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From risk prediction to causal policy: a decision-support platform for healthy ageing that separates confounded risk factors from modifiable social and systemic levers

Background

Europe is ageing and prevention budgets are finite, yet much guidance is correlational — and predictive models add a trap: a variable that predicts late-life disease is not necessarily one worth acting on. We ask which risk factors are causal and modifiable.

Methods

AETAS, built on the cohort-agnostic CAUSEWAY framework (described elsewhere), is deployed on the observational SHARE panel (≈160,000 adults aged 50+, 28 countries; waves 4–8 + COVID surveys + a regional exposome). It couples predictive risk stratification; a causal layer (Double Machine Learning, negative controls, Oster δ, E-values, Holm correction, and a "Causal Firewall" that refuses to estimate under severe confounding); and a policy layer turning effects into health–cost–equity trade-offs via Monte-Carlo and multi-objective optimisation.

Findings

Predictive models rank fine-particulate air pollution (PM2.5) among top features, yet causal adjustment nulls it: long-term regional PM2.5 shows no detectable effect on late-life disease across ~12 cohorts (0 of 44 tests survive correction), while the same engine detects the smoking–COPD control everywhere. What survives is social and systemic: everyday ageism prospectively drives worsening depression ($\beta \approx +0.37$; Oster $\delta = 4.1$, E-value 1.68; survives Holm); life-course persecution drives depression (Spanish Civil War cohort, $p < 10^{-5}$, $\delta = 13.9$); and pre-pandemic chronic-disease burden drove loss of care during COVID, surviving age, sex, education, income — those who lost care were more often hospitalised a year later. In the policy layer the pollution lever pays nothing; anti-ageism is fiscally efficient, care-continuity the equity lever.

Significance. Rigour redirects prevention from a confounded pollution target toward modifiable social and systemic levers — anti-ageism as clinical prevention, and care continuity for the multimorbid — with a path to cross-cohort extension (HRS, ELSA, CHARLS)

Keywords: healthy ageing; causal inference; ageism; continuity of care; COVID-19; multi-objective policy optimisation; SHARE cohort

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Biography

Alina Fedorova is a bioinformatician and longevity researcher leveraging her background in computational physics and population genetics. She applies machine learning and statistical modeling to large-scale health data to investigate the mechanisms of aging. Her research interests include genomic diversity, positive selection, and developing personalized longevity and health strategies, including organ-specific aging trajectories

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