

Air quality at the interface: Between the ambient and indoor environment

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Indoor environmental quality: why should we care?

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We breathe a lot of indoor air.

Air quality is indoor as well as ambient

Buildings matter

1: We breathe a lot of indoor air.

What do we know?

We spend about 65-75% of time in our homes and
about 80-90% of our time indoors

Indoor occupancy varies with point in life course and
occupation.

1: We breathe a lot of indoor air.

How do we know?

1: We breathe a lot of indoor air.

How do we know?



2018 update on earlier work by Denman et al. 2000)

Denman A R, Gulliver J, Kennedy C A, Briggs D and Phillips PS (2000). The Impact of Occupancy Patterns on the Assessment of the Value of Domestic Radon Remediation Programmes in the UK. Proceedings of the 10th International Congress of the International Radiation Protection Association, May 14-19, 2000, Hiroshima.

Journal of Exposure Analysis and Environmental Epidemiology (2001) 11, 231–252

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www.nature.com/jea

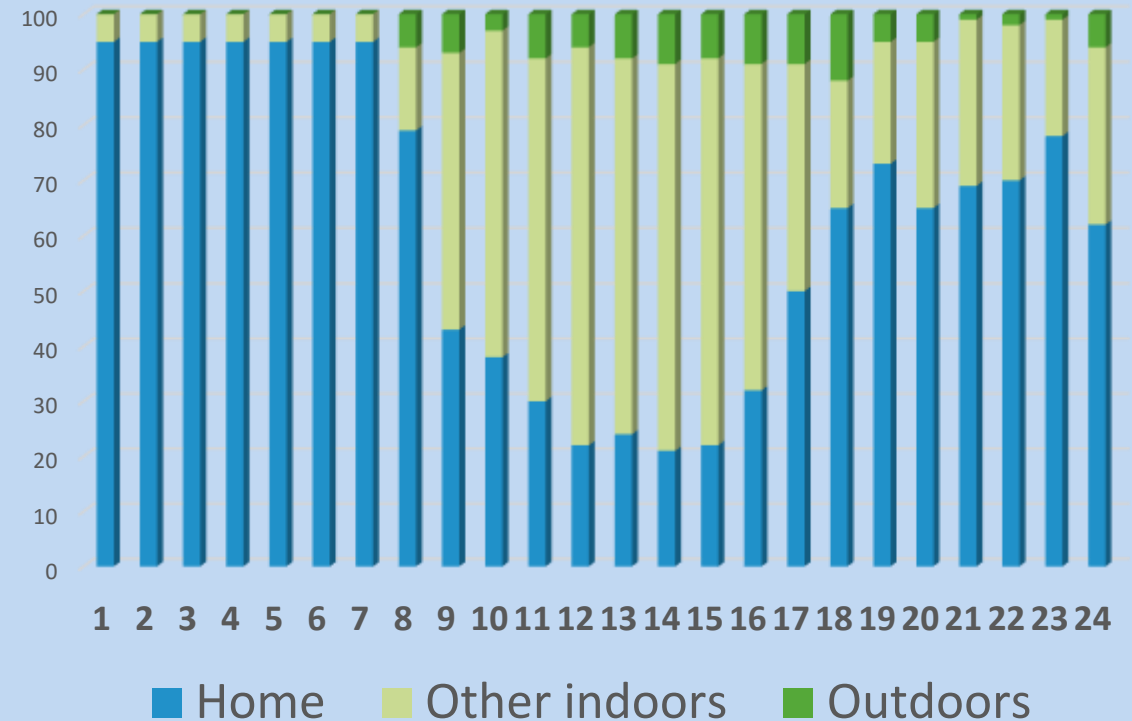
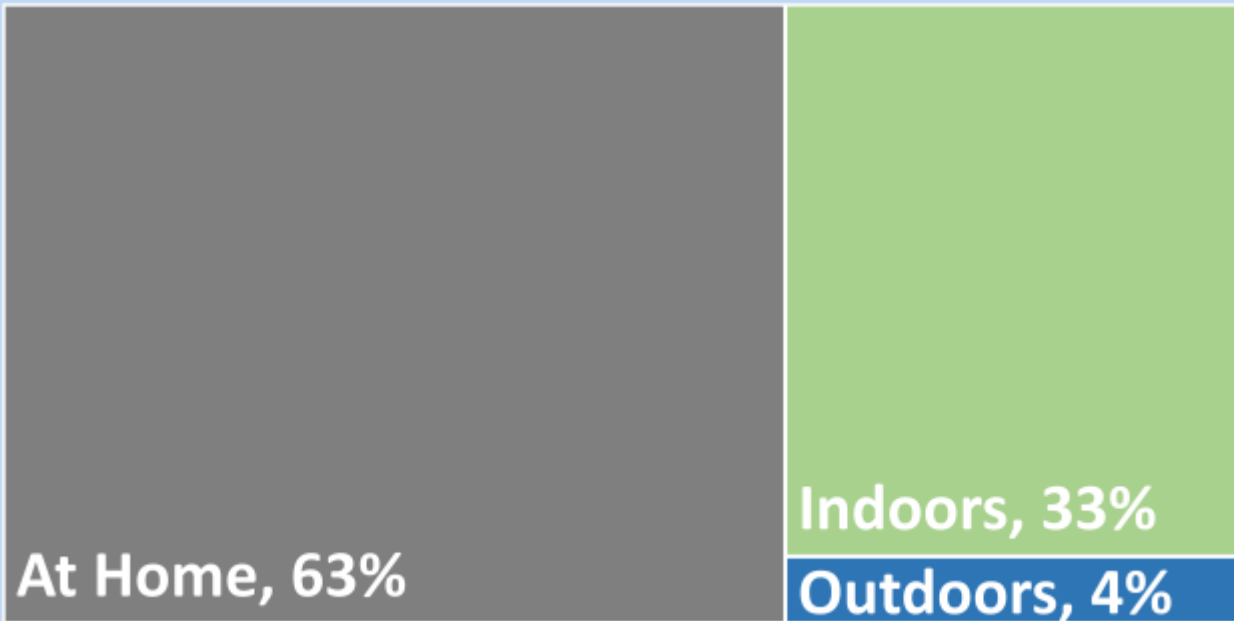
The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants

NEIL E. KLEPEIS,^{a,b} WILLIAM C. NELSON,^c WAYNE R. OTT,^d JOHN P. ROBINSON,^e ANDY M. TSANG,^f PAUL SWITZER,^d JOSEPH V. BEHAR,^g STEPHEN C. HERN^g AND WILLIAM H. ENGELMANN^g

Comprehensive survey in USA in 2001

Home occupancy levels for managing Radon exposure risks

1: We breathe a lot of indoor air.



College students in Northampton

What do we know?

Denman, A. R., Gulliver, J., Kennedy, C. A., Briggs, D., & Phillips, P. S. (2000, May). The impact of occupancy patterns on the assessment of the value of domestic radon remediation programmes in the UK. In *Proceedings of the 10th international congress of the international radiation protection association* (pp. 166-167).

1: We breathe a lot of indoor air.

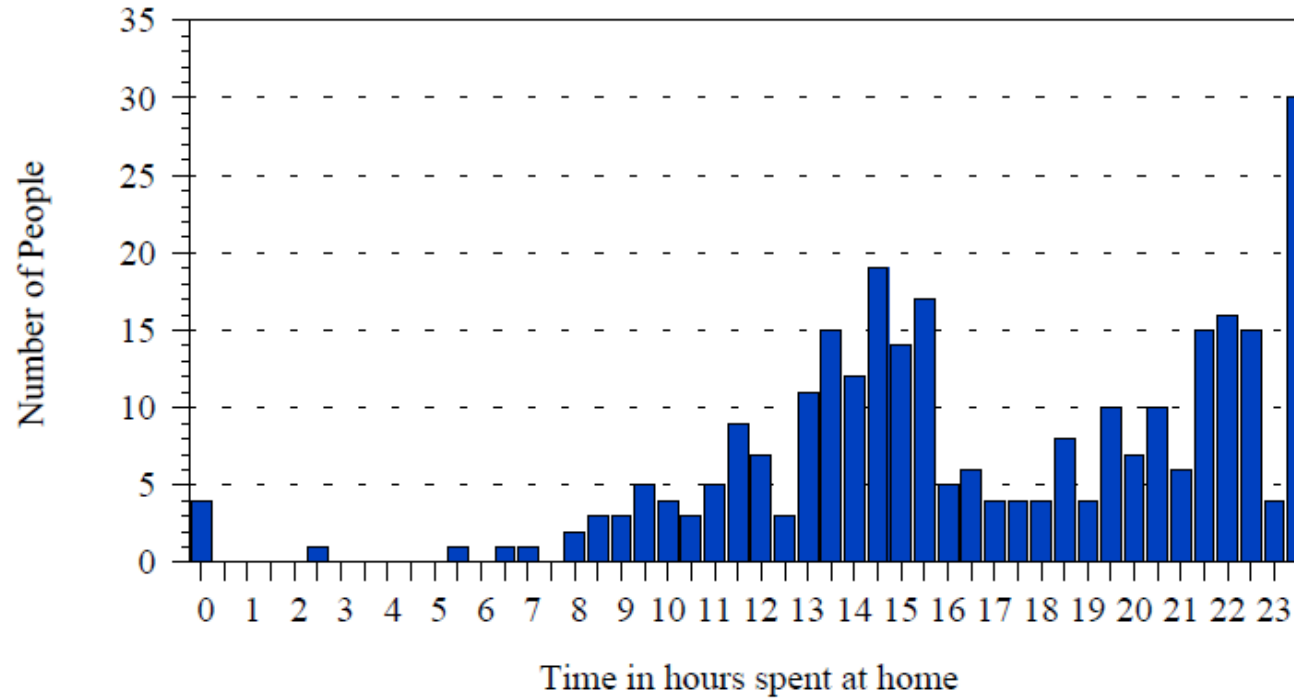


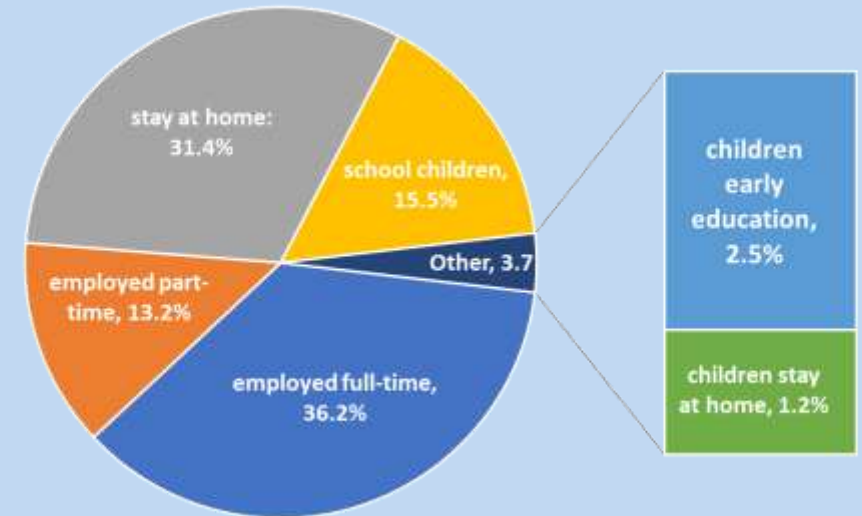
Figure 1 - Hours per day spent at home - Adults in Northampton

What do we know?

Denman, A. R., Gulliver, J., Kennedy, C. A., Briggs, D., & Phillips, P. S. (2000, May). The impact of occupancy patterns on the assessment of the value of domestic radon remediation programmes in the UK. In *Proceedings of the 10th international congress of the international radiation protection association* (pp. 166-167).

1: We breathe indoor air a lot.

Life stage and occupation
determines what type of air
you breath



We spend about 65-75% of time in our homes and about 80-90% of our time indoors

Indoor occupancy varies with point in life course and occupation.

Sources
(indoor,
outdoor)



Pathway
(indoor air)

Receptor (i.e. us)

Air quality is indoor as well as ambient



Domestic indoor sources:

PM: cooking, oxidation of VOCs, smoking, mould spores

VOCs: personal care products, cleaning, scents, and air fresheners, cooking, bioeffluents, solvent use, materials

NOx: combustion for space heating, cooking and hot water

Ambient sources: (we all know these!)

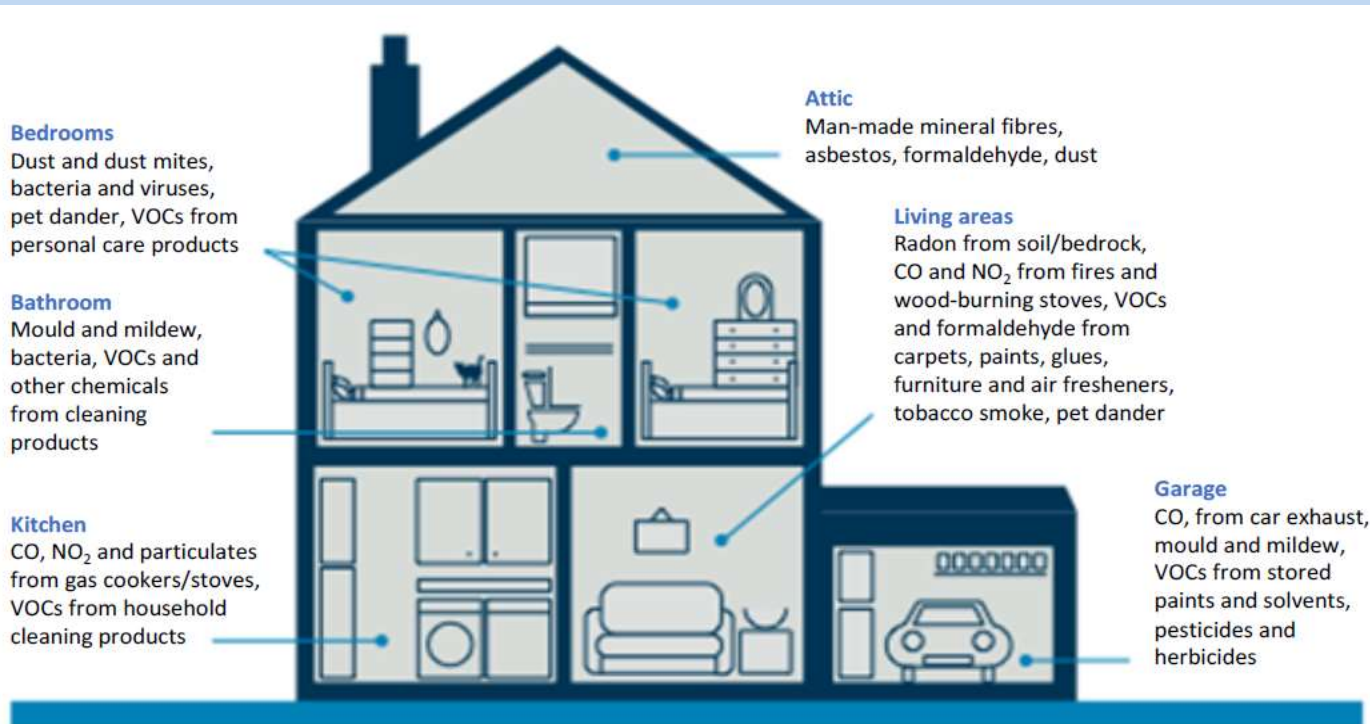
PM: secondary aerosol, combustion, transport, industry, agriculture

VOCs: industry, transport

NOx: combustion



Air quality is indoor as well as ambient



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.

The interaction of the “ingredients of indoor air is not well studied, especially in realistic environments.

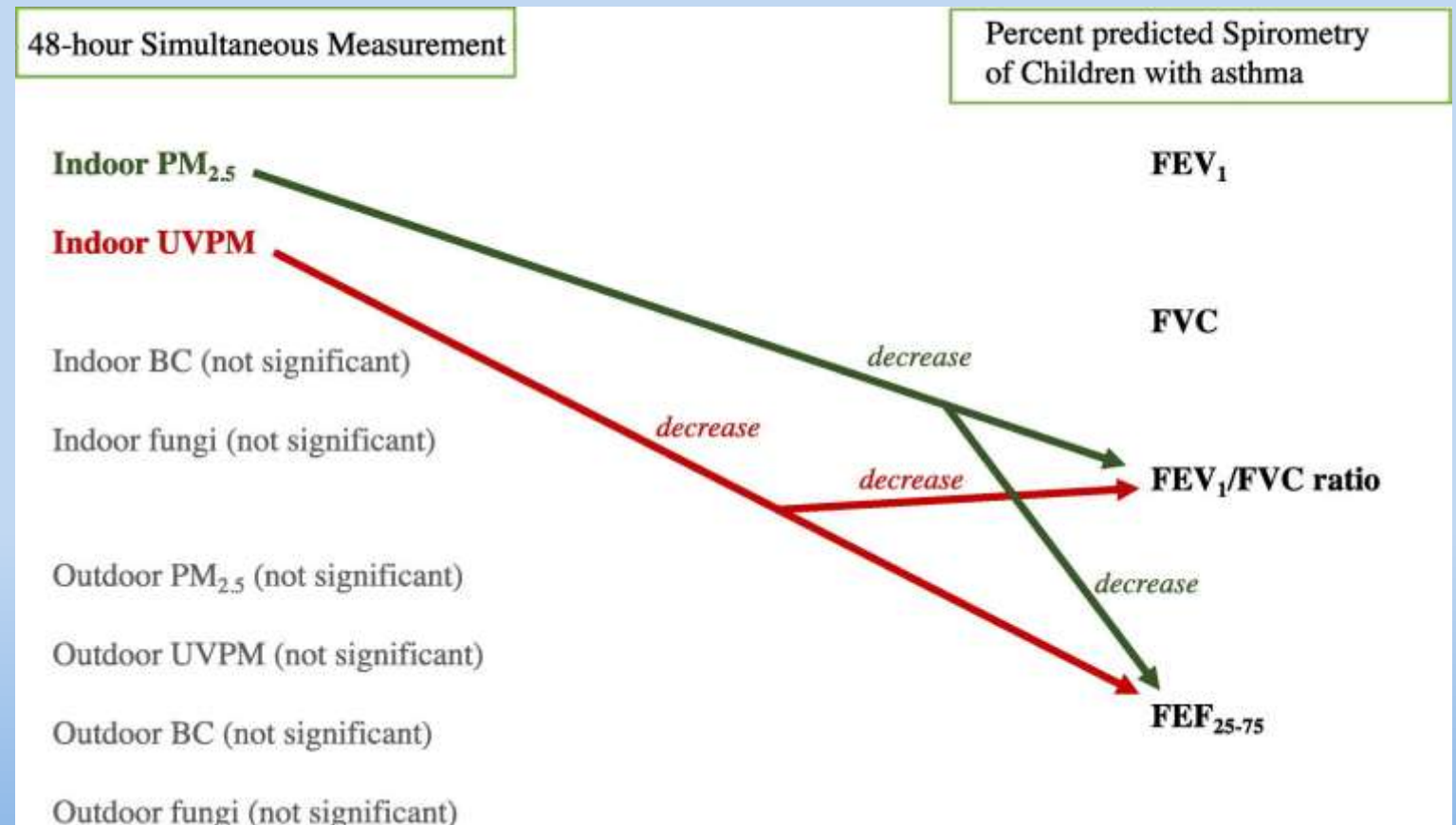
Air quality is indoor as well as ambient

Domestic exposure to PM is a significant proportion of exposure for certain people.

E.g. Work by Isiugo and others in 2019

Reduction in lung function in children associated with indoor not outdoor PM

<https://doi.org/10.1016/j.scitotenv.2019.01.309>



Air quality is *indoor* as well as ambient

Domestic exposure to NO_x is correlated with use of gas for cooking and heating.

AND

Ambient NO_x is a significant factor in indoor NO_x concentrations

Air quality is indoor as well as ambient

For example:

Pollutant Exposures from Natural Gas Cooking Burners: A Simulation-Based Assessment for Southern California

Jennifer M. Logue,^{1,2} Neil E. Klepeis,^{3,4} Agnes B. Lobscheid,¹ and Brett C. Singer^{1,2}

Environmental Health Perspectives

<https://doi.org/10.1289/ehp.1306673>

Review article

Human exposure to NO₂ in school and office indoor environments

Heidi Salonen^{a,b,*,1}, Tunga Salthammer^{b,c,*,1}, Lidia Morawska^b

^a Aalto University, Department of Civil Engineering, PO Box 12100, FI-00076 Aalto, Finland

^b Queensland University of Technology, International Laboratory for Air Quality and Health, 2 George Street, Brisbane Q 4001, Australia

^c Fraunhofer WKI, Department of Material Analysis and Indoor Chemistry, 38108 Braunschweig, Germany

Environment International 2018

<https://doi.org/10.1016/j.envint.2019.05.081>

24-Hour Nitrogen Dioxide Concentration is Associated with Cooking Behaviors and an Increase in Rescue Medication Use in Children with Asthma

Laura M Paulin^a, D'Ann L Williams^b, Roger Peng^c, Gregory B Diette^a, Meredith C McCormack^a, Patrick Breyse^d, and Nadia N Hansel^a

In general indoor NO₂ is approximately half the ambient concentration, unless there is indoor source, e.g. gas central heating or cooking.

In the presence of gas for cooking is associated with significant increases of NO₂ indoors leading to indoor/outdoor ratios of one-to-two compared with 0.5 for building without indoor sources.

Air quality is *indoor* as well as ambient

Domestic exposure to PM is a significant proportion of exposure for certain people.

Domestic exposure to NO_x is correlated strongly with use of gas for cooking and heating.

Ambient NO_x is a significant factor in indoor NO_x concentrations

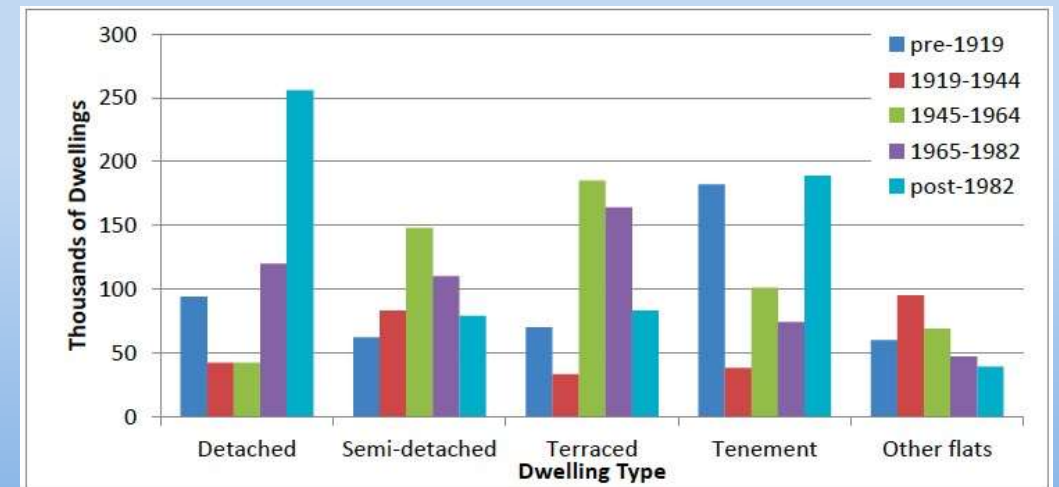
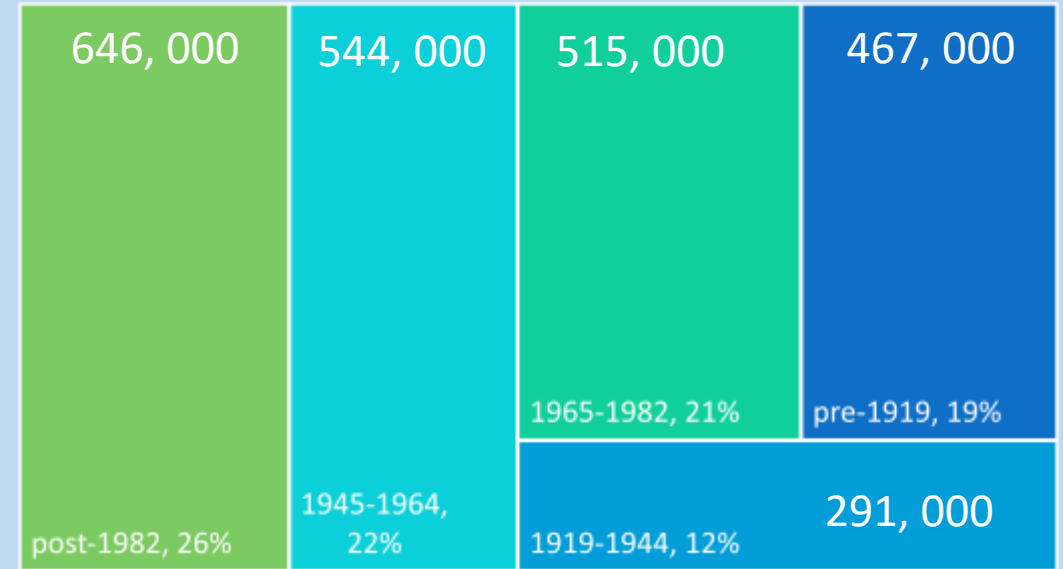
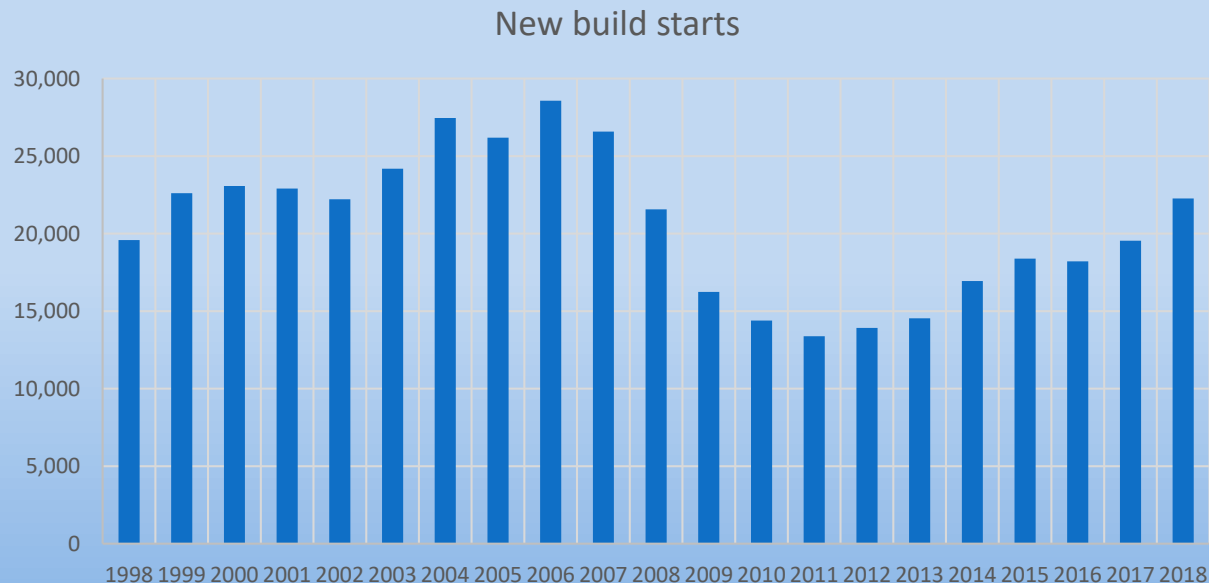
VOC concentration can be an order of magnitude higher indoors v. ambient.

Issues such as damp, moulds, carbon monoxide, and radon are still serious issues needing management

Buildings matter

Retrofit needed to achieve carbon targets.

Scottish housing stock age
(Scottish housing stock condition survey 2017)



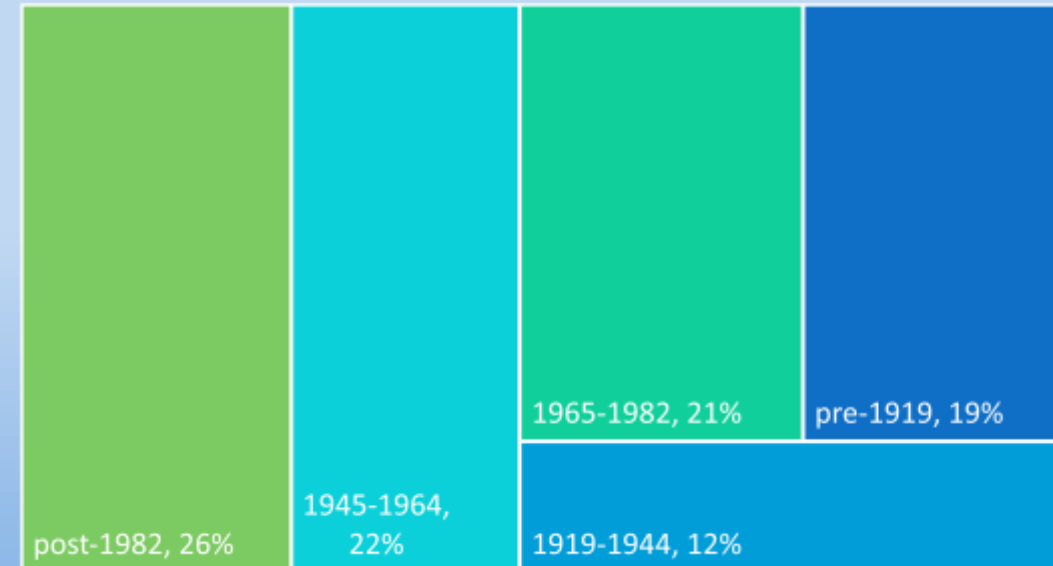
Buildings matter

Ventilation rate strongly controls indoor environmental performance.

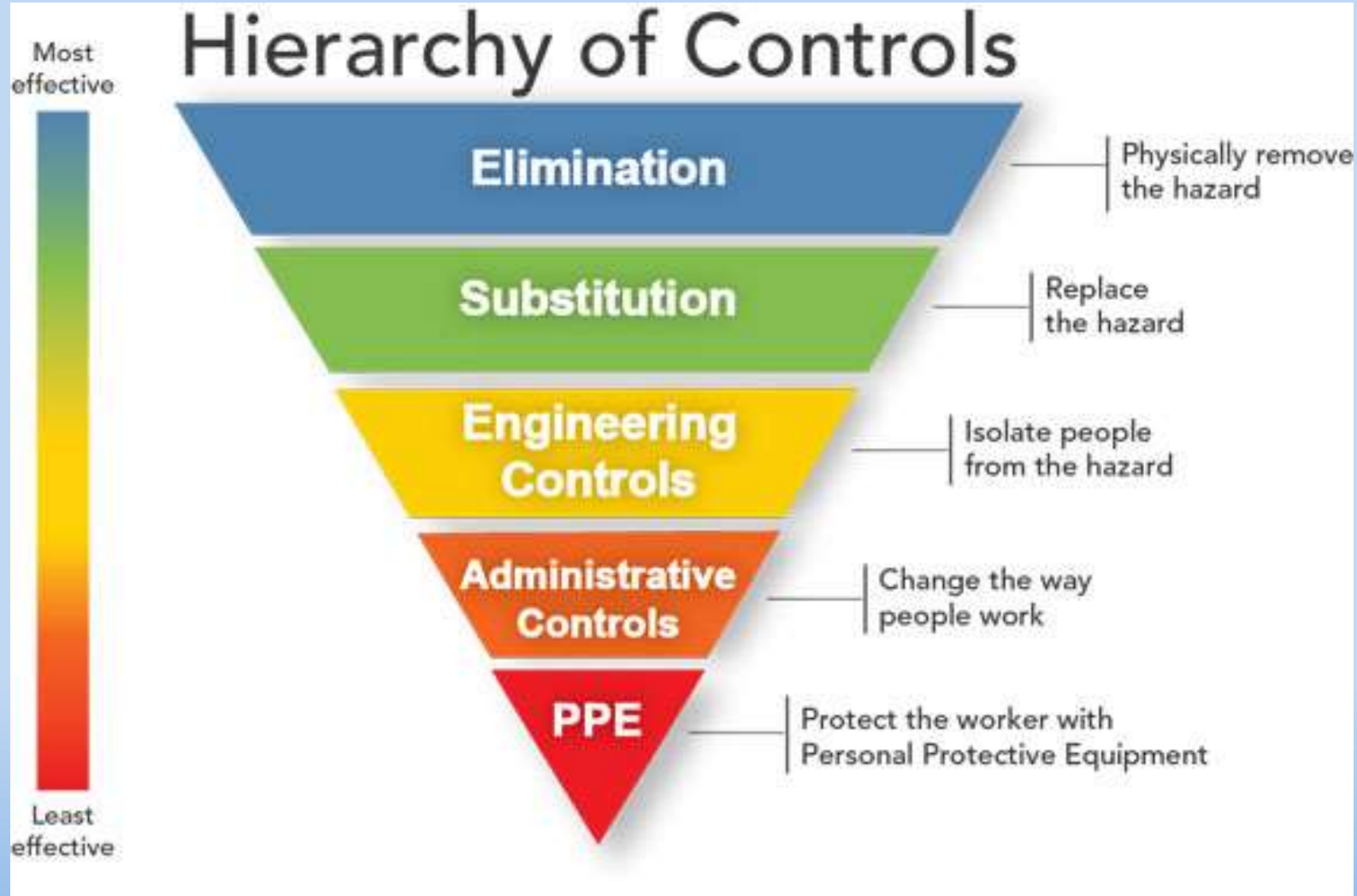
Increasing building tightness will lead to deterioration of the indoor environment unless mechanical means of ventilation are installed.

Mechanical ventilation systems are often badly installed or incorrectly used.

Occupant behaviour varies widely.



Buildings *matter*



Buildings *matter*

Eliminate/substitute sources of emissions:

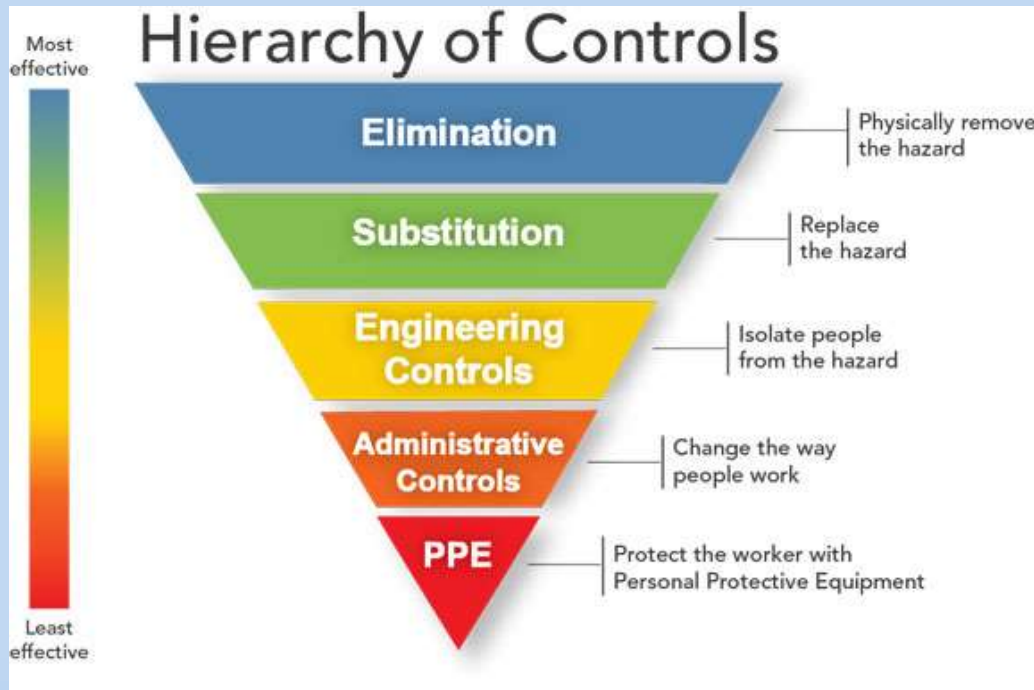
Natural gas to electric/heat pumps.

(hydrogen...more NO_x?)

Low VOC products, reduce use of air fresheners, low-VOC cleaning products.

Engineering: Fit correctly and maintain MVHR, dMEV, well-design cooker ventilation systems. Separate kitchens from living areas.

Legislation and checks on retrofit, new home, schools, public building placement.



The indoor environment is an important contributor to human exposure to airborne pollutants.

Intensity of indoor sources of pollution will change as we begin moving toward efficient new-build, retro-fit, fuel-use change, mechanical ventilation.

Addressing harms ***must*** involve:

buildings engineering/architects, planning and home building (volume home builders, institutional landlords, planners, regulators and en, environmental scientists

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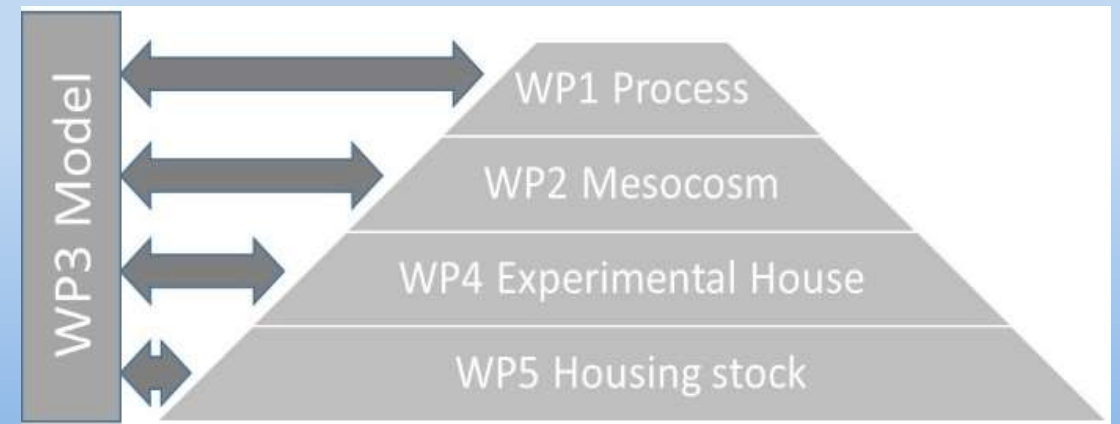
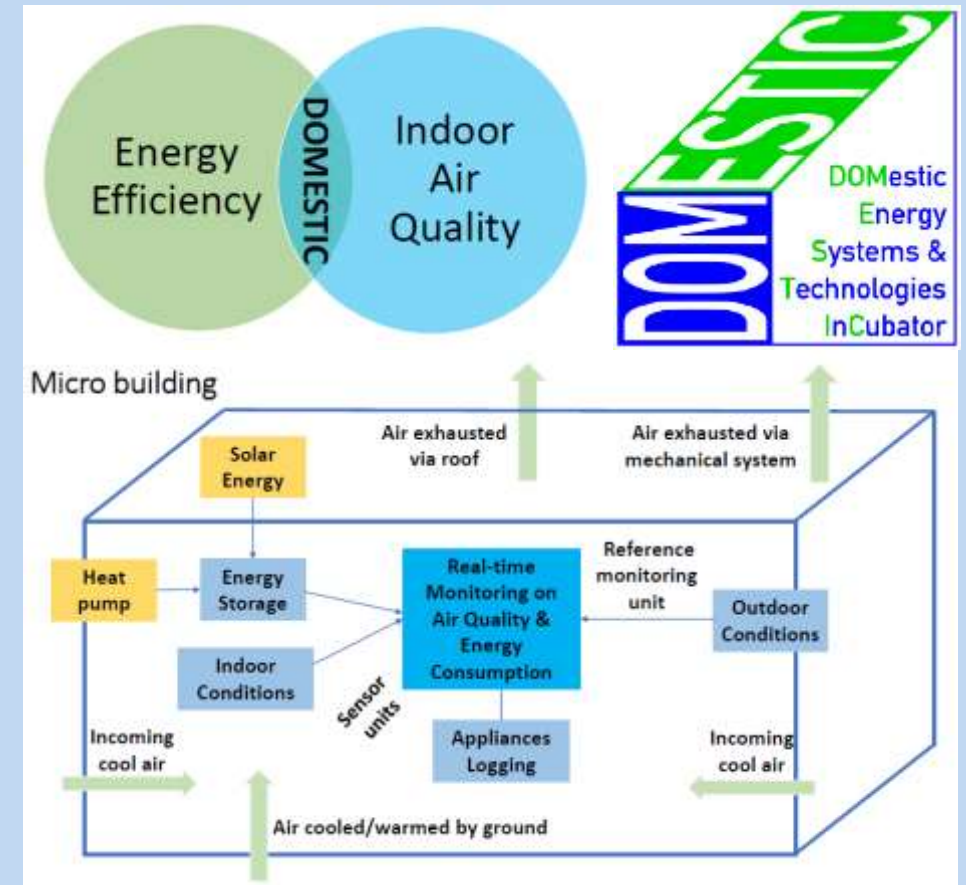
Current work at Chester

DOMESTIC Facility (2019 – current)

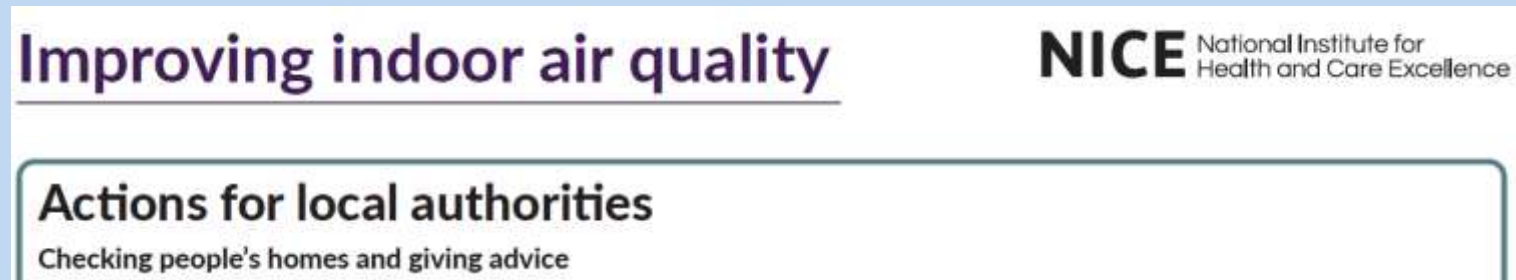
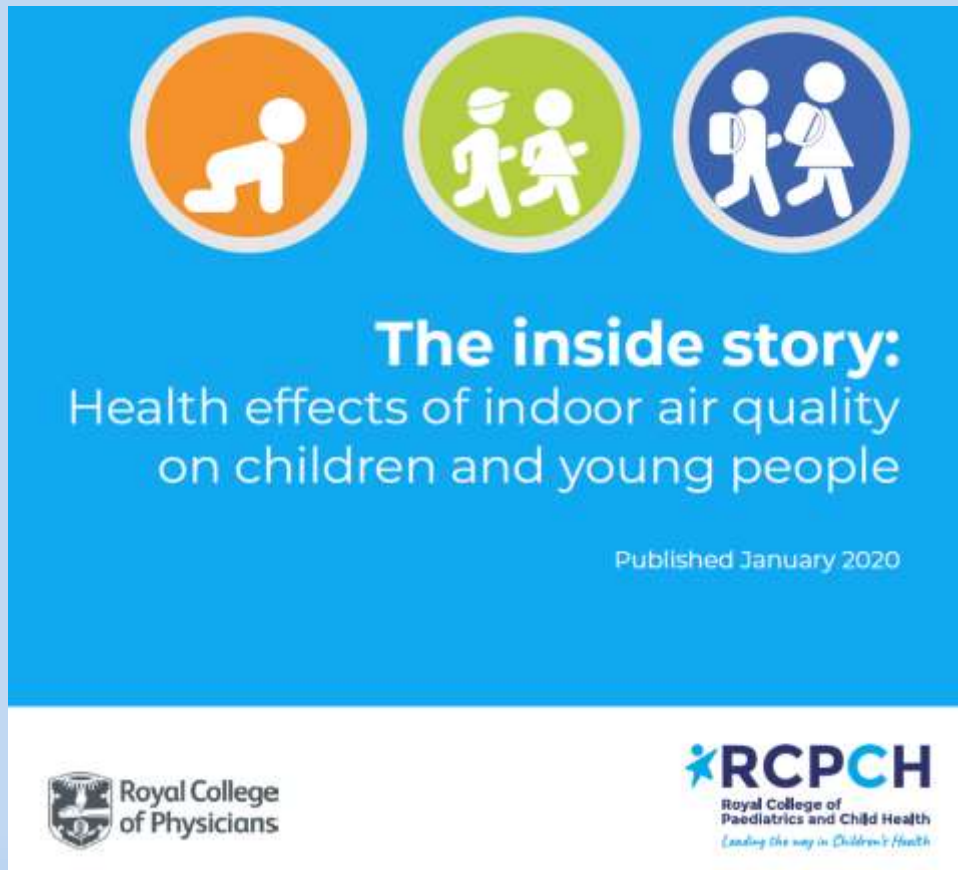
A micro-building for studying the effects of indoor activity and building technology on energy efficiency and indoor environment and developing technology for managing indoor environments.

EPSRC-funded Impacts of Cooking and Cleaning on indoor air: Healthy buildings for the future. (2020-2022)

£1.1M project lead by Prof. Nic Carslaw at University of York with Nottingham (Ben Jones) and Chester (Gavin Phillips)



Recommended reading



NICE Guidance on Indoor Air Quality at Home

<https://www.nice.org.uk/guidance/ng149>

Inside Story: Health effects of indoor air quality on children and young people

<https://www.rcpch.ac.uk/resources/inside-story-health-effects-indoor-air-quality-children-young-people>