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Short-term effects of ultrafine particles on mortality

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Particulate matter (PM) was estimated to cause 4.2 million deaths worldwide in 2019; however, evidence on which components are responsible for its effects on mortality remains inconsistent. Ultrafine particles (UFP, < 100 nm in diameter), the smallest fractions of PM, have the potential to individually harm health as they are small enough to reach multiple organs of the human body in contrast to larger fractions. To efficiently decrease the effects of PM on health, it is crucial to understand which PM components pose the highest health risks and to tackle them in future regulations.

In this study, we aim to quantify the short-term effects of PM properties and components on mortality from natural, cardiovascular and respiratory causes. We associated daily concentrations of different PM properties and components (including UFP size fractions, UFP sources, black carbon, lung deposition surface area, PM_{2.5} (<2.5µm) and PM₁₀ (<10µm)) with daily counts of mortality from 12 EU cities using quasi-Poisson single and multi-pollutant regression models (Generalized non-linear model framework). The models were adjusted for seasonal and long-term trends, temperature (cold and warm days), relative humidity, bank holidays and day of the week. The effects of lagged exposure (0-7 days) and lagged temperature were also evaluated. To minimize the impact of different analytical methodologies, measurements were conducted following a standardised protocol in all cities, particles were size classified consistently, and all the data was treated by the same research team.

A random effect meta-analysis was carried out to average the effects across all EU cities. The preliminary results reported here focus on the health effects of different particle size fractions and are based on seven cities (Athens, Barcelona, Budapest, Granada, Helsinki, Madrid and Zurich). The remaining cities will be analysed in situ and included in the meta-analysis soon.

Our meta-analysis of single pollutant models suggests that nearly all particle size modes (e.g., nucleation (10-25 nm), Aitken (25-100nm), UFP (<100nm), Ntotal (>10nm) and N25 (>25 nm) are associated with significant increases in relative risk (RR) of natural and cardiovascular disease mortality, at lags 0 to 3. For example, an interquartile range increase in UFP (IQR: 3804 particles/cm³) was associated with a 0.8% [95% confidence interval: 0.2%, 1.5%] increase in natural mortality and 1% (95% confidence interval: 0.2%, 1.8%) in cardiovascular mortality. A significant risk of cardiovascular mortality was also observed 4-6 days after exposure to most particle size

modes. We did not find significant associations between particle modes and respiratory mortality.

The Nucleation, Aitken, UFP and Ntotal (>10 nm) modes showed similar results, indicating that both UFP and Ntotal (>10 nm) could potentially be used as indicators for the health effects of the smallest aerosol size fractions, dominant in number. The health effects of the UFP mode remained statistically significant for natural mortality after adjusting for PM_{2.5}. Similarly, the effects of the UFP mode remained significant for natural and cardiovascular mortality after individually adjusting for PM₁₀ and NO₂.

Our preliminary results suggest that the smallest aerosol particle size fractions (e.g., UFP) may independently impact health.

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