Social and Environmental Sources of Cognitive Decline in Adults

David Cutler, Harvard and NBER
Graeme Peterson, Harvard
and Susan Stewart, NBER

2023 CAPRA-NBER Scientific Meeting Abstract Submission

As the United States population ages, neurodegenerative conditions such as Alzheimer's disease and related dementias (ADRD) – and cognitive decline more generally – have become increasingly common (Manly et al., 2022; Rajan et al., 2021). Despite the growing importance of these conditions and a variety of hypotheses about their origins, the etiology of cognitive decline remains poorly understood, and there is limited understanding of how public policy can reduce its onset.

In this paper, we examine two commonly posited social and environmental contributors to cognitive decline: air pollution (Bishop et al., 2022; Nauze & Severnini, 2021) and education (Choi et al., 2022; Stern, 2012). We examine the impact of these potential contributors using data from the Health and Retirement Study (HRS). We use a battery of memory exercises in the HRS to build an index of cognitive function (as in Crimmins et al., 2011) and leverage the rich demographic and polygenetic information in the data to examine the causal impact of educational attainment and pollution exposure on cognition. We further consider subgroups with greater and lesser genetic predisposition to cognitive impairment.

Our pollution analyses focus on exposure to small particulate matter (PM2.5). Unlike previous analyses, which have focused largely on day-to-day variation in PM2.5, we construct longer-term exposure to pollution, including 1-2 years and up to 10 years. Observed pollution might vary with the business cycle, which might also affect cognition for other reasons. We thus instrument for observed pollution in an area with emissions data from U.S. electricity generation plants, holding constant potential electricity output. Our instrument is thus identified off of changes in pollution reduction technology (such as scrubbers) and changes in the inputs for electricity generation (coal v. natural gas). To deal with selective migration (higher income people moving out of more polluted environments), we use the history of living patterns to construct exposure to pollution for each person. To construct the instrument, we use a pollution transport model from the environmental engineering literature (Tessum et al., 2017) combined with power plant facility characteristics (Hernandez-Cortes et al., 2022) to generate plausibly exogenous estimates of PM2.5 exposure for every Census block in the U.S. from 1995-2018.

Our education analysis examines whether education has a protective effect on cognition; that is, do more years of education causally reduce cognitive decline? To make progress on this question, we use the HRS' detailed historical data on respondents' locations while of school age to link a subsample of our respondents to historical data on state compulsory schooling and child labor laws from 1910-1939 (Goldin & Katz, 2011). For each individual, we summarize these laws with a measure of the required years of education in their state at age 15 and use this to instrument for their educational attainment (Acemoglu & Angrist, 2000).

We find that air pollution has modest but significant effects on individuals' cognition. A 1 standard deviation decline in PM2.5 in the year prior to the survey improves cognition by about 2.5%, roughly 0.1 standard deviations. This average effect masks considerable underlying heterogeneity. For individuals in particularly high-risk groups – such as the oldest elderly, racial and ethnic minorities, and those in manual labor – a 1 standard deviation decline in PM2.5 improves cognition by 7-15%.

We further find that education has large, significant effects on individuals' cognition in old age. An (exogenous) additional year of schooling induced by compulsory schooling laws increases individual cognition by approximately 1 point on our 27-point index, an effect that is roughly 10% of mean cognition and 0.2 standard deviations for this subsample. We find that this effect is roughly equal across a number of subgroups, including individuals of differing ages and racial and ethnic groups.

References

Acemoglu, D., & Angrist, J. (2000). How Large Are Human-Capital Externalities? Evidence from Compulsory Schooling Laws. *NBER Macroeconomics Annual*, *15*, 9–59. https://doi.org/10.1086/654403

Bishop, K. C., Ketcham, J. D., & Kuminoff, N. V. (2022). Hazed and Confused: The Effect of Air Pollution On Dementia. *The Review of Economic Studies*, rdac078. https://doi.org/10.1093/restud/rdac078

Choi, E., Kim, S.-G., Zahodne, L. B., & Albert, S. M. (2022). Older Workers with Physically Demanding Jobs and their Cognitive Functioning. *Ageing International*, *47*(1), 55–71. https://doi.org/10.1007/s12126-020-09404-8

Crimmins, E. M., Kim, J. K., Langa, K. M., & Weir, D. R. (2011). Assessment of Cognition Using Surveys and Neuropsychological Assessment: The Health and Retirement Study and the Aging, Demographics, and Memory Study. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *66B*(Supplement 1), i162–i171. https://doi.org/10.1093/geronb/gbr048

Goldin, C., & Katz, L. F. (2011). Mass Secondary Schooling and the State: The Role of State Compulsion in the High School Movement. In D. L. Costa & N. R. Lamoreaux (Eds.), *Understanding Long-Run Economic Growth: Geography, Institutions, and the Knowledge Economy*. University of Chicago Press.

Hernandez-Cortes, D., Meng, K., & Weber, P. (2022). *Decomposing Trends in U.S. Air Pollution Disparities from Electricity* (No. w30198; p. w30198). National Bureau of Economic Research. https://doi.org/10.3386/w30198

Manly, J. J., Jones, R. N., Langa, K. M., Ryan, L. H., Levine, D. A., McCammon, R., Heeringa, S. G., & Weir, D. (2022). Estimating the Prevalence of Dementia and Mild Cognitive Impairment in the US: The 2016 Health and Retirement Study Harmonized Cognitive Assessment Protocol Project. *JAMA Neurology*, *79*(12), 1242. https://doi.org/10.1001/jamaneurol.2022.3543

Nauze, A. L., & Severnini, E. (2021). *Air Pollution and Adult Cognition: Evidence from Brain Training* (No. w28785; p. w28785). National Bureau of Economic Research. https://doi.org/10.3386/w28785

Rajan, K. B., Weuve, J., Barnes, L. L., McAninch, E. A., Wilson, R. S., & Evans, D. A. (2021). Population estimate of people with clinical Alzheimer's disease and mild cognitive impairment in the United States (2020–2060). *Alzheimer's & Dementia*, *17*(12), 1966–1975. https://doi.org/10.1002/alz.12362

Stern, Y. (2012). Cognitive reserve in ageing and Alzheimer's disease. *The Lancet. Neurology*, *11*(11), 1006–1012. https://doi.org/10.1016/S1474-4422(12)70191-6

Tessum, C. W., Hill, J. D., & Marshall, J. D. (2017). InMAP: A model for air pollution interventions. *PLOS ONE*, *12*(4), e0176131. https://doi.org/10.1371/journal.pone.0176131