City of London

What research is needed to understand and manage air pollution exposure in indoor public spaces and transport environments?

Ruth Calderwood

Air Quality Manager, City of London Corporation

CITY OF LONDON

City of London

Indoor public spaces

Issue

- Which spaces: offices, schools, community hubs, railway stations, markets
- Range of sources – building materials, furnishings, fire retardants, combustion, solvents, cleaning products, electronic equipment, people
- Ingress of poor air quality becoming less of an issue?

Need to understand

- Health impact, toxicity of PM type, asthma triggers
- Synergistic effect
- Quantification. Personal exposure – wearable monitors
- Potential solutions - test

Standards

- WHO guidelines v Workplace exposure limits, e.g. NO_2
  - WHO 2010 Guideline: 1hr 200µg/m3, annual 40µg/m3
  - WEL 2020 8hr 960µg/m3, 15 min 1910µg/m3
- BREEAM / WELL building standard / BS EN 16798 -1:2019

Transport environments

- Smaller range of sources, outdoor air quality has more of an impact on air quality inside
- Some VOCs – fabric and cleaning products, de-icing etc
- Vehicle tailpipe emissions declining, number of petrol vehicles may increase (VOCs) , PM may also increase (heavier vehicles and increase in number)
- Research already undertaken e.g. Emissions Analytics
- Exposure comparison by mode, research e.g. ERG

Recommendations:

- Pull all information together e.g. AQEG report, IAQM Air Quality Guidance, ERG research, Emissions Analytics
- Monitor indoor public spaces / exposure
- Test out solutions for impact
- Facilitate health research – e.g. synergistic effects, PM toxicity
- Building design – thermal efficiency v ventilation

What research is needed to understand and manage air pollution exposure in indoor public spaces and transport environments?

Dr Matt Loxham
University of Southampton

Research Gaps

- What is “the environment”?
  - What are the contributing sources?
  - What are their characteristics, and the characteristics of the contributions?
  - How does this relate to health?
- What are the most effective ways to reduce dose?
  - Reducing emissions
  - Reducing exposure to emissions
  - Do we need to do anything?

“Railway”

Andersen *et al. Particle and Fibre Toxicology* (2019) 16:21
https://doi.org/10.1186/s12989-019-0306-4

Particle and Fibre Toxicology

RESEARCH Open Access

Health effects of exposure to diesel exhaust in diesel-powered trains

Maria Helena Guerra Andersen[1,2*], Marie Frederiksen[2], Anne Thoustrup Saber[2], Regitze Sølling Wils[1,2], Ana Sofia Fonseca[2], Ismo K. Koponen[2], Sandra Johannesson[3], Martin Roursgaard[1], Steffen Loft[1], Peter Møller[1] and Ulla Vogel[2,4]

Table 1 Black carbon, ultrafine particles and nitrogen oxides concentrations and contrast between diesel and electric trains

Exposure	Electric ($n = 29$)	Diesel ($n = 54$)	Mean difference (95% CI)
Black carbon (μg/m^3)	1.8 (0.5)	10.3 (2.0)	8.5 (7.9; 9.1)***
Ultrafine particles from DiscMini (#/cm^3) [a)]	8100 (2400)	189,200 (91,900)	181,000 (153,700; 208,400)***
Ultrafine particles from NanoTracer (#/cm^3)	9100 (3500)	133,400 (52,100)	124,300 (110,000; 138,500)***
NOx (μg/m^3)	45 (16)	363 (73)	317 (297; 338)***
NO_2 (μg/m^3)	18 (9)	54 (16)	36 (31; 42)***

The exposure was assigned to study participants (study participants rode the trains in groups of different sizes. The exposure average levels for each calendar day were assigned to all members of the relevant group). Exposure levels in both scenarios are presented as mean and standard deviation. $PM_{2.5}$, polycyclic aromatic hydrocarbons and aldehydes are not assigned to study participants, as the data were not collected throughout all the study period. [a)] missing values for DiscMini equipment indexed to four study persons for the exposure scenarios ($n = 46$ diesel and $n = 25$ for electric). ***$p < 0.001$

Environmental Science & Technology — Article
Cite This: Environ. Sci. Technol. 2019, 53, 4579−4587
pubs.acs.org/est

Exposure to Air Pollution inside Electric and Diesel-Powered Passenger Trains

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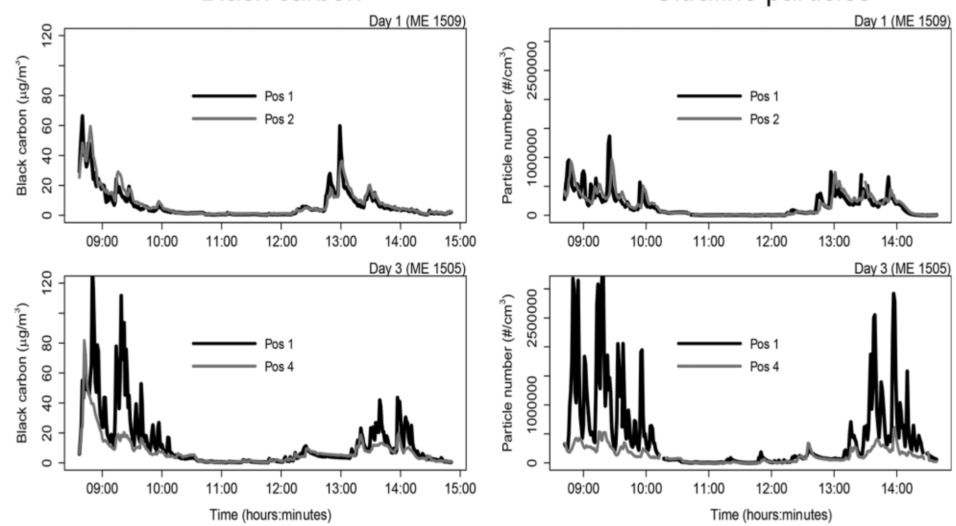
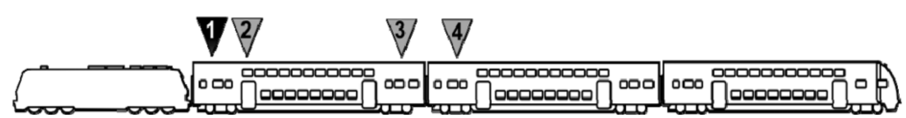
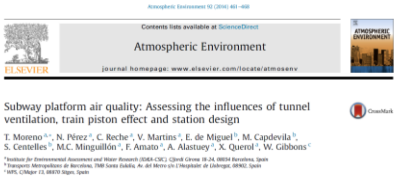
Biomarker	Electric (mean ± SD)	Diesel (mean ± SD)	% Change (95% CI)	*p*-value
FVC (L)	4.20 ± 1.24	4.18 ± 1.16	−2.3 (−4.7; 0.25)	0.077
FEV1 (L)	3.32 ± 0.96	3.24 ± 0.96	−3.6 (−5.5; −1.6)	0.0003***
FEV1/FVC (%)	79.1 ± 6.8	77.2 ± 9.2	−1.8 (−3.8; 0.2)	0.073
PEF (L/s)	7.26 ± 2.13	7.15 ± 2.42	−5.6 (−10.7; −0.5)	0.031*
SB (lesions/10^6 bp)	0.12 ± 0.13	0.18 ± 0.13	46.3 (5.0; 100.9)	0.025*



Exposure levels	FVC	FEV1	FEV1/FVC	PEF	LF	DNA SB
UFP (NanoTracer)	↓	↓↓↓	↓	↓	↑↑	↑↑↑
UFP (DiscMini)	-	↓↓	-	↓↓	↑↑	↑↑↑
BC	↓	↓↓↓	↓	↓	↑↑	↑↑
NO_x	↓	↓↓↓	↓	↓↓	↑↑↑	↑↑
NO_2	↓	↓	-	↓↓↓	↑↑↑	-



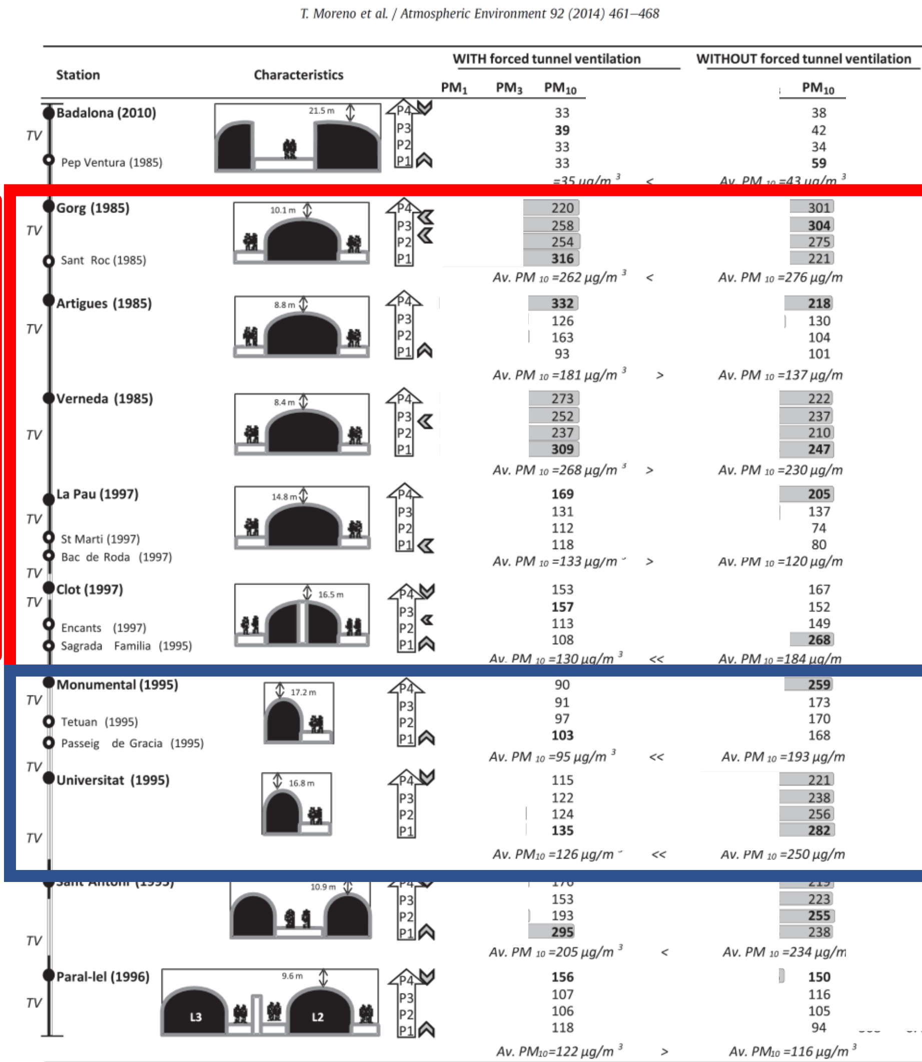


Double track tunnel

- AQ worse than single track
- Older stations have more PM than newer stations
- In older double track stations, less effect of stopping forced ventilation (or might improve AQ) but less consistent effect in newer stations.
- With ventilation – PM peak further from access point
- Without ventilation – PM increased near access points
- Stations with P1 access show clearest platform gradients
- Badalona has 7 in-station fans and is unusually spatious

Single track tunnel

- Much higher PM if forced ventilation off



Solutions?

Aerosol and Air Quality Research, 17: 1527–1538, 2017

ISSN: 1680-8584 print / 2071-1409 online
doi: 10.4209/aaqr.2017.03.0120

Analysis of Aerosol Composition and Assessment of Tunnel Washing Performance within a Mass Rapid Transit System in Taiwan

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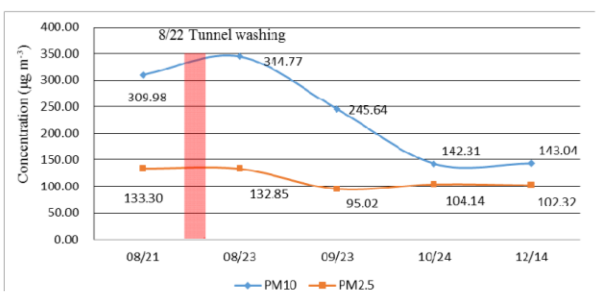

Atmospheric Environment 49 (2012) 219–223
Contents lists available at SciVerse ScienceDirect
Atmospheric Environment
journal homepage: www.elsevier.com/locate/atmosenv

A noticeable shift in particulate matter levels after platform screen door installation in a Korean subway station

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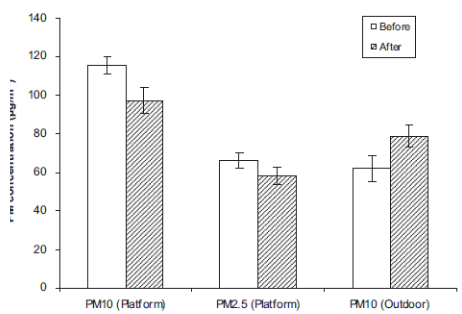

g. 2. Comparison of PM concentration: (A) between indoor platform and outdoors id (B) between before and after PSD installation. Here error bar is drawn by standard error (SE) of the mean.

Installation of platform screen doors and their impact on indoor air quality: Seoul subway trains

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[2] *Seoul Metropolitan Research Institute of Public Health and Environment, Seoul, Republic of Korea*
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Before PSDs (from March 17, 2008 to May 7, 2008)							After PSDs (from April 5, 2010 to May 6, 2010)					
Indoor PM_{10} (μg/m³) a)			Outdoor PM_{10} (μg/m³) b)				Indoor PM_{10} (μg/m³) a)			Outdoor PM_{10} (μg/m³) b)		
SN e) (n)	Mean (SD)	Min–max	SN e) (n)	Mean (SD)	Min–max		N e) (n)	Mean (SD)	Min–max	SN e) (n)	Mean (SD)	Min–max
12	96.4 (36.5)	60.5–146.4	66	74.6 (36.4)	35.3–127.9		4	126.0 (67.7)	78.1–173.8	22	47.0 (2.0)	45.6–48.5
14	88.1 (12.8)	75.3–108.9	77	52.4 (16.6)	33.2–84.2		4	63.8 (14.4)	53.6–74.0	22	56.6 (11.2)	48.7–64.5
12	95.2 (27.3)	67.9–137.1	66	60.2 (24.6)	31.2–102.5		4	106.0 (24.8)	88.4–123.5	22	36.8 (6.7)	32.0–41.5
12	67.9 (23.3)	43.7–95.5	66	83.8 (30.9)	45.3–123.9		4	110.1 (41.8)	80.5–139.6	22	58.5 (26.5)	39.7–77.2
12	91.6 (12.2)	74.7–107.9	66	121.4 (159.4)	33.8–445.4		4	81.4 (7.2)	76.3–86.5	22	60.2 (0.9)	59.6–60.8
10	73.3 (8.7)	58.0–79.0	55	70.4 (9.3)	57.9–82.1		4	148.8 (8.5)	142.8–154.8	22	17.1 (7.7)	11.6–22.5
10	63.6 (8.4)	50.2–70.9	55	50.2 (17.4)	25.4–69.8		4	108.4 (10.0)	101.3–115.5	22	45.3 (8.9)	39.0–51.6
10	68.3 (10.3)	50.4–76.4	55	72.2 (18.6)	53.8–96.2		4	92.1 (8.0)	86.4–97.7	22	54.6 (14.9)	44.1–65.2
92	80.5 (13.6)	43.7–146.4	506	73.2 (22.6)	25.4–445.5		32	104.6 (26.2)	53.6–173.8	176	47.0 (14.4)	11.6–77.2

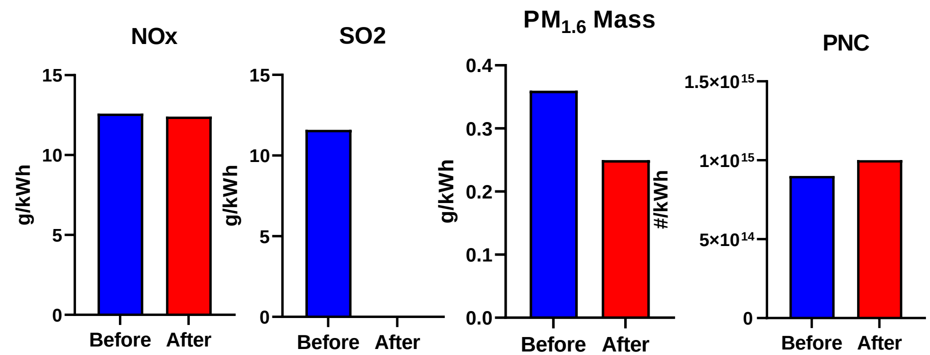
Shipping

Table 2. Average and maximum particulate matter concentrations measured in different environments on the deck of the ship **Carnival Freedom**

	IN PORT			AT SEA		
	Average particle count Pt/cc	Minutes of monitoring	Maximum 1-minute concentration Pt/cc	Average particle concentration Pt/cc	Minutes of monitoring	Maximum 1-minute concentration Pt/cc
Stern	5,740	89	31,367	9,702	512	47,823
Track	11,880	73	56,091	12,747	512	73,621
Bow	15,604	100	119,983	1,540	523	14,533

Table 4. Average and maximum particulate matter concentrations measured in different environments on the deck of the ship **Emerald Princess**

	IN PORT			AT SEA		
	Average particle count Pt/cc	Minutes of monitoring	Maximum 1-minute concentration Pt/cc	Average particle concentration Pt/cc	Minutes of monitoring	Maximum 1-minute concentration Pt/cc
Upper Stern	6,502	42	15,416	30,647	269	144,500
Lower Stern	8,234	42	17,140	32,628	268	157,716
Bow	33,408	43	126,786	5,167	257	24,696



Adapted from Winnes et al (2020) J Mar Sci Eng

Effect	HFO	DF
Pro-inflammatory signaling	↑	-
Oxidative stress	↑	-
Cell homeostasis	↑	-
Response to chemicals	↑	↓↑
Cellular stress response	↑	↑
Motility	↑	↑
Endocytosis	↑	↑
Cellular signalling	MAPK, TGF beta, PDGF, EGF, GPCR	ID, kinase cascade
Energy metabolism	-	↓↑[x]
Protein synthesis	-	↓
Protein degradation	-	↑
RNA metabolism	-	↓
Chromatin modifications	-	↑
Cell junction and adhesion	-	↓↑[*]

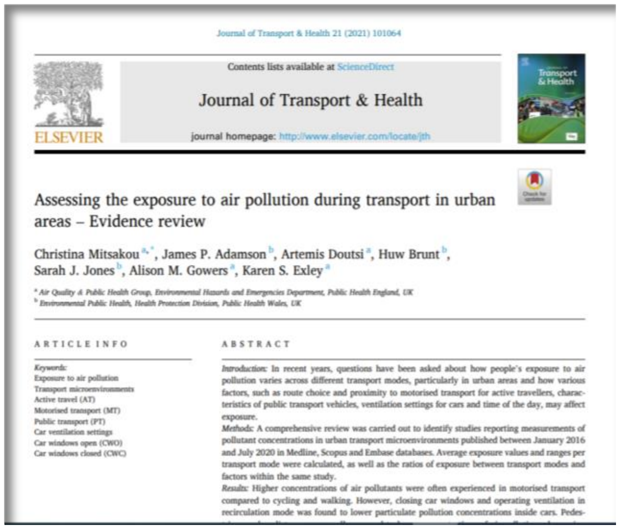
Oeder et al (2015) PLoS ONE 10(6):e0126536

UK Health Security Agency

Transport environments and air pollution exposure

Dr Christina Mitsakou
Air Quality and Public Health

Exposure to air pollution in transport



Journal of Transport & Health 21 (2021) 101064

Contents lists available at ScienceDirect

Journal of Transport & Health

journal homepage: http://www.elsevier.com/locate/jth

ELSEVIER

Assessing the exposure to air pollution during transport in urban areas – Evidence review

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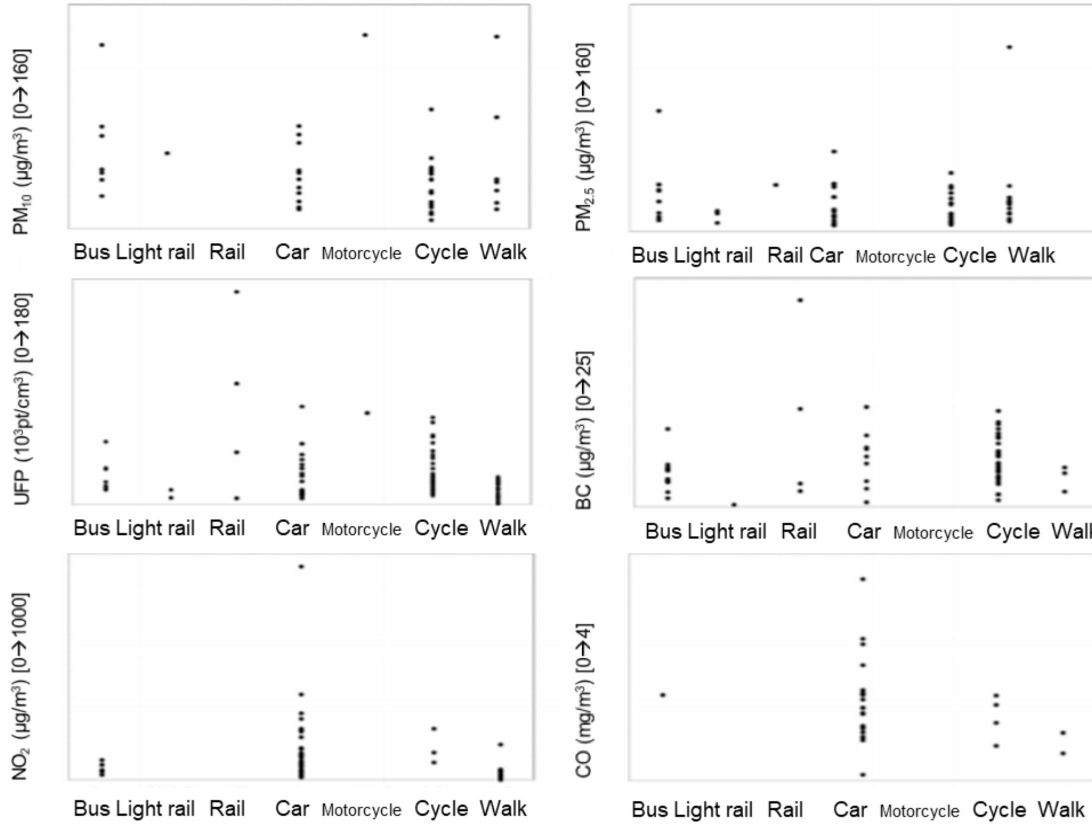
ARTICLE INFO

Keywords:
Exposure to air pollution
Transport microenvironments
Active travel (AT)
Motorised transport (MT)
Public transport (PT)
Car ventilation settings
Car windows open (CWO)
Car windows closed (CWC)

ABSTRACT

Introduction: In recent years, questions have been asked about how people's exposure to air pollution varies across different transport modes, particularly in urban areas and how various factors, such as route choice and proximity to motorised transport for active travellers, characteristics of public transport vehicles, ventilation settings for cars and time of the day, may affect exposure.
Methods: A comprehensive review was carried out to identify studies reporting measurements of pollutant concentrations in urban transport microenvironments published between January 2016 and July 2020 in Medline, Scopus and Embase databases. Average exposure values and ranges per transport mode were calculated, as well as the ratios of exposure between transport modes and factors within the same study.
Results: Higher concentrations of air pollutants were often experienced in motorised transport compared to cycling and walking. However, closing car windows and operating ventilation in recirculation mode was found to lower particulate pollution concentrations inside cars. Pedes-



https://www.sciencedirect.com/science/article/pii/S2214140521000943

Exposure to air pollution in transport – study limitations and research recommendations

- **Study designs**

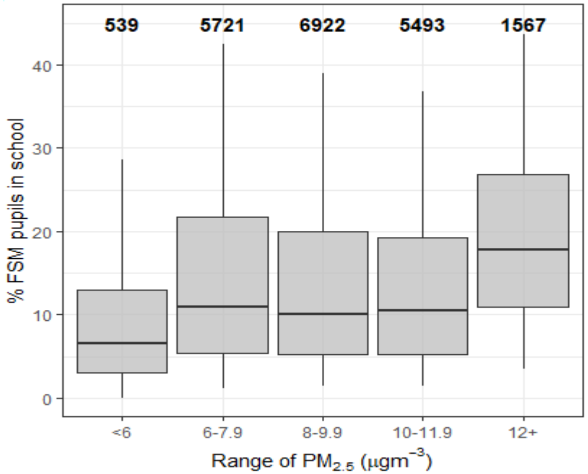
  exposure measurements using different transport modes **at the same time, in the same location and on as similar routes as practical**.

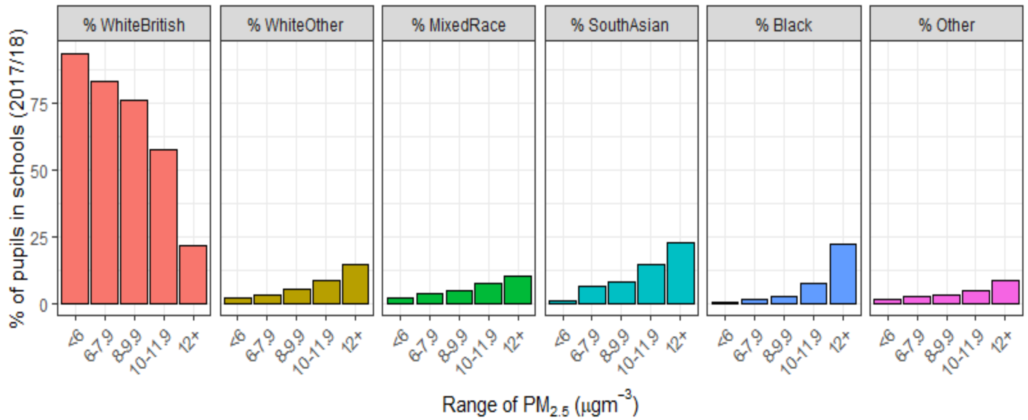
- **Consistency in the monitoring techniques**

  will allow the investigation of **inequalities in transport** and associations between specific population groups with exposure to poorer air quality while travelling.

Vulnerable population and inequalities

Air quality at school locations and deprivation





Children on free school meals, and from a minority ethnic background, are more likely to attend a school co-located with high outdoor $PM_{2.5}$

- Need for monitoring of vulnerable populations (eg children, elderly, deprived communities) exposure to air quality during commuting and other activities

Osborne, Uche, Mitsakou, Exley, Dimitroulopoulou (2021) Air quality around schools: Part II – Mapping $PM_{2.5}$ concentrations and inequality analysis, *Environmental Research* 197: 111038.

Holistic assessment of transport interventions

Recommending interventions based on holistic assessments that would consider (a few examples):

- **Vehicle transport**

  Negative impacts on the environment (pollutant emissions), climate change, road traffic etc

- **Active travel**

  Health co-benefits related to active travel

EMISSIONS ANALYTICS

What research is needed to understand and manage air pollution exposure in indoor spaces and transport environments?

Nick Molden

19 December 2022

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Our Belief

When it comes to the pursuit for improved air quality, we believe in the power of clarity, transparency and integrity. With real-world data we can meet emissions challenges – instilling trust and confidence in our industry partners and public.

It's with our commitment and independence we are able to make a significant contribution toward positive change and to achieve enduring results.

EMISSIONS ANALYTICS

Research gaps

1. TRANSITION Network multi-modal study – follow-on work
2. Private vehicle exposures – comparative rating vehicles
3. Commercial and industrial vehicle exposures – workplace risk

Priority pollutants

- Particle number
  - Mass already well measured generally
  - Growing concern about health effects of nanoparticles
- Broad spectrum volatile and semi-volatile organic compounds
  - Often low concentrations
  - But high toxicity potential
  - Emitted everywhere – especially plastics, solvents, tyres, tailpipe
  - Secondary organic aerosol formation
- Carbon dioxide
  - Safety risk while operating vehicles and machinery

TRANSITION study

- Journeys typically involve high variations in exposure concentrations
- Priority to clean up stations and interchanges ahead of upgrading rolling stock
- Improve filtration and ventilation on coach
- Extending range of active travel
- Restrict smoking and food cooking

➢ Reproduction of results

➢ Specific problem areas for further research

Private cars – CWA17934

- New standardised methodology for measuring in-cabin pollution
- Product of CEN Workshop 103
- Measurement of PN ingress and CO_2 build-up
- Light-duty vehicles
- Real on-road protocol
- Metric is ratio between external and internal concentrations – proven repeatability

➢ Objective to compare between different vehicles or different filters

Heavy-duty operations

- Harsh environments
- Long hours
- Health and safety at work, duty of care
- In-cabin exposures
- Local air quality impact

Thank you.

Nick Molden

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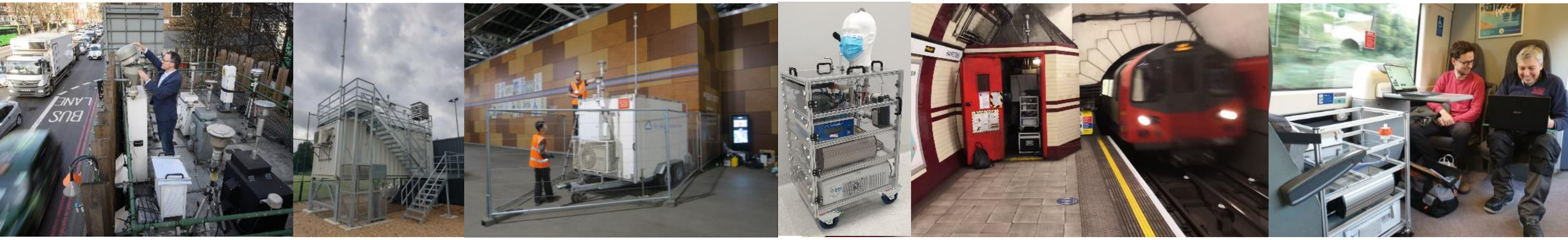
Assured
Emissions testing in real-world conditions brings challenges that experience anticipates and expertise overcomes. We deliver.

Independent
Objectivity and candour are the driving forces in all our work, so you know the facts.

Responsive
We're fast on our feet so we can conduct emissions testing when and where we're needed.



Indoor Public Spaces and Transport Environments

David Green

Clean Air Research Futures Group 19th December 2022

NIHR | Health Protection Research Unit in Environmental Exposures and Health at Imperial College London

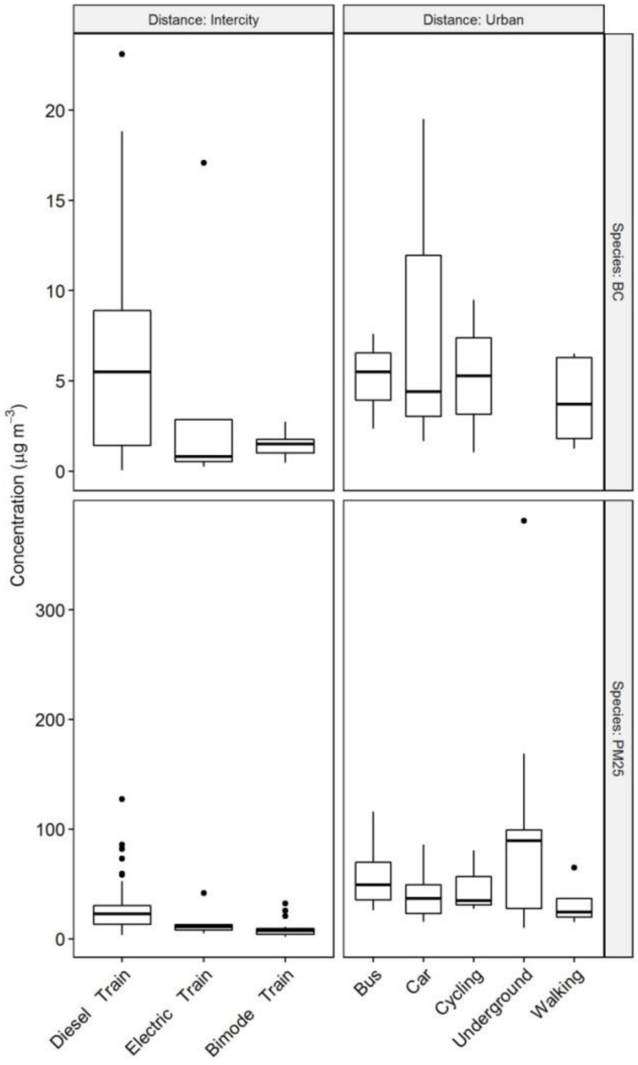
MRC
Centre for Environment & Health

UKRI Medical Research Council

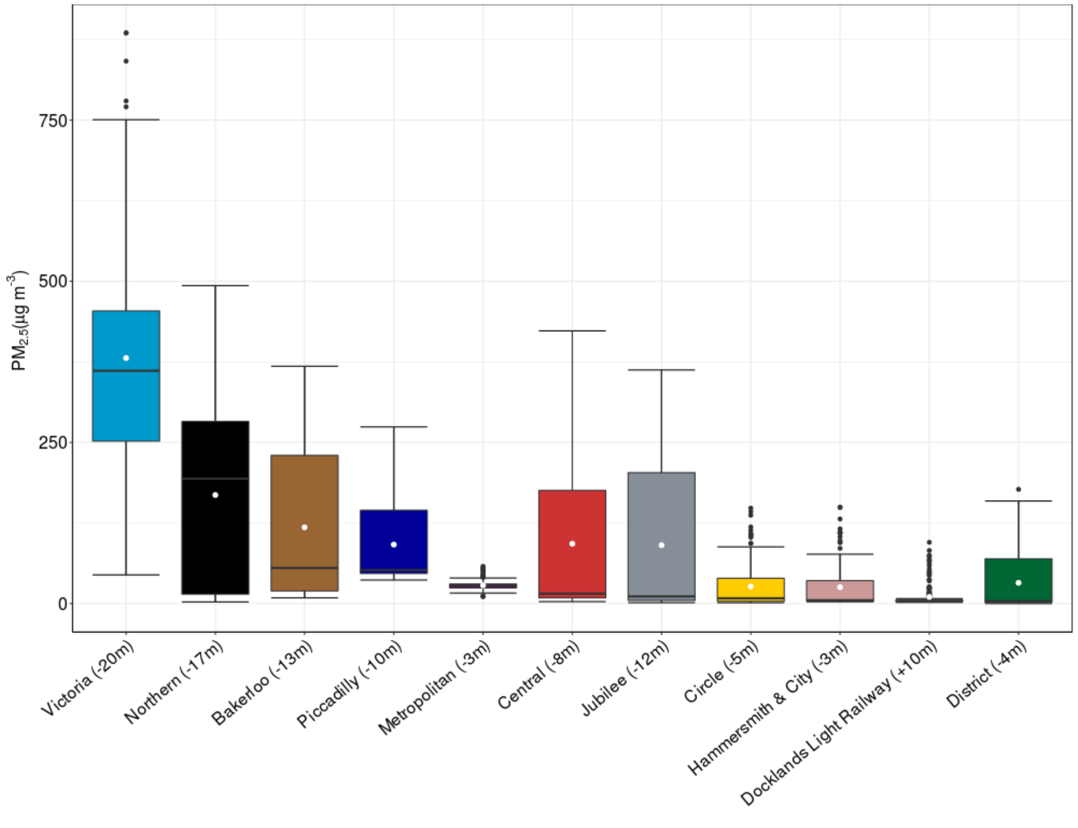
Imperial College London

Indoor and Transport Environment Challenges

- High concentrations
- Substantial spatial and temporal variability
- Generally short term exposure
- Different physical and chemical composition of PM
- Uncertainty around health effects
- Poorly characterised source indoor and outdoor contributions

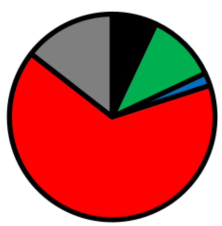


Passenger Exposure to $PM_{2.5}$



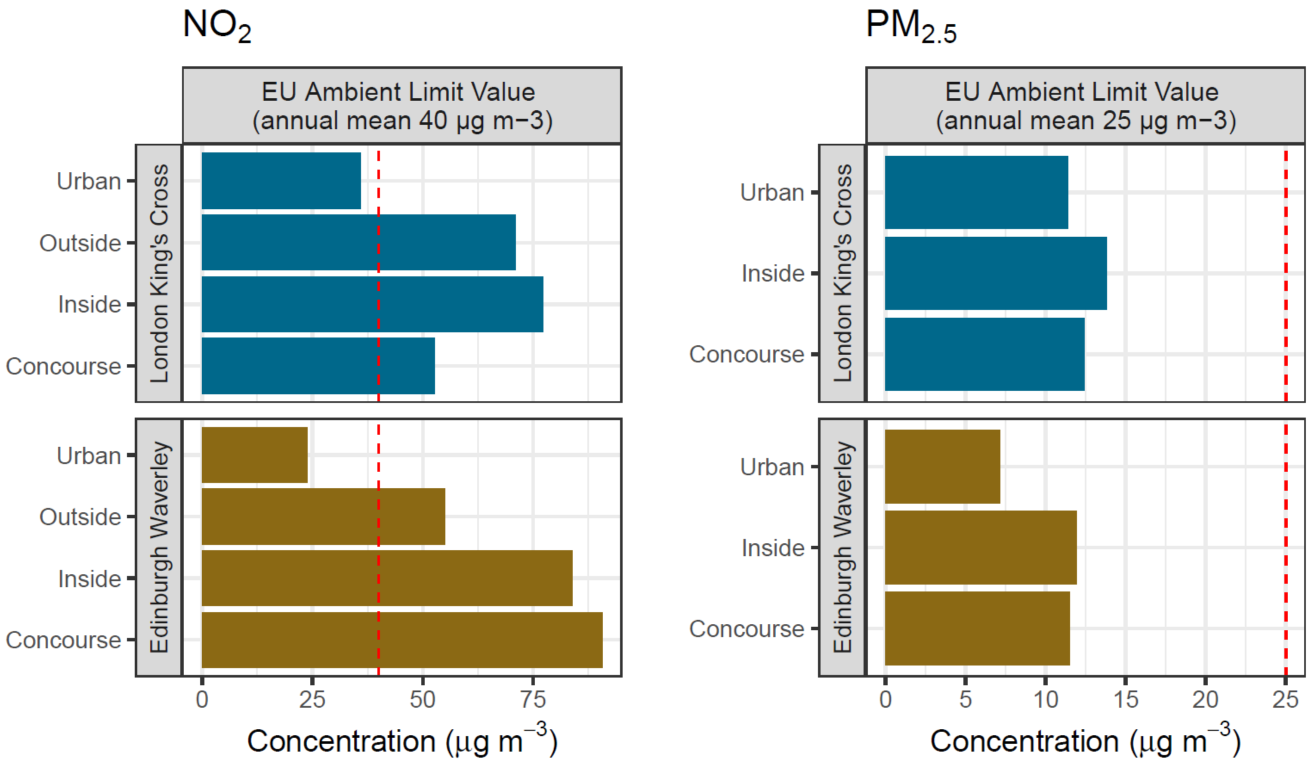
J.D. Smith et al. $PM_{2.5}$ on the London Underground (2020) Environment International

$PM_{2.5}$ Physical and Chemical Composition

	Chemical Composition							
Ambient		−	+	+	+	−	+	+
Subway		+	−	−	−	+	−	−

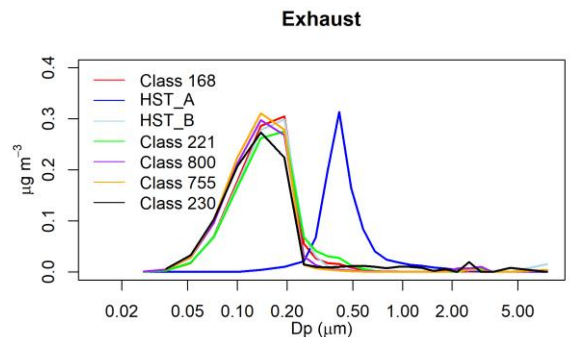
■ Elemental Carbon ■ Organic ■ Inorganic ■ Metals ■ Unidentified

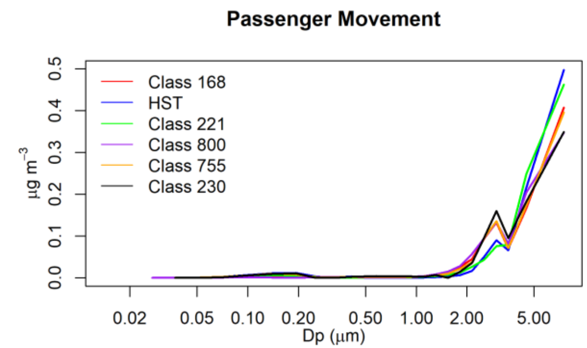
Concentrations in Enclosed Stations

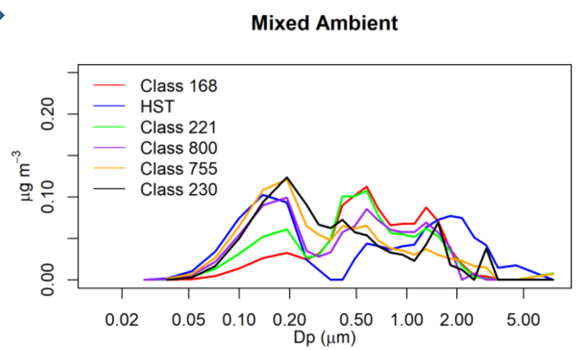


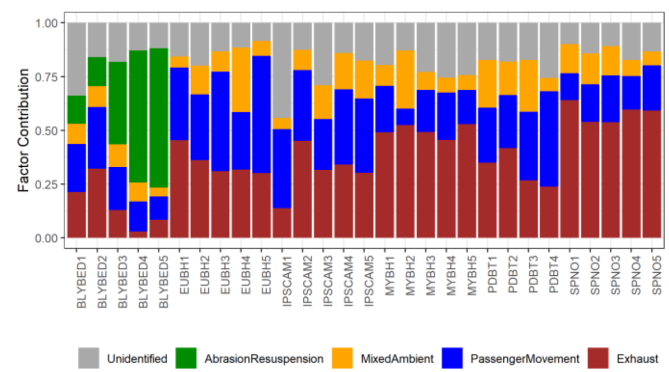
On-board Diesel Train Source Apportionment

PMF









Requirements

- Improved exposure assessment
  - Measurements reflecting spatial and temporal variability
  - Quantify measurement uncertainty
- Understand source contribution
  - Overcome methodological challenges in measurement and data analysis approaches
- Explicit links to health impacts
  - New health studies reflecting exposure to representative mixtures
  - Complementary in vivo / in vitro exposures, epidemiological studies of public and working populations
- Solutions driven approaches to minimise exposure now
  - Emission abatement requires significant investment
  - Recognise that irrefutable health impact quantification will not be immediate
  - Build exposure reduction into all transport investment planning

NIHR | Southampton Biomedical Research Centre

University of Southampton | NHS University Hospital Southampton NHS Foundation Trust

What research is needed to understand and manage air pollution exposure in indoor public spaces and **transport environments**?

Dr Lareb Dean

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19th December 2022

National Oceanography Centre, Southampton

Wessex Medical Research

The Academy of Medical Sciences

LEVERHULME TRUST

Dr Matthew Loxham

Our Group

EPSRC Engineering and Physical Sciences Research Council

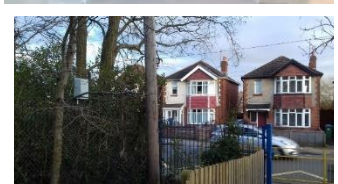
BBSRC bioscience for the future

AAIR Asthma Allergy & Inflammation Research

Pollution Source → *Regulation* → Air Pollution → *Mitigation* → Exposure → *Mechanisms* → Health Effects

Prof Simon Cox

Dr Florentin Bulot

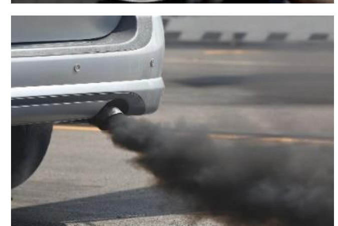


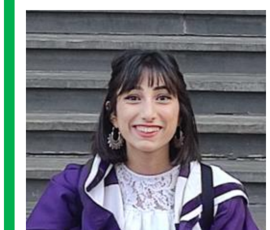
Prof Gavin Foster

Natasha Easton

Dr Richard Cook

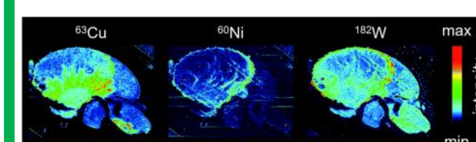
James Parkin



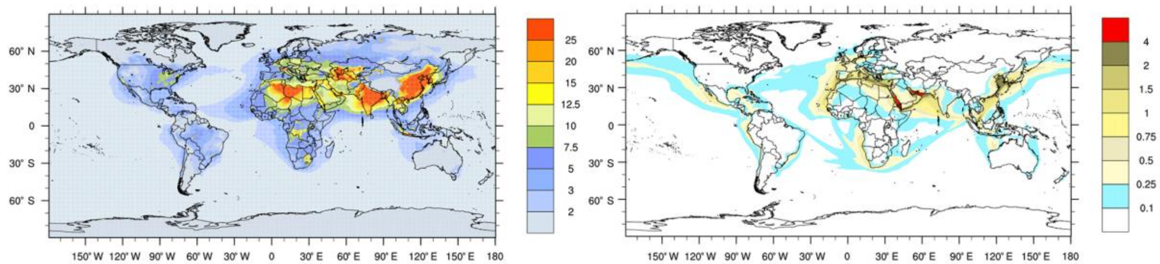


Dr Lareb Dean

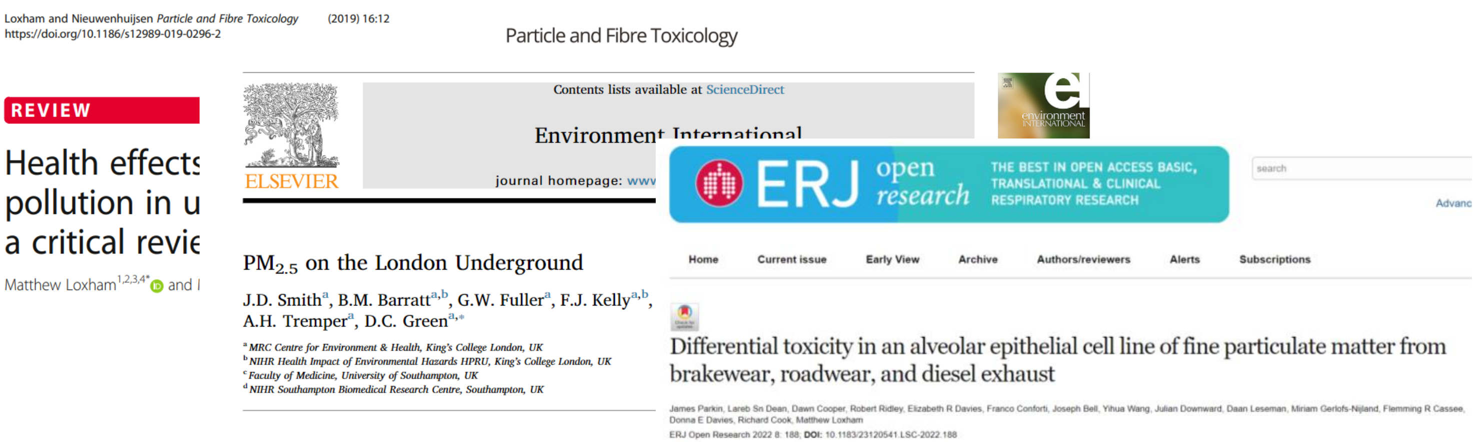
Liam Edgeway



Current evidence and gaps



(a) Annual average $PM_{2.5}$ (in $\mu g\,m^{-3}$)   (b) Annual average $PM_{2.5}$ from ships (in $\mu g\,m^{-3}$)



Loxham and Nieuwenhuijsen *Particle and Fibre Toxicology* (2019) 16:12
https://doi.org/10.1186/s12989-019-0296-2
Particle and Fibre Toxicology

REVIEW

Health effects
pollution in u
a critical revie

Matthew Loxham[1,2,3,4*] and I

Contents lists available at ScienceDirect

Environment International

journal homepage: www

ELSEVIER

$PM_{2.5}$ on the London Underground

J.D. Smith[a], B.M. Barratt[a,b], G.W. Fuller[a], F.J. Kelly[a,b], A.H. Tremper[a], D.C. Green[a,*]

[a] MRC Centre for Environment & Health, King's College London, UK
[b] NIHR Health Impact of Environmental Hazards HPRU, King's College London, UK
[c] Faculty of Medicine, University of Southampton, UK
[d] NIHR Southampton Biomedical Research Centre, Southampton, UK

ERJ open research — THE BEST IN OPEN ACCESS BASIC, TRANSLATIONAL & CLINICAL RESPIRATORY RESEARCH

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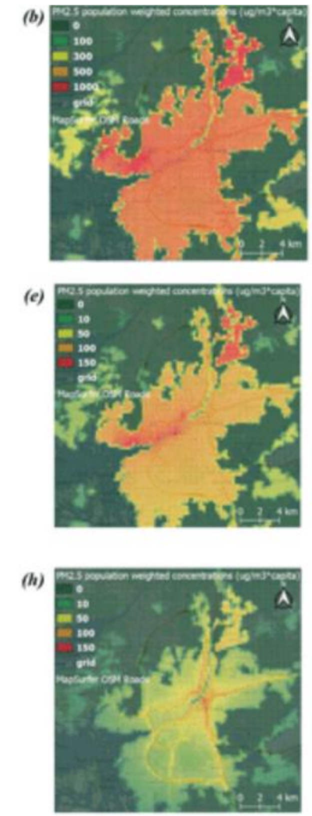
Differential toxicity in an alveolar epithelial cell line of fine particulate matter from brakewear, roadwear, and diesel exhaust

James Parkin, Lareb Sn Dean, Dawn Cooper, Robert Ridley, Elizabeth R Davies, Franco Conforti, Joseph Bell, Yihua Wang, Julian Downward, Daan Leseman, Miriam Gerlofs-Nijland, Flemming R Cassee, Donna E Davies, Richard Cook, Matthew Loxham

ERJ Open Research 2022 8: 188; DOI: 10.1183/23120541.LSC-2022.188



- Transboundary air pollution
- Emerging health effects
- Indoor air pollution: occupational and commuter exposure

Jonson et al, Atmos. Chem Phys., 20, 1139-11422, 2020.
Tang et al, Atmos. Chem, Phy., 20, 7509-7530, 2020.

N A Q T S

What research is needed to understand and manage air pollution exposure in indoor public spaces and transport environments?

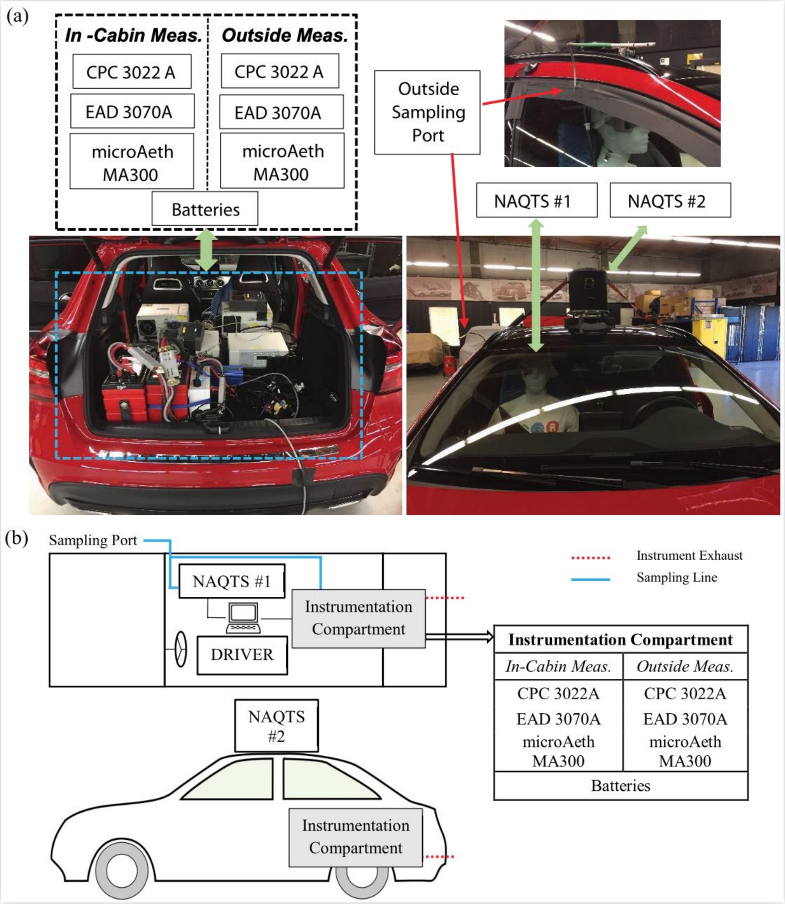
Douglas Booker, CEO @ NAQTS

Clean Air Research Futures Group

19th December 2022

Vehicle Interior Air Quality (VIAQ)

- ~100 minutes per day in vehicles (Dong et al. 2004)
- Immediate proximity to significant pollutant sources (other vehicles) & high outdoor concentrations
- Vehicle km travelled projected to ↑ ~ 14% from 2019 to 2030 (DfT)



Dong, L.; Block, G.; Mandel, S. Activities contributing to total energy expenditure in the Unites States: Results from the NHAPS study. Int. J. Behavioral Nutrition Phys. Activity 1, 4 (2004)
Pham, Liem, Nick Molden, Sam Boyle, Kent Johnson, and Heejung Jung. 2019. "Development of a Standard Testing Method for Vehicle Cabin Air Quality Index." *SAE International Journal of Commercial Vehicles* 12 (2). https://doi.org/10.4271/02-12-02-0012.

NAQTS

Understanding and managing VIAQ – The Vehicle

- How does the vehicle influence VIAQ?
- CWA17934
- UFP – largely ingress of outdoor air pollution
- CO_2 – 'stuffiness' / concentration
- How does this change with a shifting vehicle fleet?
- What about in other types of vehicles? Buses, taxis, trains, trams, etc.

S. Lim et al.

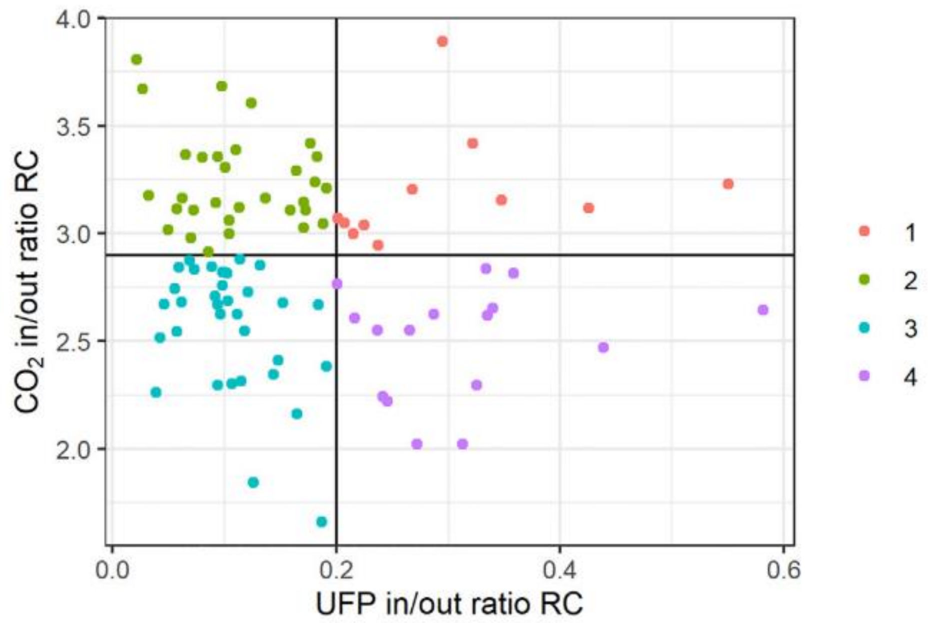


Fig. 4. Scatterplot comparing CO_2 and UFP in/out ratio for recirculate (RC) ventilation settings for 92 vehicle models, split into quadrants to group vehicles. Group 1 are vehicles which have an in/out UFP ratio > 0.2 and in/out CO_2 ratio > 2.9, group 2 an in/out UFP ratio < 0.2 and in/out CO_2 ratio > 2.9, group 3 an in/out UFP ratio < 0.2 and in/out CO_2 ratio < 2.9 and group 4 an in/out UFP ratio > 0.2 and in/out CO_2 ratio < 2.9.

Lim, Shanon, Ian Mudway, Nick Molden, James Holland, and Benjamin Barratt. 2021. "Identifying Trends in Ultrafine Particle Infiltration and Carbon Dioxide Ventilation in 92 Vehicle Models." *Science of The Total Environment*. https://doi.org/10.1016/j.scitotenv.2021.152521.

NAQTS

Understanding and managing VIAQ – The Driver

- How does occupant behaviour influence VIAQ?
- What information can be provided to drivers for manual HVAC control?
- How much control do drivers actually have on managing their VIAQ exposures?

S. Lim et al.

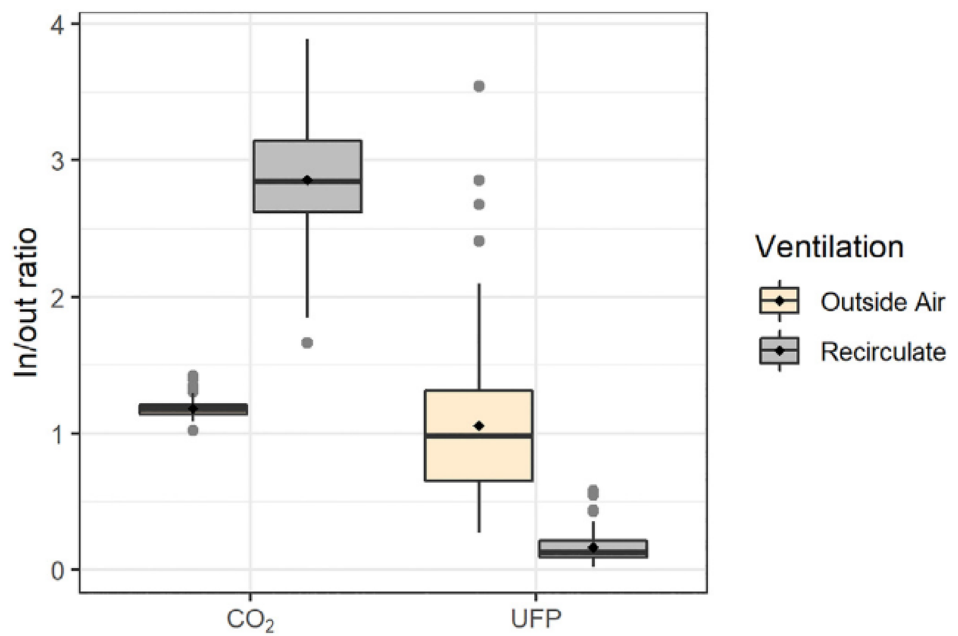


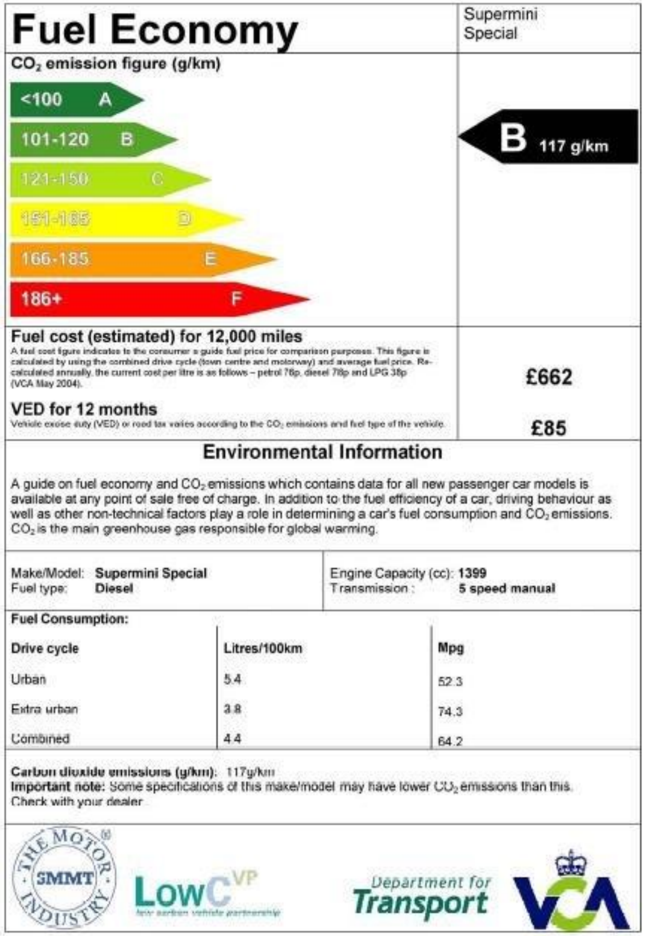
Fig. 1. Boxplot of CO2 and UFP in/out ratios for the 92 vehicles tested for OA and RC ventilation settings. Bold horizontal black lines denote the median in/out ratio; boxes extend from 25th to 75th percentile; vertical lines indicate 1.5 times the interquartile range; with grey dots being ratios outside the range of these values. Mean in/out ratios are represented by black diamonds.

Lim, Shanon, Ian Mudway, Nick Molden, James Holland, and Benjamin Barratt. 2021. "Identifying Trends in Ultrafine Particle Infiltration and Carbon Dioxide Ventilation in 92 Vehicle Models." *Science of The Total Environment*. https://doi.org/10.1016/j.scitotenv.2021.152521.

NAQTS

Understanding and managing VIAQ – Policy & Economics

- Is VIAQ captured in vehicle purchasing decisions?
- What behavioural 'nudges' to cleaner VIAQ are effective?
- What policy levers can be used to improve VIAQ?



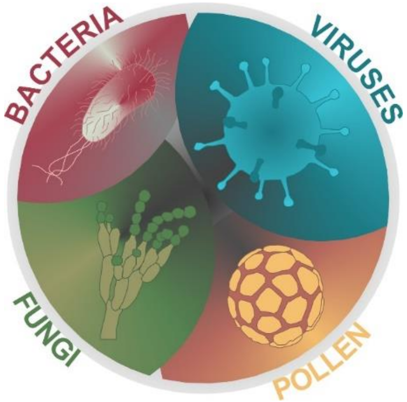
UK Health Security Agency

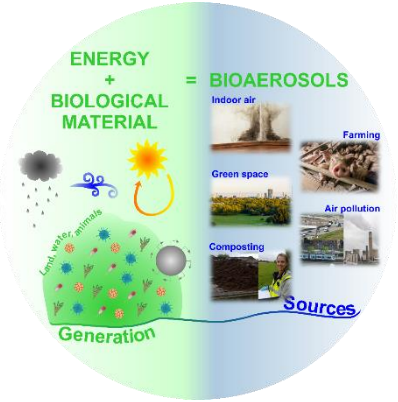
What research is needed to understand and manage air pollution exposure in indoor public spaces and transport environments:

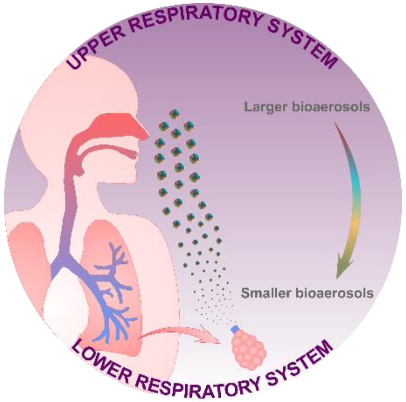
Bioaerosols

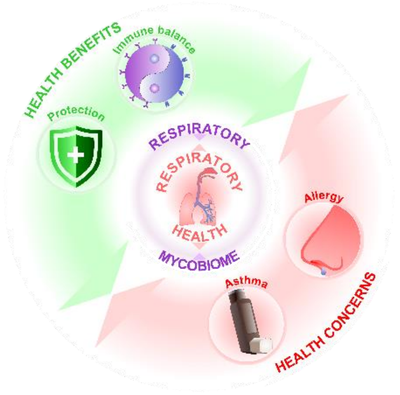
E Marczylo, P Douglas

(Fungal) bioaerosols









Systematic reviews and epidemiology

Pearson *et al*, 2015, J Toxicol Environ Health B Crit Rev,18:43-69

Robertson *et al*, 2019, Int J Hyg Environ Health, 222:364-86

Douglas *et al*, 2016, Int J Hyg Environ Health, S1438-4639:30022-0

Douglas *et al*, 2018, Int J Hyg Environ Health, 221:134-173

Research communities and networks

MetaSUB

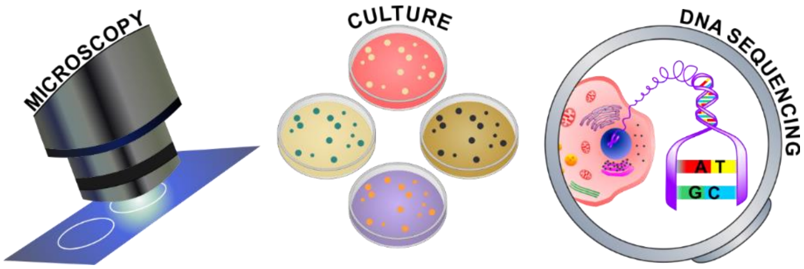
http://metasub.org/

BioAirNet

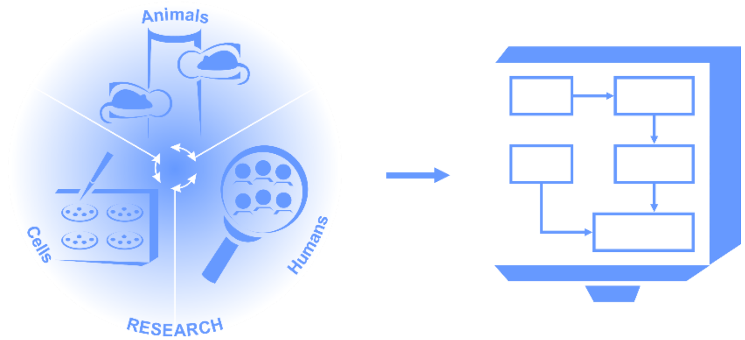
https://bioairnet.co.uk/

Research needs

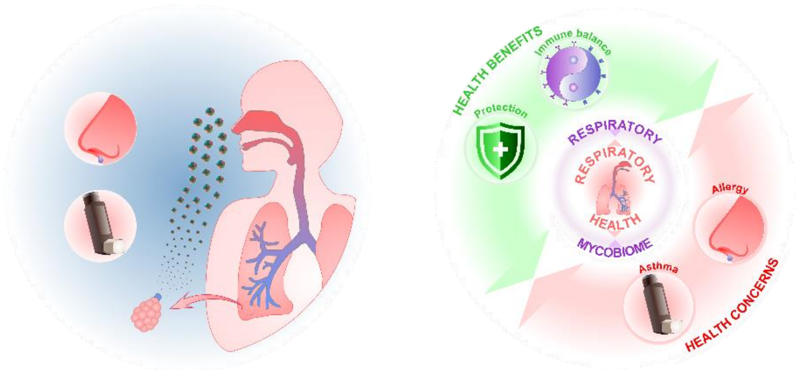
Characterisation



Toxicological profiling



Links with health data



Interventions

Current work

Characterisation

Journal of Applied Microbiology
sfam
Journal of Applied Microbiology ISSN 1364-5072

ORIGINAL ARTICLE

Background levels of micro-organisms in the busy urban environment of transport hubs

K.V. Patel[1,*], C.L. Bailey[1], A.-H. Harding[1], M. Biggin[2] and B. Crook[1]

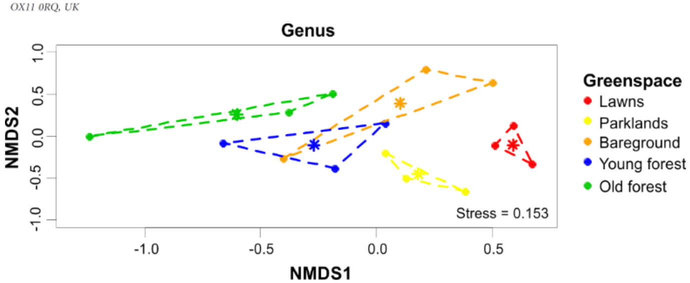
1 Health and Safety Executive Science Division, Buxton, UK
2 Safety Technical and Engineering, Network Rail, Milton Keynes, UK

EcoHealth 18, 315–330, 2021
https://doi.org/10.1007/s10393-021-01523-1
ECOHEALTH

Metabarcoding of Soil Fungi from Different Urban Green-spaces Around Bournemouth in the UK

Emma L. Marczylo,[1] Sameirah Macchiarulo,[1] and Timothy W. Gant[1]

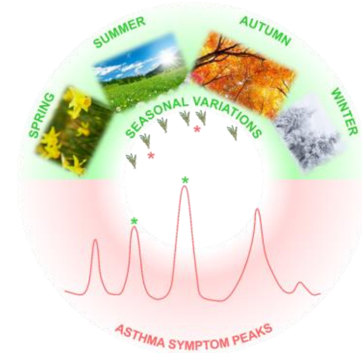
Toxicology Department, Centre for Radiation, Chemical and Environmental Hazards, Public Health England, Harwell Campus, Chilton, Oxfordshire OX11 0RQ, UK



Links with health data

A real-time molecular epidemiological investigation into the contribution of fungal spores to seasonal asthma spikes

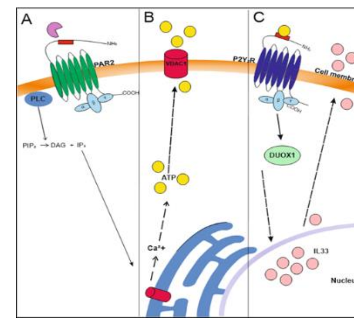
Sam Anees-Hill

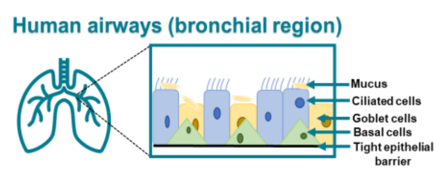


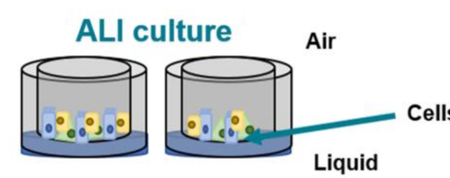
Toxicological profiling

What drives allergic inflammatory responses to the known fungal allergens at the epithelial barrier in the lungs?

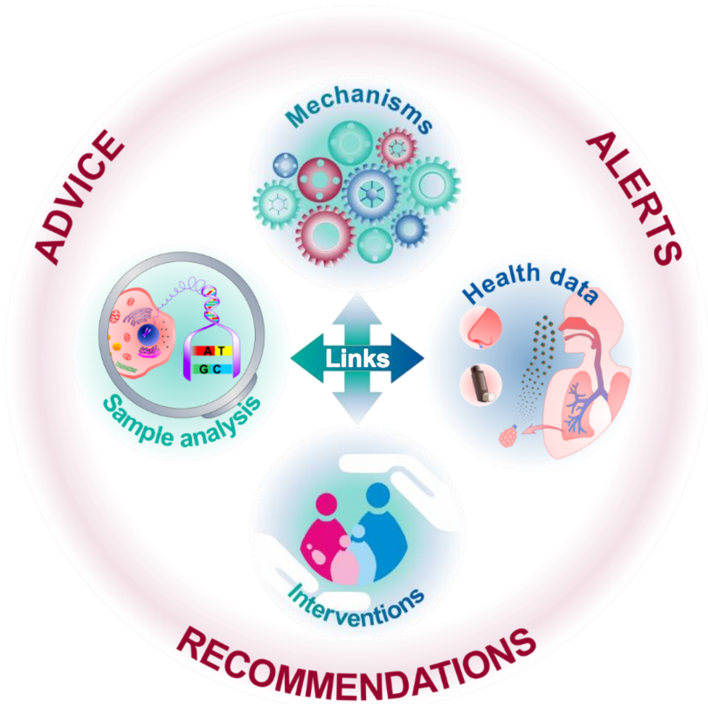
Emma-Jane Goode and Emma Marczylo







Ultimate aim



To patients & health professionals

UNIVERSITY OF LEICESTER

HSE Health & Safety Executive

UK Health Security Agency

Imperial College London

NIHR | Health Protection Research Unit in Environmental Exposures and Health at Imperial College London

MRC Toxicology Unit
UNIVERSITY OF CAMBRIDGE

Health Protection Research Units

THANK YOU FOR LISTENING!