

# ASBP HEALTHY BUILDINGS TUTORIAL

## *INDOOR AIR QUALITY AND HEALTH IN*



**The inside story:**  
Health effects of indoor air quality  
on children and young people



**Indoor Air Quality**  
WORKING PARTY



Royal College  
of Physicians **RCPC**H

# Dr Marcella Ucci



- **Associate Professor in Environmental and Healthy Buildings at University College London**
- **Founder of the MSc Health, Wellbeing and Sustainable Buildings at UCL**
- **Secretary of the UK Indoor Environments Group (UKIEG)**
- **Member of the RCPCH/RCP's Workforce Group**

# The IAQ Working Group



1. **Stephen Holgate\*** - Co-Chair – MRC Clinical Professor, University of Southampton and UKRI Clean Air Champion.
2. **Jonathan Grigg** - Co-Chair - Prof of Paediatric Respir. and Environ. Med., QMUL.
3. **Marcella Ucci** - Assoc Prof, Environmental and Healthy Buildings, UCL.
4. **Benjamin Jones** - Assist Prof, Architecture and Built Environ., University of Nottingham
5. **Paul Cullinan** - Prof of Occupational and Environmental Respiratory Disease, IC.
6. **Anne Greenough** - Prof of Neonatology and Clinical Respiratory Physiology, KCL.
7. **Briony Turner** - Climate Services Development Manager for the Space4Climate group.
8. **Hasan Arshad** - Prof of allergy and clinical Immunol, University of Southampton.
9. **Alan Short** - Prof of Architecture, University of Cambridge.
10. **Sotiris Vardoulakis** - Prof of Global Environmental Health, Austr Natl Univ, Canberra.
11. **Tim Sharpe** - Prof of Environmental Architecture, Glasgow School of Art.
12. **Mike Holland** - freelance consultant at Ecometrics Research and Consulting, Reading.
13. **Nicola Carslaw** - Prof in Air Pollution, Environment and Geography, University of York,
14. **Sani Dimitroulopoulou** - Principal Environ Publ. Health Scientist, Indoor Environments, PHE.
15. **Paul Linden** - Professor of Fluid Mechanics, Dept of Applied Mathematics and Theoretical Physics, University of Cambridge.

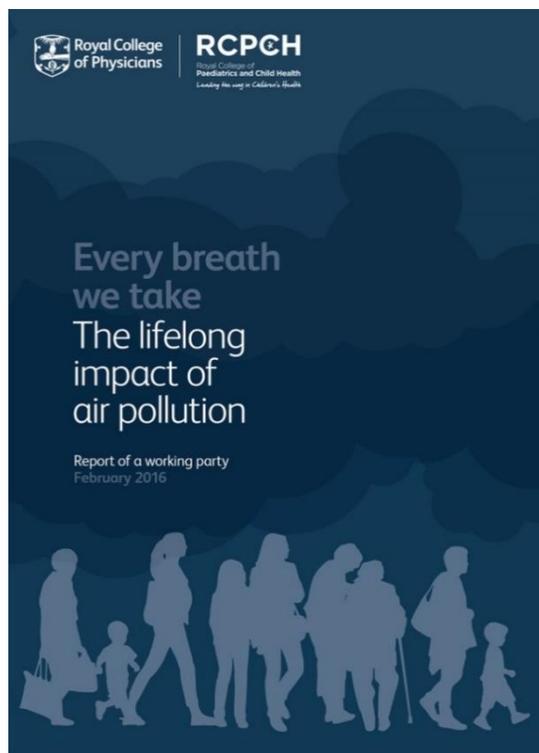
\*Slides from Prof Holgate gratefully acknowledged

# Air Pollution: the Public Health Problem of Our Time

February 23<sup>rd</sup> 2016



The report starkly set out the dangerous impact air pollution is currently having on our nation's health



- **Outdoor air pollution (PM and NO<sub>2</sub>) estimated to bring forward around 40,000 (COMEAP 36,000) deaths per year**
- **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 and dementia**



# Common Indoor Air Problems



Moisture



VOCs and Chemicals



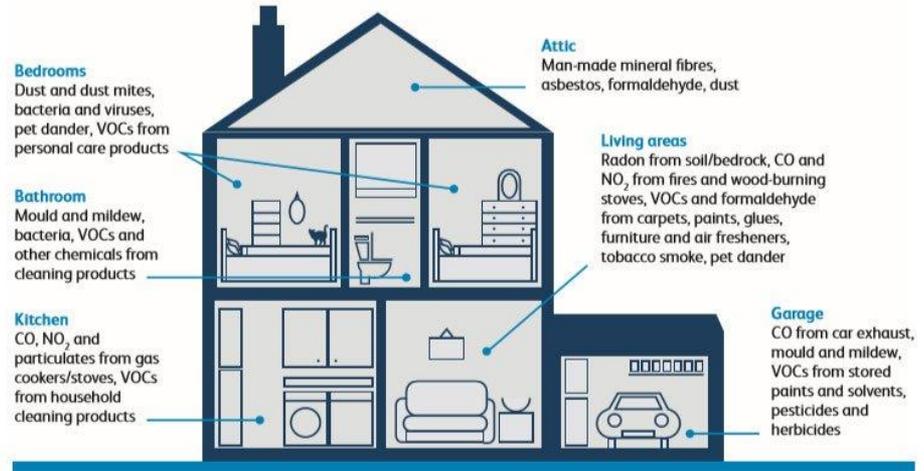
Smoking



Dust



Pet Dander



**Recommendation: Quantify the relationship between indoor air pollution and health.** We must **strengthen our understanding of the relationship between indoor air pollution and health**, including the key risk factors and effects of poor air quality in our homes, schools and workplaces. A coordinated effort among policymaking bodies will be required to develop and apply any necessary policy changes

# Better homes, better air, better health April 2017

ARCC, 2017 Edited by Briony Turner Event report, UKCIP, University of Oxford

**bre**

**Building research establishment**



**arcc**

**Adaptation and Resilience  
in the Context of Change  
network (ARCC)**

The workshop highlighted the need to understand how indoor air pollution exposure impacts on health; to identify ways to reduce indoor air pollution; and to communicate this information clearly to the public.



New Yorker Magazine. 2019. The hidden air pollution in our homes

**“Outdoor air has been regulated for decades, but emissions from daily domestic activities may be more dangerous than anyone imagined”**

**“We must further expand this focus to indoor air. Work to gather evidence of health impacts, raise awareness of any harm and highlight actions to address this is needed”**

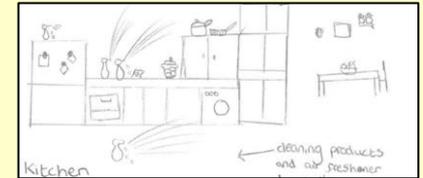
*Former Chief Medical Officer for England, Professor Dame Sally Davies*



Davies S. Chief Medical Officer 9th annual report, 2017: Health impacts of all pollution – what do we know?

# The inside story: health effects of indoor air quality on children and young people

The Royal College of Paediatrics and Child Health (RCPCH) with the Royal College of Physicians (RCP) have collaborated on the indoor air quality project. There were three strands:



## Strand 1: Literature Reviews -

- 1) RCPCH - Stacey H, Grigg J, Holgate ST Effects of Indoor Air Quality on Children and Young People's Health. Arch Dis Child Submitted. A systematic evidence review identified 221 eligible studies of indoor pollution and health effects. 0-18 years.
- 2) KCL - Kelly FJ, Fussell JC. Improving indoor air quality, health and performance within environments where people live, travel, learn and work. Atm Env. 2019; 200: 90-109.
- 3) IOM, Edinburgh - Vardoulakis S. Indoor exposure to selected chemicals on health effects. To be published.

# The inside story: health effects of indoor air quality on children and young people

The Royal College of Paediatrics and Child Health (RCPCH) with the Royal College of Physicians (RCP) have collaborated on the indoor air quality project. There were three strands:

Strand 2: a) **Establish Interdisciplinary Working Group**

b) **Recruit a Technical Advisory Panel**

Dr Blanca Beato-Arribas, Professor Derek Clements-Croome, Dr Andy Dengel, Nigel Gaymond, Professor Paul Harrison, Professor Alastair Lewis, Professor Dejan Mumovic, Professor Malcolm Richardson, Professor Anna Stec, Catherine Sutton, Professor Paul Wilkinson, Tom Wooley.

c) **Call for written evidence** – 18 responses

# The inside story: health effects of indoor air quality on children and young people

The Royal College of Paediatrics and Child Health (RCPCH) with the Royal College of Physicians (RCP) have collaborated on the indoor air quality project. There were three strands:

Strand 3: Engagement with over 200 young people and parents with:

Interviews, discussion groups, art sessions and ‘challenge’ days, led by a young people – produced key themes and recommendations included in the report.



**#TeamCleanAir&Us**



# The inside story: health effects of indoor air quality on children and young people

## Structure of Report:

- 1) Indoor air quality in homes and schools
- 2) Children and young people: Clean air & Us
- 3) Factors affecting indoor air quality
- 4) Health effects for children
- 5) Improving indoor air quality
- 6) Clean air for children: a call to action
- 7) Recommendations

# The importance of the indoors: health impacts



**32,000**  
schools in the UK



**10.3 million**  
pupils in the UK



**3.6 million**  
children living in  
poor quality housing



**68 minutes**  
outdoors per day



## Birth and infancy

- Respiratory problems – rhinitis, wheeze, atopic asthma, respiratory infections
- Low birthweight and pre-term birth



## Pre-school

- Respiratory problems – asthma, allergies, wheeze, risk of respiratory diseases and pneumonia
- Eczema and atopic dermatitis
- Greater hyperactivity, impulsivity and inattention



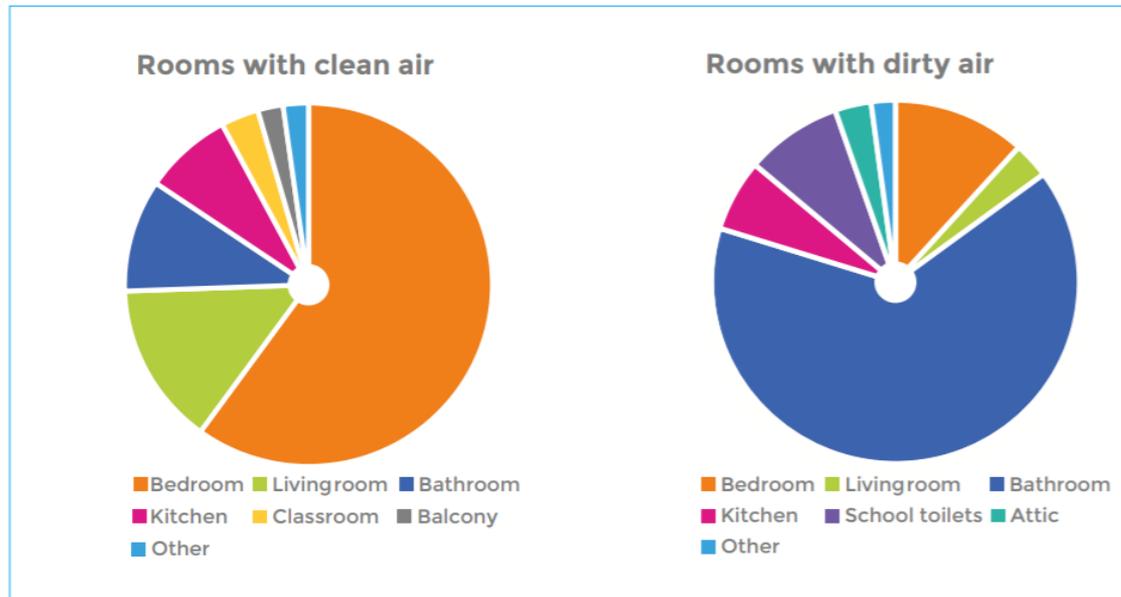
## School age

- Respiratory problems – asthma, wheeze, rhinitis, throat irritation, nasal congestion, dry cough
- Eczema, dermatitis, conjunctivitis, skin and eye irritation
- Reduced cognitive performance, difficulty sleeping

# Some highlights from the children and young people's group

*“Is indoor air pollution farts?” – Maya (9)*

Figure 4: Rooms identified by children as having clean and unclean air.



Source: Analysis of 94 drawings by children aged 5-11 years

## Things that make the air dirty

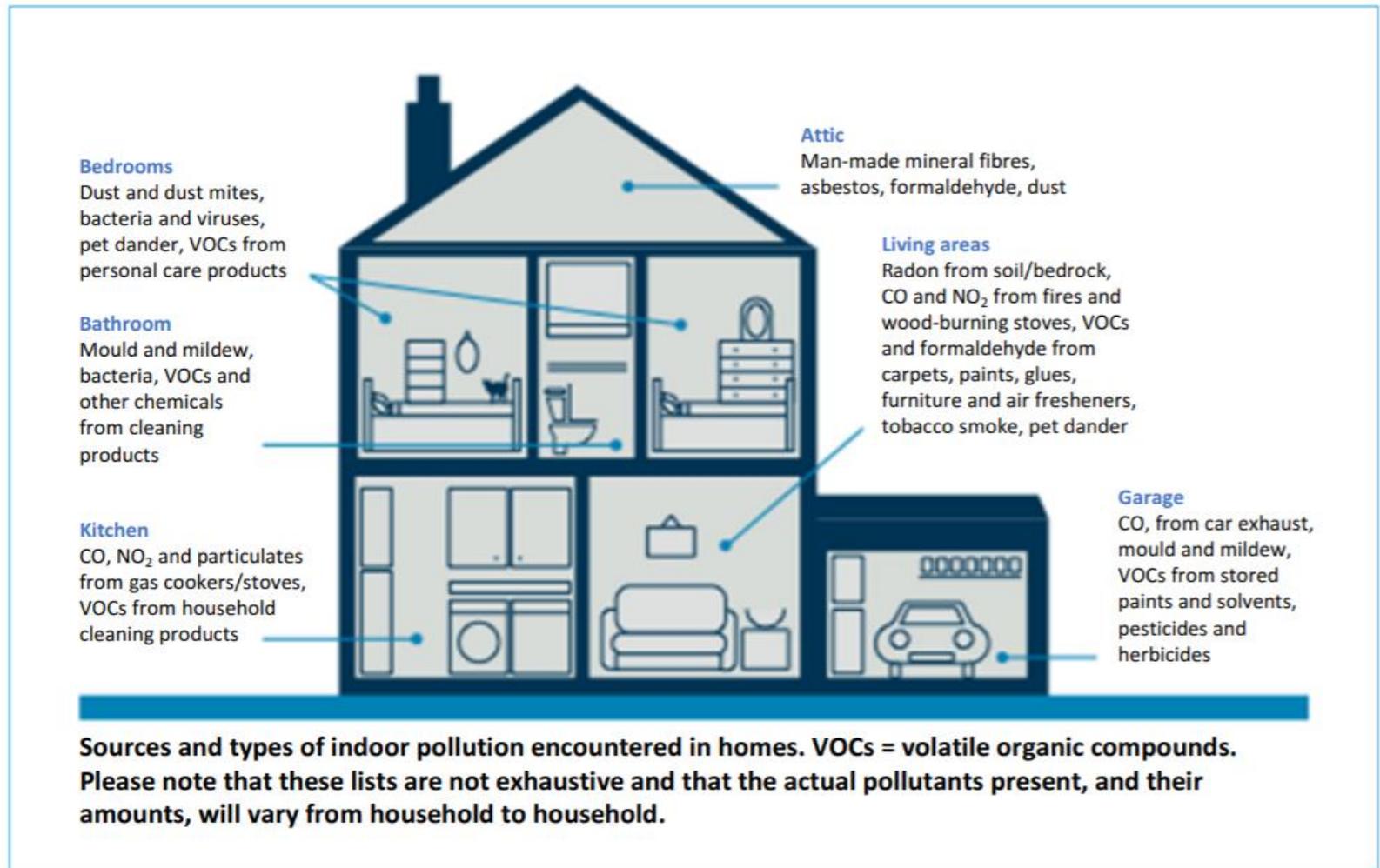
- |                 |                   |
|-----------------|-------------------|
| Mould           | Dust              |
| Gas             | Carbon monoxide   |
| People smoking  | Cleaning products |
| People spraying | Nail varnish      |
| Cooking smells  | Body smells       |

Source: RCPCH &Us voice bank 2019

*“We have black mould in bedrooms. My parents are really worried, they clean it off every couple of months but it comes back. It affects our skin and we breathe it in. It makes me feel drowsy. I just go to sleep to avoid the dust,”* said Shazia (18).

# Pollutants in the home - examples

Figure 5: An overview of sources of indoor pollutants in a home.



Source: Royal College of Physicians<sup>9</sup>

# Factors affecting exposure to pollution

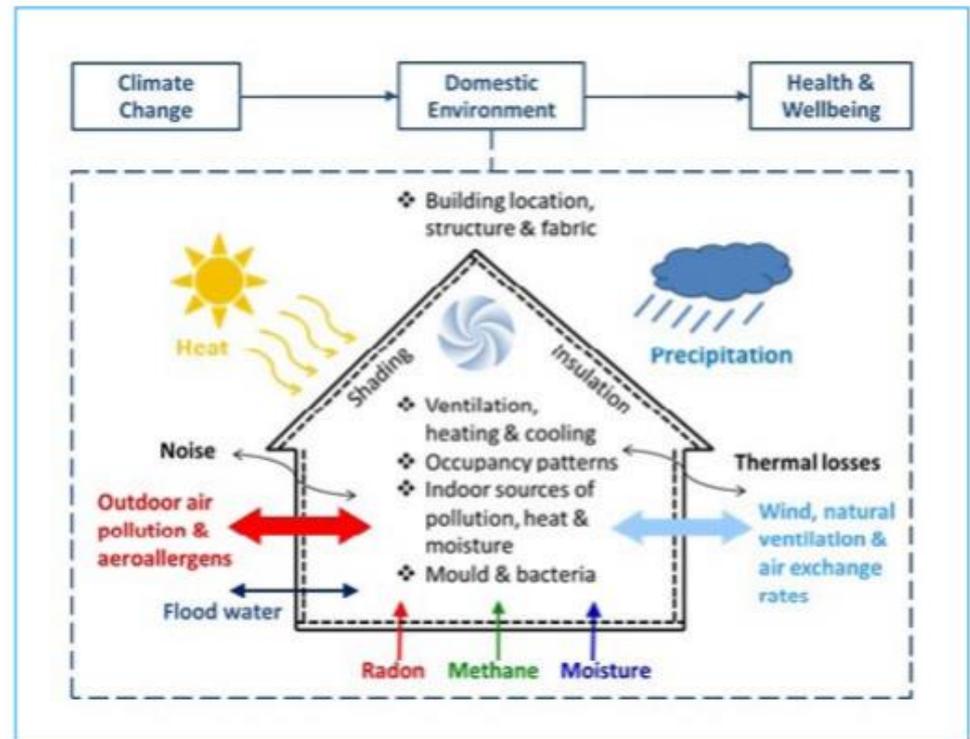
## Outdoor Factors

- Location
- Urban planning/layout
- Weather and season

These have direct and indirect effects, e.g.

- Outdoor pollution
- Building performance

Figure 6: Drivers of indoor air quality in homes and schools.



Source: Vardoulakis et al<sup>58</sup>

# pollution

## Building Characteristics and Activities

### Building characteristics

- Emissions from construction materials
- Interior finish and furniture
- Ventilation and heating (fabric and systems)
- Air filters and purifiers

### Activities

- Cooking
- Burning
- Smoking
- Use of consumer products
- Heating and ventilation patterns
- Moisture production
- Plants, pets

# Example of pollutants from building materials

Figure 8: Table of indoor pollutants from building materials.

Sources	Emissions of pollutants and chemicals
Mineral wool insulation <sup>71</sup>	Particulate matter (PM)
Polyurethane spray-foam insulation <sup>72</sup>	Flame retardants (tris phosphate) as well as aldehydes, under specific conditions
Urea-formaldehyde insulation <sup>67, 73</sup>	Formaldehyde
Paints (water-type latex types <sup>67, 74</sup>	Texanol® and formaldehyde
Older paints <sup>67</sup>	Mercury and lead
Green or natural paints <sup>75</sup>	Linseed oil, limonene, and other terpenoids, which can react with ozone to produce inhalable aerosols and formaldehyde
Wallpapers <sup>76, 77</sup>	Phthalate plasticisers
Adhesives and preservatives <sup>67, 73</sup>	Formaldehyde throughout their life, along with benzene, aldehydes and terpenoids
Furniture, soft furnishings, and soft toys, mattresses, and curtains <sup>73</sup>	Natural fibres or synthetic foams containing bromine flame retardants, dust mites
Flame retardants <sup>78</sup>	Organophosphates, both halogenated and non-halogenated
Carpets <sup>73, 79</sup>	Dust mites, VOCs, flame retardants
Flexible smooth floors <sup>67</sup>	Phthalate plasticisers
Composite wooden floors <sup>73</sup>	Formaldehyde and VOCs

# How to improve air quality at home: overall guidance



## Cleaning and ventilation

- Regularly clean and vacuum to reduce dust. Ventilation is important during and after cooking, cleaning, and activities that create moisture or pollutants.
- Try to reduce moisture in the home to prevent damp, cleaning away condensation or mould. Ventilation (e.g. an extractor fan or temporarily opening windows) can remove moisture after bathing or drying clothes indoors. If you are a tenant with persistent damp or mould at home, contact your landlord or environmental health department.
- Many windows have small, built-in vents; keep these 'trickle vents' open if you have them. If your home has a mechanical ventilation system, make sure you regularly use and maintain it.
- Do not smoke, or allow others to smoke, in your home.

# How to improve air quality at home: overall guidance



## Cooking

- Use ventilation in the kitchen when you cook and try to avoid burning food. Closing internal doors when cooking reduces pollutants from entering other rooms. If you can, put hot pans outside to cool.
- If you have one, use the cooker hood or extractor fan while cooking with an oven, hob, or any other appliance. Try to use the back rings of the hob, as this can work best with a cooker hood. Use the highest fan setting and, if possible, continue to use it for around 10 minutes after cooking.
- If you are replacing appliances, it can reduce NO<sub>2</sub> to choose electricity rather than gas. Some newer ovens have 'self-cleaning' functions; try to stay out of the kitchen if you are using this function.

# How to improve air quality at home: overall guidance



## **Furnishings and consumer products**

Without clearer labels, it will be hard to know all the different properties of the products in our homes. If available, choose products labelled with clear information about their contents and instructions for use.

- Increase the ventilation after painting, decorating or having new furniture. Follow any manufacturer's guidance on products, for example to 'use in a well-ventilated room'.
- Reduce the number of cleaning or cosmetic products used to avoid them mixing in the air
- Increase the ventilation if you use cleaning or cosmetic products, air fresheners, candles or incense.

# How to improve air quality at home: overall guidance



## **Children with respiratory allergies** (such as asthma and rhinitis)

Taking steps to reduce exposure to allergens (from house dust mites, moulds and pets) is recommended to reduce symptoms and exacerbations.

Depending on the allergy, measures which can help include:

- reducing dust and dampness in the home
- reducing items which collect dust such as soft toys and, if possible, replacing carpets with hard flooring.
- washing bedding and covers (at 60°C every two weeks), or using allergen-impermeable covers
- avoiding direct exposure to furry pets if the child is sensitised.

# Working Group Recommendations

## Establish national strategy and regulations

### The Government

1. should establish a **cross-government committee** to co-ordinate working in health, environment, education and homes for indoor air quality.
2. **Set emission standards and a labelling system** for building materials, furniture, and home decorating, products based on any health hazards.
3. Use regulations to **take a precautionary approach** to restrict the use of chemicals which have not been tested for their potential health effects.
4. Set **quality standards for home air quality monitors, air filtration and air cleaning devices**, to protect consumers from ineffective devices and ensure they do not re-introduce pollutants.

# Working Group Recommendations

## Advise the public and professionals

**The Government and Local Authorities** should provide the public with **advice and information** about the risks, and ways of preventing, poor indoor air quality. This should include tailored messages for:

- residents of social or rented housing
- landlords and housing providers
- home-owners
- children with asthma and other relevant health conditions
- schools and nurseries
- architects, designers and the building professions.



# Working Group Recommendations

## Increase public awareness

The appropriate Medical Royal Colleges should raise awareness among their members of the potential health effects of poor indoor air quality for children, and help to identify approaches for prevention.

This must include:

- Support for smoking cessation services, including for parents to reduce tobacco smoke exposure in the home.
- Guidance for health professionals to understand the health risks of poor indoor air and how to support their patients with indoor-air-related illnesses.



# Working Group Recommendations

## Increase Local Authority oversight and powers

**Local authorities** should have the power to **require improvements** where the **air quality** fails to meet minimum standards in local authority-controlled schools and wherever **children live**. This should be extended **beyond damp and mould** (where powers already exist) to include other indoor pollutants.



# Working Group Recommendations

## Increase Local Authority oversight and powers Revise the Building Regulations.

This should include:

- 1) **Setting legally binding performance standards for indoor air quality** that include: ventilation rates, testing of materials and appliances with maximum concentration levels for specific pollutants, labelling materials and testing of appliances.
- 2) **Conducting air quality tests when construction is complete** and before the building is signed-off.
- 3) **Checking compliance after construction stages** and assess buildings once they are occupied and in-use. This may require greater, ring-fenced resources for Local Authorities to take effective enforcement actions.

# Working Group Recommendations

## Increase Local Authority oversight and powers

### Local authorities should:

- 1) Follow the recommendations in the 2019 NICE guidelines for 'Indoor air quality at home' .
- 2) Include indoor air in Air Quality Plans. Ensure these specify how they met the needs of low-income households and homes in areas of high outdoor pollution.
- 3) Update existing instruments, such as the Housing Health and Safety Rating System, to include more comprehensive and periodically updated evidence on a wider range of indoor pollutants. Greater support for environmental health officers must be provided for the evaluation of indoor air quality risks in homes and schools.

# Working Group Recommendations

1. **Local authorities** and housing providers should offer indoor air quality testing for their residents.
2. **Local authorities** should establish a process or portal for residents to report potential problems with indoor air quality and access services.
3. **Central Government** should provide a national fund for households with air quality issues caused by their housing but who are unable to make necessary improvements due to financial circumstances, or who are prevented from making necessary improvements by tenancy and leasehold conditions.



# Working Group Recommendations

## Performance-based building design, construction and management

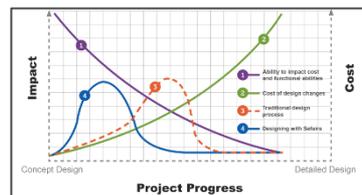
- 1) Those responsible for construction, maintenance and repair of building must **avoid the use of harmful chemicals and pollutants**. This needs to be supported by **clear labelling** and a **national system for control**, in line with recommendation number 1. Attention should be paid when substituting materials or changing ventilation levels during construction and maintenance to ensure they meet the same, or higher, performance standards.
- 2) **Building managers must keep this under review** as they maintain and operate the property, providing residents with an effective channel to raise concerns.

# Working Group Recommendations

## Performance-based building design, construction and management

With new or renovated buildings the ventilation, and heating or cooling should be designed to:

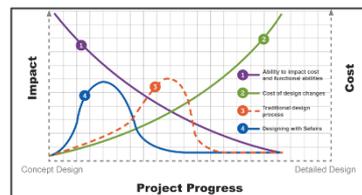
- 1) **Account for the location of nearby outdoor pollution sources, and barriers** to opening windows (noise, pollution, or security).
- 2) Take a **performance-based approach which delivers effective ventilation** while reducing energy demand and carbon emissions.
- 3) **Avoid including gas heating or burning wood and coal for heating.**
- 4) Be **correctly installed and tested after occupancy**, with clear instructions for use.



# Working Group Recommendations

## Performance-based building design, construction and management

- 1) **Professional bodies for design and construction** should **provide or accredit training** about indoor air quality. This should provide high standards for ventilation, energy efficiency, and reduction in exposure to allergens and pollutants.
- 2) **Building professionals** should ensure **adequate ventilation is included in planning renovation and refurbishment** works for existing properties, while reducing energy demand and carbon emissions; in line with the newly released PAS2035 (Specification for the energy retrofit of domestic buildings).



# Working Group Recommendations

## Protect school children

**Schools should:**

- (a) Use **adequate ventilation** to prevent the build-up of harmful indoor pollutants, between classes if noise causes a problem.
- (b) Ensure classrooms are **regularly cleaned to reduce dust, and that damp or mould** is removed.
- (c) Ensure that any air **filtering or cleaning devices** are **regularly maintained**.
- (d) **Work with the local authority**, through the ambient air quality action plans, and with parents or carers **to reduce traffic and idling vehicles close to the school**.

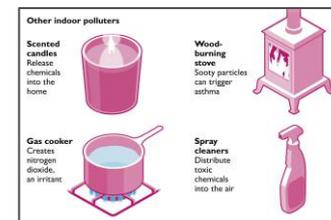
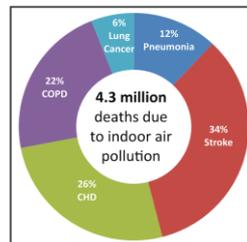


# Working Group Recommendations

## Provide high-quality research and evidence

**UKRI/Research Charities/industry should set the following priorities for indoor air quality research:**

- (a) Establish **large-scale research of UK homes and schools** on the indoor air quality, linking this with health and public health datasets.
- (b) Research into the **potential adverse health effects for children for a wider array of indoor pollutants**, increase the number of studies in UK, study the effects from **exposures in schools and nursery or day-care settings and children with chronic respiratory conditions e.g.CF.**



# Working Group Recommendations

## Provide high-quality research and evidence

**UKRI (and research charities) should set the following priorities for indoor air quality research:**

c) Gather **evidence on emissions and ventilation rates in buildings of differing age and design** – identify most cost-effective interventions for improving indoor air quality, and lowering energy demand and carbon emissions.

(d) **Measure emissions and exposure in more realistic indoor environments** such as the US House Observations of Microbial and Environmental Chemistry (HOMEChem) experiments.

(e) **Test the safety of chemicals used in buildings and household products under realistic indoor conditions** to mimic indoor environment, mixtures of pollutants and effects of humans.

# Other relevant publication: NICE IAQ Guidelines (NICE)

## Actions for architects, designers, builders and developers

These recommendations apply both to building new homes and renovating or refurbishing existing homes.

### Building materials and products

- Architects and designers should consider specifying materials and products that emit low levels of formaldehyde and volatile organic compounds (VOCs)
- Builders and developers should use materials as specified or substitute with products of the same or lower emission levels
- Builders and developers should ensure materials and products comply with building regulations, design specifications and the manufacturer's guidance

### Designing heating and ventilation systems

- Adopt a whole-building approach to heating and ventilation, balancing indoor air quality with standards for energy use
- Use heating systems that minimise exposure to particulate matter
- Ensure there is permanent, effective ventilation
- Include provision for removing indoor air pollutants in designs, for example, windows that open and extractor fans that extract to outside
- Design ventilation to reduce exposure to outdoor air pollution, for example, with windows that face away from busy roads

### Installing heating and ventilation systems

- Ensure heating and ventilation is installed and commissioned in accordance with the manufacturer's instructions and meets building regulation requirements
- When installing heating and ventilation systems, ensure they are easily accessible for regular maintenance
- Ensure any variations to the heating and ventilation specification comply with design specifications and building regulations

# Other relevant publications: IAQ Guidelines

Health and wellbeing  
in building services



TM40: 2020



Public Health  
England

Protecting and improving the nation's health

**Indoor Air Quality Guidelines for  
selected Volatile Organic Compounds  
(VOCs) in the UK**



**Indoor Air Quality**  
WORKING PARTY

# THANK YOU - Q&A



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