



Public Health  
England

# Indoor Air Pollution, Personal Exposure and Health

Dr Sani Dimitroulopoulou

Principal Environmental Public Health Scientist - Indoor Environments, Environmental Hazards and Emergencies Dept, Public Health England

Honorary Senior Lecturer, The Bartlett School, University College London

Vice Chair, UK Indoor Environments Group

*Investigation of Air Pollution Standing Conference; London, 12 June 2018*

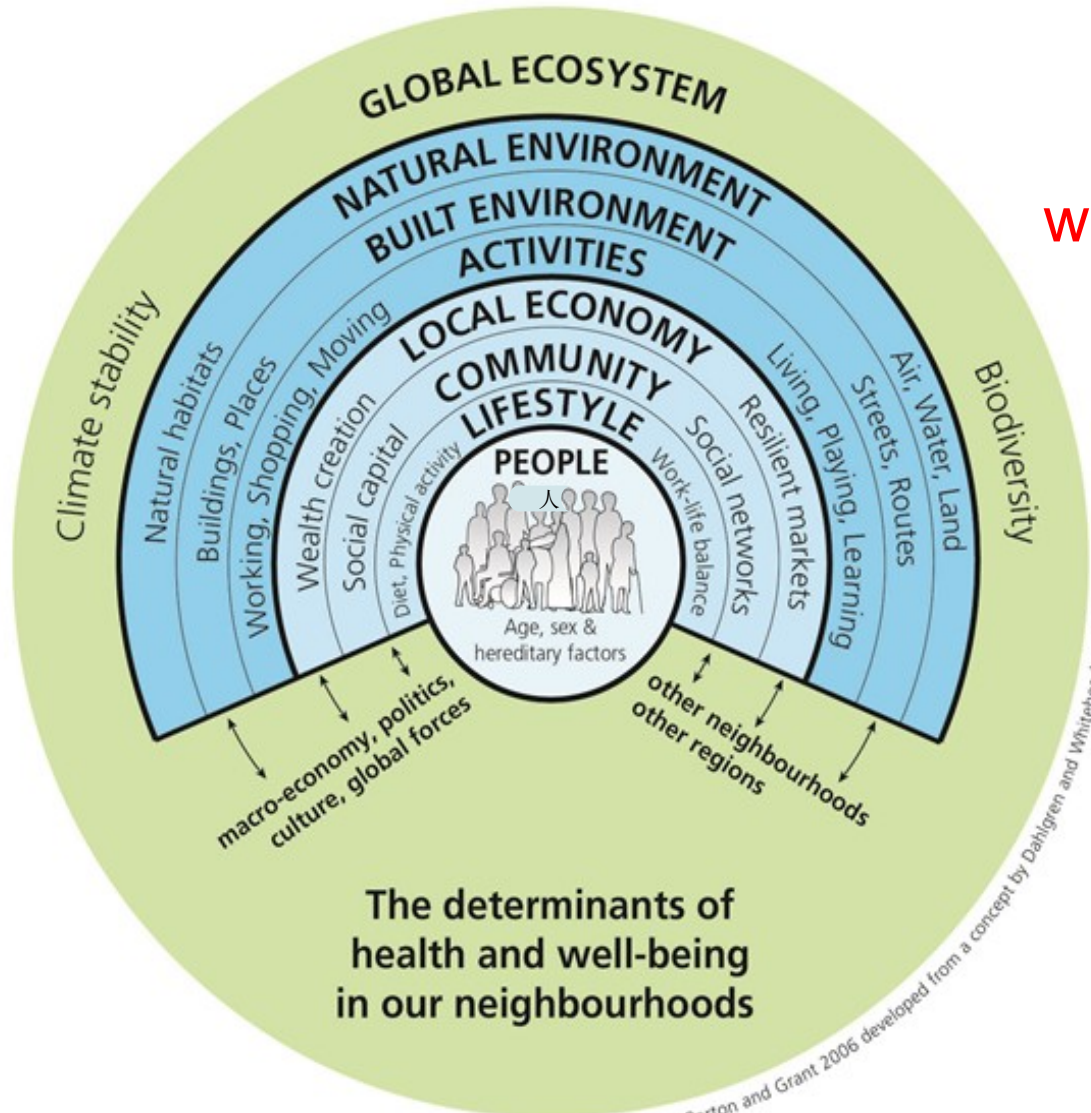


# Our health is determined by:

what we do

where we live

who we are



The health map: Barton and Grant 2006 developed from a concept by Dahlgren and Whitehead 1991



# Buildings and Health

- Provide shelter and enhance wellbeing
- Can be associated with a range of health hazards:
  - Building overheating
  - Cold weather
  - Indoor air pollution, Radon
  - Pests and infestations
  - Noise
  - Airborne infectious diseases
  - Water or mould contamination
  - Domestic injuries and poisoning
  - Mental health effects.



Public Health  
England

# Factors affecting IAQ

**Ambient air**  
Urban planning



**Material and equipment  
In buildings**

*Ventilation*

**Design and maintenance  
Of buildings**

**Occupant  
activities**



**Combustion equipment  
Inappropriate  
energy saving**



# Sources of IA pollutants

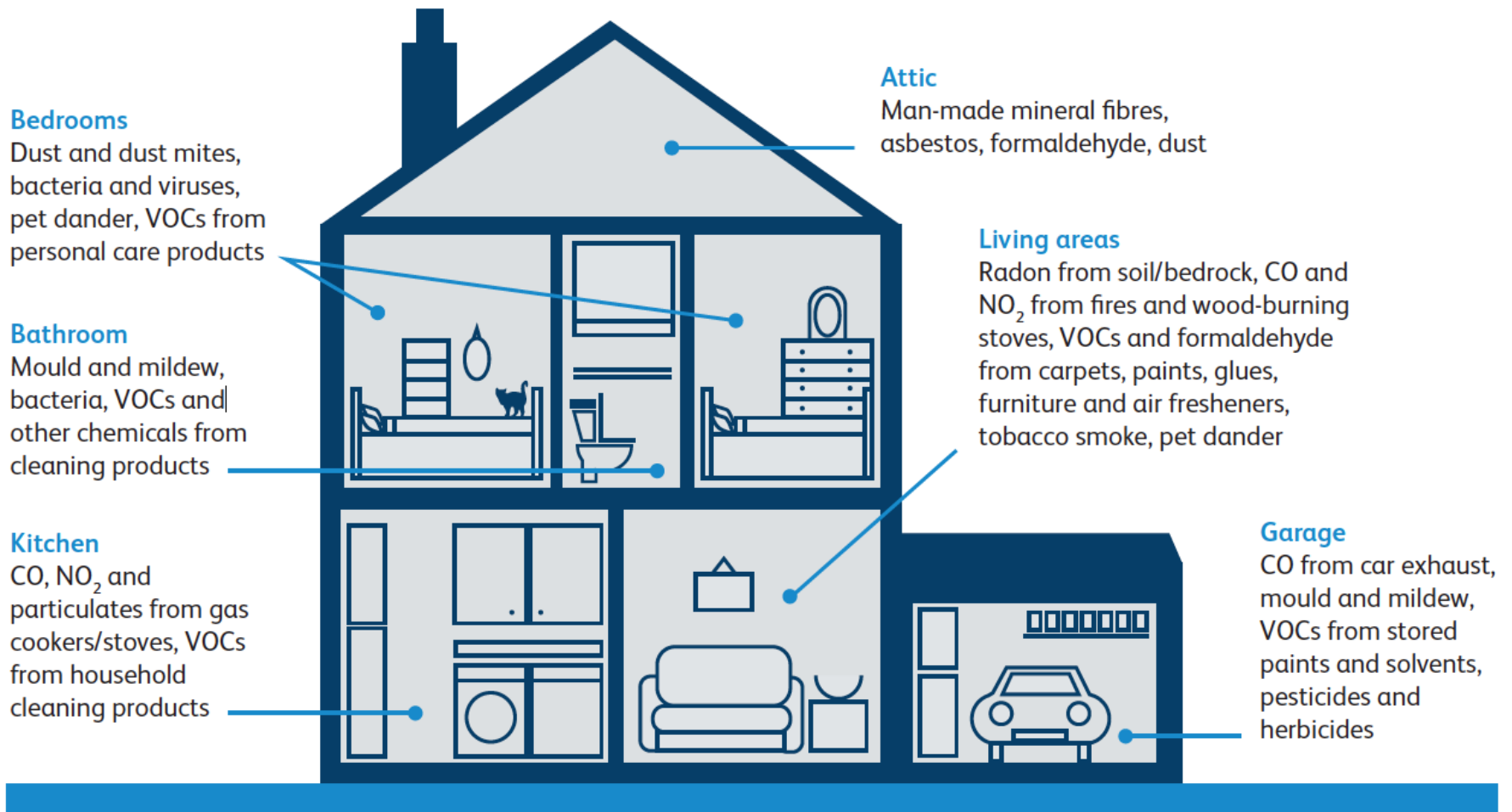
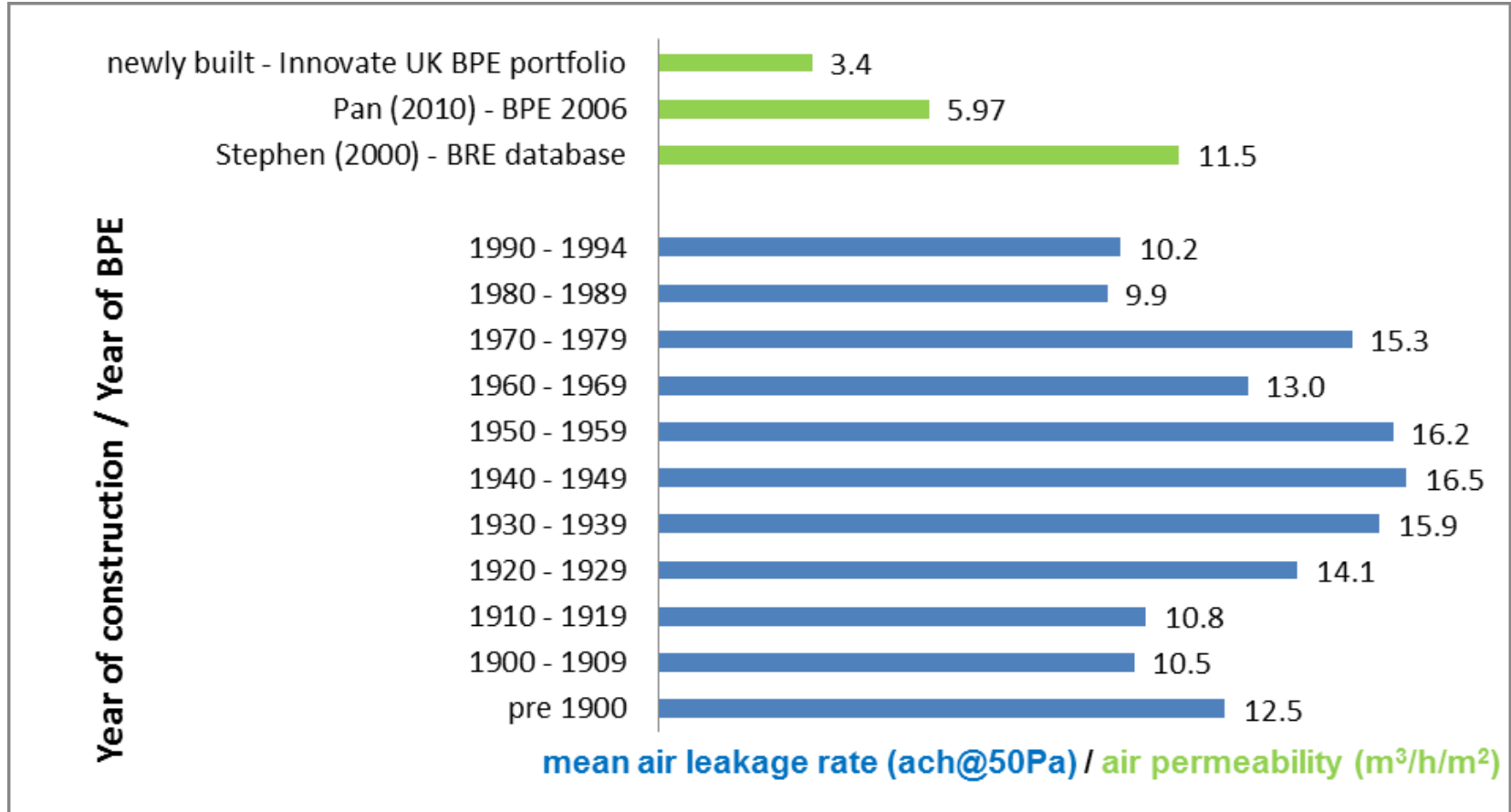


Fig 3. Sources and types of indoor pollution encountered in homes. VOCs = volatile organic compounds. Please note that these lists are not exhaustive and that the actual pollutants present, and their amounts, will vary from household to household.



# UK Homes - Air permeability





# Energy efficiency and unintended consequences

Ventilation strategy	Best practice / Target Air Permeability (m <sup>3</sup> /h/m <sup>2</sup> at 50 Pa)	Best practice / Target Air change rate (ach at 50 Pa)
Trickle Ventilators and/or intermittent extractors	3.0 - 5.0	-
Passive stack	3.0 - 5.0	-
Continuous Mechanical Ventilation	2.0 - 4.0	-
Continuous Mechanical Ventilation – with heat Recovery	1.0 - 2.0	-
Other	Seek Specialist Advice	-
Passivhaus Standard	-	0.6

ATTMA,  
TS1 – 2016

- Large-scale installation of MVHR systems
- Very high degree of airtightness in homes



if the systems are not properly designed, installed, commissioned or used by occupants.



# Unintended consequences

- Indoor Air Quality (IAQ) problems
- Condensation and mould growth
- Building overheating

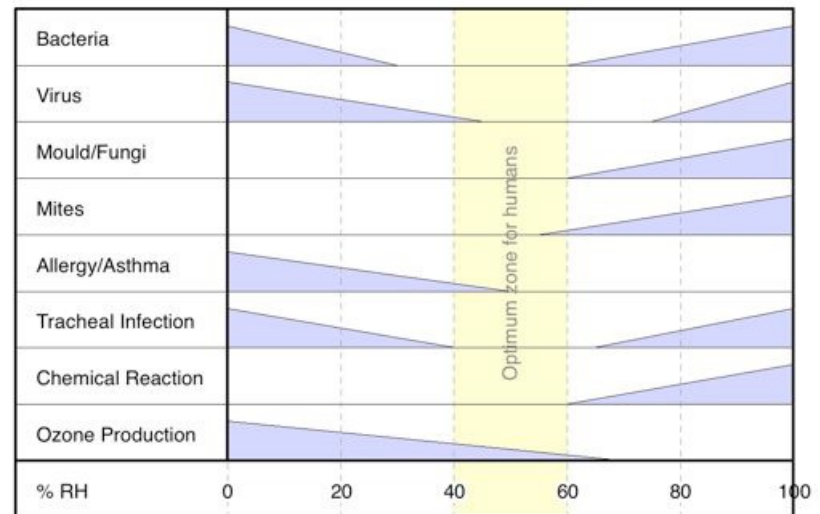


Figure 1: -Arundel, V., et al. Indirect Health Effects of Relative Humidity in Indoor Environments. *Environ Health Perspect.* 1986; 65: 351–361.





# Indoor air quality – Health effects

## Short-term effects

- Irritation of the eyes, nose, and throat, headaches, dizziness, and fatigue (VOCs)
- Cognitive performance, productivity (CO<sub>2</sub>)
- likelihood of effects depends on:
  - age
  - pre-existing medical conditions
  - individual sensitivity
  - repeated exposure or high level exposure





# Indoor air quality – Health effects

## Long-term effects

May show up either years after exposure has occurred or only after long or repeated periods of exposure (traffic related pollutants, radon)

- Respiratory diseases (asthma, chronic obstructive pulmonary disease - COPD)
- Heart disease (cardiovascular disease)
- Cancer (lung cancer)



## HEALTHVENT project

Otto Hänninen and Arja Asikainen (Eds.) (2013).

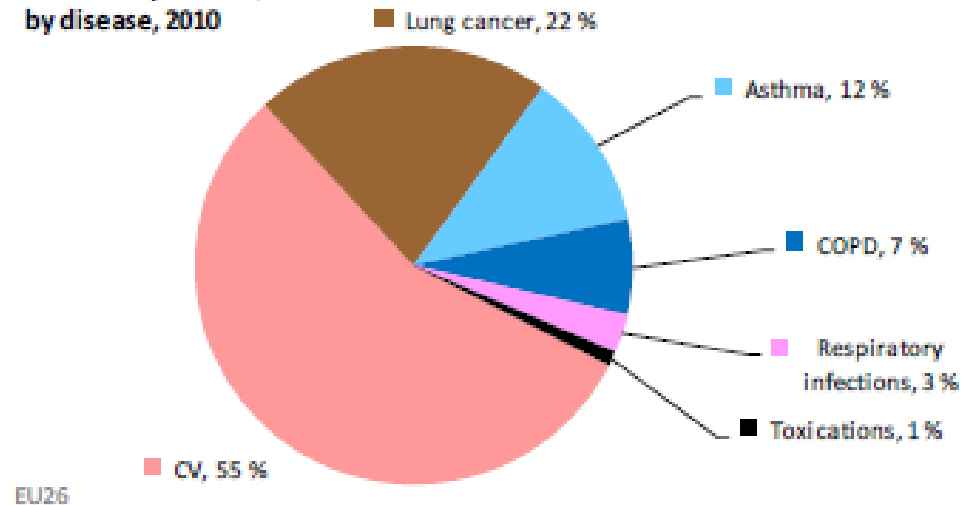
**Efficient reduction of indoor exposures -**

**Health benefits from optimizing ventilation, filtration and indoor source controls.**

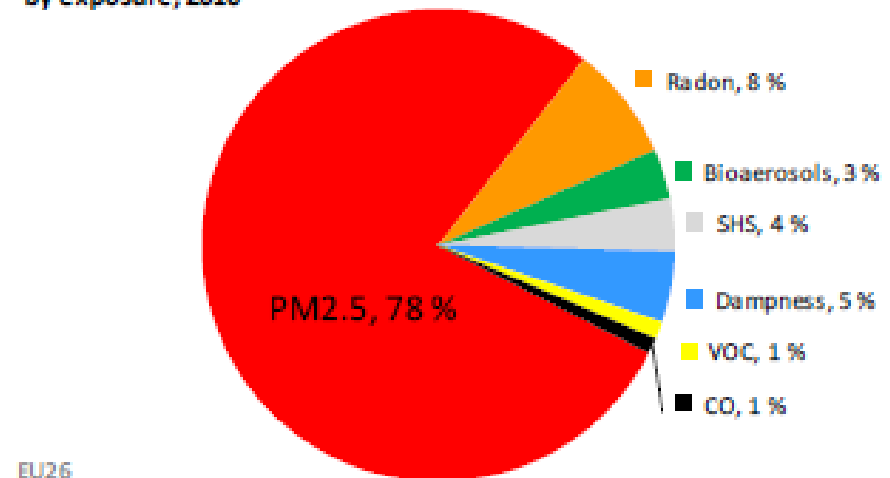
ISBN 978-952-245-821-6

(printed) ISBN 978-952-245-822-3 (online publication)

BOD from poor IAQ by disease, 2010



BOD from poor IAQ by exposure, 2010



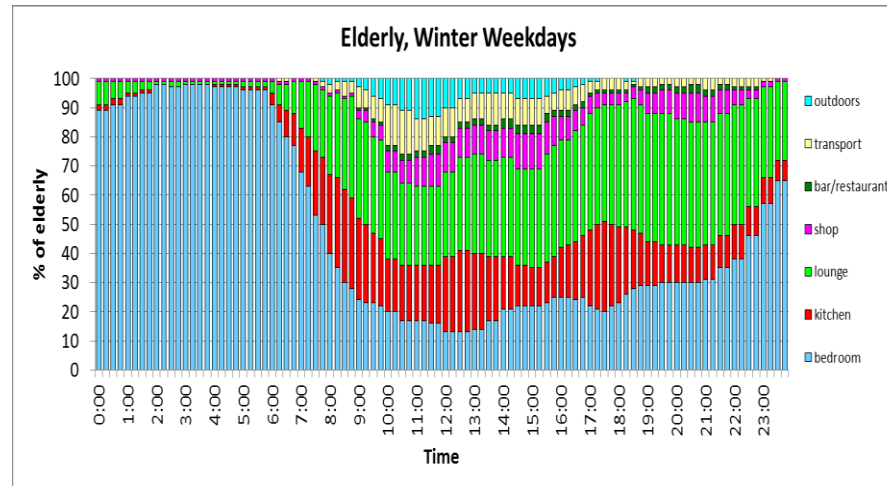
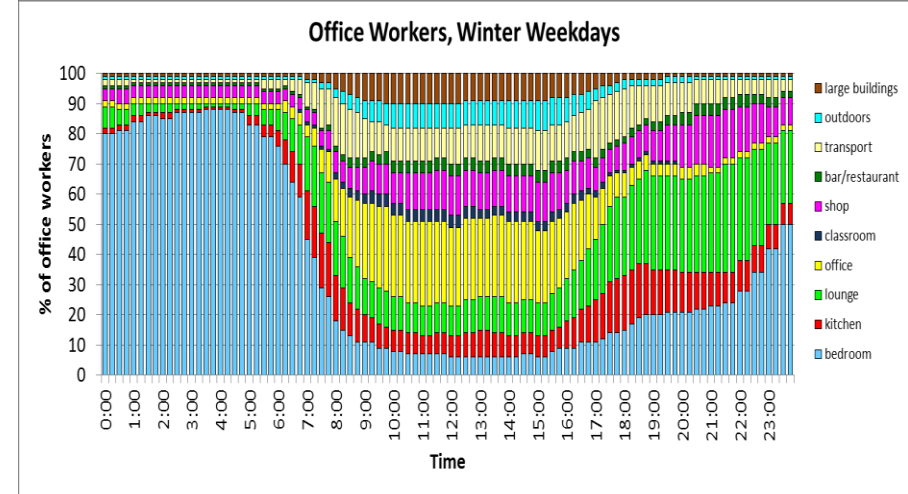
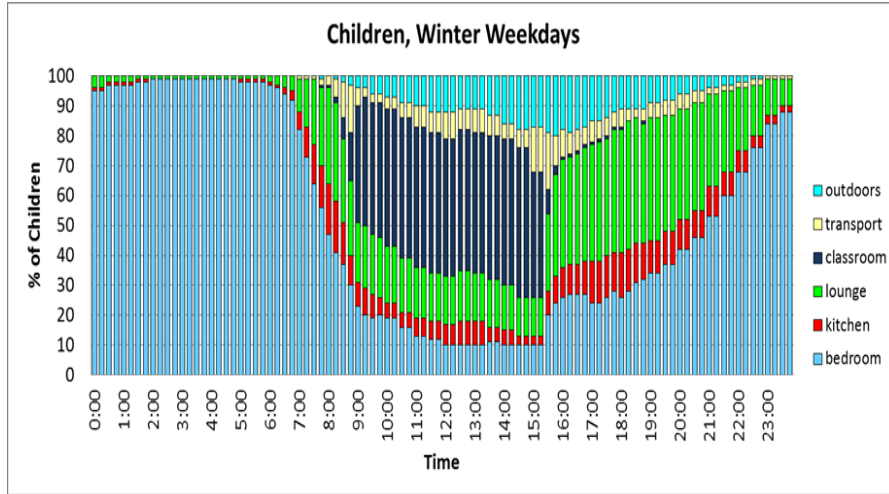


## Exposure and Health

- Real effects of air pollution depend on exposures of individuals not of monitors
- Variations of exposure within a population are large
- Need to consider frequency distributions of exposure within a population
- Most people spend most time indoors
- Need to be able to assess how policy might change local and urban exposure distributions.



# Generic time activity profiles \*\*



\*\* Dimitroulopoulou C, Ashmore MR, Terry A, Hill MTR. Use of Population Exposure Frequency Distributions to simulate effects on policy interventions on NO<sub>2</sub> exposure. *Atmospheric Environment*. 2017; 150: 1-14.



# Modelling personal exposure in the context of local transport policy

*Time spent in indoor and outdoor MEs*

*Indoor exposure*

- Indoor concentrations at home
- Concentrations in non-residential locations
- Concentrations in transport modes

*Outdoor exposure*

- Small scale variation in outdoor concentrations due to proximity to roads

*Link these to time-activity-location profiles for different groups within the population*



# Our probabilistic exposure modelling framework - Population Exposure Frequency Distribution (PEFD)

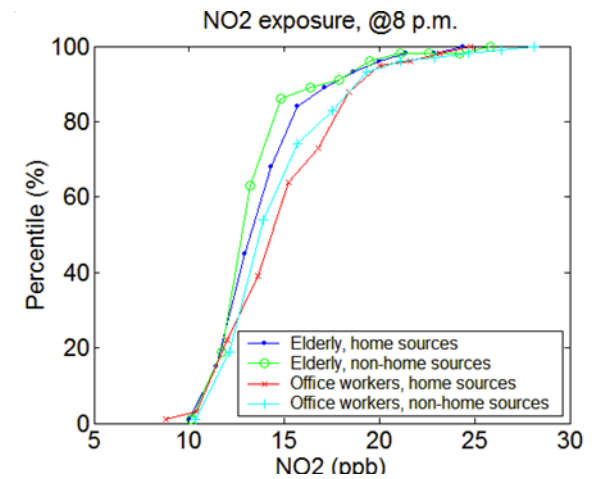
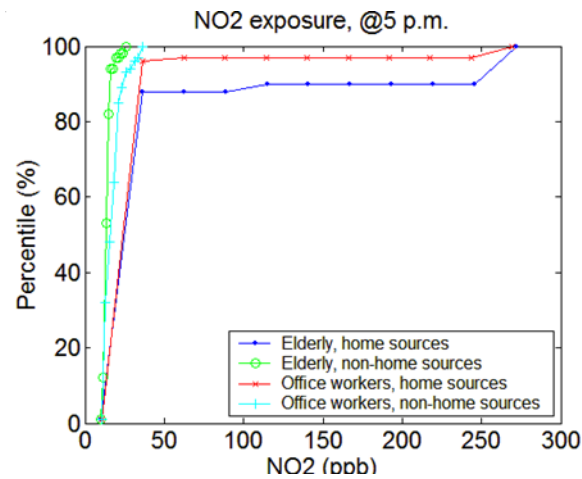
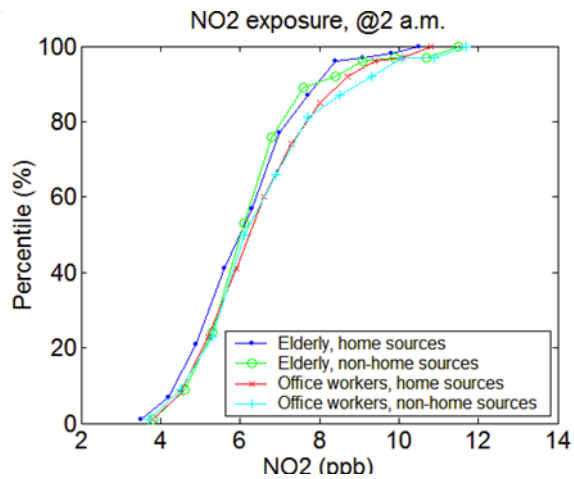
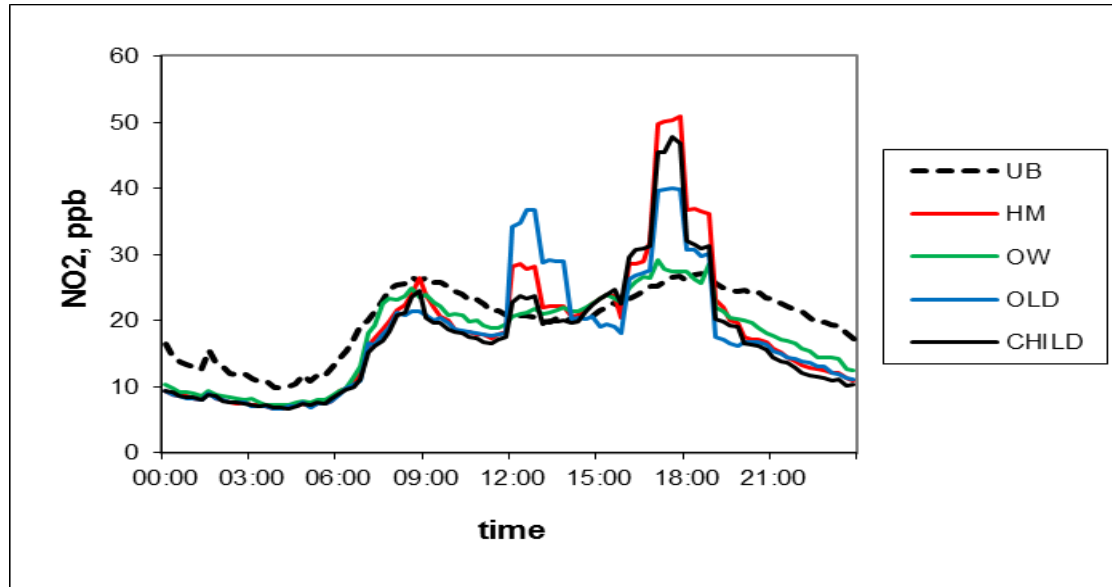
(Dimitroulopoulou et al., 2017)

- **INDAIR** - simulates diurnal profiles of frequency distributions of air pollutant concentrations
  - different micro-environments (MEs)
  - function of outdoor concentrations, indoor sources, pollutant and building characteristics
- **EXPAIR** - simulates PEFDs based on time-activity patterns and probabilistic ME concentration profiles from INDAIR
- Simultaneous **CO**, **NO<sub>2</sub>**, **PM<sub>2.5</sub>**, **PM<sub>10</sub>**



# Results from EXPAIR

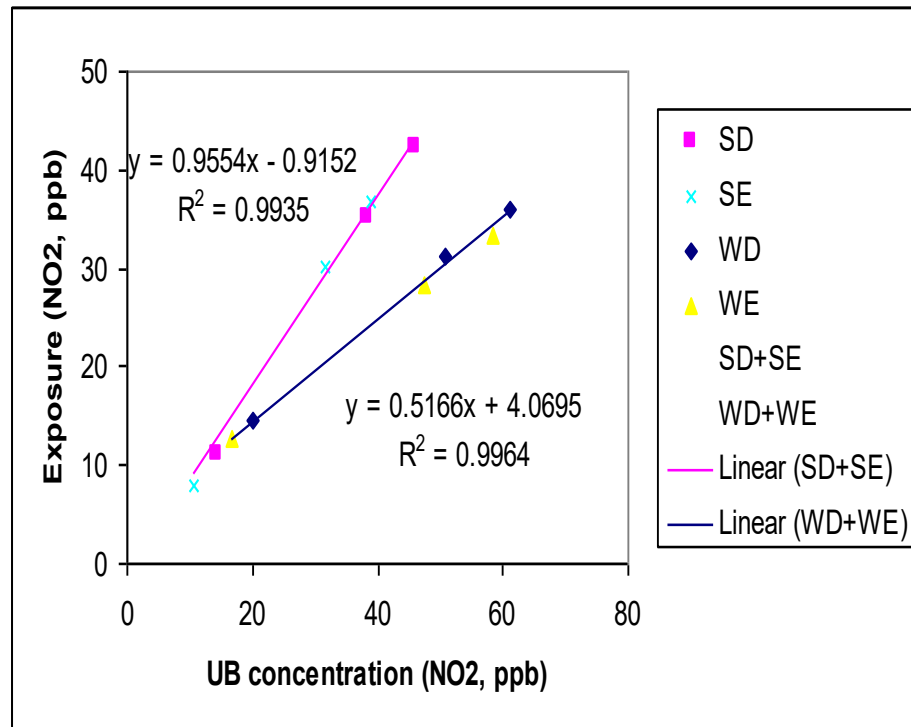
(Dimitroulopoulou et al., 2017)







# Empirical relationships between urban background and mean PEFD: Leicester / NO<sub>2</sub> / elderly



- the two lines represent seasonal differences
- mainly due to air exchange rate, not time-activity patterns



## Cross-government / Organisations / Stakeholders

- Cross Government Group On Gas Safety And Carbon Monoxide Awareness / All Fuels Action Forum
- Department for Education – BB101 Guidance on ventilation, thermal comfort and indoor air quality in schools
- NICE guidance on indoor air quality at home - PHETA
- CIBSE TM40: Health Issues in Building Services
- RCP and RCPCH Systematic Review: “Effects of Indoor Air Quality on Children and Young People’s Health”.
- PhD projects (co-funded PHE and UCL LoLo CDT)

PhD project 1 (2017-2021): “Quantifying the benefits of measures to reduce exposure of deprived communities to indoor and outdoor sources of air pollutants”.

PhD project 2 (2018-2022): “Ventilation practices in new homes in relation to air quality, noise and overheating risk, and their impact on health”



Public Health  
England

**Let's work together**



**To reduce exposure to indoor and outdoor air pollution**

***Thank you!***

**[www.gov.uk/phe](http://www.gov.uk/phe)**

**[Sani.Dimitroulopoulou@phe.gov.uk](mailto:Sani.Dimitroulopoulou@phe.gov.uk)**