Indoor Air Quality and health impacts

Dr Sani Dimitroulopoulou

Principal Environmental Public Health Scientist - Indoor Environments, Air Quality and Public Health, Environmental Hazards and Emergencies Dept, Public Health England
Honorary Senior Lecturer, The Bartlett School, University College London
Vice Chair, UK Indoor Environments Group

Future Urban Ventilation Network kick off meeting – Monday 18 January 2021
Factors affecting IAQ

Factors affecting IAQ include:

- Ambient air quality
- Urban planning
- Building and construction materials, furnishing, and consumer products
- Design and maintenance of buildings
- Ventilation
- Occupant activities
Sources of IA pollutants

Bedrooms
Dust and dust mites, bacteria and viruses, pet dander, VOCs from personal care products

Bathroom
Mould and mildew, bacteria, VOCs and other chemicals from cleaning products

Kitchen
CO, NO₂ and particulates from gas cookers/stoves, VOCs from household cleaning products

Attic
Man-made mineral fibres, asbestos, formaldehyde, dust

Living areas
Radon from soil/bedrock, CO and NO₂ from fires and wood-burning stoves, VOCs and formaldehyde from carpets, paints, glues, furniture and air fresheners, tobacco smoke, pet dander

Garage
CO from car exhaust, mould and mildew, VOCs from stored paints and solvents, pesticides and herbicides

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.

RCP (2016); RCPCH / RCP (2020)
Evidence Reviews

• Studies that examined the association between individuals and building characteristics and health outcomes

• Studies that examined the association between
  o sources of pollutants and health outcomes
  o exposure levels and health outcomes

Interpreting the evidence

“Nitrogen dioxide (NO₂), volatile organic compounds (VOCs), particulate matter (PM), polycyclic aromatic hydrocarbons (PAHs, naphthalene and benzo[a]pyrene) and biological agents (mould and pet dander) are sometimes associated with respiratory, cardiovascular and neurological systems”
WHO - Development of a tool to assess cumulative risks from exposure to indoor chemicals in schools (WHO, 2018; WHO 2020)

- respiratory system;
- nervous system;
- cardiovascular system
- carcinogenicity
- respiratory irritation

https://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications
### The inside story:
**Health effects of indoor air quality on children and young people**

#### Research project
Produced an evidence-based report on the impact of indoor air pollution

<table>
<thead>
<tr>
<th>Birth and infancy</th>
<th>Pre-school</th>
<th>School age</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Respiratory problems – wheeze, rhinitis, atopic asthma, respiratory infections</td>
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<tr>
<td>- Low birthweight and pre-term birth</td>
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<tr>
<td>- Respiratory problems – wheeze, allergies, asthma, risk of respiratory diseases and pneumonia</td>
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<tr>
<td>- Eczema and atopic dermatitis</td>
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<tr>
<td>- Greater hyperactivity, impulsivity and inattention</td>
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<tr>
<td>- Respiratory problems – wheeze, rhinitis, asthma, throat irritation, nasal congestion, dry cough</td>
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</tr>
<tr>
<td>- Eczema, dermatitis, conjunctivitis, skin and eye irritation</td>
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<td>- Reduced cognitive performance, difficulty sleeping</td>
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</tbody>
</table>

Setting the standard: The acceptability of kitchen ventilation for the English housing stock

Catherine O'Leary a, Benjamin Jones a, Sani Dimitroulopoulou b, Ian P. Hall c

a Department of Architecture and Built Environment, University of Nottingham, Nottingham, UK
b Centre for Radiation, Chemical and Environmental Hazards, Public Health England, Harwell Science and Innovation Campus, UK
c Division of Public Health, University of Nottingham, Nottingham, UK

Exposure to indoor air pollution across socio-economic groups in high-income countries: A scoping review of the literature and a modelling methodology

Lauren Ferguson 1,2,3,4,5,6,7, Jonathon Taylor b, Michael Davies b, Clive Shrubsole 1,6,7, Phil Symonds b, Sani Dimitroulopoulou 1,6,7

Review

Exposure to indoor and outdoor air pollution from solid fuel combustion and respiratory outcomes in children in developed countries: a systematic review and meta-analysis

Valentina Guercio *, Julia C. Pujum, Giovanni S. Leonardi, Clive Shrubsole, Alison M. Gowers, Sani Dimitroulopoulou, Karen S. Edley

Centre for Radiation, Chemical and Environmental Hazards, Public Health England, Chilton, Oxfordshire, OX1 1BQ, United Kingdom
PHE indoor air quality guidelines for selected VOCs


Building and Environment, 2019,
https://doi.org/10.1016/j.buildenv.2019.106382
## PHE Indoor Air Quality Guidelines for Selected VOCs

<table>
<thead>
<tr>
<th>VOCs</th>
<th>Limit Values in μg.m⁻³</th>
<th>Source Document</th>
<th>Reasoning for choice</th>
<th>Potential Health Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetaldehyde</td>
<td>1,420 (1h) 280 (1day)</td>
<td>Health Canada (2018)⁴</td>
<td>Most recent appraisal of evidence</td>
<td>Irritation of the eyes, skin, and respiratory tract following acute exposure. Long-term animal studies have reported carcinogenicity and inflammation and injury to tissues of the upper respiratory tract (Health Canada, 2018)</td>
</tr>
<tr>
<td>α-Pinene</td>
<td>45,000 (30min) 4500 (1 day)</td>
<td>EPHECT (Trantallidi et al., 2015)</td>
<td>Critical Exposure limit (CEL) inhalation exposure to key and emerging indoor air pollutants emitted during household use of selected consumer products</td>
<td>With the exception of its irritative (skin, eyes) and sensitizing properties, it is a chemical with fairly low acute toxicity. Ozone initiated reactions with terpenes produce gaseous and aerosol phase products, causing sensory irritation of upper airways and airflow limitation.</td>
</tr>
<tr>
<td>Benzene</td>
<td>No safe level of exposure can be recommended. The unit risk of leukaemia per 1μg.m⁻³ air concentration is $6 \times 10^{-4}$. The concentrations of airborne benzene associated with an excess lifetime cancer risk of 1/10 000, 1/100 000 and 1/1 000 000 are 17, 1.7 and 0.17μg.m⁻³, respectively.</td>
<td>World Health Organisation (2010)</td>
<td>The risk estimates are based on human health risk. However, it is noted that the current Defra national air quality objectives for benzene for England and Wales is an annual mean of 5μg.m⁻³, based on the European (EU) ambient air quality directive 2008/50/EC (EU, 2008), (Defra, 2010).</td>
<td>The International Agency for Research on Cancer has classified benzene as carcinogenic to humans (Group 1). Benzene causes acute myeloid leukaemia in adults. Positive associations have been observed for non-Hodgkin lymphoma, chronic lymphoid leukaemia, multiple myeloma, chronic myeloid leukaemia, acute myeloid leukaemia in children and cancer of the lung. (IARC, 2018a).</td>
</tr>
<tr>
<td>D-Limonene</td>
<td>90,000 (30min) 9000 (1 day)</td>
<td>EPHECT (Trantallidi et al., 2015)</td>
<td>Critical Exposure limit (CEL) inhalation exposure to key and emerging indoor air pollutants emitted during household use of selected consumer products</td>
<td>As for α-Pinene above</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>100 (30min) 10 (1yr)</td>
<td>World Health Organisation (2010), ATSDR MRL (1999)</td>
<td>World Health Organisation guidelines valid for short term exposure. ATSDR value of 10 µg/m³ suggested as the long-term health-based guideline value which accounts for the potential for child susceptibility.</td>
<td>Sensory irritation of the eyes, nose and throat, together with exposure-dependent discomfort, lachrymation, sneezing, coughing, nausea and dyspnoea. Human carcinogen -long-term exposure linked to nasal cancer.¹</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>- 3.0¹ (1yr)</td>
<td>Agency for Toxic Substances &amp; disease Registry (2005), USA</td>
<td>Value also selected by the Flemish Government (2018)</td>
<td>Haemolytic anaemia in humans at high doses. Respiratory tract lesions including carcinogenicity reported in long-term animal studies. ¹³</td>
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¹¹²³⁴⁵⁶⁷⁸⁹¹⁰¹¹¹²¹³¹⁴¹⁵¹⁶¹⁷¹⁸¹⁹²⁰²¹
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<tr>
<td></td>
<td>Short Term</td>
<td>Long Term</td>
<td></td>
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<tr>
<td>Styrene (100-42-5)</td>
<td>-</td>
<td>850 (1y)</td>
<td>Health Canada (2018)</td>
<td>Most recent appraisal of evidence</td>
</tr>
<tr>
<td>Toluene (108-88-3)</td>
<td>15,000 (8h)</td>
<td>2,300 (1 day average)</td>
<td>Health Canada (2018)</td>
<td>Most recent appraisal of evidence, specifically the dose response relationship.</td>
</tr>
<tr>
<td>Trichloroethylene (71-01-06)</td>
<td>-</td>
<td>0.2* (1yr)</td>
<td>US EPA (2011)</td>
<td>This value is based on human data for kidney cancer, which has also been adjusted for other cancers.</td>
</tr>
<tr>
<td>Xylenes-mixture (1330-20-7)</td>
<td>-</td>
<td>100 (1y)</td>
<td>Health Canada (2018)</td>
<td>Most recently derived and most precautionary value.</td>
</tr>
</tbody>
</table>

*No safe level of exposure can be recommended. The concentrations shown are associated with an excess lifetime risk of 1/1,000,000 and are applicable to both long and short-term exposures.

1We are aware of new data that indicates that effects may occur at lower doses; however, this new data has not yet been evaluated by an authoritative body.

Health Canada uses screening values for some species - Indoor Air Reference Levels (IARL). These are used to assess possible risk. They are associated with acceptable levels of risk after long-term exposure (over several months or years) for each specific VOC. Due to uncertainties in derivation; these have simply been labelled as annual. In these cases, no separate short-term exposure limit has been stated.

Main References

1World Health Organisation. WHO Guidelines for selected pollutants.
4Sarigiannis et al., 2011


Exposure to air pollution from indoor solid fuel combustion and respiratory outcomes in children in developed countries


There is currently little evidence linking exposure to indoor coal or wood burning with asthma or other respiratory diseases in children.

This does not mean that exposure to these sources of air pollution is not having health effects, but rather that there is currently no strong scientific evidence showing this. Further research would be needed to establish whether there is a link.

The epidemiological evidence on the association between indoor wood, coal and all solid fuel use and lung cancer risk is still limited, as only a few studies evaluate such an association.

This review shows that portable air purifiers can improve indoor air quality significantly by reducing particulate air pollution.

There is currently not enough evidence to confirm health benefits because there are so few properly designed studies. But given that there is strong evidence that the exposure to particulate pollutants is harmful to health, there are likely to be positive impacts.

https://doi.org/10.1016/j.scitotenv.2020.142585
Improving indoor air quality

Actions for local authorities

Checking people’s homes and giving advice
Use inspections and home visits to identify poor indoor air quality.
Staff who visit people’s homes should:
• know about sources of indoor air pollutants and their effects on health
• give advice on avoiding activities that increase pollutants and improving ventilation (see below)
• know who can provide help with repairs and necessary improvements
• give advice on requesting a housing assessment if poor indoor air quality is suspected.
Advise private and social tenants to contact their landlord if:
• ventilation is inadequate
• repairs are needed to prevent water from entering the home
• improvements are needed to heating or insulation to prevent condensation.
Advise tenants to contact their local authority if no action is taken to improve ventilation or carry out repairs.

Advice on reducing damp and condensation
• Use background ventilation (trickle vents or whole-house mechanical ventilation).
• Use extractor fans and open windows (if possible and safe).
• Avoid moisture-producing activities (such as air-drying clothes) or if unavoidable, improve ventilation.
• Repair sources of water damage and remove residual moisture.

Advice on increasing ventilation
• Use extractor fans in bathrooms and kitchens, or open windows (if possible and safe) when:
  • using cookers, especially gas cookers
  • using open solid-fuel fires or free-standing gas heaters
  • using candles
  • using cleaning products, household sprays or aerosols and paints
  • having a bath or shower
  • air-drying clothes

Other advice
• Do not use unflued paraffin heaters.
• Follow product instructions if using, for example, paint, glue and solvents.
• Choose low-emission materials if replacing furniture or flooring.
• Ensure adequate ventilation when installing a new cooker, especially for gas cookers.
• Do not use gas cookers to heat a room.
• Avoid smoking in the home.

Actions for healthcare professionals

Advice for people with breathing or heart problems
• Explain that indoor air pollutants can trigger or exacerbate asthma, other respiratory conditions and cardiovascular conditions.
• If repeated or worsening cough or wheezing, ask about housing conditions and help request a housing assessment if concerned.
• If household sprays or aerosols trigger asthma, advise avoiding them or using non-spray products.

Advice for people allergic to house dust mites
• Advise on how to reduce exposure to house dust mites, including:
  • avoiding second-hand mattresses if possible
  • using allergen barriers such as mattress and pillow covers
  • washing bedding regularly

Advice for pregnant women and babies under 12 months
• Advise on the increased risks from poor indoor air quality:
  • Explain the risks of tobacco smoke
  • Ask about housing conditions and help request a housing assessment if concerned.
  • Advise on reducing use of household sprays and aerosols
  • Advise on avoiding or reducing use of open solid-fuel fires or candles
  • Advise on avoiding smoking in the home or around the woman and baby.
PHE work / contribution to new IAQ activities

**PHE**

- CO2 project: an indicator or a pollutant?
- HECC 2021 report – Impact of Climate Change on indoor environmental quality and Health
- UKRI funded Networks

**Organisations**

- WHO Experts Group on IAQ and children’s health
- BSI – PAS3003 Development of new standard Non-domestic buildings – Health and wellbeing performance

**Government**

- MHCLG Revision of Building Regulations (Part L and Part F)
- MHCLG Planning – Revision of HHSRS (Housing Health and Safety Rating System)
- Defra - AQEG report on VOCs
Let’s work together
to reduce our exposure to indoor air pollution

Thank you!
www.gov.uk/phe
Sani.Dimitroulopoulou@phe.gov.uk