Lifetime Trajectories and Drivers of Socioeconomic Health Disparities: Evidence from Longitudinal Biomarkers in the Netherlands

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Jan 9, 2025

Outline

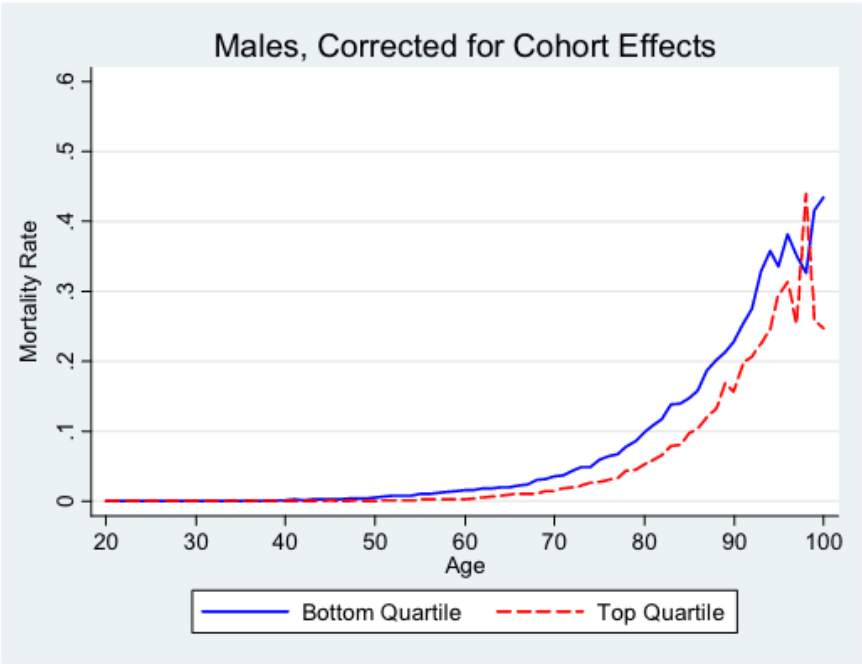
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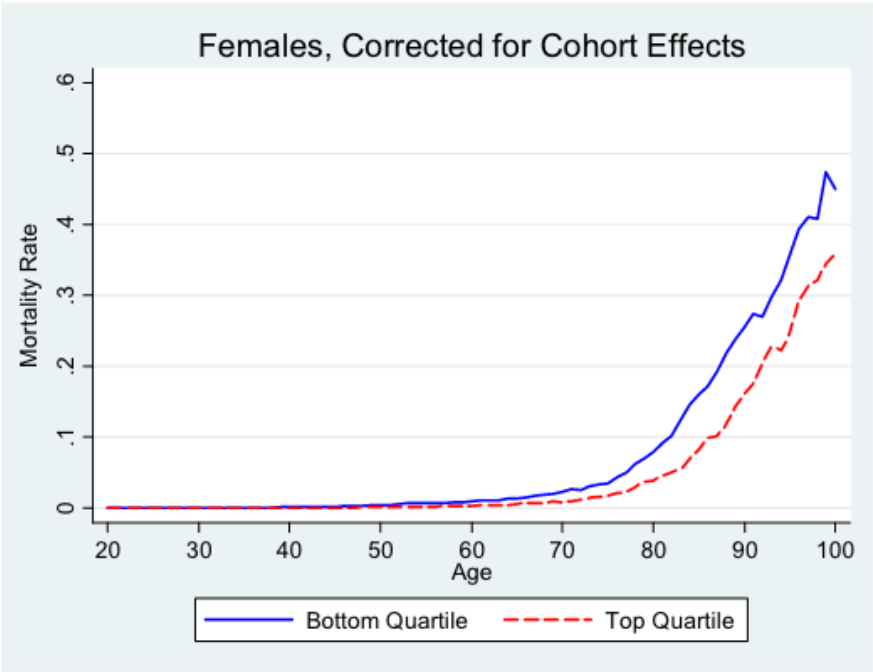
Motivation

- Substantial health disparities exist over the lifespan and across the individuals:
  - Reducing the health gap is a common goal.
- Many existing studies measuring health disparities use metrics such as mortality or self-rated health:
  - Mortality often becomes apparent only later in life,
  - Self-rated health is inherently subjective and non-specific.
- Limited knowledge exists regarding health disparities before they are clinically diagnosed.

Mortality rate by age and current income in the NL

Absolute mortality rate





Source: Van Kippersluis et al., 2010

The role of biomarkers

- Biomarkers are objective, quantifiable indicators of biological processes.
- The dynamic of biomarkers is often linked to the aging process, onset of diseases, and mortality.
- Biomarkers provide objective measures and can indicate medical conditions before a clinical diagnosis is reached.
- Offer policy insights for early interventions before diseases fully develop.

Sketch of Literature

- Socioeconomic health disparities:
  - Morbidity (Cutler & Lleras-Muney, 2006; Kivimäki et al., 2020; Pallesen et al., 2024; Danesh et al., 2024)
  - Mortality/life expectancy (Deaton, 2003; Van Kippersluis et al., 2010; Chetty et al., 2016)
  - Self-rated health (Van Kippersluis et al, 2010; Van Ooijen et al., 2015)
- Biomarkers and allostatic load
  - Health disparities in biomarkers (Kavanagh et al., 2010; Davillas & Jones, 2020)
  - Allostatic load (Seeman et al., 2004; Carrieri et al., 2020)
- The determinants of health disparities
  - Health-related behaviors and lifestyles (Adler & Stewart, 2010; Suvarna et al., 2020; Danesh et al., 2024)
  - Early life conditions (Van den Berg et al. 2010; Alessie et al., 2019)
  - Environmental exposure (Danesh et al., 2024)

Research questions and contribution

- Research questions:
  - Do patterns in biomarkers predict the onset of chronic disease burden?
  - Is the socioeconomic health gap already visible in biomarkers at lower ages?
  - To what extent are those biomarkers driven by modifiable (lifestyle) factors?
- Additional contributions:
  - Leverages large-scale biomarker data to examine the biological health prior to reaching the diagnosis.
  - Employs objective measurements to analyze socioeconomic health disparities across the life cycle.

Overview of the Dutch Lifelines cohort study and biobank

- A large-scale longitudinal cohort study conducted in the northern Netherlands:
  - More than 167,000 participants at baseline in 2006, representing approximately 10% of the population,
  - Currently includes 3 waves of biomarker measurements,
  - Participants range in age from 18 to over 80 years,
  - Includes family connections.
- Repeated measures of various biomarkers, including:
  - Anthropometry (e.g., body measurements)
  - Blood pressure
  - Electrocardiogram (ECG)
  - Biomaterial collection (fasting blood and urine)
  - Lung function
- Comprehensive survey data:
  - Demographic and socioeconomic status.
  - Health-related behaviors.
  - Information on diseases, medication use, and mortality.

Allostatic load index

- Concept: Allostatic load measures the cumulative dysregulation of physiological systems in response to social and environmental stress (Seeman et al., 1997, 2004).
- We create an index based on 12 biomarkers:
  - Cardiovascular system (n=3): systolic blood pressure, diastolic blood pressure, ECG heart rate.
  - Metabolic system (n=8): body mass index, waist-to-hip ratio, total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, glycosylated hemoglobin, glucose, triglycerides.
  - Kidney function (n=1): creatinine.

Allostatic load index

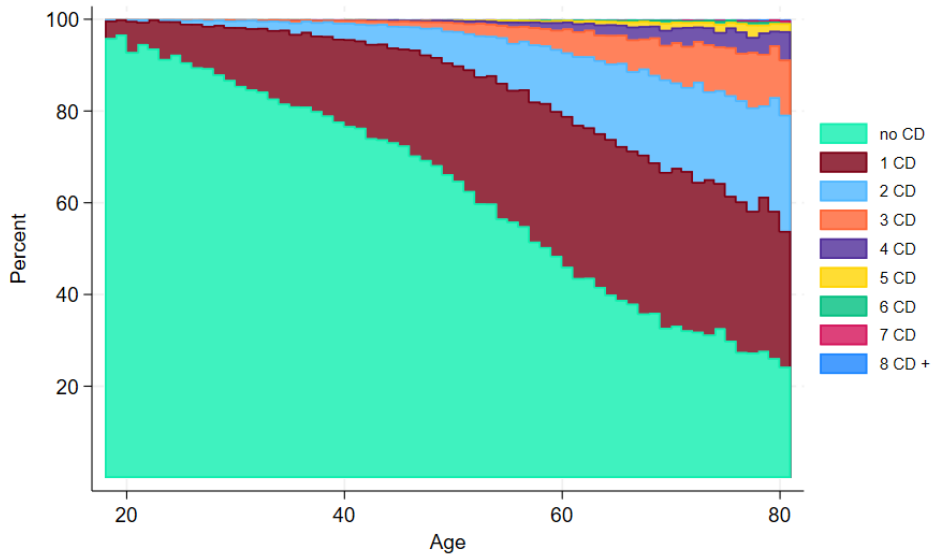
- Clinically established threshold cut points are applied for each biomarker.

$$ALindex_{i,a} = \sum_{k=1}^{12} I_{i,a}^{k} \tag{1}$$

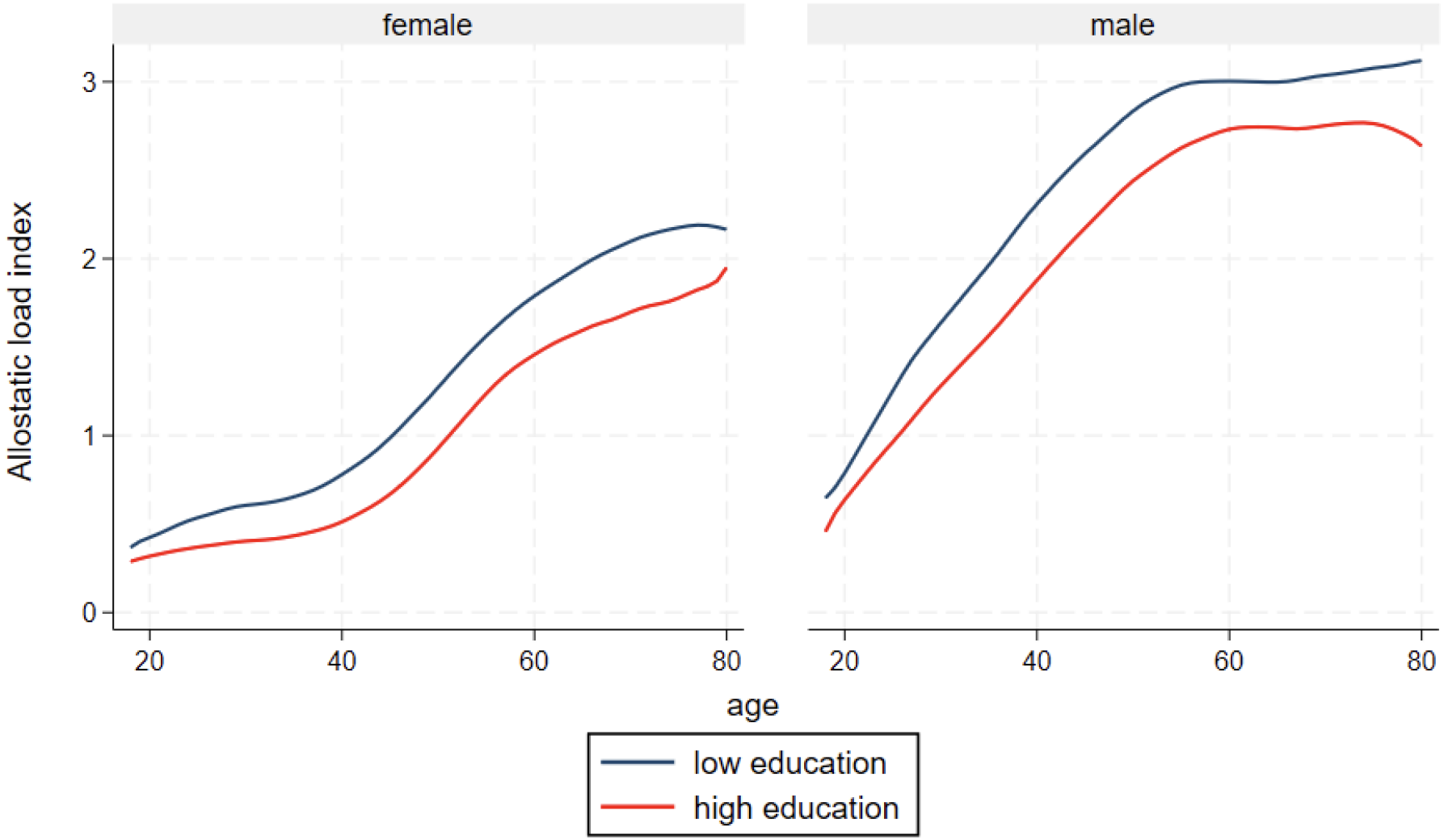
- Higher ALI scores indicate greater physiological stress.

Allostatic load index and aging-related chronic disease index





Educational allostatic load disparities by age and gender



Regression analysis

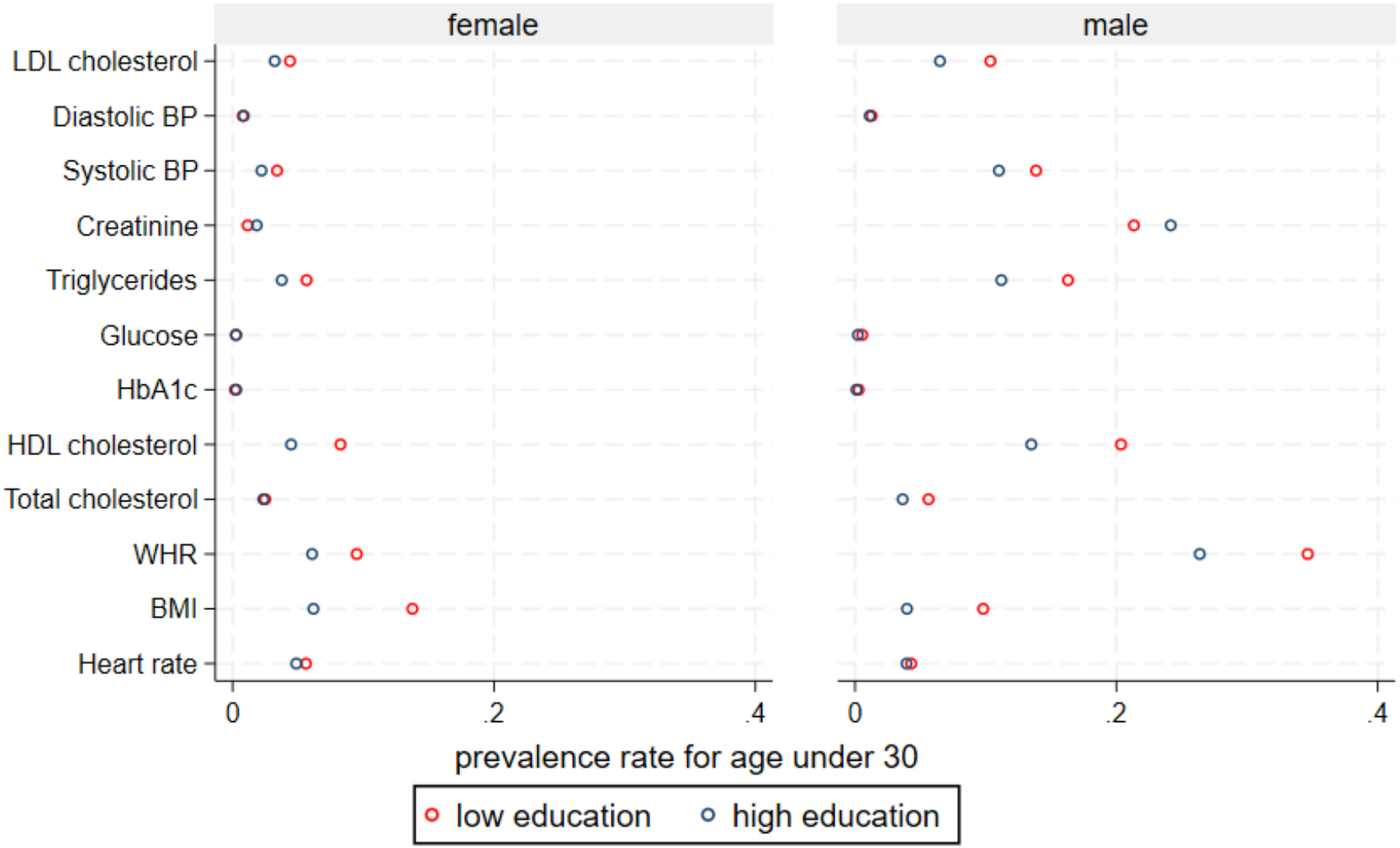
Regression Results of Chronic Disease on Allostatic Load

	25-34		35-44		45-54	
	(1)	(2)	(1)	(2)	(1)	(2)
ALI	0.024***		0.048***		0.056***	
	(0.004)		(0.003)		(0.002)	
ALI_{a-t}		0.033***		0.051***		0.070***
		(0.005)		(0.003)		(0.003)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,287	8,287	20,789	20,789	40,046	40,046
R-squared	0.019	0.025	0.027	0.037	0.027	0.041

	55-64		65-74	
	(1)	(2)	(1)	(2)
ALI	0.068***		0.075***	
	(0.004)		(0.005)	
ALI_{a-t}		0.086***		0.072***
		(0.004)		(0.006)
Controls	Yes	Yes	Yes	Yes
Observations	30,120	30,120	16,898	16,898
R-squared	0.041	0.057	0.031	0.039

Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Controls are age, age squared, gender, cohort, urban, province, and survey year.

The gender gap in biomarkers at ages below 30



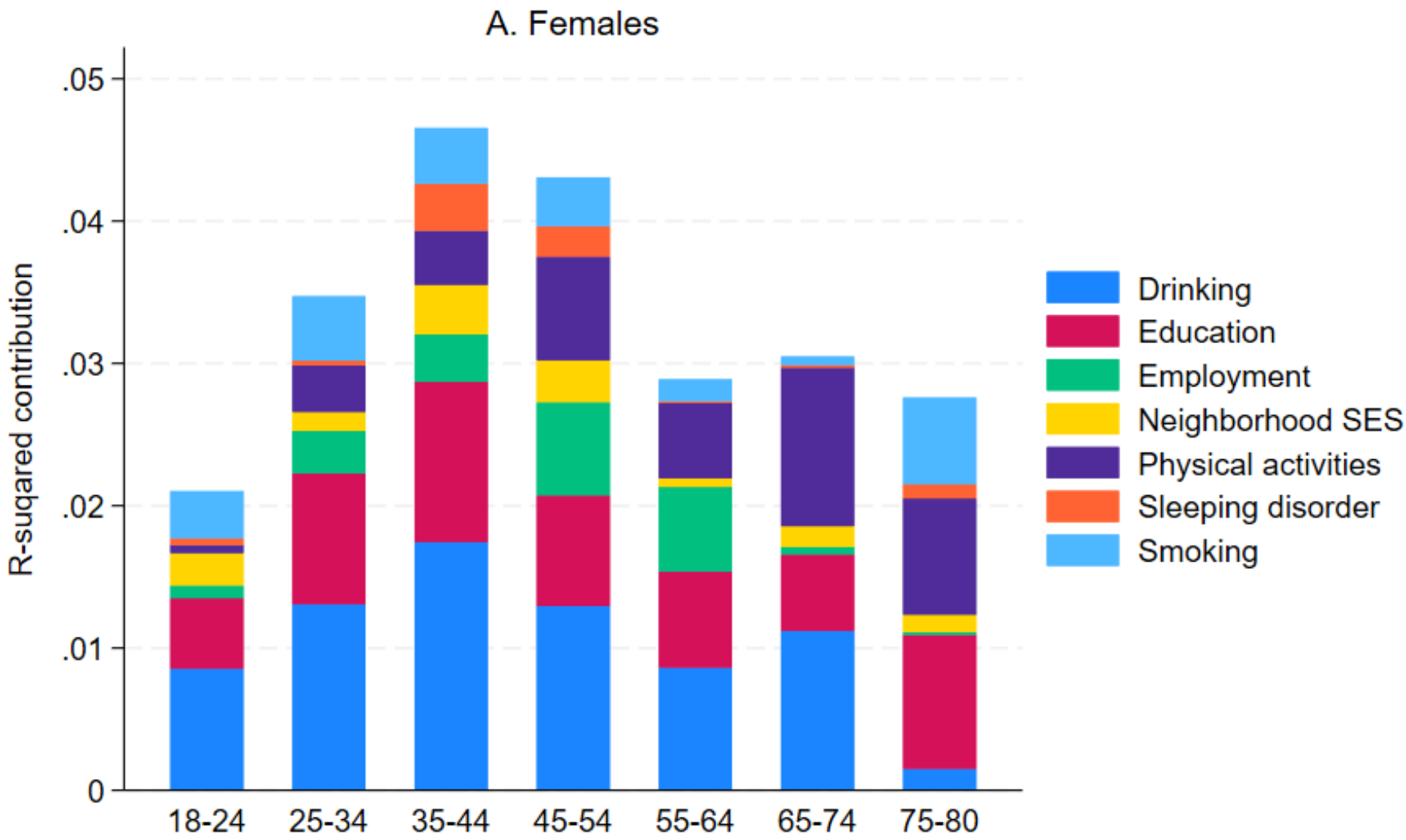
A framework

- We employ a linear regression for different 10-year age bins:

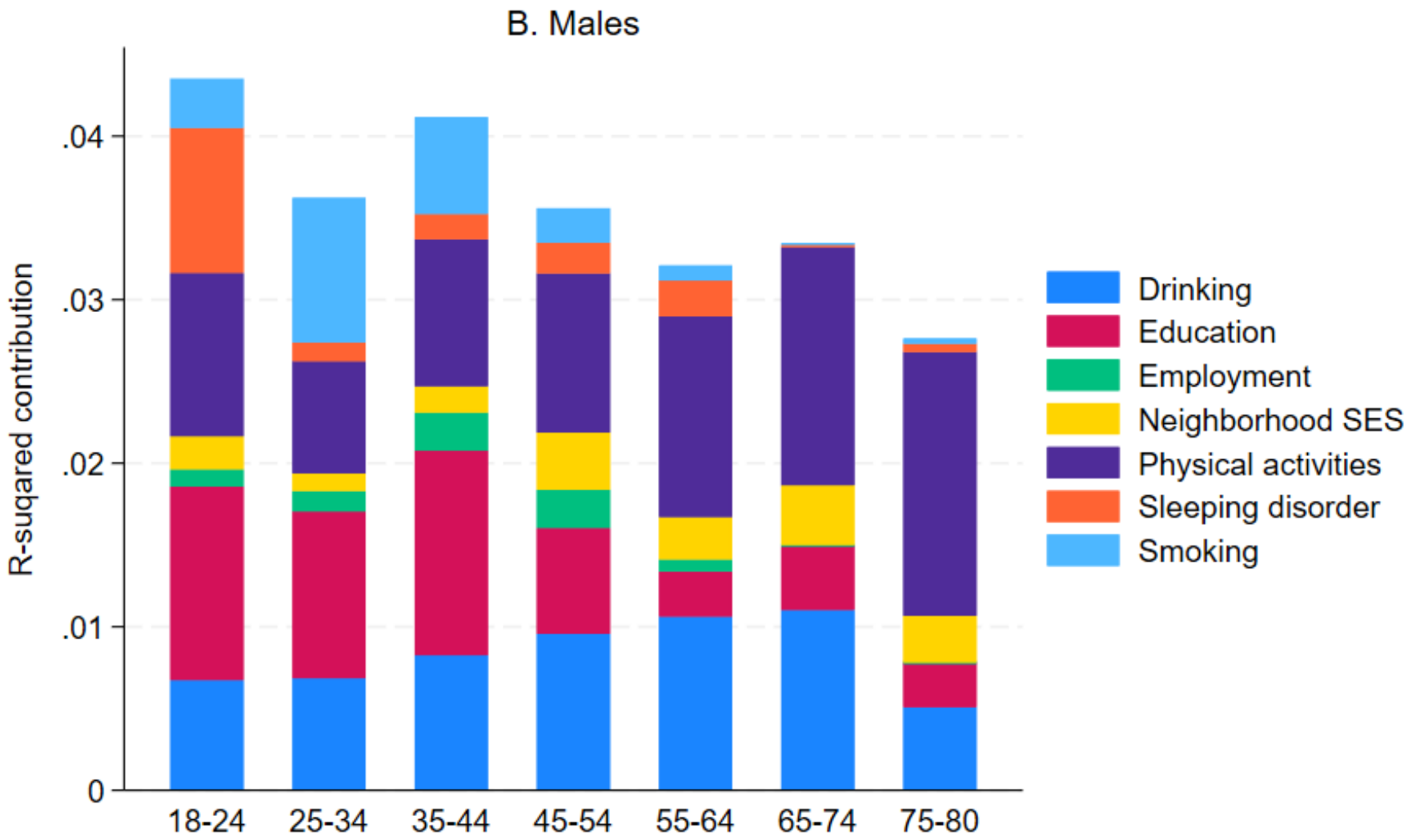
$$ALI_{i,a} = \sum_{j=1}^{J} X_{i,a}^{j} \gamma_{j,a} + \epsilon_{i,a} \tag{2}$$

- Where:
  - $ALI_{i,t}$ is the level of the current allostatic load index,
  - $X_{i,t}$ is a vector of factors, including health behaviors, educational attainment, employment status, and neighborhood SES.
- Then, we decompose the total R-squared of this regression based on Shapley-Owen values (Huettner & Sunder, 2012):-
  - This method calculates the average contribution of each regressor to R-squared among all possible regression sequences.

The contribution of factors for allostatic load



The contribution of factors for allostatic load



Take away for current analysis

- Biomarker-related health risks emerge early in adulthood, preceding aging-related chronic disease.
- Biomarker-related socioeconomic health disparities emerges early in adulthood, widens with age, and peaks in late middle age.
- Health behaviors play an important role in allostatic load.
- There are clear gender differences in the life cycle pattern and drivers of biomarker-related risks.

Limitations and Next Steps

- Limitations:
  - The results may be influenced by the number and types of biomarkers we selected.
  - The current analysis does not account for time-varying confounders.
  - The analysis does not consider the impact of factors such as environmental exposure and early life conditions in the decomposition analysis.
- Next Steps:
  - Future analyses will focus on accounting for confounders in the analysis:
    - Robustness analysis shows that using parental education gives rise to qualitatively similar findings.
  - We aim to capture biological aging speed based on our dynamic biomarkers.

Thanks!