Universiteit Antwerpen
Faculteit Geneeskunde en Gezondheidswetenschappen

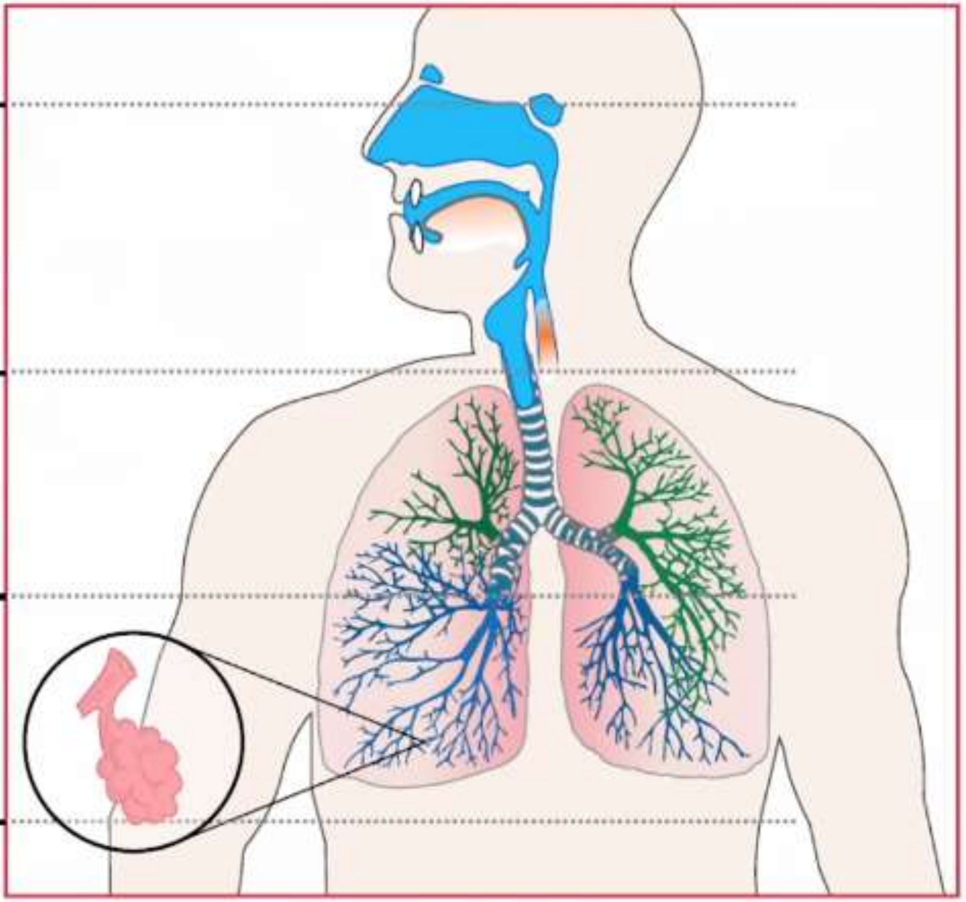
De longen als eerste passage van luchtverontreiniging: reageren kinderen anders dan volwassenen?

Prof. Dr. T. Laperre – Pneumologie

Prof. Dr. S. Verhulst - Pediatrie/Kinderpneumologie

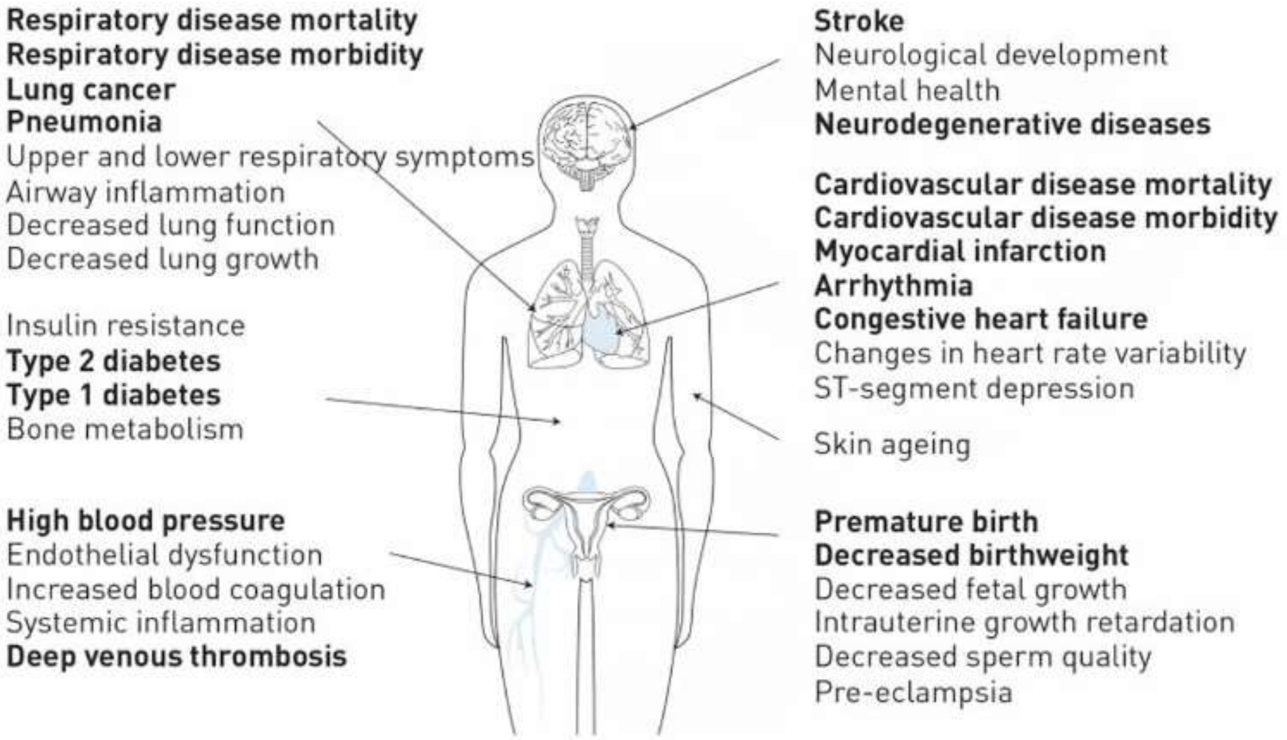
Introduction

Nose, throat:	Particles <30 µm
Trachea, bronchi, bronchioli:	Particles <10 µm SO_2, NO_2, ozone
Pulmonary alveoli:	Particles <2–3 µm NO_2, ozone
Pulmonary tissue, circulation:	Ultrafine particles <0.1 µm



ERS. Air quality and health 2010

Introduction

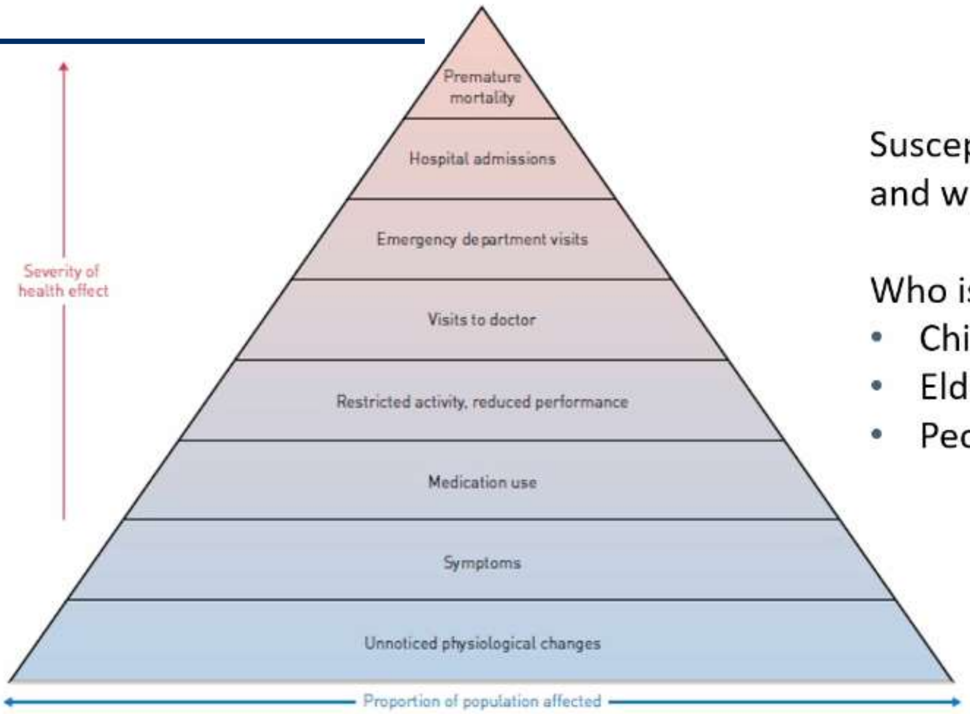


Air pollution affects nearly all organ systems

Thurston et al. Eur Respir J 2017;49:1600419

Introduction

On 17 December 2020, the H.M. Assistant Coroner for Inner South London, Dr Philip Barlow, opened an inquest into the death of Ella Roberta Adoo Kissi-Debrah from an asthma attack.[1] Ella lived next to the South Circular Road and for most of her short life had been exposed to excessively high levels of a traffic-derived mix of nitrogen dioxide (NO_2) and particulate matter (PM) less than 10 microns in aerodynamic diameter (PM_{10}—the inhalable fraction), and the non-exhaust sources of PM such as tyre and brake wear. After hearing extensive evidence from medical and pollution monitoring experts, his decision was Ella died from acute respiratory failure, asthma, and air pollution exposure—the first time ever that a coroner has found air pollution as a contributory cause of illness and death, and providing support for future litigation. In



Utrecht University

ERS. Air quality and health 2010

Susceptibility differs between people and within people over time!

Who is more affected?

- Children
- Elderly
- People with lung/heart disease

BMJ Paediatrics Open

Air pollution and children's health: where next?

Abigail Whitehouse, Jonathan Grigg

Universiteit Antwerpen | Faculteit Geneeskunde en Gezondheidswetenschappen

Why are children more affected?

- Immature immune system.
- Developing lung and metabolic systems.
- Co-occurence of respiratory infections.

- Children spend more time outdoors
- Children are more physically active
- This results in more exposure: higher concentration of air pollution and increased ventilatory rates.

Prenatal exposure is also relevant!

- **Combination of direct and indirect effects.**

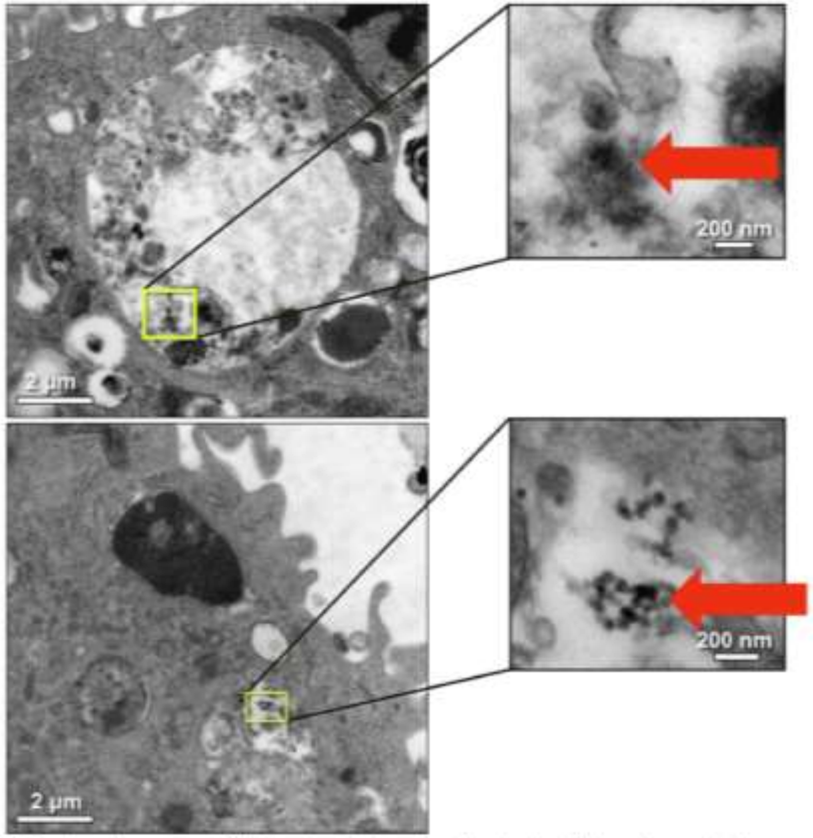


Figure 1 Showing -Electron microscopy (EM) imaging of placenta with clearly visible carbon particles, reproduced with permission from Liu et al.[5]

Asthma

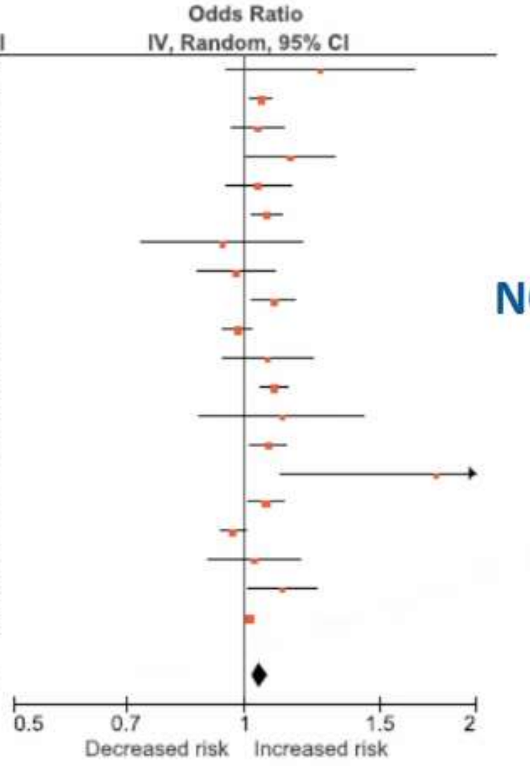
- **Similar as in adults: more pollution results in more asthma symptoms, exacerbations, medication use, emergency visits and hospitalisations.**

Asthma

Exposure to traffic-related air pollution and risk of development of childhood asthma: A systematic review and meta-analysis

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Carlsten et al. 2010 - at 7 y.o.	0.2253	0.1448	0.6%	1.25 [0.94, 1.66]
Clark et al. 2010 LUR - at mean age of 4 y.o.	0.0489	0.0171	9.5%	1.05 [1.02, 1.09]
Dell et al. 2014 LUR - 5 to 9 y.o.	0.039	0.04	5.0%	1.04 [0.96, 1.12]
Deng et al. 2016 - 3 to 6 y.o.	0.1374	0.0689	2.4%	1.15 [1.00, 1.31]
Gehring et al. 2015 b - BAMSE birth to 16 y.o.	0.0397	0.0498	3.8%	1.04 [0.94, 1.15]
Gehring et al. 2015 b - PIAMA birth to 14 y.o.	0.0665	0.0246	7.8%	1.07 [1.02, 1.12]
Gehring et al. 2015b - GINI&LISA North birth to 15	-0.0679	0.1235	0.8%	0.93 [0.73, 1.19]
Gehring et al. 2015b - GINI&LISA South birth to 15	-0.0252	0.0602	2.9%	0.98 [0.87, 1.10]
Jerret et al. 2008 - 10 to 18 y.o.	0.0874	0.033	6.1%	1.09 [1.02, 1.16]
Kim et al. 2016 - 6 to 7 y.o.	-0.0214	0.0219	8.4%	0.98 [0.94, 1.02]
Krämer et al. 2009 - 4 to 6 y.o.	0.0698	0.069	2.3%	1.07 [0.94, 1.23]
Liu et al. 2016 - 4 to 6 years old	0.0877	0.0215	8.5%	1.09 [1.05, 1.14]
MacIntyre et al. 2014 - CAPPS&SAGE only birth to 8	0.1111	0.1268	0.8%	1.12 [0.87, 1.43]
McConnell et al. 2010 - 4th to 6th grade	0.0698	0.0281	7.1%	1.07 [1.01, 1.13]
Mölter et al. 2014 b - MAAS only birth to 8 y.o.	0.574	0.2374	0.2%	1.78 [1.11, 2.83]
Nishimura et al. 2013 - 8 to 21 y.o.	0.0632	0.0269	7.3%	1.07 [1.01, 1.12]
Oftedal et al. 2009 - birth to 10 y.o.	-0.0359	0.0196	8.9%	0.96 [0.93, 1.00]
Ranzi et al. 2014 - birth to 7 y.o.	0.0289	0.0701	2.3%	1.03 [0.90, 1.18]
Shima et al. 2002 - 6 to 12 y.o.	0.1136	0.0534	3.5%	1.12 [1.01, 1.24]
Tétreault et al. 2016 - birth to 12 y.o.	0.0153	0.0048	11.6%	1.02 [1.01, 1.03]
Total (95% CI)			**100.0%**	**1.05 [1.02, 1.07]**

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 54.38$, $df = 19$ ($P < 0.0001$); $I^2 = 65\%$
Test for overall effect: $Z = 3.76$ ($P = 0.0002$)



NO_2

Khreis et al. Environ Int 2017;100:1-31

Lung growth

TABLE 4 Additionally adjusted associations of average air pollution exposure in the preschool time window with lung function growth from age eight to age 16 (n=871)#

Pollutant	Increment	Difference in FEV_1 % (95% CI)¶	Difference in FVC % (95% CI)¶
NO_2	7.8 $\mu g \cdot m^{-3}$	–0.31 (–0.47 to –0.14)	0.01 (–0.14 to 0.16)
$PM_{2.5}$ absorbance	0.3 $10^{-5} \cdot m^{-1}$	–0.33 (–0.51 to –0.16)	0.05 (–0.11 to 0.22)
$PM_{2.5}$	1.2 $\mu g \cdot m^{-3}$	–0.26 (–0.49 to –0.03)	0.24 (0.03 to 0.45)
PM_{10}	0.9 $\mu g \cdot m^{-3}$	–0.20 (–0.33 to –0.08)	–0.02 (–0.13 to 0.09)
PM_{coarse}	0.5 $\mu g \cdot m^{-3}$	–0.17 (–0.28 to –0.06)	–0.01 (–0.11 to 0.09)

Milanzi et al. *Eur Respir J* 2018; 52: 1800218

Open questions

- **Are different types of PM equally toxic?**
  - Unknown
  - Assume that they all are evenly toxic – major implications for policy makers

- **Health effects of personal efforts to reduce exposure?**
  - Effects of personal measures?
  - Role of air sanitizers etc.?

Box 1 Advice that can be given to children with asthma to reduce personal exposure

- When there is a short-term increase in air pollution levels across the city, there is an increased risk of more asthma symptoms. So when levels are high, the government will issue an air pollution alert or you may see reports included as part of the weather forecast.
- These short-term increases (spikes) in air pollution will increase your exposure, no matter where you are. It is therefore sensible to take extra precautions when there is a high pollution day.
- This includes reducing or avoiding strenuous outdoor exercise. Since exercise has many benefits, if possible, keep doing your exercise indoors in a well-ventilated room or gym.
- Stay away from pollution hotspots such as main roads and busy road junctions.
- Try to get to school a little earlier before rush hour has begun and levels of pollution have built up.
- Walk to school or the shops on the inside of the pavement—the further you are from the traffic, the lower the pollution levels are.
- Make sure you carry your reliever inhaler. Consider taking your reliever before entering a pollution hotspot.
- Make extra sure that you use your regular preventer inhaler as prescribed.
- When there is a short-term increase in air pollution levels across the city, there is an increased risk of more asthma symptoms. So when levels are high, the government will issue an air pollution alert or you may see reports included as part of the weather forecast.

Adapted from the British Lung Foundation.[19]

The NEW ENGLAND JOURNAL of MEDICINE
ESTABLISHED IN 1812 MARCH 5, 2015 VOL. 372 NO. 10

Association of Improved Air Quality with Lung Development in Children

W. James Gauderman, Ph.D., Robert Urman, M.S., Edward Avol, M.S., Kiros Berhane, Ph.D., Rob McConnell, M.D., Edward Rappaport, M.S., Roger Chang, Ph.D., Fred Lurmann, M.S., and Frank Gilliland, M.D., Ph.D.

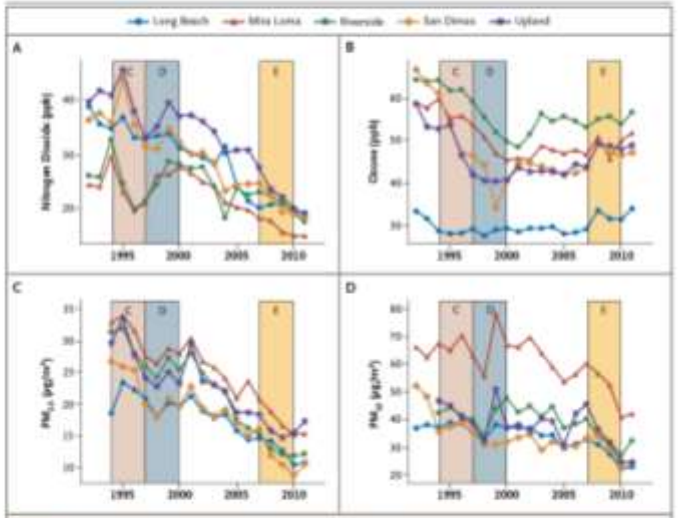


Figure 1. Levels of Four Air Pollutants from 1994 to 2011 in Five Southern California Communities.
Colored bands represent the relevant 4-year averaging period for the analysis of lung-function growth in each of the three cohorts, C, D, and E. $PM_{2.5}$ denotes particulate matter with an aerodynamic diameter of less than 2.5 μm, and PM_{10} particulate matter with an aerodynamic diameter of less than 10 μm.

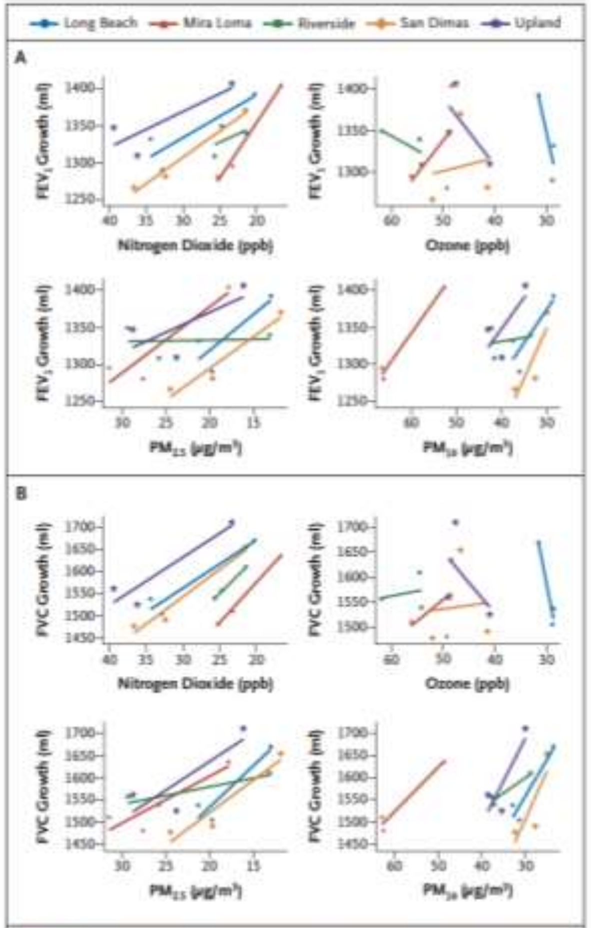


Figure 2. Mean 4-Year Lung-Function Growth versus the Mean Levels of Four Pollutants.
The mean growth in forced expiratory volume in 1 second (FEV_1) (Panel A) and the mean growth in forced vital capacity (FVC) (Panel B) from 11 to 15 years of age are plotted against the corresponding levels of nitrogen dioxide, ozone, $PM_{2.5}$, and PM_{10} for each community and cohort.

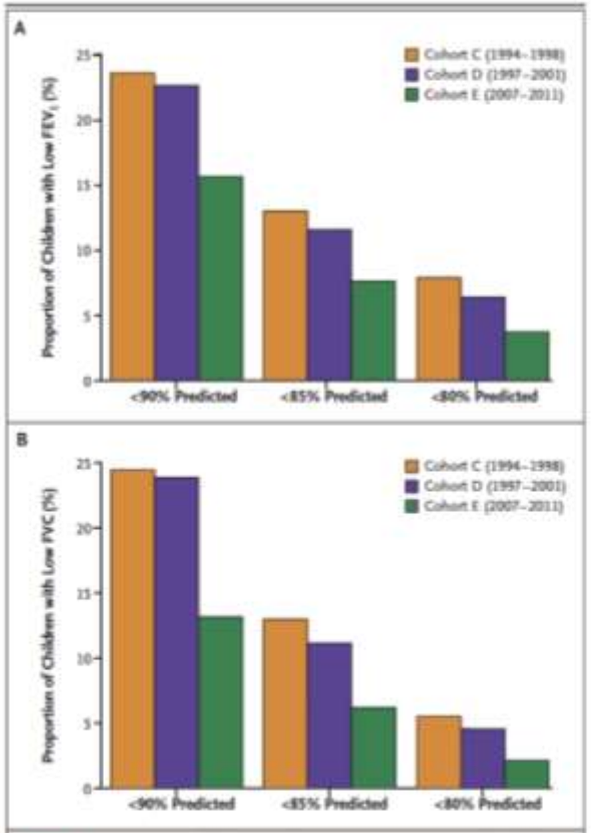


Figure 3. Proportions of Children with Low Lung Function in Each Cohort.
The proportions of children with lung function below 90%, 85%, or 80% of the predicted value at 15 years of age in cohorts C, D, and E are shown for FEV_1 (Panel A) and FVC (Panel B).

Impact of London's low emission zone on air quality and children's respiratory health: a sequential annual cross-sectional study

Ian S Mudway, Isobel Dundas, Helen E Wood, Nadine Marlin, Jeenath B Jamaludin, Stephen A Bremner, Louise Cross, Andrew Grieve, Alex Nanzer, Ben M Barratt, Sean Beevers, David Dajnak, Gary W Fuller, Anna Font, Grainne Colligan, Aziz Sheikh, Robert Walton, Jonathan Grigg, Frank J Kelly, Tak H Lee, Chris J Griffiths

Research in context

Evidence before this study

Exposure to traffic pollutants has been associated with adverse health effects, especially in children, with the ESCAPE meta-analysis of data for 5921 children showing that poor air quality was associated with reduced lung function in preadolescent children (aged 6–8 years). The introduction of low emission zones (LEZ) has been proposed to improve air quality and improve public health. These operate either by restricting vehicle entry into urban areas, or through fixed penalties on polluting vehicles to encourage uptake of lower emission technologies. Despite the political and financial costs of LEZ implementation, studies on the impact of these schemes on air quality and public health remain scarce. We searched MEDLINE for publications from 2009 until Nov 1, 2017, using keywords "low emission zone" AND/OR "traffic", "air quality", and "health". These reviews showed LEZs do not consistently improve air quality, and effects are small. Few studies addressed health impacts, and these have tended to rely on modelled predictions of air quality improvements.

Added value of this study

We exploited the comprehensive monitoring network in London, UK, to evaluate the changes in air pollution following the introduction of the LEZ. Our study covered the tightening of emission controls within the LEZ in 2012, which occurred alongside national, regional, and local policies to improve air quality. We based our study in four inner-city London boroughs, which were identified as non-compliant with EU annual NO_2 limit values at the start of study. Despite the problems associated with vehicle non-compliance with European class emission standards over this period, we have provided evidence of improvements in air quality. We also confirmed the previously reported association between pollutant exposures and reduced children's lung volume. We observed some evidence of a reduction in rhinitis, but not asthma symptoms or the proportion of children with small lungs over the study period.

Implications of all available evidence

Large-scale LEZs can deliver improvements in urban air quality and these can be linked to changes in childhood respiratory health. However, more ambitious schemes than those evaluated here are required to meet legislative limits and deliver improvements to respiratory health in many European cities.

CV system

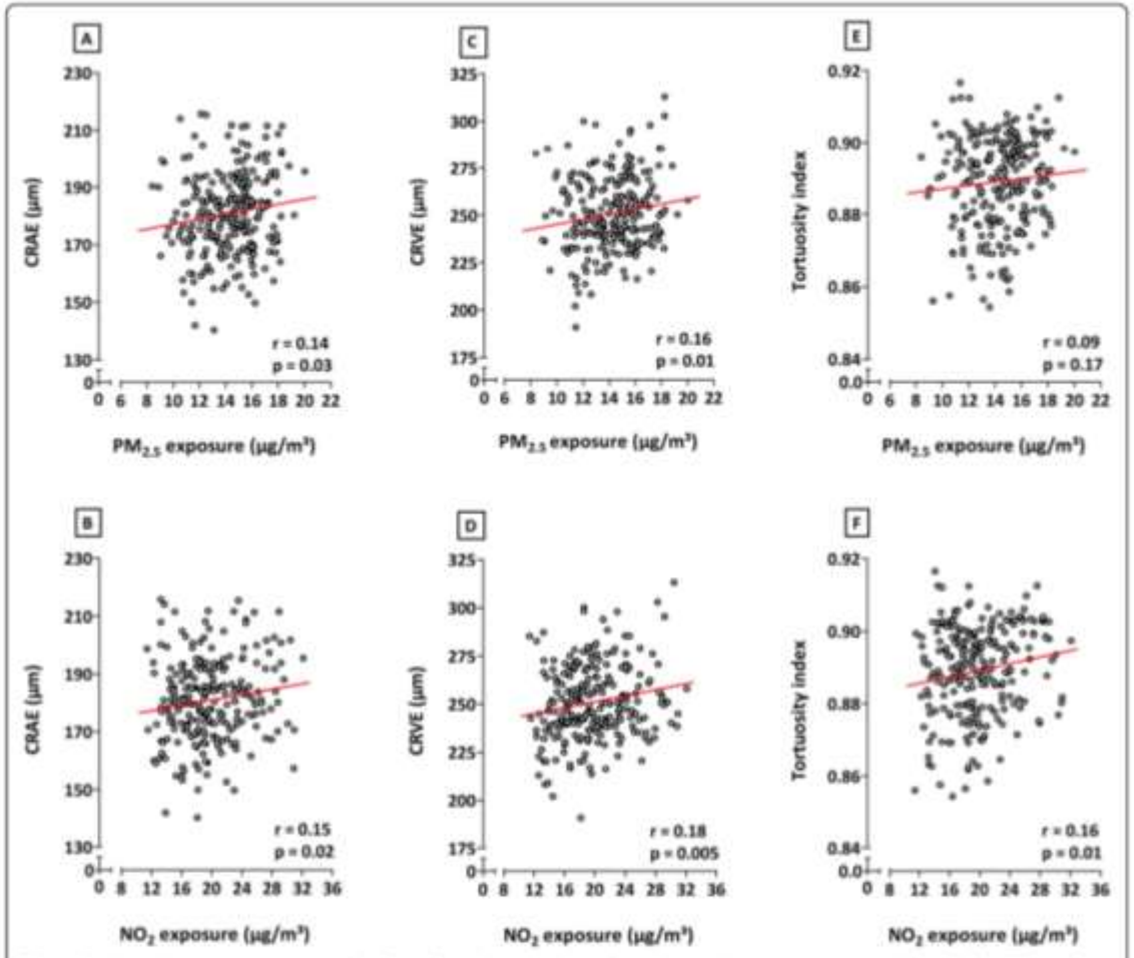


Fig. 1 Correlations between exposure to either $PM_{2.5}$ (first row) or NO_2 (second row) during the entire pregnancy and CRAE (**a**, **b**), CRVE (**c**, **d**), and tortuosity index (**e**, **f**). The respective *r* and *p* values are depicted on each plot. *Abbreviations*: CRAE, central retinal arteriolar equivalent; CRVE, central retinal venular equivalent; NO_2, nitrogen dioxide; $PM_{2.5}$, particulate matter with a diameter smaller than 2.5 μm

Luyten et al. BMC Medicine (2020) 18:128
https://doi.org/10.1186/s12916-020-01586-x
BMC Medicine
RESEARCH ARTICLE Open Access

Children's microvascular traits and ambient air pollution exposure during pregnancy and early childhood: prospective evidence to elucidate the developmental origin of particle-induced disease

Leen J. Luyten[1,2], Yinthe Dockx[1], Eline B. Provost[1,3], Narjes Madhloum[1], Hanne Sleurs[1], Kristof Y. Neven[1], Bram G. Janssen[1], Hannelore Bové[1], Florence Debacq-Chainiaux[2], Nele Gerrits[3], Wouter Lefebvre[3], Michelle Plusquin[1], Charlotte Vanpoucke[4], Patrick De Boever[1,3] and Tim S. Nawrot[1,5*]

Conclusions

Both prenatal and early childhood exposures to $PM_{2.5}$ and NO_2 were associated with changes in retinal vessel diameters and altered vessel tortuosity in young children. Our study adds to the knowledge of basic fundamental mechanisms on the complex relationship between early life exposure to ambient air pollution and cardiovascular disease development later in life. In future research projects, focus should be put on the implications of our findings on the cardiovascular development of the children in our prospective cohort.

Conslusion

- **The health of the current generation of children is certainly affected by pollution.**

On 17 December 2020, the H.M. Assistant Coroner for Inner South London, Dr Philip Barlow, opened an inquest into the death of Ella Roberta Adoo Kissi-Debrah from an asthma attack.[1] Ella lived next to the South Circular Road and for most of her short life had been exposed to excessively high levels of a traffic-derived mix of nitrogen dioxide (NO_2) and particulate matter (PM) less than 10 microns in aerodynamic diameter (PM_{10}—the inhalable fraction), and the non-exhaust sources of PM such as tyre and brake wear. After hearing extensive evidence from medical and pollution monitoring experts, his decision was Ella died from acute respiratory failure, asthma, and air pollution exposure—the first time ever that a coroner has found air pollution as a contributory cause of illness and death, and providing support for future litigation. In

- **The impact starts before birth and continues during development.**
- **Air pollution can contribute to the development of asthma in children.**
- **Air pollution can impact lung growth in children.**
- **Air pollution can impact the development of the cardiovascular system in children.**

Conslusion

- **Open questions:**
  - Differences between PMs
  - Tresholds?
  - Effects of air quality programs?
  - Effects of personal measurements?

- **BUT:**

health benefits? What is clear though is that air pollution exposure continues to be a significant risk across the life course, with both short-term and long-term health effects. Since delaying exposure–mitigation policies puts at risk this generation of children, ensuring the right to breathe clean air must be higher up the political agenda, with major investment in small-scale local interventions (eg, low-pollution streets outside schools), and both city-wide (eg, clean air zones) and national actions (eg, scrappage schemes for the most polluting vehicles).

BMJ Paediatrics Open

Air pollution and children's health: where next?

Abigail Whitehouse, Jonathan Grigg