0.79	[0.74,0.85]	0.57	[0.52,0.62]
Health: ever diagnosed with:								
Diabetes					-0.42	[-0.51,-0.34]	-0.36	[-0.44,-0.28]
High blood pressure					-0.14	[-0.19,-0.08]	-0.08	[-0.13,-0.03]
Heart problems					0.02	[-0.05,0.08]	-0.03	[-0.09,0.04]
Stroke					-0.90	[-1.02,-0.77]	-0.79	[-0.91,-0.67]
Arthritis					-0.14	[-0.20,-0.09]	-0.06	[-0.11,-0.01]
Cancer					0.12	[0.04,0.21]	0.03	[-0.05,0.11]
Lung disease					-0.24	[-0.35,-0.14]	-0.07	[-0.17,0.03]
Psychological problems					-0.12	[-0.21,-0.04]	-0.22	[-0.30,-0.14]
Constant	11.65	[11.54,11.76]	10.36	[10.25,10.47]	11.45	[11.32,11.59]	10.25	[10.12,10.38]
N	64,735		64,735		64,658		64,658	

Notes: Full results for models M1-M4 using ELSA data. Notes from Appendix Table 2A apply, with the exception that M1 does not adjust for race/ethnicity and interview mode.

Appendix Table 2C. Full regression results of models M1-M4 for SHARE-11

	M1 - descriptive		M2 - education		M3 - health, demographic		M4 - full adjustment	
Linear time trend (unit: 10 years)	0.84	[0.80,0.89]	0.54	[0.50,0.58]	0.92	[0.88,0.96]	0.62	[0.58,0.66]
Demographic								
Male	-0.53	[-0.56,-0.50]	-0.72	[-0.74,-0.69]	-0.67	[-0.70,-0.64]	-0.83	[-0.86,-0.80]
Partnered					0.12	[0.09,0.15]	0.14	[0.11,0.17]
Foreign born					-0.04	[-0.09,0.01]	-0.34	[-0.39,-0.30]
Age group (ref: 50-54)								
55-59	-0.43	[-0.49,-0.38]	-0.32	[-0.37,-0.26]	-0.38	[-0.43,-0.32]	-0.29	[-0.34,-0.23]
60-64	-0.91	[-0.97,-0.86]	-0.69	[-0.74,-0.64]	-0.81	[-0.87,-0.76]	-0.63	[-0.68,-0.58]
65-69	-1.58	[-1.64,-1.53]	-1.23	[-1.29,-1.18]	-1.43	[-1.49,-1.38]	-1.14	[-1.20,-1.09]
70-74	-2.42	[-2.48,-2.37]	-1.93	[-1.98,-1.87]	-2.18	[-2.24,-2.12]	-1.77	[-1.83,-1.71]
75-79	-3.46	[-3.52,-3.40]	-2.80	[-2.86,-2.74]	-3.09	[-3.16,-3.03]	-2.55	[-2.61,-2.49]
80-84	-4.66	[-4.73,-4.59]	-3.86	[-3.92,-3.79]	-4.15	[-4.22,-4.08]	-3.49	[-3.56,-3.43]
85-89	-5.70	[-5.78,-5.61]	-4.79	[-4.87,-4.71]	-5.07	[-5.16,-4.98]	-4.32	[-4.41,-4.24]
90-94	-6.60	[-6.74,-6.46]	-5.60	[-5.73,-5.47]	-5.89	[-6.03,-5.75]	-5.06	[-5.19,-4.93]
95-99	-7.25	[-7.58,-6.91]	-6.16	[-6.47,-5.84]	-6.51	[-6.84,-6.18]	-5.59	[-5.90,-5.27]
100+	-9.14	[-10.12,-8.16]	-7.88	[-8.81,-6.96]	-8.55	[-9.52,-7.58]	-7.41	[-8.33,-6.49]
Education (ref: < upper sec.)								
Upp sec./voc. train.			1.79	[1.75,1.82]			1.67	[1.63,1.70]
Tertiary Education			2.81	[2.77,2.84]			2.64	[2.60,2.67]
Test #								
2	0.34	[0.30,0.38]	0.34	[0.30,0.38]	0.39	[0.35,0.43]	0.37	[0.34,0.41]
3-4	0.57	[0.52,0.61]	0.53	[0.49,0.58]	0.66	[0.61,0.70]	0.60	[0.56,0.64]
5-7	0.79	[0.73,0.85]	0.75	[0.69,0.80]	0.86	[0.80,0.92]	0.80	[0.74,0.86]
8+								
Obesity (ref.: Normal)								
Underweight					-0.09	[-0.22,0.04]	-0.16	[-0.28,-0.03]
Overweight					-0.31	[-0.34,-0.27]	-0.13	[-0.16,-0.10]
Obese					-0.41	[-0.45,-0.36]	-0.14	[-0.18,-0.10]
Behaviors								
Former smoker					0.48	[0.45,0.51]	0.34	[0.31,0.38]
Current smoker					0.09	[0.05,0.13]	0.14	[0.10,0.18]
Exercises >1/week					0.87	[0.84,0.90]	0.69	[0.66,0.72]
Health: ever diagnosed with:								
Diabetes					-0.59	[-0.63,-0.55]	-0.44	[-0.48,-0.40]
High blood pressure					-0.20	[-0.23,-0.17]	-0.13	[-0.16,-0.10]
Heart problems					-0.18	[-0.22,-0.14]	-0.14	[-0.18,-0.11]
Stroke					-0.55	[-0.61,-0.49]	-0.61	[-0.66,-0.55]
Arthritis					-0.25	[-0.28,-0.22]	-0.13	[-0.16,-0.10]
Cancer					0.29	[0.24,0.34]	0.13	[0.08,0.17]
Lung disease					-0.25	[-0.30,-0.20]	-0.15	[-0.20,-0.11]
Psychological problems					-0.59	[-0.63,-0.54]	-0.47	[-0.51,-0.43]
Constant	9.71	[9.64,9.77]	8.55	[8.49,8.61]	9.18	[9.11,9.26]	8.12	[8.04,8.19]
N	217,291		217,291		212,774		212,774	

Notes: Full results for models M1-M4 using SHARE-11 data. Notes from Appendix Table 2A apply, with the exception that M1 does not adjust for race/ethnicity and interview mode.

Appendix Table 3A. Change in continuous cognitive score over 10 years, by subsamples of gender, education, and age group: HRS, ELSA, and aggregate SHARE-11

	HRS		ELSA		SHARE	
	b	**95% CI**	**b**	**95% CI**	**b**	**95% CI**
Full sample	-0.02	[-0.03, -0.01]	0.08	[0.05, 0.10]	0.23	[0.21, 0.24]
Gender						
Men	-0.02	[-0.03, -0.01]	0.08	[0.04, 0.11]	0.26	[0.24, 0.28]
Women	-0.02	[-0.03, -0.01]	0.08	[0.05, 0.11]	0.20	[0.18, 0.22]
Age						
50-64	-0.05	[-0.06, -0.04]	0.09	[0.05, 0.12]	0.26	[0.24, 0.28]
65-74	0.01	[-0.01, 0.03]	0.16	[0.11, 0.21]	0.27	[0.25, 0.30]
75+	0.04	[0.01, 0.06]	-0.04	[-0.11, 0.03]	0.17	[0.14, 0.19]
Education						
< Upp. secondary	-0.07	[-0.09, -0.05]	-0.06	[-0.11, -0.01]	0.17	[0.15, 0.19]
Upp sec./voc. train.	-0.09	[-0.10, -0.08]	0.01	[-0.02, 0.05]	0.13	[0.11, 0.15]
Tertiary	-0.07	[-0.08, -0.05]	0.02	[-0.04, 0.07]	0.17	[0.14, 0.19]

Notes: Standardized coefficient estimates as in Figure 2; see the figure note in the main text. Numbers in brackets are lower and upper bounds of 95% confidence intervals.

Appendix Table 3B. Change in continuous cognitive score over 10 years, by subsamples of gender, education, and age group: Individual SHARE countries.

	Austria		Belgium		Denmark		France	
	b	95% CI	b	95% CI	b	95% CI	b	95% CI
Full sample	0.44	[0.38, 0.49]	0.33	[0.30, 0.36]	0.07	[0.03, 0.11]	0.28	[0.24, 0.32]
Gender								
Men	0.44	[0.36, 0.52]	0.36	[0.31, 0.41]	0.12	[0.06, 0.18]	0.31	[0.25, 0.37]
Women	0.43	[0.36, 0.50]	0.31	[0.27, 0.35]	0.02	[-0.03, 0.08]	0.27	[0.22, 0.32]
Age								
50-64	0.49	[0.41, 0.57]	0.38	[0.33, 0.42]	0.08	[0.02, 0.14]	0.41	[0.35, 0.47]
65-74	0.57	[0.48, 0.66]	0.38	[0.31, 0.45]	0.09	[0.01, 0.17]	0.34	[0.25, 0.42]
75+	0.24	[0.13, 0.35]	0.30	[0.22, 0.38]	0.03	[-0.07, 0.13]	0.05	[-0.04, 0.14]
Education								
< Upp. secondary	0.23	[0.14, 0.33]	0.25	[0.20, 0.30]	0.09	[0.00, 0.18]	0.24	[0.18, 0.30]
Upp sec./voc. train.	0.38	[0.30, 0.45]	0.19	[0.13, 0.26]	-0.05	[-0.11, 0.01]	0.27	[0.20, 0.34]
Tertiary	0.46	[0.35, 0.58]	0.31	[0.25, 0.37]	0.10	[0.03, 0.17]	0.34	[0.25, 0.43]

	Germany		Greece		Israel		Italy	
	b	95% CI	b	95% CI	b	95% CI	b	95% CI
Full sample	0.18	[0.15, 0.22]	0.32	[0.29, 0.36]	0.38	[0.30, 0.45]	0.30	[0.27, 0.33]
Gender								
Men	0.13	[0.08, 0.19]	0.36	[0.31, 0.41]	0.42	[0.31, 0.53]	0.34	[0.29, 0.39]
Women	0.22	[0.17, 0.27]	0.29	[0.25, 0.34]	0.36	[0.26, 0.46]	0.27	[0.22, 0.31]
Age								
50-64	0.25	[0.20, 0.31]	0.37	[0.33, 0.42]	0.50	[0.39, 0.60]	0.30	[0.25, 0.35]
65-74	0.16	[0.10, 0.23]	0.38	[0.31, 0.44]	0.42	[0.27, 0.57]	0.36	[0.29, 0.43]
75+	0.09	[0.00, 0.18]	0.27	[0.19, 0.34]	0.20	[0.03, 0.38]	0.34	[0.26, 0.42]
Education								
< Upp. secondary	0.01	[-0.09, 0.11]	0.37	[0.33, 0.42]	0.06	[-0.07, 0.20]	0.33	[0.29, 0.37]
Upp sec./voc. train.	0.18	[0.13, 0.22]	0.14	[0.08, 0.21]	0.21	[0.08, 0.34]	0.07	[-0.01, 0.15]
Tertiary	0.22	[0.16, 0.29]	0.23	[0.15, 0.31]	0.31	[0.19, 0.43]	0.04	[-0.10, 0.17]

	Spain		Sweden		Switzerland	
	b	95% CI	b	95% CI	b	95% CI
Full sample	0.40	[0.36, 0.44]	0.08	[0.04, 0.12]	0.33	[0.28, 0.39]
Gender						
Men	0.40	[0.34, 0.45]	0.10	[0.04, 0.15]	0.36	[0.28, 0.45]
Women	0.40	[0.36, 0.45]	0.07	[0.02, 0.12]	0.31	[0.23, 0.39]
Age						
50-64	0.46	[0.40, 0.52]	0.09	[0.03, 0.15]	0.41	[0.32, 0.50]
65-74	0.55	[0.48, 0.63]	0.06	[-0.01, 0.12]	0.38	[0.27, 0.49]
75+	0.30	[0.23, 0.38]	0.12	[0.04, 0.20]	0.24	[0.11, 0.36]
Education						
< Upp. secondary	0.37	[0.33, 0.41]	0.01	[-0.05, 0.07]	-0.06	[-0.17, 0.05]
Upp sec./voc. train.	0.31	[0.18, 0.44]	-0.03	[-0.10, 0.04]	0.19	[0.11, 0.27]
Tertiary	0.20	[0.07, 0.33]	-0.01	[-0.08, 0.06]	0.42	[0.26, 0.58]

Notes: See Appendix Figure 3A.

Appendix Table 4. Odds ratios from logistic regressions for 10-year change in cognitive impairment, models M1-M4

			M1 - descriptive		M2 - education		M3 - health, demographic		M4 - full adjustment	
		N	b	95% CI	b	95% CI	b	95% CI	b	95% CI
Survey	HRS	205,084	1.06	[1.02, 1.09]	1.18	[1.14, 1.22]	1.01	[0.98, 1.04]	1.13	[1.09, 1.17]
	ELSA	64,735	0.93	[0.85, 1.02]	1.08	[0.99, 1.19]	0.90	[0.82, 0.98]	1.01	[0.92, 1.11]
	SHARE	217,291	0.63	[0.61, 0.66]	0.70	[0.68, 0.73]	0.61	[0.58, 0.63]	0.68	[0.65, 0.71]
SHARE Countries	Austria	17,891	0.46	[0.39, 0.55]	0.56	[0.47, 0.66]	0.50	[0.42, 0.6]	0.57	[0.47, 0.69]
	Belgium	27,970	0.56	[0.5, 0.63]	0.67	[0.6, 0.75]	0.51	[0.45, 0.57]	0.62	[0.55, 0.69]
	Denmark	18,462	1.00	[0.87, 1.15]	1.08	[0.94, 1.25]	1.07	[0.93, 1.24]	1.14	[0.99, 1.32]
	France	23,330	0.71	[0.62, 0.81]	0.74	[0.65, 0.85]	0.71	[0.62, 0.81]	0.74	[0.64, 0.85]
	Germany	21,570	0.86	[0.75, 0.98]	0.92	[0.8, 1.05]	0.82	[0.71, 0.94]	0.88	[0.77, 1.02]
	Greece	15,731	0.65	[0.58, 0.74]	0.69	[0.61, 0.79]	0.58	[0.51, 0.66]	0.62	[0.55, 0.71]
	Israel	9,864	0.52	[0.39, 0.67]	0.81	[0.61, 1.06]	0.42	[0.32, 0.57]	0.66	[0.49, 0.89]
	Italy	23,268	0.57	[0.5, 0.65]	0.62	[0.55, 0.71]	0.54	[0.47, 0.62]	0.58	[0.51, 0.66]
	Spain	23,835	0.49	[0.44, 0.55]	0.54	[0.48, 0.6]	0.50	[0.44, 0.56]	0.53	[0.47, 0.6]
	Sweden	19,901	0.86	[0.76, 0.99]	1.01	[0.89, 1.16]	0.88	[0.77, 1.01]	1.01	[0.88, 1.16]
	Switzerland	15,445	0.58	[0.48, 0.71]	0.91	[0.74, 1.11]	0.53	[0.43, 0.65]	0.82	[0.67, 1.02]

Notes: Based on survey/country-specific logistic regressions on binary impairment, defined by scores lower than 1.5 standard deviations below the mean for ages 50-69. Other than that, notes from Table 2 apply.

Appendix Table 5. Linear time trend coefficients for continuous score, models M1-M4: No adjustment for practice effects

			M1 - descriptive		M2 - education		M3 - health, demographic		M4 - full adjustment	
		N	b	95% CI	b	95% CI	b	95% CI	b	95% CI
Survey	HRS	205,084	0.05	[0.05, 0.06]	-0.01	[-0.01, 0]	0.07	[0.07, 0.08]	0.01	[0.01, 0.02]
	ELSA	64,735	0.27	[0.25, 0.28]	0.17	[0.15, 0.18]	0.27	[0.25, 0.28]	0.18	[0.17, 0.19]
	SHARE	217,291	0.33	[0.32, 0.34]	0.24	[0.23, 0.25]	0.36	[0.35, 0.37]	0.27	[0.26, 0.27]
SHARE Countries	Austria	17,895	0.42	[0.39, 0.46]	0.36	[0.32, 0.39]	0.39	[0.36, 0.43]	0.34	[0.3, 0.37]
	Belgium	27,975	0.42	[0.39, 0.44]	0.34	[0.32, 0.36]	0.45	[0.43, 0.48]	0.36	[0.34, 0.39]
	Denmark	18,462	0.19	[0.16, 0.22]	0.14	[0.11, 0.17]	0.19	[0.16, 0.22]	0.14	[0.11, 0.17]
	France	23,335	0.44	[0.42, 0.47]	0.36	[0.33, 0.38]	0.45	[0.42, 0.48]	0.37	[0.34, 0.39]
	Germany	21,571	0.32	[0.29, 0.35]	0.28	[0.25, 0.3]	0.35	[0.32, 0.37]	0.30	[0.27, 0.32]
	Greece	15,731	0.25	[0.23, 0.28]	0.21	[0.18, 0.24]	0.29	[0.26, 0.32]	0.24	[0.22, 0.27]
	Israel	9,869	0.46	[0.42, 0.51]	0.39	[0.35, 0.44]	0.50	[0.45, 0.54]	0.42	[0.37, 0.46]
	Italy	23,268	0.29	[0.26, 0.32]	0.23	[0.21, 0.26]	0.32	[0.29, 0.35]	0.27	[0.24, 0.29]
	Spain	23,835	0.44	[0.41, 0.46]	0.37	[0.35, 0.4]	0.46	[0.43, 0.49]	0.40	[0.37, 0.43]
	Sweden	19,904	0.21	[0.18, 0.24]	0.13	[0.1, 0.16]	0.21	[0.18, 0.24]	0.13	[0.1, 0.16]
	Switzerland	15,446	0.43	[0.39, 0.46]	0.34	[0.3, 0.37]	0.46	[0.42, 0.49]	0.37	[0.34, 0.41]

Notes: Notes from Table 2 apply, with the exception that none of the specifications includes a measure of practice effects as a control.

Appendix Table 6. Odds ratios from logistic regressions for 10-year change in cognitive impairment, models M1-M4: No adjustment for practice effects

			M1 - descriptive		M2 - education		M3 - health, demographic		M4 – full adjustment	
		N	b	95% CI	b	95% CI	b	95% CI	b	95% CI
Survey	HRS	205,084	0.80	[0.78, 0.82]	0.92	[0.9, 0.94]	0.78	[0.76, 0.8]	0.89	[0.87, 0.91]
	ELSA	64,735	0.62	[0.59, 0.65]	0.75	[0.71, 0.78]	0.61	[0.58, 0.64]	0.72	[0.68, 0.75]
	SHARE	217,291	0.53	[0.51, 0.54]	0.59	[0.57, 0.61]	0.49	[0.48, 0.51]	0.56	[0.54, 0.57]
SHARE Countries	Austria	17,891	0.42	[0.37, 0.48]	0.48	[0.42, 0.55]	0.44	[0.39, 0.5]	0.49	[0.43, 0.56]
	Belgium	27,970	0.46	[0.42, 0.5]	0.53	[0.49, 0.58]	0.43	[0.39, 0.47]	0.50	[0.46, 0.55]
	Denmark	18,462	0.75	[0.68, 0.83]	0.85	[0.76, 0.94]	0.73	[0.66, 0.82]	0.82	[0.74, 0.92]
	France	23,330	0.45	[0.41, 0.49]	0.52	[0.48, 0.57]	0.44	[0.4, 0.48]	0.51	[0.46, 0.56]
	Germany	21,570	0.60	[0.54, 0.66]	0.67	[0.6, 0.74]	0.57	[0.51, 0.63]	0.63	[0.57, 0.71]
	Greece	15,731	0.64	[0.58, 0.7]	0.69	[0.63, 0.76]	0.56	[0.51, 0.62]	0.61	[0.55, 0.68]
	Israel	9,864	0.49	[0.42, 0.57]	0.54	[0.47, 0.63]	0.41	[0.35, 0.49]	0.47	[0.4, 0.55]
	Italy	23,268	0.51	[0.46, 0.57]	0.56	[0.5, 0.62]	0.46	[0.41, 0.51]	0.50	[0.45, 0.56]
	Spain	23,835	0.44	[0.4, 0.48]	0.47	[0.43, 0.51]	0.41	[0.37, 0.45]	0.43	[0.39, 0.48]
	Sweden	19,901	0.68	[0.61, 0.75]	0.77	[0.7, 0.86]	0.67	[0.6, 0.75]	0.76	[0.68, 0.85]
	Switzerland	15,445	0.50	[0.45, 0.57]	0.61	[0.53, 0.69]	0.47	[0.41, 0.53]	0.57	[0.5, 0.65]

Notes: Notes from Table 2 and Appendix Table 4 apply, with the exception that none of the specifications includes a measure of practice effects as a control.

Appendix Table 7. Linear time trend coefficients for continuous score, models M1-M4: Age adjustment as continuous (quadratic) age

			M1 – descriptive		M2 – education		M3 – health, demographic		M4 – full adjustment	
		N	b	95% CI	b	95% CI	b	95% CI	b	95% CI
Survey	HRS	205,084	-0.03	[-0.04, -0.02]	-0.08	[-0.09, -0.07]	-0.01	[-0.02, 0]	-0.06	[-0.07, -0.05]
	ELSA	64,735	0.07	[0.05, 0.1]	-0.01	[-0.03, 0.01]	0.08	[0.05, 0.1]	0.01	[-0.01, 0.03]
	SHARE	217,291	0.23	[0.21, 0.24]	0.15	[0.14, 0.16]	0.25	[0.23, 0.26]	0.17	[0.15, 0.18]
SHARE Countries	Austria	17,895	0.44	[0.39, 0.49]	0.34	[0.29, 0.39]	0.39	[0.34, 0.44]	0.32	[0.27, 0.37]
	Belgium	27,975	0.33	[0.3, 0.36]	0.24	[0.21, 0.27]	0.37	[0.34, 0.4]	0.27	[0.24, 0.3]
	Denmark	18,462	0.07	[0.03, 0.11]	0.03	[-0.01, 0.07]	0.04	[0, 0.08]	0.02	[-0.02, 0.06]
	France	23,335	0.29	[0.25, 0.32]	0.25	[0.21, 0.29]	0.28	[0.24, 0.32]	0.25	[0.21, 0.28]
	Germany	21,571	0.18	[0.15, 0.22]	0.17	[0.13, 0.2]	0.21	[0.17, 0.25]	0.18	[0.15, 0.22]
	Greece	15,731	0.32	[0.29, 0.36]	0.28	[0.25, 0.32]	0.36	[0.33, 0.39]	0.32	[0.29, 0.35]
	Israel	9,869	0.38	[0.3, 0.45]	0.19	[0.12, 0.26]	0.40	[0.33, 0.48]	0.23	[0.16, 0.3]
	Italy	23,268	0.30	[0.27, 0.33]	0.25	[0.21, 0.28]	0.30	[0.27, 0.33]	0.26	[0.23, 0.29]
	Spain	23,835	0.40	[0.37, 0.44]	0.33	[0.3, 0.37]	0.39	[0.35, 0.42]	0.33	[0.3, 0.37]
	Sweden	19,904	0.08	[0.05, 0.12]	-0.01	[-0.05, 0.02]	0.07	[0.03, 0.1]	-0.01	[-0.05, 0.02]
	Switzerland	15,446	0.33	[0.27, 0.39]	0.14	[0.08, 0.2]	0.36	[0.31, 0.42]	0.18	[0.13, 0.24]

Notes: Notes from Table 2 apply, with the exception that age now enters the regression as a continuous and quadratic variable.

Appendix Table 8. Linear time trend coefficients for continuous score, models M1-M4: Practice effect measure is indicator variable for first test.

			M1 – descriptive		M2 – education		M3 – health, demographic		M4 – full adjustment	
		N	b	95% CI	b	95% CI	b	95% CI	b	95% CI
Survey	HRS	205,084	0.04	[0.03, 0.05]	-0.02	[-0.02, -0.01]	0.06	[0.05, 0.07]	0.00	[-0.01, 0.01]
	ELSA	64,735	0.23	[0.21, 0.24]	0.12	[0.11, 0.14]	0.22	[0.21, 0.24]	0.14	[0.12, 0.15]
	SHARE	217,291	0.27	[0.26, 0.28]	0.19	[0.18, 0.2]	0.29	[0.28, 0.3]	0.21	[0.2, 0.22]
SHARE Countries	Austria	17,895	0.35	[0.31, 0.39]	0.27	[0.23, 0.31]	0.31	[0.27, 0.35]	0.25	[0.21, 0.29]
	Belgium	27,975	0.37	[0.34, 0.39]	0.28	[0.26, 0.31]	0.40	[0.37, 0.43]	0.31	[0.28, 0.34]
	Denmark	18,462	0.11	[0.08, 0.15]	0.07	[0.03, 0.1]	0.10	[0.07, 0.13]	0.06	[0.03, 0.1]
	France	23,335	0.38	[0.35, 0.41]	0.31	[0.28, 0.34]	0.38	[0.35, 0.41]	0.31	[0.28, 0.34]
	Germany	21,571	0.23	[0.2, 0.26]	0.20	[0.17, 0.23]	0.26	[0.22, 0.29]	0.22	[0.19, 0.25]
	Greece	15,731	0.29	[0.26, 0.32]	0.25	[0.22, 0.28]	0.32	[0.3, 0.35]	0.28	[0.25, 0.31]
	Israel	9,869	0.42	[0.36, 0.48]	0.30	[0.25, 0.36]	0.45	[0.39, 0.51]	0.34	[0.28, 0.39]
	Italy	23,268	0.29	[0.26, 0.32]	0.23	[0.2, 0.26]	0.31	[0.28, 0.34]	0.26	[0.23, 0.29]
	Spain	23,835	0.40	[0.37, 0.43]	0.34	[0.31, 0.37]	0.40	[0.37, 0.44]	0.35	[0.32, 0.38]
	Sweden	19,904	0.14	[0.11, 0.18]	0.06	[0.03, 0.09]	0.14	[0.1, 0.17]	0.06	[0.03, 0.09]
	Switzerland	15,446	0.36	[0.32, 0.41]	0.25	[0.2, 0.29]	0.39	[0.34, 0.43]	0.28	[0.23, 0.32]

Notes: Notes from Table 2 apply, with the exception that practice effects are measured differently, as a binary indicator for the first test occasion.

Appendix Table 9. Linear time trend coefficients for continuous score, models M1-M4: Samples restricted to first-time test takers.

			M1 – descriptive		M2 – education		M3 – health, demographic		M4 – full adjustment	
		N	b	95% CI	b	95% CI	b	95% CI	b	95% CI
Survey	HRS	34,781	-0.05	[-0.07, -0.04]	-0.11	[-0.12, -0.09]	-0.04	[-0.06, -0.03]	-0.10	[-0.11, -0.08]
	ELSA	10,836	0.22	[0.17, 0.28]	0.13	[0.07, 0.18]	0.22	[0.17, 0.28]	0.15	[0.09, 0.2]
	SHARE	64,563	0.27	[0.25, 0.29]	0.20	[0.19, 0.22]	0.28	[0.26, 0.3]	0.21	[0.2, 0.23]
SHARE Countries	Austria	5,412	0.38	[0.3, 0.46]	0.30	[0.22, 0.38]	0.36	[0.27, 0.44]	0.29	[0.21, 0.37]
	Belgium	8,207	0.39	[0.34, 0.44]	0.30	[0.25, 0.35]	0.42	[0.37, 0.48]	0.33	[0.28, 0.38]
	Denmark	4,988	0.13	[0.07, 0.19]	0.11	[0.04, 0.17]	0.10	[0.03, 0.16]	0.08	[0.02, 0.14]
	France	6,647	0.45	[0.38, 0.51]	0.42	[0.35, 0.48]	0.42	[0.35, 0.48]	0.39	[0.33, 0.45]
	Germany	6,933	0.16	[0.11, 0.22]	0.14	[0.09, 0.2]	0.21	[0.15, 0.26]	0.18	[0.12, 0.24]
	Greece	5,558	0.33	[0.29, 0.37]	0.28	[0.23, 0.32]	0.36	[0.31, 0.4]	0.30	[0.26, 0.35]
	Israel	2,786	0.33	[0.22, 0.43]	0.12	[0.01, 0.22]	0.33	[0.22, 0.44]	0.12	[0.01, 0.23]
	Italy	7,194	0.36	[0.31, 0.41]	0.31	[0.26, 0.36]	0.34	[0.29, 0.39]	0.31	[0.26, 0.36]
	Spain	7,330	0.45	[0.39, 0.5]	0.39	[0.34, 0.45]	0.43	[0.37, 0.49]	0.39	[0.34, 0.45]
	Sweden	5,432	0.09	[0.04, 0.15]	0.01	[-0.05, 0.07]	0.07	[0.02, 0.13]	0.00	[-0.06, 0.06]
	Switzerland	4,076	0.42	[0.33, 0.52]	0.24	[0.15, 0.34]	0.44	[0.34, 0.53]	0.26	[0.16, 0.36]

Notes: Based on regressions restricted to samples of first-time test takers. Other than that, notes from Table 2 apply.

Appendix Table 10. Comparison of main logistic HRS regressions to Hale et al. (2020)

	Adjustment: PE		Adjustment: PE + education	
Original study results				
Hale et al. 2020 (last wave: 2014)	1.29	[1.16, 1.44]	1.54	[1.39, 1.70]
Current study (CS)	1.06	[1.02, 1.09]	1.18	[1.14, 1.22]
Variations of current study				
CS, but without common sample restriction	1.15	[1.12, 1.18]	1.28	[1.24, 1.32]
CS, but using data up to 2014 only	1.16	[1.11, 1.21]	1.31	[1.25, 1.37]
CS, but using complex survey design	1.01	[0.95, 1.08]	1.12	[1.06, 1.19]
CS, but age is continuous quadratic	1.08	[1.05, 1.12]	1.21	[1.17, 1.25]
CS, but impairment is 0-6 of 27 cog score	1.05	[1.00, 1.10]	1.25	[1.18, 1.31]
CS, but using proxy interviews	1.15	[1.12, 1.18]	1.28	[1.24, 1.32]
CS, but using the HRS education variable	1.06	[1.02, 1.09]	1.19	[1.15, 1.23]
Hale at al. specification				
CS, with all of the above (last wave: 2018)	1.25	[1.17, 1.34]	1.47	[1.38, 1.57]

Notes: Comparison of current study specifications with results from Hale et al. 2020 (henceforth: HEA) (1), as well as various modifications of the baseline specifications of the current study. Values shown are odds ratios for cognitive impairment for 10-year trend coefficients along with corresponding 95% confidence intervals. Columns "Adjustment: PE" and "Adjustment: PE + education" correspond to Model 1 and 2 of the current study, respectively. The first table section contrasts the results of HEA and of the current study. The second table section adapts the specifications of the current study towards the ones in HEA in order to investigate where differences in the estimates stem from. It does so by varying one specification setting at a time. The bottom table section applies all specification modifications at once, making the regressions of the current study fully compatible with the ones in HEA, except for the sample span, which ends in 2014 for HEA and 2018 for the current study.

Appendix Table 11. Main linear HRS regressions exclusive of observations with imputed word recall scores

		M1 - descriptive		M2 - education		M3 - health, demographic		M4 - full adjustment	
	N	b	95% CI	b	95% CI	b	95% CI	b	95% CI
Imputations									
Yes	205,084	-0.02	[-0.03, -0.01]	-0.07	[-0.08, -0.07]	0.00	[-0.01, 0.01]	-0.05	[-0.06, -0.05]
No	193,461	-0.04	[-0.04, -0.03]	-0.09	[-0.10, -0.08]	-0.02	[-0.02, -0.01]	-0.07	[-0.08, -0.06]

Notes: Comparing standardized 10-year time trend coefficients in cognition for baseline linear HRS regressions, models M1-M4, with corresponding regressions whose samples exclude imputed word recall scores. Notes from Table 2 apply.

Appendix Table 12. Comparison of ELSA regressions when sample is not restricted by the availability of BMI data

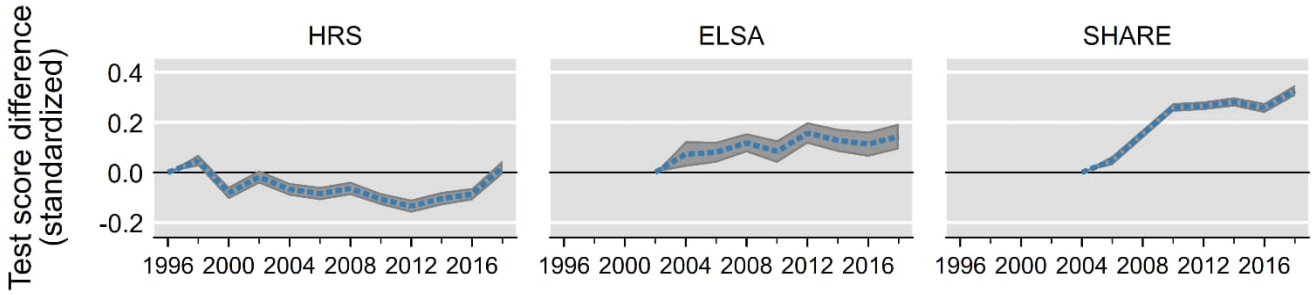
	M1 - descriptive				M2 - education			
	Sample:				Sample:			
	BMI-restricted		Unrestricted		BMI-restricted		Unrestricted	
	b	95% CI	b	95% CI	b	95% CI	b	95% CI
Continuous score								
Baseline	0.08	[0.05, 0.10]	0.07	[0.05, 0.08]	0.00	[-0.03, 0.02]	-0.01	[-0.03, 0.01]
Sample: 1. test occasion	0.22	[0.17, 0.28]	0.12	[0.09, 0.16]	0.13	[0.07, 0.18]	0.04	[0.01, 0.07]
No adj. for prior testing	0.27	[0.25, 0.28]	0.27	[0.26, 0.29]	0.17	[0.15, 0.18]	0.17	[0.16, 0.18]
Test adjustment is 1. test	0.23	[0.21, 0.24]	0.21	[0.20, 0.22]	0.12	[0.11, 0.14]	0.11	[0.10, 0.13]
Logistic regression								
Baseline	0.93	[0.85, 1.02]	0.91	[0.84, 0.97]	1.08	[0.99, 1.19]	1.05	[0.98, 1.13]
No adj. for prior testing	0.62	[0.59, 0.65]	0.56	[0.54, 0.59]	0.75	[0.71, 0.78]	0.69	[0.66, 0.72]

Notes: 10-Year trend coefficients and corresponding 95% confidence intervals for ELSA data comparing samples that are restricted by data availability of BMI versus samples that are not restricted in that respect. Comparisons are performed for models M1 and M2, which do not contain BMI as a right-hand side variable. Continuous score regressions are compared for the baseline specification (Table 2), for the first-time test taker sample (Appendix Table 9), for specifications that do not control for the number of prior test occasions (Appendix Table 5), and for specifications whose control variable for the number of prior tests consists solely of a binary indicator for the first test occasion (Appendix Table 8). Logistic regressions for binary cognitive impairment are compared for the baseline specification (Appendix Table 4) and for specifications that do not control for the number of prior test occasions (Appendix Table 6). Dropping the sample restriction of BMI availability increases the sample from 64,735 observations to 76,423 observations for all specifications except for the first-time test taker sample, for which the sample increases from 10,836 observations to 16,277 observations.

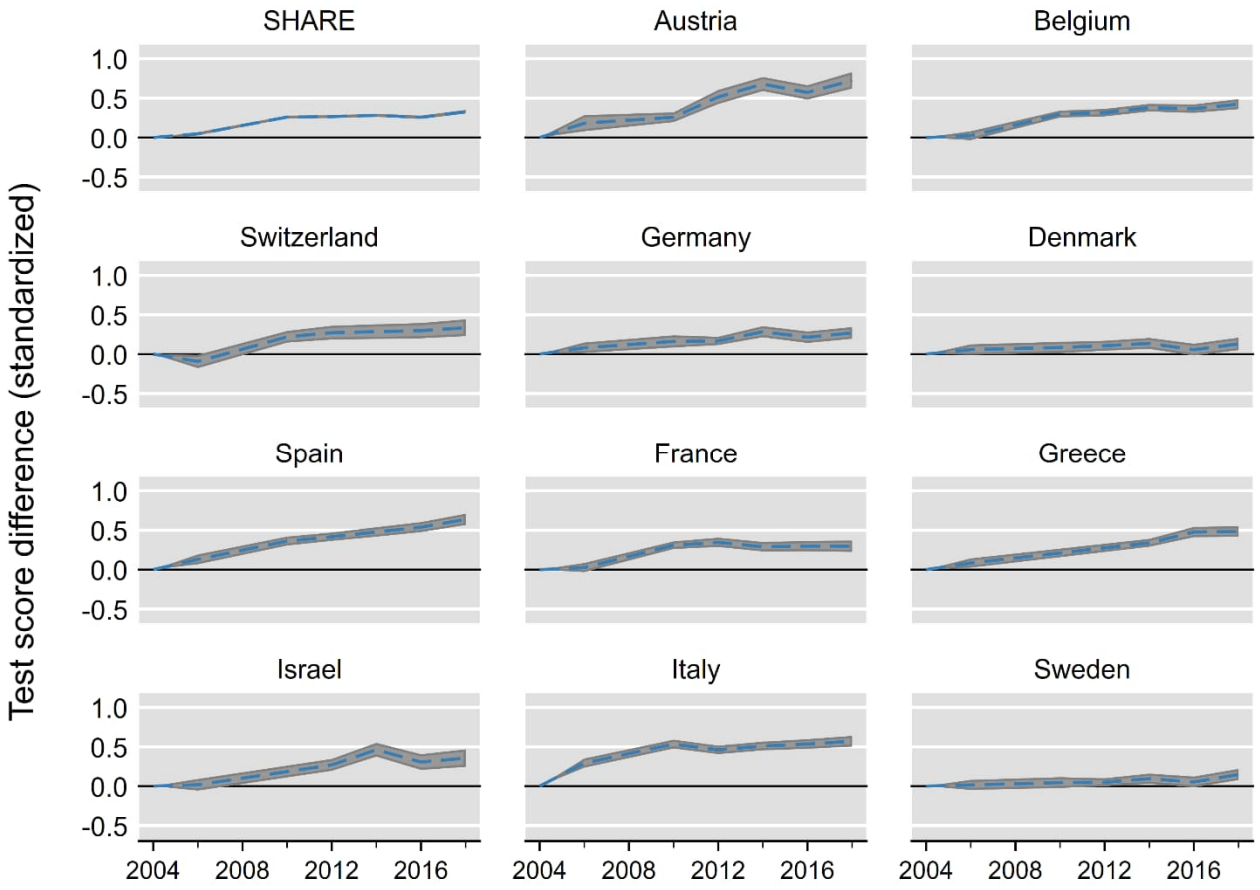
Appendix Figures

Appendix Figure 1. Time trend with confidence bounds for continuous score models M1

A: By Survey

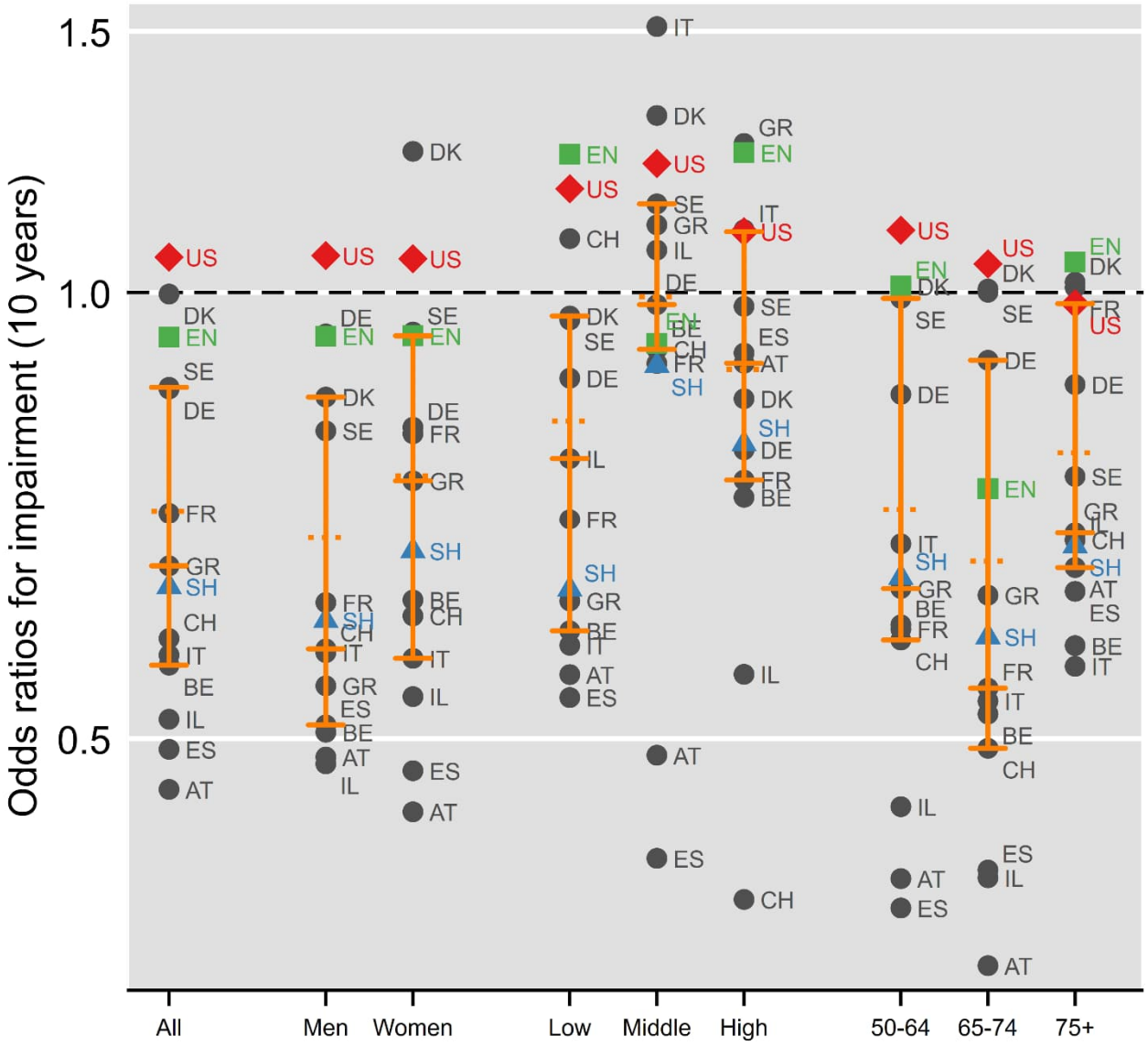


B: SHARE Total and Individual Countries



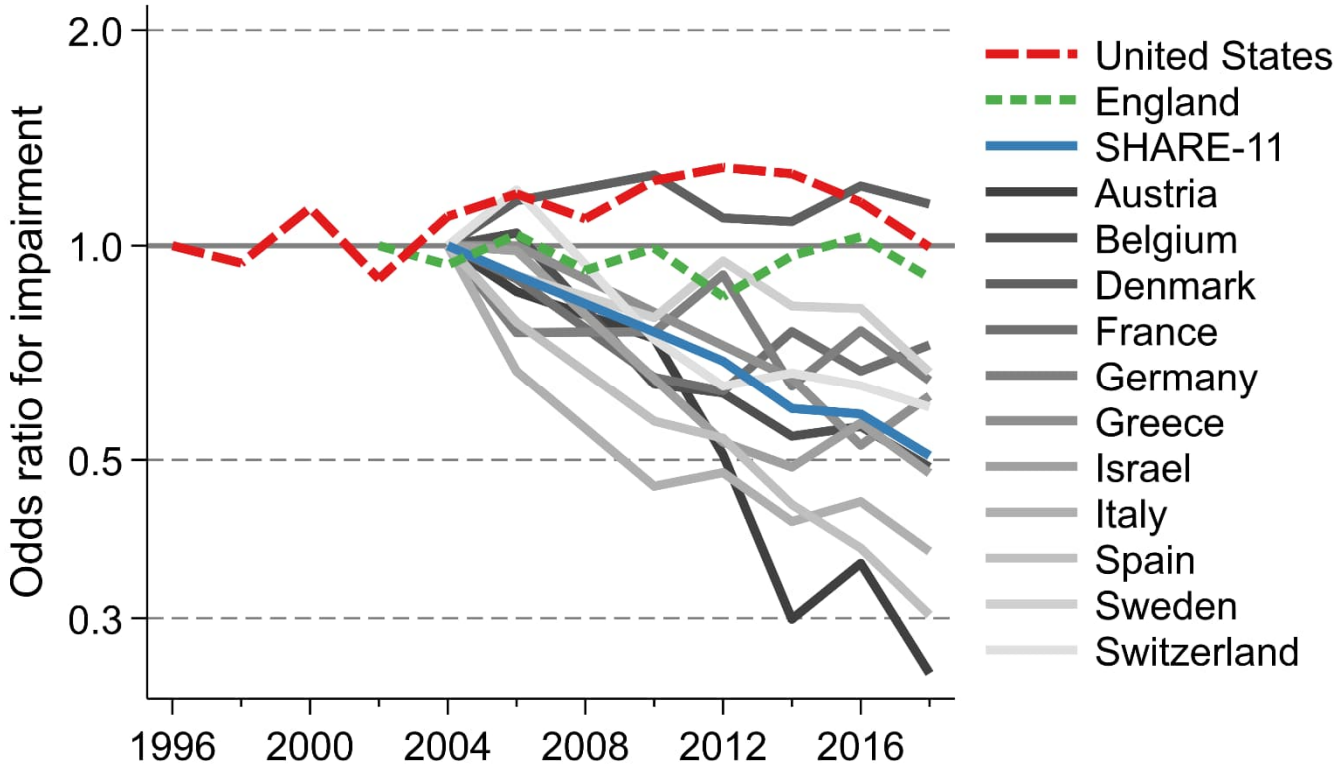
Notes: Coefficients for wave indicators and their confidence bounds for continuous score models M1. Notes from Figure 1 apply.

Appendix Figure 2. Change in binary cognitive impairment over 10 years, by subsamples of gender, education, and age group



Notes: Based on survey/country-specific logistic regressions on binary cognitive impairment based on a country-specific cutoff value of 1.5 standard deviations below the mean for age group 50-69. Values shown are odds ratios. Other than that, notes from Figure 2 apply.

Appendix Figure 3. Odds ratios for cognitive impairment of wave year indicator variables (model M1)



Notes: Based on survey/country-specific logistic regressions on binary impairment based on a country-specific cutoff value of 1.5 standard deviations below the mean for age group 50-69. Each line depicts odds ratios for impairment for different survey wave year indicator variables. , relative to the first survey year in the sample (HRS: 1996; ELSA: 2002; SHARE: 2004). The underlying model M1 adjusts for age, gender, number of tests taken, and for the U.S., race/ethnicity and interview mode.

Appendix references

1. Hale JM, Schneider DC, Gampe J, Mehta NK, Myrskylä M. Trends in the Risk of Cognitive Impairment in the United States. *Epidemiology*. 2020;31(5):745-754. doi:10.1097/EDE.0000000000001219