Education and Late-Life Cognitive Health: Causal Evidence from Compulsory Schooling Reforms

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Background and Motivation

- Education is strongly associated with enhanced cognitive health
  - In Grossman's model (1972), schooling raises health-production efficiency, increasing health stock and slowing cognitive decline
  - Education builds cognitive reserve that protects against dementia (Valenzuela & Sachdev, 2006; Stern, 2012)
    - Selection effects: higher cognitive ability, better childhood health, and privileged family background predict both educational attainment and dementia risk
- Causal evidence remains limited and mixed
  - Swedish register-based evidence from Seblova et al. (2021) shows negligible effects of reform-induced increases in education on dementia diagnoses
  - UK Biobank evidence from Barcellos et al. (2025) points to sizable protective effects of additional schooling on Alzheimer's disease and related dementias

  → We estimate the causal effect of additional compulsory schooling on late-life cognitive health in a pooled European sample, exploiting compulsory schooling reforms and clinically validated cognitive-state measures

Data and School Reforms Used as Natural Experiments

- Data Sources:
  - SHARE (Survey of Health, Ageing and Retirement in Europe) Waves 4-9: harmonized panel data on Europeans aged 50+, comprising 38,715 respondents and covering health, cognition, socioeconomic status, and social networks
  - SHARE-HCAP (Harmonized Cognitive Assessment Protocol): an extension offering clinically validated cognitive measures, covering 2,685 respondents
- School reforms:

Table 1. Summary of compulsory schooling reforms

Reform	Schooling	School Starting Age	School Leaving Age	Pivotal cohort
Austria 1966	8-9	7	15	September 1951
Denmark 1972	7-9	7	15	January 1958
Estonia 1958	7-8	8	15	August 1944
France 1959	8-10	7	16	January 1953
Italy 1963	6-8	7	14	January 1950
Netherlands 1950	7-8	7	14	January 1937
Portugal 1964	3/4-6	8	13	January 1956

  - The reforms extended compulsory schooling nationwide without major changes to tracking, school types, access, or financial barriers

Measurement and Extrapolation of Cognitive Status

- Cognitive status is assigned using Manly et al. (2022) and a battery including CERAD Word List, Serial 7, orientation, semantic fluency, ADL/IADL, MMSE, SDMT, Raven's Matrices, and Trail Making A/B
  1. Latent cognitive scores are derived via factor analysis of five domains: memory, executive function, orientation, visuospatial ability, and language
  2. Classification rules:
  - Dementia: ≥ 1.5 SD below the normative mean in ≥ 2 domains + functional impairment
  - MCI: impairment in one domain without functional limitations
  - Normal: no impairment
- HCAP-based classifications are extended to the full SHARE sample via an ordered probit model estimated on the SHARE-HCAP subsample and extrapolated following Hurd et al. (2016) and Börsch-Supan et al. (2025)
  - The model uses variables measured identically in both datasets, including orientation, immediate and delayed recall, serial 7, animal naming, ADL/IADL, sex, and country indicators

Model Validation and Cognitive Status Patterns

Table 2: Clinical and model-based estimates of cognitive prevalence in SHARE-HCAP and parent SHARE

		Classified using Manly et al. (2022)			Predicted using Hurd et al. (2016)		
Sample	No.	Normal	MCI	Demented	Normal	MCI	Demented
Czech Republic	501	72.10 (2.87)	20.28 (2.38)	7.62 (1.40)	71.08 (1.80)	21.04 (1.16)	7.88 (0.86)
Denmark	573	77.24 (2.10)	17.94 (1.98)	4.82 (0.93)	75.38 (1.20)	18.81 (0.67)	5.74 (0.64)
France	528	72.12 (2.60)	21.67 (2.36)	6.22 (1.13)	71.66 (1.31)	21.07 (0.78)	7.27 (0.69)
Germany	547	76.57 (2.07)	18.99 (1.88)	4.44 (1.06)	76.02 (0.11)	18.57 (0.68)	5.41 (0.57)
Italy	536	65.85 (3.31)	23.15 (2.78)	12.00 (2.16)	64.54 (1.30)	26.27 (0.80)	9.19 (0.64)
SHARE-HCAP subsample	2,685	71.78 (1.42)	20.96 (1.25)	7.27 (0.82)	71.38 (0.66)	21.53 (0.41)	7.10 (0.33)
SHARE reform sample	38,715	–	–	–	70.17 (0.26)	21.71 (0.14)	8.12 (0.14)

Note. Entries are percentages; standard errors are reported in parentheses. Cognitive status is clinically classified in SHARE-HCAP using the three-stage algorithm of Manly et al. (2022). Model-based prevalence estimates are obtained using the approach of Hurd et al. (2016) and extrapolated from SHARE-HCAP to the parent SHARE sample using SHARE Waves 4–9.

- Predicted weighted shares of cognitive states closely match the diagnostic classifications across all countries → high internal validity of the prediction model
- Predicted prevalence estimates for the parent SHARE sample closely resemble those for the SHARE-HCAP calibration sample

Empirical Strategy

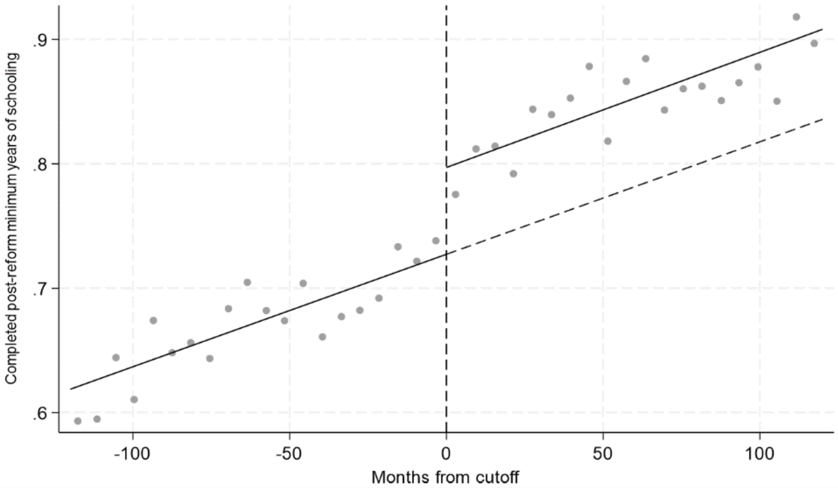
- Identification: Fuzzy regression discontinuity design using local linear estimates with data-driven bandwidth choice and bias-adjusted confidence intervals (Calonico et al., 2014)
  - Sensitivity is assessed using confidence intervals valid for a discrete running variable (Armstrong & Kolesár, 2018; Kolesár & Rothe, 2018)

$$H_{ic} = \alpha + \tau D_{ic} + f_0(q_{ic})\mathbf{1}(q_{ic} < 0) + f_1(q_{ic})\mathbf{1}(q_{ic} \geq 0) + X'_{ic}\gamma + u_{ic} \quad (1)$$

  - Outcome H_{ic}: predicted probability of MCI, dementia, or their sum
  - Running variable q_{ic}: birth month relative to the country-specific reform cutoff
  - Treatment D_{ic}:
    - Years of schooling
    - Indicator for completing the post-reform minimum compulsory years of schooling
  - Covariates X_{ic}: sex, age, and fixed effects for birth month, interview month, interview year, and country
  - Standard errors are clustered at country × birth-month

First Stage of Post-Reform Mandatory Schooling Completion

Figure 1. First-stage regression of completed post-reform minimum years of schooling on months from the cutoff



Estimated Effects of Schooling on Cognitive Impairment Risk

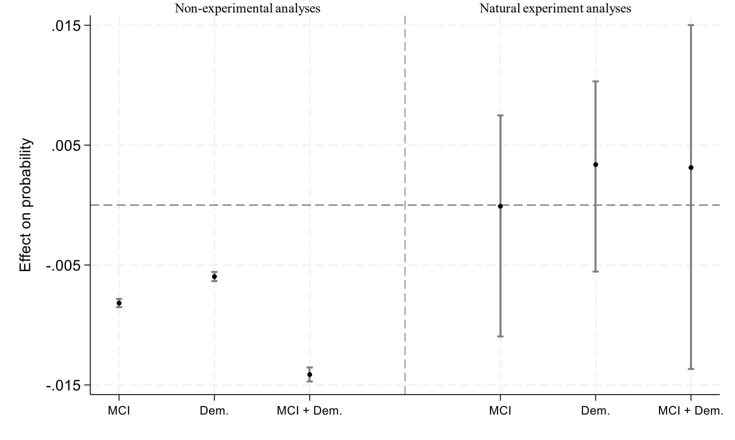


Figure 2. The left panel reports observational OLS estimates capturing the conditional association between years of schooling and cognitive impairment in later life. The right panel presents intention-to-treat (ITT) estimates that isolate variation in schooling induced by the compulsory schooling reform, with robust bias-corrected confidence intervals. While the observational estimates suggest that higher schooling is associated with a lower probability of cognitive impairment, the ITT estimates provide no evidence that reform-induced increases in compulsory schooling causally affect the risk of MCI, dementia, or their combined outcome.

Conclusions

- Reform-induced increases in compulsory schooling show no statistically detectable effect on clinically defined MCI or dementia in later life
  - Results are robust when focusing on marginal students with low predicted educational attainment, where the complier population is concentrated
  - Although small effects cannot be ruled out, the estimates reject large cognitive returns to compulsory schooling, implying limited scope for preventing clinical MCI or dementia at this margin