Association of ultrafine particle exposure with lung and neuro-cognitive functions in elementary school children in the Berlin-Brandenburg Air Study (BEAR)

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Health effects of ambient ultrafine particles (UFP), especially those from aviation sources (AC-UFP), are attracting growing interest, yet limited evidence is available. The Berlin-Brandenburg Air Study (BEAR)[1], a natural experiment, focuses on short-, medium-, and long-term health effects of UFP and AC-UFP on children. The children in the study were attending elementary schools in proximity to the newly opened Berlin-Brandenburg Airport (BER) (opened in October 2020), the former operating Airport Tegel (TXL) (closed in November 2020), and in control areas in Berlin, Germany.

Total particle number concentration (PNC) and meteorological parameters were continuously monitored at 16 elementary schools of participating children using three matching condensation particle counters (CPC) with a 50% cut-size at 7 nm, (EDM 465, Grimm, Germany). To ensure data quality, we implemented a rigorous quality assurance protocol.

Each child underwent repeated (at least two times) school-based health-examinations between January 2020 and June 2023 including spirometry to assess lung function (forced expiratory volume (FEV) and forced vital capacity (FVC) analysed here) and standardized tests to measure neurocognitive function (N-back Test, a parameter hit reaction time (HRT) analysed here, and Attentional Network Task Test). To estimate the association between daily PNC exposure (with lag 0, 1 and 2), as a proxy of UFP, and health outcomes, we employed a nested linear mixed-effect model with random intercepts for school and participant. All models were adjusted to the temperature at the previous day. The results were given by an interquartile range (IQR) increase.

Our findings revealed a discernible decrease in measured PNC with an increase in distance from the airfield, a trend that varied by season and yielded inconclusive results for detecting an airport fingerprint. Within BER airport, a daily average of approximately 16,600 cm^{-3} was measured, and in the vicinity of TXL during high airport activity, it reached approximately 15,400 cm^{-3}—nearly twice as high as the PNC

recorded when the airport remained closed. Median PNC concentrations (6,200 cm^{-3}) across 16 measurement sites throughout the entire study period closely align with reported PNC values observed in other urban environments.

In total, 1,094 children (mean age at baseline 8.6 years, 51% female) were examined. Preliminary analyses of 1,150 complete observations showed a negative association between PNC on the day of the examination and FEV1 (-0.14 litters per each IQR increase of 4,390 particles/cm^3, 95% CI [-0.16; -0.11]) and FVC (-0.17 litres per 4,390 particles/cm^3, 95% CI [-0.20; -0.14]). On lags 1 and 2 the similar associations were detected. HRT was 17.25 ms [95% CI 1.09; 33.41] longer per 4,390 particles/cm^3, measured on the day before the examination, and 19.21 ms [95% CI 2.84; 35.58] longer per 4,390 particles/cm^3, measured two days before the examination. No effect was found for PNC at the day of the examination. After adjusting for area (BER, TLX, CA), the estimates remained unchanged. Also, we didn't find any area-specific effect.

The BEAR Study is a unique experiment investigating effects of AC-UFP, approximated by PNC, on children. The observed associations between measured PNC in proximity to Berlin airports and lung and neurocognitive functions in school-aged children raise concerns about the potential health impact of AC-UFP.

[1] Soppa, V., Lucht, S., Ogurtsova, K., Buschka, A., López-Vicente, M., Guxens, M., ... & Hoffmann, B. (2023). The Berlin-Brandenburg Air Study—A Methodological Study Paper of a Natural Experiment Investigating Health Effects Related to Changes in Airport-Related Exposures. International Journal of Public Health, 68, 1606096.