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

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Introduction

Background

- Effects of ultrafine particles (UFP) and aviation-derived ultrafine particles (AC-UFP), are not well understood[1,2,3].
- In children there is an evidence on respiratory and cardiovascular effects[1,2,3].
- Children are vulnerable due to ongoing lung and immune system development, incomplete detoxification mechanisms, higher inhalation rates per body weight, and metabolic differences[4].
- The particle number concentration (PNC) in the vicinity of airports are very high and can exceed 100,000 particles/cm^3 [5].

Objectives

- To assess short-, medium- and long-term exposure to source-specific UFP for schoolchildren in the vicinity of the Berlin-Brandenburg Airport (BER), the former Tegel Airport (TXL) and in control areas in Berlin.
- To investigate the health impacts of UFP, particularly AC-UFP.

Material and Methods

Study design[6]:

- Natural experiment
- Acute, medium, and long-term health effects of UFP and AC-UFP in primary schoolchildren in Berlin, Germany

Study area:

- Elementary schools close to the operating BER Airport (opened in October 2020), the former operating TXL Airport (closed in November 2020) and in control areas (CA) in Berlin, Germany.

Health examinations:

- School-based health examinations (**lung function**, cognitive function, blood pressure, FeNO & quality of life) at least twice (January – June 2023).
- Concurrent-total PNC and meteorology at 16 schools since January 2020.
- Nested linear mixed-effect model with random intercepts for school and participant.

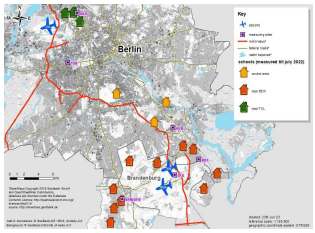

Figure 1: Included schools, airports (blue airplane) and monitoring stations (purple) (BEAR Study, Germany 2020-2023).

Results

Exposure assessment:

Table 1: PNC at schools; Median, 25th and 75th percentile of PNC at all measurement sites (schools). Measurement period: January 2020 to December 2022.

Study Area	Elementary school	N	Median	25th percentile	75th percentile
Control Area (CA)	CA-1	2,502	6,508	4,444	9,250
	CA-2	1,259	8,191	5,737	11,773
	CA-3	1,477	7,755	5,650	10,647
	CA subtotal	***5,238***	***7,610***	***5,012***	***10,336***
Tegel Airport (TLX)	TLX-1	1,730	7,487	5,075	11,959
	TLX-2	3,367	6,631	4,604	9,684
	TLX-3	2,779	6,917	4,949	9,990
	TLX subtotal	***7,876***	***6,872***	***4,786***	***10,150***
Berlin-Brandenburg Airport (BER)	BER-1	2,261	6,113	4,025	9,665
	BER-2	547	6,896	4,736	9,823
	BER-3	1,925	6,337	4,137	9,802
	BER-4	2,792	5,703	4,021	8,363
	BER-5	2,551	7,663	5,179	11,771
	BER-6	1,535	6,548	4,628	9,270
	BER-7	8,72	6,120	3,741	9,597
	BER-8	1,585	4,492	2,854	6,781
	BER-9	913	6,984	4,700	10,426
	BER-10	2,635	7,143	4,864	10,220
	BER subtotal	***18,616***	***6,371***	***4,286***	***9,597***
CA, TLX, BER	*Total*	***31,730***	***6,200***	***4,100***	***9,500***

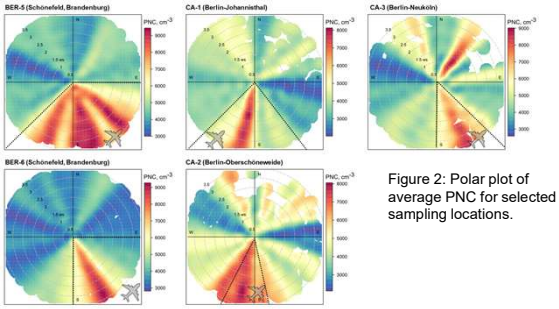

Figure 2: Polar plot of average PNC for selected sampling locations.

- PNC in relation to the direction of incoming air masses.
- The scale is specific to each sampling site (low: blue to high: red)
- The sector assigned to the air mass coming from the airport is delimited by the dotted line and marked by the aircraft symbol.

Health outcomes:

- 1,094 children from 16 schools had repeated health examinations.
- Baseline lung function were within a normal range and did not differ between areas (BER: 1.96±0.4 (FEV_1), 2.30±0.5 (FVC); TLX: 2.03± 0.5 (FEV_1), 2.36±0.6 (FVC); CA: 1.95± 0.4 (FEV_1), 2.29±0.5 (FVC)) (Table 2 and Figure 3).
- A continuous increase in FEV_1 and FVC was observed from the first to the third assessment, in line with an age-related lung growth of the children (Figure 3).

Table 2: Description of the study population at first (t0), second (t1) and third (T3) examination

	t_0 (n=1094)	t_1 (n= 714)	t_2 (n= 194)
Female[n](%)	561 (51.3%)	373 (52.2%)	96 (49.5%)
Male[n] (%)	533 (48.7%)	341 (47.8%)	98 (50.5%)
Age [years] (mean ± SD)	8.6±1.1	9.8±1.1	11.0±0.9
Height [m] (mean ± SD)	1.4±0.1	1.4±0.1	1.5±0.1
Weight [kg] (mean ± SD)	33.9±8.6	39.3±11.9	46.2±11.3
BMI [kg/m^2] (mean ± SD)	17.8±3.0	18.7±4.0	19.9±3.8
Blood pressure [m] (mean ± SD)			
Systolic blood pressure	102.7±10.8	104.0±11.0	106.3±9.7
Diastolic blood pressure	63.9±8.3	64.1±8.3	65.3±8.0
FeNO [ppb] (mean ± SD)	13.2±11.4	15.3±13.4	15.8±12.9
FEV_1 [L] (mean ± SD)	1.86±0.4	2.22±0.5	2.55±0.4
FVC [L] (mean ± SD)	2.18±0.4	2.61±0.6	2.99±0.5
PNC [particles/m^3]	8440±3650	7700±2860	6890±3450

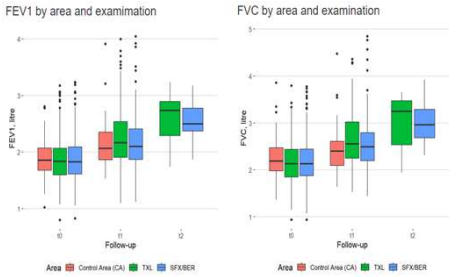

Figure 3: Description (median, minimum, maximum, first and third quartile) of FEV_1 (left) and FVC (right) measured at t0, t1 and t2 in children from CA, TLX and SFX/BER

Preliminary results of crude model (adjusted to temperature, area):

- PNC on the day of the examination (lag0) and outcomes in lung function were correlated (Figure 4).
- Negative association between PNC (lag0, lag1, lag2) and FEV_1 and FVC, independent of region

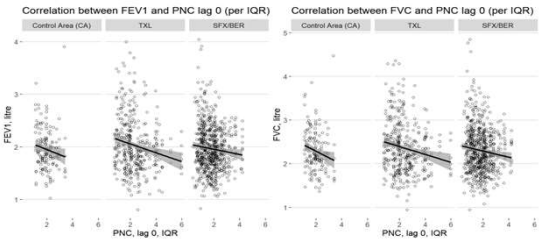

Figure 4: Correlation (Pearson) between PNC (24h mean) measured at lag0 and FEV_1 (left) and FVC (right) stratified by area (CA, TLX and BER).

- Adjusted model (outcome: % of age-sex-specific reference FEV_1(Global Lung Initiative); adjusted to temperature, humidity, season):
- No association of PNC and calculated predicted percent of FEV_1 in children (Figure 5, without interaction) (Figure 6, interaction of PNC and air traffic); same results for FVC

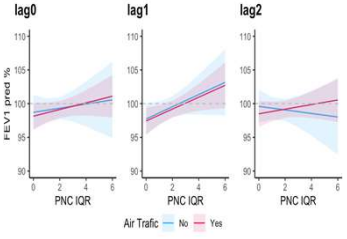

Figure 5: Marginal means of % predicted FEV_1 in association with daily PNC (per IQR) in children exposed to air traffic or not.

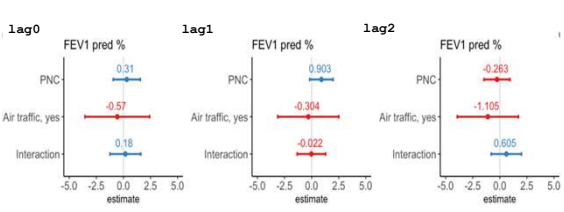

Figure 6: Estimates of association between daily PNC (per IQR), predicted FEV_1 for children exposed to air traffic and with interaction of PNC and air traffic indicator

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Conclusion and Outlook

- The BEAR Study is a cohort study, using an unique experiment to investigate effects of AC-UFP on children.
- In preliminary analyses we observed negative associations between PNC and children's lung function in the crude model
- In fully adjusted analyses, using the calculated predicted percent of lung function values, we did not see any associations between PNC and lung function
- Further analyses on source-specific UFP associations with the complete data set are ongoing
- Phase 2 will focus on: Cardiovascular health, especially arterial stiffness as a key factor for cardiovascular events and coronary heart diseases