EU Regional Development Funds - Interreg Central Europe AWAIR

Strategies and operational tools to support adaptation actions
in vulnerable population groups during the Severe Air Pollution Episodes (SAPEs)

PARMA - APE PARMA MUSEO, VIA FARINI 32A, NOVEMBER 6TH, 2019

Air pollution and asthma in childhood

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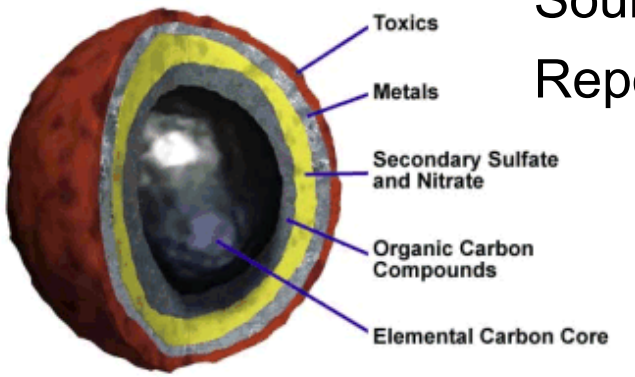
Problem

- Global

- Up to 13 000 deaths per year among children aged 0–4 years are attributed to PM outdoor air pollution in the European Region.

Key pollutants

- Particulate matter (PM, measured as either PM less than 10 μm in diameter (PM10) or 2.5 PM2.5)
- Nitrogen oxides (NOx, such as nitrogen dioxide, NO2)
- Sulfur dioxide (SO2)
- Carbon monoxide (CO)
- Ozone (O3)
- Volatile organic compounds benzene & 1,3-butadiene
- Polycyclic aromatic hydrocarbons (PAH)



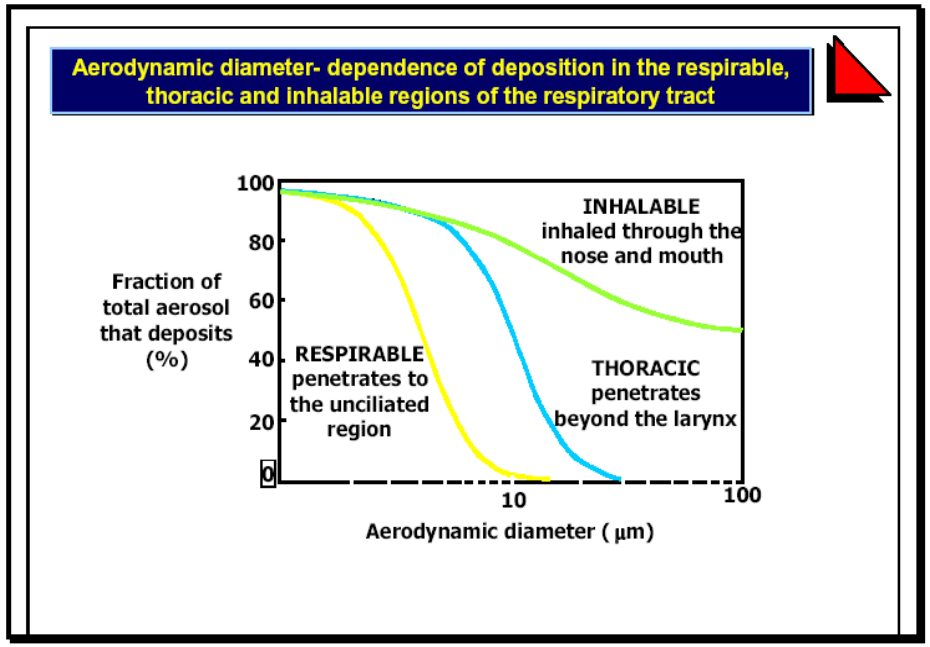
Particulate matter

Chemical composition

Size: PM_{10}, $PM_{2.5}$

Source:Primary, secondary and coarse

Reported as $\mu g/m^3$



Pollutants effects on airway

- Irritation in nose and mouth
- Dyspnoea, wheezing, chest tightness
- Decrease in lung function tests (FEV1, FEF 25-75)
- Increase in airway hyperresponsiveness

Brunekreef B Lancet 2002,360,1233
Peden DB Allergy 1997, 52 (suppl 38), 37

Susceptible and vulnerable groups

- Children
- Asthma/Chronic airway diseases
- Athletes
- Elderly
- Pregnancy
- Socioeconomically disadvantaged populations

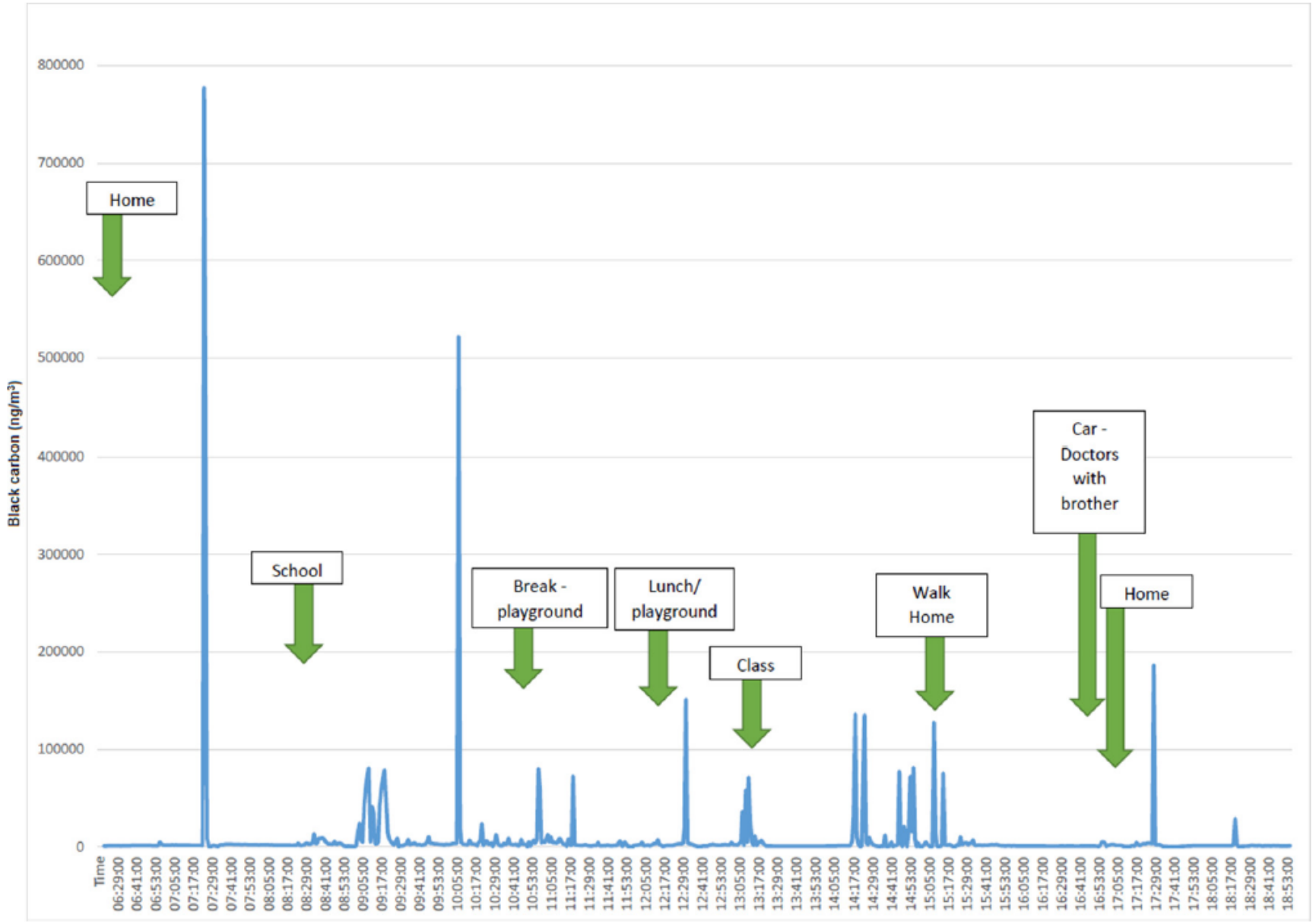
Air pollution effects in children

Functional and structural immaturity of lung and immune system

Higher breathing rates

Higher activity levels (open air)

Reduced antioxidant defences (high level of enviromental oxidant)



Liu NM BMJ Paediatrics Open 2018;2:e000210

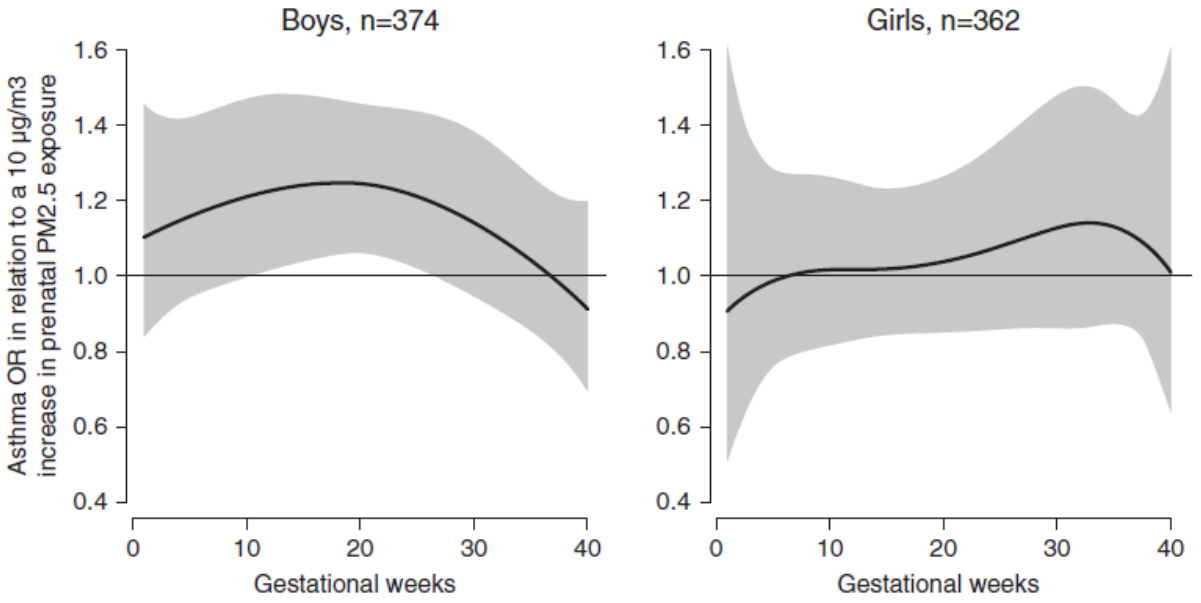
Early life health effects

- increased infant mortality, reduced fetal growth, low birth weight at term and premature birth
- Increased neonatal admissions for respiratory problems
- Increased cough without cold

Prenatal Particulate Air Pollution and Asthma

- Independent associations between antenatal exposure to NO2 and reduced FEV1 later in childhood are reported

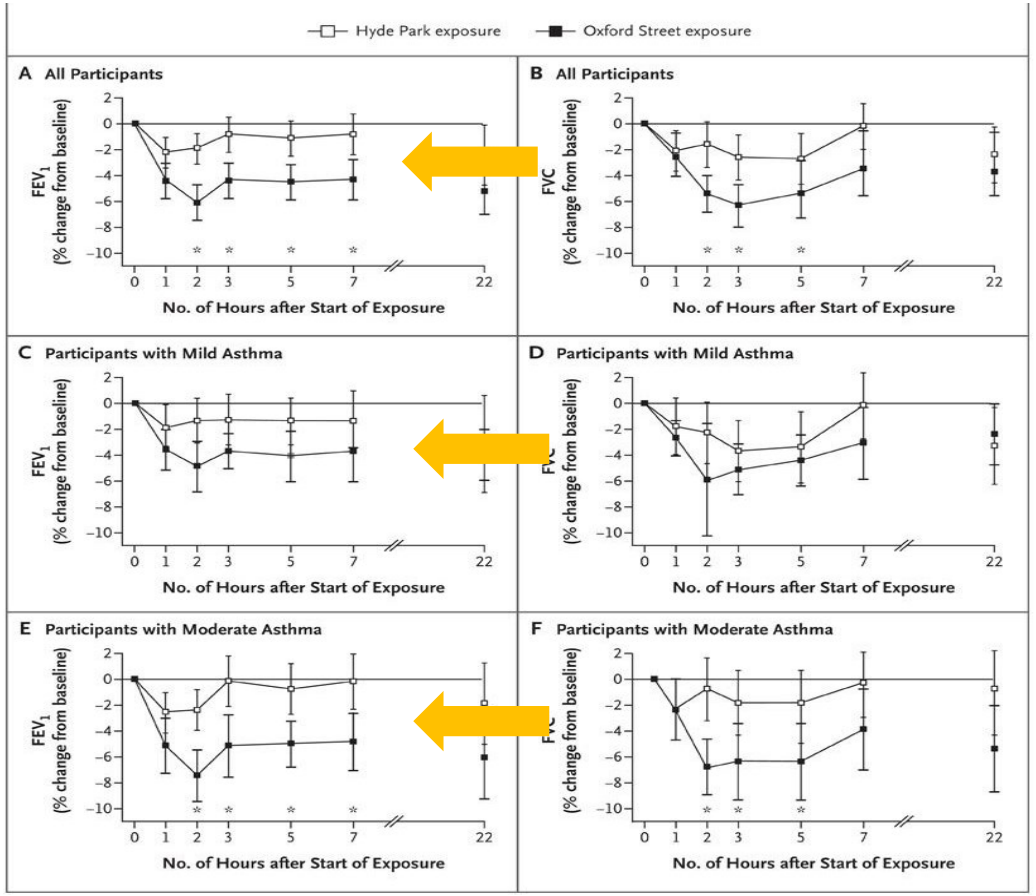
- Increased PM2.5 exposure levels at 16–25 weeks gestation were significantly associated with early childhood asthma development by 6 years



Hsu H-H L Am J Resp Critical Care Med 2015,192,1052

Lung function
Diesel traffic pollution

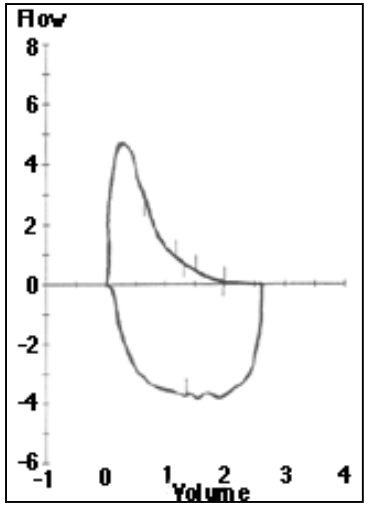
- Asthmatic subjects walked for 2 hours on Oxford St and through the nearby Hyde Park
- Higher exposure to particles and NO2 in Oxford St than in Hyde Park
- Walking on Oxford St induced significant reductions in lung function tests (FEV1, FEF 25-75)
- EBC pH was lower while sputum myeloperoxidase levels were higher after walking in Oxford St



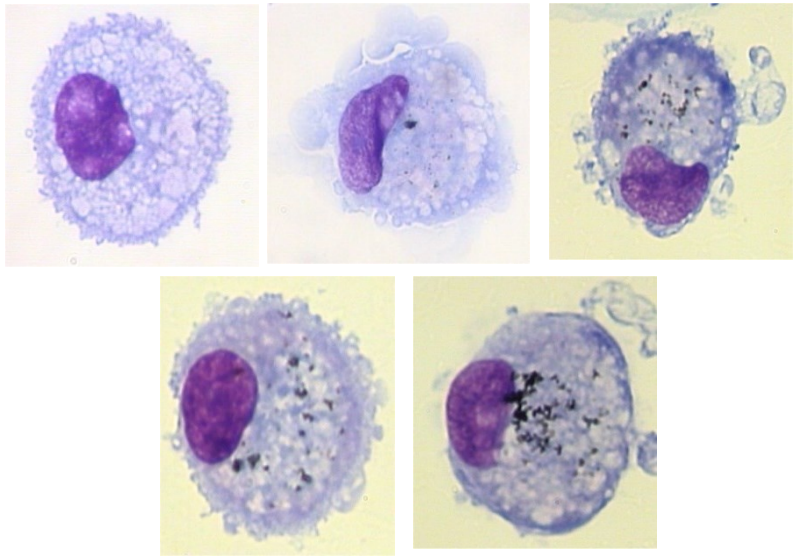
McCreanor J NEJM 2007

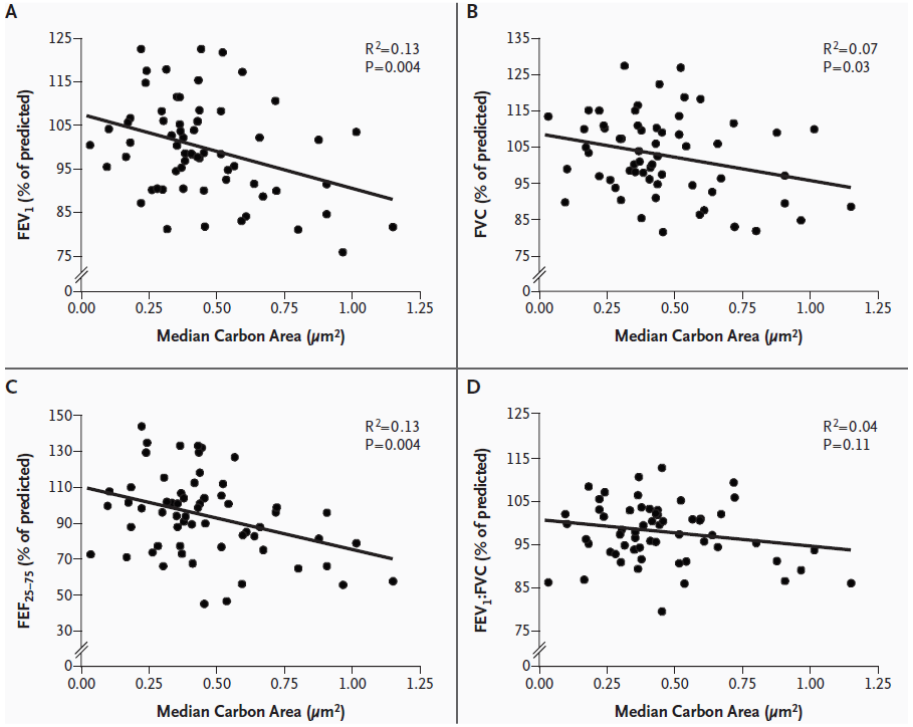
Lung function

- Most robust
- California:
  - 1759 children, 12 communities
  - Followed for 8 years
  - Reduced FEV1- PM and NO_2
- Mexico:
  - 3170 children
  - Deficits in FEV_1 and FVC; PM_{10}, O_3, NO_2



Carbon in Airway Macrophages and lung function

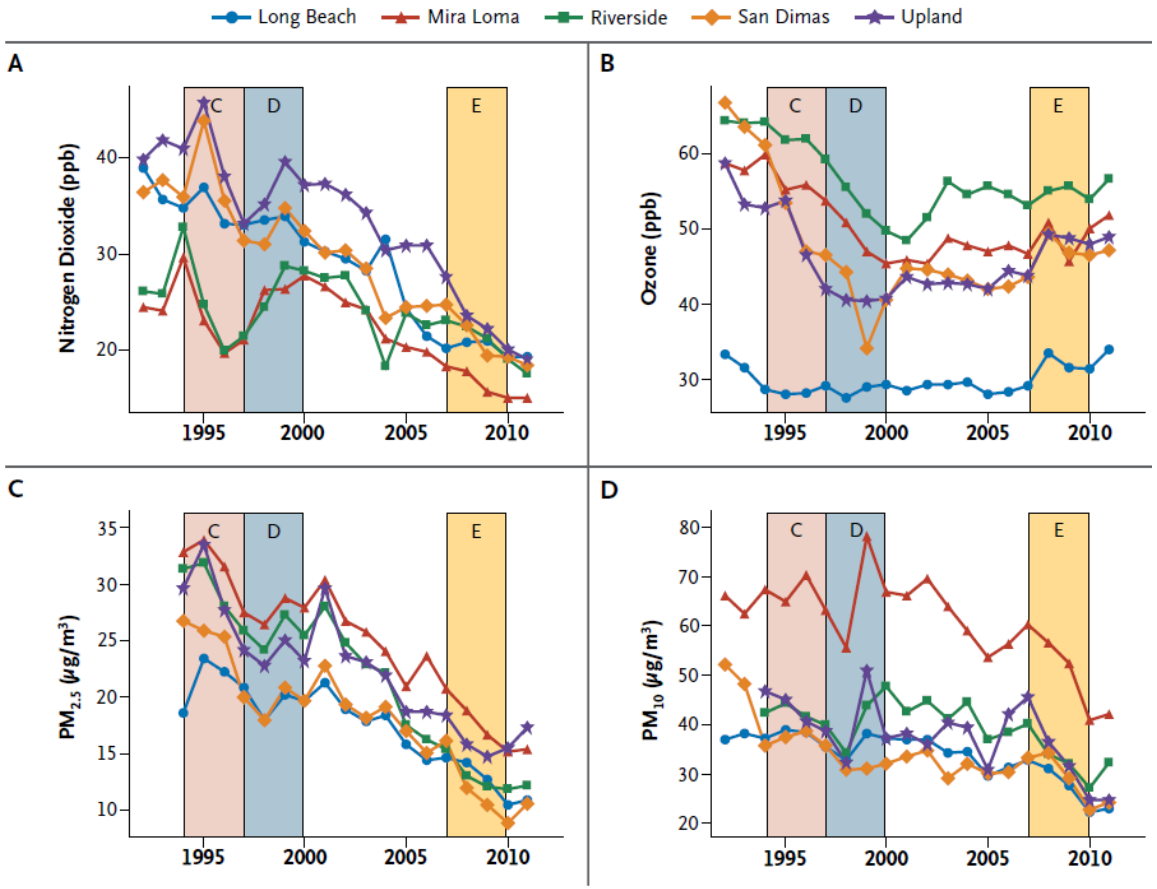


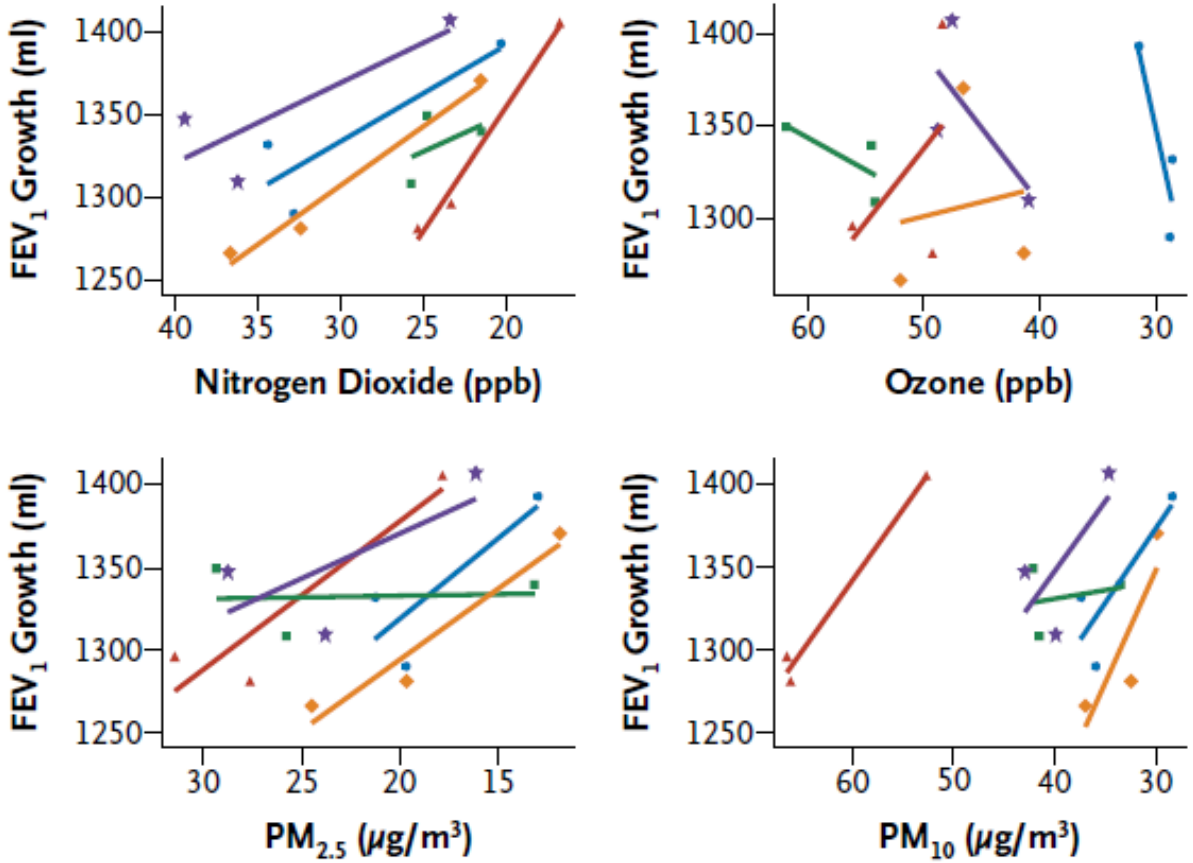


There is a dose-dependent inverse association between the carbon content of airway macrophages and lung function in children. There is no evidence that reduced lung function itself causes an increase in carbon content

Kulkarni N N Engl J Med 2006; 355(1): 21-30

Association of improved air quality with lung development in children



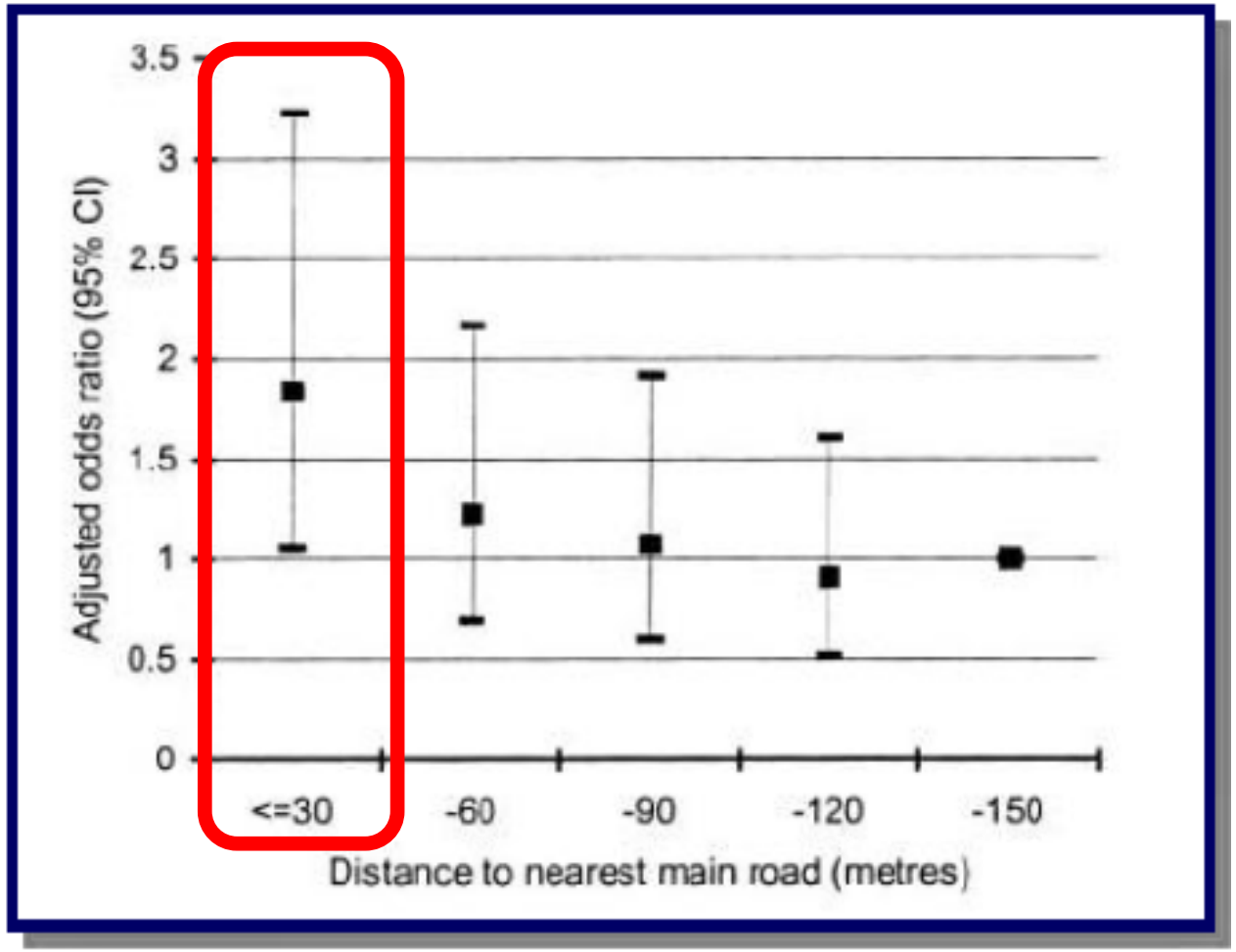


Gauderman WJ N Engl J Med 2015;372:905-13

Am J Respir Crit Care Med Vol 164. pp 2177–2180, 2001

Living Near a Main Road and the Risk of Wheezing Illness in Children

ANDREA J. VENN, SARAH A. LEWIS, MARIE COOPER, RICHARD HUBBARD, and JOHN BRITTON

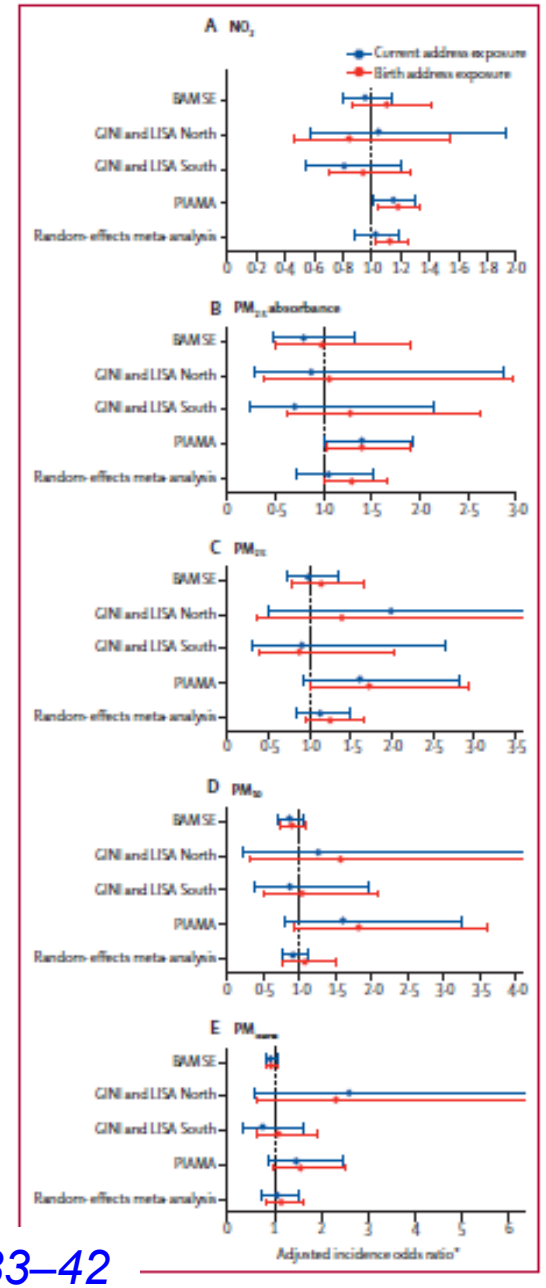


PM2.5 exposure is the main risk factor for asthma, rhinoconjuntivitis, pollen sensitization in children living near busy roads (<50 meters)

Air pollution and development of asthma throughout childhood and adolescence

Population-based birth cohort study of 14 126 participants from four prospective birth cohort studies from Germany, Sweden, and the Netherlands with 14–16 years of follow-up.
Repeated questionnaire reports of asthma linked with annual average air pollution concentrations (nitrogen dioxide [NO_2], particulate matter < 2.5 μm [$PM_{2.5}$], less than 10 μm [PM_{10}], and between 2.5 μm and 10 μm [PM_{coarse}], and $PM_{2.}$ at the participants' home addresses.

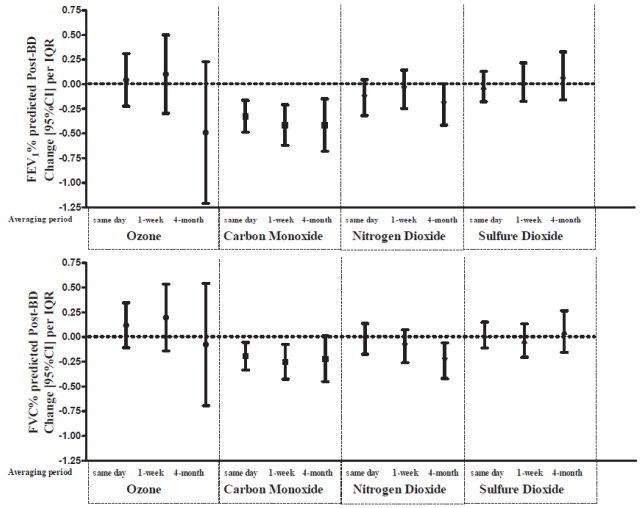
Risk of incident asthma up to age 14-16 years increased with increasing exposure to NO2 and PM2.5

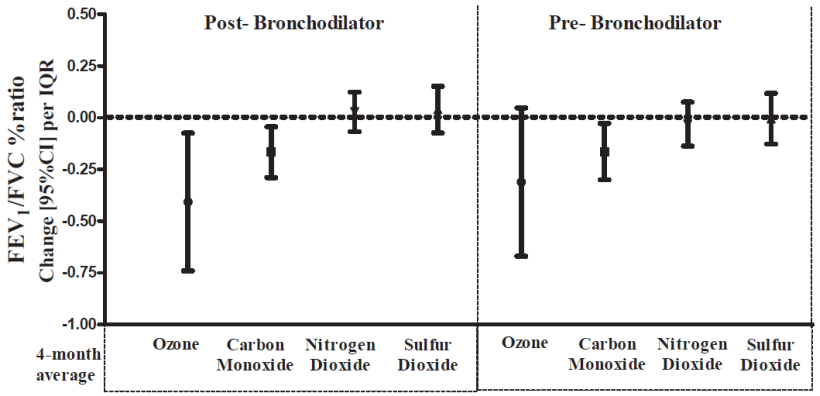


Gehring U Lancet Respir Med 2015;3:933–42

Air pollution, lung function, and airway responsiveness in asthmatic children

- 1003 asthmatic children
- lung function and methacholine responsiveness (PC20)
- ozone, carbon monoxide (CO), nitrogen dioxide, and sulfur dioxide concentrations





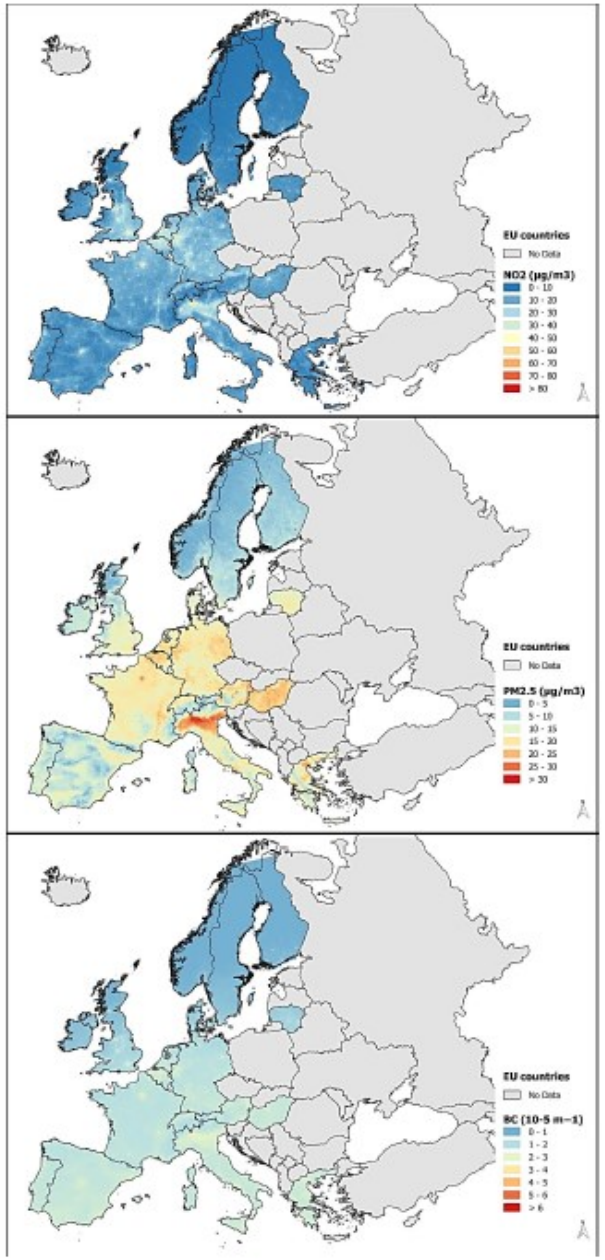
- Same-day, 1-week, and 4-month averages of **CO concentrations** and 4-month average of **NO_2 concentrations** had negative associations with **postbronchodilator FEV1 and FVC**
- **Reduced postbronchodilator FEV1/FVC** ratio was associated with 4-month averages of **ozone and CO concentrations** but not with NO_2 or SO_2 concentrations.
- The only pollutant that was significantly associated with **PC20** was the 4-month average **SO_2 concentration.**

Conclusions: Air pollution adversely influences lung function and PC20 in asthmatic children.

Ierodiakonou D Allergy Clin Immunol 2016;137:390-9.

Outdoor air pollution and asthma

- Asthma incidence across 18 European countries and 63,442,419 children (0-14 years old)
- Exposure to pollutants estimates at 1,540,386 1 km x 1 km cells,
- Annual average pollutant concentrations were obtained from validated and harmonized European land-use regression (LUR) mode.



Results.

- NO2 ranged from 1.4 to 70.0 µg/m^3, with a mean of 11.8 µg/m^3. PM2.5 ranged from 2.0 to 41.1 µg/m^3, with a mean of 11.6 µg/m^3. BC ranged from 0.003 to 3.7 x 10-5 m-1, with a mean of 1.0 x 10-5 m-1.

- Compliance with the NO_2 and PM2.5 WHO guidelines, respectively, was estimated to prevent 2,434 (0.4%) and 66,567 (11%) incident cases.

- Meeting the minimum air pollution levels for NO_2 (1.5 µg/m^3), PM2.5 (0.4 µg/m^3) and BC (0.4 x 10-5m-1), respectively, was estimated to prevent 135,257 (23%), 191,883 (33%) and 89,191 (15%) incident cases.

Khreis H Eur Resp J 2019

Traffic-related air pollution exposure and allergic sensitization, asthma, and poor lung function in middle age

Tasmanian Longitudinal Health Study.

- In 1968, 8583 Tasmanian children aged 7 years were studied.
- When the probands were 44 years old, were investigated for allergic sensitization, lung function, current wheeze, and asthma
- Outdoor levels of mean annual nitrogen dioxide (NO2) exposure were determined.

Type of allergen/respiratory outcomes	Adjusted*		
	OR	95% CI	*P* value
Atopy	1.14	1.02-1.28	.02
Cat allergen sensitization	1.31	1.15-1.49	<.01
HDM sensitization	1.20	1.08-1.34	<.01
Any mold sensitization	1.11	0.96-1.28	.16
Mix grass and rye sensitization	1.05	0.94-1.17	.37
Current wheeze	1.14	1.02-1.28	.02
Current asthma	1.10	0.97-1.24	.13
Current nonatopic asthma†	0.96	0.76-1.22	.75
Current atopic asthma†	1.14	1.00-1.30	.05

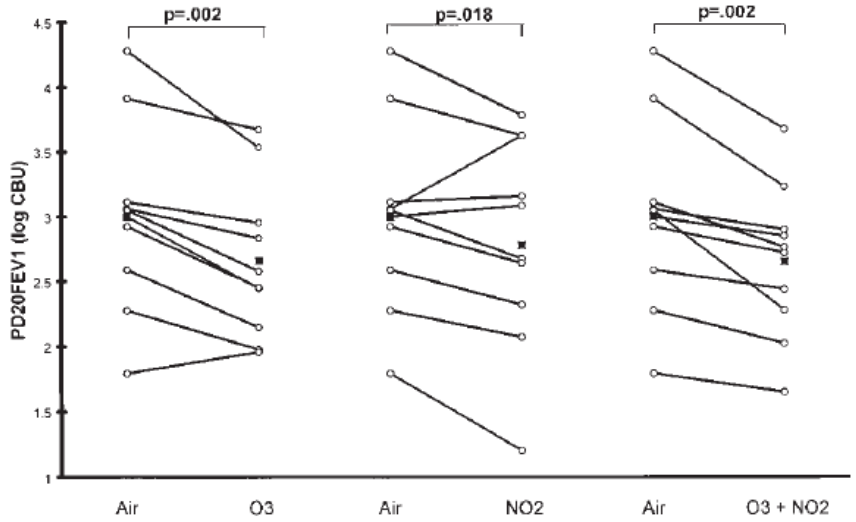
Increased mean annual NO_2 exposure was associated with increased risk of atopy and current wheeze.
Living less than 200 m from a major road was associated with current wheeze, atopy, significantly lower prebronchodilator and postbronchodilator FEV1 and prebronchodilator FEF 25%-75%

Carriers of the Glutathione S-Transferase genes variant, GSTT1 null genotype had an increased risk of asthma and allergic outcomes if exposed to traffic-related air pollution .

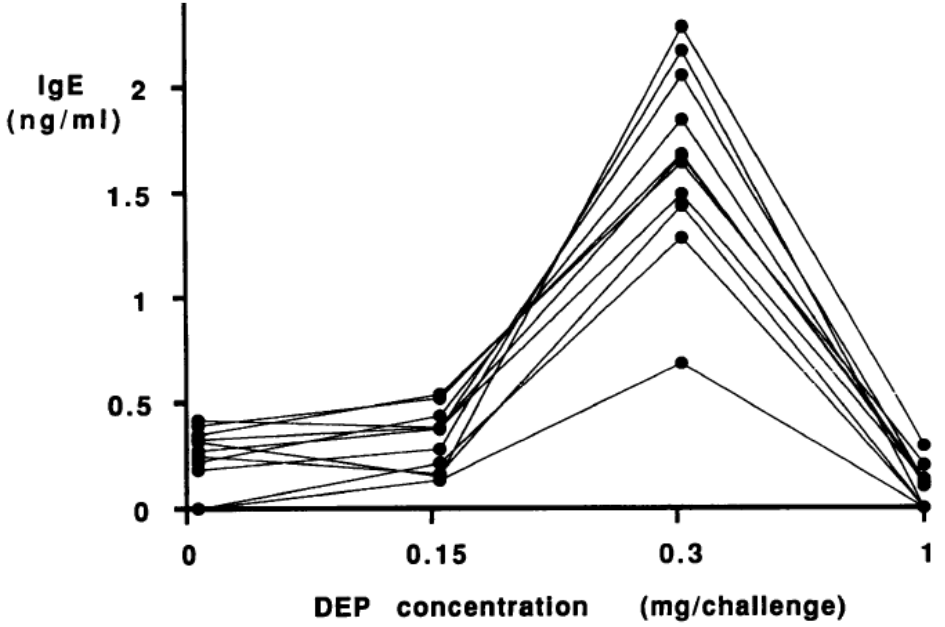
Bowatte G Allergy Clin Immunol 2017;139:122-9

Pollutants increase response to inhalant allergens

The airway response of asthmatics to bronchial inhaled allergen challenge (Dermatophagoides pteronyssinus) is increased by exposure to NO_2, O_3, NO_2+ SO_2.
Devalia JL Lancet 1994,344,1668
Huw S Am J Respir Crit Care Med 1999;160:33



Intranasal DEP increases local levels of IgE to ragweed or pollens
Diaz Sanchez D Allergy 1997, 52 (suppl 88), 52-56
Diaz Sanchez D J Clin Invest. 1994;94(4):1417-1425



Environmental changes

- **Early starting of pollen season (higher temperature)**
- **Longer pollen season**
- **Enhanced pollen production** (CO_2 increase)
- **Spread of allergenic plants in different areas because of climatic change** (ragweed)

Tim K Takaro et al. Expert Rev Resp Med 2013
Ayres JG et al. Eur Respir J 2009
Cecchi L et al Allergy 2010

Respiratory symptoms

- A meta-analysis concluded that exposure to NO_2 is linked to new-onset asthma, while exposure to PM is linked to new-onset wheeze. (Gasana J Environ Res 2012;117:36–45)
- Levels of PM2.5 are associated with asthma exacerbations (Bouazza N Arch Dis Child 2017)
- Daily fluctuations of PM10 associated with
  - Acute respiratory admissions
  - Absences from school/kindergarten
  - Increased use of asthma medications
- Distance from road
  - Not consistent findings

Clinics

- Inform parents and asthmatic children
- History of possible sources
- Air quality and health effects websites
  - http://www.airquality.co.uk/archive/index.php
  - http://rcweb.leicester.gov.uk/pollution/asp/home.asp
  - Committee on the Medical Effects of Air Pollutants (COMEAP)
- ?increasing treatment
- ?increase in antioxidants Vit C,A

Pollution level	Measures
Low	▶ Avoid spending long periods of time along busy roads
Moderate	▶ Reduce or avoid strenuous outdoor activities
High	▶ Reduce or avoid strenuous outdoor activities ▶ Avoid pollution hotspots ▶ Avoid rush hours, travel earlier before pollution levels build up ▶ Use less polluted routes when cycling, walking or running ▶ Use of reliever inhaler if pollution is a trigger to asthma symptoms ▶ Seek medical attention

British Lung Foundation website (https://www.blf.org.uk/support-for-you/airpollution/what-can-i-do)

Evolution of Asthma Self-Management Programs in Adolescents: From the Crisis Plan to Facebook

SMS

Smartphone application

Authors	Year	Number subjects	Control group	Age (y)	Intervention	Duration (wk)	Primary outcome	Result	Secondary outcome	Result
Britto et al[27]	2012	23	Yes	13-18	Text messages	52	Acceptability/usefulness/ease of use	Y	Self-reported asthma control	N
Burbank et al[28]	2015	20	No	12-17	Application	8	Use of application/satisfaction	Y	Asthma control	Y†
Dzubar et al[29]	2014	20	No	12-17	Application	1	Satisfaction/ease of use	Y		
Farooqui et al[30]	2014	21	No	9-16	Application	4	Acceptability/usefulness	Y	Adherence	Y
Haze and Lynaugh[31]	2013	25	No	13-18	Application	26	Relationship with asthma nurse	Y		
Mosnaim et al[32]	2015	12	No	11-16	Application	8	Tracked adherence	Y	Asthma control	Y
Neville et al[33]	2002	30	No	10-46	Text messages	4	Acceptability/usefulness	Y		
Perry et al[20]	2016	34	Yes	*	Mobile AAP	6	Utilization	Y	Asthma control	Y†
Petrie et al[34]	2012	147	Yes	16-45	Text messages	18	Understanding of asthma	Y	Self-reported adherence	Y
Searing and Bender[35]	2012	43	Yes	*	Text messages	4	Acceptability/usefulness	Y	Asthma control and adherence	Y
Seid et al[36]	2012	26	Yes	12-18	Text messages	12	Acceptability/usefulness	Y	Asthma control	Y
Vasbinder et al[37]	2016	209	Yes	4-11	Text messages	52	Adherence	Y	Asthma control, quality of life	N

Facebook group

Liptzin DR J Pediatr 2016 ;179:19-25

Summary

- Children are susceptible
- Air pollution exacerbates asthma
- Lung function deficit is well documented
- Reducing road traffic and planting trees can reduce air pollution

Thank you