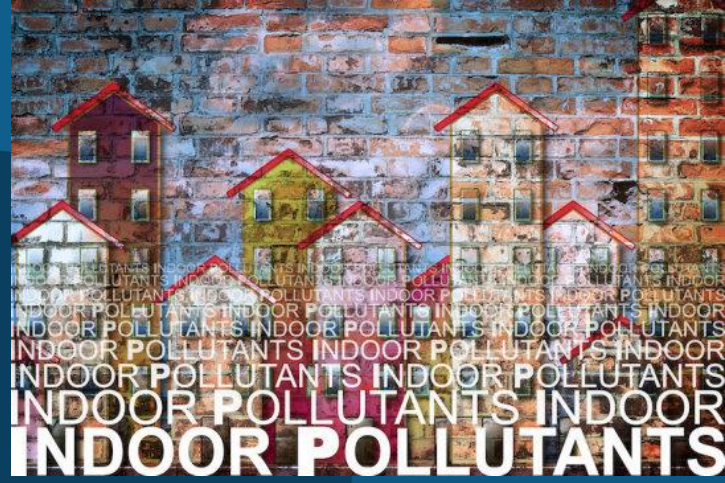
**UKIEG Meeting June 27th 2019**




# How important is indoor air pollution in indoor homes?

Stephen Holgate

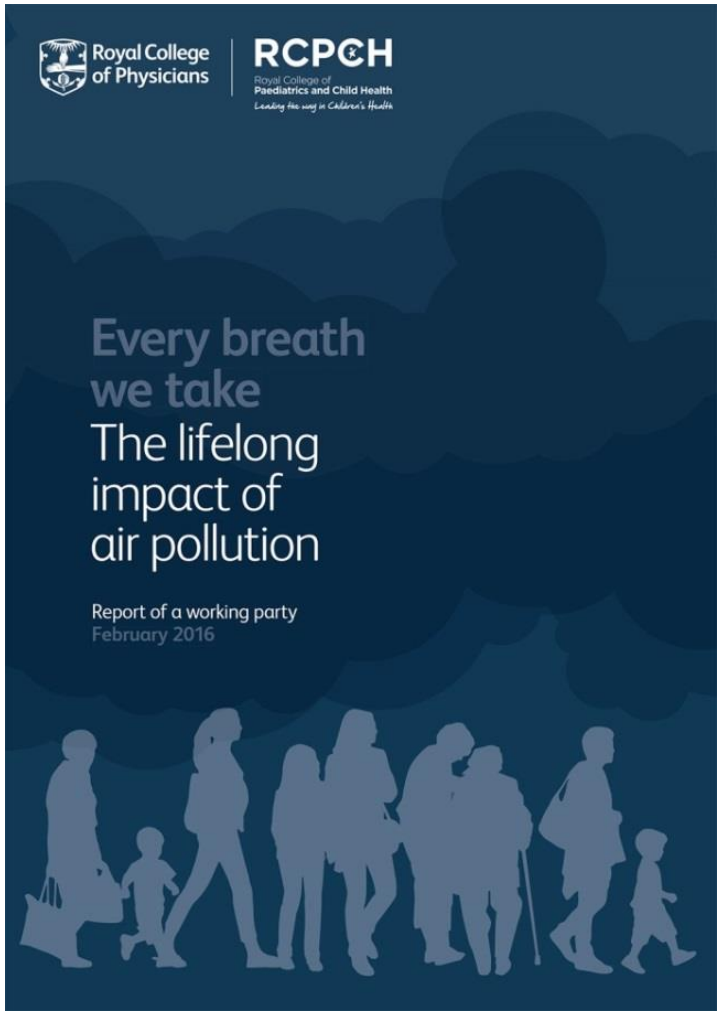
Special Advisor to the RCP on Air Quality,
Co-Chair RCPCH WP on Indoor Air Pollution and Children's Health,
UKRI Clean Air Champion

MRC Professor University of Southampton.

Royal College of Physicians

RCPCH Royal College of Paediatrics and Child Health
Leading the way in Children's Health

Setting higher standards

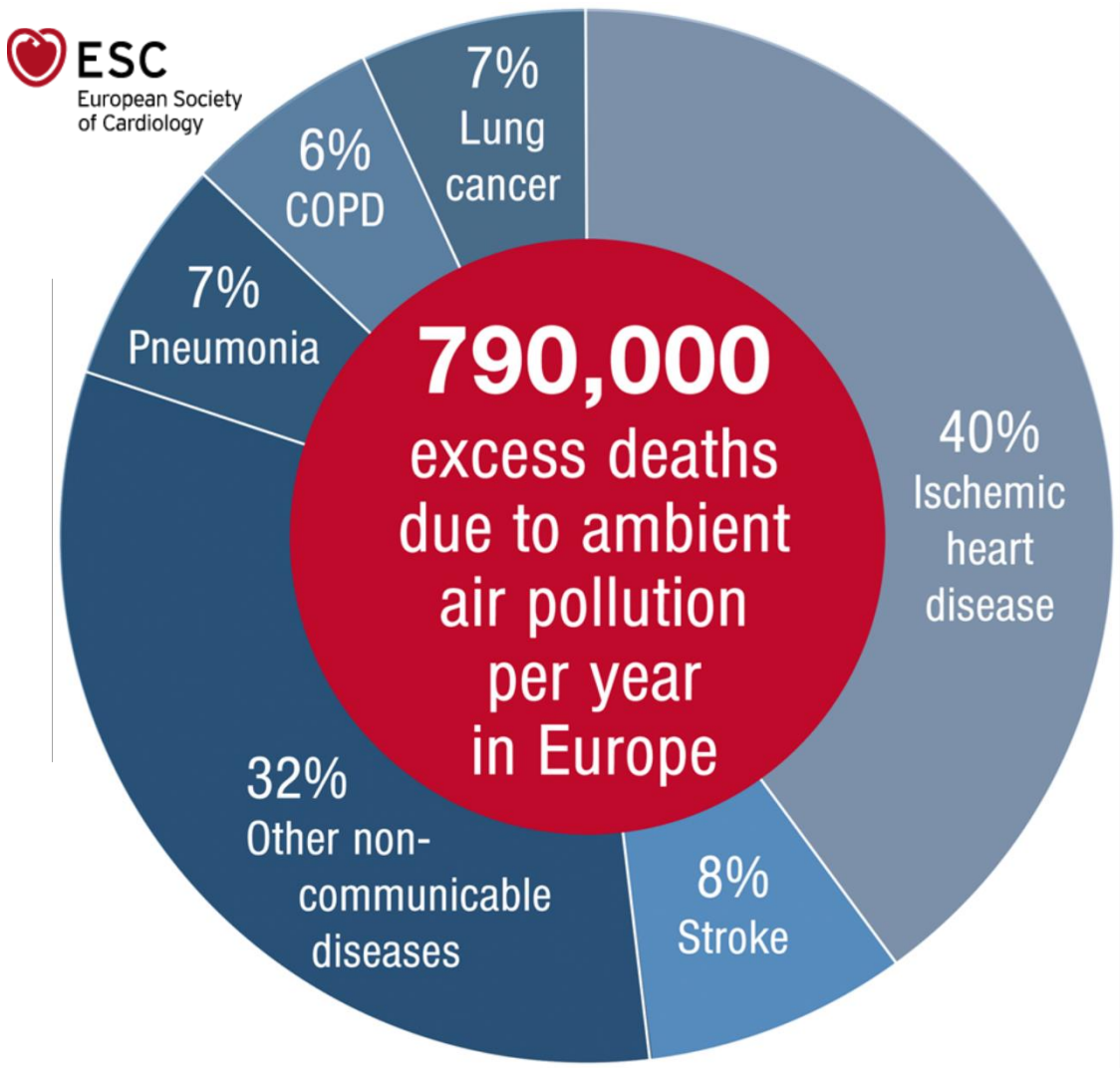


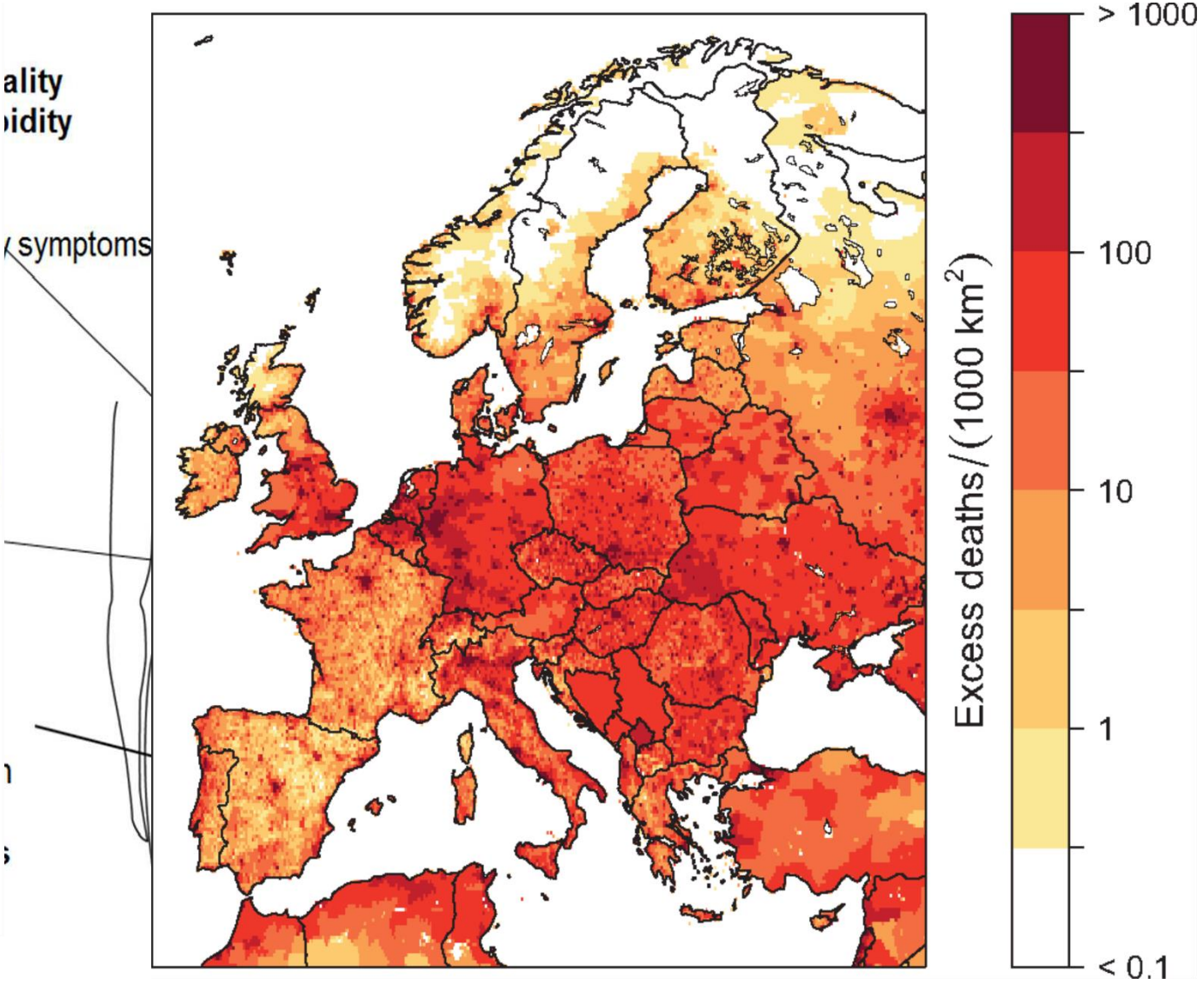

# Air Pollution: the Public Health Problem of Our Time

- Air pollution (PM and Nox) estimated to cause around 40,000 (COMEAP 36,000) deaths per year in the UK
- Estimated cost of air pollution is £20bn annually in the UK
- Linked to major health challenges of our day such as heart disease, asthma, COPD, lung cancer, diabetes, infertility, premature organ aging, dementia

Cardiovascular disease burden from ambient air pollution in Europe reassessed using novel hazard ratio functions

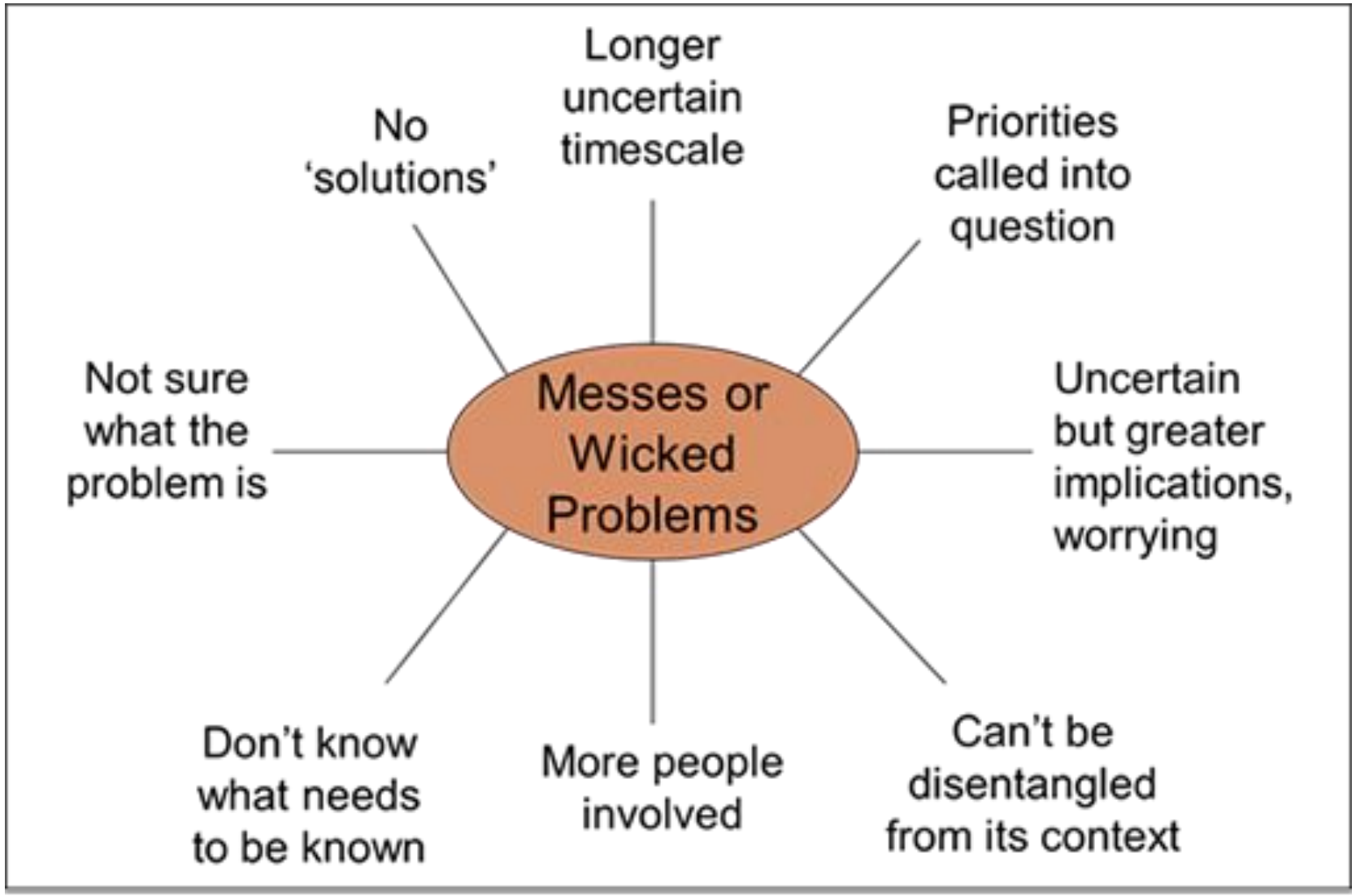
Lelieveld J et al. European Heart Journal 2019 Mar 12. pii: ehz135



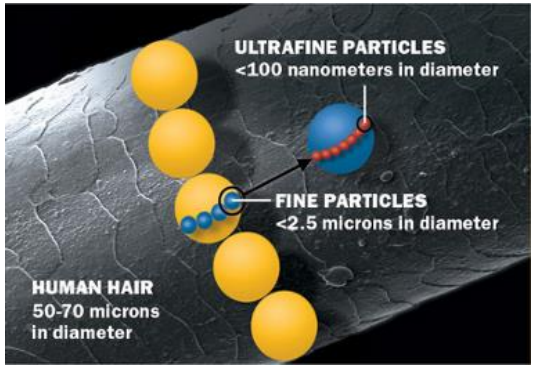



# Air pollution is an example of a wicked problem

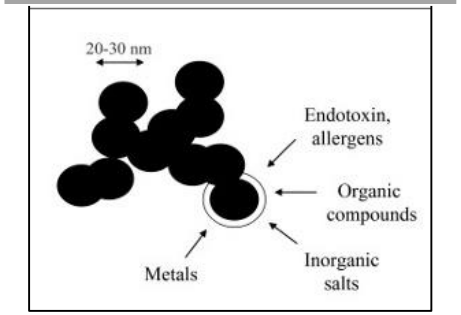
The use of the term "wicked" here has come to denote resistance to resolution



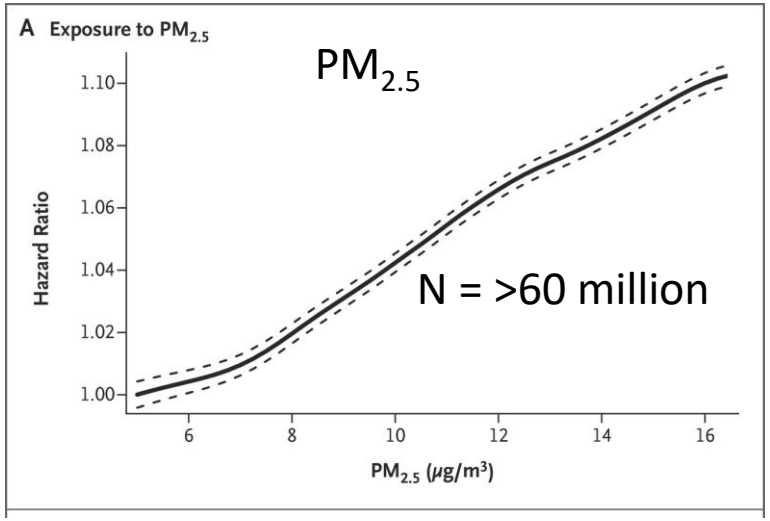
- Regulators – what to regulate EU Limit values or Health based limits and multiple sources of exposure.



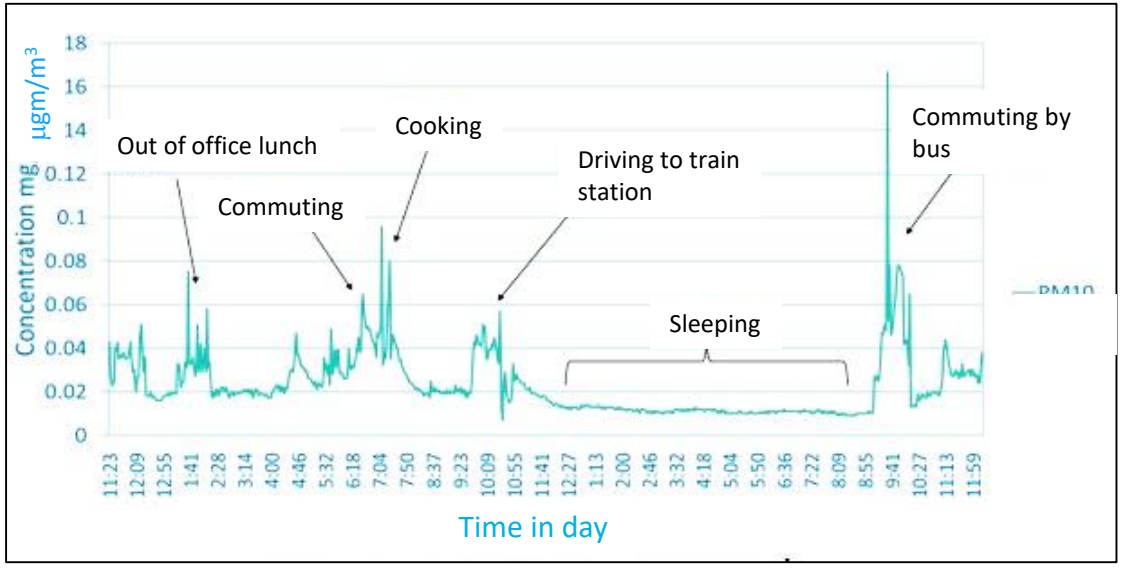

Combustion Particles




Absence of threshold – mortality Medicare Population



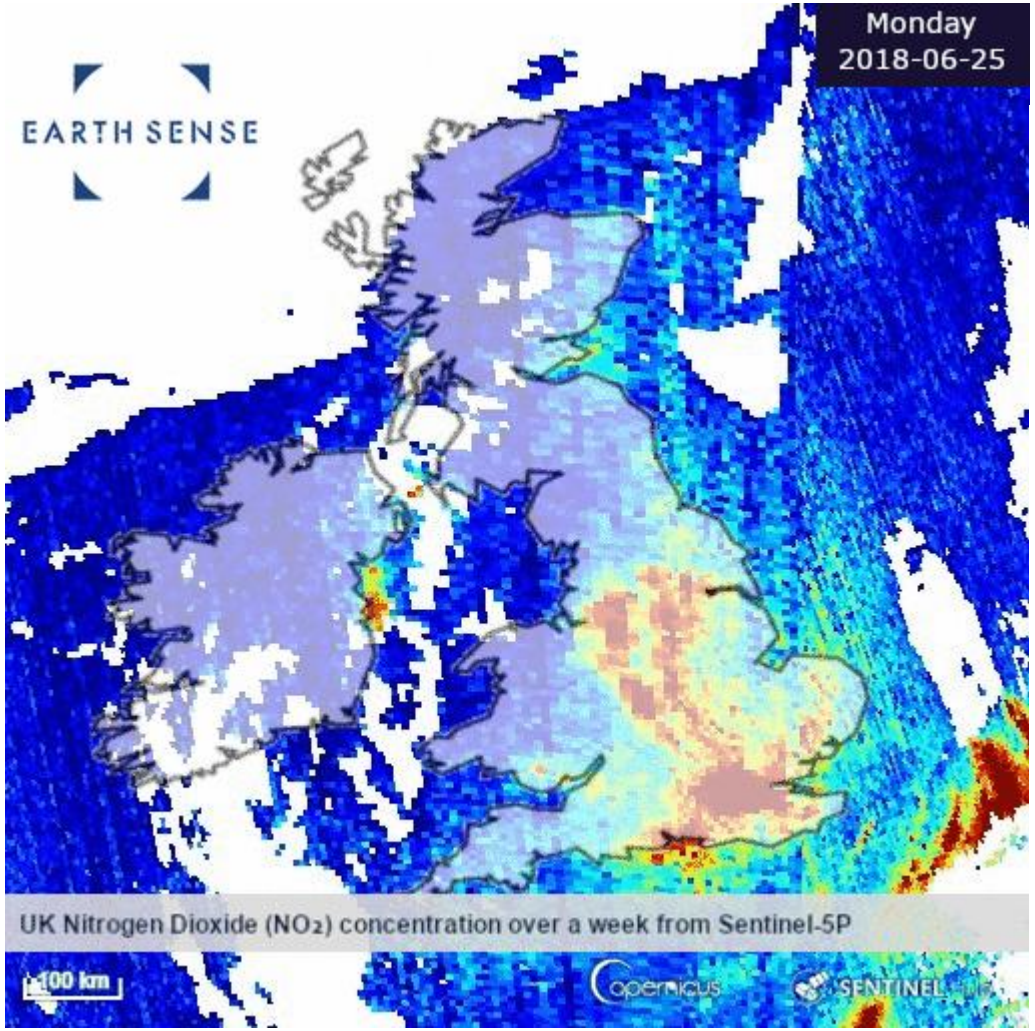

Personal exposure - Concentration of Particulate matter, $PM_{10}$

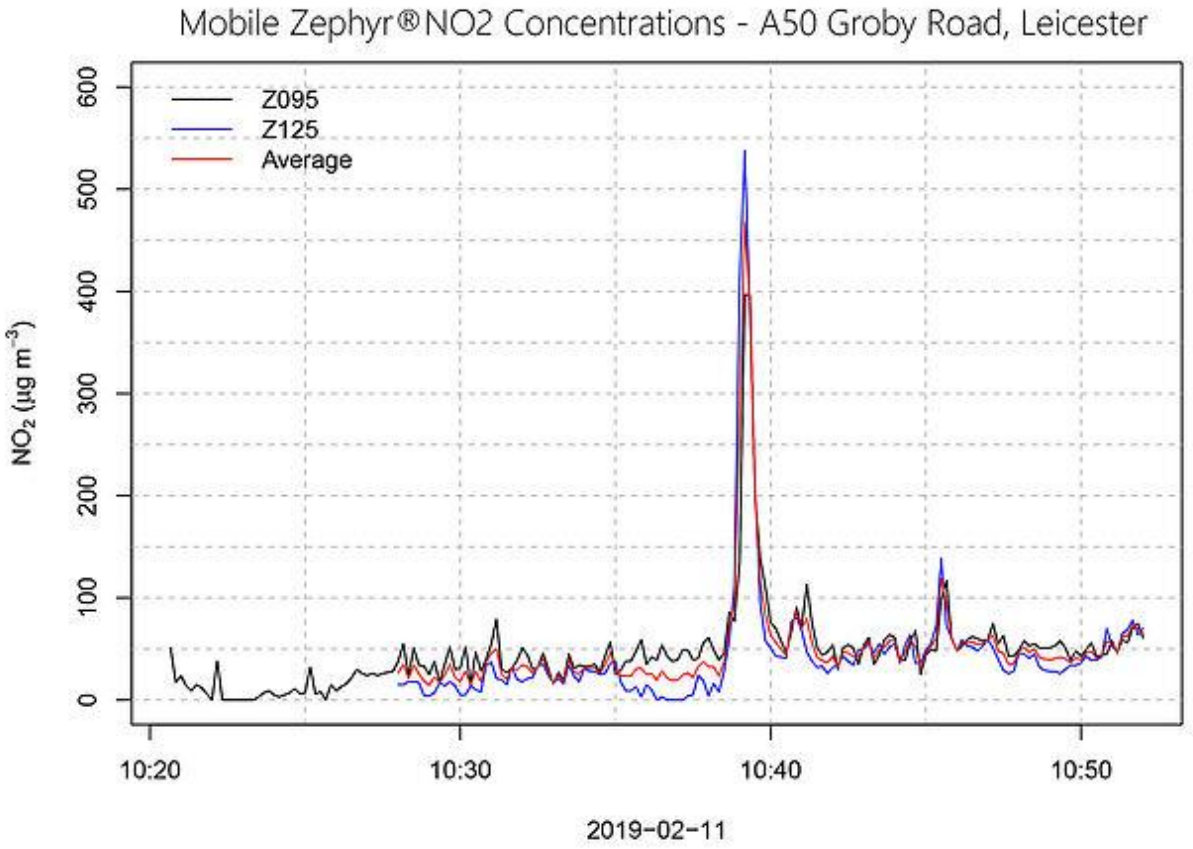



**Example of a 24 hour real-time sample of air pollutant particle exposure**

EU urban population exposed to harmful levels of air pollutants

# Satellite versus local air pollution monitoring



# Pioneering sensor technology

**Project #1**: Breathe London installed a network of 100 state-of-the-art sensor pods on lampposts and buildings throughout the city, continuously transmitting air quality measurements.

**Project #2**: Specially equipped Google Street View cars are using mobile sensors to measure air pollution on a variety of London roadways, taking readings approximately every 30-60 metres in representative areas of the city.

**Project #3**: In a linked study funded by the Greater London Authority, King's College London is using wearable sensors that will allow schoolchildren and teachers to monitor air quality during their journey to and from school.

**This project will create a picture over the course of a year, identifying pollution 'hotspots' that the existing network of fixed monitors cannot currently**

February 5th 2017 - Ribble Cycles surveyed more than 1,060 adults in Britain.

The average person spent 92% of their time indoors on a weekly basis.

**The average person in Britain spends just 8 per cent of their time outside on a week day, meaning less than two hours a day out of doors.**

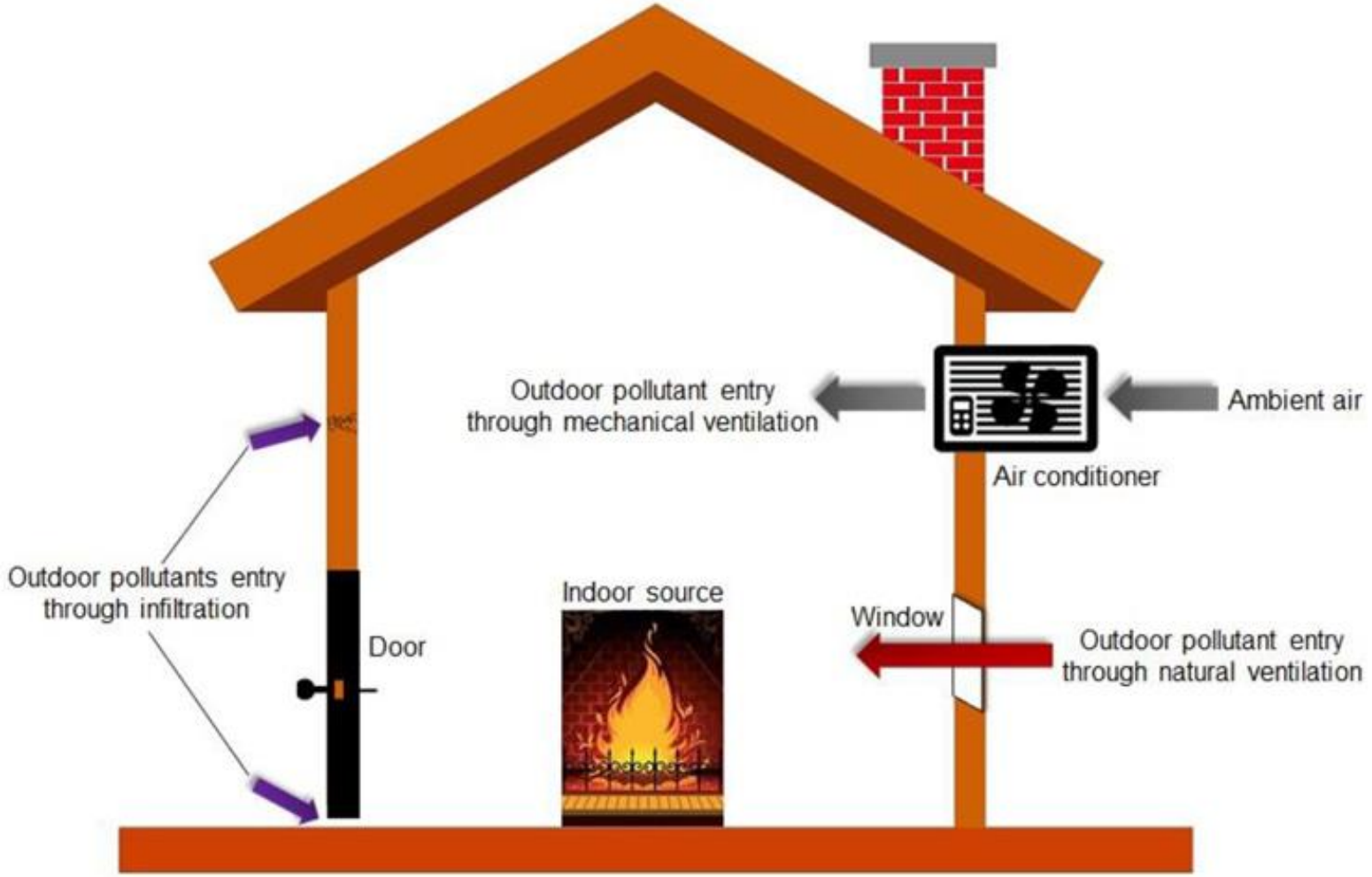
Most of this time is spent walking to the shops or the car, but men are slightly better at getting out than women, at 28 minutes more per week day.

Brits also admit to spending 1 hour 37 minutes per day less outside during winter in comparison to summer.

- **Taking pets for a walk (17%)**
- **Walking to the shop at lunchtime (16%)**
- **Walking to and from the car (15%)**
- **Walking to work from my bus/train (14%)**
- **Going for a run (6%)**
- **Walking the kids to school (5%)**
- **Smoking (4%)**
- **Cycling to work (2%)**

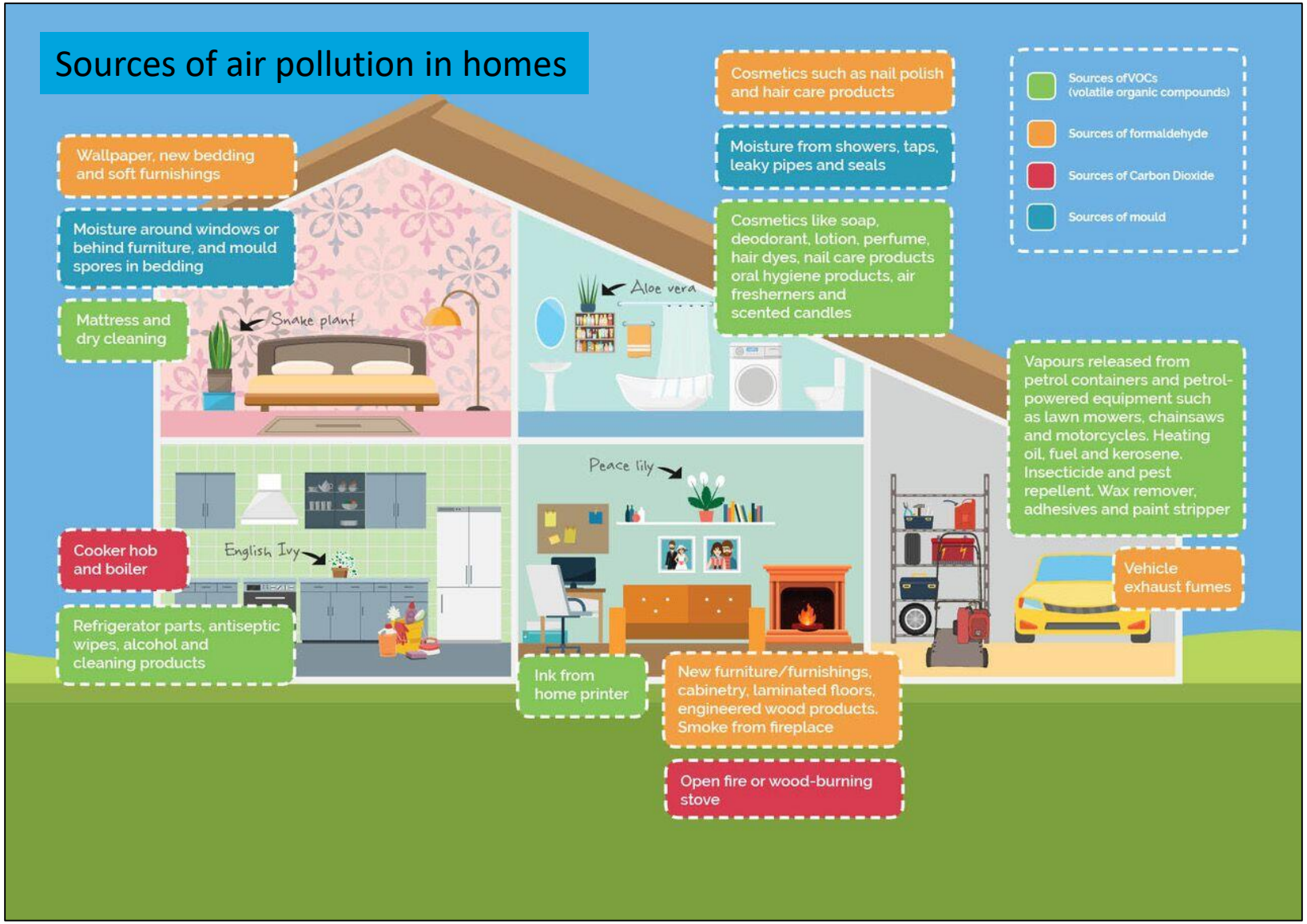
# Outdoor-indoor air pollution in urban environment: challenges and opportunity

Leung DYC Front. Environ. Sci., 15 January 2015; https://doi.org/10.3389/fenvs.2014.00069



According to the EPA, our indoor environment is two to five times more toxic than our outdoor environment, and in some cases, the air measurements indoors have been found to be 100 times more polluted

# What are the sources of indoor air pollutants?




airtopia

# Water, moisture and damp as air pollutants augmented by poor ventilation

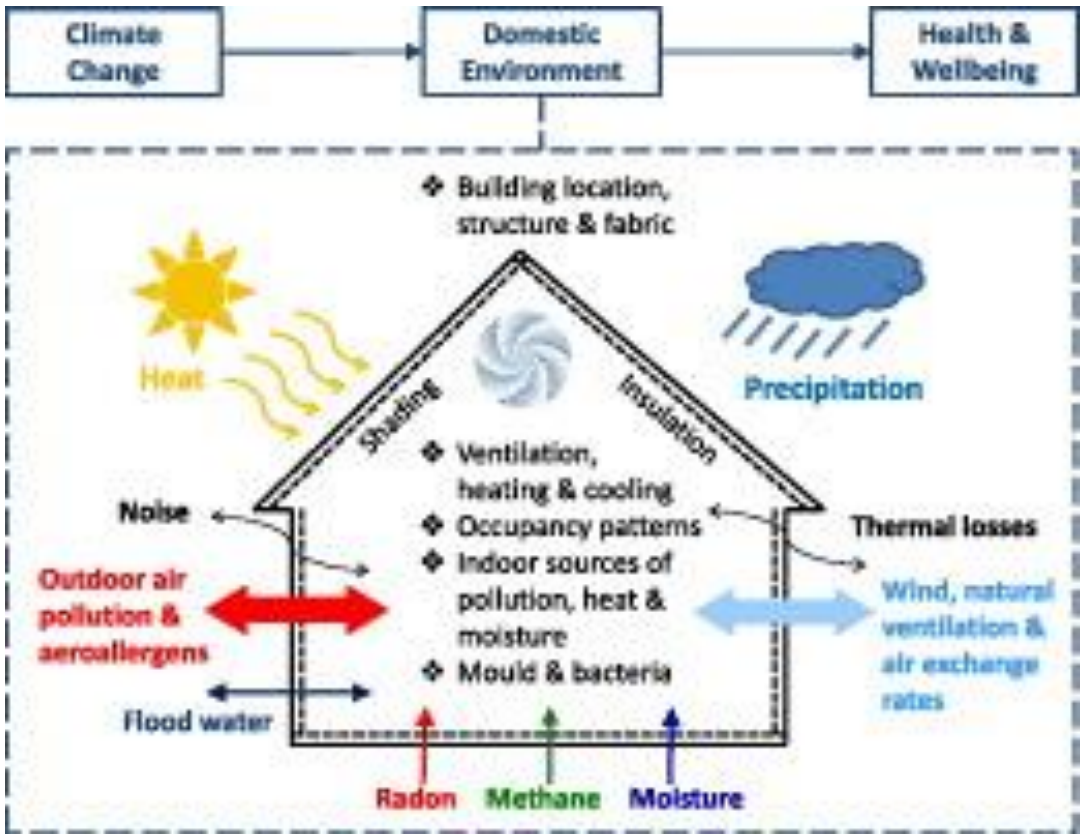

**20 KEY CAUSES OF DAMP**

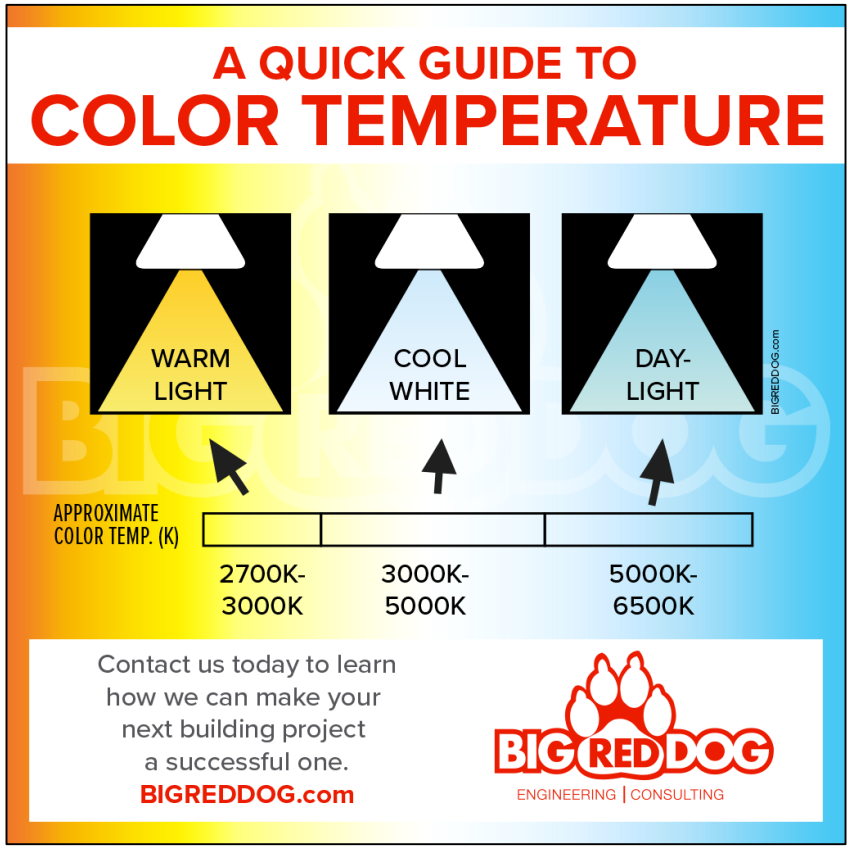
1. Coping missing.
2. Open joints in brickwork.
3. Cement mortar cracked, replace with lead.
4. Tiles lose or missing.
5. Defective or blocked valley.
6. Decayed bearings cause damaged purlins.
7. Verge tiles missing.
8. Leaves may block gutters.
9. Tree roots may damage foundations.
10. Damaged gutters.
11. Blocked or damaged rainwater pipe.
12. Hairline cracks in render.
13. Defective window cill.
14. Cement render preventing the wall from breathing.
15. Blocked gulleys.
16. Wallplate resting on ground without a damp course.
17. Floor below ground level.
18. Brick nogging require repointing.
19. Vegetation encouraging damp.
20. Timber frame decay at joint with brickwork.

# Indoor temperature and climate change

## Impact of climate change on the domestic indoor environment and associated health risks in the UK. risks in the UK

Vardoulakis S et al. Environment International 2015; 85: 299-313



# Indoor Air Quality Testing

**- 47 homes in Birmingham, London and the Home Counties**
**June 20th, 2019**

- **Temperature and Relative Humidity** – the temperature distribution and the amount of water vapour in the air across the house (degrees centigrade and %)
- **Carbon Dioxide** – as a good proxy for air movement, measured in several locations including near heating source (ppm.
- **Volatile Organic Compounds (VOCs)** – the overall levels of these airborne chemicals (TVOC) with full breakdown into 16 source categories. Range C3-C16. ($\mu g/m^3$).
- **Observed Mould and Microbial Volatile Organic Compound** (MVOC) – visual check and chemical analysis which identifies both visible evidence and invisible but actively growing mould ($\mu g/m^3$).
- **Formaldehyde** – can be taken either by TDT sample or hand-held unit ($\mu g/m^3$).
- **Observations and Questionnaire** – photos are taken, outdoor temperature and weather conditions are noted + Simple health and lifestyle questionnaire to create context for the specific property report and also important research data for future analysis.

# Pre-sampling preparation

- Test parameters
  - External windows and doors
    - Should ideally be closed for a minimum of 24 hours before test is performed
  - If windows and outside doors are open
    - Close them and wait approximately 30 to 60 minutes before starting test
    - Note if external windows and doors were open
  - Indoor temperature should be between 15-27ºC (21ºC ideal)
    - This is the temperature range for most homes
    - Lower temperatures can cause VOCs to condense and result in low reading
    - Higher temperatures might cause a slightly higher TVOC reading
    - Mould growth rate is reduced at lower temperatures
  - All inside doors should be open

# IAQ data from 47 homes in Birmingham, London and the Home Counties June 20th, 2019

airtopia

CleanAirDay®

- 71% of people feel that their health is affected by indoor air pollution.
- 47% of households surveyed confirmed that they never ventilate their homes at night.
- Levels of awareness among households as to the main sources of indoor air pollution were also incredibly low: when asked to select the three biggest sources of indoor air pollution from a list provided, 16 % of people were unable to give an answer.
- 20% of homes showed more than double the amount of safe levels of **formaldehyde**.
- 45% of homes had significantly increased levels of Total Volatile Organic Compounds (TVOCs) - with 28% of householders in homes with high TVOCs. readings reporting multiple respiratory difficulties.
- 98% of householders didn't identify chipboard furniture as one of their top sources of pollution - chipboard is a major source of formaldehyde.

# Adverse effects of indoor air pollution on child health to be investigated in first ever UK review

- Review evidence of the causes and ways in which indoor air pollution in homes and schools adversely affects the health of children.
- Produce a report that makes recommendations to influence the planning and building of new homes and schools in order to mitigate risk.
- Highlight the potential contributions of climate change on indoor air pollution.
- Undertake a health economic assessment.

- We are spending more and more of our lives indoors, and the health impact of the air within our homes and schools needs to be taken seriously as a significant source of ill health.
- Children spend a greater proportion of their lives indoors than outdoors.
- The air inside our homes can be five times more polluted than the air outside.
- Children's bedrooms are often the most polluted.
- Children's lungs are most susceptible to the harmful effects from damp, mould and airborne toxins.

# What pollutants will the Report examine?

The review will cover the following indoor airborne pollutants, including those resulting from outdoor pollutant ingress:

• Oxides of nitrogen • Carbon dioxide • Carbon monoxide – excluding acute exposure as this is a well-established serious hazard to human health • Ozone • Particulate matter • Volatile organic compounds • Aldehydes • Secondary organic aerosols • Terpenes • Polycyclic aromatic hydrocarbons • Perfluoroalkyl substances • Flame retardants • Phthalates • Biological materials (e.g. allergens from house-dust mites, animal dander, mould and pollen; and bioaerosols such as endotoxins, bacteria, viruses and fungi) • Biocides • Moisture • Temperature • Mineral dusts and fibres • Methane • Lead • Combined effects of any of the above

# An experimental study of permeability characteristics of outdoor particles under indoor and outdoor temperature differences

Lu Y, Qiu J, Liu Y. Procedia Engineering. 2017; 205: 226-2

1) Indoor and outdoor temperature differences significantly affected the outdoor particulate penetration .
2) The greater the temperature difference, the more easily the outdoor particles penetrated into the room.
3) When there was no temperature difference between indoor and outdoor, the I/O ratio of $PM_{2.5}$ was less than $PM_{10}$, both of which were less than 1.
4) When there was an obvious temperature difference, the I/O ratio of $PM_{2.5}$ was greater than that of $PM_{10}$, and the temperature difference greatly impacted the I/O ratio of $PM_{2.5}$.

# Project update - June 2019

**Stage 1:** April 2018 - a systematic review of the literature regarding the health effects of indoor air pollution on infants, children and young people. The systematic review is now complete and has provided us with the evidence needed to develop recommendations and identify areas where further research is needed.

Will supplement 2 further systematic reviews on **sources of pollutants** (IOM, Edinburgh) and **Interventions** (KCL).

**Stage 2:** October 2018 - a wider call for evidence from stakeholders, including engagement with children and young people, regarding indoor air quality.

The WP meets every 2 months + Technical Advisory Group + Parents and Children's Group
Date of publication: November 29th 2019.

UK Research and Innovation

# Strategic Priorities Fund
# Clean Air: Analysis and Solutions

Met Office

NERC, ESRC, EPSRC, MRC, InnovateUK on behalf of UKRI, and the Met Office and NPL on behalf of BEIS

The objectives of the SPF Clean Air programme are to:

1. Drive forward new interdisciplinary research and innovation.
2. Leverage existing UK investments and enable a challenge-focussed interdisciplinary community to work together.
3. Inform implementation of the UK Government's Clean Air Strategy 2019.
4. Develop new solutions to reduce emissions of atmospheric pollution and protect public health, whilst avoiding perverse consequences.
5. Present information to stakeholders and public in an accessible way.

**Wave 1 – Systems approach to reducing outdoor air pollution - £18.5 million 3 years**

**Wave 2 – Indoor air pollution, indoor/outdoor nexus and secondary air pollutants £22.0 million 3years**

# Air quality dependencies and basis for Clean Air systems analysis framework

Failure of engagement and ownership of the health problems by medical community

CleanAir — CHAMPIONS —

Communication barriers between physical and biological/health scientists

Lack of public understanding

Little motivation for behaviour change

X X X X


**Feedbacks**

| Global/Local Weather | Emissions | Air Quality | Impacts | Action |
|---|---|---|---|---|
| ➢ Weather forecast<br>➢ Multi year weather analysis<br>➢ Nested finer scale local weather models<br>➢ Climate change | ➢ Anthropogenic and biogenic<br>➢ Temporal and spatial variation<br>➢ Street, local, national, regional, global<br>➢ Observations | ➢ Street to global<br>➢ Hourly to climatic variation<br>➢ Gas and aerosol chemistry, deposition, etc<br>➢ Weather and climate feedbacks<br>➢ Observations | ➢ Hazard x Vulnerability x Exposure<br>➢ Economic cost/benefit<br>➢ Health and Environmental<br>➢ Measurement of impact/mitigated impact | ➢ Long term policy e.g. energy mix, vehicle, clean air zones, international<br>➢ Tactical e.g. health advice, industrial and traffic management, individual choice |

X

Lack of interfaces to promote innovations

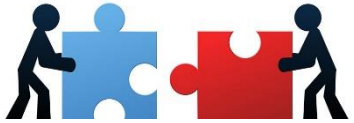
X


Industry/economic pushback

**Capability/Linkages limited, fragmented and not aligned: Street ⟺ Global a particular challenge**

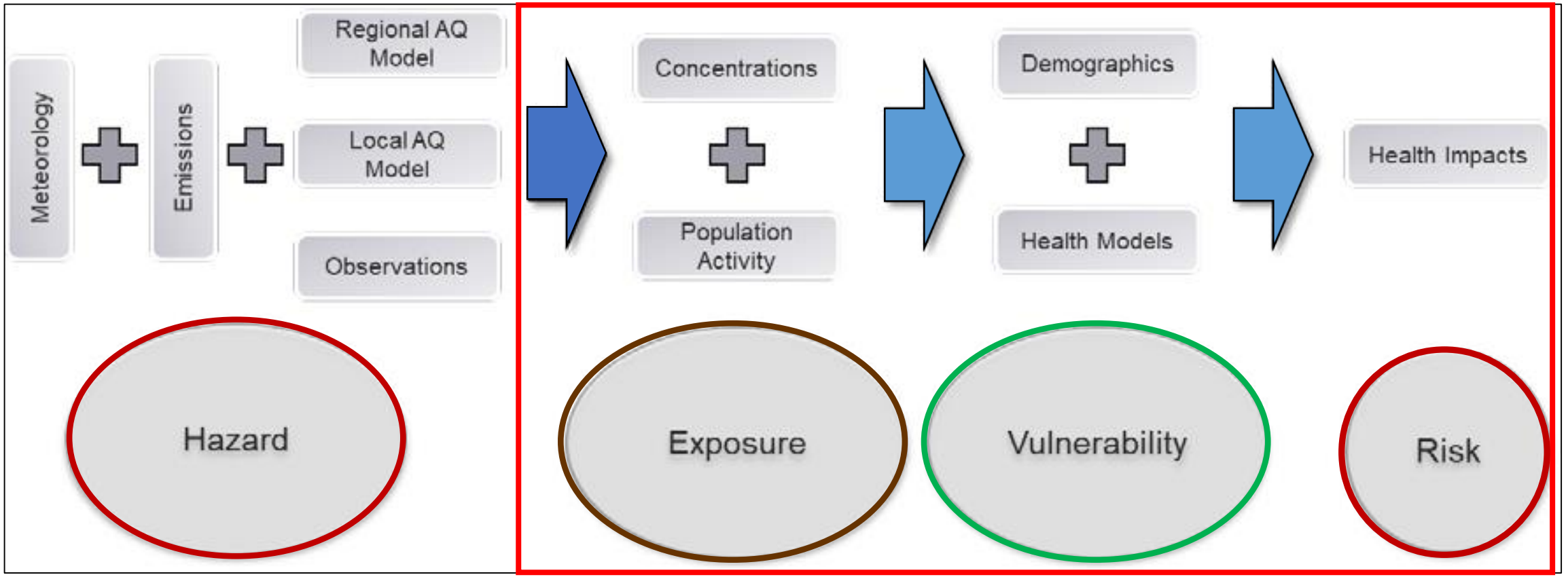
# Scientific components required for Clean Air Analysis, described as a process chain, categorized according to hazard, exposure and vulnerability

**Atmospheric Science**



**Health and Medical Sciences**

CleanAir — CHAMPIONS —




# UKRI Clean Air Champion Team

**Prof Stephen T Holgate**, MRC Clinical Professor,
Clinical and Experimental Sciences, Faculty of Medicine University of Southampton.

- Respiratory medicine, clinical science and environmental health

**Dr. Jenny Baverstock**, Senior Collaboration Fellow,
Faculty of Environmental and Life Sciences, University of Southampton.

- Interdisciplinary research, research networks facilitator and delivery manager.

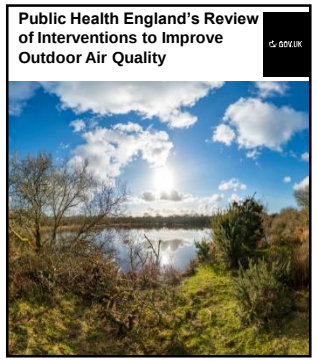
**Prof Martin Williams**, Head, Science Policy Unit,
Environmental Research Group, King's College, London

- Application of atmospheric science to policy on air quality, the relationship between air quality and health, and on the linkages between air quality and climate change.


# Objectives of the UKRI SPF Clean Air Programme

UK Research and Innovation

CleanAir CHAMPIONS




1. **Drive forward new interdisciplinary research and innovation.**
2. **Leverage existing UK investments and enable a challenge-focussed interdisciplinary community to work together.**
3. **Inform implementation of the UK Government's Clean Air Strategy.**
4. **Develop new solutions to reduce emissions and exposures of atmospheric pollution and protect public health, whilst avoiding perverse consequences.**
5. **Present information to stakeholders and public in an accessible way.**


1

DAY TO GO

76% of people would find more public information campaigns on air pollution helpful

20 June 2019

CleanAirDay





**People will change their behaviour only if they see the new behaviour as easy, rewarding, empowering and normal**