Associations between Short-Term Ambient Ultrafine and Fine Particulate Matter and Markers of Inflammation and Coagulation in Seniors in the German CorPuScula Study

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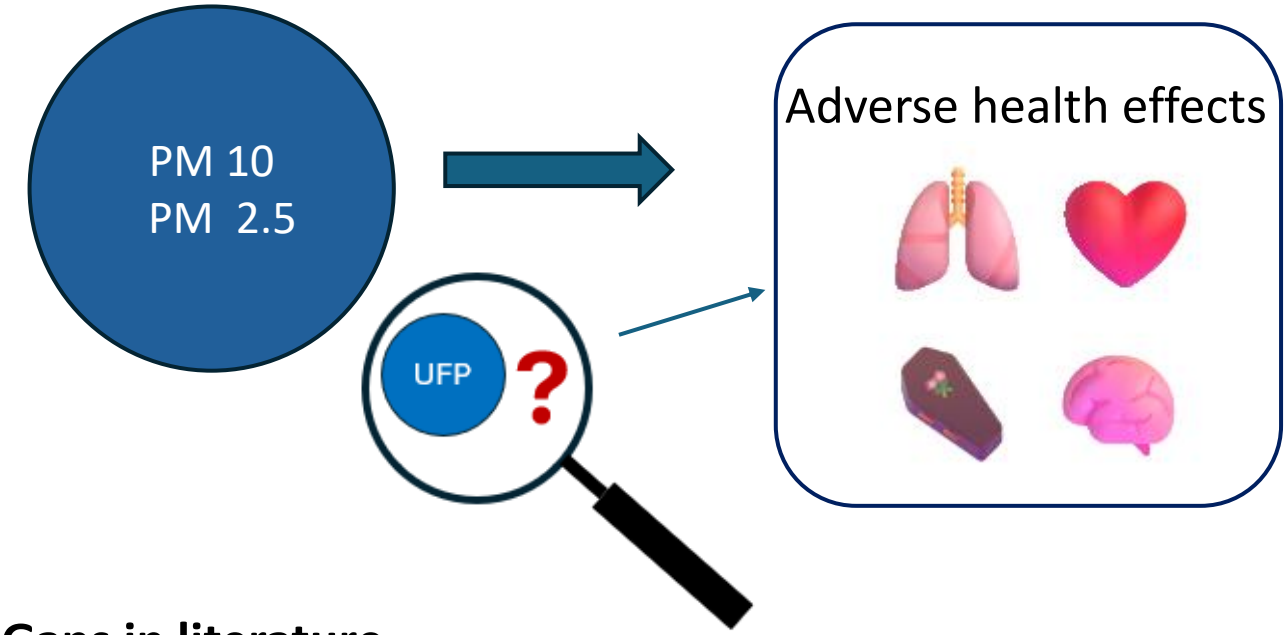
Background



WHO Air Quality Guidelines (2021)			
	Particles	Annual mean (µg/m³)	Short-term mean (µg/m³)
PM_{10}	< 10 µm	15	45
$PM_{2.5}$	< 2.5 µm	5	15
UFP	**< 0.1 µm**	**No evidence – No Guidelines**	

Gaps in literature

- UFP – Limited evidence on health effects
- UFP – Few systematic reviews or meta-analyses on blood markers
- UFP – Inconsistent adjustment for co-pollutants in existing studies

Objective: Associations between UFP, PM_{10}, $PM_{2.5}$ and inflammatory/coagulation markers, adjusted for co-pollutants

Methods: Study Design and Participants

- **CorPuScula**

Cor = Heart **Pu**lmo = Lung **S**anguis = Bood **C**orpus = Body **Corpuscula** = Small particle

- **LMU Munich**, Germany
- (Institute of Occupational, Social and Environmental Medicine)
- Longitudinal study with repeated measurements

- **Blood samples** collected from **50** elderly participants
- Measurement period for elderly:

June 1, 2000 – July 4, 2001

Photo: Prof. Höppe and Prof. Nowak, LMU Munich

Methods: Exposure Assessment

UFP
Condensation Particle Counter (TSI 3022A)
Particles ≥ 7 nanometers as particle number concentrations (PNC) per volume

PM_{10} and $PM_{2.5}$
Low Volume Sampler (LVS3, Leckel)

Meteorological data

NO2/O3

Photos: Prof. Höppe and Prof. Nowak, LMU Munich

Methods: Exposure Assessment

1h	3h	12h	24h	Lag0	Lag 1	Lag 2
				PM2.5	PM2.5	PM2.5
	PM10	PM10	PM10	PM10	PM10	PM10
UFP	UFP	UFP	UFP	UFP	UFP	UFP

Daily means (9:30–21:30)

- day of sampling (Lag 0)
- 1 day before (Lag 1)
- 2 days before (Lag2)

Hourly exposures calculated for UFP and PM_{10} only

Methods: Outcomes

Blood sampling: every two weeks

19 samples per participant on average

Analysis: LMU Munich (Department of Medicine, Central Laboratory)

Inflammatory marker:	Coagulation markers:
CRP (C -reactive protein)	Fibrinogen
	VWF (von Willebrand factor)
	FVIII (Factor VIII)
	PAI-1 (Plasminogen activator inhibitor-1)

Methods: Statistical analysis

Main models:

- Linear mixed-effects regression
- Adjusted for environmental & individual confounders and covariates

Environmental covariates:
- •Ambient temperature
- •Relative humidity
- •Season (categorical)

Behavioural and short-term covariates:
- •Regular medication intake (binary indicator)
- •Alcohol consumption in the past 24 hours
- •Cold or flu symptoms (yes/no)
- •Day of the week

Individual-level covariates:
- •BMI at baseline, Age, Sex
- •Cardiovascular dysfunction at baseline

Two - pollutant models:

- **NO_2** (nitrogen dioxide) or **O_3** (ozone)
- or **$PM_{2.5}$** (only in UFP models)

Multi- pollutant models:

- **NO_2** (nitrogen dioxide) and **O_3** (ozone)
- and **$PM_{2.5}$** (in UFP models)

Results: Characteristics of participants at baseline

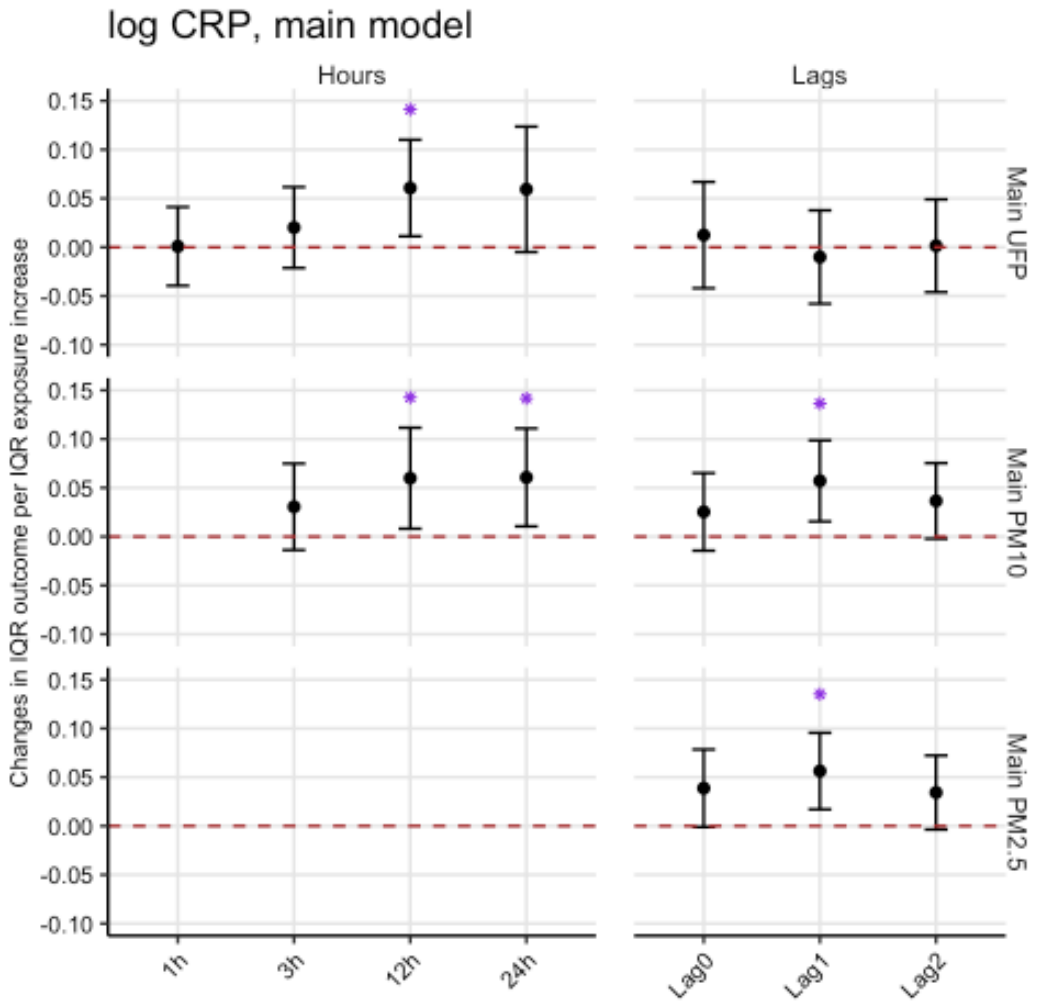
Final sample:

571 observations

11.4 observations per person

Study Population	(N = 50 seniors)
Mean age:	76.9 years
Sex female	78%
≥1 chronic condition	82%
Medication	84%
Anti-inflammatory drugs	36.6%

Results: Single Models



	1h	3h	12h	24h	Lag0	Lag1	Lag2	
CRP log								UFP
								PM10
								PM2.5

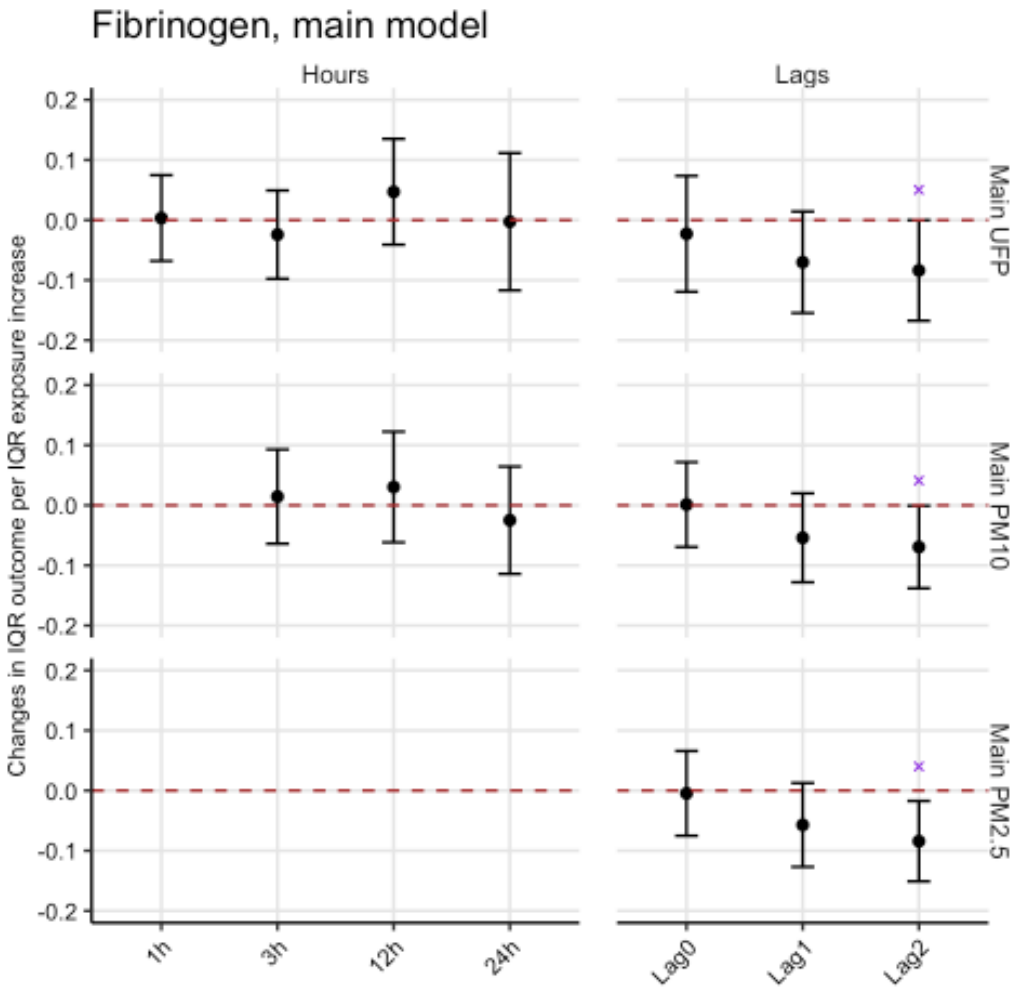
No measurement

Measurement without significance

Significant positive association

Significant negative association

Results: Single Models



	1h	3h	12h	24h	Lag0	Lag1	Lag2	
CRP log								UFP
								PM10
								PM2.5
Fibrinogen								UFP
								PM10
								PM2.5

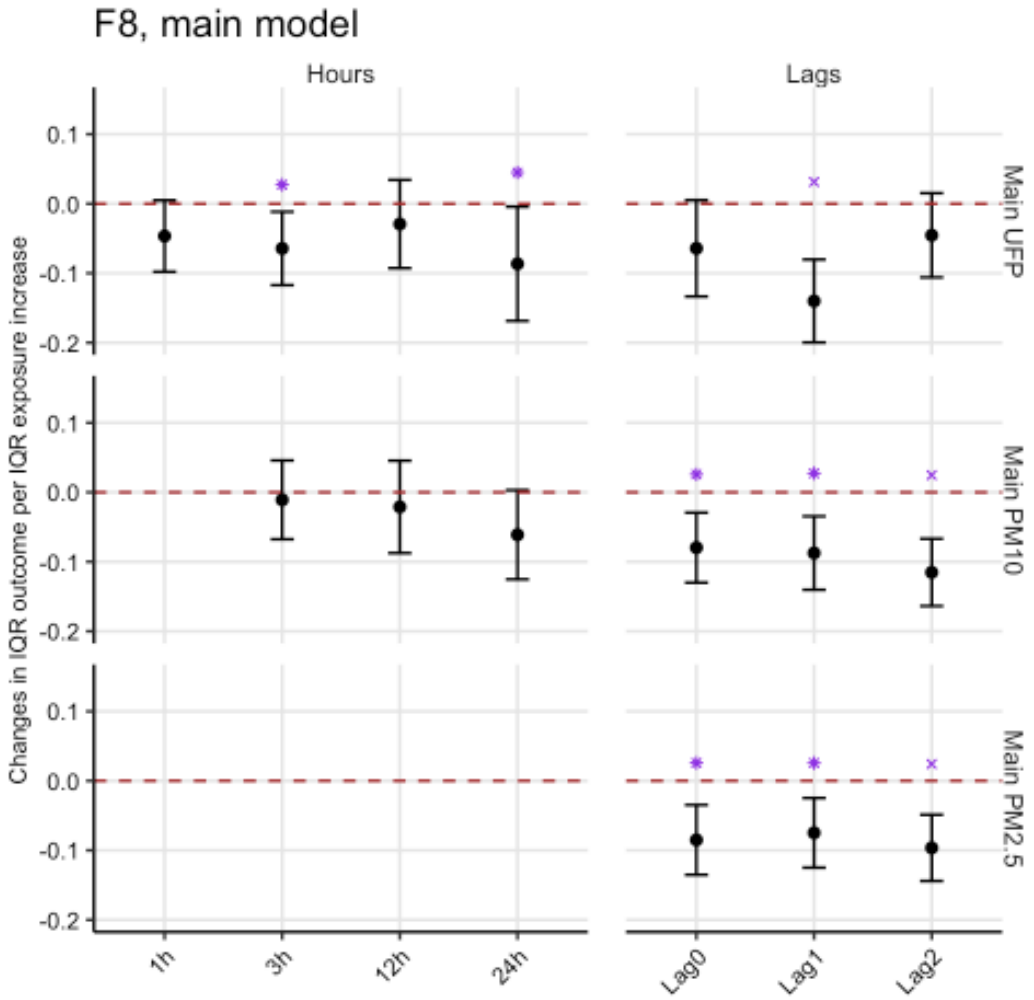
No measurement

Measurement without significance

Significant positive association

Significant negative association

Results: Single Models



	1h	3h	12h	24h	Lag0	Lag1	Lag2	
CRP log								UFP
								PM10
								PM2.5
Fibrinogen								UFP
								PM10
								PM2.5
FVIII								UFP
								PM10
								PM2.5

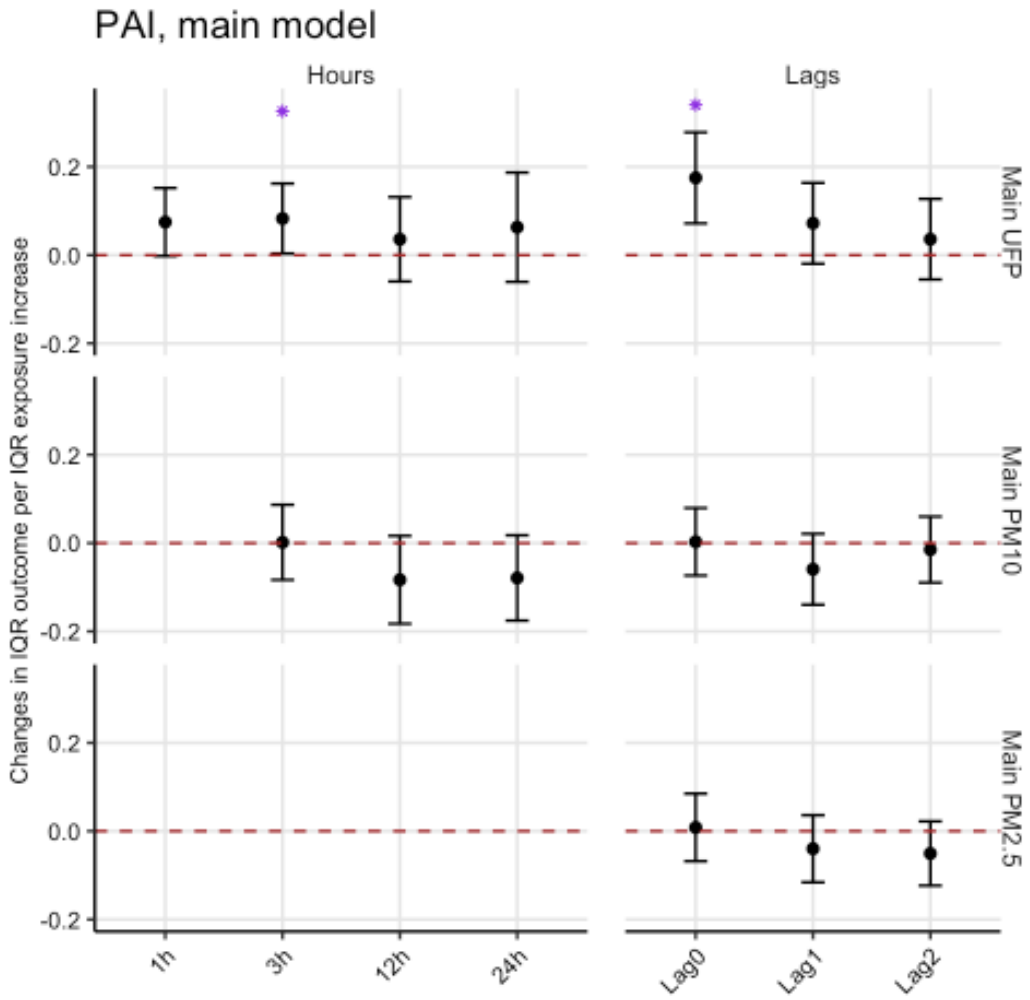
No measurement

Measurement without significance

Significant positive association

Significant negative association

Results: Single Models



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Fibrinogen								UFP
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								PM2.5
FVIII								UFP
								PM10
								PM2.5
PAI-1								UFP
								PM10
								PM2.5

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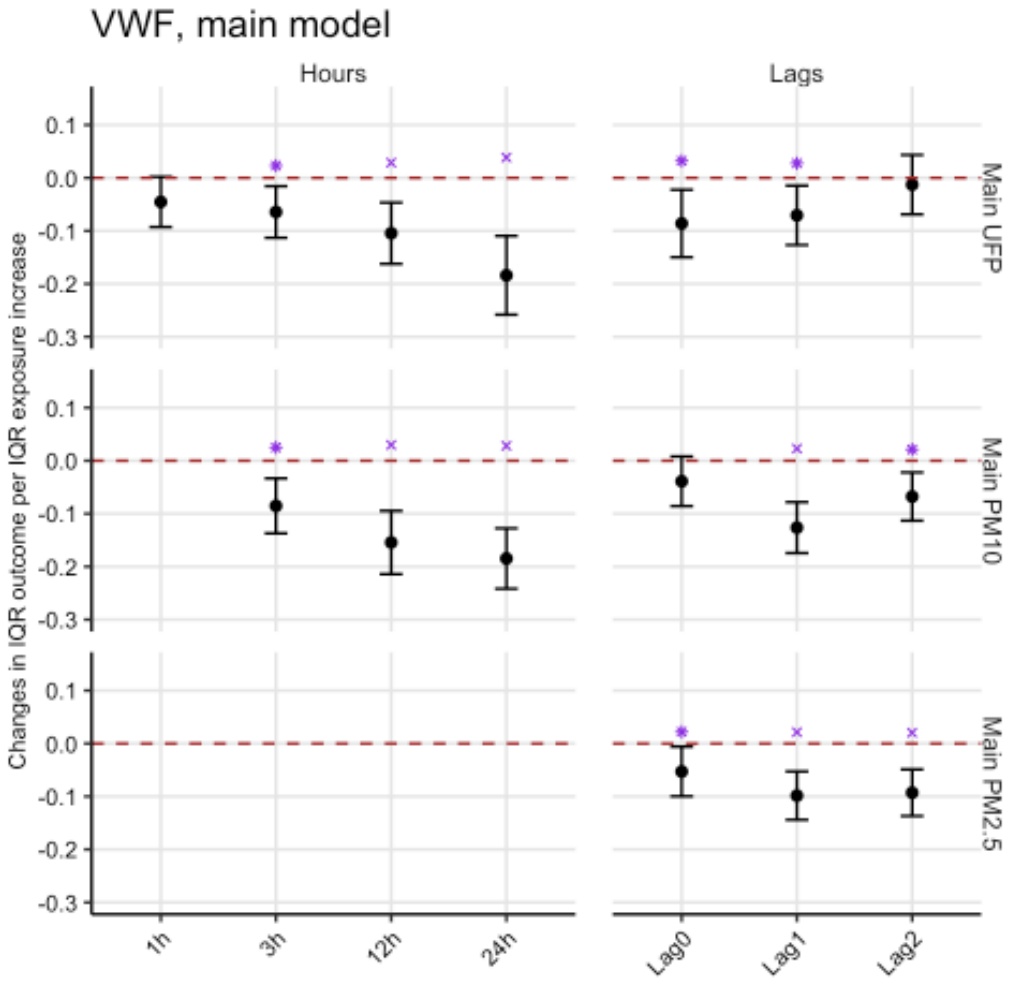
Results: Single Models



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Fibrinogen								UFP
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FVIII								UFP
								PM10
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PAI-1								UFP
								PM10
								PM2.5
VWF								UFP
								PM10
								PM2.5

No measurement

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Significant positive association

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Comparison with Literature and Summary

Biomarker	Corpuscula Findings	Association	Robust after adjustments	Comparison with Literature
CRP	↑ after UFP (12h) ↑ after PM_{10} (12h/24h, lag 1), $PM_{2.5}$ (lag 1)	+	✓	Consistent with meta-analyses (Zhu 2021, Sun 2020, Lachowicz & Gać 2024); UFP effects less often included
PAI-1	↑ after UFP (3h, lag 0)	+	✓	Adds novel evidence for short-term UFP effects; aligns with Sun 2020; rarely addressed in meta-analyses
Fibrinogen	↓ after UFP, ↓ after PM_{10}, $PM_{2.5}$ (lag 2)	-	X	Contrasts with meta-analyses (Tang 2020, Zhu 2021); aligns with Rückerl 2006 and Nitter 2021 in parts
vWF	↓ after UFP (lags 0–1) ↓ after PM_{10} (lags 1–2), $PM_{2.5}$ (lags 0–2)	-	✓	Few studies cover short-term effects; our results align with Nitter 2021, Hildebrandt 2009; differ from Liang 2020
FVIII	↓ after UFP (3h, 24h, lag 1), ↓ after PM_{10} / $PM_{2.5}$ (lags 0–2)	-	✓	Literature is limited on UFP and FVIII; Consistent with Rückerl 2006

Strengths & Limitations

Strengths:

- High-resolution exposure data
- Repeated biomarker measurements
- Multi-pollutant models increase robustness

Limitations:

- Small sample (n = 50), elderly only
- Exposure data from 2000–2001
- UFP station 3 km away → possible exposure misclassification

Conclusion

- Time-dependent associations found between air pollutants and blood biomarkers in older adults
- Historic data remain valuable for current public health research

- Findings underline the need for:
  - More diverse and contemporary cohort studies
  - Stronger evidence on health effects
  - Better understanding of mechanisms
  - Improved adjustment for co-pollutants and confounders

Acknowledgements

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Thank you for listening!

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