Breathing Clean Air, Remembering Better: A Cross-Regional Study of Air Quality and Episodic Memory in European Older Adults

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Introduction

Shedding light on the relationship between environmental factors and population's health is gaining relevance in recent research. Moreover, older adults as a highly vulnerable group to environmental factors and climate change are of particular interest. The aim of this study is contributing to the research gap by investigating the association of air pollution and cognitive functioning of older adults across European regions.

Air quality is a pressing global concern with profound implications for both human health and the environment (Manisalidis et al. 2020). It is well-established that exposure to air pollution such as particulate matter is associated with a wide range of adverse health outcomes, including respiratory diseases, cardiovascular issues, and even premature mortality (Cohen et al. 2017). The impact of air pollution on cognitive health is a subject that has garnered increasing attention in recent years (Chandra et al. 2022; Delgado-Saborit et al. 2021). However, research on air pollution and older adults' cognitive functioning as one of the most vulnerable groups is only scarce.

The share of older adults is increasing in most countries across the world and even more so in urban areas (Duminy et al. 2023; United Nations 2022). Furthermore, older adults are becoming a more substantial segment of the society, therefore understanding the factors that influence their cognitive health has become paramount. Episodic memory, in particular, is a crucial component of cognitive functioning, which plays a pivotal role in daily life activities and thus contributes to an individual's quality of life, independence and wellbeing.

So far, research has shown that individual factors such as education, age, and health behavior are associated with episodic memory (Engelhardt et al. 2008; Nisbett 2009). Additionally, contextual and societal factors, including regional development and societal equality, have been identified as beneficial for cognitive functioning of older adults (Breda et al. 2018; Weber et al. 2014). However, the role of environmental factors, particularly air pollution, remains an under-investigated dimension in understanding the complexities of cognitive health in this vulnerable demographic group (Ailshire and Clarke 2015; Delgado-Saborit et al. 2021). This study seeks to bridge this knowledge gap by delving into the intricate relationship between air pollution and the cognitive functioning of older adults in European regions, shedding light on the potential impact of environmental quality on their well-being and offering insights for more targeted interventions and policy measures.

Data and Variables:

Air pollution data was obtained from the WHO_2021_AQG_Scen_Base scenario of the Air Quality Health Risk Assessments (European Environment Agency 2022). The dataset contains observational values of the concentration of air pollutants, such as PM2.5, PM10 and O3, at the different NUTS level by the degree of urbanization.

Furthermore, we used data from seven waves of the Survey of Health, Ageing and Retirement in Europe (SHARE), which is a representative cross-national longitudinal survey of populations aged 50 or older in the selected European countries (Bergmann et al. 2019; Börsch-Supan et al. 2013). SHARE provides not only detailed information on its participants' socioeconomic characteristics but also their cognitive status and geographical location, therefore it is particularly suitable for our purposes.

The study sample is derived from seven out of eight waves of SHARE (those having information on the geographical location), covering the period from 2004 to 2019 and excluding the third wave (i.e., the year 2008/2009) that focused on life-history and doesn't include the variables of interest. Additionally, we excluded respondents younger than 50 years old, as well as those who with missing data on individual-level covariates. The final sample consists of 265,111 observations.

Cognitive functioning is addressed by an episodic memory test, where participants are asked to recall (immediately and delayed) as many nouns as possible out of 10 read out words. Episodic memory stands out as the cognitive function that starts deteriorating relatively early and exhibits varying degrees of severity over time, therefore it is widely accepted as an important indicator of healthy and sustainable ageing (Herlitz and Rehnman 2008; van Rossum et al. 2010; Weber et al. 2014). We used the participants' total memory score that sums the numbers of correctly recalled words in the immediate and delayed recall tests and ranges from 0 to 20, with higher values indicating better cognitive functioning.

As a measure of air pollution, we used the average concentrations of annual PM10 (particulate matter 10 micrometers or less in diameter, in μg/m3). Each SHARE observation was matched with the average air pollutant concentrations of their corresponding survey year, NUTS level, and degree of urbanization combination, where NUTS level is the most detailed level between NUTS2 and NUTS3 that the observation presents. Observations where only NUTS1 or no-NUTS information is available are dropped from the sample because the intensity of their air pollutant exposure could not be assessed properly.

We used three sets of individual-level covariates including information on demographic and socioeconomic characteristics, as well as physical health status. Demographic information included gender, age, and marital status comprising single (never married, divorced, widowed, or separated) and partnered (married or living with a partner). Socioeconomic characteristics included the level of education (divided into three categories based on ISCED classification: no education (ISCED 1, 2), medium (ISCED 3), and high (ISCED 4+)); current employment status (two categories: "working" if employed or self-employed and "not-working" if retired or unemployed or permanently sick or disabled or homemaker); and wealth (in quintiles). Measures of physical health status included the Body Mass Index (BMI) and binary indicator of physical activity limitation (based on the global activity limitation indicator, namely GALI). Behavioral risk factors such as smoking, alcohol consumption, and physical inactivity are not included because of the high number of missing observations.

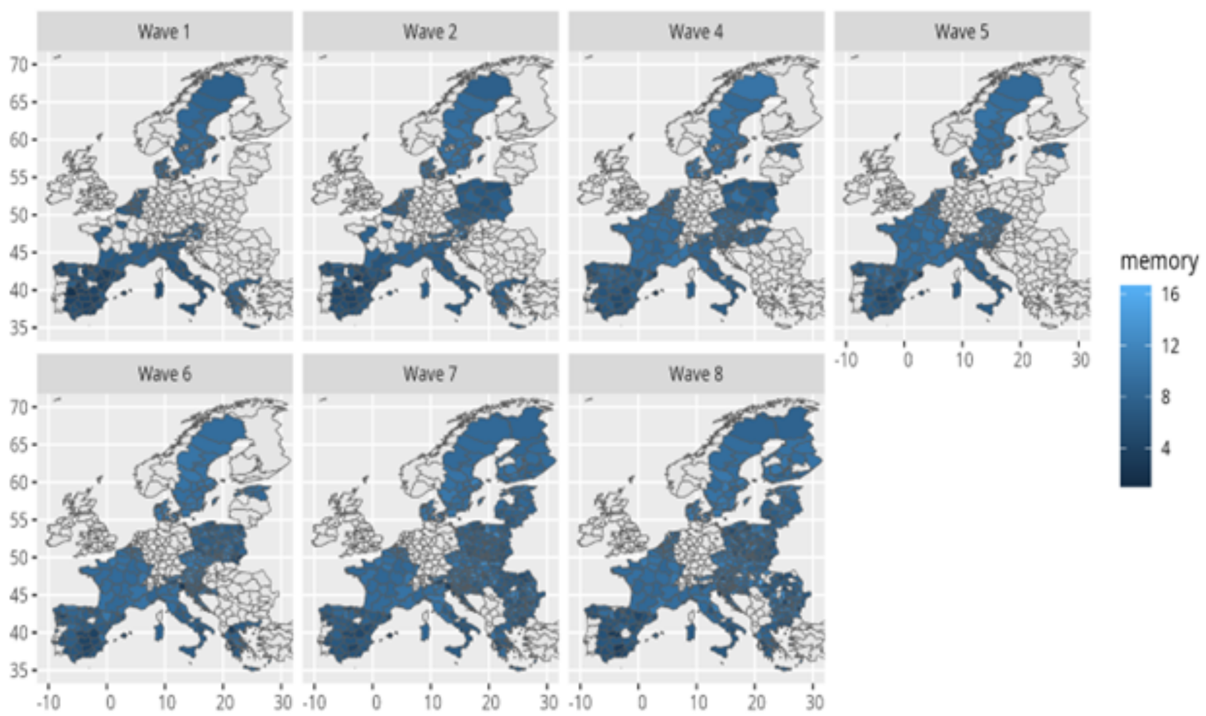
Analytical Strategy

We use multilevel linear regression models for the longitudinal analysis of the association between the levels of concentration of air pollutant PM10 and cognitive functioning considering a random intercept. Given the hierarchical structure of the data we distinguish three-levels with individuals (level 1) nested in NUTS3 regions (level 2) and countries (level 3). Employing a sequential adjustment approach, we define three models with different levels of adjustment. The first model was adjusted for demographic characteristics. The second model was additionally adjusted for socioeconomic measures. The third model (hereafter referred to as the main model) incorporates physical health indicators. Each model also counts for fixed time effects. We also conducted gender-based stratified analyses and controlled for the effects of the interaction between gender and air pollution exposure. To test the sensitivity of the findings, we explored different model specifications and various control variables.

Preliminary results:

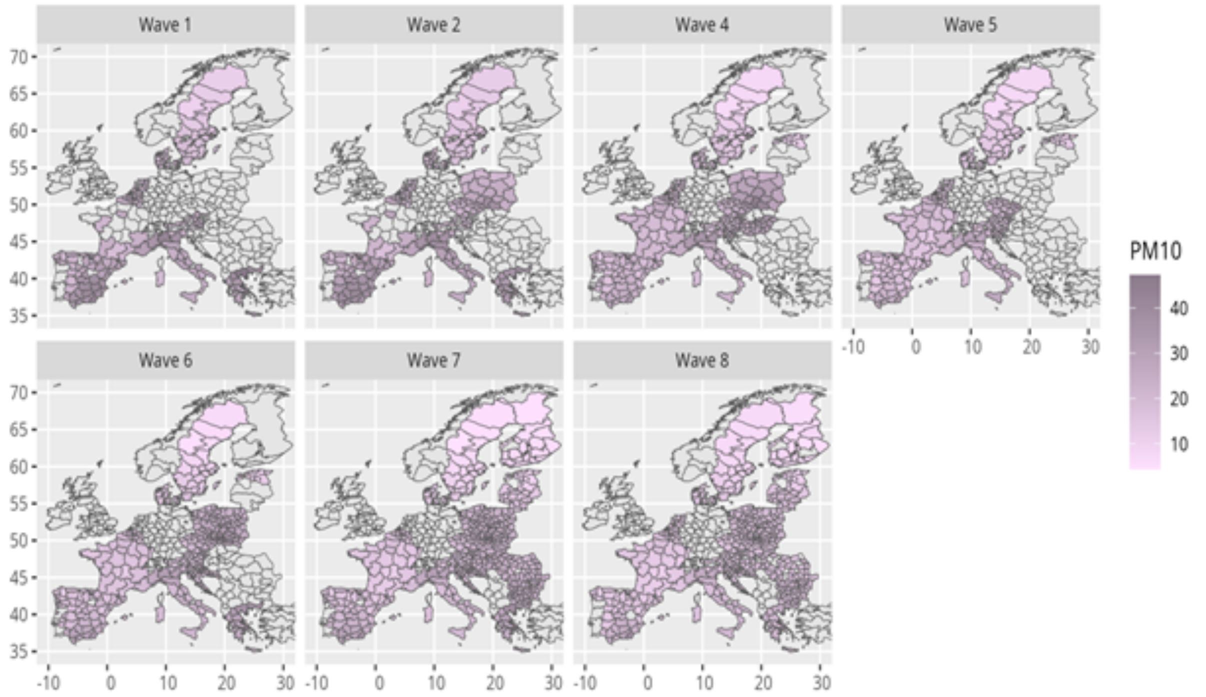
Descriptive investigations show the spatial distribution of the average memory scores in our sample at different years (Fig. 1). We can see variation across and within countries. Further, also the mean PM10 values vary across and within European countries (Fig. 2).

Figure 1: Mean episodic memory scores at different regions and years



Preliminary findings of our multilevel regressions of cognitive functioning measured by the total memory score are presented in Table 1. We find negative and significant association between the exposure to PM10 and memory test score meaning that the cognitive functioning of older adults living in the higher concentrations of PM10 deteriorates more than their counterparts living in the less polluted area.

Figure 2: Spatial distribution of average concentrations of annual PM_{10} ($\mu g/m^3$) per wave.



The marginal effect of PM10 on cognitive test score ranges from 0.005 to 0.011 across different models. The strength of this association increases as more covariates are included in the analysis. When examining coefficients of the covariates, we observe that cognitive function weakens with age. However, the extent of this effect is limited for individuals who are currently working as well as those with the higher levels of education and household wealth. Finally, females exhibit a higher cognitive performance compared to their male counterparts, as also demonstrated in previous studies.

	Mod. 1			**Mod. 2**			**Mod. 3**		
	β		SE	β		SE	β		SE
Intercept	17,056	***	0,095	16,962	***	0,098	16,554	***	0,108
Annual PM10 exposure (mg/m^3)	-0,005	*	0,002	-0,011	***	0,002	-0,011	***	0,002
Age (years)	-0,154	***	0,001	-0,132	***	0,001	-0,125	***	0,001
Female	0,561	***	0,016	0,681	***	0,015	0,710	***	0,015
Marital Status (Ref:Single)									
Married & Partnered	0,424	***	0,017	0,246	***	0,017	0,215	***	0,017
Education (Ref: High (post-sec.+))									
Low (lower secondary or less)				-2,133	***	0,021	-2,083	***	0,021
Medium (upper sec. completed)				-0,958	***	0,020	-0,949	***	0,020
Wealth Quintiles (Ref: Q1)									
Q2				0,159	***	0,020	0,147	***	0,020
Q3				0,296	***	0,021	0,275	***	0,021
Q4				0,471	***	0,022	0,440	***	0,022
Q5 (Highest)				0,645	***	0,023	0,604	***	0,023
Employ. Status (Ref: Not Working)									
Working				0,047		0,018	0,022		0,018
Body Mass Index (BMI)							0,008	***	0,002
Activ. Limitations (Ref: Limited)							-0,431	***	0,013

Table 1: Results of the linear multilevel model for episodic memory controlling for survey wave.

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