Effects of indoor air quality on children and young people's health

RCP & RCPCH Call for Evidence

December 2018

The respondent is **The Chartered Institution of Building Services Engineers (CIBSE).**

The Chartered Institution of Building Services Engineers is the professional body that exists to:

> 'support the Science, Art and Practice of building services engineering, by providing our members and the public with first class information'

CIBSE members are the engineers who design, install, operate, maintain and refurbish the energy using systems installed in buildings, including homes, and are specifically trained in the assessment of heat loss from building fabric and the design of energy using systems for the provision of heating and hot water, lighting, ventilation and cooling and small power distribution in homes. Many CIBSE members work in the public sector in general and in higher education in particular.

CIBSE has over 20,000 members, of whom around 75% operate in the UK and many of the remainder in the Gulf, Hong Kong and Australasia. Many are actively involved in the energy management of commercial buildings for larger businesses, and so this consultation is highly relevant to us and to our members.

CIBSE is the sixth largest professional engineering Institution, and along with the Institution of Structural Engineers is the largest dedicated to engineering in the built environment. Our members design, install, manufacture, maintain, manage, operate and replace all the energy using systems in buildings as well as public health systems.

As an Institution CIBSE publishes Guidance and Codes which provide best practice advice and are internationally recognised as authoritative. The CIBSE Knowledge Portal, makes our Guidance available online to all CIBSE members and is the leading systematic engineering resource for the building services sector. Over the last twenty-one months it has been accessed over 200,000 times, and is used regularly by our members to access the latest guidance material for the profession. Currently we have users in over 170 countries, demonstrating the world leading position of UK engineering expertise in this field.

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1. About you (required)

Name	**Dr Julie Godefroy**
Role	**Technical Manager**
Organisation (if applicable)	**Chartered Institution of Building Services Engineers (CIBSE)**
Contact email	**JGodefroy@cibse.org**
Motivation for submission	CIBSE is a charity with a statutory duty to provide public benefit through the delivery of knowledge and guidance. We produce guidance, support research and inform policy on issues affecting the health and wellbeing of building occupants, including air quality, thermal and humidity conditions.

Question number:	Response:
2.	*Are you, and/or your organisation, aware of any issues of poor indoor air quality in home or school environments and its effects on the health of infants, children and young people? (Please provide supporting evidence)*
	As a built environment organization, CIBSE are not experts on health effects and we will refer to sources well-known to the RCP and RCPCH, such as the WHO (e.g. http://www.who.int/ceh/publications/air-pollution-child-health/en/) and Public Health England (and the RCP & RCPCH's own 2016 report). We have however been very active in compiling information from experts on pollutants and their effects, in order to provide advice on the measures that can be adopted through building design, construction and operation to avoid detrimental health effects. We have attached two documents in appendix which we hope will be useful to this call for evidence; we refer to particular sections of these documents throughout our responses: • Appendix A: Upcoming CIBSE publication: Guide on Health and Wellbeing in Buliding Services, currently in its final draft form and informed by a steering group including representatives from Public Health England and the UK-Indoor Environmental Group; this includes a summary of key health effects, pollution sources, guidance in the building design, construction and operation, and our understanding of important gaps in knowledge and solutions. **Please note** the publication is currently undergoing peer-review and is therefore subject to changes. The draft is subject to change and is not intended for widespread distribution. Please do contact us at the time evidence is reviewed, and we would be happy to provide the latest version. • Appendix B: position paper on Building Regulations, which summarises our recommendations to government on this matter. Current Building Regulations Part F only addresses *ventilation*, without consideration of factors such as outdoor pollutants; it also has an incomplete approach to sources of indoor air pollution, as it is mainly concerned with moisture and combustion products from heating equipment and cooking appliances and does not properly address other sources, such as formaldehyde. While Approved Document F recommends a total VOC limit, this does not recognise that some VOCs (e.g. formaldehyde) are much more detrimental to health than others; furthermore, this TVOC limit is only for guidance and is widely acknowledged NOT to be used by designers or building control bodies. Another cause of concern is the lack of enforcement of existing requirements; not only does it affect buildings subject to Building Regulations, it also means there is a lack of knowledge and availability for low-emission building materials and other products used inside all buildings. More comprehensive and better enforced regulations would assist in developing a market for such solutions, which could ultimately benefit all buildings. There is an additional concern amongst Building Regulations experts that buildings with particularly low (i.e. good) airtightness performance, may not be adequately ventilated.

	There is also growing concern about the possible effects of carbon monoxide in dwellings. CIBSE is aware of some buildings where carbon monoxide levels have been recorded during normal operation of the building services systems which are well in excess of safe levels. See also response to Question 9, and further information can be provided in confidence. In the context of this call for evidence, we think important gaps in the mix of regulations, knowledge, skills and solutions that are needed for healthy indoor environments are: • lack of a comprehensive regulatory framework for indoor air quality and overheating • lack of guidance on procedures and equipment for indoor air quality monitoring, striking a balance between costs and accuracy. • lack of knowledge and availability of solutions such as low-emission materials; to some extent this results from the lack of a comprehensive regulatory framework, as more comprehensive and well-enforced building regulations on the matter could help develop a market. • Energy efficient housing retrofit projects can have unintended consequences on indoor air quality due to a number of factors including insufficient ventilation after airtightness improvements, or fabric degradation; there is not widespread knowledge of suitable solutions, and competence to deliver them. • Widespread operational issues resulting from inadequate design, installation, and maintenance.
Section 2: Health effects (max. 1,000 words)	
3.	*What are your views on the effects of indoor air pollution on pregnancy and the future health of children after they are born? (Please provide supporting evidence where possible)*
	No response – this is not our area of expertise
4.	*We are very interested in hearing your views on the quality of indoor air in homes and schools and whether this affects the health of infants, children and young people. (Please provide supporting evidence where possible)*

See also our response to Question 2.

We understand there is widespread evidence that indoor air in a large proportion of UK buildings is likely not to be of sufficient quality to avoid detrimental health effects, with “sufficient quality” broadly defined as at least meeting the WHO guidelines. We attribute this to several factors, including (but not limited to):

- Regardless of the individual causes of indoor air pollution, a key reason for our concerns is that indoor air quality is not appropriately considered in **Building Regulations** – see our response to Question 2, and Appendix B .
- **Outdoor air pollution**, particularly in urban areas, is known to exceed WHO guidelines for a number of pollutants. This is of particularly concern for **existing homes and schools** as, compared to other building types, they are more likely to host vulnerable occupants AND are in large proportion naturally ventilated, with little opportunity for filtration (compared to other uses such as offices, which are more often mechanically ventilated).
- **Energy efficient housing retrofit projects:** see our response to Question 2.
- **Indoor sources of pollution:** see response to question 2 on the treatment in Building Regulations and the lack of a well-established market for low-emissions building materials.
- **Ventilation: see Question 9**
- **Health inequalities:** there is strong evidence that people living in areas of high outdoor air pollution are also on average exposed to other environmental stressors contributing to poor health, such as noise and lack of green space. We would refer to the work of the ULC Institute of Health Inequality on this matter http://www.instituteofhealthequity.org/home . There is also evidence that these inequalities in environmental determinants apply to indoor conditions, with homes occupied by people on poorer incomes more likely to be cold and damp, with associated risks of health effects from cold temperatures and mould growth (Marmot Review Team, 2011, *The health impacts of cold homes and fuel poverty*, http://www.instituteofhealthequity.org/resources-reports/the-health-impacts-of-cold-homes-and-fuel- poverty/the-health-impacts-of-cold-homes-and-fuel-poverty.pdf; NICE (2015), *Excess winter deaths and illness and the health risks associated with cold homes*, https://www.nice.org.uk/guidance/ng6/resources/excess-winter-deaths-and-illness-and-the-health- risks-associated-with-cold-homes-51043484869).

Possible references

We are aware these are likely to be known already to the RCP and RCPCH, but they have been highlighted by our members as particularly useful:

- One of the most comprehensive studies in indoor air quality, SINPHONIE, involved 36 institutions over 25 countries and provided evidence that: there are 250,000 asthma cases among school children in Europe; nearly 100,000 cases of asthma attacks occur in classrooms; and there is greater risk of respiratory related issues in school environments with elevated levels of air pollutants (http://www.sinphonie.eu/materials)
- A study in five London primary schools demonstrated that prevalence of asthmatic symptoms and asthma attacks were significantly higher in urban than in suburban schools, attributed to higher NO2 concentrations from traffic (Chatzidiakou etc. al, 2015).

	• A study of 2120 children in the U.S. found that decreased levels of city wide NO2 were directly related with increased lung performance in children (Gauderman et. al, 2015). • WHO (2018) reported that exposure to household air pollution nearly doubles risk of childhood pneumonia and causes 45% of pneumonia deaths in young children (less than 5 years old). https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health
5.	*There are many substances that escape into the air indoors, including chemical and biological pollutants (those pollutants derived from living organisms such as bacterial, fungal and viral products). Which substances and/or pollutants do you believe pose the greatest risk to the health of infants, children and young people both in the short- and long-term? (Please provide supporting evidence where possible)*
	We understand "risk to health" here relates to the effects <u>in the case of exposure</u>, while exposure is treated in Section 3. It is not our area of expertise and we defer to others such as the WHO and Public Health England on this. Of particular relevance to the construction industry, as construction materials are a potential source of pollutants, we would highlight: • VOCs, due to their prevalence and the difficulty to define a simple target, due to the huge number of VOCs and their potential sources, and the wide variety of effects from short-term, long-term, to benign. Some can have a significant impact at ppb levels (such as isocyanates or amines), whilst others could be abundant and have negligible effect on health. • Fire retardants, which are subject to only few restrictions and which can lead to effects during fire (e.g. toxic smoke) as well as potentially through long-term release. See work by Prof Anna A Stec, 2018 (https://asbp.org.uk/wp-content/uploads/2018/02/Prof.-Anna-Stec-University-of-Central-Lancashire-HealthyBuildings18.pdf) We would also highlight that little is known on **cumulative and cocktail effects** (as noted in the 2016 RCP & RCPCH report); we think this is a **significant and important knowledge gap** when considering the risk of health effects from real-life. <u>Possible references</u> • WHO guidelines, and their report on persistent organic pollutants impact on child health http://apps.who.int/iris/bitstream/handle/10665/44525/9789241501101_eng.pdf?sequence=1 • The EU-LCI initiative has produced a systematic analysis of chemical indoor pollutants and recommended thresholds to reduce impact on health & wellbeing https://ec.europa.eu/growth/sectors/construction/eu-lci/values_en • Nazaroff (2018), which points out that comparing particulate matter (PM) air pollution to gaseous pollutants is broadly impossible due to their different characteristics and crude aggregate measures (https://onlinelibrary.wiley.com/doi/full/10.1111/ina.12444) .

6.	*Which other indoor air quality factors (e.g. temperature, moisture) do you think pose the greatest risk to the health of infants, children and young people in the short- and long-term? (Please provide supporting evidence where possible)*
	CIBSE are very aware of the risks to health and comfort caused by excessive hot or cold t**emperature**; there is a lack of clear guidance from health authorities on suitable temperatures. See the following CIBSE references: • Appendix A, chapter 7 for our summary on health effects, prevalence in the built environment, recommendations, and research gap areas • Appendix B, section 5, for a summary of how overheating risk is currently addressed in the regulatory framework, and our recommendations to government to improve this • Submission to the Environment Audit Committee enquiry on heatwaves: written evidence: http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/environmental-audit-committee/heatwaves-adapting-to-climate-change/written/86448.html ; oral evidence http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/environmental-audit-committee/heatwaves-adapting-to-climate-change/oral/82876.html We are not sure **moisture** can be considered in isolation as many concerns are not related to moisture as such, but to the fact that, in combination with temperature, it creates supportive conditions for mould and microbial pollutants. See also our response to Question 10. We cannot comment on which ones pose "the greatest" risk as this is not our area of expertise, and we are unsure whether this is meant on a population level, or in the case of exposure of one individual. As also noted in our response to previous questions, it is important to note possible **interactions and compounding factors** between air pollution, moisture and temperature, rather than only considering them separately.
Section 3: Factors driving exposure (max. 1,000 words)	
7.	*In your view, which sources of pollution dominate in determining the quality of indoor air in homes and schools? (Please provide supporting evidence where possible)*

	We assume the term “dominates” here relates to exposure (prevalence and extent), rather than the impact should they be present. This will be quite dependent on the context, including the building location, the type of use, its design, ventilation and construction characteristics, maintenance (e.g. poorly maintained combustion appliances releasing carbon monoxide), and occupant behaviour. According to the WHO, the most commonly found substances in indoor air with implications on health are benzene, carbon monoxide, formaldehyde, naphthalene, nitrogen dioxide, polycyclic aromatic hydrocarbons (especially benzo[a]pyrene), radon, trichloroethylene and tetrachloroethylene. (http://www.euro.who.int/__data/assets/pdf_file/0009/128169/e94535.pdf). We would make the following observations on sources and trends: • Outdoor sources of pollution such as PM and NOx are likely to be important in urban areas, particularly for naturally ventilated buildings. This is however a generalisation as other sites (e.g. radon-affected areas, near airports, near industrial sites, near intensive agriculture areas) may be exposed to high levels of particular pollutants too. • Airtight buildings (e.g. new buildings, and some refurbished buildings) risk seeing higher concentrations of pollutants from indoor sources, unless this is properly addressed through ventilation. • Combustion equipment and appliances e.g. cooking equipment, boilers – see response to Question 9 • In existing and refurbished homes, there is a risk of mould and microbial pollution due to a variety of factors – See Chapter 8 of our upcoming publication in Appendix A, in particular Thematic Box 8.1.
8.	*Which building materials (e.g. interior finishes, furniture) do you understand affect indoor air quality the most in homes and schools? (Please provide supporting evidence where possible)*
	Historically, building materials causing a particular risk include lead-based paints and asbestos. Remaining instances in existing buildings are understood to have reduced drastically, but not completely. The RCP & RCPH report includes a comprehensive review of potential pollutants and associated potential sources and we are not therefore expanding on this; see also sections 9.1 and 18.2 of our upcoming publication in Appendix A. From a **building materials** perspective we understand the main sources are the following; we are not aware of studies on which sources affect indoor air quality “the most”: • those releasing formaldehyde (e.g. paints, solvents, glues, varnishes etc) • those releasing ozone (e.g. photocopiers and printers) • of more recent and growing concern, those containing fire retardants - See Stec, 2018 in our response to Question 5, and also a recent study in the U.S. which demonstrated that some flame retardants which were banned, or severely restricted, in the 90s and early 2000s were still present in indoor air and dust in schools in significant concentrations in 2018 (Li, Corsi, et.al, 2018)

	Note that indoor materials have a wide implication on air quality as they are not only sources of pollution, as some can act as adsorptive sinks and attract indoor pollutants, which are later released back into the environment, such as carpets, beds and upholstery (Won, et. al, 2000 https://pubs.acs.org/doi/abs/10.1021/es9910412). See recent study comparing exposure levels to pollutants and dust from carpets in a robotic crawling baby and a walking man (Wu et al., 2018).
9.	*Which building characteristics (e.g. construction, heating and ventilation systems) do you understand affect the quality of indoor air in homes and schools? (Please provide supporting evidence where possible)*

	Key influencing building characteristics are as follows (ignoring other factors such as building location, which are covered in previous questions):
	
	• **Airtightness** - see Question 7 ; note we are not advocating for less attention to airtightness, as this has benefits for comfort, energy efficiency, and indeed for air quality as it prevents the uncontrolled infiltration of outdoor air. What we highlight is the need to consider it alongside ventilation, particularly in the case of buildings which achieve high standards of air tightness, as noted above in section 2.
	• **Existing and refurbished buildings** – see Question 7 and Question 10
	• **Ventilation rates** are often insufficient to address fresh air requirements and indoor sources of pollution:
	  ○ Actual rates often do not meet the design intent, and often not even the minimum ventilation provision recommended by Building Regulations Approved Document F. While this is widely reported in dwellings with mechanical ventilation with heat recovery systems, it is also prevalent in other ventilation systems, such as continuous or intermittent extract, for example when they are poorly installed and so noisy that occupants switch them off. More generally and as highlighted in Question 2 and in Appendix B, there is a need for the Building Regulations relating to ventilation to be reviewed and for the performance requirement to relate to the quality of indoor air and not the rate at which indoor air is changed.
	  ○ There is often insufficient provision in refurbishment projects where the works may have reduced uncontrolled air infiltration with insufficient thought to the need for increasing other means of ventilation.
	  ○ Ventilation provision is a particular concern in homes and schools as the expertise of occupants and maintenance resources can be very limited, which means that systems must be simple to operate effectively; unfortunately this is often not the case in new buildings, with much evidence that occupants find systems too complex to operate, and are provided with little information on how to do it.
	  ○ For reasonably recent reviews, see for homes Ian Mawditt and Prof Rajat Gupta (e.g. http://asbp.org.uk/wp-content/uploads/2017/02/Ian-Mawditt-Four-Walls-ASBP-Expo-2017.pdf) and Sharpe, Mawditt, Gupta & McGill, 2016 (https://www.researchgate.net/publication/296195471_Characteristics_and_performance_of_MVHR_systems_A_meta_study_of_MVHR_systems_used_in_the_Innovate_UK_Building_Performance_Evaluation_Programme); for schools, see the non-domestic Innovate UK Building Performance Evaluation programme (https://buildingdataexchange.org.uk/bpe-final-non-domestic-report/).

	• **Presence of combustion appliances** including boilers, cookers, indoor fires etc: There is some concern over carbon monoxide levels in dwellings, and this requires further investigation. We suggest that the Carbon Monoxide & Gas Safety Society (CoGas) are consulted about this issue. See also Myers, 2018 (*Indoor Air Quality and Health - Spotlight on CO: A Call For Action By Healthcare Professionals* ; abstract: http://ukieg.yolasite.com/resources/Abstract%20Book%20UKIEG%202018.pdf) • More generally, building **designs which do not help separate sources of pollution from occupants** e.g. single aspect spaces with openings on busy roads or other sources of pollution; kitchens and bathrooms with insufficient extract ventilation; garages adjacent to homes (on this specific last point, see Dimitroulopoulou C, Crump D, Coward S K D, Brown V, Squire R, Mann H, White M, Pierce B and Ross D, BR 477 *Ventilation, air tightness and indoor air quality in new homes*, BRE bookshop, for evidence on resulting indoor benzene levels). We would also note the following potential sources from **plant and equipment**: • dust or dirt in ductwork or other components; microbiological growth in drip pans, humidifiers, ductwork, coils. This will usually be related to poor installation and maintenance. See section 9.4 of our upcoming publication in Appendix A on preventive measures through design, construction and operation. • leaks from plant such as refrigeration and cooling equipment; large-scale plant will often be located outdoors or in unoccupied areas; we are not aware of studies on the impact that smaller plant and associated distribution pipes located indoors (e.g. fridges, small air-conditioning units) may have on the indoor environment; • pollution from combustion appliances and plant , as sources of pollutants such as NOx; see also above on carbon monoxide.
10.	*What factors have the greatest influence on heating and/or poor moisture conditions (e.g. those related to mould growth) in homes and schools? (Please provide supporting evidence where possible)*
	Condensation and associated mould growth "is governed by complex interrelationships between heat, moisture, air movement, building lay out and the physical properties of building material" BS 5250 2011. Relative humidity is one of the key factors in mould growth. This is an extremely complex subject and, in addition to building design and construction characteristics, social and economic factors clearly have an impact on heating regimes, lifestyle, occupancy density and moisture production, all of which will affect the relative humidity levels within the building. We would recommend liaising with the UK Centre for Moisture, and the BSi whitepaper by Neil May "Moisture in buildings: an integrated approach to risk assessment and guidance". See also Chapter 8 of our upcoming publication in Appendix A. Table 2 from Approved Document F (ADF) indicates the relative humidity criteria required for mould growth to occur. It also highlights the significance of time in the potential for mould growth. Ventilation systems such as those described in ADF can be employed to control excess humidity arising from water vapour indoors but unfortunately many systems fail to do this adequately, typically, because they have not been installed and commissioned correctly or due to poor occupant understanding of the significance of ventilation – see references in our response to Question 9.

11.	*What type of occupant activities (e.g. consumer product use, cooking, heating) do you understand influence indoor air quality and the heat and moisture conditions in homes and schools? (Please provide supporting evidence where possible)*
	They include: • Smoking • Cooking • Cleaning • Physical activities in general, particularly vigorous ones • Cleaning and pest control activities, with sources including products and equipment (e.g. sweeping and vacuuming circulating airborne dust or dirt) • Home decoration and other DIY activities generating dust and volatile organic compounds • Use of indoor combustion appliances (including chimney fires and other burners) • Consumer product use e.g. candles, indoor air fresheners, perfume, deodorizers … • Daily shower / bath regimes. <u>Possible references:</u> • Upcoming CIBSE publication in Appendix A: sections 9.1 and 18.2 on sources and effects, and section 9.4 on preventive measures • Consumer products: see EPHECT Emissions, Exposure Patterns and Health Effects of Consumer Products in the EU, funded by the Health Programme of the European Union, final documents available: https://esites.vito.be/sites/ephect/Pages/home.aspx • During cooking using gas appliances, PM2.5 levels can increase drastically to 100-500µg/m3 and are slow to decay afterwards (Hourigan and Miller, 2018). This highlights the need for suitable ventilation. In the UK, there are 23 million natural gas customers (BEIS, 2018) therefore a large proportion of domestic cooking likely to be with gas cookers. • One of the most detailed and comprehensive studies of a single house in relation to cooking and cleaning pollutants is the HomeChem project. https://indoorchem.org/projects/homechem/

Section 4: Measuring exposure and outcomes (max. 1,000 words)

12.	*What do you believe are the most appropriate ways of measuring and quantifying the levels of indoor air pollution for investigating adverse health effects in communities? (Please provide supporting evidence where possible)*
	For information on equipment, standards and procedures, please refer to sections 4.5 and 9.4.9 of our upcoming publication in Appendix A. As highlighted in our response to Question 2, there is a lack of standardized guidance on procedures and equipment for the "average cost & accuracy" range. We would make the following recommendations: • Identify the purpose of monitoring, which may be different in different studies; some may focus on particular aspects and require accuracy (e.g. identifying whether some pollutants are present and at which levels, identifying variations in exposure depending on occupants height (or age) and activity, or the effectiveness of particular interventions); for others, trends and volume may be more valuable and equipment of lower cost and accuracy may be acceptable (e.g. to establish pollution patterns between building types, ventilation approaches or occupancy patterns, or to follow long-term trends and health outcomes). • In any case, we would recommend seeking the input of UKAS accredited laboratories to advise on procedures and equipment. • We would recommend studies on buildings that have been retrofitted with energy efficiency measures in recent years, in order to gather data on indoor air quality and signs of mould growth and fabric degradation, if any. This could provide really valuable information to fit into the UK's expected future large-scale retrofit programmes. • It may also be useful to liaise with health practitioners to identify pilot areas where, for example, if surgeries reported high levels of respiratory disease, patients could be offered home monitoring services; similar partnerships could be sought with schools. For control, schools and surgeries with low reported levels of symptoms should also be identified and similar monitoring carried out. • For buildings subject to building regulations, we would also advocate progressing towards more testing of indoor air quality at completion, and in the future possibly in operation too (acknowledging that the operational stage currently may sit outside building regulations).
13.	*What are your views on the roles of outdoor air pollutants on the quality of indoor air in homes and schools? (Please provide supporting evidence where possible)*

	We have expanded in responses to previous questions on the inadequate provisions in Building Regulations to consider the impact of outdoor air pollution on indoor air quality. We think this means that in most buildings, particularly homes and schools that are naturally ventilated, or those with ventilation systems with little or no filters, the influence of outdoor air pollution on indoor air quality is likely to be significant. Possible references: CIBSE (1999) TM21 Minimising pollution at air intakes – **we are aware this is NOT a recent publication and it is an area we would be very happy to collaborate on.** See also our response to Question 30. https://files.datapress.com/london/dataset/understanding-health-impacts-of-air-pollution-in-london-/2015-09-29T13:18:57/HIAinLondon_KingsReport_14072015_final.pdf https://journals.sagepub.com/doi/full/10.1177/1420326X17753513 http://discovery.ucl.ac.uk/10054611/1/IBPC2018_First_Paper_EBurman_180701.pdf http://discovery.ucl.ac.uk/10026085/ https://www.pdx.edu/green-building/sites/www.pdx.edu.green-building/files/2018%20-%20IEQ%20applications_TRAP.pdf http://discovery.ucl.ac.uk/10028165/ http://discovery.ucl.ac.uk/10047043/
14.	*What are the levels of indoor pollutants that may cause short-term health effects, including the worsening of existing diseases, in infants, children and young people? (Please provide supporting evidence where possible)*
	This is not our area of expertise – we would defer to the WHO

15.	*What are the levels of indoor pollutants that are detrimental to the long-term health of infants, children and young people? (Please provide supporting evidence where possible)*
	This is not our area of expertise – we would defer to the WHO
16.	*At what level is indoor exposure to heat and/or damp/moisture detrimental to the short- or long-term health of infants, children and young people? (Please provide supporting evidence where possible)*
	This is not our area of expertise – we would defer to the WHO; see also sections 7.3 and 8.3 of our upcoming publication in Appendix, which summarise our understanding of current guidelines on recommended exposure levels (including short and long-term, where relevant and available)

Section 5: Prevention and interventions (max. 1,000 words)

17.	*Can you provide evidence of which interventions can be used to prevent the presence of harmful indoor air pollutants and reduce excessive levels of heat and moisture in homes and schools? (Please provide supporting evidence where possible)*
	<u>Air pollution</u> For more information, please refer to section 9.4 of our upcoming publication, in Appendix A. This details a recommended approach starting from site assessments, site and building layout, through to monitoring and maintenance. References are included where available on the effectiveness of interventions.

	Broadly speaking we recommend a hierarchical approach, which requires input from several disciplines in the design, construction and operational of buildings: • Site assessment • Site and building layout, to incorporate source control in the design e.g. location of sensitive uses, location of air inlets • Ventilation strategy for provision of fresh air, removal of indoor pollutants, and filtration if required • Best practice measures during construction e.g. avoiding material deterioration through protection on site; avoiding penetration of dust in air inlets; cleaning and inspection at completion; provision of information to building users and facilities maintenance teams • Monitoring, regular inspections, cleaning and maintenance Overarching principles are the precautionary principle and source control. **Moisture** Key factors are ventilation, control of sources of moisture (for those that can be controlled, accepting that some such as those related to occupant activities cannot), ventilation, and control of surface temperatures (to avoid mould growth and fabric degradation, both surface and interstitial) . See section 8.4 of our upcoming guidance in Appendix A for details and sources of further information. We would also refer to the work of the UK Centre for Moisture for the latest research and evidence. **Heat** We would refer to our publications including CIBSE TM52 and CIBSE TM59 on the prevention of excessive heat, including risk assessments to influence design and mitigation measures. See also our response to Question 6 for recent CIBSE references on this issue, particularly on the need for interventions in the regulatory framework (planning, building regulations, national adaptation plan etc).
18.	*How should homes and schools be designed, constructed and used to improve children's exposure to cleaner air? (Please provide supporting evidence where possible)*
	Please see our response to the previous question 17, and Appendix B for recommendations on the regulatory framework.

19.	*How effective do you understand filtering systems, such as personal or household devices, are at reducing exposure to indoor air pollution? (Please provide supporting evidence where possible)*
	For more information, please refer to section 9.4.7 of our upcoming publication in Appendix A. For filtration against physical pollutants (from dirst and dust to particulates, from coarse to ultra fine), we recommend referring to the latest standards on filters (BS EN ISO 16890, 2016)), which have specifically been revised in order to provide a classification more clearly related to filter effectiveness. The standards working groups could probably be contacted for evidence that led to the creation of these classes. Filtration against gaseous pollution in standard applications, such as homes and schools, is much more scares as these systems are still much less common. While a standard is available (BS EN ISO 10121 parts 1 and 2, 2013 and 2014) which gives a test method for assessing the performance of gas phase air cleaning media against gas pollutants, our experience so far is that it is not widely used; in addition, it does not provide effectiveness classes, which are a useful tool for people involved in specifying equipment. We are aware of a recent study by one of our members on effectiveness of NOx filters in residential settings, presented at our recent Build2Perform event; while small-scale and on a low budget, it provides useful information on reductions in NOx levels, even in homes which are not particularly airtight and where there is regular opening of doors and windows; we would be happy to put the working group in contact with the authors of this study . We are not aware of comprehensive studies on the effectiveness of in-room purification systems such as those claiming to filter VOCs. As a general rule we would recommend that, should high levels of harmful VOCs be found, attention should be placed on removing the source first. We would recommend caution about some products currently on the market with often unproven claims of effectiveness, for example against NOx and VOCs. At best these may have only a very small benefit, but at worse some unintended consequences such as the creation of other pollutants as by-products. Please refer to section 9.5 of our upcoming publication in Appendix A (especially page 151 and Thematic Box 9.4), and to Appendix C which summarises our current understanding of the effectiveness of plants on indoor air quality, including “tips” on what to look for when assessing such claims. Possible sources of information: Standard for air filters classification: http://www.eurovent-certification.com/en/Certification_Programmes/Programme_Descriptions.php?lg=en&rub=03&srub=01&select_prog=FIL http://www.ncceh.ca/sites/default/files/INSPQ_2010_Pollutants_and_Air_Cleaners.pdf

20.	*How can ventilation provision be used to minimise infants', children's and young people's exposure to poor indoor air quality in homes and schools? (Please provide supporting evidence where possible)*
	Please refer to our response to Question 17 for overall design principles, and to Question 9 for commonly found problems. Ventilation can support indoor air quality by providing: • Flexibility on air intakes e.g. away from polluted façade, higher on the roof : this flexibility is much higher in the case of mechanical ventilation; in naturally ventilated buildings, it is particularly restricted in the case of single aspect spaces • Filtration of outdoor air pollutants • Provision of sufficient fresh air • Extraction of pollutants from indoor sources • Ease of operation and maintenance. <u>Possible sources of information:</u> Comparing Victorian schools and low carbon design school in terms of IAQ: https://journals.sagepub.com/doi/abs/10.1177/1420326X14532388?casa_token=u-BVZjtNXHMAAAAA%3Ancpp4_r5yzGX4GHnVYe9za2LZNhxkC9vNzn_zr4fF7eN580_dVGHYGa1vg0x1LVXBh9LC7lHrEJg6ag IAQ and ventilation strategies in classrooms in London https://journals.sagepub.com/doi/abs/10.1177/0143624414566245?casa_token=PAb45zhoVb4AAAAA%3ASyqqUvTOX_QVGk7qUS_kTcixzBzK7-O7pMfCcOB5uRkpqtTauJzlQE-Ca6SLozjKz3LqpBbvEYhcRj8 Economic benefit of reducing NO2 near primary schools https://www.sciencedirect.com/science/article/pii/S0301479716303863 Executive summary report of Sinphonie project http://www.sinphonie.eu/sites/default/files/ExecutiveSummary/lbna26730enn.pdf
21.	*Are you aware of any evidence on the clinical efficacy and effectiveness of interventions to reduce exposure to, and/or health effects of, poor indoor air quality for infants, children and young people in homes and schools? (Please provide supporting evidence where possible)*

	No – our expertise focuses on their effectiveness on the indoor environment, not on the ultimate outcome i.e? clinical efficacy and effectiveness
22.	*Should we seek to try to remove all pollutants or just some, based on their effect on the health of infants, children and young people? (Please provide supporting evidence where possible)*
	We think that for all pollutants raising concern, as a minimum as covered by the WHO, the ultimate aim should be to bring levels to recommended guidelines, or lower. Judgments can be made on a case by case depending on the practicalities of this, which pollutants are present in excessive levels, and which ones are likely to cause the most detrimental effect. We would also emphasise that the best strategy is control at source, i.e. avoiding the introduction of the pollutant, rather than removing it as the question implies.
Section 6: Interacting factors (max. 1,000 words)	
23.	*Across environmental, climate, construction and health and safety legislation in the UK, what is currently in place that relates to indoor air quality? Are you aware of any other relevant legislation or policy?*
	There is no comprehensive regulatory approach to indoor air quality in the UK (with radon an exception). The recent review of Building Regulations and Fire Safety, undertaken by Dame Judith Hackitt in the aftermath of the Grenfell Tower fire, shows in some detail how fragmented, siloed and lacking in co-ordination the current regulatory regime is across construction and operation of buildings. It is no better in relation to ventilation and air quality. Please refer to Appendix B for a summary of our recommendations to address this in Building Regulations, and to our upcoming publication in Appendix A for a summary of the regulatory framework (section 9.2), limits in place (section 9.3) and voluntary product standards and labels (thematic box 9.2). Broadly speaking, the framework includes: • Radon regulations

	• Workplace exposure limits (COSHH). http://www.hse.gov.uk/coshh/basics/exposurelimits.htm • Building Regulations Part F • Product standards and chemical safety data sheets http://www.hse.gov.uk/coshh/basics/datasheets.htm • Planning framework • Voluntary schemes, such as BREEAM & WELL, and product labelling
24.	*What do you understand is the true cost (both direct and indirect) of poor indoor air quality to infants, children and young people? What metric(s) best represents this cost?*
	This is not our area of expertise. We understand DALY and QALY are the most commonly used metrics, and they are useful for overall trends at the population level, but we also understand their limitations (including the difficulty of communicating accurate but simple messages to the public on issues such as "deaths which are *attributable to*", or translating DALYs into "equivalent number of deaths").
26.	*How do the risks of poor indoor air quality inform building and furniture design decisions? (Please provide supporting evidence where possible)*
	As detailed in previous questions, there is little from a regulatory perspective, and our understanding is that the influence of air quality on building and furniture decisions is largely limited – see Appendix B and response to Question 2. As previously noted, we believe that a stronger framework in building regulations would help not only new buildings, but also support the development of a supply chain that would benefit the whole market, including existing buildings. We have received anecdotal evidence that some local authorities have recently started to impose more requirements as part of the planning system, but this is not yet widespread and only concerns buildings that are subject to planning application, rather than the vast majority of the housing and schools building stock. There is some influence from voluntary and market drivers e.g. the WELL Building standard, product labels – see details in response to the previous question; however, this is currently only addressing a very small proportion of the market, such as high-profile commercial offices or individual concerned residential homeowners.
27	*How do you do so alongside efforts to improve energy efficiency?*

The focus should be on ventilating for people, not ventilating the space (except in some very specific applications, such as laboratories). This means paying attention to air flow and the breathing zone, and incorporating measures such as demand control which can provide sufficient ventilation when needed, and reduce it when possible to reduce energy consumption.

We would also note that buildings should be energy efficient at delivering an environment that is fit for purpose, not one that compromises the health of occupants. Energy efficiency and ventilation need to be considered together, and one should not be pursued at the expense of the other. Again, to quote Dame Judith Hackitt, there is a need for buildings to be seen as systems, which need to able to be occupied and operated safely. That means that they should be ventilated appropriately and adequately in an energy efficient manner. Recent revisions to the Energy Performance of Buildings Directive will require energy regulations to take account of indoor air quality and comfort.

There may be areas where compromises will be needed between energy consumption and air quality, for example in terms of ventilation rates and filtration. However, we would highlight there are important synergies:

- a simple system which is easy to operate and is well-maintained will benefit energy consumption, comfort, and indoor air quality ; we believe this is of primary importance.
- an airtight building, as long as it is accompanied by good ventilation, will help not only energy efficiency and thermal comfort, but also prevent the uncontrolled ingress of outdoor pollutants.
- A well- insulated building with attention to avoid thermal bridges will limit the risk of condensation, mould growth, and fabric degradation, as well as improving comfort and reducing energy consumption for heating.

For recent examples of best practice, see for example the studies by Architype of several schools, which reported on energy consumption and indoor air quality (using CO2 as indicator). This shows very good levels of energy consumption as well as air quality and thermal comfort (see details in https://architype.co.uk/project/wilkinson-primary-school/ and https://www.cibsejournal.com/case-studies/a-lesson-in-passivhaus-award-winning-wilkinson-primary- school/).

In addition to the references already provided in Appendix, CIBSE have a number of publications on energy efficient design and ventilation, including Guide F and Guide B.

Possible other sources of information:

TOP project : https://www.ucl.ac.uk/bartlett/environmental-design/top-total-performance-low-carbon-buildings-china-and-uk

http://www.iea-ebc-annex68.org/ - Annex 68

Section 7: For respondents with technical building expertise

28	*What do you understand are the most appropriate metrics for describing indoor air quality?*
	We understand the most appropriate from a health perspective are pollutant levels, and how they relate to guidelines such as those from the WHO, even if there are limitations such as accounting for people with different sensitivities and accounting for cumulative effects of exposure to several pollutants. From a practical point of view this can be difficult for people involved in the design, construction and operation of buildings, therefore some simplifications often have to be made for high-level assessments before focusing on particular pollutants if needed, for example using indicators such as CO2, humidity and TVOC levels. It should be clear these are simplifications, not reliable assessments of indoor air quality; moreover, CO2, humidity and TVOC are mainly indicators of indoor sources and whether ventilation is effective at addressing these sources, not the impact of outdoor sources on the indoor environment. Overall, the usefulness of indicators will very much rely on the context of the building (e.g. building location and outdoor sources, building use, occupancy density, type of indoor materials etc). Similarly, user feedback is still often used by practitioners to gauge air quality; while this may be appropriate to gauge user satisfaction, CIBSE are working to increase awareness among practitioners that this should not be seen as a metric of "air quality", since many pollutants with detrimental health effects will not be perceived. We are aware of attempts to create single, multivariable metrics such as that developed by the Annex 68 group (http://www.iea-ebc-annex68.org/subtasks/defining-the-metrics) but do not know enough about it to comment on it. <u>Possible additional reference:</u> https://www.nist.gov/publications/challenges-development-ventilation-and-indoor-air-quality-standards-story-ashrae
29	*How are homes and schools designed to provide the best indoor air quality? What are the main drivers for design?*
	Because of the lack of regulatory framework (see Appendix B and response to Question 2, this varies significantly between projects and will often be limited. Commercial offices, particularly high-end ones, increasingly use voluntary drivers such as the WELL Building Standard, which gives much attention to indoor air quality including maximum levels of certain pollutants, ventilation rates, monitoring of CO2 etc.

	In schools, more attention to indoor air quality may be expected due to the recent publication of revised guidance, BB101 (Section 6.1 Indoor and outdoor air quality guidelines), and the ESFA's Output Specification Generic Design Brief (Section 2.7.5 Indoor Air Quality) and Technical Annexes. Some local authorities have recently started giving more attention to indoor air quality in their planning decisions, but this is still the case in only a small number of local authorities and typically only for some building uses (e.g. homes).
30	*What external factors (e.g. roads, building form, urban design and urban heat island) may affect indoor air quality? (Please provide supporting evidence where possible)*
	See Chapter 6 and section 9.4.2 of our upcoming publication in Appendix A. Urban micro-climates are a significant area where more guidance and knowledge would be extremely useful to bridge the gap between general principles and high-level rules of thumb on one end, and very project-specific, resource-intensive CFD modelling on the other end. We are supporting developments in this area and would be very happy to discuss further opportunities for collaboration. <u>Possible recent sources of information</u> CIBSE (1999) TM21 *Minimising pollution at air intakes* – **we are aware this is NOT a recent publication and it is an area we would be very happy to collaborate on**. MAGIC and REFRESH academic research projects – we are aware these will be well-known to some of members of the RCP & RCPCH working group! Ruth Calderwood, City of London corporation: project monitoring air quality across the City of London Edge debate, November 2018: Urban Form, Density & Microclimate – http://www.edgedebate.com/?p=3412 CIBSE Resilient Cities & ARCC event, January 2017: Urban microclimate: overcoming obstacles to high density resilient cities https://arcc.ouce.ox.ac.uk/people-making-changes/urban-micro-climate/ Trees, urban design and air quality: *First steps in urban air quality*, by the University of Birmingham and the Trees and Design Action Group http://www.tdag.org.uk/first-steps-in-urban-air-quality.html

	Traffic related air pollution and urban building design: https://www.pdx.edu/green-building/sites/www.pdx.edu.green-building/files/2018%20-%20IEQ%20applications_TRAP.pdf
31	*In relation to urban environments in the UK where outdoor air is more polluted than indoor air, at what air change rate does ingress of pollutants outweigh the reduced exposure benefits of ventilation? (Please provide supporting evidence where possible)*
	The question implies natural ventilation, or mechanical ventilation without filters. We cannot judge as "outweigh" would imply we know relative health effects, which is not our area of expertise. Furthermore, it is difficult to provide a single answer since it will depend, among other factors, on the pollutants present from indoor sources, at what levels, and whether they are more or less harmful than outdoor pollutants. Occupant feedback (e.g. "stuffiness", smells) would also have to be taken into account even if, from a health perspective, levels may be acceptable. Recent and upcoming developments in standards such as BS EN 16798-1 (upcoming) and ISO 17772:2017propose procedures for establishing a ventilation strategy, with reference to WHO guidelines.
32	*Can you provide any experimental evidence (not modelled) of how different levels of air changes per hour impact on indoor air quality? (Please provide supporting evidence where possible)*
	This is obviously a vast topic; there would be information in the references quoted in our responses to the previous question. In addition, the following sources may include useful information https://ws680.nist.gov/publication/get_pdf.cfm?pub_id=917750 - Air change rate impact on VOCs. Particular attention to Figure 4. https://www.sciencedirect.com/science/article/pii/S1352231007011466 - Air change rate and formaldehyde relationship in Canada https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1600-0668.1999.00003.x - Association of ventilation rates and CO2 concentrations with health covering 30,000 subjects. https://onlinelibrary.wiley.com/doi/10.1111/ina.12202 - Ventilation rate in day care and sick leave among nursery children https://onlinelibrary.wiley.com/doi/10.1111/j.1600-0668.1997.00007.x - Radon and naturally ventilated buildings

33	*Are there data demonstrating seasonal variation in the presence and levels of indoor air pollutants? If so, does this vary on a daily temporal basis or based on the different climate regions of the UK? (Please provide supporting evidence where possible)*
	Evidence of seasonal variations: • VOCs: Total VOCs (TVOC) concentrations can vary significantly with the season, affected by variations in off-gassing with ventilation, temperature and humidity (Coward S K D, Brown V M, Crump D R, Raw G J and Llewellyn J W, BR 433, Indoor air quality in homes in England; volatile organic compounds (Garston: BRE) (2002); Dimitroulopoulou C, Crump D, Coward S K D, Brown V, Squire R, Mann H, White M, Pierce B and Ross D, BR 477 Ventilation, air tightness and indoor air quality in new homes, BRE bookshop ; Jamieson SS, Dimitroulopoulou S, Brown, VM, Simon HM and Colvile RN (2005) 'Levels of indoor VOCs in workplaces in a polluted urban area of London' Indoor Built Environment 14 (3/4) 259–268 • Outdoor pollutants, typical ratio of summer:winter mean concentration: see CIBSE TM21, 1999 though this may be in need of an update • https://onlinelibrary.wiley.com/doi/10.1034/j.1600-0668.2003.00206.x - Seasonal cycle of VOCs in apartments • https://onlinelibrary.wiley.com/doi/10.1111/j.1600-0668.1994.t01-3-00003.x - Seasonal and yearly indoor NO2 from New Mexico
34	*Is there experimental evidence (not modelled) of how pollutants infiltrate from outdoors into indoor home or school environments? (Please provide supporting evidence where possible)*
	We are not aware of such studies
35	*Are there any other specific issues relating to indoor air quality in homes and schools that you wish to draw to the Working Group's attention, that are not covered by the questions above? (Please limit to 200 words)*

	We would be very happy to support this work and discuss how best to collaborate. In particular, we would point to the topics we have identified as warranting more research and development, highlighted as “emerging themes” in sections 6.4, 8.5 and 9.5 our upcoming publication, Appendix A.

APPENDICES

APPENDIX A: Upcoming CIBSE Guide on Health and Wellbeing in Building Services: link to dropbox folder provided by email alongside this submission

APPENDIX B: CIBSE position paper on Building Regulations Part L and F, November 2018: https://www.cibse.org/getmedia/4a601f5c-a866-41a2-8cf7-1bab17f4f57e/Position-Paper-on-Building-Regulations-Part-L-F.pdf.aspx

APPENDIX C: Plants and indoor air quality, CIBSE presentation at Ecobuild, March 2018: attached to email alongside this submission.