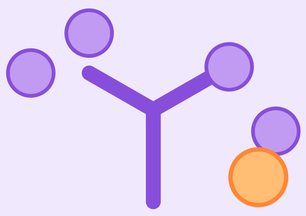
Endocrine-Disrupting Chemicals in School Indoor Air and Childhood Health: Baseline evidence for climate-resilient and health-protective school environments

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Background

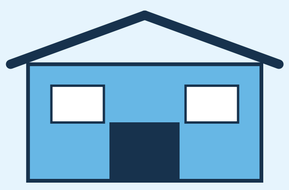
WHAT ARE EDCs?



Chemicals interfering with hormonal signaling

May alter endocrine functions during critical periods of development

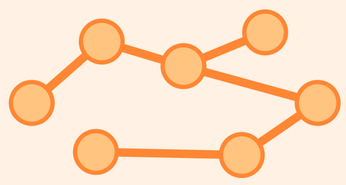
SCHOOL ENVIRONMENT



Key indoor environments shaped by climate adaptation

Building materials and retrofitting
Ventilation and cooling practices
Furnishings and consumer products

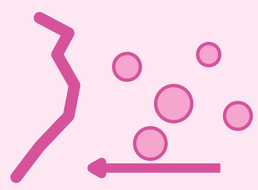
POLLUTANTS IN INDOOR AIR



PFAS and BFRs Persistent pollutants

Legacy and replacement compounds; some have endocrine-disrupting potential

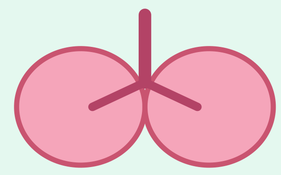
EXPOSURE PATHWAYS



Multiple routes of exposure

Inhalation of indoor air
Ingestion of settled dust
Potential repeated exposure

CHILDREN'S HEALTH



Respiratory and skin outcomes

Asthma and wheezing
Eczema
Childhood susceptibility

Aim and Methods Overview

Overall aim: Assess children's exposure to endocrine-disrupting chemicals in school, related respiratory and skin health, and implications for climate-resilient, health-protective school environments.

EVIDENCE SYNTHESIS



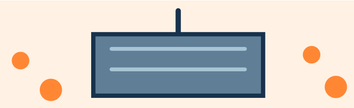
- Systematic reviews and meta-analyses
- EDCs, PFAS and childhood respiratory/skin outcomes
- Indoor PFAS occurrence and internal burden

SCHOOL-BASED EPIDEMIOLOGY



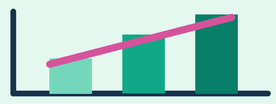
- 20 public primary schools in Porto, Portugal
- Children aged 5-11 years Parental questionnaires
- Individual, family, residential and behavioral factors

ENVIRONMENTAL MONITORING



- 28-day passive air sampling
- BFRs: 80 classrooms across 20 schools
- PFAS: 36 indoor + 8 outdoor samples across 8 schools

STATISTICAL ANALYSES



- Meta-analysis and pooled effect estimates
- Multivariable and multilevel regression
- Exposure-outcome associations Confounding and clustering

Key Findings

01 | SYSTEMATIC EVIDENCE

61 EDC studies

28 PFAS studies

64,851 Participants in EDC review

SELECTED POOLED ASSOCIATIONS

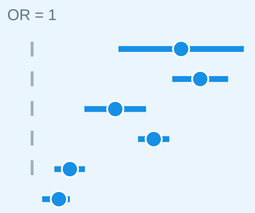


Dust phthalates / asthma	1.21 [1.02-1.44]
Prenatal PFAS / asthma	0.97 [0.94-0.99]
Postnatal PFAS / asthma	1.20 [1.07-1.35]
PFAS / wheezing	0.96 [0.94-0.98]
PFAS / eczema	0.92 [0.89-0.96]

02 | CHILDHOOD HEALTH DETERMINANTS

Respiratory and skin outcomes reflect multiple individual, familial and environmental factors

SELECTED ADJUSTED ASSOCIATIONS



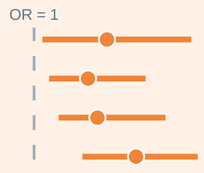
Pneumonia / ever asthma	4.69 [2.45-8.99]
Bronchiolitis / wheezing	5.72 [4.28-7.64]
Home mold / wheezing	2.37 [1.72-3.26]
Family history / eczema	3.53 [3.00-4.15]
Postnatal smoke / eczema	1.48 [1.26-1.73]
Traffic proximity / eczema	1.32 [1.11-1.48]

03 | BFRs: SCHOOL AIR AND HEALTH

28.12–154.54 Total BFRs (pg/m³)

80 classrooms | 20 schools 28-day passive air sampling

ASSOCIATIONS PER LOG10-UNIT INCREASE



BDE-209 / ever asthma	2.13 [1.09-5.11]
BDE-209 / wheezing	1.75 [1.17-3.18]
Total BFRs / current asthma	1.93 [1.29-3.91]
Non-BDEs / eczema	2.88 [1.65-5.46]

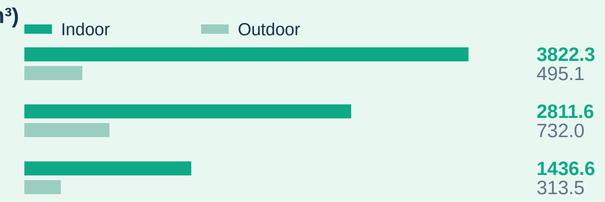
Replacement BFRs, especially DBDPE, predominated; legacy BFRs remained detectable

04 | PFAS: INDOOR AIR EXPOSURE

66.5% Indoor PFAA precursors

64 PFAS Targeted in 8 schools

MEDIAN CONCENTRATIONS IN AIR (pg/m³)



All measured PFAS classes showed indoor enrichment relative to outdoor air

Conclusion

School indoor air may contribute to children's exposure to legacy and emerging PFAS and BFR. Observed associations highlight the interplay among chemical exposures, early-life factors, and indoor environments, supporting continued monitoring, climate-resilient and health-protective school environments, and longitudinal research to clarify potential health effects.

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