

A BBRC study links air pollution to early signs of neuroinflammation in people at risk of Alzheimer's disease, particularly in women

- The study, published in *Alzheimer's & Dementia: The Journal of the Alzheimer's Association* analyses these biomarkers longitudinally and identifies changes in astroglial and neuroinflammatory processes associated with exposure to pollutants, with differences by sex.
- The findings suggest that chronic exposure to traffic-related air pollution is associated with increases in GFAP, a biomarker of astroglial reactivity, and IL-6 protein, an inflammatory marker, primarily in women.
- The research was carried out using data from 226 cognitively unimpaired individuals, most of whom were at increased risk of developing Alzheimer's disease, from BBRC's ALFA+ cohort, with support from "la Caixa" Foundation.



Barcelona, October 14, 2026 -Air pollution is a well-established environmental risk factor for cardiovascular and respiratory health, and evidence of its impact on the brain is becoming increasingly robust. In fact, the [2024 Lancet Commission](#) report on dementia prevention already includes **air quality among the 14 modifiable risk factors associated with Alzheimer's disease**, with an estimated contribution of nearly 3% of dementia cases worldwide. However, its specific role in the preclinical, asymptomatic stages of the disease had been little explored.

Now, a study led by researchers at the Barcelonaβeta Brain Research Center (BBRC), the Pasqual Maragall Foundation's research centre, **has provided the first scientific evidence in cognitively**

unimpaired individuals of a direct relationship between chronic exposure to air pollutants (nitrogen oxides and particulate matter [PM10 and PM2.5]) and biomarkers of Alzheimer's disease and neuroinflammation in cerebrospinal fluid (CSF).

The study, published in the journal *Alzheimer's & Dementia: The Journal of the Alzheimer's Association* reports findings consistent with the hypothesis that air pollution may promote neuroinflammatory processes and astroglial responses. Previous studies have proposed both direct pathways, such as the olfactory route, and indirect pathways through systemic inflammation and oxidative stress.

Over three years, the study followed **226 cognitively unimpaired individuals from the Barcelona metropolitan area in the ALFA+ cohort at BBRC**, with support from "la Caixa" Foundation. The ALFA+ cohort follows people without cognitive impairment, most of whom have a family history of Alzheimer's disease. Data on Alzheimer's disease biomarkers in cerebrospinal fluid were cross-referenced with air quality data using the methodology developed by the European [ESCAPE](#) project, an initiative that brings together more than 30 European cohort studies to quantify the impact of air pollution on health.

GFAP and IL-6, Two Indicators of the Brain's Response to Pollution

One of the study's main findings is the association between greater exposure to air pollution and a longitudinal increase in **GFAP** (glial fibrillary acidic protein). GFAP is **a protein associated with astrocyte reactivity**. Astrocytes are glial cells that help maintain and protect neurons and can become activated by different types of stress or damage, such as pollution. When activated, they release this protein.

In Alzheimer's disease, astrocytes can shift from this normal state and become 'reactive'. When this happens, GFAP levels rise; therefore, **elevated levels of the marker indicate that this astroglial activation is taking place**.

The study also analysed IL-6, a cytokine involved in inflammatory signalling. The analyses identified differences by sex in how pollution-associated IL-6 levels changed over the three years of follow-up. Taken together, the **GFAP and IL-6 findings point to astroglial and neuroinflammatory responses associated with exposure to traffic-related pollution, particularly in women**.

Furthermore, in women, the increase in GFAP partially explained (approximately **5% to 10%**, depending on the pollutant and cognitive domain) the association between greater exposure to pollution and declines in **attention and executive function**. The findings therefore point to astrocyte reactivity as one of the possible pathways that could link air pollution to cognitive changes.

'Our findings suggest that astrocyte activation could form part of the biological pathways linking exposure to air pollution to cognitive changes, and that these responses may differ between women and men. This is a first step towards understanding why, at the same level of exposure, some people are more vulnerable', explains Dr Blanca Rodríguez, researcher and co-author of the study.

Another important aspect of the study is that these associations are independent of APOE ε4 status and classical biomarkers of the disease, such as amyloid-β and tau. The absence of associations with typical Alzheimer's biomarkers may indicate that **pollution-induced neuroinflammatory processes emerge early or in parallel with the classical pathological changes of Alzheimer's disease at preclinical stages.**

A Modifiable Risk Factor

These findings add to a growing body of evidence showing that air pollution affects not only cardiovascular health but also brain health, and they have important implications for public health: reducing pollution could provide long-term preventive benefits for brain health at population level.

The study provides new evidence and reinforces the view that **air pollution is an important modifiable risk factor relevant to dementia prevention, particularly in women.** Policies aimed at reducing traffic-related emissions may help reduce this risk.

'Although these findings will need to be replicated in larger and more diverse cohorts, our findings reinforce the importance of reducing exposure to traffic-related pollution to support brain health. In addition, observing that the association between pollution and the indicators studied may differ between women and men helps us better understand which groups may be especially vulnerable to its effects', adds **Dr Natàlia Vilor-Tejedor**, first author of the study and Molecular Epidemiology and Data Science Group Leader at BBRC.

The research team notes that the study has some limitations typical of this early stage, including a small male sample, which may have made it harder to detect similar effects in men, and the fact that exposure was measured solely on the basis of residential address, without accounting for travel or exposure to pollutants at work. Future research will include the use of portable sensors for more precise, individualized monitoring.

Reference article: Vilor-Tejedor, N., Rodríguez-Fernández, B., Genius, P., Fernández-Bonet, A., González-Escalante, A., Brugulat-Serrat, A., Sanchez-Benavides, G., Cumplido-Mayoral, I., Minguillón, C., Cirach, M., Nieuwenhuijsen, M., Kollmorgen, G., Quijano-Rubio, C., Zetterberg, H., Blennow, K., Navarro, A., Suárez-Calvet, M., Gispert, J. D., & ALFA Study. (2026). Air pollution is associated with sex-specific longitudinal changes in astrocytic and neuroinflammatory processes linked to cognitive decline in Alzheimer's disease at-risk individuals. *Alzheimer's & Dementia*. <https://doi.org/10.1002/alz.71837>

Alzheimer's in figures

Currently in Spain, it is estimated that Alzheimer's disease and other dementias affect between 850,000 and 950,000 people, a figure that translates to one in ten people over the age of 65 and one in three of those over 85. These conditions are among the leading causes of mortality, disability, and dependency. If no effective cure is found and, with life expectancy increasing, by 2050 the number of cases could triple worldwide, exceeding one and a half million people in Spain alone, a situation that could overwhelm healthcare and social care systems.

About the Barcelonaβeta Brain Research Center and the Pasqual Maragall Foundation

The Barcelonaβeta Brain Research Center (BBRC) is the research center of the Pasqual Maragall Foundation dedicated to the prevention of Alzheimer's disease and the study of cognitive functions affected in healthy and pathological aging. BBRC's research focuses on the preclinical stage of Alzheimer's, a period prior to the appearance of the first

symptoms, when changes in the brain associated with the disease are already occurring. The BBRC, supported by the "la Caixa" Foundation since its creation, has more than 150 professionals dedicated to contributing to the forefront of research on Alzheimer's and other neurodegenerative diseases.

The Pasqual Maragall Foundation is a non-profit organization founded in April 2008 as a response to the commitment made by Pasqual Maragall, former mayor of Barcelona and former president of the Government of Catalonia, when he publicly announced that he had been diagnosed with Alzheimer's disease. The Foundation's mission is to promote research to prevent Alzheimer's and contribute to social transformation by improving the quality of life of affected individuals and their families, as well as raising public awareness about the disease.

The Pasqual Maragall Foundation has the support of more than 115,000 members and:



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