




Frontiers in Air Quality
Advances in Air Quality Toxicology

Fumifugium 2014

Ian Mudway

MRC-PHE
Centre for Environment & Health





Cleaner Fuels (wood vs. coal)
Separate population from
pollution sources
Economic benefits
Green infrastructure

FUMIFUGIUM:
OR
The Inconveniencie of the AER
AND
SMOAK of LONDON
DISSIPATED.
TOGETHER
With some REMEDIES humbly
PROPOSED
By J. E. Esq;
John Evelyn
To His Sacred MAJESTIE,
AND
To the PARLIAMENT now Assembled.

Published by His Majesties Command.

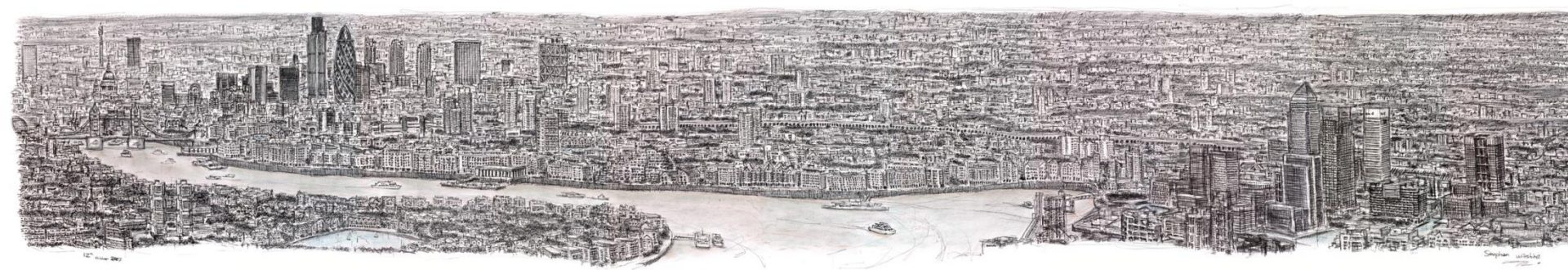
Lucret. l. 5.
*Carbonumque gravis vis, atque edor insinuat
Quam facile in cerebrum? —*

LONDON,
Printed by W. Godbid for Gabriel Redel, and Thomas Collins,
and are to be sold at their Shop at the Middle Temple Gate
near Temple-Bar. M. D. C. L. X. I.

John Evelyn 1620 –1706

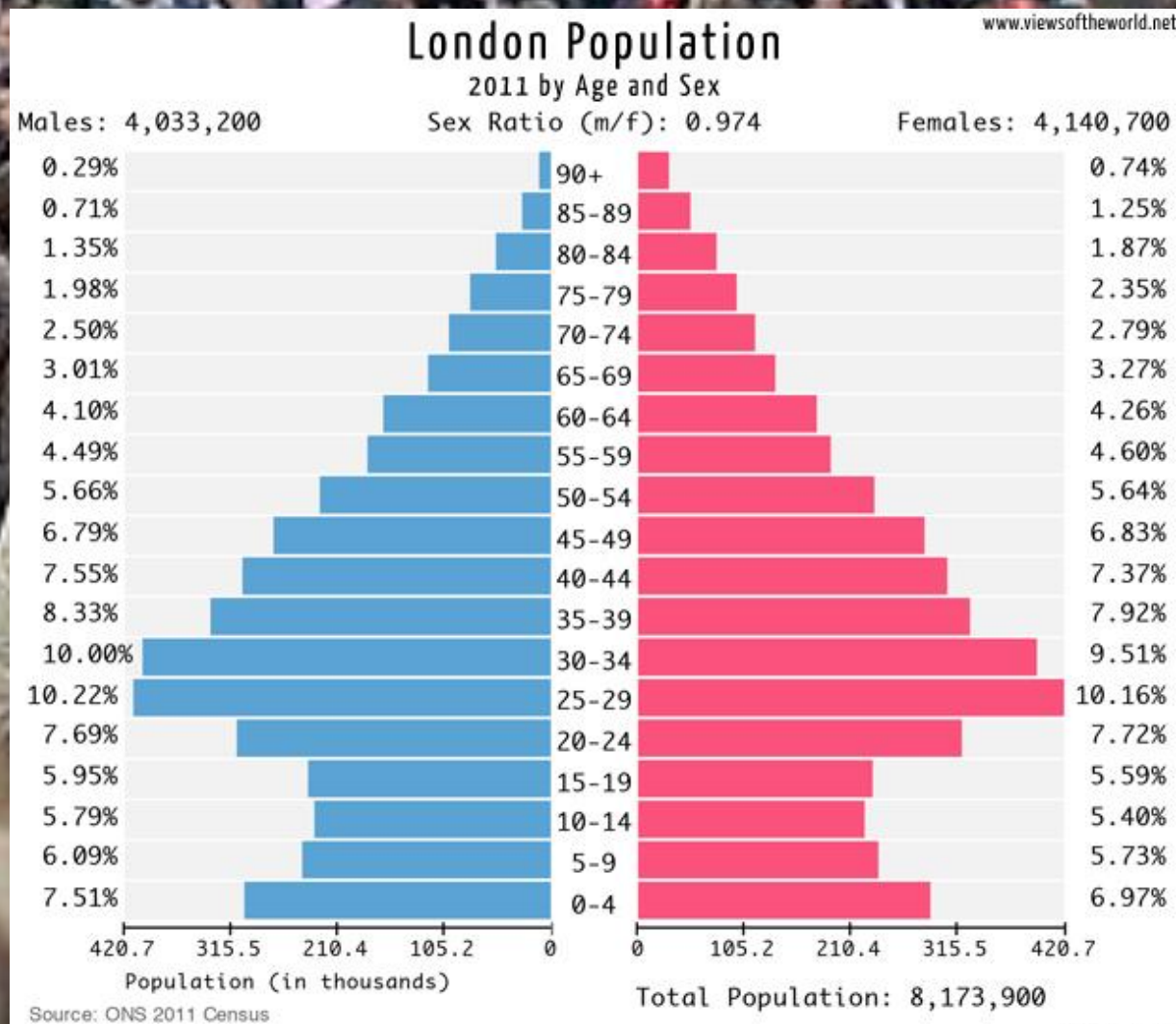
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One very large seething Petri dish

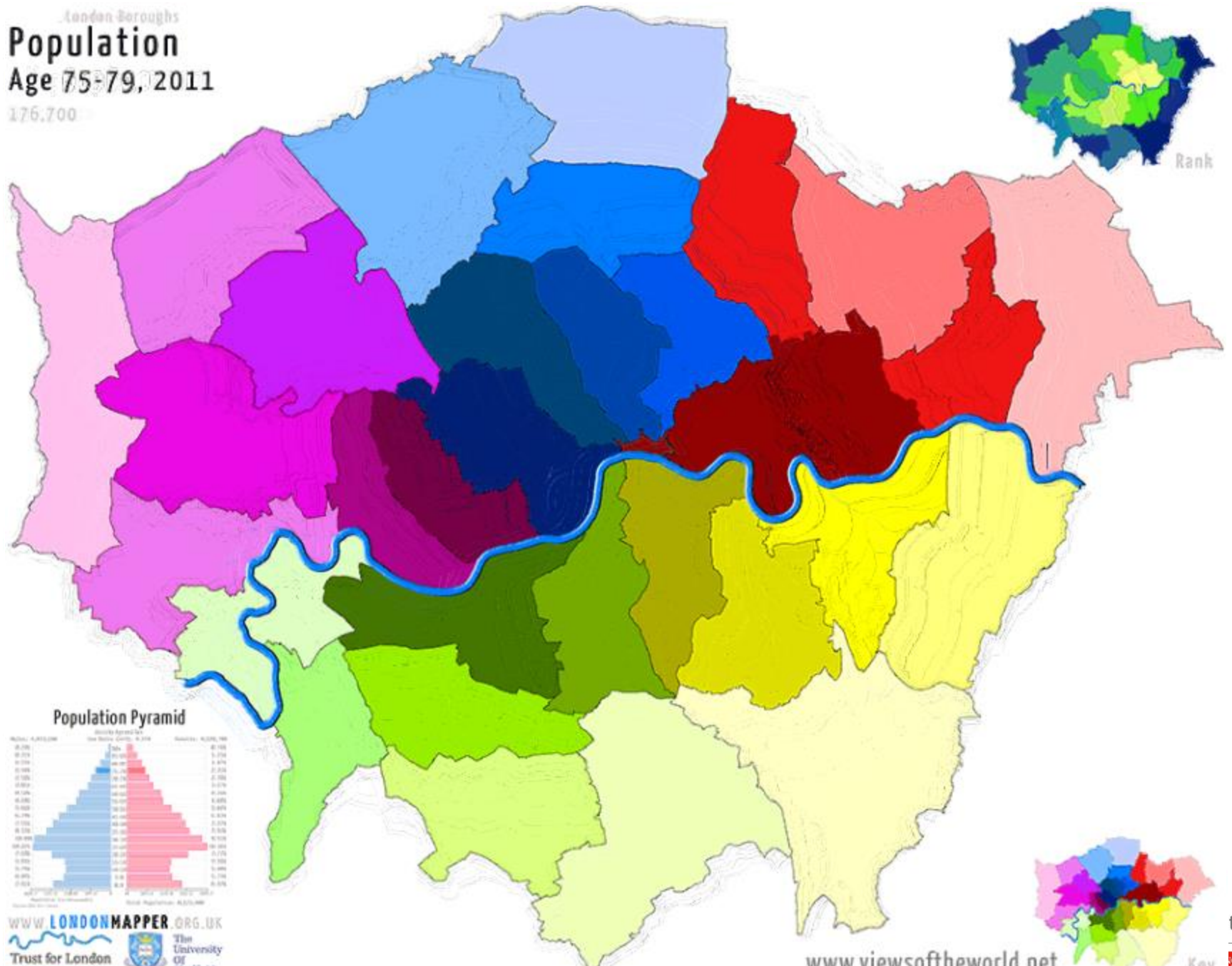
Know your model organism



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London Boroughs
Population
Age 75-79, 2011
 176,700



Population Pyramid



Think about susceptibility

**Deaths Registered in London Administrative County Classified by Age
(Bates, 1995)**

	< 1 Month of Age	1-12 Mo. Old	1-14 Years of Age	15-44 Years of Age	45-64 Years of Age	65-74 Years of Age	75+ Years of Age
Week Before the Episode	16	12	10	61	237	254	335
Week After the Episode	28	26	13	99	652	717	949
Before/ After Episode Ratio	1.75	2.17	1.3	1.62	2.75	2.82	2.83

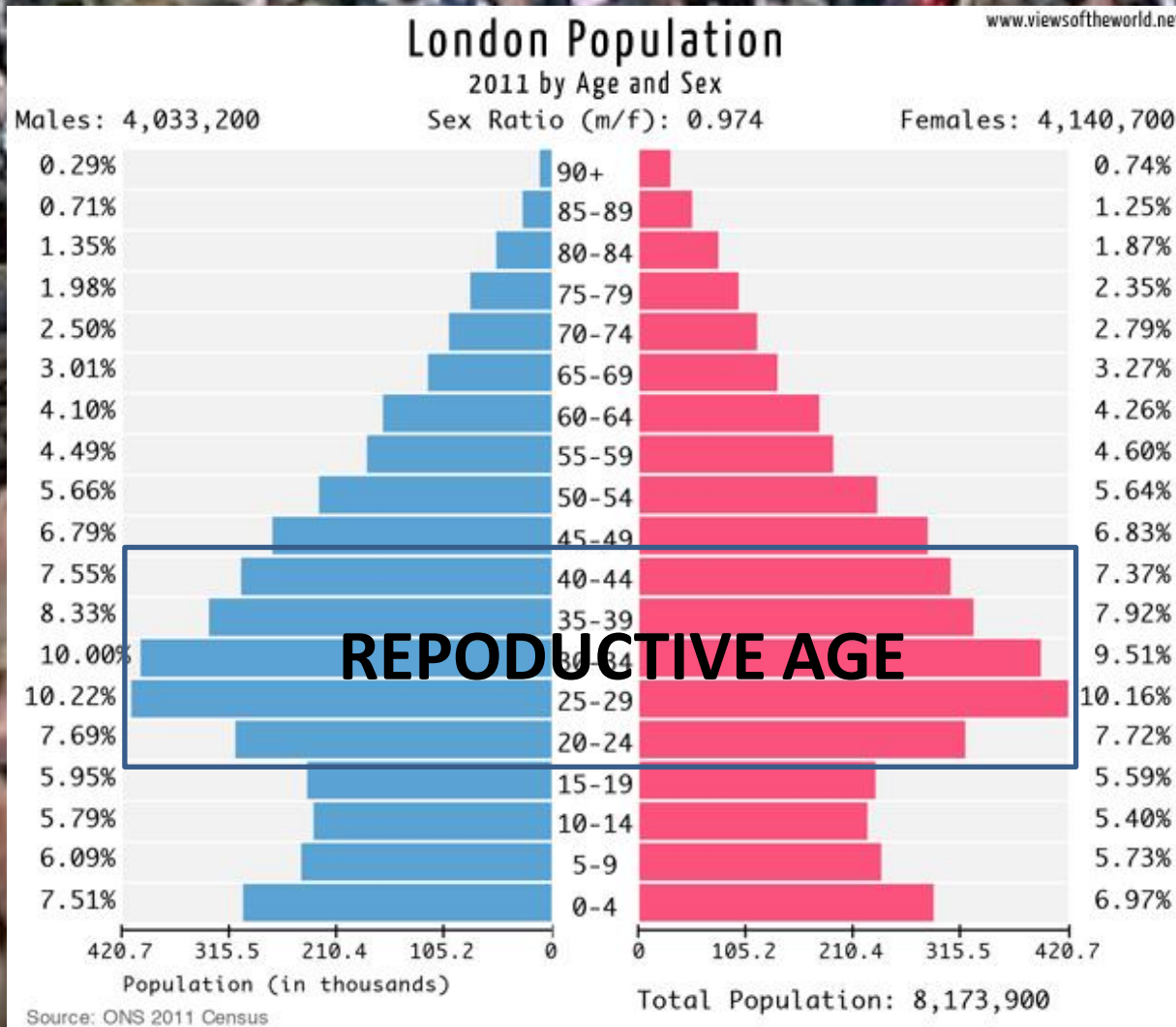
Vulnerability

“This cloud is so inextricably mixed with the naturally wholesome and excellent air that the inhabitants can breathe nothing but thick, dirty, smoggy air. This makes them vulnerable to thousands of diseases, corrupting their lungs and disordering their bodies, so that catarrh, coughs and tuberculosis.”

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Critical windows of enhanced vulnerability



Degradation of defence mechanism with age

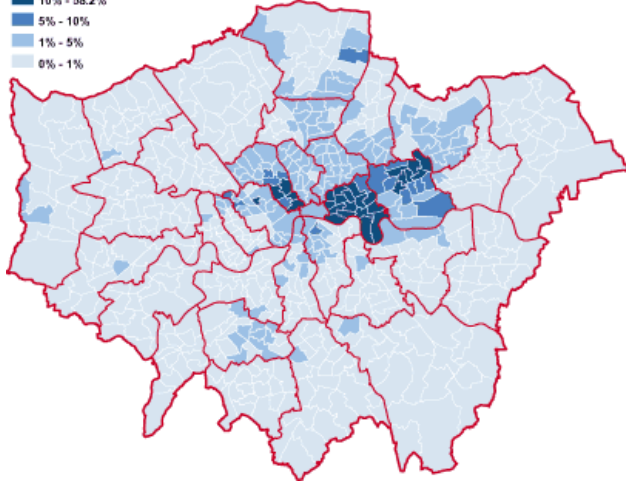
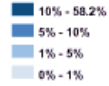
REPRODUCTIVE AGE

Development

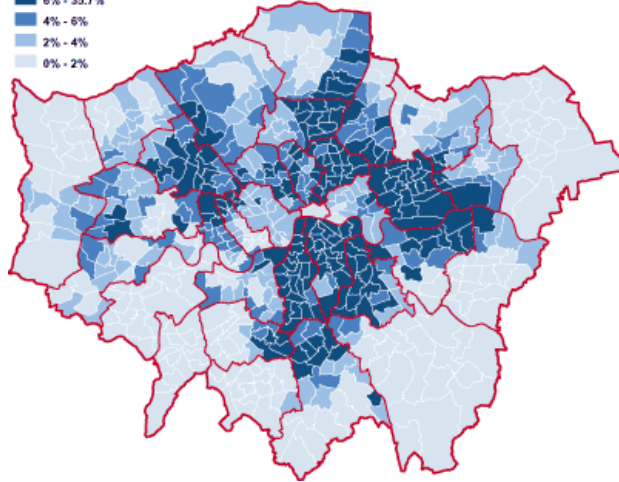
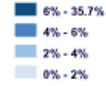
In utero

Appreciate varying genetic background: An ethnically diverse city

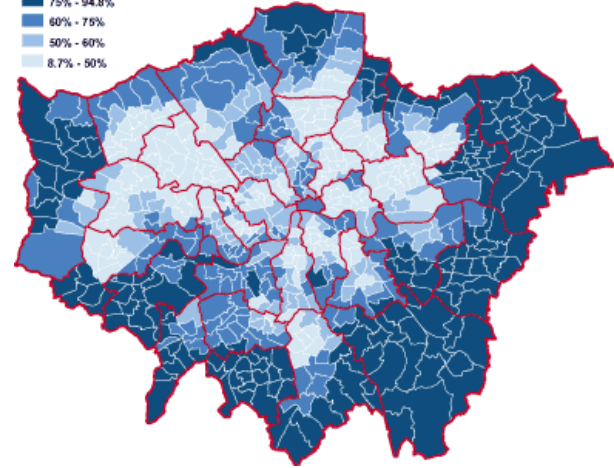
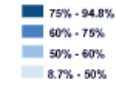
Bangladeshi



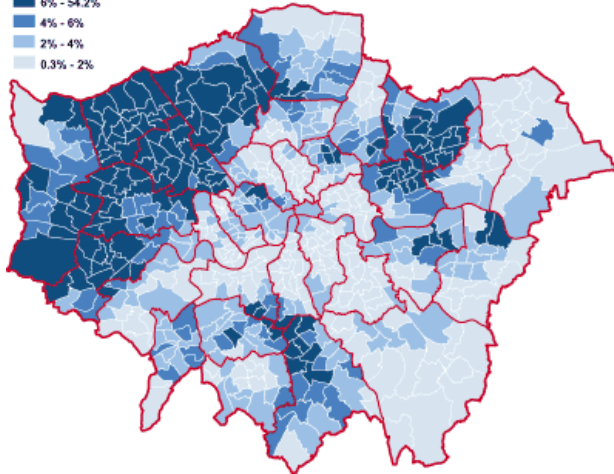
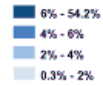
Black African



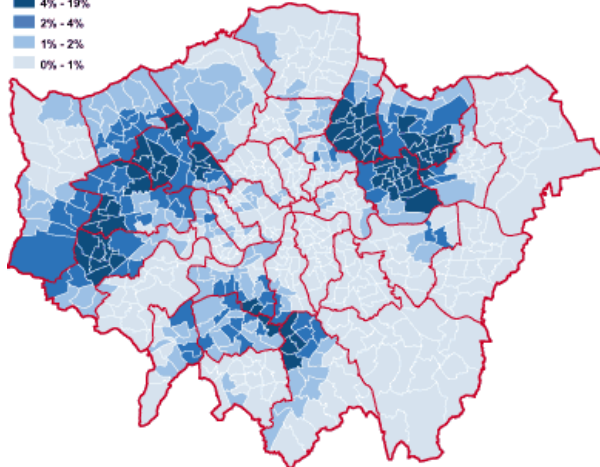
White British



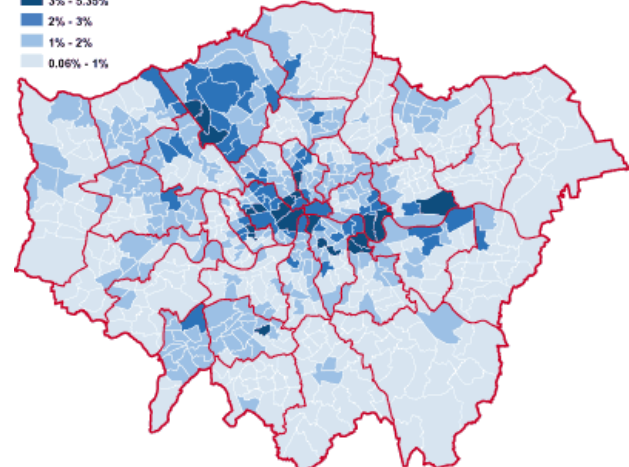
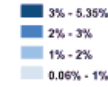
Indian



Pakistani



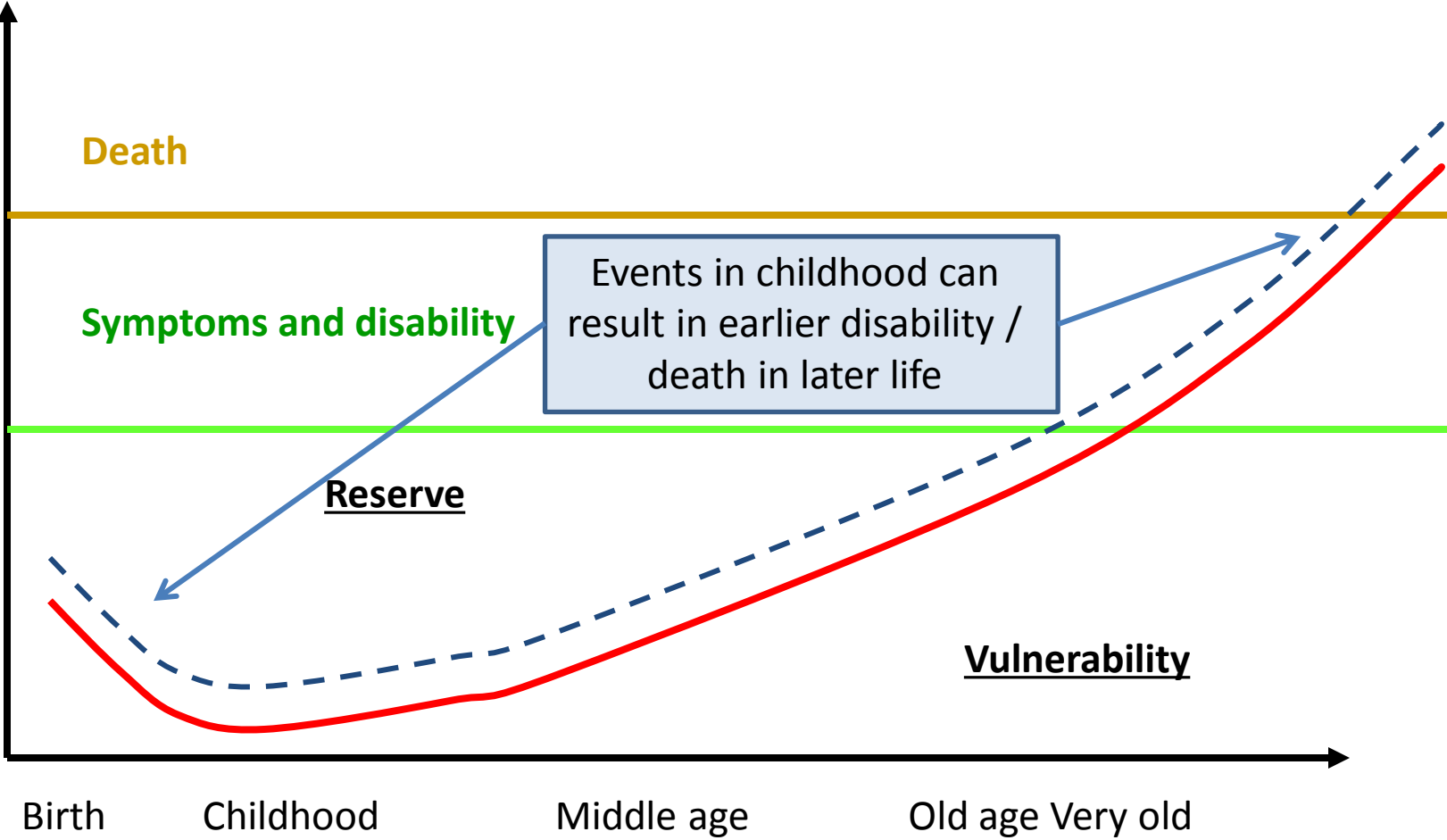
Chinese



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*“This plague of a smoke is truly intolerable because, although **it does not kill at once, it is deadly and to slowly perish is worse than death itself.** Is there any other place on Earth where such coughing and snuffling is to be heard as in the churches and assemblies of London, where the barking and spitting is incessant? Need I say more?”*

Role of air pollution in chronic disease



“There are, I must accept, certain differences in people which allow them to thrive more in some airs compared to others.”

Environment

Genes

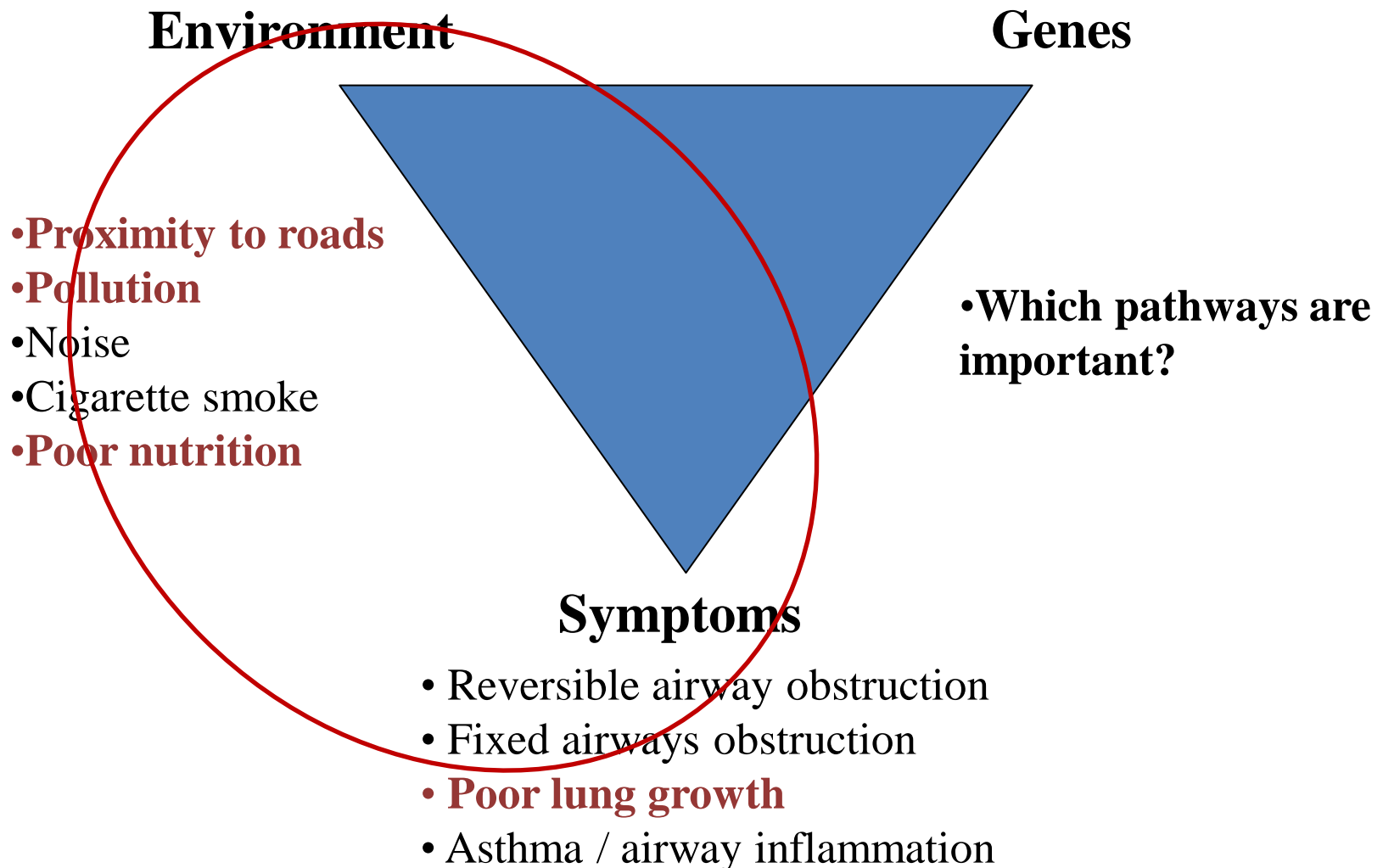
- Proximity to roads
- Pollution
- Noise
- Cigarette smoke
- Poor nutrition

• Which pathways are important?

Symptoms

- Reversible airway obstruction
- Fixed airways obstruction
- Poor growth
- Asthma / airway inflammation

“There are, I must accept, certain differences in people which allow them to thrive more in some airs compared to others.”



Impaired lung growth

Gauderman et al, 2004 (NEJM); southern California

- 1,759 10-yr old children, 12 communities, 8-yr follow up
- Lung function growth significantly reduced in areas with higher levels of traffic-related pollutants
 - NO₂, PM_{2.5}, elemental carbon (EC) associated with reduction in growth of FEV₁ of between 79.7 and 101.4 mL
 - Clinically low FEV₁ at age 18 positively correlated with level of exposure to NO₂, PM₁₀, PM_{2.5}, EC

Gauderman et al, 2007 (Lancet); southern California

- Same study, local vs. regional pollutant levels
 - Living <500m from freeway associated with reduction in FEV₁ growth of 81mL (vs. living >1500m away)
 - Significantly lower attained FEV₁ by 18 yrs

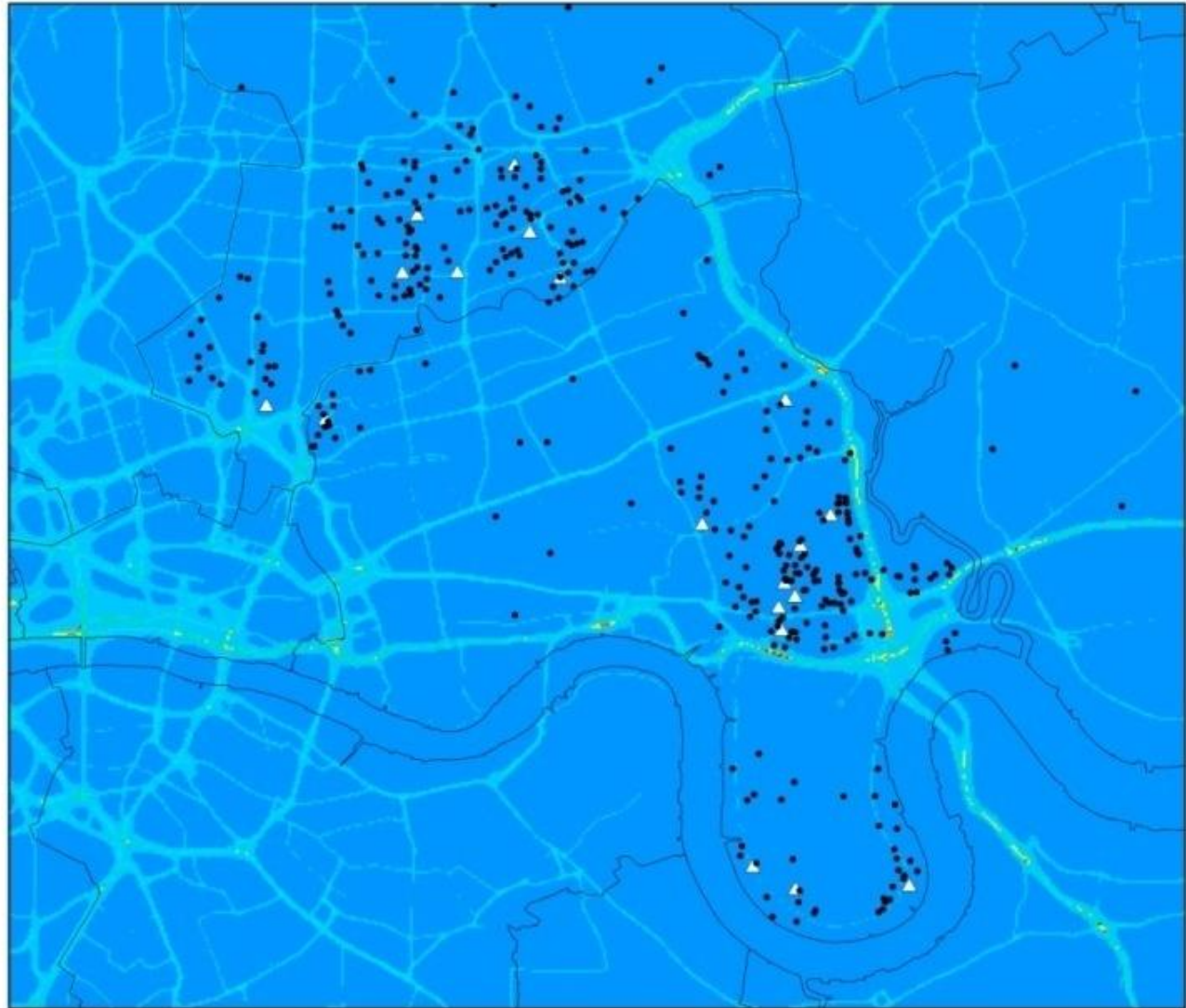
Pollution in Tower Hamlets & Hackney

2009 PM₂₅ Annual
($\mu\text{g m}^{-3}$)



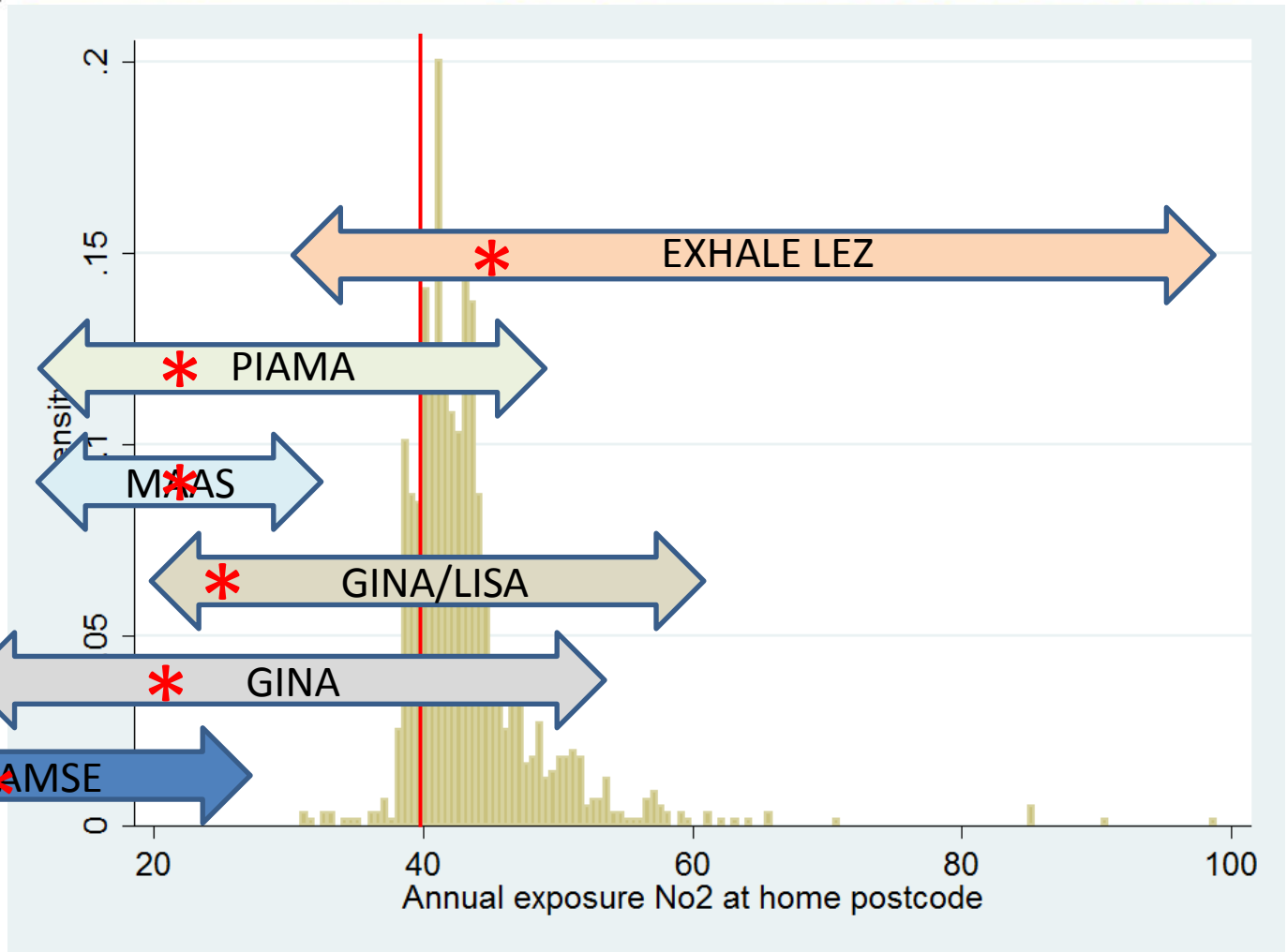
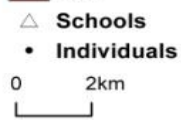
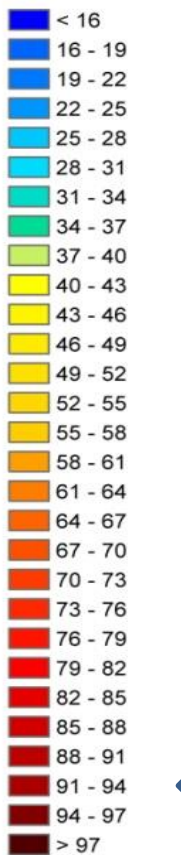
△ Schools
• Individuals

0 2km

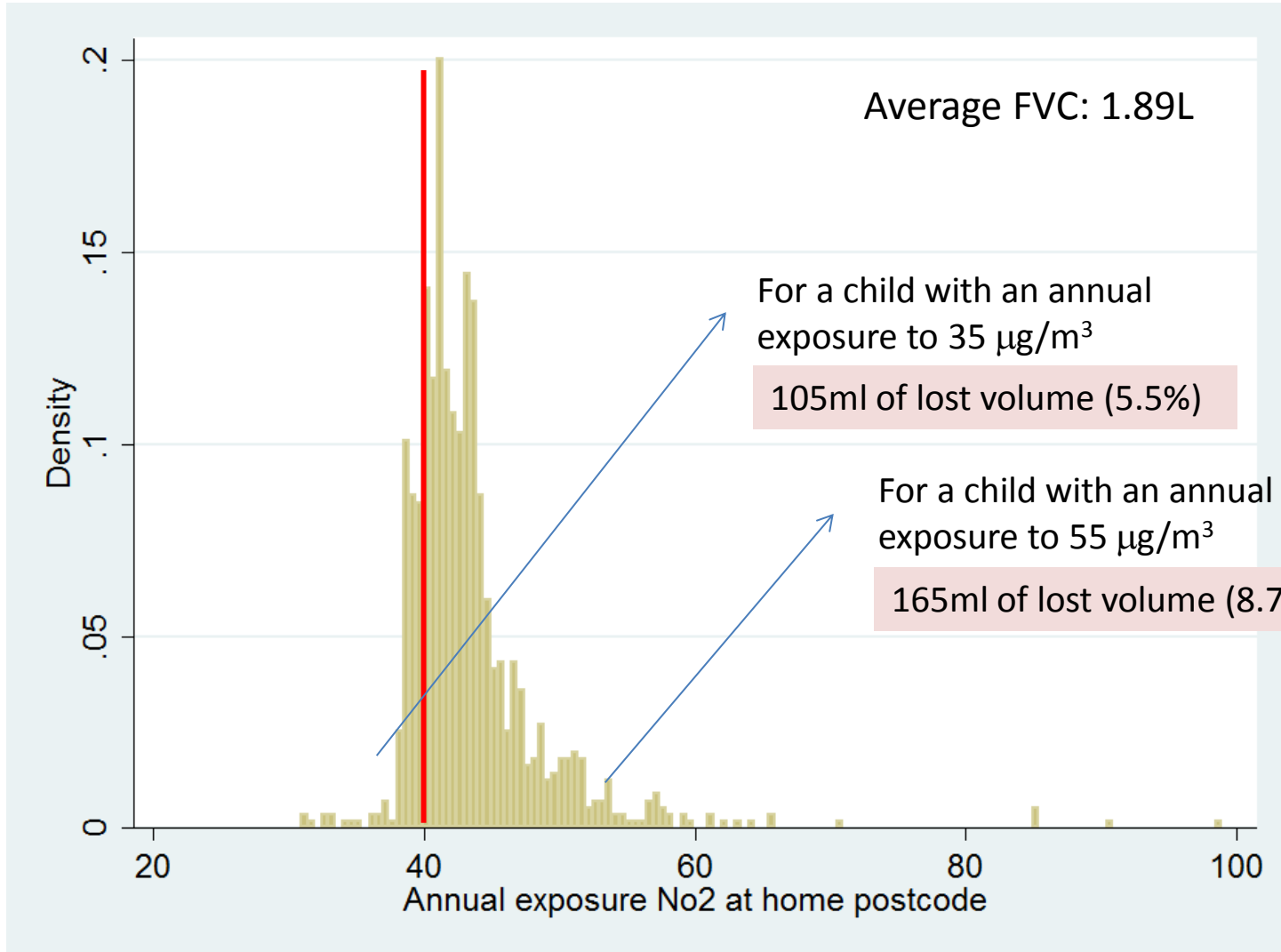


Modelled annual NO₂ concentrations

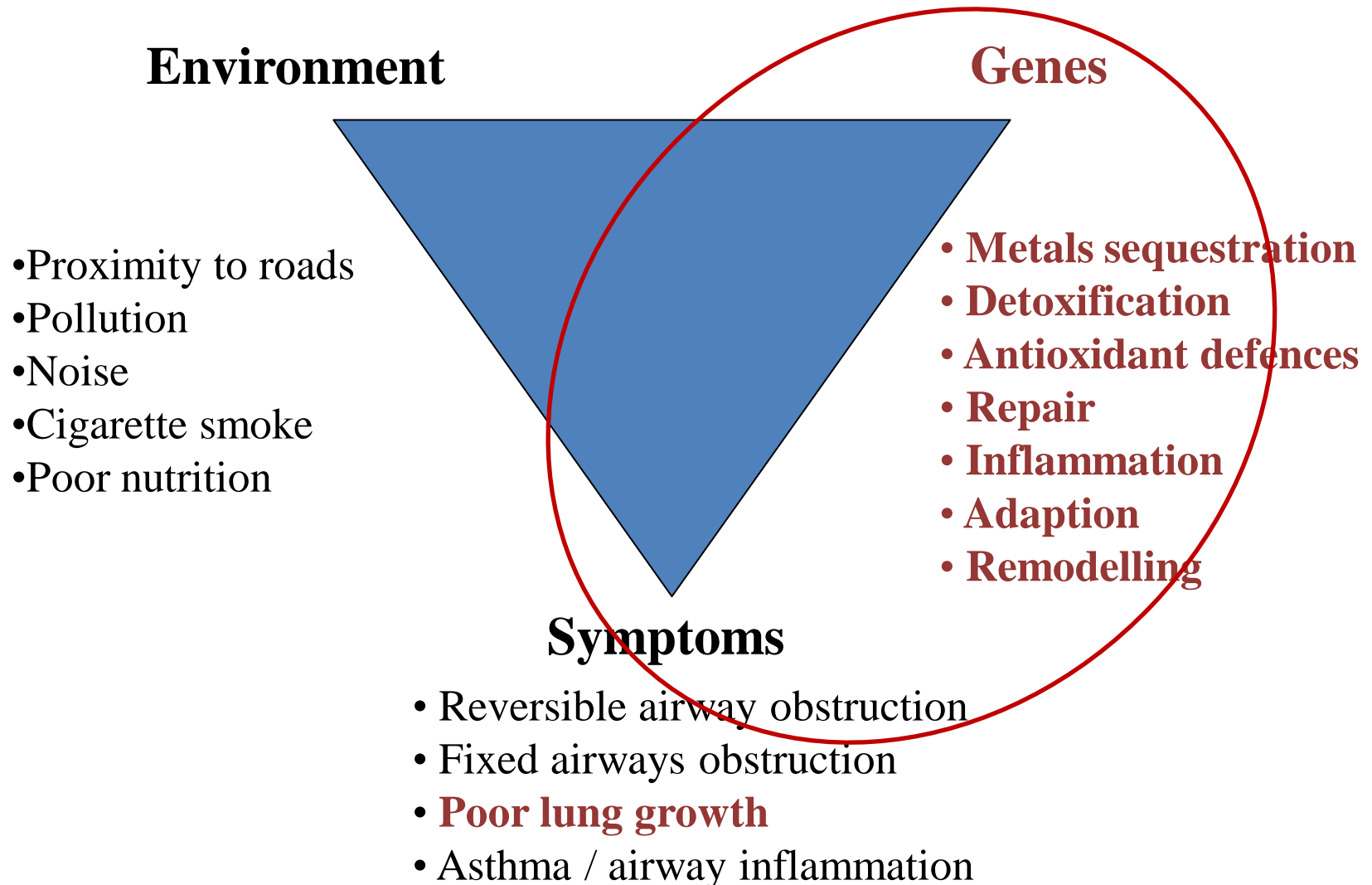
2009 NO₂ Annual Mean
($\mu\text{g m}^{-3}$)



Context



“There are, I must accept, certain differences in people which allow them to thrive more in some airs compared to others.”



Genetic Modification

Xenobiotic metabolism:

- CYP1A1, GSTM1, GSTT1, GSTP1, EPHX1, NQO1, AhR

Antioxidant defence:

- GCL, ECSOD, Nrf2

Nitrosative stress:

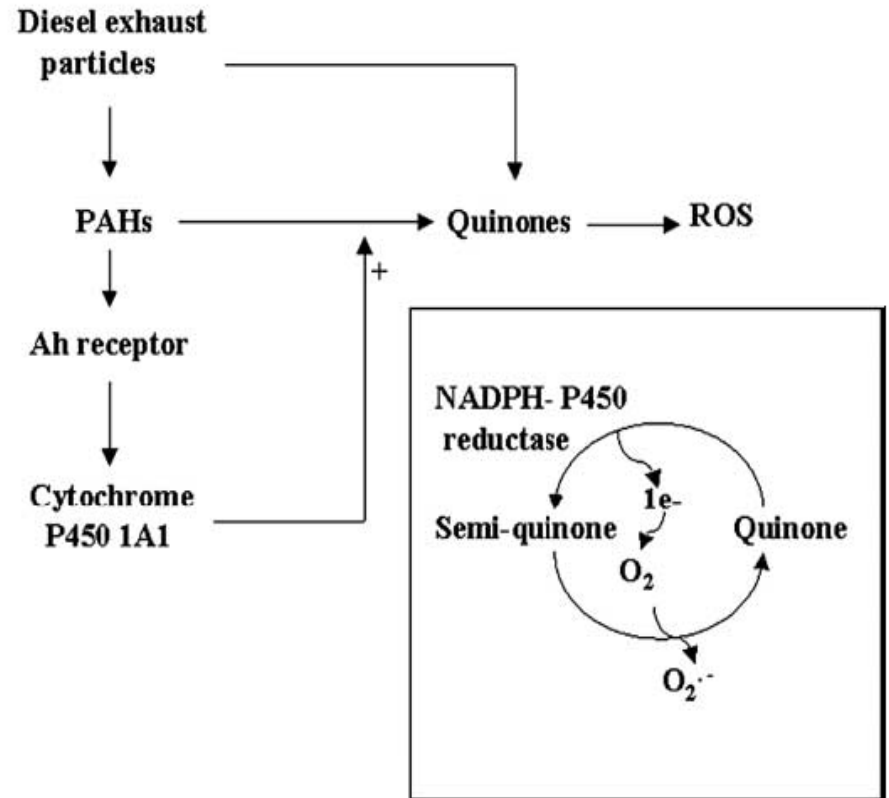
- iNOS , ARG1, ARG2

Onset of childhood asthma

- GSDMA, GSDMB

Random ancestry markers:

- Adjust for population stratification and predict lung function as proxy for ethnic group



Quantifying exposure BIOMARKERS

Air in



Traffic related metals

															18 VIII A			
1 IA											13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIII A		
1 H 1.008 Hydrogen											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon		
2 IIA											11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIII A
2 Li 6.94 Lithium	3 Be 9.01 Beryllium											13 Al 26.98 Aluminum	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon	
3	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII B	9 VIII B	10 VIII B	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIII A		
3 Na 22.99 Sodium	4 Mg 24.31 Magnesium	21 Sc 44.96 Scandium	22 Ti 47.88 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 72.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton	
4	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII B	9 VIII B	10 VIII B	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIII A			
4 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.88 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 72.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton	
5	5 VB	6 VIB	7 VIIB	8 VIII B	9 VIII B	10 VIII B	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIII A				
5 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc (97.9) Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.91 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.87 Silver	48 Cd 112.41 Cadmium	49 In 114.82 Indium	50 Sn 118.71 Tin	51 Sb 121.76 Antimony	52 Te 127.60 Tellurium	53 I 126.90 Iodine	54 Xe 131.29 Xenon	
6	6 VIB	7 VIIB	8 VIII B	9 VIII B	10 VIII B	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIII A					
6 Cs 132.91 Cesium	56 Ba 137.33 Barium	57 La 138.91 Lanthanum	72 Hf 178.49 Hafnium	73 Ta 180.95 Tantalum	74 W 183.85 Tungsten	75 Re 186.21 Rhenium	76 Os 190.2 Osmium	77 Ir 192.22 Iridium	78 Pt 195.08 Platinum	79 Au 196.97 Gold	80 Hg 200.59 Mercury	81 Tl 204.38 Thallium	82 Pb 207.2 Lead	83 Bi 208.98 Bismuth	84 Po (209) Polonium	85 At (210) Astatine	86 Rn (222) Radon	
7	7 VIIA	8 VIII A	9 VIII A	10 VIII A	11 VIII A	12 VIII A	13 VIII A	14 VIII A	15 VIII A	16 VIII A	17 VIII A	18 VIII A						
7 Fr 223.02 Francium	88 Ra 226.03 Radium	89 Ac 227.03 Actinium	104 Rf (261) Rutherfordium	105 Db (262) Dubnium	106 Sg (263) Seaborgium	107 Bh (262) Bohrium	108 Hs (265) Hassium	109 Mt (266) Meitnerium	110 Unnamed Discovery 110 Nov. 1994	111 Unnamed Discovery 111 Nov. 1994	112 Unnamed Discovery 112 1996	114 Unnamed Discovery 114 1999	115 Unnamed Discovery 115 2015	116 Unnamed Discovery 116 1999	118 Unnamed Discovery 118 1999			

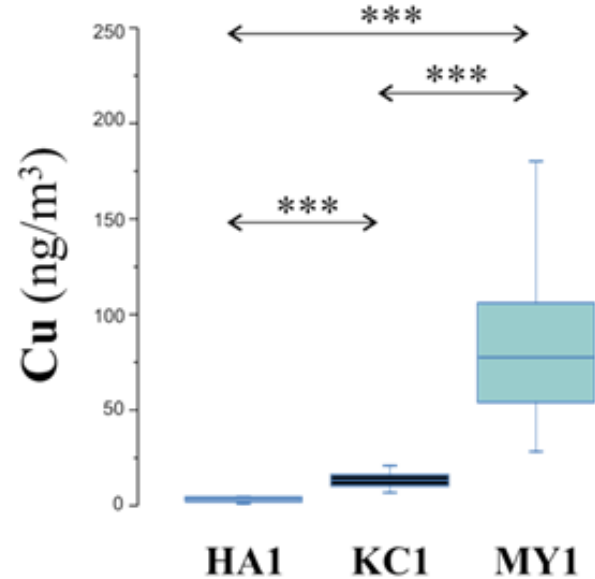
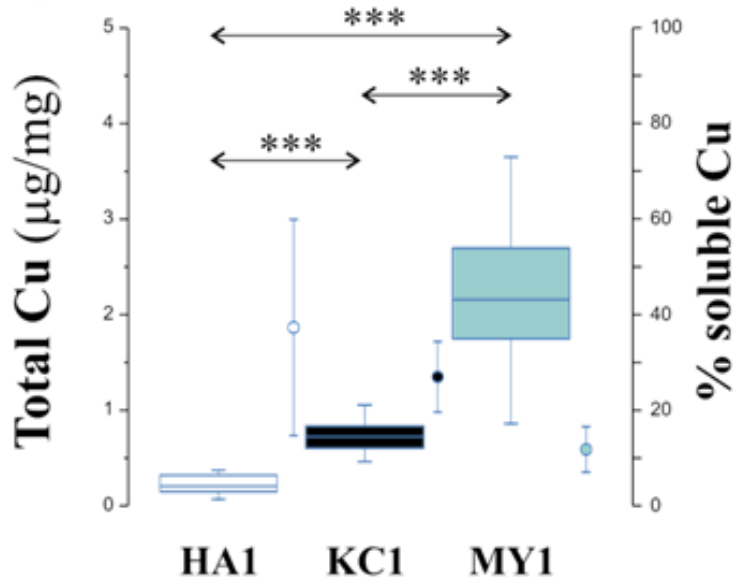
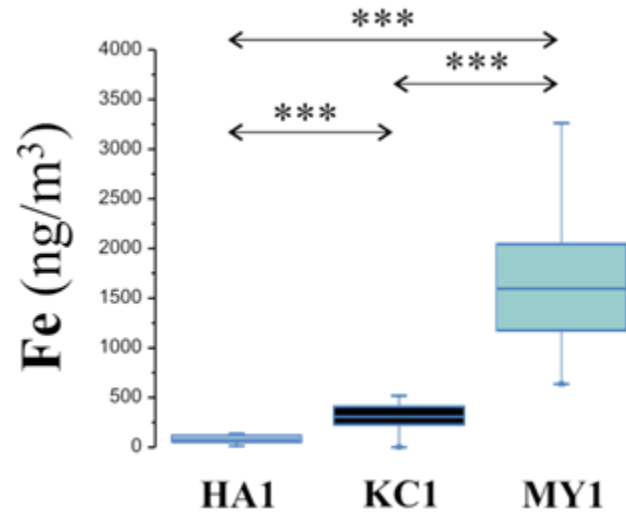
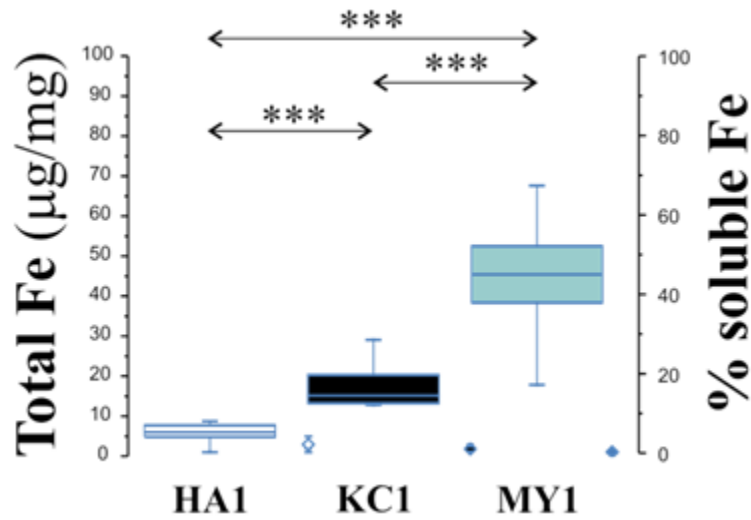


Biomarkers out

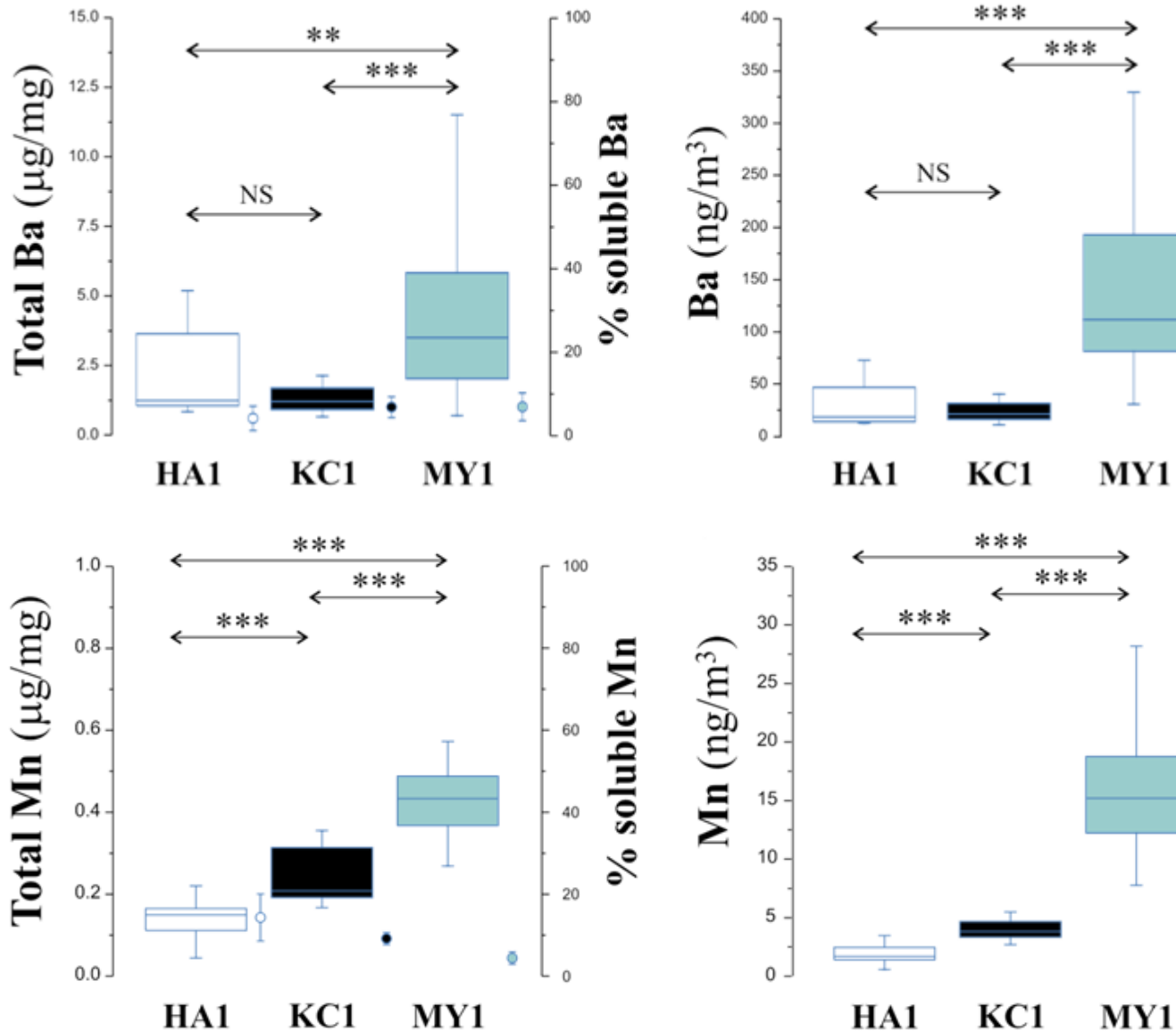
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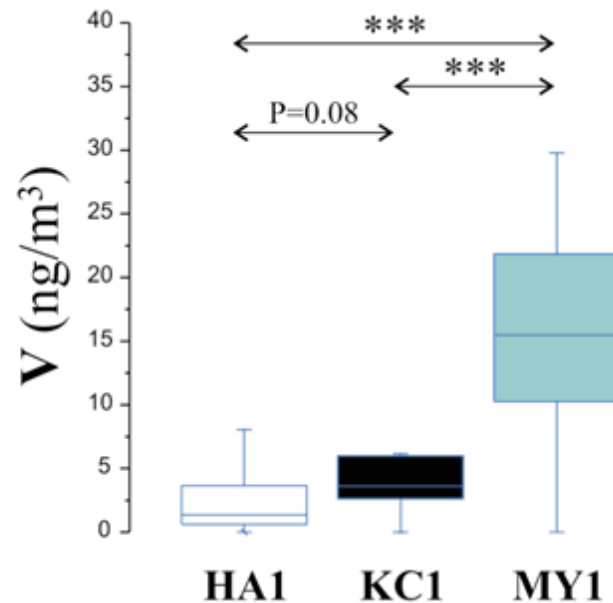
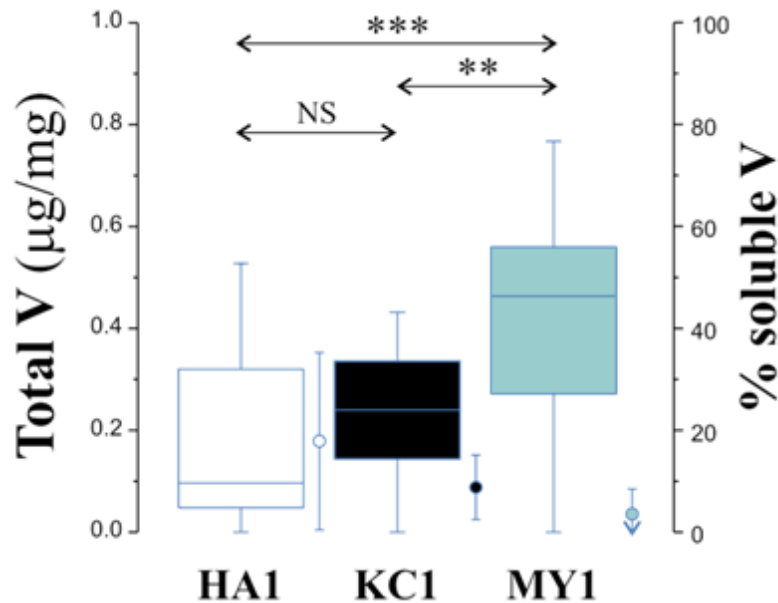
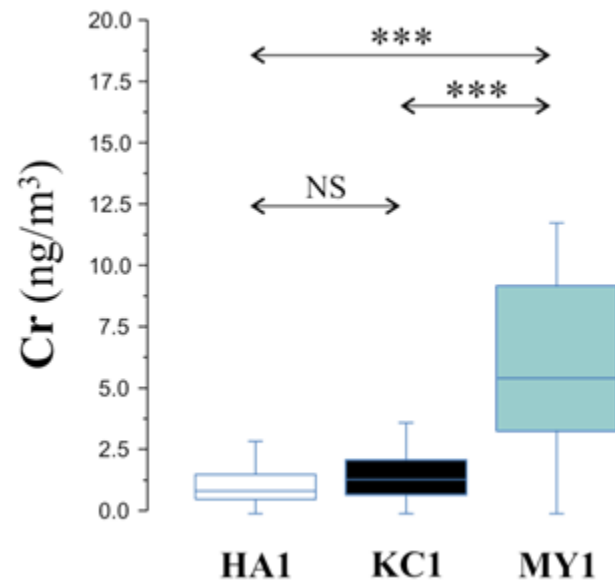
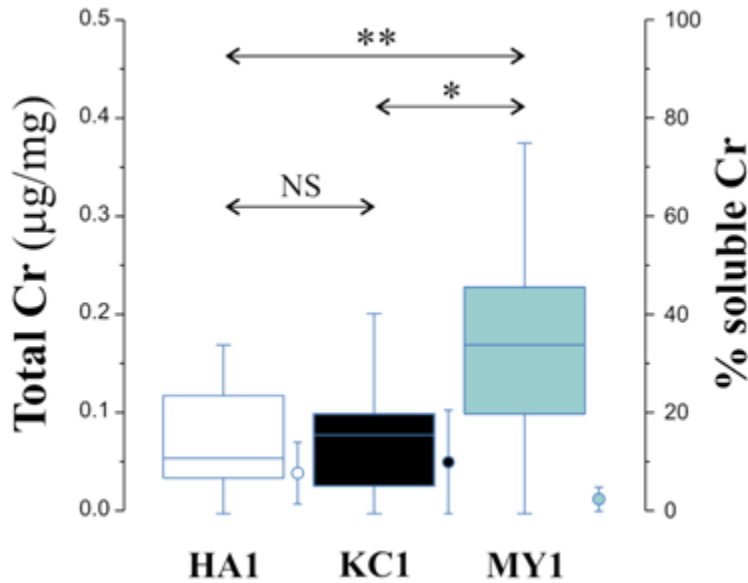
PM₁₀ Metals (Fe and Cu)



PM₁₀ Metals (Ba and Mn)



PM₁₀ Metals (Cr and V)



A portrait of John Evelyn, an English naturalist, diarist, and politician, shown from the chest up, wearing a dark coat and a white cravat.

Cleaner Fuels (diesel)

Separate the vulnerable population from pollution sources

Economic benefits

Green infrastructure

Moral imperative

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*“I have made this proposal for refining the quality of air in London because I believe that we should do whatever we can to enhance the honour of our nation that is capable of such greatness. **It troubles me that the health and happiness of so many people should suffer from the greed of a few in a city that contains enough to make its people the happiest on Earth.** Money has blinded people to the thing which keeps them alive and which can, for their own sake, be improved so easily.”*

Omnia explorate; meliora retinete