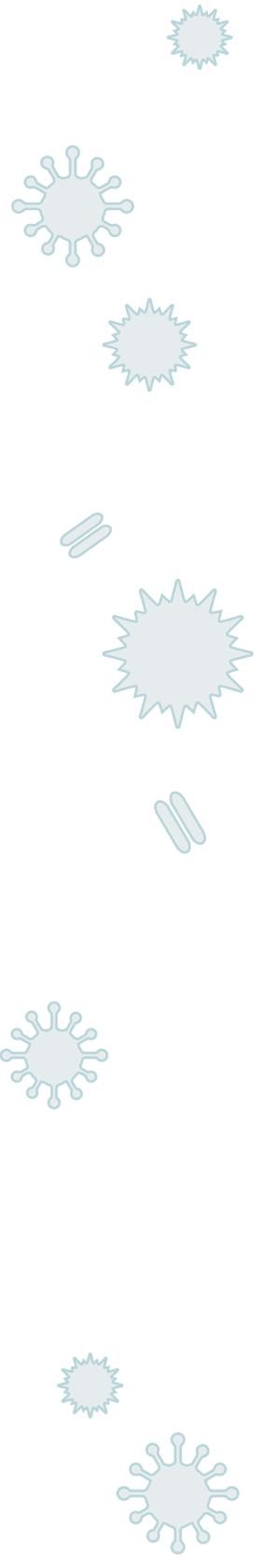


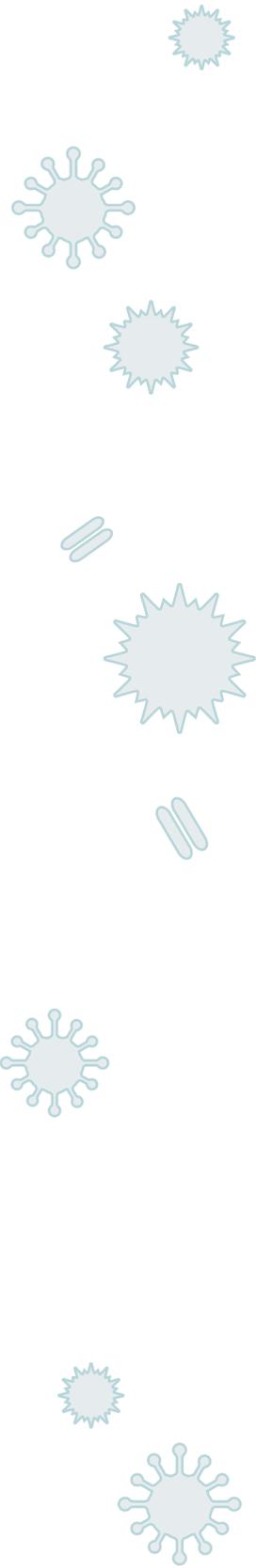
Co-ordinating Research Action: Air Quality & COVID-19



Contents

1. Executive summary	3
1.1 Background	3
1.2 Research priorities and knowledge gaps	3
1.3 Calls to action	4
2. Introduction	7
3. Background	8
4. Workshop process	10
4.1 Agenda	11
4.2 Delegate information packs	12
5. COVID-19 context in the UK: Summary of presentations and reflections from invited speakers	13
5.1 Stephen Holgate and Jenny Baverstock Clean Air Champions	13
5.2 Cath Noakes University of Leeds	14
5.3 Sani Dimitrolopoulou Principal Environmental Health Scientist – Indoor Environments, Public Health England	17
5.4 Ally Lewis Air Quality Expert Group	19
5.5 Mike Holland Committee on the Medical Effects of Air Pollutants COVID Group	20
5.6 Matthew Hort Met Office	21
6. Potential applications of STFC capability	23
6.1 SAQN Collaboration Building Workshop	23
Annex 1: Delegate list	25
Annex 2: Discussion board content	51
1. Lockdown – many vulnerable remain on full lockdown and there could be periods of recurrence where lockdown needs reinstating	51
2. Recovery – including how recovery can have multiple benefits, reducing pollutant emissions, improving health and wellbeing and enabling climate action	60
3. Longer term – including lessons to be learnt for pandemic management of communicable diseases	70
4. Next steps & Matchmaking room – review, and add to, the ideas for action to address the identified lockdown, recovery and longer term knowledge gaps.	78

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1. Executive summary

1.1 Background

Air quality is relevant to the pandemic for two reasons. Firstly, the quality of the air indoors and out is important in creating, sustaining or inhibiting conditions for virus viability. Secondly, air pollution is a potentially significant environmental risk factor for groups socio economically and physiologically vulnerable to COVID-19, including those with underlying respiratory or cardiovascular diseases.

Unprecedented changes in living and working patterns during the pandemic are likely to have had a significant, but as yet unquantified, effect on air pollution and our exposure to it. There are questions crucial to our nation's public health that need an interdisciplinary scientific response. Yet there is no UK group with a remit to coordinate across the many disciplines that need to co-operate to address COVID-related air quality knowledge gaps.

On 20 May 2020 an [online workshop](#) was held to begin coordinating research action on the interactions between air quality and COVID-19. The workshop was run by the Science and Technology Facilities Council (STFC) [Air Quality Network](#) (SAQN) in partnership with the [UK Indoor Environments Group](#) (UKIEG) and [Air Quality Network UK](#) (AQN UK) in response to requests by the UK Research and Innovation (UKRI) [Clean Air Champions](#).

The purpose of the event was twofold. Firstly, to convene the UK-based research community and establish the current state of knowledge. Secondly, to begin coordinating priority actions that will address critical knowledge gaps. The event was open to researchers in industry, policy, third sector and academia. International participants were welcomed where they could address COVID-related air quality challenges of national importance. In total there were 239 registrants, and over 170 live attendees.

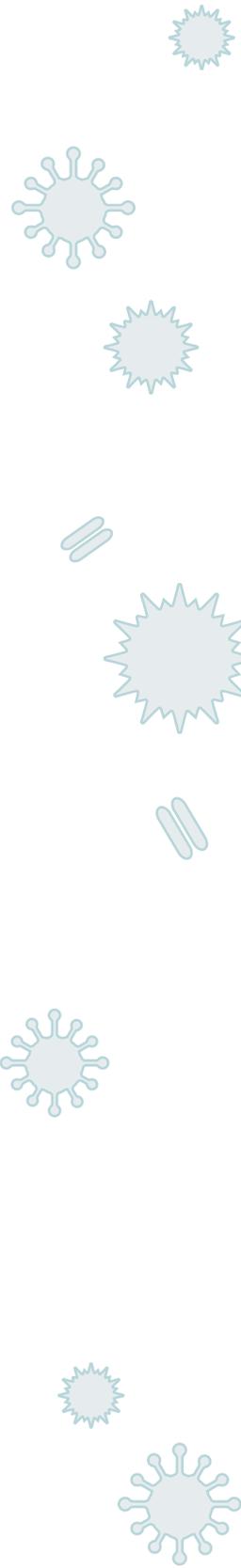
Prior to the workshop delegates completed registration forms capturing initial thoughts on key research priorities and knowledge gaps. The first part of the meeting was held in plenary with invited speakers¹ and provided the context for later discussions conducted via breakout rooms and digital discussion boards. The latter were pre-populated with ideas from the delegate registration forms and were further populated during and after the event.

1.2 Research priorities and knowledge gaps

Several key research priorities and knowledge gaps were identified by workshop participants, which can be grouped into three interconnected areas:

1. How environmental factors – e.g. outdoor/indoor pollutants, hygrothermal conditions, ventilation and airflow – affect the virus survival, transmission and exposure mechanisms, as well as associated health outcomes. For example:

¹ Note: this document reflects the points discussed at the online workshop on 20th May. The calls to action do not necessarily represent the views of the individual speakers involved in the plenary session.

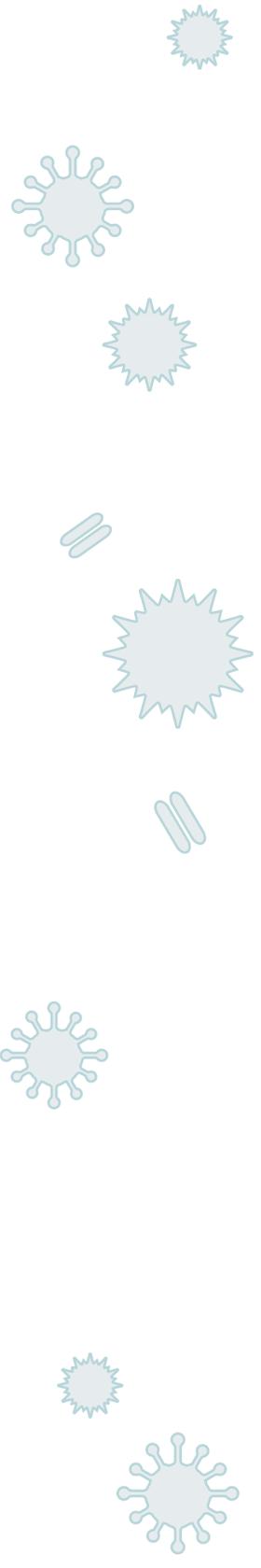


- To what extent air pollution outdoors and indoors affects viral transmission and/or associated health outcomes?
 - How do environmental factors such as airborne pollutants, temperature and/or humidity, increase/reduce virus viability and/or risk of transmission?
2. The extent, significance and overall net effect of changes in emission and exposure patterns, resulting from current lockdown policies, through to the recovery period and the emerging 'new normal' in the upcoming years. For example:
- Was there a significant net reduction in UK outdoor pollution levels during the COVID-19 lockdown period, and if so could we build on any lessons learnt, in order to support policies to reduce pollution in the near future?²
 - Was there an increase in exposure to indoor pollutants, especially within residential environments, during lockdown and/or shielding, due to prolonged time indoors and/or changes in activities at home? Could this have adverse health effects and to what extent can this 'natural experiment' be used to understand further the impact of indoor air quality and the overall impact of the pandemic on public health?
 - How will the recovery period, any further waves of infection and/or the emerging 'new normal', change how we use environments such as the workplace (including home working), schools, public spaces or transport? What will the impact of this be on outdoor and indoor emissions and exposures?
 - How do we design and test interventions so that they are simultaneously able to reduce the spread of the virus alongside maintaining comfortable and healthy working, learning and domestic environments, whilst also addressing – rather than contributing to – the challenges posed by fuel poverty and climate change mitigation/adaptation?
3. Longer term: impacts on air quality of societal, environmental and economic changes arising from COVID-19 and any other relevant policies. These include:
- What are the synergies and tensions with climate action and sustainable development, particularly with regard to climate change adaptation and green recovery?
 - How can we better identify and protect vulnerable populations from the cumulative effects of poor air quality and other inequalities as well as infectious diseases?

1.3 Calls to action

Based on the research priorities and associated suggestions arising from the discussion, the following Calls to Action were formulated, which are primarily relevant to researchers and research funding organisations, with some aspects being also relevant to local and national government:

2 Since the meeting was held, [AQEG have published their report](#) following the rapid call for evidence on Air Quality and COVID-19. The report contains evidence regarding UK outdoor pollution levels, and will be valuable in terms of building on lessons learnt in the future.

- 
1. Better and more comprehensive data on air quality and exposure is urgently needed, especially for indoor environments. This will require:
 - 1.1. Building upon and broadening the current urban-focused air quality research supersites; setting up a suite of nation-wide representative sites, indoors and out, paired wherever possible, in urban and rural locations, for long-term multi-observation monitoring of air quality.
 - 1.2. Agreeing on minimum standards and harmonised protocols for monitoring indoor air, to be adopted in separate monitoring campaigns and individual research projects;
 - 1.3. New networks of intensive, and, or, high resolution monitoring stations in representative indoor public spaces are needed to understand the occurrence and transmission pathways of the virus in indoor environments, and any potential links with environmental factors including air pollutants. This will necessitate active sampling of air, as well as the swabbing of surfaces and could include other forms of sampling;
 - 1.4. Running citizen science projects using low-cost sensors in homes and schools to help build a better understanding of indoor air quality and its significance for public health, to increase public awareness.
 2. Connecting existing air quality models and data to inform predictions
 - 2.1. Optimise collection and unify curation of the many types of relevant air quality models and data on both emission generating activities and exposure. For example, any data regarding the initial lockdown period, to help model emissions and, or, exposures and the associated health and societal impacts before, during and after lockdown. This could help inform approaches in the eventuality of a further wave of infection. Such information could include data from smart meters, household surveys, time use diaries, any other relevant personal exposure studies alongside outdoor pollution data from established and new air quality ground-based monitoring instruments and other Earth observation devices such as satellites.
 - 2.2. Air quality data and models should be used to help address questions such as:
 - a. What is the net impact of working from home, in terms of indoor/outdoor emissions and personal exposure?
 - b. Does exposure to poor air quality make people more susceptible to COVID-19 and does it impact the severity of disease? And/or;
 - c. Are any links between COVID-19 incidence and air pollution attributable to other factors such as housing conditions and social inequality?
 3. Control strategies indoors and potential links with other issues
 - 3.1. There is emerging evidence that increased ventilation, bringing external air into buildings, may help control viral transmission but information is needed on air volumes and optimal ventilation rates versus indoor occupancy levels.



3.2. Optimum ways should be identified of managing building ventilation through different seasons, and especially in winter, in the context of the UK's Net Zero commitment and inequalities such as fuel poverty. Consideration must be given to tailoring such strategies to natural as well as mechanical ventilation as the vast majority of buildings in the UK are naturally ventilated;



3.3. Interventions such as regulation, standards and policies are needed to ensure that buildings and other public enclosed and semi-enclosed spaces (e.g. transport forms and stations) are designed/retrofitted and managed to combat exposures to poor air quality and reduce viral transmission risk.



4. Policies and tools for harnessing co-benefits; transforming shorter-term changes in behaviours into longer-term collective lifestyle and workplace changes.



4.1. Identification of policies and digital and non-digital tools, which can build on any positive changes in travel mode and/or emissions/exposures arising from lockdown and recovery policies, thus engraining positive changes in daily life, travel and work in the long term for improved indoor and outdoor air quality and better health and wellbeing;



4.2. Strategies or incentives should be introduced to test for, and mitigate the risk of, unintended consequences of COVID-19 policies on air quality emissions/exposures, particularly for socio-economically disadvantaged groups;



4.3. Interventions such as strategies, tools and policies are needed to increase public awareness and understanding of the value of good air quality, informed by improved access to current and future robust evidence on the links between air quality and the COVID-19 pandemic.





2 Introduction

On 20 May 2020 an online workshop was held to begin coordinating research action on the relationship between air quality and COVID-19. The workshop was run by the Science and Technology Facilities Council (STFC) Air Quality Network (SAQN) in partnership with the UK Indoor Environment Group (UKIEG) and Air Quality Network UK (AQNUK) in response to requests by the UK Research and Innovation (UKRI) Air Quality Champions.

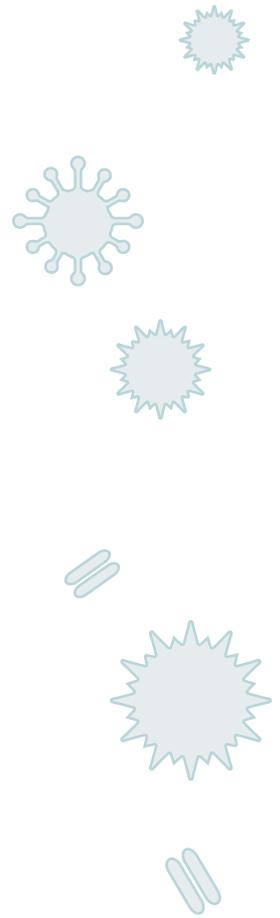
The purpose of this event was twofold:

1. To convene the UK-based research community and establish the state of knowledge of the interplay between air quality (indoors and out) and COVID-19, leading to implications for the management of air quality during a global pandemic.
2. To assist the research community in coordinating priority action to address critical knowledge gaps.

The event was open to researchers in industry, policy, third sector or academia, particularly those based in the UK or affiliated with a UK research network. International participants were welcomed, especially those able to contribute expertise to address COVID-related air quality challenges of national (UK) importance. Table 1 summarises the registrations received by sector.

Table 1. Registered participants by sector

Sector	Number registered (n.)	% Registered delegates
Research	126	53
Public sector	63	26
Industry	38	16
Third sector	12	6
Total	239	(100%)



3. Background

In April 2020, the Air Quality Expert Group (AQEG), acting on a request from the Department for Environment, Food and Rural Affairs (Defra), conducted an urgent call and review of evidence from the research and air quality management user communities on recent and ongoing changes in UK air quality related to the lockdown restrictions. The reported evidence (AQEG 2020³) shows that there was a drop in the emissions and concentrations of some pollutants and a possible associated drop in individual exposure to pollutants. A contribution to the report by the Committee on the Medical Effects of Air Pollutants (COMEAP) suggested the possibility that past exposure to air pollution was likely to impact on Covid-19 but noted the need for further studies and evidence on this.

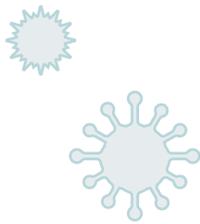
The Environment, Food and Rural Affairs (EFRA) Select Committee has since launched an inquiry into Air Quality. The Committee are scrutinising whether the Government's 2019 Clean Air Strategy and the Environment Bill will deliver the national leadership needed to urgently tackle the UK's poor air quality. The Committee is calling for evidence from the COVID-19 pandemic about the current and emerging risks and opportunities for air quality posed by:

- Short-term policy and societal changes in response to the pandemic, for example changes to transport to reduce the risk of transmission, and;
- Medium and long-term actions to promote economic recovery.



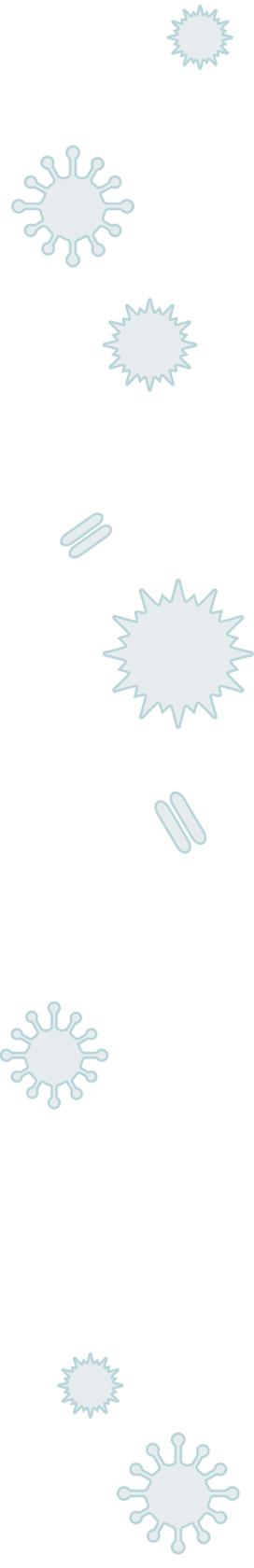
As these calls for evidence demonstrate, expertise in air quality emissions and exposure, is vital for informing Government's management of the Covid-19 pandemic and economic recovery. Yet, within the UK, there has been no group with a remit to coordinate the many disciplines (air quality, virology, aerosol, metrology, climate, meteorology, health and built environment) required to:

- a. determine the current state of knowledge on possible interactions between air quality (indoor and out) and the virus;
- b. identify evidence gaps and
- c. make recommendations for necessary rapid responses and the longer term research agenda.



Air quality, indoors and out, is an important factor in creating, sustaining or inhibiting ambient conditions for virus viability. Air pollution has been identified as a potentially significant environmental risk factor for vulnerable groups to COVID-19, including those with underlying respiratory or cardiovascular diseases. Outdoor air pollution can also impact on indoor environments, in which the nation has spent more time during lockdown, and many vulnerable continue to spend time in whilst self-isolating. Furthermore, AQEG acknowledges that unprecedented changes in living and working patterns during the

3 Estimation of changes in air pollution emissions, concentrations and exposure during the COVID-19 outbreak in the UK

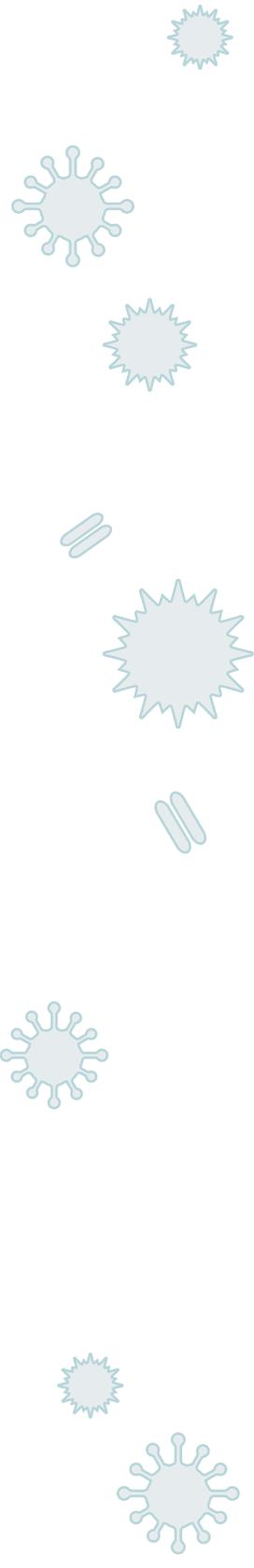


COVID-19 pandemic are likely to have had a significant, but as yet unquantified, effect on air pollution in the UK.

Since the start of lockdown, it is likely that the UK population will have experienced different patterns of exposure to poor air quality compared with the period before March 2020. For instance, it is possible that whilst there may have been reductions in a number of outdoor pollution levels, resulting from significantly decreased use of private motor vehicles and reduced industrial activity, these could have been offset by greater exposure to indoor sources of pollution as people have spent much more time at home, and may have more frequently used cleaning products.

Knowledge of these exposure changes is crucial to inform more accurate assessment of, and measures to manage, the potential health impacts of air quality and pollution in the coming months. For instance, some built environment professionals and researchers are advocating greater ventilation rates to limit the exposure to, and, or levels of, the virus within buildings. However, if unfiltered, as we move towards recovery, as traffic volumes increase and industry activity resumes, enhanced ventilation may result in greater exposure to outdoor pollutants than before the pandemic. Increased use of cleaning products in buildings, in homes, in schools, in workplaces, may also raise some indoor air quality concerns due to higher levels of associated pollutants. In addition, the variety and levels of pollutants, and degree of exposure, can be further impacted by environmental conditions, particularly heat and moisture both outdoors and indoors. This complex combination of factors acting on indoor and outdoor air quality has the potential to impact virus viability, transmission and immune system response.

The pandemic has highlighted the current absence of coordination across the indoor and outdoor air quality academic communities with regard to indoor environments, infectious pollutants and the efficacy of air quality management for communicable and non-communicable diseases. There are vital questions, crucial to pandemic management and our nation's public health, that need an interdisciplinary scientific response, from across the indoor and outdoor air quality and health research communities, in consultation with other areas of expertise. This workshop was held to initiate the coordinating research action on the relationship between air quality and COVID-19.



4 Workshop process

Ongoing government restrictions on gatherings in the UK meant that the workshop was held using online video conferencing. Prior to the workshop delegates were required to complete registration forms. As well as capturing contact information about the attendees, the registration forms asked delegates to provide a profile highlighting their air quality or COVID-relevant research expertise. The form also captured early thoughts on key research priorities and knowledge gaps for air quality and Covid-19 during lockdown, recovery and in the longer-term.

Registration data was taken from the 210 participants who had registered on 19 May. Participant sector data was cleaned so that all participants were assigned to one of four sectors: research,⁴ public sector, industry or third sector.

The first part of the meeting was held in plenary and provided the context for later discussions. The workshop was challenge-led, therefore all of the speakers focused on the big research challenges that exist regarding air quality and COVID-19 from a range of different perspectives.

There were two methods used to facilitate wider discussion.

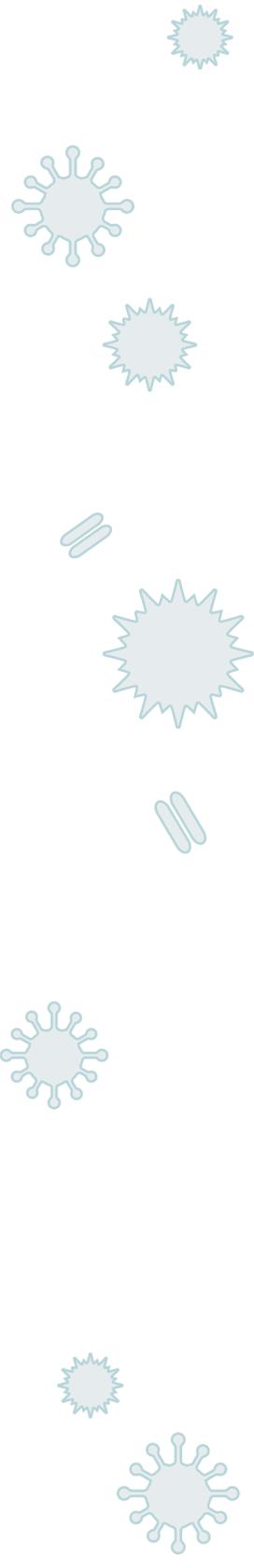
1. Breakout rooms within the video conferencing application provided delegates with an opportunity to discuss ideas in small groups.
2. An online discussion board allowed delegates to record their contributions, and enabled others in the meeting to make comments and vote for their favourite ideas.

The online discussion board had been pre-populated with ideas taken from the delegate registration forms and time was given during the workshop in a breakout session for participants to take a look at, and contribute to the discussion board.

On the discussion board, ideas were organised into four discussion topics, according to which phase of the pandemic response they related to (#Lockdown, #Recovery, #Long term, #Next steps). Within each of these topics there were four subsections pre-determined from a thematic analysis of the registration form information (for full coding method and themes see Annex 2):

- Covid-19
- People & activities
- Pollutant sources and
- Pollutant exposure

4 All of the self-identified researchers were classed as research whether or not they were from an academic institution and all that identified as consultants were classed as industry.



After the breakout session, very brief summaries of the participant contributions to the online discussion board topics were given in plenary.

The workshop ran between 14.00 and 16.00 and the presentations were recorded for those who could not attend in real time. The online discussion board was left open for one week following the event to capture further thoughts from delegates, and as a means of matchmaking between researchers.

4.1 Agenda

Event chair: Marcella Ucci

13:50 Zoom meeting opened for participant entry

14:00 Part 1: Welcome and context

UKRI Clean Air Champions

Professor Stephen Holgate | Medical Research Council Clinical Professor of Immunopharmacology at the University of Southampton

Professor Martin Williams | Head of Science Policy and Epidemiology team at King's College London and former Head of the Air Quality programme at the Department for Environment, Food and Rural Affairs

Dr Jenny Baverstock | Senior Collaboration Fellow at the University of Southampton.

Brief summary of CV-19 context in the UK

Professor Catherine Noakes | University of Leeds

Sani Dimitroulopoulou | Principal Environmental Public Health Scientist – Indoor Environments, PHE

Prof Ally Lewis | Chair, Defra Air Quality Expert group

Mike Holland | Committee on the Medical Effects of Air Pollutants COVID group

Scenarios to be considered – pandemic & concurrent risks

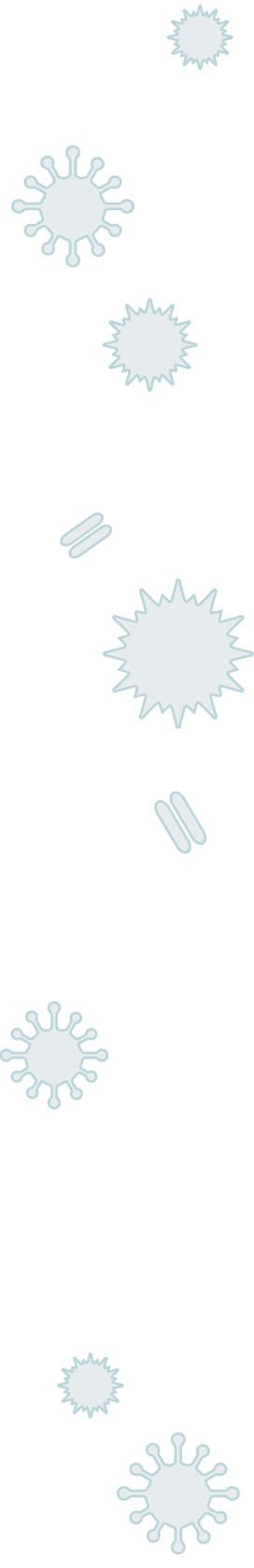
Dr Matthew Hort | Head Atmospheric Dispersion and Air Quality, Met Office

14:50 Part 2: State of knowledge

Present state of evidence and knowledge – summary of themes that emerged from the registration questions

Key knowledge gaps:

- Lockdown period
- Recovery
- Longer-term pandemic management including incidence of resurgence



Most critical knowledge gaps

15:30 Part 3: Research Community Action

Ideas for research action to tackle the most critical gaps

Lessons to be learned for air quality and communicable and non-communicable diseases research

15:50 Summary and next steps

15:55 Funding landscape for research

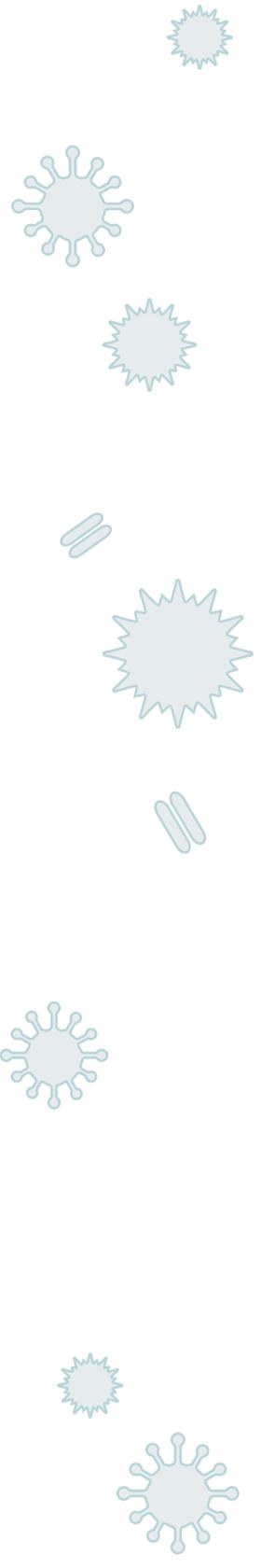
16:00 Meeting closes

For those who wish to remain and network, you will be put in breakout rooms of up to 10. These will be closed at 5pm.

4.2 Delegate information packs

Delegate information packs were sent electronically to all those registered for the event. The pack included:

1. Instructions about how to join the online conference, including a telephone number for those without a reliable internet connection. An email address was provided for any technical questions prior to the meeting.
2. The procedure for asking questions or making comments during the meeting, using the chat function in the online video conferencing platform. Delegates were requested to pre-face their contributions with one of the following 'Q' (question), 'DP' (response to a point made) or 'CQ' (clarifying question). This made it easier for questions to be directed appropriately.
3. Details of the online discussion board, where most of the inputs from delegates were recorded.
4. Suggested ways to use social media. The meeting was run according to Chatham House rules, to encourage openness in discussion and sharing of ideas. Delegates were asked not to share screen shots of the discussion board on social media. However, tweets about attending the event or related news were welcomed, using @STFC_AQN, @theUKIEG or #AQCv-19.
5. Background information about the meeting convenors (STFC, UKIEG and AQNUK).
6. The meeting agenda.
7. Suggested pathways to research action, including links to appropriate funding calls and information on the UKRI Clean Air Programme.
8. A list of delegates broken down by sector, including information on research interests taken from the registration forms.



5. COVID-19 context in the UK: Summary of presentations and reflections from invited speakers

5.1 Stephen Holgate and Jenny Baverstock | Clean Air Champions

Air pollution is the most important environmental public health issue in the UK, and the Clean Air Programme is a £42.5m initiative funded through the Strategic Priorities Fund that was launched about two years ago. It is a partnership between UKRI, The Met Office and the National Physical Laboratory. As part of the programme, clean air champions were appointed through a competitive process to catalyse interdisciplinary air quality research and innovation and leverage existing investments across the whole of the UK, to develop clean air solutions and provide information to government to inform their clean air strategy.

The clean air champions are:

- **Dr Jenny Baverstock** | Senior Research Fellow at the University of Southampton.
- **Professor Stephen Holgate** | Medical Research Council Clinical Professor of Immunopharmacology at the University of Southampton.
- **Professor Martin Williams** | Head of Science Policy and Epidemiology at King's College London and former Head of the Air Quality programme at the Department for Environment, Food and Rural Affairs.

The COVID-19 pandemic, and the measures introduced to control it, have had large impacts on air quality. This presents opportunities for new research to help drive forwards the clean air agenda.

During the months of lockdown nitrogen dioxide concentrations in London have fallen by 21.5% on average. PM2.5 concentrations have however increased for two reasons. Firstly, during the cold period at the start of lockdown an increase in domestic wood burning led to raised levels of PM2.5 in our residential areas, and secondly weather patterns have blown in particulates from Eastern Europe. Ozone concentrations have also increased in our towns and cities during the same period.

Not only have the concentrations of outdoor pollutants changed but our exposure has changed due to the disruption in our daily routines. More time spent indoors in the home environment has increased our exposure to domestic sources of pollution, for example from cooking.

In terms of research, how can we make the most of this period in the UK, and also look at changes abroad? For the latter this is especially true for countries, such as China, that are significantly ahead of the UK in terms of recovery.



Generally people are becoming more interested in their environment. There is an appetite to change amongst the public. How can we capitalise on this to introduce some behavioural aspects to the research?

We should not underestimate the importance of communication and the language that is used between communities across interdisciplinary activities. Currently there are barriers particularly between the atmospheric scientists and the health and medical scientists. Anything that can be done to draw together these communities by the language that we use would be beneficial. It is important to bring in social science, psychology and economics into the discussion, as these are essential to the drivers of societal change.

Speaker reflection – Dr Jenny Baverstock:

“ Covid-19 is a grave burden to society across the globe, but from the experience of various degrees of lockdown, a picture is beginning to emerge of what cleaner air is like and how society can use this as an opportunity of moving towards zero carbon without returning to the old ways.”

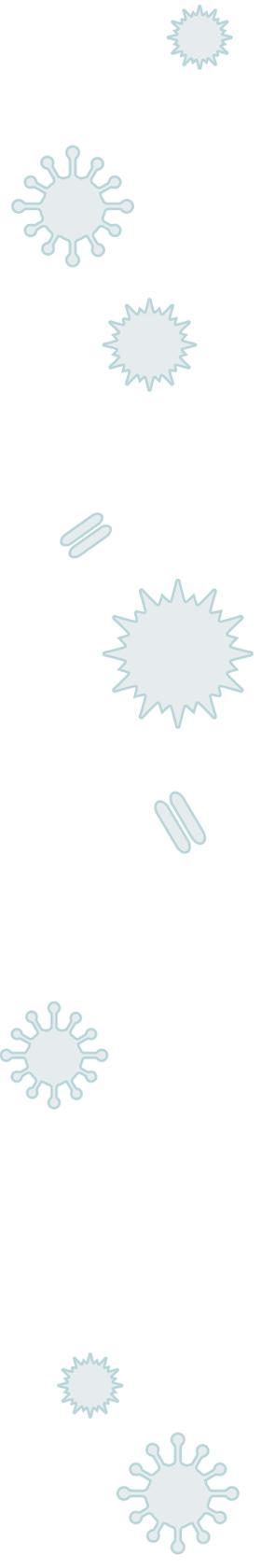
5.2 Cath Noakes | University of Leeds

Speaker slides

SARS-CoV-2 is a small virus of about 100 nm diameter. It is an envelope virus with a lipid bilayer, and can be washed away with soap easily. The international consensus is that the virus is dispersed predominantly through respiratory aerosols. However, there is a possibility that it may be released via faecal aerosols by sanitation systems. Transmission is mainly through prolonged close contact with an infected person. This might be through touching contaminated surfaces or from inhaled droplets and aerosols from their exhaled breath, a cough or a sneeze.

There is growing evidence that transmission mainly occurs in indoor environments, and that this could in part be through airborne transmission in poorly ventilated spaces. Droplets of a range of sizes expelled during a cough or sneeze will travel to a greater or lesser extent through the air and may partially evaporate before depositing onto a surface, or the skin or mucous membranes in the nose, mouth or eyes. Some larger aerosols may be inhaled into the upper respiratory tract and the smaller aerosols may deposit in the lungs. The relative importance of these mechanisms is currently unknown, and there is likely to be a complex relationship between the physics, biology and people's behaviour.

Very few studies have sampled the microorganism content of exhaled breath and cough particles, for any diseases, and therefore we do not know how many virus particles can be released by someone when they cough. It is likely that the number of virus particles in cough droplets will depend on the viral titre (i.e. the quantity of virus per unit volume of fluid), but whether it is related to virus levels in an individual's nose or throat is currently unknown. It is known that the viral titre of people with COVID-19 varies widely from 600 to 1011 RNA copies per millilitre, with most around 10⁶ RNA copies per millilitre.



Coughs do not only release virus particles. The viral particles will be contained in respiratory fluid which contains proteins, surfactants, salts, etc, and as droplets evaporate these substances are retained and remain much larger than the virus particles. It is unlikely that nanometre-size virus particles will be suspended in air by themselves.

The spread of the virus, from individuals into their surrounding environment, known as 'viral shedding' has many dependencies. The fate of droplets is complex and is dependent on the particular environment, the interaction between humans, the space they are in and the ventilation patterns. What we do know about the virus is that:

- the virus remains stable in aerosols under laboratory conditions for three hours or more⁵
- deposition on surfaces is important and we know the virus can survive for varying lengths of time depending on the surface material (on copper for four hours, on plastic and steel for two days).⁶
- in chilled environments the virus can survive longer – at four degrees Centigrade the virus persists for up to fourteen days.⁷
- heat and humidity shorten the lifetime of the virus on surfaces.⁷
- research suggests that the virus may only survive a few minutes in direct sunlight.⁸

Research is focusing on how to control the virus, thinking about the different transmission routes:

- **Direct and indirect contact transmission** due to the droplet form and short range travel of these droplets, falling onto surfaces
 - where two-metre distancing, face coverings and avoiding face-to-face contact using screens are effective;
 - hand hygiene, surface cleaning and avoiding touching your face are important;
- **Airborne transmission**, where ventilation, the use of filtration and ultraviolet light air cleaning devices are relevant. Other measures include: reducing the occupancy, to reduce the potential viral load in a particular space and to reduce the chances of infected people being in the space; reducing the time that people might be exposed, through changing shift patterns, etc. If these measures are taken then the chances that anyone in that environment receives an infectious dose will be reduced.

5 van Doremalen, N. et al. 2020. Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. *New England Journal of Medicine*, **382**: 1564–1567. doi: 10.1056/nejmc2004973

Fears, A.C. et al. 2020. Persistence of severe acute respiratory syndrome Coronavirus 2 in aerosol suspensions. *Emerging Infectious Diseases*, **26** (9). doi: 10.3201/eid2609.201806

6 van Doremalen, N. et al. 2020. Aerosol and surface Stability of SARS-CoV-2 as compared with SARS-CoV-1. *New England Journal of Medicine*, **382**: 1564–1567. doi: 10.1056/nejmc2004973

7 Chin, A.W.H. et al. 2020. Stability of SARS-CoV-2 in different environmental conditions. *Lancet Microbe*, **1** (1). doi: 10.1016/S2666-5247(20)30003-3

8 Schuit, M. et al. 2020. Airborne SARS-CoV-2 is rapidly inactivated by simulated sunlight. *Journal of Infectious Diseases*, **222** (4): 564–571. doi: 10.1093/infdis/jjaa334



Outstanding questions on transmission, droplet behaviour and environmental factors:

1. What dose must an individual must receive to become infected? The presence of droplets containing the virus does not necessarily mean that there is enough virus present for someone to become infected.
2. What is the prevalence of the virus in different real-world environments other than hospitals, e.g. a school, a transport network?
3. How are infected people shedding the virus, where are they shedding it and how much are they shedding at different stages of the disease?
4. What is the relative importance of the different transmission routes including faecal shedding?
5. How might we best mitigate transmission in different specific environments such as schools, care homes, hospitals, dentists, hairdressers and on transport systems?
6. What are the synergistic aspects of the mitigation measures, how do they interact? Does one control measure affect another?

In the longer term we should consider:

1. How do we adapt our buildings to become more resilient?
2. How do we balance energy consumption, comfort and transmission risk within buildings?
3. How does human behaviour interface with control measures in buildings? Is it a behaviour challenge, an engineering challenge or both?
4. How do we adapt our behaviours without losing social context?
5. What do we do in winter? Social distancing is easier when activities can be done outdoors. Ventilation is easier in the summer.

These are big interdisciplinary questions that will need to be addressed by large projects, engaging large groups of researchers. However, the rapid UKRI call project ideas need to demonstrate the potential to deliver public health benefits within twelve months.

Speaker reflection:

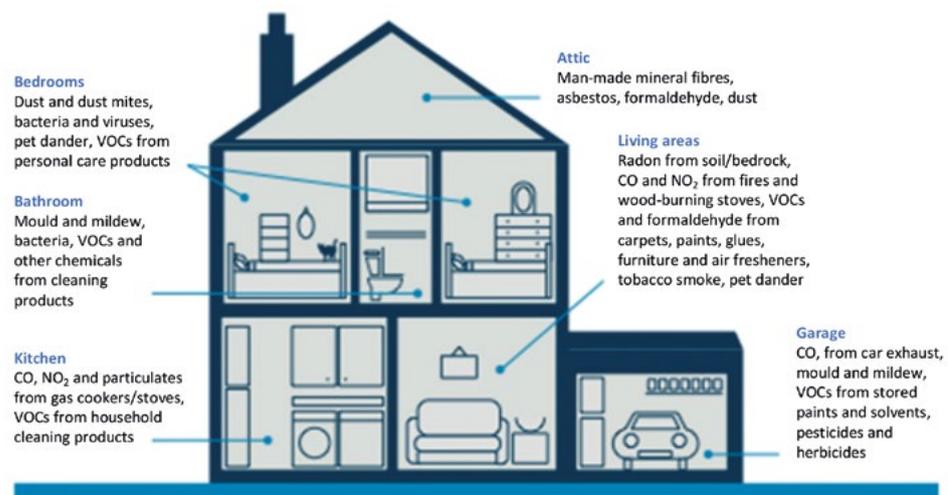
“ COVID-19 remains a vast and complex challenge. Although an enormous amount of knowledge has been gathered through a mammoth effort over the past 8 months, there are still very significant unknowns, particularly in how it transmits and how best to control the transmission while enabling people to return to normal life. The intersection with ventilation and air quality poses a particular issue for the SAQN community. Improving ventilation of buildings is a key mitigation strategy, yet the poor outdoor air quality makes this a challenge in many locations. Collaborative working to tackle both issues together will be important for the long term health of the population.”

5.3 Sani Dimitropoulou | Principal Environmental Health Scientist – Indoor Environments, Public Health England

Indoor air quality is affected by outdoor air pollutants, including emissions from transport and industrial activity. It is also dependent on urban planning, as this affects the dispersion processes of pollutants around buildings and the concentrations of pollutants adjacent to building façades. The design and maintenance of the buildings can have an impact on ventilation. Although ventilation is important, it is not a panacea for indoor air quality problems. The first step should always be to reduce emissions at source and then apply ventilation.

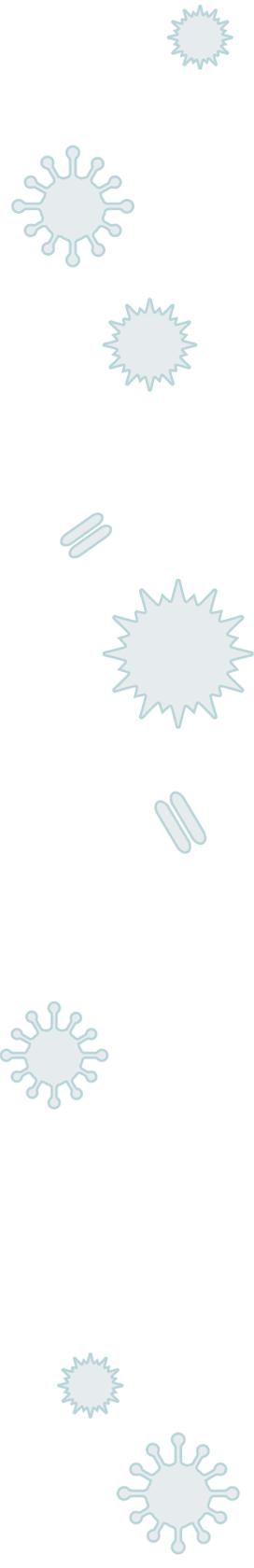
Emissions from indoor sources come from building and construction materials, furnishings and consumer products. Also important are emissions from human activities, such as wood burning, use of cleaning products and other consumer products, smoking, cooking and drying clothes indoors. The hours spent on cooking and cleaning may have changed during lockdown compared to times before the pandemic, due to more time at home. So it might be expected that indoor air quality deteriorated in our homes, especially in springtime, although information is not currently available from lockdown to compare with the pre-lockdown period.

The common indoor air pollutants, apart from radon, originate from combustion (carbon monoxide, nitrogen dioxide and particulate matter) and also hydrocarbons from cooking, volatile organic compounds (formaldehyde, benzene, naphthalene, limonene, alpha-pinene, etc.) from cleaning products, personal care products and furnishings. Also of great concern is the persistent pollution from organic chemicals used as flame retardants and in electrical equipment.



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.

Figure: Reproduced from Royal College of Paediatrics and Child Health, Royal College of Physicians (2020), [The inside story: Health effects of indoor air quality on children and young people](#)



Poor indoor air quality may be associated with several health conditions including allergies, respiratory problems, cardio-vascular disease, neurological issues or even cancer, in the case of radon. For school-age children, poor air quality has been linked to reduced cognitive performance.

Public Health England review and develop evidence about indoor air quality and impacts on health, often in collaboration with other government departments and organisations. During 2019 the first [UK indoor air quality guidelines](#) were published, covering selected health-relevant VOCs that are commonly present in homes and offices. Included are guidelines to help with measurements and inter-comparisons between measurement campaigns. PHE was involved in setting the scene for a cross-government meeting on indoor air quality led by the Chief Medical Officer in February 2020, the actions from which have been postponed due to the current crisis. PHE works with other organisations, including the Chartered Institution of Building Services Engineers (CIBSE),

The National Institute for Health and Care Excellence (NICE), the Royal College of Physicians, The Royal College of Paediatrics and Child Health⁹ and the World Health Organisation, to provide expert advice on indoor air quality.

The [NICE guidelines](#) on indoor air quality interventions, which are PHE co-badged, were published before the COVID-19 pandemic. However, the behavioural interventions addressed to Local Authorities about reducing damp and condensation, increasing ventilation and reducing indoor sources are very relevant during lockdown to all house occupants who wish to improve indoor air quality; the NICE guidelines and the visual summary, can be downloaded from the [NICE website](#).

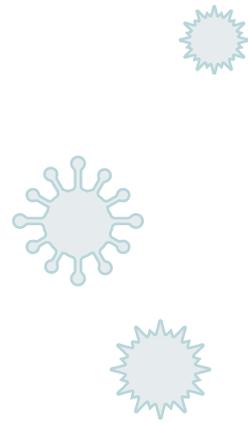
PHE have been reviewing evidence about indoor air quality in the context of COVID-19 in order to inform the PHE guidance and advice. Current attention is focused on how SARS-CoV-2 is transmitted indoors, and how building services could operate in order to minimise the spread of the virus. Generally, coronaviruses are quite resistant to environmental changes and only become inactive at very high relative humidity, above 80%, and temperatures above 30°C. With typical UK indoor humidity in the range 40 to 65% and temperatures between 21 and 23°C, it can be assumed that coronaviruses are stable in these conditions (Casanova et al., 2010; Doremalen et al., 2013).¹⁰

It is thought that aerosols containing viable virus can remain stable for two to three days on typical indoor surfaces, unless there is specific cleaning. The virus is more stable, up to three days, on plastic and stainless steel surfaces but has a shorter lifetime on cardboard (24 hours) and copper (4 hours).

PHE supports the guidance from The [Federation of European Heating, Ventilation and Air Conditioning associations](#) (REHVA) and [CIBSE](#) on changes in ventilation practices in buildings to reduce the risk of SARS-CoV-2 transmission. These propose higher outdoor air ventilation rates, better filtration and to avoid the use of air recirculation.

9 See also: [The inside story: Health effects of indoor air quality on children and young people](#).

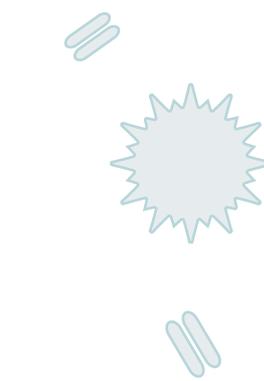
10 van Doremalen, N. et al. 2020. Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. *New England Journal of Medicine*, **382**: 1564–1567. doi: 10.1056/nejmc2004973



PHE is keen to work with PHE stakeholders to reduce personal exposure to indoor air pollution and SARS-CoV-2.

Speaker reflection:

“ Apart from the devastating effects of COVID-19 pandemic on health, the lockdown measures had an impact on the environment. As an air pollution scientist, I would recommend the investigation of the lockdown consequences on our personal exposure to air pollution, considering both outdoor and indoor air.”



5.4 Ally Lewis | Air Quality Expert Group

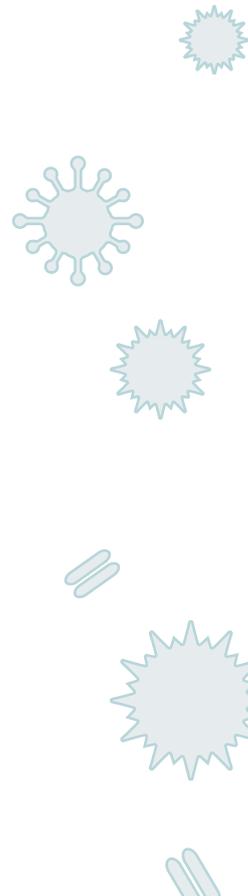
During April the Defra Air Quality Expert Group (AQEG) released a call for evidence regarding the changes in air quality that were occurring in the UK as a result of the lockdown. The research community were asked a set of questions.

- 
- What sectors or areas of socioeconomic activity do you anticipate will show a decrease in air pollution emissions, and by how much? Are there any emissions sources or sectors which might be anticipated to lead to an increase in emissions in the next three months?
 - Can you provide estimates for how emissions and ambient concentrations of NO_x, NO₂, PM, O₃, VOC, NH₃¹¹ etc. may have changed since the COVID-19 outbreak?
 - What changes do you anticipate in indoor air quality as a result of the COVID-19 pandemic?
 - How might public exposure to air pollution have changed as a consequence of restrictions on movement?
 - How might altered emissions of air pollutants over the next three months affect UK summer air quality?
 - Based on what is already known about air pollutants as respiratory irritants or inflammatory agents, can any insights be gained into the impact of air quality on viral infection?
 - Are there any insights that can be gained from aerosol science on possible viral transmission mechanisms?

This is a first step on what is likely to become a major area of scientific research and evidence analysis in government.

Fifty-four separate organisations responded, together submitting over five-hundred pages of evidence. Responses came from universities, research institutes, industry, consultants, the devolved administrations and their agencies and local authorities. The range of organisations highlights how broad interests are in the interactions of air quality with COVID-19.

11 NO_x = Oxides of nitrogen; NO₂ = Nitrogen dioxide; PM = Particulate Matter; O₃ = Ozone; VOC = Volatile Organic Compounds; NH₃ = Ammonia



There is a good consensus view on the initial changes to UK concentrations of pollutants and emissions, drawn from a wide range of data sources. The exercise has been useful to identify the sources of data that are available, which include Defra's air quality networks and those of local authorities, and also Earth observation and mobility data (the latter from Google). This has shown that in general air pollution data is very accessible and generally of high quality, and is not likely to be the limiting factor when comparing against health data.

There have been some modelling studies that have looked at changes that might be expected moving into summer. Some modelling work has also been done on changes to exposure from indoor pollution, but this has highlighted that measurements of indoor exposure are not routinely made, so this limits what conclusions can be drawn about changes as they are almost entirely based on theory. There is very limited evidence on the interactions between indoor air quality and COVID-19.

There is very strong evidence, arising from multiple different methods of observation, that concentrations of nitrogen dioxide have reduced across the UK with the range 20 to 60% depending on location, and allowing for the effects of weather. Although it is harder to see, there is evidence now that concentrations of PM2.5 have reduced when the effects of weather have been accounted for. There have been estimations of emissions reductions based on changes in commuting behaviour. The conclusions drawn from the evidence will be submitted to Defra in a report during June 2020.

Workshop postscript: report, together with the evidence, was published on 01 July 2017: [Estimation of changes in air pollution emissions, concentrations and exposure during the COVID-19 outbreak in the UK.](#)

5.5 Mike Holland | Committee on the Medical Effects of Air Pollutants COVID Group

Although the Committee on the Medical Effects of Air Pollutants is discussing the issue of air pollution and COVID-19 in depth, the committee is yet to agree any firm positions on this topic. Therefore, the views expressed here are personal and do not necessarily reflect the views of the committee membership.

Potential links between air quality and COVID-19 include:

1. The virus attacking similar systems in the body (principally the respiratory and cardiovascular systems) as air pollutants such as fine particles, NO₂ and ozone.
2. Transmission through particle dispersion, also air pollution leading to predisposition for contracting COVID-19.

Evidence for the second point, transmission through air pollution, is less convincing. Whilst traces of genetic material have been found on particles it is unclear whether this is viable and capable of causing infection.



It is expected that there have been changes in pollution exposure linked to lockdown, and related behavioural changes. Most of the population has been spending more time indoors. There is a huge quantity of literature emerging very quickly. However, articles are often un-reviewed prepublication papers reporting scientific findings but not subject to peer review at the time of first release. The lack of peer review and the speed of release have resulted in materials being of very variable quality, leaving open the question of the strength of association between COVID-19 and air pollution, and hence its potential for informing the policy debate.

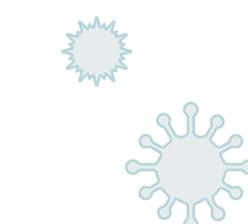
There is good data from many countries on all-cause deaths, and from some countries on tests for COVID-19, but often not very good data on COVID-19 deaths. The latter depends on how medics classify the cause of death.

There are conflicting findings in the literature regarding the effects of PM2.5 and NO2, and often there is inconsistency in other variables (size of population, age, housing conditions, underlying health status, etc.). Problems can arise from the rush to publish findings, and studies comparing the number of COVID-19 deaths with avoided air pollution deaths may be difficult, as the estimates may not be comparable due to uncertainties in the two sets of numbers.

Useful research ideas include:

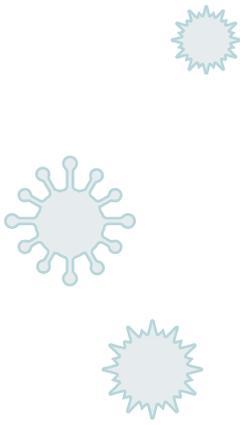
- looking at COVID-19 outcomes, indoor pollutants and changes in outdoor pollutants. The challenge will be overcoming the many confounding factors that are present, not least the reduction in air pollution during the period when COVID-19 deaths were highest. Asthma symptoms reported in asthma diaries may provide useful insights about the role of pollution in asthma exacerbation.
- COVID-19 policy consequences, for example: improving the indoor environment; recommendations on the use of cleaning products; evidence to support the case for banning solid fuel use and bonfires; and keeping vehicles away from schools and care homes. Many of these recommendations can be made based on what we already know and represent 'no regret' actions.

5.6 Matthew Hort | Met Office



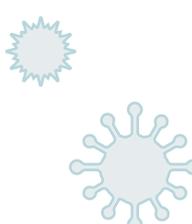
The Met Office is concerned with forecasting weather, climate change, air quality and pollen from hourly to seasonal and longer time frames. In the area of air quality the Met Office delivers the UK national forecast and is also a delivery partner with UK Research and Innovation in the Strategic Priorities Fund Programme for Clean Air.

In the context of the COVID-19 pandemic the Met Office is well-positioned to help address questions concerning the effect of the weather and climate (e.g. temperature, humidity) and air quality. Forecasts may be important to help organisations prepare on a number of levels. For example, high temperatures may cause heat stress, especially for frontline healthcare workers wearing PPE. Also, the level of adherence to government guidelines may depend in part on the weather. The Met Office is also interested in compound risks such as how COVID-19 may affect the UK's ability to respond to a wider range of incidents such as flooding or severe air quality.

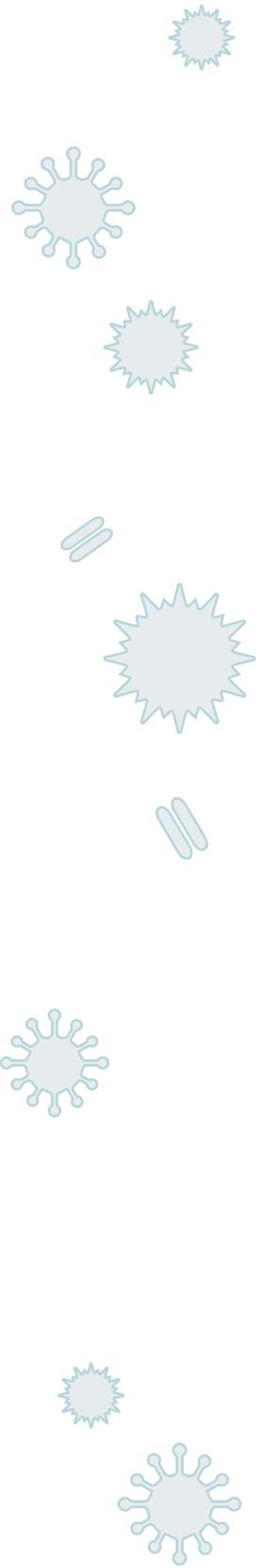
To support the scientific community response to COVID-19 the Met Office has established a cloud platform where there is a range of gridded and spatially aggregated data readily available (for the UK and overseas) on air quality and weather. Researchers can use the resources available on the cloud computing platform to access data and perform analysis of that and their data. This is an effective way of making government-funded data available to researchers, for wider exploitation and investigation of links between various aspects of the pandemic.The measures to control the COVID-19 pandemic have had an impact on the emission of pollutants that contribute to air quality and this needs to be reflected in Met Office models and forecasts. Determining emissions reductions is challenging, as direct measurements of emissions are not widely available and they are not normally available until significantly later in time. Therefore, estimates of emissions have to be made from air quality measurements. This is not straightforward as many different activities often emit the same species and understanding which activity (e.g. cars, industry) can be hard. The representation of emissions in the forecasts were adjusted on 8 April and will be adjusted again as lockdown restrictions are lifted. There are also wider implications for weather and climate, for example through aerosol feedbacks on the weather and greenhouse gas emissions on the climate.Beyond the immediate changes it is also important that we consider the implications that changed emissions may have at different times of the year. The reduction on road traffic emissions favours higher levels of ozone. As we enter warmer and drier conditions that also lead to increased ozone we need to be conscious that these events may combine to give changing air quality challenges.

The Met Office is contributing to a Defra modelling group on what we can learn from this event to help inform possible future policy and deal with the air quality challenge.

Speaker reflection:



“The spread of COVID-19 and the impacts of the lockdown measures have raised many challenges and questions regarding both the direct consequences of the virus and also for our impact on the much wider environment. Air quality, which for many species has been improved due to lock down measures, is an example of something that both interacts with the impact of the disease but that the changes of which are also illustrating and providing much opportunity to learn and plan for a better air quality future. In highlighting the complexity and inter-relationships affecting air quality this has greatly reinforced the need for multi-disciplinary and multi-organisation research and action on air quality.”



6. Potential applications of STFC capability

The primary purpose of this initial workshop was to identify gaps in knowledge and further work is required to investigate potential capabilities that could provide solutions. However, the following are preliminary suggestions of areas where STFC community capabilities could potentially be applied to air quality and COVID-19 challenges.

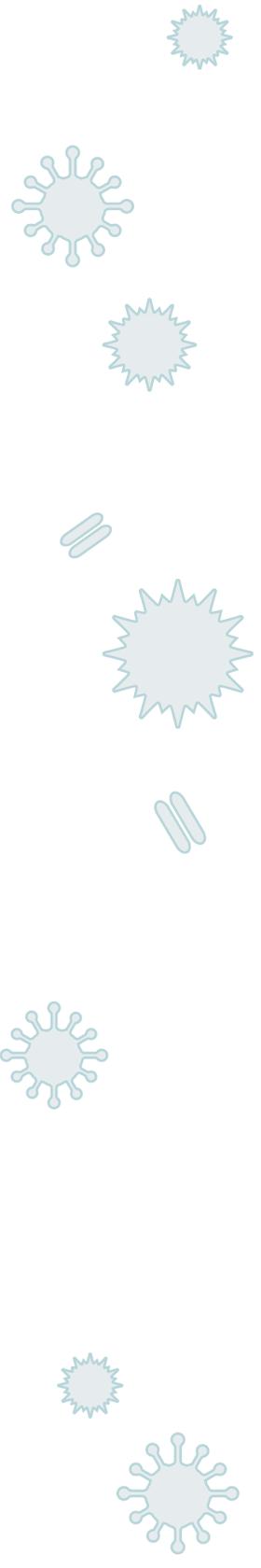
- **Computational fluid dynamics (CFD).** The Scientific Computing Department and its network could provide assistance with computationally demanding CFD analysis to understand complex air flows within buildings. This could help to assess and validate different approaches to minimising transmission risk within buildings.
- **Data curation, access and cloud computing through CEDA and JASMIN.** The Centre for Environmental Data Analysis (CEDA) operates data curation and computing services on behalf of the NERC atmospheric science and Earth observation communities. CEDA can provide access to a variety of data relevant to air quality. JASMIN is a globally unique data intensive supercomputer for environmental science. Over 160 science projects are currently supported, covering topics ranging from climate science and oceanography to air pollution, earthquake deformation and analysis of wildlife populations. JASMIN consists of multi-Petabyte fast storage co-located with data analysis computing facilities, with dedicated light paths to various key facilities and institutes within the community.
- **Sensors and testing.** STFC has a long heritage of novel detector development and deployment. The community also has experience of validating technologies in controlled environments to verify performance prior to field deployment. The science campuses at Harwell and Daresbury could potentially be used to trial novel sensor technologies in different types of built environment. The Hartree Centre at the Daresbury campus in particular has experience trialling internet of things approaches across the campus.
- **Robotics.** RAL Space has experience developing and deploying rovers and drones that could be used to carry sensors in high-risk environments.

Further discussions are required to investigate these possibilities.

Contact: Kevin Smith (kevin.smith@stfc.ac.uk)

6.1 SAQN Collaboration Building Workshop

The SAQN will run a Collaboration Building Workshop, with the aim of connecting network members with STFC researchers. The workshop will take place online between 2-13 November 2020. We aim to offer a space for exploration of new research ideas and the application of STFC capabilities to air quality challenges, and to foster new collaborations that can develop further project ideas and apply for funding. We want to encourage participants to think innovatively about challenges and solutions in air quality. We will be addressing the following question:



“How might we respond collaboratively to societal air quality challenges using Science and Technology Facilities Council capabilities to explore the potential of new research ideas?”

To inform their response to this question, applicants may wish to review the air quality challenges identified at the network launch meeting, as well as the challenges related to COVID-19 that are identified in this report.

Participants will be selected based on information provided in their applications. Further information about the workshop, application process and selection criteria are available from the [SAQN website](#).

Annex 1: Delegate list

Note: 20 delegates chose not to disclose their contact details in the delegate list.

First name	Second name	Profile (max. 400 characters)	Organisation	Sector
Joe	Acton	My research focuses on the sources and chemistry of volatile organic compounds (VOCs) and their impacts on air quality. I am currently working on two large NERC-funded projects using eddy covariance to quantify VOC emissions and identify VOC sources in Beijing and Delhi. I am also interested in the influence of science policy on air quality and how this translates into measurable impacts.	Lancaster University	Academia
w.acton@lancaster.ac.uk				
Bethany	Adams	I am a Senior Programme Manager within NERC's Healthy Environment team, my portfolio includes air quality. I am also part of the programme management team for the UKRI Strategic Priorities Fund Clean Air programme.	NERC	Public Sector
bethany.adams@nerc.ukri.org				
Zulfikar	Adamu	Dr Zulfikar Adamu's PhD thesis (Loughborough University, 2013) was on modelling the effects of natural ventilation in managing airborne infection in healthcare buildings. Modelling of indoor air quality (IAQ) remains a subject his is passionate about. His expertise is in computational modelling including CFD, DTM and BIM.	London South Bank University	Academia
www.linkedin.com/in/zulfikaradamu/				
Paul	Ajiboye	CETEC have been operating for over 30 years addressing IAQ at the work. As a science based consultancy we evaluate IAQ performance in buildings for clients pursuing various standards (e.g. NABERS IE/WELL). To date we have performed IAQ tests in over 1000 buildings world wide and have recently developed an approach that will assess risks in relation to COVID-19 spread in buildings.	CETEC	Third Sector
www.cetec.com.au/services/covid-19.html				
James	Allan	James Allan is an atmospheric scientist specialising in online aerosol measurement, but also works in wider air quality sciences. He is a member of the DEFRA Air Quality Expert Group (AQEG).	University of Manchester / NCAS	Academia
james.allan@manchester.ac.uk				
Manna	Alwadei	I am a PhD researcher interested in air quality and health effect.	University of Birmingham	Academia

First name	Second name	Profile (max. 400 characters)	Organisation	Sector
Ben	Anderson	I have experience of leading and conducting pure & applied research in a number of sectors (telecoms, water, energy) and contexts (commercial, academic). Most recently I have spent 2 years at the University of Otago (NZ) working at the intersection of climate change and energy uses (heating/transport) with an emerging interest in air quality as part of an EU-funded MSCA Global Fellowship.	University of Southampton, Energy & Climate Change, Engineering	Academia
@dataknut				
Kiran	Apsunde	I am a Civil Engineer with Masters in Climate Change and Sustainable Development. Presently, I am an Erasmus+ Scholar researching on influence of Urban form on air quality – how the urban form manipulates the wind circulation, pollution dispersion, and thus the ambient air quality. I have worked in the Environmental Planning sector of India for about 4 years.	Glasgow Caledonian University	Academia
Alexander	Archibald	Science Director of the UK Chemistry and Aerosols model – a community model developed by NCAS and the Met Office. Over 10 years experience in atmospheric chemistry modelling with specific focus on tropospheric ozone. Lead author of IGAC Tropospheric Ozone Assessment Report (TOAR) Chapter on the ozone budget.	University of Cambridge & NCAS-Climate	Academia
www.ch.cam.ac.uk/person/ata27				
Lauren	Armstrong	I work in Extreme Events so am interested in the intersection between indoor overheating, indoor AQ and COVID risks	Public Health England	Public Sector
Nick	Avis	Currently working on an InnovateUK funded industrial decarbonisation roadmap for the North West. Interested in how lesson resulting from COVID-19 lockdown can inform future actions and policies associated with restarting the UK economy	University of Chester	Academia
Jake	Backus	Project lead for OxAir, measuring air quality in Oxford from a human perspective.	Empathy Sustainability	Academia
www.empathysustainability.com				
Richard	Ball	Materials scientist based in Architecture and Civil Engineering. My research has investigated how construction materials (natural and man-made) can influence indoor air quality, the development of photocatalytic surfaces and coatings for the neutralisation of pollutants and pathogens, and indoor air quality monitoring.	University of Bath	Academia
r.j.ball@bath.ac.uk				

First name	Second name	Profile (max. 400 characters)	Organisation	Sector
Alexandra	Barker	Business Development Manager at Airbus Intelligence in the UK responsible for our EO Services with a background in air quality and emissions monitoring, currently looking to utilise satellite-based data to improve AQ & GHG monitoring and reporting.	Airbus	Industry
alexandra.barker@airbus.com				
Elizabeth	Bates	Local authority AQ officer not involved directly with research on a day to day basis but interested in research outcomes and impacts of this for future air quality action planning and reporting..	Bradford MDC	Public Sector
Jenny	Baverstock	I am a UKRI Clean Air Co-Champion supporting the UKRI SPF. I have considerable experience in interdisciplinary research and I am a biochemist by training, with a career spanning bench science to research management and science leadership. I have considerable experience in public health including running trials and conducting research in the NHS (NIHR) and the University sector as well as industry.	Southampton University	Academia
J.Baverstock@soton.ac.uk				
Sean	Beevers	I undertake air quality modelling and have developed an advanced personal exposure model of people in London, indoors, outdoors and whilst travelling, important for the effects of behaviour change due to the pandemic.	King's College London	Academia
Kristine	Belesova	Epidemiology, policy, sustainable development	LSHTM	Academia
kristine.belesova@lshtm.ac.uk				
James	Bellinger	James Bellinger has 10 years' experience in leading air quality assessments in the UK and overseas. James manages air quality assessments for a range of clients and across a wide range of spatial scales, from small developments to the city scale. James works with clients and stakeholders to identify solutions which will provide suitable mitigation to local air quality issues.	Arup	Industry
james.bellinger@arup.com				
Kelly	BéruBé	Dr Kelly BéruBé is Director of the Lung & Particles Research Group at Cardiff University that specialises in 'Respiratory Health'. The principal research focus is the determination of intelligent biomarkers of exposure and harm in the human respiratory system following exposure to aerial xenobiotics.	Cardiff University	Academia
berube@cardiff.ac.uk				

First name	Second name	Profile (max. 400 characters)	Organisation	Sector
William	Bloss	Atmospheric chemistry and clean air science, including understanding the sources and transformations of air pollutants; quantifying the sources and sinks for atmospheric oxidants; applying air pollution science to improve local and regional air quality policy measures for human and environmental health. Testing West Midlands policies through air pollution lockdown response.	University of Birmingham	Academia
w.j.bloss@bham.ac.uk				
Hartmut	Boesch	I am coordinating the NCEO response to COVID-19. See www.nceo.ac.uk/article/using-sentinel-5p-to-monitor-air-quality-changes-since-the-coronavirus-outbreak-a-uk-expert-view/	University of Leicester	Academia
Zak	Bond	Policy and Public Affairs Officer (Air Pollution) – British Lung Foundation	British Lung Foundation	Third Sector
Zbond@auk-BLF.org.uk				
Douglas	Booker	Development of tools and instruments for monitoring indoor air quality (NAQTS V2000 – including measurements for PN & PM, and CO2).	NAQTS	Industry
dbooker@naqts.com				
Christine	Braban	UK rural and urban air quality; Use of AQ Supersite information to understand air pollution events; instrumentation, special interest in ammonia pollution.	UK Centre for Ecology & Hydrology	Third Sector
chri2@ceh.ac.uk				
Shaun	Brace	Defra Air Quality scientist and SAQN Steering Committee Chair.	Defra	Public Sector
Mario	Brito	I am involved in two research bids: one on data science and one of behavioural research. I have submitted a paper to the journal of Mind & Society special issue about Covid-19	University of Southampton	Academia
www.southampton.ac.uk/business-school/about/staff/mpb2o07.page				
Luisa	Brotas	Senior Sustainability and Climate Change Officer dealing with planning applications in a London borough. This involves looking at energy, sustainability, overheating, air quality, wellbeing and daylighting assessments to improve the quality of spaces and urban areas, comfort and wellbeing of the occupants whilst reducing carbon emissions associated with buildings.	London Borough of Hackney	Public Sector
Richard	Brown	Air quality research into PM composition; operation of two of UK's Air Quality networks,	National Physical Laboratory	Public Sector
richard.brown@npl.co.uk				

First name	Second name	Profile (max. 400 characters)	Organisation	Sector
Yvonne	Brown	I am part of the Strategic Analysis team in Transport for London responsible for the LAEI, modelling of air quality impacts of policies such as ULEZ. I am involved in air quality analysis on a daily basis and work closely with the GLA air quality and with academics on air quality as part of my day to day role.	Transport for London	Public Sector
Alison	Buckley	I work at PHE's Centre for Radiation, Chemical and Environmental Hazards in the Nanoparticle Inhalation Research Group as a senior aerosol scientist. I have expertise in aerosol instrumentation, characterisation and dynamics, particularly in the sub-micron size range. I have considerable experience of both lab-based and atmospheric aerosol measurement.	Public Health England	Public Sector
alison.buckley@phe.gov.uk				
Sri Hapsari	Budisulistiorini	My research interest is on atmospheric aerosol formation and composition. I have been studying biogenic secondary organic aerosol and biomass burning aerosol in urban and rural areas. I am currently working on a complex organic aerosol project in megacities.	University of York	Academia
James	Burke	Biological aerosol scientist	DSTL	Public Sector
jsburke@dstl.gov.uk				
John	Burns	Product Manager for Energy & Environment at NPL. Background in Chemical Engineering and Mathematics. Currently managing products & services related to air quality and environmental monitoring.	National Physical Laboratory (NPL)	Public Sector
john.burns@npl.co.uk				
Bryan	Bzdek	Aerosol microphysics; indoor air quality	University of Bristol	Academia
bb14562@bristol.ac.uk				
Ruth	Calderwood	I am the Air Quality Manager for the City of London Corporation. We work with a very wide range of organisations on air quality policy and to support trials of new technology to minimise emissions to air. We have commissioned research into the impact of urban form on air pollution and actively engage with City businesses and their employees to reduce exposure to poor air quality	City of London Corporation	Public Sector
ruth.calderwood@cityoflondon.gov.uk				
Paul	Callow	I currently work in Environmental Public Health for PHE (CRCE) with Public Health Wales. I have an interest in AQ monitoring and public health impacts of exposure.	Public Health England	Public Sector
Leticia	Campello	Project engineer at RWDI working in the air quality sector. Interested in outdoor and indoor air quality.	RWDI	Industry
Leticia.Campello@rwdi.com				

First name	Second name	Profile (max. 400 characters)	Organisation	Sector
Melisa	Canales	My research interest lies in understanding how individual microorganisms and microbial communities interact with different environments; my goal is to contribute towards understanding infectious disease transmission.	University College London	Academia
Nic	Carslaw	Indoor air chemist, interested in impacts of covid-19 on indoor air chemistry.	University of York	Academia
nicola.carslaw@york.ac.uk				
Veronica	Chan	Senior Advisor on Air Quality	Port of London Authority	Public Sector
Gregory	Chawynski	Senior Lecturer and Researcher	Massey University	Academia
g.chawynski@massey.ac.nz				
Emily	Cheek	Environmental public health scientist working at Public Health England as part of the Air Quality and Public Health team. Researching and providing support and evidence on the links and potential impacts surrounding air pollution on human health.	PHE	Public Sector
Lena	Ciric	Environmental microbiologist interested in the prevention of the spread of infectious disease in the built environment.	University College London	Academia
l.ciric@ucl.ac.uk				
Hugh	Coe	Air quality monitoring, COVID and aerosol	University of Manchester	Academia
hugh.coe@manchester.ac.uk				
Alexia	Coke	Social researcher in Defra's air quality and industrial emissions team	Defra	Public Sector
Alexia.Coke@defra.gov.uk				
Malcolm	Cook	Coupled CFD and thermal comfort modelling using breathing computational manikins. Design and operation of natural ventilation strategies. Numerical modelling and definition of ventilation effectiveness.	Loughborough University	Academia
malcolm.cook@lboro.ac.uk				
Daniel	Cooper	Policy and Public Affairs Coordinator at the British Lung Foundation	British Lung Foundation	Third Sector
dcooper@auk-blf.org.uk				
Elizabeth	Cooper	I research indoor air quality with special interest on advanced air filtration/cleaning.	University College London	Academia
elizabeth.cooper.18@ucl.ac.uk				

First name	Second name	Profile (max. 400 characters)	Organisation	Sector
Erwan	Corfa	Working on air quality and traffic analysis in TfL's Strategic Evaluation team, using monitoring data, pollutant emissions and dispersion models to support the Mayor's policies for London, such as the Low and Ultra-Low Emission Zones, Mayor's Transport Strategy and London Environment Strategy. Currently working on understanding the impact of COVID-19 on traffic and air quality in London.	Transport for London	Public Sector
Helen	Crabbe	Environmental Epidemiologist. Worked at National Incidence Control Centre, Epicell for PHE. Writing proposals for research bids examining environmental conditions on the transmission of COVID and risk factors.	PHE	Public Sector
helen.crabbe@phe.gov.uk				
Paul	Cropper	Computer modelling of building ventilation systems and ventilation effectiveness, with an emphasis on natural ventilation, using computational fluid dynamics.	Loughborough University	Academia
Derrick	Crump	Undertaken research, policy and consultancy concerning air pollution and the indoor environment and health in government, academia and the private sector since the early 1980s. Convene BSI committee on IAQ measurement and serve on ISO/CEN/EU groups.	IAQ Consulting Limited and Chair, UKIEG	Industry
crumpiaq@btinternet.com				
Lareb	Dean	Background in respiratory nanotoxicology and currently exploring lung cell receptor-virus interactions in light of COVID-19 pandemic.	University of Southampton	Academia
l.s.n.dean@soton.ac.uk				
Sebastian	Diez	Expertise on industrial emissions measurements, emissions inventories, air quality modelling, remote sensing, and air quality low costs sensors.	University of York	Academia
sebastian.diez@york.ac.uk				
Sani	Dimitroulopoulou	Sani is a Principal Environmental Public Health Scientist on Indoor Environments at Public Health England. She works closely with Government Departments (DfE, MHCLG, Defra) and organisations (WHO, NICE, CIBSE, RCP/RCPCH) to provide expert advice on IAQ and health. PHE are actively reviewing evidence on indoor air and COVID-19 to inform PHE's guidance and advice.	Public Health England (PHE)	Public Sector
Sani.Dimitroulopoulou@phe.gov.uk				
Benjamin	Drummond	Air quality forecasting / atmosphere modelling	Met Office, UK	Public Sector

First name	Second name	Profile (max. 400 characters)	Organisation	Sector
Andy	Duncan	NPL are the Government Measurement Laboratory and work on all aspects of air quality supporting the DEFRA and Local AQ networks for particles, NO ₂ , etc., NPL offer and underpin many techniques for emissions monitoring, new regulations and best practice. NPL have multiple projects on sensor validation and also satellite monitoring and data science. www.npl.co.uk/products-services/environmental	National Physical Laboratory	Public Sector andy.duncan@npl.co.uk
Pete	Edwards	Atmospheric chemist in the University of York's Wolfson Atmospheric Chemistry Laboratories	University of York	Academia
		pete.edwards@york.ac.uk		
Mat	Evans	Atmospheric chemistry modelling and data analysis.	University of York	Academia
		mat.evans@york.ac.uk		
Karen	Exley	Lead Air Quality and Public Health	Public Health England	Public Sector
		Karen.Exley@phe.gov.uk		
Faisal	Farooq	Working on a PhD with ventilation company nuair on designing new domestic ventilation systems at the Welsh School of Architecture. The aim is to design systems that reduce the harmful impact from pathogens, carcinogens and particulate matter.	Cardiff University	Academia
		farooqf@cardiff.ac.uk		
Naomi	Farren	Research scientist – urban air pollution, vehicle emissions	University of York	Academia
		naomi.farren@york.ac.uk		
Rob	Ferguson	My research focuses on using molecular tools to investigate environmental microbiology and its relation to public health. One of my key areas of research is bioaerosols (airborne microorganisms). I optimized methods for molecular bioaerosol sampling and developed tools for rapid in-field detection of bioaerosol pathogens.	University of Essex	Academia
		rmwfer@essex.ac.uk Academia		
Douglas	Finch	I am a postdoc researching air quality using observations and modelling. I also develop online analysis tools for people to access AQ data. My work involves at multiple pollutants but focus on ozone over the UK.	University of Edinburgh	Academia
		d.finch@ed.ac.uk		
Peter	Fleming	Peter Fleming has 35 years experience in Ambient Air Quality Monitoring from pen and ink chart recorders to networked sensor systems.	Campbell Associates	Industry
		peter@campbell-associates.co.uk		
Martin	Fletcher	Research expertise in indoor environments, specifically domestic air quality, space conditioning and occupant comfort.	Leeds Beckett University	Academia
		m.f.fletcher@leedsbeckett.ac.uk		

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Virginia	Foot	Research in bio-aerosol sampling and characterisation.	DSTL	Public Sector
Julie	Futcher	My research is concerned with the important but overlooked role of urban morphology as a prime driver of climate responsive urbanism & its influence on a wide range of energy exchanges that characterise densely built urban landscapes, i.e., its direct & indirect influence on access to passive resources, air quality & health & wellbeing, & in turn, the net-energy effects on the neighbouring setting	urb gen	Academia
julie@climate22.com				
Tim	Gant	Head of the Department of Toxicology PHE & Visiting Professor; King's College London. Graduated School of Pharmacy, University of London 1985 & PhD (Pharmacology) in 1988. PHE responsibilities include air pollution research. Fellow of the British Toxicological Society and Co-Editor of Toxicology Letters. Further roles with HESI (Washington DC) & ECETOC (Brussels)	Public Health England	Public Sector
tim.gant@phe.gov.uk				
Ivan	Gee	I am a Public Health lecturer with a longstanding research interest in air quality, particularly related to particulate matter, tobacco smoke and vaping. I am particularly interested in determining the impact of smoking and vaping on COVID risk and the impact of COVID on smoking/vaping behaviour.	Liverpool John Moores University, Public Health Institute	Academia
i.l.gee@ljmu.ac.uk				
Mohamed	Ghalaieny	As part of Defra's Air Quality and Industrial Emissions Evidence team, I am involved in the commissioning of evidence to inform air quality policy development and assessment.	Defra	Public Sector
Adina	Gillespie	GHGSat monitors and characterises methane emissions from oil & gas and other industrial facilities, working with industrial operators and regulators to mitigate those emissions. The product includes proprietary analytics applied to unique emissions data, collected by GHGSat's patented satellites. GHGSat generates operational, environmental, health & safety, market and regulatory insights.	GHGSat	Industry
www.ghgsat.com				
Siobhan	Goodman	Graduate Air Quality Consultant	Delta-Simons Environmental Consultants Ltd	Other: Environmental Consultancy
Hannah	Gough	Data analyst with a background in airflow around urban environments, natural ventilation and indoor-outdoor air exchange. Currently working on the resilience of infrastructure and the impacts of climate change at the IEA based in the University of Reading.	IEA	Industry
h.gough@the-iea.org				

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David	Green	Senior Research Fellow at King's College London where he leads the Aerosol Science Team. Research interests focus on the measurement of particles and gases, and their use in source apportionment and health studies. COVID related activity includes understanding the impact of lockdown on exposure, measurement of aerosols in hospitals and the detection of COVID in atmospheric samples.	King's College London	Academia
david.c.green@kcl.ac.uk				
Chris	Griffiths	Evaluating health impacts of Ultra Low Emission Zone on health; diverse COVID-19 projects.	Queen Mary University of London, Institute of Population Health Sciences	Academia
c.j.griffiths@qmul.ac.uk				
Sue	Grimmond	Urban meteorology	University of Reading	Academia
c.s.grimmond@reading.ac.uk				
Kristen	Guida	Climate change adaptation partnership looking at interacting risks with heat, air pollution, and pandemic	London Climate Change Partnership	Public Sector
climatelondon.org				
Chang	Guo	I am working on inhalation toxicology, focus on the engineered nanomaterials, which exist in air pollutants, from public health and occupational health points of view. I have particular interests in developing in vitro strategies for risk assessment from air quality perspective.	Public Health England	Public Sector
Rajat	Gupta	Rajat Gupta is Professor of Sustainable Architecture at Oxford Brookes University. His research interests lie in modelling and monitoring overheating risks at a building and neighbourhood level using mapping, monitoring and social science methods. Resilience to summertime overheating in homes during Covid-19 lockdown is vital. As PI he has won over £12 million in research grants from UKRI.	Oxford Brookes University	Academia
rgupta@brookes.ac.uk				
Jacqui	Hamilton	Expertise in measurement of volatile organic compounds and the formation of secondary organic aerosols.	University of York, Wolfson Atmospheric Chemistry Laboratories	Academia
jacqui.hamilton@york.ac.uk				
Adam	Hardy	My research experience in this area includes the study of air quality in London, and the effect the green space can have. I have also conducted work into urban canyons, their ability to trap pollutants, and how this effect can be mitigated.	Leeds Beckett University	Academia
a.l.hardy@leedsbeckett.ac.uk				

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Lee	Hargreaves	Provision of ventilation design (systems and equipment) to the built environment including design criteria, filtration, air balancing, equipment and systems and controls. And other standards and regulations including institution guidance and facilities management maintenance requirements.	Buro Happold	Other: Consultancy
Lee.hargreaves@burohappold.com				
Abigail	Hathway	I am a Building Services Engineer with a PhD in the modelling of pathogen transport in indoor air flows. My work has considered the generation and transport of aerosols due to human activities in buildings. More recently I have moved into building operation providing a more practical skill set related to the operation and running of building services for better air quality.	University of Sheffield	Academia
a.hathway@sheffield.ac.uk				
Aiden	Heeley-Hill	Researcher of VOC emissions, with particular regard to indoor air quality	University of York	Academia
achh500@york.ac.uk				
Carole	Helfter	I study greenhouse gases (predominantly carbon and methane) and have a particular interest in urban emissions. I have been running long-term measurements in central London (BT Tower) since 2011 and I am currently studying the impacts of lockdown on emission dynamics.	UK Centre for Ecology & Hydrology	Third Sector
caro2@ceh.ac.uk				
Stephen	Holgate	UKRI Clean Air Champion, Special Advisor to the RCP on air quality and has led two recent reports for the RCP and RCPCH on the effects of air pollution on human health	University of Southampton Faculty of Medicine	Academia
www.southampton.ac.uk/medicine/about/staff/sth.page				
Mike	Holland	Mike Holland has worked on air pollution since 1985. Since the mid-1990s he has focused on impact assessment and cost-benefit analysis related to policies to reduce pollution at levels from Local Authorities to national to European and global. He is a member of the Committee of the Medical Effects of Air Pollutants (COMEAP).	EMRC	Other: Consultancy
mike.holland@emrc.co.uk				
Claire	Holman	I chair the Indoor Air Quality Committee of the Institute of Air Quality Management and am interested in the interactions between outdoor and indoor air, and the role of ventilation strategies.	Brook Cottage Consultants	Other: Consultancy
claireholman@brookcottage.info				

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Matthew	Hort	I lead the Dispersion and Air Quality team at Met Office. We conduct research in areas including air quality and the spread of animal and plant disease. In response to Covid-19 I am coordinating changes to our air quality forecasts and was instrumental in establishing a platform to support Covid-19 response effort with global & UK meteorological data, UK air quality data and cloud-based analyses.	Met Office	Public Sector
matthew.hort@metoffice.gov.uk				
Shih-Che	Hsu	Indoor air quality simulation. GIS-based public health research.	UCL	Academia
shih-che.hsu.15@ucl.ac.uk				
Stefan	Huber	Our company specializes on indoor air quality solutions, especially on experimental solutions for low-energy and Passivhaus dwellings. We have accompanied a number of research projects and are very interested in the advance and development of ventilation technologies. Recently I looked closer into the impact that indoor climates have on CV and am keen to learn more.	PAUL Heat Recovery Scotland	Industry
stefan.paulheatrecovery.co.uk				
Fleur	Hughes	I am the Network Manager for STFC Air Quality Network (SAQN). I co-ordinate air quality activity between academia, industry and policy, and our network offers opportunities to make use of Science and Technology Facility Council (STFC) capabilities to address air quality challenges.	SAQN	Academia
fleur.hughes@york.ac.uk				
Rob	Hughes	Senior Fellow, Child Health and Development, Clean Air Fund	Clean Air Fund	Third Sector
cleanairfund.org				
Emma	Hutchinson	Environmental epidemiologist with interest in health risk assessment, particularly in relation to indoor air quality, and energy efficiency measures in UK housing.	London School of Hygiene and Tropical Medicine	Academia
emma.hutchinson@lshtm.ac.uk				
Judith	Jeffery	I'm based at STFC Chilbolton Observatory, which is home to both the NCAS Chilbolton Atmospheric Observatory (including radars, lidars, microwave radiometers and met. instruments for atmospheric measurements) and the DEFRA air quality rural background site.	STFC	Public Sector
judith.jeffery@stfc.ac.uk				
Nigel	Jenkins	25 years in air quality field, member of EPUK Air Quality Committee, member on NICE ambient air quality review, MIAQM, developed airAlert service for Sussex, research on air quality with KCL, Uni. of Brighton, Uni Greenwich. >15 years local authority experience and >10 years in private consultancy across UK.	Phlorum Ltd	Other: Consultancy/ research
nigel.jenkins@phlorum.com				

First name	Second name	Profile (max. 400 characters)	Organisation	Sector
Rod	Jones	Atmospheric Scientist, Breathe-London co-I, SAQN steering group member	University of Cambridge	Academia
Benjamin	Jones	My expertise is in measurement and modelling approaches to the indoor environment that can inform policies to create low-carbon and healthy building stocks.	University of Nottingham	Academia
benjamin.jones@nottingham.ac.uk				
Sally	Jones	CAZ project manager AQ & Health, co-applicant to BIB Breathes, NIHR funded research project – Evaluating the life-course health impact of a city-wide system approach to improve air quality in Bradford	Bradford MDC	Public Sector
sally.jones@bradford.gov.uk				
Marilena	Karyampa	I work as a senior air quality consultant managing impact assessments for large infrastructure projects in the UK.	Arup	Public Sector
Peter	Keig	We are developing an IoT enabled smart residential ventilation system. The system provides indoor environmental conditions of each room and aggregates the data into a central-repository enabling access for academic researchers and development of policies.	Smart-Ventilation Ltd	Industry
peter.keig@thinkair.org				
Steve	Kelly	I am currently Chairman of a company developing indoor pollution control technology by molecular adsorption. I have over 20 years experience successfully building startup companies in the deep-tech market.	CageCapture Ltd	Industry
skskelly41@gmail.com				
Frank	Kelly	Director, Environmental Research Group and Chair, COMEAP Covid SubGroup	Imperial College London	Academia
www.imperial.ac.uk/people/f.kelly				
Andrew	Kibble	Currently work in Environmental Public Health for both PHE (CRCE) and Public Health Wales and involved in air quality work in Wales including looking at the effects of covid-19 on air quality with Welsh Government.	Public Health England / Public Health Wales	Public Sector
andrew.kibble@phe.gov.uk				
Astrid	Kiendler-Scharr	Atmospheric Chemistry, SLCF	Forschungszentrum Jülich	Academia
Rob	Kinnersley	Principal Air Scientist at the Environment Agency. Research expertise in environmental physics including aerosol science, source-pathway-receptor-impacts of air pollution, monitoring and modelling of air pollution, sampling network design, bioaerosol risk assessment.	Environment Agency	Public Sector
Joanne	Kwan	CIRIA has published over 10 good practice report on ground gases	CIRIA	Industry
joanne.kwan@ciria.org				

First name	Second name	Profile (max. 400 characters)	Organisation	Sector
Simon	Lannon	Simon Lannon is a Research Fellow who has undertaken extensive inter-disciplinary research in the built environment. The focus of his research is the energy use and emissions for large urban areas. He recently was part of an NIHR funded project which investigated the impact of large scale retrofitting on health, including cardiorespiratory conditions.	Welsh School of Architecture, Cardiff University	Academia
lannon@cardiff.ac.uk				
Kieran	Laxen	Air quality consultant, member of IAQM committee, interest in indoor and outdoor air quality.	Air Pollution Services Limited	Industry
contact@airpollutionservices.co.uk www.airpollutionservices.co.uk				
Duncan	Laxen	I am a visiting professor in air quality management and assessment at the University of the West of England. I have many years' consultancy experience in monitoring, modelling and assessing air quality. I have been a member of AQEG and COMEAP.	Freelance Consultant	Other: Consultant
DuncanLaxen@hotmail.com				
James	Lee	I have carried out research looking at trends in air pollution since the lockdown using data from the DEFRA AURN monitoring sites using a variety of statistical techniques. This has involved pre and post lockdown comparisons as well as comparisons with levels from previous years. Air pollution levels have been compared to activity (in particular traffic flow) data to assess any relationship.	University of York / NCAS	Academia
james.lee@york.ac.uk				
Gunyoung	Lee	I am a public officer related to public health management	Public Health England (CRCE)	Academia
Andrea	Lee	Andrea is the Clean Air Campaigns and Policy Manager for environmental law charity ClientEarth, which has successfully challenged the UK government in court for failing to meet legal levels of air pollution. She advocates for the effective implementation of the national and local air quality plans to meet legal limits for NO2 in the shortest time possible, as well as for new clean air legislation.	ClientEarth	Third Sector
Popoola	Lekan	I am an atmospheric scientist, focusing on air quality measurement, modelling, big data analysis and interpretation. I'm particularly interested in the use of high dense sensor network and the evaluation of personal exposure using portable instrumentation.	University of Cambridge	Academia
oamp2@cam.ac.uk				
Mike	Leonard	I am a Visiting Professor at Birmingham City University and I am jointly leading research into Indoor air quality and overheating in new build homes	Building Alliance	Industry

First name	Second name	Profile (max. 400 characters)	Organisation	Sector
Giovanni	Leonardi	As head of PHE Environmental Epidemiology Group I am supporting the arrangements for air quality surveillance developments in England, as part of the Environmental Public Health Tracking programme. This includes weather data surveillance. I have worked on air pollution epidemiology contributing to international studies and analysed role of the immune function as part of the causal pathway.	Public Health England	Public Sector
		www.gov.uk/government/publications/environmental-public-health-surveillance-system		
Alastair	Lewis	Alastair Lewis is professor of atmospheric chemistry at the University of York and a Science Director at the National Centre for Atmospheric Science. He is currently Chair of the Defra Air Quality Expert Group (AQEG) and leading the Defra Air Quality – COVID-19 rapid evidence review.	University of York / NCAS	Academia
		ally.lewis@ncas.ac.uk		
Jinghua	Li	I am working as a researcher of the built environment and IAQ, and the topic on how to deal with air quality Post-Covid 19 is very attractive to me, both indoors and outdoors. Ideally, some sort of regulation should be in place prior to the lift period, which may not yet been considered fully at current stage.	University of Chester	Academia
		jinghua.li@chester.ac.uk		
Ming	Liu	CageCapture Ltd is a University of Liverpool start-up, based in the Materials Innovation Factory, an £81 million facility dedicated to the research and development of advanced materials. CageCapture creates, develops and supplies novel advanced materials to address some of the most pressing indoor air pollution problems facing modern society.	University of Liverpool	Academia
Larissa	Lockwood	Global Action Plan is developing a #buildbackcleanerair campaign that needs to be informed by the science to help bring the life back to our streets, but not the air pollution. Get in touch if interested.	Global Action Plan	Third Sector
		larissa.lockwood@globalactionplan.org.uk		
Matthew	Loxham	Particulate matter toxicology, airway and lung cell biology (focus on epithelial cells in bronchi and alveoli)	University of Southampton	Academia
		m.loxham@soton.ac.uk		
Gongda	Lu	My relevant research skills are processing large air quality datasets from surface monitoring networks and satellite platforms. Thanks.	University of Birmingham	Academia
Zhiwen	Luo	My research focuses on how the built environmen design affects air pollution exposure (both indoor and outdoor) through engineering approaches.	University of Reading	Academia
		www.reading.ac.uk/CME/about/staff/z-luo.aspx		

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Donna	Lyndsay	Donna Lyndsay is the Commercial Director of 4EI, a leading UK EO company. Along with Kings College London, we are creating a new Global Air Quality Index and data to enable key decision-makers to understand the impacts air quality has on their countries, businesses and homes. We have also delivered the first national heat hazard index free to Category 1 Responders as our COVID response .	4 Earth Intelligence	Industry
dl@4ei.co.uk				
Liang	Ma	PhD research student on the air quality and public health impacts of transport policies	Imperial College London	Academia
Yuki	Machida	Developing indoor air quality monitors to provide recommendations on how to improve indoor air to reduce risks of respiratory illnesses. We want to make research publications in relation to air quality and its long term health impacts more accessible to domestic living to incentivise indoor air quality improvements. We see a need for change in the UK.	SORA	Industry
Helen	Macintyre	I have worked in air pollution and climate change effects on health for the past 10 years. I have a highly multi-disciplinary background, covering earth sciences, air pollution, climate change, the built environment, and now work in the field of environmental change and health.	Public Health England	Public Sector
Roger	Macklin	We specialise in making working environments productive. COVID impacts this	Hoare Lea	Industry
Donald	MacLeod	STFC Builds space, ground and airborne instrumentation for environmental monitoring including for air quality and climate change.	STFC – UK ATC	Public Sector
donald.macleod@stfc.ac.uk				
Liora	Malki-Epshtein	Collaboration with TfL on ventilation and airflow on buses for COVID outbreak. Research indoor and outdoor air quality, urban fluid mechanics, wind engineering, by CFD modelling and Air quality monitoring. Civil Engineering lead and co-founder, MEng Engineering and Architectural Design (EAD), co-director, UCL-RAEng Centre of Excellence in Sustainable Building Design (CofESBD)	University College London, Department of Civil Engineering	Academia
l.malki-epshtein@ucl.ac.uk				
Eloise	Marais	I am providing atmospheric chemistry modelling support to the NERC NCEO to aid in interpreting satellite observations of NO2 and also providing satellite observations of NO2 and SO2 to researchers in South Africa to assess the effects of the lockdown on air quality there.	University of Leicester	Academia
maraisresearchgroup.co.uk/				

First name	Second name	Profile (max. 400 characters)	Organisation	Sector
Rachael	Marsh	Led local authority approach to air quality improvements. Lead on assessment of COVID-19 on inequalities including environmental mechanisms.	NHS	Public Sector
Nick	Martin	NPL has developed exposure chambers and field facilities to test air quality (AQ) monitoring instrumentation and evaluate low cost sensor systems. NPL is also involved in Breathe London, QA/QC of Local Air Quality Management (LAQM) and the UK Urban National NO2 Network (UUNN). It participates in the development of European documentary standards on AQ through CEN TC264 Working Groups.	National Physical Laboratory, UK	Public Sector
nick.martin@npl.co.uk				
Dan	Maskell	Research involved with construction, building materials and indoor air quality	University of Bath	Academia
D.Maskell@me.com				
Monica	Mateo-Garcia	Research expertise in indoor air quality and occupant satisfaction	Birmingham City University	Academia
monica.mateogarcia@bcu.ac.uk				
James	Matthews	I am an experimental physicist who has measured aerosols and gas dispersion both indoors and outdoors. My research interests have included the chemical and physical properties of aerosols (size, electrical charge state and metal content), and the dispersion within cities and infiltration indoors of pollutants using chemical tracers.	University of Bristol	Academia
j.c.matthews@bristol.ac.uk				
Anna	Mavrogianni	Dr Anna Mavrogianni is an Associate Professor in Sustainable Building and Urban Design at the UCL Institute for Environmental Design and Engineering. She is an expert in indoor environmental quality, and associated public health impacts, focusing on climate change adaptation, environmental justice, inequalities and vulnerable populations.	University College London, Institute for Environmental Design and Engineering, The Bartlett	Academia
a.mavrogianni@ucl.ac.uk				
Ian	Mawditt	Technical adviser to MHCLG in relation to Part F of the Building Regulations. Conducted IAQ investigations, including obo MHCLG, to help inform ventilation standards. Intend to passively participate in this event to help understand if there is a need for extraordinary operation and/or behavior change in relation to domestic ventilation to mitigate internal spread and/or ingress if CV-19 is aerosol	Four Walls	Public Sector
ian@fourwalls-uk.com				
Alfie	Mayhew	My research focuses on the role of biogenic VOCs in air pollution, particularly regarding the night-time chemistry of isoprene and the resulting formation of SOA.	University of York	Academia
am1837@york.ac.uk				

First name	Second name	Profile (max. 400 characters)	Organisation	Sector
Gordon	McFiggans	My group are atmospheric aerosol scientists, primarily related to the roles of particles in air pollution, their measurement, laboratory investigation and modelling but most recently related to the potential for viral transmission in the clinical environment. Our team are working on quantifying the effectiveness of aerosol removal technologies to mitigate surgical exposure to airborne particles.	University of Manchester	Academia
g.mcfiggans@manchester.ac.uk				
Gráinne	McGill	Ventilation performance, indoor air quality	Glasgow School of Art, MEARU	Academia
g.mcgill@gsa.ac.uk				
Jim	McQuaid	Measurement of pollutants, both gas phase and particulate material. Use of low cost sensors to study health intervention strategies	University of Leeds	Academia
j.b.mcquaid@leeds.ac.uk				
Mohammed Iqbal	Mead	Iq Mead is a lecturer at the Cranfield University Centre for Environmental and Agricultural Informatics and is leading work there on developing and deploying sensors to investigate atmospheric pollutants. His research is primarily on studies of trace gases with both traditional and emergent sensing techniques and spatio-temporal scales of air quality using low-cost high-density networks.	Cranfield University	Academia
www.cranfield.ac.uk/people/dr-iq-mead-14147237				
Francis	Mills	Chartered Engineer, specialist in infection control ventilation engineering, Chair of CIBSE Healthcare Group, Chair of IMechE Construction Division, member of IMechE Covid task force, Member of ASHRAE's Healthcare TC9.6, Member of ASHRAE's emergency epidemic task force, Specialist in sustainable design including health and well being and IAQ, Energy specialist working toward Net Zero buildings	Frank Mills Consulting	Other: Consultant for infection control by engineering
famills@hotmail.co.uk				
Jim	Mills	Air Quality Monitoring specialist working within several AQ networks in the UK and abroad, also a partner in Breathe London	ACOEM Air Monitors	Industry
jim.mills@acoem.com				
Azadeh	Montazami	Dr. Montazami has a strong background on thermal comfort, indoor air quality and resilience in Architecture and sustainable principles in school buildings in the light of future climate. In recent years, she has carried out various researches looking at the integration of thermal comfort and indoor air in school buildings and how they may change based on Context, Occupants and Buildings factors.	Coventry University	Academia

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Alejandro	Moreno Rangel	Alejandro is currently researching the use of low-cost IAQ monitors and how they can be used to improve health. Currently developing a project proposal to understand the effects of the self-isolation to IAQ	Lancaster University	Academia
a.morenorangel@lancaster.ac.uk				
Anastasia	Mylona	What are the installation and maintenance requirements of building services systems to be able to stop the spread of COVID and other potential airborne diseases?	CIBSE	Other: Professional body
Dzhordzhio	Naldzhiev	Researcher on indoor air quality at UCL (particular area of expertise: VOCs and total environmental building performance). Head of science strategy at Office for Product Safety and Standards (OPSS, part of BEIS).	UCL	Academia
dzhordzhio.naldzhiev.16@ucl.ac.uk				
Lucy	Natarajan	Built Environment, Spatial Planning, Public Engagement	University College London	Academia
lucy.natarajan@ucl.ac.uk				
Paul	Nathanail	Interest in the fate & transport of and exposure to fugitive ground gases, vapours, nano particles (including spores and viruses), micro plastics and asbestos fibres to inform risk based decision making.	LQM	Industry
paul@lqm.co.uk				
Eiko	Nemitz	Emission quantification and assessment of emission changes due to COVID19 on air pollutant levels.	UK Centre for Ecology & Hydrology	Third Sector
en@ceh.ac.uk				
Mark	Nichols	Air Quality Consultant in Brighton	Phlorum	Industry
Rosalind	O'Driscoll	I lead the research programme on air quality at the Greater London Authority. I have a PhD in air quality from the Centre of Environmental Policy at Imperial College London.	Greater London Authority	Public Sector
rosalind.o'driscoll@london.gov.uk				
Emer	O'Connell	I'm a Consultant in Public Health specialising in environmental public health. My PhD looked at the burden of disease of air pollution. I previously worked with TfL supporting assessments of the impacts on health of air quality and the effectiveness of the ULEZ. I currently lead the Extreme Events and health protection team in PHE but split my time to support the COVID-19 response.	Public Health England	Public Sector
Freja	Oesterstroem	I have experience in gas phase kinetics and reaction mechanisms of atmospheric species, both man-made and naturally occurring. I have performed laboratory experiments on species relevant outdoors as well as modelled ozone over London using a box model with explicit chemistry. Currently, I am modelling indoor air with a similar model, looking into the impact of human activities on air quality.	University of York	Academia

First name	Second name	Profile (max. 400 characters)	Organisation	Sector
Flora	Ogilvie	Public Health Consultant at Transport for London	Transport for London	Public Sector
Tayo	Owodunni	I am involved in the management of a programme of projects focused on generating new capabilities for environmental public health tracking & surveillance-enabled research. Two projects I manage provide novel, multi-sourced data-interoperability infrastructural capabilities for population health research & surveillance of (1) air quality/pollution exposure and (2) weather & climatic determinants.	Public Health England	Public Sector
Isabella	Panovic	Senior Programme Manager for the STFC 21st Century Challenges Networks, which include the SAQN	STFC	Public Sector
Helen	Pearce	PhD student focusing on high resolution real-time vehicle traffic speeds in cities, and resulting emissions & pollution concentrations through a modelling framework	University of Birmingham	Academia
Bethan	Perkins	I have a PhD thesis in the climatic impact of super-volcanic eruptions (with E Highwood, UoReading) as well as 7 years' experience working commercially in Earth Observation (Assimila Ltd). I joined the DAFNI project at STFC in Sept 2019. DAFNI's aim is to support development of essential infrastructure services, by bringing researchers from different domains together one data-processing platform.	DAFNI at the Science and Technology Facilities Council	Public Sector
	bethan.perkins@stfc.ac.uk			
Paul	Pfeffer	Paul Pfeffer is a Consultant Respiratory Physician at Barts Health NHS Trust and a member of the Trust Covid-19 Clinical Guidelines Committee. His research interest is in the capacity of environmental factors such as vitamin D, air pollution and airway infections to subvert homeostatic and protective adaptive immune responses in the lung resulting in airway pathology.	QMUL	Academia
Revati	Phalkey	Lead the Climate Change and Health Group at CRCE, PHE. Work includes assessing the climate change aspects of infectious diseases transmission as well as air quality with respect to health.	Public Health England	Public Sector

First name	Second name	Profile (max. 400 characters)	Organisation	Sector
Gavin	Phillips	A researcher with over a decade in the field studying atmospheric chemistry and air pollution. My interests are the science of reactive nitrogen and indoor air chemistry. I currently co-I on the EPSRC-funded IMPECCABLE project investigating the science of domestic indoor atmospheres. I work with a number of industry partners on indoor air and industrial emission via regional funding mechanisms.	University of Chester	Academia
www1.chester.ac.uk/departments/natural-sciences/staff/gavin-phillips				
Robyn	Phipps	Robyn is Professor in Construction at Massey University, Co Director of the Healthy Housing research group that won the New Zealand Prime Ministers prize for Healthy Housing Research, and Director of the NZ Green Building Council. My team is focused on evaluating low cost and effective solutions for making homes and schools healthier and lower carbon.	Massey University, School of Built Environment	Academia
r.a.phipps@massey.ac.nz				
Rebeka	Popovic	PhD student at the MRC Toxicology Unit, investigating links between air pollution and COVID-19 in England.	University of Cambridge	Academia
rp636@cam.ac.uk				
Ruth	Purvis	Work in air quality monitoring, specialise in NHMC analysis	University of York / NCAS	Academia
Frank	Quinn	We are building out the UK's first Hyper Local Pollution Monitoring Network with Smart Inhaler Ecosystem.	QIoT	Industry
frank.quinn@qiot.co.uk				
Gordon	Rates	AirNode – making our user feel like they have 'X-ray specs for Air Quality' – a cloud based software as a service to increase awareness of air quality levels and design novel air quality analysis	AirNode	Industry
www.airnode.co.uk				
Teresa	Raventos	My research interests are focused on research of the gas phase and particulate matter concentrations in urban areas, emission sources and the effect of mitigation actions to their levels. Also, the volatile organic compounds and their chemical evolution with emissions and transport over megacities, the transformation of their chemical composition and conversion to particulates PM2.5.	University of Leicester	Academia
Stefan	Reis	Science Area Head Atmospheric Chemistry and Effects, with experience in integrated assessment modelling of air pollution effects on human health and ecosystems.	UK Centre for Ecology & Hydrology	Other: Research Institute
srei@ceh.ac.uk				
Giridharan	Renganathan	My area of expertise is urban morphology and climatology	University of Kent	Academia
www.kent.ac.uk/architecture-planning/people/1087/renganathan-giridharan				

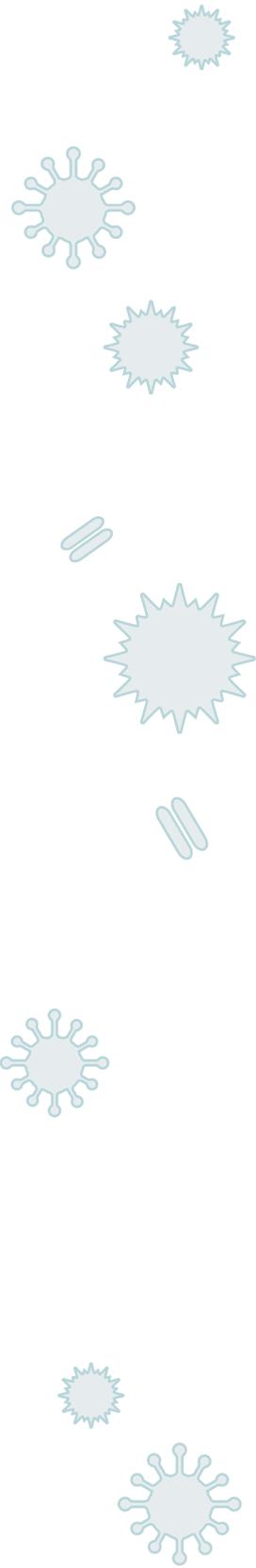
First name	Second name	Profile (max. 400 characters)	Organisation	Sector
Helen	Rogers	I am a Senior Portfolio Manager in ESRC's Environment Team. My portfolio includes, climate change, air quality, food systems, energy, landscapes, and sustainability.	ESRC-UKRI	Public Sector
helen.rogers@esrc.ukri.org				
Stefano	Rolfo	Expert in CFD and HPC modelling.	STFC DL	Academia
stefano.rolfo@stfc.ac.uk				
Chris	Rush	I lead the Air Quality Group at Hoare Lea, am a committee member for the Institute of Air Quality Management (IAQM) and am on the CIBSE Air Quality Working Group. So very much air quality focused and this being particularly true for Indoor Air Quality.	Hoare Lea	Industry
chrisrush@hoarelealea.com				
Marion	Samler	DAFNI is a computer collaborative hub supporting research into our everyday infrastructure services. It facilitates access to data, provides a suite of analytical enabling tools to help researchers understand insights from data. It will enable testing of different scenarios to reveal a greater understanding of transport, telecommunications, energy, water and waste, and air quality.	STFC	Other: STFC – DAFNI – Research Sector
Christian	Saravia	Air quality research, founder of Ambente Air Quality project to monitoring pollutants in the atmosphere.	AMBENTE	Academia
Liza	Selley	I am a UKRI Research Fellow working to identify mechanisms by which traffic-related particulates enhance susceptibility to bacterial infections within the lungs. This work seeks to characterise responses to particle exposure in both host and pathogens. During the lock-down period I have contributed to the MRC Toxicology Unit's public engagement regarding COVID-19.	MRC Toxicology Unit	Academia
ls802@mrc-tox.cam.ac.uk				
Sean	Semple	Dr Sean Semple is particularly interested in indoor air quality related to tobacco and e-cigarette use. He is involved in behavioural interventions around using exposure measurements to encourage smoke-free homes. His background is in occupational hygiene and he has expertise in personal exposure assessment and measurement of respiratory hazards (and control measures) in the workplace.	University of Stirling	Academia
sean.semple@stir.ac.uk				
Calum	Shaw	Clean Air Bill Manager in Welsh Government	Welsh Government	Public Sector
David	Shaw	Research focussing on indoor air modelling, specifically indoor air chemistry	University of York	Academia
david.shaw@york.ac.uk				

First name	Second name	Profile (max. 400 characters)	Organisation	Sector
Marvin	Shaw	Air quality Expert. Specialising in real-time VOC measurements	University of York	Academia
marvin.shaw@york.ac.uk				
Zongbo	Shi	I am interested in air pollution science with a particular focus on airborne particles.	University of Birmingham	Academia
z.shi@bham.ac.uk				
Clive	Shrubsole	Dr Clive Shrubsole is an Environmental Public Health Scientist within the Air Pollution Group at Public Health England. He supports work assisting national and local government to reduce the health effects of air pollution, providing expert research and advice on indoor and outdoor air pollution and interventions aiming to improve air quality.	Public Health England	Public Sector
clive.shrubsole@phe.gov.uk				
Ajit	Singh	Dr Ajit Singh is an environmental scientist with particular interest in air pollution measurements and public health. His current collaboration with academics at the University of Cambridge is based on Covid-19 and air quality, where his research involves human-mobility reduction strategies based on the air quality in London.	University of Birmingham	Academia
www.birmingham.ac.uk/staff/profiles/gees/singh-ajit.aspx				
Rudy	Sinharay	Respiratory physician with interest in COPD, pleural and lung cancer. I have published work on the effects of short term exposures to air pollution on patients with copd.	Imperial College Healthcare NHS Trust	Academia
rudy.sinharay1@nhs.net				
Daniel	Slade	I am a Policy and Projects Manager at the TCPA. We have more than a century of campaigning for sustainable urban development and healthy place making. We are currently developing legislation that fundamentally changes how we regulate the built environment, and ensures that all new homes and neighbourhoods support residents' wellbeing.	www.tcpa.org.uk/healthy-homes-act Town and Country Planning Association	Third Sector
daniel.slade@tcpa.org.uk				
Kevin	Smith	Member of the SAQN leadership and management team	STFC	Public Sector
kevin.smith@stfc.ac.uk				
Olwen	Spiller	Acting Deputy Director for Environment Quality. Leading the development of policy and regulation to improve air quality for Wales. Emerging research gained from the impacts of COVID will support and inform future action to tackle air pollution.	Welsh Government	Public Sector
olwen.spiller@gov.wales				
Marc	Stettler	Aerosol measurement and characterisation	Imperial College London	Academia

First name	Second name	Profile (max. 400 characters)	Organisation	Sector
Vicki	Stevenson	As course leader of MSc Environmental Design of Buildings, I have a specific interest in improving indoor air quality while minimising environmental impact. This has been represented in my PhD supervision and participation in funded research as part of the Low Carbon Research Institute.	Cardiff University	Academia
stevensonv@Cardiff.ac.uk				
Catherine	Sutton	Indoor and outdoor air Quality Research Dissemination with particular emphasis on the role of inhaled allergens	Airborne Allergy Action	Third Sector
Catherine.sutton@lawnside.ltd.uk				
James	Tate	Break-point and Change-segment analysis of: traffic count, AURN air quality concentrations and the local traffic air quality increment (deseasonalised, deweathered, time varying local background subtracted). Analysis now run for majority of UK sites with provisional NO2 data available for 2020.	University of Leeds, ITS	Academia
environment.leeds.ac.uk/transport/staff/980/dr-james-tate				
John	Thornes	Professor John E Thornes Principal Climate Change Scientist PHE interested in the links between air quality, transport and climate change and the likely post COVID impact.	PHE	Public Sector
john.thornes@phe.gov.uk				
Anna	Tuddenham	Climate change consultant	Arup	Industry
anna.tuddenham@arup.com				
Briony	Turner	Expertise in UK built environment, academic-industry knowledge sharing, air quality, multi-sensory design, interested in interdependencies between indoor&outdoor air quality, brownfield land, microclimate, climate change and secondary pollutants. IAQ & Child Health group secretary, co-founder AQNUK, Vice Chair CIBSE Resilient Cities Group, Steering Group member London Climate Change Partnership.	Space4Climate, NCEO, University of Reading	Other: Boundary organisation spanning academia, policy and industry
www.space4climate.com				
Marsailidh	Twigg	Dr Marsailidh Twigg is an atmospheric scientist with expertise on reactive trace gases and particulate matter (PM) using both low cost and state of the art methods. She has conducted research studying water-soluble inorganic PM in the UK rural background atmosphere, fluxes of reactive nitrogen compounds (e.g. NH3), as well as citizen science studies on personal exposure to air pollutants.	UK Centre for Ecology & Hydrology	Academia
Sail@ceh.ac.uk				
Marcella	Ucci	Associate Professor in Environmental and Healthy Buildings at UCL, with expertise in indoor environmental factors and health/wellbeing, particularly air quality.	University College London (UCL)	Academia
www.ucl.ac.uk/bartlett/environmental-design/dr-marcella-ucci				

First name	Second name	Profile (max. 400 characters)	Organisation	Sector
Maria	Val Martin	I am an atmospheric scientist working in understanding how human activities and natural processes (eg, wildfires) change the atmosphere. My research uses ground and satellite observations with numerical models to address questions related to air pollution and atmospheric composition and atmosphere-biosphere-climate interactions.	University of Sheffield	Academia
Karn	Vohra	I am a PhD student at University of Birmingham focusing on monitoring city-level air quality using Earth Observations.	University of Birmingham	Academia
kxv745@bham.ac.uk				
Katie	Wade	Hoping to write a dissertation on COVID-19 and air quality	Student	Academia
pr17kw@leeds.ac.uk				
Katie	Wade	Student doing research on covid-19 lockdowns impact on air quality	University of Leeds	Academia
Fan	Wang	I am a member of CIBSE. My research interests are Low-energy building ventilation and environmental control. Airflow modelling is my approach of studying the airflow and indoor pollution distribution. The recent outbreak has brought my interest back, especially to the aerosol dispersion and ventilation in large classrooms.	Heriot-Watt University	Academia
www.researchgate.net/profile/Fan_Wang14				
Mike	Webley	I & my company Enviro Technology have been supplying AQ equipment in the UK for 37 years. Our equipment is used by National Government, Local city's & University's	Enviro Technology	Other: Supplier of Environmental equipment
mike.webley@et.co.uk				
Andy	Williams	Andy is one of the SAQN Co-Investigators with expertise in particle behaviour and filtration technologies.	University of Chester	Academia
www1.chester.ac.uk/departments/mechanical-engineering/staff/andy-williams				
Martin	Williams	Outdoor air quality changes	King's College London	Academia
martin.williams@kcl.ac.uk				
Paul	Willis	Air quality measurements team leader at Ricardo. Ricardo has been carrying out extensive analysis of the Covid-19 lock-down period. We have reported on the reduction in measured concentrations compared to expected business as usual, we have considered the likely reduction in emissions across sectors, how this can be modelled, and the scenarios for overall impact on the 2020 air pollution climate.	Other: Consultancy	Ricardo
paul.willis@ricardo.com				

First name	Second name	Profile (max. 400 characters)	Organisation	Sector
Rose	Willoughby	I have been involved in coordinating work relating to Covid-19 symptoms and links to air quality.	Defra	Public Sector
Jacky	Wood	NERC Head of Business Partnerships, Strategic Programme Generation team	UKRI-NERC	Public Sector
jacqueline.wood@nerc.ukri.org				
Darren	Woolf	Building physics / fluid dynamics engineer. Expert areas inc ventilation performance and air quality. Visiting Professor Loughborough University. Chair CIBSE Building Simulation Group. Designed many healthcare facilities and industrial supervisor for bioaerosol PhDs.	Independent consultant	Industry
darren@woolfcs.com				
Matthew	Wright	Aerosol physico-chemical transformations in indoor and outdoor environments, Aerosol measurement and sampling instrumentation, Lung deposition and dose, Size-segregated particle composition, Electrostatic effects	Public Health England	Public Sector
matthew.d.wright@phe.gov.uk				
Jingsha	Xu	As a research fellow in school of Geography, Earth & Environmental Sciences at University of Birmingham, I'm currently working on projects of "Atmospheric Pollution and Human Health in a Chinese Megacity (APHH-China, £12 m)". My current research work involves laboratory analysis of aerosol components and modelling work including aerosol acidity calculation and aerosol source apportionment.	University of Birmingham	Academia
Ying	Zhang	NPL is one of the UK's Air Quality Reference Laboratories and has over 30 years' experience in making air quality measurements in the UK. NPL currently operates three of the UK's air quality networks, does quality assurance and control for AURN and provides measurement expertise for LAQM. NPL is also part of a new collaboration with the London Mayor's Office to monitor and tackle air pollution.	National Physical Laboratory (NPL)	Public Sector
ying.zhang@npl.co.uk (www.npl.co.uk)				
Svetlana	Zolotikova	NCEO International Project Coordinator	National Centre for Earth Observation	Academia
Svetlana.Zolotikova@nceo.ac.uk				



Annex 2: Discussion board content

The Discussion Board was structured and pre-populated with thematic coding devised from content submitted by delegates during registration. New comments were made by participants during the event and the board was kept open for a week following the event, closed at 4.30pm on the 29th May 2020. The discussion board contained a total of 551 contributions, this figure includes the thematic headers.

Many participants listed their comments at the end of the discussion thread so to aid analysis, these comments were moved to the relevant sub-theme/new sub-theme created. The event report was then downloaded from Meeting Sphere on the 30th May 2020. Participant names of those who took part in the discussion board have been removed as these appear where participants have actively made a comment. 147 event delegates took part in the discussion board, not all made comments. Of the 147, 7 chose to remain anonymous.

Sticky points were available but due to technical difficulties, initially were not activated in all rooms and some participants struggled to use them and used verbal 'agree' to indicate they felt a point was important.

Note on citations: due to time constraints, some comments referred to existing data or research but did not include references. Where possible, the report authors have requested reference links from the authors and added these to the discussion thread. Where no reference is given, it was not possible to identify the source.

Sticky points:

- Important knowledge gap (200 points per participant)
- Critical priority knowledge gap that needs action (200 points per participant)

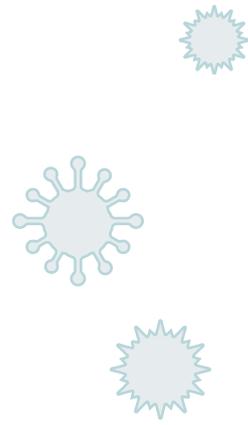
1. Lockdown – many vulnerable remain on full lockdown and there could be periods of recurrence where lockdown needs reinstating

Question or instruction for the discussion:

Lockdown – many vulnerable remain on full lockdown and there could be periods of recurrence where lockdown needs reinstating

We are aiming to foster interdisciplinary conversations. We're asking you to:

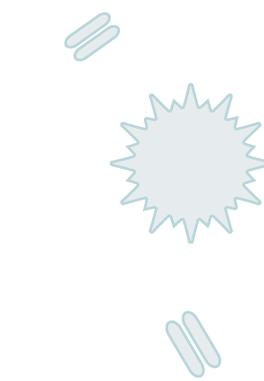
1. review identified gaps in the knowledge
2. point out what is known about a gap raised, from your discipline/area of expertise, using the comment function.
3. note down any other critical knowledge gaps, using the comment function 89 delegates on registration provided content on knowledge gaps which has been used to pre-populate this section



Covid-19

What do we actually know about intervention efficacy?

- Use of masks to mitigate aerosol transmission isn't a given; properly blocking aerosols requires a well-fitting mask of a certain quality, so may not be the best solution as an intervention for the general public (as opposed to e.g. healthcare professionals) (James Allan | May 20, 2020, 15:13 BST)
- mobile UV units for Covid hot spots
 - » What is an infectious dose?



Virus characteristics -we need to know about the following, what do we know and what don't we for a UK setting?

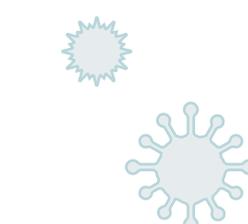
- » Survivability
- » Behaviour and viability in air
- We need much more measurement of virus in indoor environments (e.g. active sampling of air using filters/ impingers, swabs on surfaces) to understand occurrence not just measurement of virus in people (swab tests) (Derrick Crump | May 27, 2020, 10:40 BST)
- ● (1) What is the concentration of viral particles in aerosol derived from patients (Rudy Sinharay | May 20, 2020, 15:14 BST)

Transmission – environmental drivers – impact of air quality on transmission

- 
- The emerging evidence is that transmission is very rare in outdoor spaces. (Sean Semple | May 20, 2020, 15:16 BST)
 - Homes particularly important – 83% of clusters in China occurred in households

Transmission – how to control

Transmission mechanisms (May 20, 2020, 02:27 BST)

- 
- We don't know how much transmission is from inhalation and how much from surface/skin contact. (Sean Semple | May 20, 2020, 15:17 BST)
 - Airborne
 - » Whilst droplets can be blocked by visors and barriers, fine aerosol must be removed at source or require extremely efficient well-fitting masks. This means wearing masks to protect others is much more likely to be more effective than distancing just 2 m. If such particles can be shown to carry an infectious load, then mask-wearing should be mandated.
 - Specific pollutants e.g. PM

Impact of air quality on transmission of Covid-19

- Develop the evidence on the transmission of COVID-19 indoors. Where did the outbreaks occur in the UK? (Sani Dimitroulopoulou | May 20, 2020, 15:16 BST)
- Air quality does impact on COVID19.
- How improved air quality – allergen and pollutant removal or PM2.5 reduction etc can improve COVID19 stats

Impact of Covid-19 on air quality

- Dangers to the lungs from exposure to cleaning products, detergents etc. (Paul | May 20, 2020, 15:15 BST)

Management

- How can we design new buildings or adapt existing buildings to be more resilient in the future? (Gráinne | May 20, 2020, 15:18 BST)
- Can we do better when there are second/third waves of COVID-19 pandemic? and how? (Vincent Luo | May 20, 2020, 15:14 BST)
- Advice on cleaning surfaces in buildings safely and effectively; USEPA has a register of products and associated guidance; should be something similar relevant to UK market (Derrick Crump | May 20, 2020, 15:14 BST)
- Frontline workers (e.g. health and care workers) who are exposed to Covid19 are capable of infecting their family members who are otherwise under lockdown.

Other (if you made these, perhaps provide more detail)

- We have advanced modelling tools already available for providing advice on lockdown
- How much aerosol is actually generated by oxygen delivery devices e.g. CPAP, high flow nasal canulae. (Rudy Sinharay | May 20, 2020, 15:14 BST)
- Just saw this today – www.medrxiv.org/content/10.1101/2020.05.14.20102517v1 (Sean Semple | May 20, 2020, 15:15 BST)

People & activities

Data and models (Briony Turner | May 29, 2020, 00:27 BST)

- Whether low cost monitors can help to motivate people to improve their indoor air quality by making them aware that there may be an issue and therefore impact any possible viral transmissions (Catherine Sutton | May 27, 2020, 12:50 BST)
- Is there any data on differences in indoor air quality in different countries which could be associated with different death rates eg. more hard floors & less furnishings in hotter countries, different humidity, different indoor and outdoor allergens and pollutants etc (Catherine Sutton | May 27, 2020, 12:32 BST)
- Citizen science angle – folks with low cost AQ monitors aren't seeing the same changes in "NO2" as the networks – likely due to cross-interferences between NO2 (down) and O3 (up) in their monitor (Ox conserved) – hence challenging the "air quality much better" narrative (William (Bill) Bloss | May 20, 2020, 15:36 BST)

- The current situation is a significant intervention with substantial changes to many areas which impact on AQ. Concerted effort is needed to maximise the detailed data regarding the impacts, to allow more accurate interpretation of the data. This requires unified means of collecting and storing data which multiple disciplines can access and understand. (Andy Williams | May 20, 2020, 15:31 BST)
- Models for air pollution will be expected to operate outside their normal situation, which would be a good test of model fidelity – and should be an important area of focus with long term benefits to future AP work. (Andy Williams | May 20, 2020, 15:28 BST)

Impact of Covid-19 on energy use

- Analysis of smart meter energy data for domestic demand
 - RCUK SERL project planning to do this <https://serl.ac.uk/> (@dataknut | May 20, 2020, 15:22 BST)

Changes in habits e.g. smoking and vaping

Changes and impact of domestic activities

- Cleaning
- BBQ& bonfires
 - The risk associated with increased wood burning, woodstoves, bbqs, bonfires etc. and how to educate and reduce these (Emily | May 26, 2020, 12:28 BST)
 - Noticed more burning of garden waste and rubbish – possible due to recycling centre shutdown – effecting PM emissions? (Andy Duncan | May 20, 2020, 15:16 BST)
 - Anecdotal evidence suggests an increase in domestic burning (bonfires) during the lock-down
- Evidence from Fire Services in Wales is that they have seen a significant increase in wild/grass fires and domestic burning including anti-social burning. (Andrew Kibble | May 20, 2020, 15:13 BST)
- Impact of summer overheating in homes and other buildings in use
 - Important in context of interacting risks/co-exposures. Are people more susceptible to effects of air pollution if already heat stressed (or vice versa?). What does this mean for how we advise the public to respond during a heatwave? (Helen Macintyre | May 20, 2020, 15:13 BST)
- Other changes to behaviour might include more time spent indoors (higher exposure), more home cooking, higher home occupancy, increase cleaning, home heating etc. – management of IAQ in home will be critical (Gráinne | May 20, 2020, 15:13 BST)

Workplace changes

- How can activities take place safely? e.g. construction
- How can buildings be made safe for work?

- ASHRAE information web pages
- Risk communication and compliance
- Working from home
 - Sustainability impacts of working from home
 - Home working – air quality in unregulated spaces

Changes in what constitutes an ‘essential’ service

- Reliability of and redundancy in broadband service – NOW an essential service!

Health

- Is there an increased incidence of poor IAQ in care homes due to more bedroom settings, increased furnishings/carpets and associated increased inhaled allergens and pollutants, increased heating, increased movement of people etc? (Catherine Sutton | May 28, 2020, 10:07 BST)
- The combined risk of heatwave and COVID-19 especially for vulnerable population (Vincent Luo | May 20, 2020, 15:16 BST)
 - Overheating risk of vulnerable people during lockdown (Derrick Crump | May 20, 2020, 15:17 BST)
- Physical (Briony Turner | May 29, 2020, 00:22 BST)
 - Even in normal times, many humans spend 80% of their time indoors, while household air pollution is one of the top 5 global risk factors
 - » People are spending even more time indoors than usual but also potentially cleaning a lot more, what is the impact on exposure to cleaning products etc. high in VOCs. Further to this lots of people are conducting DIY projects which could further increase hazardous VOC concentrations. (Emily | May 26, 2020, 11:39 BST)
 - » Time spent indoors may be even higher for some groups, e.g. people who may struggle with mobility. (Helen Macintyre | May 20, 2020, 15:15 BST)
- The comparison of the death rates between Sweden and Scotland (pro-rata 4 times higher than Sweden, where there was no lockdown) throws up important questions. I suspect that the unhealthy life-style of many Scots with poor diet and long-term exposure to poor indoor air quality, result in a compromised immune system, and this has a much greater influence on the death-rates than stringent lockdown measures.
- Mental health (Briony Turner | May 29, 2020, 00:22 BST)
 - Impact of COVID-19 on mental health and how the built environment could improve this in the post pandemic (Vincent Luo | May 20, 2020, 15:12 BST)

Habits, behaviour and lifestyle change (May 29, 2020, 00:25 BST)

- What is the trade off / balance between the increase in time people are spending indoors but also the potential increase in outdoor physical activity? How does air pollution affect this? (Emily | May 26, 2020, 11:40 BST)
- How to access to real-time personal exposure during lock down period? It is not easy but has become really important based on the fact that many life styles are and will be changed during and beyond the lock down (i.e. remote working, home-schooling). (Jinghua li | May 20, 2020, 15:14 BST)
- There appear to be lots of surveys trying to capture changes in behaviour (physical exercise, diet, smoking, drinking, gambling etc etc). If we can capture data on changes in behaviour we can perhaps model changes in indoor air quality. (Sean Semple | May 20, 2020, 15:13 BST)
- Smoking
 - Quitting smoking during COVID appears to be increasing, but this is a 'fact' from one ASH survey.

Domestic

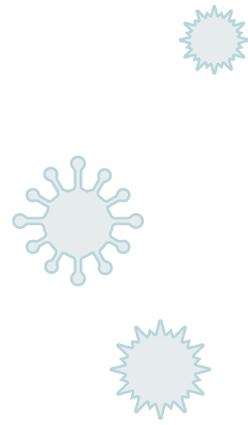
- Are people starting to turn to mitigation strategies such as air purifiers to help 'clean' the indoor air as opposed to source control and emission reduction? (Emily | May 26, 2020, 12:03 BST)
- In response to hot weather – potentially beneficial – more chance of people ventilating their houses in an attempt to cool down (Vicki | May 20, 2020, 15:14 BST)
- Managing indoor air quality during prolonged periods at home, indoors.

Schools (Briony Turner | May 29, 2020, 00:33 BST)

- What is going to be the effect of air quality in schools when they return? There is a always viral asthma spike in September in week 42 when children pass rhino virus to each other. Can this be offset by improved indoor air quality in schools by more effective removal of allergens and pollutants in dust accumulated during the school break? Will this affect COVID 19 transmission? The viral spike may be associated with other return to school timings too so is there any increase when only some children return soon or after any other lockdowns? (Catherine Sutton | May 27, 2020, 12:38 BST)

Places – changing demand (Briony Turner | May 29, 2020, 00:35 BST)

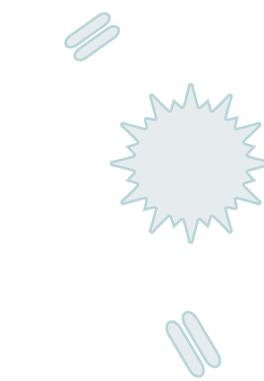
- Will covid-driven changes in housing preferences lead to important shifts in settlement patterns? E.g. Could there be a move away from the dense public-transport dependent settlement patterns are generally most environmentally sustainable? (Daniel Slade | May 28, 2020, 15:24 BST)
- Similarly, does polling suggest a long-term shift towards private vehicles and away from public transport in dense urban areas? If so, what might this mean for the design of homes and other buildings to accommodate them? Could this have negative knock-on effects, such as reducing the amount of interior space of new buildings? (Daniel Slade | May 28, 2020, 15:29 BST)



Other (Briony Turner | May 29, 2020, 00:34 BST)

- Research on inhaled allergens and asthma shows that hospitalisations for childhood asthma is 20 x more likely when there is allergen sensitivity, allergen present and a common virus. Although COVID19 doesn't seem to affect children so badly is there a similar correlation between COVID19 and the vulnerable community in relation to inhaled allergens and non allergenic pollutants? (Catherine Sutton | May 28, 2020, 10:11 BST)

Pollutant sources



Indoors (Briony Turner | May 29, 2020, 06:16 BST)

- Impact of greater use of indoor cleaning products on ambient VOCs (Derrick Crump | May 20, 2020, 15:08 BST)
- These mainly refer to ambient air. What is really happening with the indoor pollutants and their levels? (Sani Dimitroulopoulou | May 20, 2020, 15:07 BST)
 - Agree – there is emerging evidence of changes in behaviour including smoking and cooking. We have little data on what indoor/home exposures were before lockdown and during lockdown. (Sean Semple | May 20, 2020, 15:09 BST)

Variation in levels/concentrations

- 
- Impact on specific pollutants (PM, NH3, NO2, Ozone)
 - Evidence of reduction in traffic emissions (e.g. NO2) in urban environments, accompanied with an expected rise in ozone. PM concentrations not significantly changed.
 - We have monitored counted traffic (ATC) speed, number, vehicle type at 7 air quality automatic monitoring stations (7 NOX, 3 with PM10 and PM2.5) from the start of April 2020, we will monitor air quality and transport throughout lockdown, easing and post covid to see the changes in transport and the impact on air quality.
 - NH3 (Briony Turner | May 29, 2020, 06:20 BST)
 - We need to understand the role of NH3 emissions which have continued in the formation of SIA which has been observed during PM events during lockdown. (Marsailidh Twigg | May 20, 2020, 15:17 BST)
 - PM
 - Need to collect types, concentrations and distribution of particulate matter emissions
 - PM nitrate still present
 - Outdoor PM2.5 concentrations have not decreased despite motor vehicle journey reductions of >60%

- NO2
 - NO2 has dropped by around 30-50% in the UK since the lockdown, showing the effect of greatly reducing transport emissions. PM2.5 has not reduced by anywhere near as much, giving us the opportunity to study non-traffic sources of PM in detail.
- O3
 - O3 has increased since the lockdown, largely due to the reduction in primary NOx. This gives us the chance to study how O3 will behave in a potential future low carbon economy.
- Impact on primary pollutant emission (and by sector)
 - Detailed characterisation of air quality during Lockdown & release via the Birmingham Air Quality Supersite
- Role of non-transport emissions in urban air quality
- What are the pollutant reduction benefits of lockdown?
- There is evidence of wind bringing in European pollution at different stages during the pandemic.

Change of human activities on source emissions

- There is an important link between changes in air pollutant emissions and carbon emissions that could be part of the consideration. (Hartmut Boesch | May 20, 2020, 15:12 BST)
- Particle concentrations have increased at some locations but there has not been dramatic changes. We need to track the change in composition over this period to be able to understand the sources. (Jacqui Hamilton | May 20, 2020, 15:13 BST)
- These points are more about changes in concentrations than changes in emissions and the link between the two depends on meteorology. We need good near real-time activity figures and more direct emission measurements. (Eiko Nemitz | May 20, 2020, 15:14 BST)
- Low cost monitors (eg Purple Air and TSI BlueSky) may provide an easy way of capturing large amounts of data on indoor PM2.5 concentrations during and after lockdown. (Sean Semple | May 20, 2020, 15:10 BST)
- Impact of travel reduction on pollutant emissions
 - Does the conflicting data relating to reduced traffic but not necessarily reduced pollutants (depending on whose comments I read) related to the type of traffic? ie trains (generally 20+ years old – at least on the line outside my garden) are running at near normal timetable (although with reduced load), while number and driving range of private cars has been significantly reduced. (Vicki Stevenson | May 27, 2020, 11:52 BST)
 - There is an opportunity to change cultural attitudes towards unnecessary (disposable travel) – can we encourage C change and how to measure the impact (Andy Duncan | May 20, 2020, 15:14 BST)

- Urban traffic flow on arterials fell to 25% of pre-lockdown levels. local traffic air quality increment shown to fall by a similar magnitude
- Decrease of pollutant dispersion
- What impact is the increase in DIY projects (both indoor and outdoor) having on exposure? (Emily | May 26, 2020, 11:50 BST)

Pollutant exposure

Indoors (Briony Turner | May 30, 2020, 13:37 BST)

- Increased ozone indoors because of increased ozone outdoors, means more indoor air chemistry (formation of PM and HCHO indoors) (Nicola Carslaw | May 20, 2020, 15:12 BST)

Personal exposure variation

- The use of personal data on exposure to various sources throughout the day is important versus health effects as everyone's exposure is so different (Catherine Sutton | May 27, 2020, 12:49 BST)
- How can we compare personal exposure prior to lockdown? Also the composition of what we are being exposed to is changing / what impact does this have. (Emily | May 26, 2020, 11:52 BST)
- Differential toxicity of indoor versus outdoor formed PM? Outdoors has traffic component, indoors from cooking and cleaning. Which particles are more toxic and how is overall exposure affected? (Nicola Carslaw | May 20, 2020, 15:13 BST)
- The variation of our personal exposure as a result of staying indoors is unknown. (Sani Dimitroulopoulou | May 20, 2020, 15:09 BST)
- Health impact of more time indoors
 - PM2.5 concentrations increased. Indoor sources and the change in exposure whilst travelling is potentially important

Population exposure variation

- Role of re-emission and resuspension of both indoor and outdoor generated pollutants as routes for people's exposure needs greater understanding (Derrick Crump | May 27, 2020, 10:35 BST)
- Reduced exercise/outdoor exposure – reducing capability of dealing with pollutants and with COVID? (Vicki | May 20, 2020, 15:16 BST)
- Particularly to outdoor pollutants
- Here are detailed measurements of atmospheric composition from AQ networks that we can use to measure the reduction in emissions
 - Inequalities
 - » Inequalities crucial, both wrt to vulnerability from prior air pollution exposure and ability to adapt (Rob Kinnersley | May 20, 2020, 15:10 BST)

- Smoke exposure significantly reduces the availability of immune cells in human lungs
- We know that outdoor air quality has improved.
- How to maintain AQ improvements and support a Green Recovery (Andy Duncan | May 20, 2020, 15:10 BST)
- Ultrafine PM – combustion dominated => likely different response to lockdown from that of PM2.5 mass concentration -> health impacts (William (Bill) Bloss | May 20, 2020, 15:14 BST)

2. Recovery – including how recovery can have multiple benefits, reducing pollutant emissions, improving health and wellbeing and enabling climate action

Question or instruction for the discussion:

Recovery -including how recovery can have multiple benefits, reducing pollutant emissions, improving health and wellbeing and enabling climate action

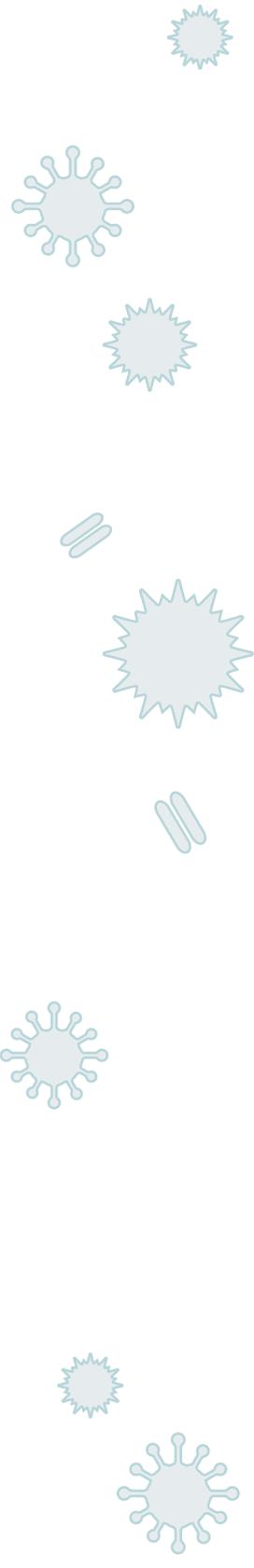
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Covid

Intervention efficacy (May 20, 2020, 02:37 BST)

- There is very little evidence for efficacy of interventions for COVID and for many other respiratory diseases. Need to build evidence base on what interventions work, which transmission routes they are effective against, how they interact together (add up small gains?) and how they interact with other aspects such as energy, comfort and AQ (Cath Noakes | May 20, 2020, 15:17 BST)
- PPE and air quality linkages including Oxygen levels
- Facemasks
- UVGI
- Ventilation
 - Air filtration through ventilation systems
 - Role of ventilation to dilute and remove infectious particles to reduce airborne and droplet transmission and contamination of surfaces.



Transmission – Environmental drivers

- Type of air pollutants or type of air pollution exposure that affect covid-19 or cases of covid-19 that are more at risk from air pollution
- Can we draw any links between presence of other bacteria, mold, other viruses, with likely presence of covid-19? (Paul Ajiboye | May 20, 2020, 15:10 BST)
- Study design options could include environmental epidemiology in the field, as a science that allows to integrate environmental/exposure data in the real world with health and host factor data in the real world. (Giovanni Leonardi | May 20, 2020, 15:13 BST)
- Role of indoor climate conditions especially humidity on viability of airborne virus (Derrick Crump | May 27, 2020, 10:46 BST)

Transmission mechanisms

- From Catherine there was a lot of emphasis on droplets and their dynamics. This point seems to be missing here and this is a very active branch of research in CFD for nuclear and combustion that we can leverage on (Stefano Rolfo | May 20, 2020, 15:16 BST)
- Airborne
 - Implications for ventilation solutions
- Indoor air pollutants
 - Aerosol instrumentation can provide insight into indoor aerosol dynamics. This may have implications for virus transmission and indoor air quality exposure in homes.
 - Methods of measuring exposure to airborne SARS-CoV-2 in the workplace are not well developed
- People
 - Just because you test negative to Covid19 today and are allowed to engage with work/society does not mean you will not (or cannot) be infected tomorrow. In this regard, what exactly does testing achieve from the medium term perspective?
 - » The independent research of German virologist Streeck found out that the infection rate between members of the same household is less than 50%. This is an interesting fact in the transmission of CVs.
- Validation of UV indices for evaluation of their role in transmission during recovery and monthly following that
 - Indoor lighting impacts – fluorescence vs LED etc (William (Bill) Bloss | May 20, 2020, 15:11 BST)

Transmission risk

- Sitting face to back has a lower transmission risk than many other sitting arrangements – as long as ventilation is flowing from the back. Ventilation flowing from the floor also reduces transmission risk to nearby people.

- Establishing 'safe distancing' rules.
- Adopting cross flow of natural ventilation in homes

Virus

- Impact of health inequalities, vulnerabilities and susceptibility to COVID-19

Covid-19 pandemic management

- Use of simulation for assessing policy effectiveness.
 - Continued use of measured data to create model predictions and possibly mitigate increases in pollutants resulting from exiting the lockdown
- Safe easing of restrictions
 - Use of PPE in public spaces
- Evolution of vehicle fleet
- Degree of rebound
- Bio security to support working well and IoT technology for people flows for business returning and social distancing in the work place.
- Rapid Assistance for Modelling the Pandemic (RAMP) initiative coordinated through the Royal Society
- Measures
 - Are traffic controls necessary to reduce further infections?
 - Contact tracing and positive contact isolation
 - Personal ventilation
 - Facemasks – psychological impact, behavioural aspects
 - Spatial distancing
 - » Uncertainty in social distancing definition encompassing all risks in all areas, e.g. tube travel, care homes bed making etc
- Vaccines or elimination of the virus via transmission control

Covid recovery

- Phases of recovery (what are they)
 - We have advanced modelling tools already available for giving advice on remobilisation.
 - Recovery that facilitates transition to net zero (carbon)
 - Government interest in a 'green' recovery
 - » Will economic recovery efforts result in lip-service only being paid to green/air quality benefits? (Vicki | May 20, 2020, 15:21 BST)
 - We will return to work in a phased way based on necessity to Covid / Medical and impact.

- We know that after the 2008 GEC, economic recovery efforts were short term focused and resulted in large increases in GHG emissions as they are associated with cheap economic wins.
- Impact of current excess deaths down the line – can we forecast a deficit in expected deaths as a result of (and I apologise for the term) harvesting ? (Rob Kinnersley | May 20, 2020, 15:13 BST)

People & Activities

Learning from Lockdown

- How has COVID-19 lockdown altered the activity patterns of adults and children. (Stephen Holgate | May 20, 2020, 15:17 BST)
- Lockdown positive impacts sustainment
- Recovery from negative impacts

Mobility

- In buildings (Briony Turner | May 30, 2020, 13:46 BST)
 - How might mobility within buildings need to change? Will we need to shift away from lifts and back to wide, open, staircases? Might there be a shift in demand away from newer office buildings and towards older buildings with these features? (Daniel Slade | May 28, 2020, 15:36 BST)
- New normal vs BAU
 - The role that improved AQ has in encouraging active travel and not going back to polluting personal vehicles.
 - Analyses into the lasting effects/changes in commuting and domestic/ international travel for collaborations and pathways to reduce air pollutant and GHG emissions in the long term via a 'green recovery' plan.
- Fleet and traffic variation vs normal
 - Reduced vehicle fleet turnover (economic downturn) (William (Bill) Bloss | May 20, 2020, 15:09 BST)
 - Increase in traffic flow now being detected as lockdown degraded and now eased
- Public transport use
 - Will there be a shift from mass transit to cars and to single occupancy journeys? – impact on air quality?
 - More cycling and walking to work? Will it be maintained?
 - » Bike shops have sold out – how to maintain this momentum? (Ivan Gee | May 20, 2020, 15:10 BST)
- Active transport (Briony Turner | May 30, 2020, 13:47 BST)
 - Have people, on average, become fitter during lockdown, due to being able to leave home to exercise? (Claire Holman | May 20, 2020, 15:10 BST)

- New cycle lanes (or similar) will be essential to keeping cycling/active travel as an option – something which has been safe/enjoyable without cars, quickly becomes scary with them (says the person with the dusty bike in the garage because she doesn't feel safe cycling on local roads). Should also remember the challenge of walking for anyone not able bodied (or with kids etc) due to number of road crossings required simply to keep on a pavement. (Vicki Stevenson | May 27, 2020, 12:03 BST)
 - » Pop up cycle lanes might help grow and keep share of active modes www.cyclinguk.org/article/10-cities-where-pop-bike-lanes-could-benefit-millions-explore-maps (James Tate | May 20, 2020, 15:11 BST)
 - » Relating to the pop up of new cycle lanes in major city thoroughfares (e.g. Central London), and general reported increased uptake of cycling, what impact will that have on the density of car use in these areas and associated PM/NOx levels? Will there also be unintended increases elsewhere due to car route change? (Boudewijn Dominicus | May 20, 2020, 16:11 BST)
- Bike sales apparently increased over lockdown (Emma Hutchinson | May 20, 2020, 15:07 BST)

Habits & Attitudes

- Disruption can sometimes be an opportunity to reassess and break out of routines to make a permanent shift in behaviour. What learning can be gained on this for activities which benefit health and the environment? (air quality, physical activity, visiting green spaces, etc.) (Helen Macintyre | May 20, 2020, 15:19 BST)
- Will the changes people make stick? e.g. more cycling offers great co-benefits (reduced GHG, better AQ, health and wellbeing), but will people go back to cars? Will people avoid public transport due to perceived transmission risks? (Helen Macintyre | May 20, 2020, 15:31 BST)
- How to sustain behaviour change that supports health co-benefits, adaptation and climate mitigation. (RP | May 20, 2020, 15:12 BST)
- Smoking & Vaping
 - Impact on quitting
 - » Considerable uncertainty about impact of smoking, still our largest cause of preventable illness – it might be positive or negative on COVID. If negative as early report suggested then has implications for encouraging quitting. If positive it might reduce quitting with considerable wider health impact. (Ivan Gee | May 20, 2020, 15:13 BST)
 - Which components of smoking/e-cigarette use are having what (positive or negative) impact e.g. smoke particles, 'vape' aerosol (glycerol/propylene glycol, flavourings), nicotine (Matthew Wright | May 26, 2020, 12:49 BST)
- Transport
 - Public attitudes towards active travel and public transport can shift fast+++

- » Road traffic is capacity limited but also car parking space limited. Behavioural responses may well be complicated i.e. households using a single-car and trip chaining. (James Tate | May 20, 2020, 15:09 BST)
- » Car sharing has been encouraged to reduce transport emissions but is now prohibited and may be discouraged for some time, how might this impact on future strategies for reducing emissions from this sector (Matthew Wright | May 20, 2020, 15:18 BST)
- » Bike sales apparently increased over lockdown (Emma Hutchinson | May 20, 2020, 15:09 BST)
- Natural environment (Briony Turner | May 30, 2020, 13:53 BST)
 - What changes are we seeing in the ways that people interact with the environment, and how is our environment reacting/adapting (Jacky Wood | May 20, 2020, 15:14 BST)

Health effects

- Remote and distributed working -impact on air quality that impacts health
- Impact of indoor air quality on recovery from the virus
- Poor air quality causes conditions that increase susceptibility to Covid-19

Energy

- Analysis of smart meter energy data for domestic demand
 - Is energy use as a result of home working potentially less efficient than in larger buildings – eg., offices, unis, etc (Emma Hutchinson | May 20, 2020, 15:11 BST)

Buildings

- How can buildings be made safe/reopened safely
 - Guidance on ventilation now improving – e.g. COVID-19 guidance from ASHRAE & CIBSE on ventilation. Less guidance available for residential sector
 - Getting back into buildings through validation of operations
 - Particularly complicated for schools, complicated by behaviour of children and challenges to social distancing, also ? well being effects of adapted use (Emma Hutchinson | May 20, 2020, 15:14 BST)
- Re-occupation of buildings after prolonged closure by safe engineering procedures and checks and the introduction of equipment and systems to reduce Covid risks.
- Understanding air flows / exchange / ventilation in indoor environments
- Better design of buildings
- How can occupant confidence be addressed? Can we create some salient measure of building performance against a baseline using sensor/BMS? Kitemark/system? (Gavin Phillips | May 20, 2020, 15:14 BST)

- Smart building design – inclusion of environmental data etc (Matthew | May 20, 2020, 15:15 BST)
 - Regarding all of the above – do we currently have a strong enough built environment regulatory systems (planning, building regs, etc) to ensure that new (or retrofitted) buildings actually have the design features and standards they need? Almost certainly not – they weren't strong enough to do this pre-covid! (Daniel Slade | May 28, 2020, 15:34 BST)

Domestic

- Overheating
 - Building resilience to summertime overheating

Workplace

- Home Working (Briony Turner | May 30, 2020, 13:56 BST)
 - Will workplaces adapt and start to implement new ways of working e.g. increasing / encouraging more homeworking therefore reducing those regularly commuting (Emily | May 26, 2020, 11:56 BST)
 - Will people in low-income jobs, 'key workers' and/or other groups be disproportionately unable to take advantage of opportunities that others may get for home/flexible working in the future, and if so will this drive further inequalities in (mental and physical) health, exposure to pollutants and possible increased risk of ongoing COVID-19 (or other disease) transmission through commuting and work activities for these groups? (Matthew Wright | May 26, 2020, 12:45 BST)
 - People who have benefited from no commuting time, and see the benefits of that continuing able to work successfully from home with good digital solutions will be expecting to continue to do so and this could cause movement of workforce to organisations who are offering greater flexibility and a new normal (Deborah | May 20, 2020, 15:12 BST)
 - » Companies who were previously averse to home working, have been forced into accepting it in an emergency situation and have found that (generally) the IT facilities are sufficient and that their staff can be trusted – increasing the potential for home working to be considered in a more favourable light going past the crisis (Vicki Stevenson | May 27, 2020, 12:00 BST)
 - Homeworking and impacts on energy use (particularly as go into winter) – impacts on domestic burning for heat, as well as others.... (Alexia Coke | May 20, 2020, 15:13 BST)
 - » Yes concerns about fuel poverty worsening (Ivan Gee | May 20, 2020, 15:17 BST)
- Industry-specific policies necessary for indoor air quality control and management
- Air quality in regulated spaces
 - Social distancing in workspaces – air quality in regulated spaces
- How can activities take place safely?

- How do we rapidly determine if people travelling to their decontaminated office building pick up the virus only to bring it into the work place? (Paul Ajiboye | May 20, 2020, 15:14 BST)
- Crowded situations
- Site investigation and groundwork
 - » Guidance on additional health and safety precautions during site investigations and ground work
- How to mitigate airborne transmission in the workplace?

Schools (Briony Turner | May 30, 2020, 13:54 BST)

- What is going to be the effect of air quality in schools when they return? There is always a viral asthma spike in September in week 42 when children pass rhino virus to each other. Can this be offset by improved indoor air quality in schools by more effective removal of allergens and pollutants in dust accumulated during the school break? Will this affect COVID 19 transmission? The viral spike may be associated with other return to school timings too so is there any increase when only some children return soon or after any other lockdowns? (Catherine Sutton | May 27, 2020, 14:31 BST)

Pollutant sources

Covid behaviour with pollutant sources (Briony Turner | May 30, 2020, 17:21 BST)

- Much more knowledge is needed on the life and infectivity of air suspended CV whether in droplets or not. (Stephen Holgate | May 20, 2020, 15:16 BST)

Change attribution – how to know whether to attribute to Covid-19 as opposed to meteorology?

Monitoring

- Mapping evolving air quality changes
- Regulation

Variation in pollutant mixes during lockdown and recovery

- Health impacts
- Impact on interplay between pollutants e.g. reduced emissions and ozone and PM
 - O3 goes up, NO2 goes down, PM composition varies – what is the net change in toxicity? (David Green | May 20, 2020, 15:09 BST)
- PM – have the changes changed the make up of PM. What can we understand from this and/or what do we think we need to be able to understand if we are to tackle PM most effectively from health impacts. (Matthew | May 20, 2020, 15:17 BST)

Variation in levels/concentrations

- Potential increase in emissions during recovery

- Pollutant reduction benefits of lockdown
- Measurement
 - Accurate AQ measurement data. NAEI assumptions, scenario modelling
 - Air quality monitoring data and smart phone app – CityAir. Business and resident engagement.
 - Types, concentrations and distribution of particulate matter emissions
 - » Need PM source apportionment to understand variability (David Green | May 20, 2020, 15:11 BST)
 - » I agree with this and think this is a key gap but cant find a stickie (Jacqui Hamilton | May 20, 2020, 15:15 BST)
- We are gathering data from AQ stations all across Europe to get a broader perspective.

Change of human activities on source emissions

- Understanding indoor air quality and impacts on health (Claire Holman | May 20, 2020, 15:06 BST)
 - Do we expect behaviour changes in the home to have changed the indoor emissions? Will this persist as new behaviour? (Matthew | May 20, 2020, 15:13 BST)
 - Although there are some areas/organisations with good quality air quality sensors (VOC/particulate), availability of data is a challenge – particularly for indoor air quality. Sensors are now becoming cheaper so there is increased possibility of citizen-science type projects, but these need to be funded (for leadership/ data analysis as well as the sensors). Also – is there potential for sensors which can detect virus material? If not – how do we relate the data we can get to virus transmission? (Vicki Stevenson | May 27, 2020, 12:08 BST)
 - Use of low-cost monitors for IAQ monitoring? (Alejandro M | May 20, 2020, 15:17 BST)
- Fleet and travel variation
- 'New normal' impacts
 - If home working increases as organisations see the benefits how will this increase pollution from home burners vs potentially more efficient commercial building heating systems and are home indoor environments generally better than workplaces? People I know report dry air in offices cause them issues vs at home (Deborah | May 20, 2020, 15:15 BST)
- Important to capture what has not changed as well as what has. (Matthew | May 20, 2020, 15:12 BST)

Covid19 as a pollutant (Briony Turner | May 30, 2020, 17:22 BST)

- Physico-chemical-engineering science basis for 2 metre guidance (variably applied to PPE especially in non-health care settings such as food manufacturing, education)

- Role of multi-disciplinary work on transmission of virus in indoor settings (including building engineers, environmental epidemiologists, industrial hygienists, as well as virologists and infectious disease specialists) (example of indoor air settings: office/ school buildings, trains/airplanes/taxis) (Giovanni Leonardi | May 20, 2020, 15:16 BST)

Pollutant exposure

Personal exposure variation

- Does exposure to poor air quality make people more susceptible to Covid and impact severity of disease or, are covid incidence & air pollution links attributable to other factors?
- Excess deaths linked with air pollution
- Are there any differences in air quality during recovery. What are the health implications?
- Impact of the indoor environment – IAQ, temperature, humidity etc on susceptibility to Covid (Claire Holman | May 20, 2020, 15:08 BST)
- How to best educate the public on reducing personal exposure to indoor and outdoor air pollution and then mitigation strategies last (Emily | May 26, 2020, 12:04 BST)

Impact of outdoor pollution bounce back on indoor air quality

Measures to enable acceptable indoor air quality

Homes (Briony Turner | May 30, 2020, 17:24 BST)

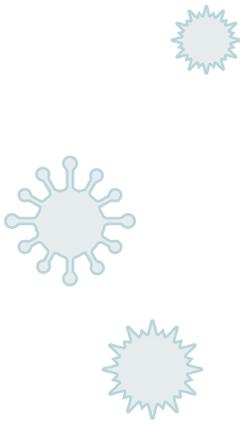
- Link to comment in people and activities on smart meters. Can we use gas meter data to estimate NOx exposure indoors, possible linked with housing stock data? (Gavin Phillips | May 20, 2020, 15:07 BST)
 - The challenge is to know what proportion of gas consumption is flued and the remainder that is not. (Benjamin Jones | May 20, 2020, 15:14 BST)

Workplace

- Providing confidence to workers working indoors by using measurements of indoor environment as a “pulse” of the health of indoor environments.
- Will this bring forward more controls on indoor air quality in workplaces? Particularly office spaces? (Deborah | May 20, 2020, 15:16 BST)
- How this changes and how quickly as restrictions begin to ease over the coming months (Emily | May 26, 2020, 12:01 BST)

Pandemic management (Briony Turner | May 30, 2020, 17:25 BST)

- Joint consideration of air quality and public health interventions across countries may be required to disentangle effect of air quality from effect of public health interventions (Giovanni Leonardi | May 20, 2020, 15:14 BST)

- 
- Unintended consequences, both good and bad, of adapting building services and occupancy to mitigate COVID risks (Derrick Crump | May 27, 2020, 10:51 BST)

3. Longer term – including lessons to be learnt for pandemic management of communicable diseases

Question or instruction for the discussion:

Longer term – including lessons to be learnt for pandemic management of communicable diseases

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Covid

Intervention efficacy (May 20, 2020, 03:02 BST)

- 
- Potential of air cleaning technologies on airborne virus indoors.
 - PPE and air quality linkages including infiltration and exfiltration + Oxygen levels
 - Preliminary data we have collected shows significantly elevated concentrations of CO2 behind some forms of facemasks. Could have a significant effect on cognitive function? (Douglas Booker | May 20, 2020, 15:14 BST)
 - UVGI
 - Ventilation
 - Dilution (ventilation) remains a cheap and effective means of controlling the spread of airborne pathogens.
 - » This could be terrible for energy efficiency of homes in the winter though – how to manage this in different seasons in context of our Net Zero commitment? (Helen Macintyre | May 20, 2020, 15:39 BST)
 - We have advanced modelling tools already available for providing advice on how to ventilate to minimise cross infection.
 - Optimising the design of ventilation systems to minimise the risks of disease transmission.
 - Communication of efficacy
 - Mis-messaging on masks and lack of communication for good ventilation response

- There should be much more information in the media and public platforms on ventilation of homes and keeping up your immune system during lockdown.
- Architectural design strategies might include: air cleaning (e.g. UV), filtration, ventilation, zoning of 'clean' / 'dirty' spaces, natural daylighting, anti-viral coating/ finishes on high touch surfaces, touch-less devices, flexible interiors, antimicrobial building materials etc.

Virus characteristics

- How do we treat viral material – as an aerosol? or as contaminated particulates? or as contaminated surfaces? different approaches to treating these. it's promising that they can be "caught" in HEPA filters (Vicki Stevenson | May 27, 2020, 12:26 BST)
- Make the science on longevity of virus on different materials/surfaces clearer to the public. There are many questions around this and it would help PH interventions and the need for PPE and disinfecting areas/surfaces. (anonymous | May 20, 2020, 15:13 BST)
- Capacity of airborne particles to act as nucleation sites for C-19 and aerial distribution
- Documenting extent of COVID-19 seasonality and analysis of factors driving it
- Survivability
 - Impact of temperature and humidity effects on viability
 - Role of air quality (chronic and acute) in outcomes of CV19 and other respiratory infections (May 30, 2020, 17:33 BST)
 - Impact of Covid on air quality including international approach to Air Quality improvement
 - Impact of air quality on Covid lifetime (and other viruses)
 - » We know that the Outdoor Air Factor reduces the lifetime of microbes and bacteria.
 - Effect of indoor air quality on COVID outcomes (Mike Holland | May 20, 2020, 15:06 BST)
 - There are synergies in the effects of air pollution on health and the course of disease for COVID
- Infection legacy (Briony Turner | May 30, 2020, 17:31 BST)
- Is the post-COVID lung less able to cope with air pollution (lower anti-oxidants?) and does pollution affect which patients go on to develop post-COVID ILD? (Paul | May 20, 2020, 15:11 BST)

Transmission – Environmental drivers

Transmission pathways – early interventions for next pandemic

Transmission mechanisms

- Role of regional, periodic and seasonal weather patterns on the wide transmissibility of SARS-COV

- Air pollution
- Indoor air pollutants
- Human waste indicators and virus presence and transmission
- Aerosol production during dental work
 - Lots of other Aerosol Generating Procedures in other disciplines (e.g. CPAP, high flow nasal oxygen) (David Green | May 20, 2020, 15:13 BST)
 - » Agreed. Ambulances could be an important area: intubation, suctioning, procedures related to cardiopulmonary resuscitation etc etc (Douglas Booker | May 20, 2020, 15:18 BST)

Management

- Buildings
 - Pandemic management revisions if the virus can travel and survive in air pollution particles and infiltrate in homes
 - Real-time management of indoor air in commercial buildings. Better ventilation standards and real-time reporting using measurements of IAQ in care-settings.
 - » Lots of voluntary standards on this (BREEAM, WELL, LEED etc.) to manage IAQ through feedback loops installed into HVAC. Key question for me relates to how we manage mitigation of potential airborne transmission of SARS-CoV-2 (i.e. increase ventilation rates), with energy efficiency (lower ventilation rates, recirculation modes etc.). (Douglas Booker | May 20, 2020, 15:12 BST)
 - On-going validation of operation of buildings to reduce exposure risks
- Traffic particulates reduce the ability of immune cells to destroy pathogens – it would be beneficial to make efforts to keep pollution levels at a lower level
- Working within environmental health, and closely with public health in local government – community engagement / messaging. citizen science
- Anti body testing and bespoke categorisation of risk across all demographics.
- Resilience plans to respond to resurgence /new pandemics
- Data for management
 - Epidemiological assessment vs AQ – likely greater sensitivity in non-UK locations
 - A better understanding of COVID in the real world requires field work with people and survey design options that allow to combine field information with other info such as geographic. Also, appropriate consideration of correct methods for measuring incidence and prevalence of people-related events (environmental epidemiology), that is including pre-symptomatic and asymptomatic people. (Giovanni Leonardi | May 20, 2020, 15:11 BST)
 - Faster data from test-track-trace gathering and publication to allow modelling

Risk assessment and management (Briony Turner | May 30, 2020, 17:36 BST)

- Working with multiple risks- being COVID resilient may lead to other factors of weakness

- Risk Assessment on safe levels of crowding- requires real data on transmission of the disease in different public settings
- In industry settings there are number performance issues that are related to human error, technology complexity and organisational factors. Research has focused on developing systems-of-systems approaches for quantifying operational risk and inform risk mitigation. How can we make the industry, for example, manufacturing industry, resilient to Covid-19. What are the most suitable risk models for informing decision making? (Mario Brito | May 20, 2020, 15:17 BST)

How to control

- Remove sources of the virus Better lab controls Honest disclosure of outbreaks from day 1 – take it seriously and be open
- Technology to deactivate viruses
- Indoor environmental conditions (temperature and humidity)
- Borders
 - Stopping the spread at borders
 - » The location of the required barrier to reduce the spread (national border, at risk situations, isolating frequent travellers or stopping frequent travelling)
 - Cross border Surveillance and Early Warning Systems
- Ventilation rates in crowded public spaces
- Infection location and contact tracing and positive contact isolation

Prevention

- Early interventions for next pandemic – transmission pathways
- Role of improved air quality in helping to prevent 'second wave' of disease
- Role of pandemic control measures and policies in generating (or not) health savings

Recovery with multiple benefits

- Combine with climate change adaptation and mitigation strategies
- Strategies to target Climate change, air quality and infectious disease
- Inclusion of equipment, systems and procedures to overcome corona virus risks through sustainability – health and well being process.
- Global evidence on scale of action needed to achieve Net Zero

Monitoring, modelling and surveillance (May 30, 2020, 17:34 BST)

- Network of air monitoring stations in key indoor public spaces to monitor prevalence of COVID (and other infectious disease) (Derrick Crump | May 27, 2020, 10:56 BST)
- How much confidence do we have in CFD to model Covid-19 and how do we validate? (Malcolm Cook | May 20, 2020, 15:16 BST)

- Identify methodologies for COVID or viral load from hotspots to background. Simple sampling/surveillance that can support policies/SOPs for safe working (Christine Braban | May 20, 2020, 15:13 BST)
- Molecular tools for resurgence monitoring, including environmental (sewage) tracking
 - Air as well as sewerage (David Green | May 20, 2020, 15:14 BST)
- We have heard a lot about being driven by the science and the evidence. As all scientist know, knowledge of these areas such as COVID are not certain and are hypothesis. The models that people are using are full of assumptions. They must not be regarded as prediction more explorations and it is their interpretation that requires expertise and discussion. A critical perspective is always welcome in science but not so in politics and even less in the media which criticises .everything (David B | May 20, 2020, 15:20 BST)
 - Great point David. There are some good discussions on this under the moniker of 'postnormal science' – which looks at science for situations “when facts are uncertain, stakes high, values in dispute and decisions urgent.” We cannot hide behind ‘the science’ when making policies that relate to COVID-19, as the decisions that are made will be political in nature. Nice article on it here: <https://steps-centre.org/blog/postnormal-pandemics-why-covid-19-requires-a-new-approach-to-science/> (Douglas Booker | May 20, 2020, 15:41 BST)

Quality of life vs. Covid contagion risk

- Impacts of mental health. (Helen Macintyre | May 20, 2020, 15:43 BST)

People & Activities

Human activities (Briony Turner | May 30, 2020, 17:41 BST)

- Ensure we take the learning forward and apply it to the Winter season given all the additional considerations such as reduced ventilation associated with this period (Emily | May 26, 2020, 12:27 BST)
- How will the increased unemployment / impact on economy etc. leading to reduced finances effect the gradual shift towards electric and alternative fuel vehicles that was emerging change as people may be less able to afford them? Will we take a step back? (Emily | May 26, 2020, 12:16 BST)
- Public opinion on changes and air quality – how would they change their pre-covid activities to reduce air pollution? (Jenny Baverstock | May 20, 2020, 15:17 BST)
 - Also: pressure points we can use to incentivise change through changing ‘choice architectures’ & meso-level constraints on practices. e.g. enforced flexible work patterns may dissipate ‘peak pollution’ ? So air qual change = happy side effect. (@dataknut | May 20, 2020, 15:38 BST)
- How does this impact the climate crisis and vice-versa. Need to deliver both. (Dan Maskell | May 20, 2020, 15:13 BST)
 - Agree also (Christine Braban | May 20, 2020, 15:14 BST)

- We need a short term and long term view. COVID may cause our attention to be taken away from other issues of air quality. This is important but the longer term issues are more significant and must not leave the agenda. (David B | May 20, 2020, 15:14 BST)
- A better understanding of the impacts of human activities on the indoor and outdoor environment at small and large scales (one room/house to city/country), helping plan adapt and mitigate impacts on air quality for future pandemics (full or partial lockdowns)

Mobility

- Is there enough mobility capacity to meet demand?

Habits and attitudes

- The need to engrain the positive behaviour changes into people so they are sustained and educate on the negative outcomes from lockdown (Emily | May 26, 2020, 12:11 BST)
- Understand why behaviour change occurred and how can we leverage those factors to sustain the change over the long term (RP | May 20, 2020, 15:08 BST)
- Home working and reduced travel is expected as a cultural change.
 - Need to understand the variety of mobility patterns that have been disrupted – commuting, travel as part of work etc. Many sectors have always been able to wfh but have not done so for range of reasons. May expect some rebound post-lockdown esp for some sectors and family situations. Need to consider modal shifts (@dataknut | May 20, 2020, 15:32 BST)
- How has the pandemic changed attitudes toward air quality and the environment?

Health effects

- Air pollution in general health and links with pandemic impact

Buildings

- How to have healthy indoor air quality without the survival of COVID or other bicontaminants
- Required fresh air levels in occupied buildings to reduce airborne disease transmission whilst controlling energy use and CO2 emissions
 - Can consider solar air preheating systems (eg transpired solar collector) to reduce fossil fuel energy required to warm outdoor air (Vicki Stevenson | May 27, 2020, 12:19 BST)
- Re-thinking how buildings are ventilated naturally or mechanically to deal with future (regular) pandemics
- Carefully consider the balance between air-tightness and adequate ventilation (natural) in buildings (Rajat Gupta | May 20, 2020, 15:10 BST)
- Optimising heat retention versus air exchanges for energy efficient buildings (Rob Kinnersley | May 20, 2020, 15:15 BST)

- Indoor air quality management plans as part of risk registers; reference to ISO, BS and EN standards
 - » Agree. (Ying | May 20, 2020, 15:13 BST)
 - » Overdue! (Vicki Stevenson | May 27, 2020, 12:15 BST)
 - » Agree (Catherine Sutton | May 27, 2020, 14:40 BST)

Workplaces

- Change in work practice and acceptability of virtual communication and electronic forms of evidence for planning and legal decision making
- Promote work environments with more fresh air and incorporate humidifiers to avoid low relative humidity.
 - I agree about fresh air, but we need to be careful about over humidifying – this can cause other air quality problems with mould. In many buildings mould problems due to high humidity are already significant – it depends a lot on the type of workplace and their air system. (Vicki Stevenson | May 27, 2020, 12:20 BST)

Domestic

- Improving indoor air quality during future waves
- Overheating
 - Building resilience to/management of summertime overheating
 - Designing for natural ventilation and summertime overheating management in homes
- One outcome of this current situation is likely to be an increase in home working. In the general population there is limited understanding of things affecting indoor environmental quality in the home. (Paul Cropper | May 20, 2020, 15:17 BST)
- How does IT infrastructure need to be developed for more home working? (Rob Kinnersley | May 20, 2020, 15:16 BST)

Cities

- Design of healthier cities.
 - Urban Heat Island effects (Helen Macintyre | May 20, 2020, 15:36 BST)
 - Should future design of buildings/cities account for a future pandemic? What resilience do we design into buildings for a 1 in (100?) year event? (Dan Maskell | May 20, 2020, 15:16 BST)

Data (Briony Turner | May 30, 2020, 17:45 BST)

- Technologies – for example, would drones be a preferred option for sampling ? If field work is limited. (Teresa | May 20, 2020, 15:15 BST)
 - Sounds interesting! (Vicki Stevenson | May 27, 2020, 12:21 BST)

- A better understanding of people and activities requires field work with people and survey design options that allow to combine field information with other info such as geographic. Also, appropriate consideration of correct methods for measuring incidence and prevalence of people-related events (environmental epidemiology), that is including pre-symptomatic and asymptomatic people. (Giovanni Leonardi | May 20, 2020, 15:09 BST)
- V. interested to combine wearable GPS/AQ sensors with e.g. time-use diaries for activities.. (@dataknut | May 20, 2020, 15:34 BST)

Pollutant sources

Monitoring – mapping evolving air quality

- How to effectively represent this behaviour in emission inventories?
- We will be collecting data post covid on transport and air quality to inform reaching compliance with legal limits
- Need for routine surveillance of air quality and pollution
- Combined data – modelling of atmospheric response

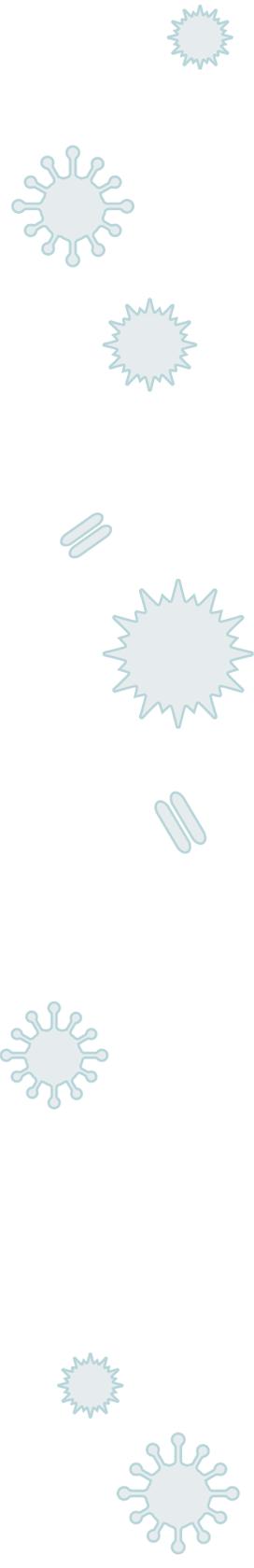
Variation in levels/concentrations

- Co-emission of AQ pollutants and “bioaerosol” would be nice to have, indoor and outdoor (Christine Braban | May 20, 2020, 15:09 BST)
- Impact on specific pollutants (Ozone)
 - Accountability – accurate quantification of the actual impact (ShiZ | May 20, 2020, 15:11 BST)
 - Pollutant role in virus transmission. (RP | May 20, 2020, 15:09 BST)
- Establish critical sources of emissions that will have higher influence post COVID19 (Teresa | May 20, 2020, 15:12 BST)
- Forthcoming NERC SPF Indoor/Outdoor interface networks... (William (Bill) Bloss | May 20, 2020, 15:38 BST)

Pollutant exposure

Personal exposure variation

- Size fractional and particle volume effects of transmission in air. Co-emitted markers of human cough. (Christine Braban | May 20, 2020, 15:15 BST)
- What do we mean by air quality in the context of Covid-19? (Malcolm Cook | May 20, 2020, 15:09 BST)
- Does exposure to poor air quality make people more susceptible to Covid and impact severity of disease or are covid incidence & air pollution links attributable to other factors?

- 
- Also if poor air quality does increase susceptibility / severity, what is the mechanism (? OxStress ? PAHs etc) and can we target those mechanisms to reduce harm? (Paul | May 20, 2020, 15:09 BST)

Develop better understanding of air quality impacts on disease (not just covid) progression and spread

- Agree (Nick Avis | May 20, 2020, 15:08 BST)
- Agree: let's understand airflow distribution and ventilation EFFECTIVENESS (Malcolm Cook | May 20, 2020, 15:08 BST)
- Agree (anonymous | May 20, 2020, 15:08 BST)
- Agree (Catherine Sutton | May 27, 2020, 14:43 BST)

Weather, Covid & Exposure (Briony Turner | May 30, 2020, 17:52 BST)

- I'm interested in understanding how readily Covid-19 would move in a buoyancy-driven regime, especially as we move into winter. (Malcolm Cook | May 20, 2020, 15:11 BST)
- How much confidence do we have in the use of CFD to explore these issues? How can we validate? (Malcolm Cook | May 20, 2020, 15:12 BST)
- Are there any simple mitigation strategies in terms of IAQ that can be quickly put into place in the future or anything to educate the public on to reduce their risk? (Emily | May 26, 2020, 12:20 BST)

4. Next steps & Matchmaking room – review, and add to, the ideas for action to address the identified lockdown, recovery and longer term knowledge gaps.

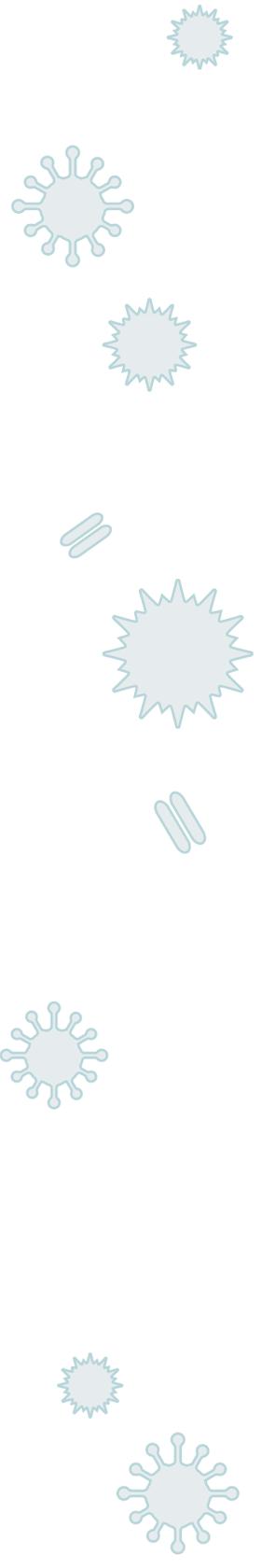
Question or instruction for the discussion:

Next steps & Matchmaking room – review, and add to, the ideas for action to address the identified lockdown, recovery and longer term knowledge gaps.

Please note down in the “Next steps” box the ideas for what type of research action is needed. You can as individuals use the stickers to mark out what you think is important, what you think is critical You can also enter the ‘Matchmaking room’ to post ‘SEEKING’/‘OFFERING’ adverts and ‘IDEAS’ for taking interdisciplinary action forward

Sticky points:

- Important knowledge gap (200 points per participant)
- Critical priority knowledge gap that needs action (200 points per participant)
- Breakout room critical action (200 points per participant)



Next steps required to address knowledge gaps

Lockdown

- Need to know/understand time activity patterns during lockdown. If know IAQ/OAP, need to know activity patterns and how they have changed during lockdown and restrictions. We need this information to feed into exposure models, in order to predict effects on health. (anonymous | May 20, 2020, 16:00 BST)

Management

- Issue of knowledge about virus behaviour on surfaces materials. This is essential to inform PH guidance. (anonymous | May 20, 2020, 15:15 BST)
- Observations of atmospheric composition both indoors and outdoors linking to chemistry for modelling and predictions for resurgence and for use in mitigation strategies – collaborations between experimentalists and modellers
- Establishment of collaborative mode for UKRI to support consortia to be working with each other across spectrum of questions related to role of lockdown among other public health interventions, and considering interaction with environmental factors
- Promote good practice for reducing indoor pollutants
- Communication of ventilation best practice to home owners and occupants

Health

- We require the immediate deployment of remotely connected medical devices to measure high risk patient hour by hour with geographical alerts on high pollution
- We need to understand the impact of tobacco smoking and secondhand smoke on COVID risk as there is conflicting evidence on this that is influencing quitting . We need to be able to give clear advice on smoking so that misunderstandings about COVID risk do not increase smoking and hence other preventable disease. (Ivan Gee | May 20, 2020, 16:57 BST)

Sources

- Role of traffic on PM2.5 seems to be small – but what does the size distribution look like – is there a change in ultrafines? (Jacqui Hamilton | May 20, 2020, 15:34 BST)
- Accurate AQ measurement data. NAEI assumptions, scenario modelling
- Networks of monitoring data, detailed research observations
- Long term PM samples are collected at the supersites. It would be really exciting to be able to get access to samples of these to look at the shift in composition

Exposure

- UK Emission Modelling System development funded by UKRI SPF Clean Air via Met Office could support future fast-track emission scenario development by providing access to and resources/platform for emission modelling and scenario building for modellers.

- Research into establishing environmental baselines of air quality and pollution levels in variety of urban, industrial and rural settings during lockdown for comparative studies.
 - With interior AQ too pls (@dataknut | May 20, 2020, 15:46 BST)
- Strong concern about IAQ – what is the potential of generating sufficient evidence to support legislation for improving air quality directly rather than just assuming ventilation rates are adequate (Vicki | May 20, 2020, 15:29 BST)
 - Need data/monitors to support any legislation (Vicki | May 20, 2020, 15:32 BST)
 - UKHLS (Understanding Society) innovation panel could be used to triangulate excellent social data with AQ via sensor install in homes? www.understandingsociety.ac.uk/documentation/innovation-panel (@dataknut | May 20, 2020, 15:50 BST)
 - Good data on indoor conditions for a range of environmental parameters (AQ, heat, cold, etc.) is challenging to collect. Can it be done in a representative way (range of housing types, energy retrofit, occupants and behaviours, etc). Can we make sure that empirical studies are useful and generalisable to the whole population? (Helen Macintyre | May 20, 2020, 15:51 BST)
 - » Yes especially given the very varied monitoring done pre-covid. In the long term is there a justification for setting up a suite of representative long term indoor monitoring sites? (Ivan Gee | May 20, 2020, 16:13 BST)
- Collect reliable activity data. Ensure equal and diverse representation of the scientists collecting and reporting on the data, and leading the scientific studies
 - As in “what are people’s activities?” ? – see comments re use of time-use diaries for example (@dataknut | May 20, 2020, 15:47 BST)
 - Combination of time-use surveys/diaries with mobile (wearable) AQ sensors? Individualised exposure... See e.g. www.timeuse.org/time-use-diaries-and-the-covid-19-crisis (@dataknut | May 20, 2020, 15:56 BST)

Recovery

- There is a move to increased active travel but also potentially an increase in private travel during the recovery – how will this effect air pollution (Jacqui Hamilton | May 20, 2020, 15:36 BST)

Longer-term

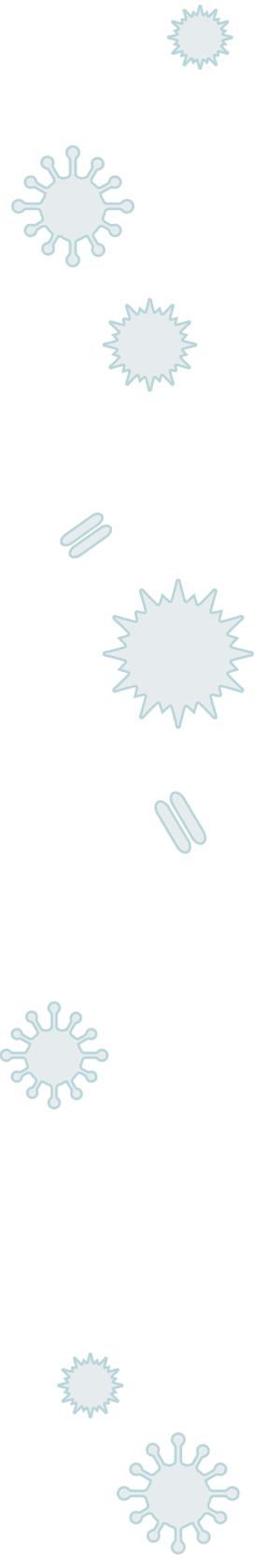
- Balancing IAQ and energy in buildings is a really important issue. It is OK to increase ventilation over a short period while we deal with the current risks, but longer term this is going to be much more challenging and may need new innovations (Cath Noakes | May 20, 2020, 15:13 BST)
 - Agreed (Douglas Booker | May 20, 2020, 15:45 BST)
- Understanding possible inequalities eg tenure, building types, regional (Karen Exley | May 20, 2020, 15:32 BST)
- Understanding what our new normal for working and travelling will be? How will that affect our exposure to air pollution? (Karen Exley | May 20, 2020, 15:35 BST)

- And how will changes in travel mode, duration & frequency lead to changes in timing & level of pollutant emissions? (@dataknut | May 20, 2020, 15:40 BST)

Cross cutting (May 20, 2020, 07:17 BST)

- Learn from good practice elsewhere and adopt / adapt for local need. e.g. other countries such as Germany have controls on emissions of VOCs from indoor products¹² and a similar approach would benefit UK indoor environments (Derrick Crump | May 27, 2020, 11:03 BST)
 - Wonder whether Germany or other countries have other indoor air quality benefits. Lead studies show that hepa filter vacuums can reduce PM2.5 etc in indoor air but could be a difference where sealed bags are used or not. Would be interesting to know which types of vacuums (non leaking sealed bag or not and level of filtration) are used most in different countries and how they influence indoor air quality. Regulations on vacuum cleaner emissions and filtration could be looked at to ensure that air quality is maintained indoors (Catherine Sutton | May 28, 2020, 10:14 BST)
- For indoor air quality there will need to be a balance between more ventilation and increased energy consumption, especially in winter. (Duncan Laxen | May 20, 2020, 15:09 BST)
 - Agree, especially as cold homes are an issue still for health, and linked to inequalities. Also in context of reaching our net zero commitments. (Helen Macintyre | May 20, 2020, 15:49 BST)
 - Cold homes are a major issue for health that is often overlooked but if lower income groups increase fuel use it will increase fuel poverty. The balance of all these effects need exploring (Ivan Gee | May 20, 2020, 16:06 BST)
- Indoor Air Quality in care homes and schools needs to be assessed. Promotion of low cost air quality monitors could highlight the issue which most people are generally unaware of. In the US certain air quality monitors can be taken out on loan from libraries in certain areas which could make them more accessible and publicise the benefits of looking into this issue (Catherine Sutton | May 27, 2020, 15:02 BST)
- More Public Health information should be given to the general public regarding the poor quality of indoor air as they are largely unaware of this and associate poor air quality with outdoor air pollution. Could the general recommendations of the recent RCPCH report be publicised by PHE? (Catherine Sutton | May 28, 2020, 09:59 BST)
- PM samples aren't necessarily being collected at the supersites. We have the samplers, but these were purchased for 'campaign' operations. If someone wants to start sampling they need to get in touch. (James Allan | May 20, 2020, 15:07 BST)
 - James – I think it would really nice if we could start doing this! (Jacqui Hamilton | May 20, 2020, 15:34 BST)

12 Brown, V., Crump, D. and Harrison, P. 2013. Assessing and controlling risks from the emission of organic chemicals from construction products into indoor environments. *Environmental Science – Processes and Impacts*, **15**: 2164–2177. doi: 10.1039/C3EM00413A

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- I don't know if we have the substrates to hand and ordering them won't be easy. Presumably you'll want prebaked quartz? We need the 150mm type for Digital samplers. Bill/Roy might have some? (James Allan | May 20, 2020, 15:42 BST)

5. Matchmaking room – pitch in here for collaborations to take ideas for interdisciplinary action forward. It's up to you to do the matchmaking!

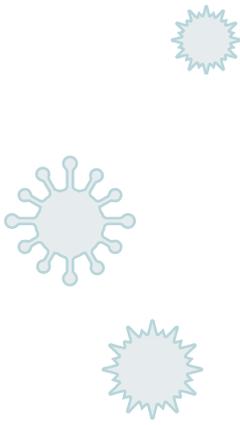
Seeking

Ideas

Offering

Offering – UKRI Funding opportunities:

- NERC has recently announced a set of 3 COVID-19 Digital Sprint Hackathons all relevant to today's event, Hackathon one: Air Quality 1–5 June, this is followed by a hackathon on Recovery 15-19 June and a hackathon on Ecosystem services 29 June to 3 July. Further details here: digitalenvironment.org/home/covid-19-digital-sprint-hackathons/ (Briony Turner | May 20, 2020, 12:11 BST)
- If the idea is not specifically Covid-19 focused, but about indoor/outdoor air quality then keep an eye on the Clean Air programme: <https://nerc.ukri.org/research/funded/programmes/clean-air/> (May 20, 2020, 12:08 BST)
- UKRI are supporting various opportunities open for responding to COVID-19, including the below main open calls:
 - **Get funding for ideas that address COVID-19** – UKRI open call for proposals for short-term projects addressing and mitigating the health, social, economic, cultural and environmental impacts of the COVID-19 outbreak. www.ukri.org/funding/funding-opportunities/ukri-open-call-for-research-and-innovation-ideas-to-address-covid-19/
 - **COVID-19 Rapid Response Rolling Call** – Building on the initial calls of their Initiative, DHSC, through the NIHR, and UKRI are jointly launching a rolling call for proposals for rapid research into COVID-19. As this is a rolling call there is currently no fixed end date to the call, we are open to applications and will aim to review complete proposals within 4 weeks of submission. For UK-led academic, SME and wider industry research that will address a wide range of COVID-19 knowledge gaps/needs, and which will lead to a benefit in UK, potentially international, public health within 12 months. mrc.ukri.org/funding/browse/ukri-nihr-covid-19/ukri-nihr-covid-19-rolling-call/?_ga=2.31325695.1312058625.1589288215-1546589592.1589288215
 - **GCRF/Newton Fund Agile Response Call** – Proposals are invited for short-term projects addressing and mitigating the health, social, economic, cultural and environmental impacts of the COVID-19 outbreak in Low and Middle Income Countries. www.ukri.org/funding/funding-opportunities/ukri-gcrf-newton-fund-agile-response-call-to-address-covid-19/

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- **Global effort on COVID-19 (GCEO) Health research** – Global Effort on COVID-19 (GECO) Health Research is a new cross UK government funding call aiming to support applied health research that will address COVID-19 knowledge gaps. The focus is on understanding the pandemic and mitigating its health impacts in low and middle-income countries (LMIC) contexts. The call prioritises epidemiology, clinical management, infection control and health system responses. www.nihr.ac.uk/documents/global-effort-on-covid-19-geco-health-research-call-specification/24832

Offering Measurement expertise and equipment (Briony Turner | May 20, 2020, 16:56 BST)

- 
- NPL can offer Covid response measurements and consultancy support to Companies for free (at least in the short term)
 - UKCEH can measure NH₃ and it can be a marker of waste and/or human activity (Christine Braban | May 20, 2020, 15:17 BST)
 - NAQTS can offer indoor air quality monitoring technologies (<https://www.naqts.com/our-technology/v2000>), and collaborative research projects with Lancaster University (we are collocated on the university campus) (Douglas Booker | May 20, 2020, 15:44 BST)

Offering experience (Briony Turner | May 20, 2020, 16:57 BST)

- 
- We are happy to provide input on practical measures associated with effective inhaled biological allergen avoidance (eg. dust mites, mould, tree and grass pollen, animal dander etc) and other non allergenic pollutants which can make a noticeable difference to health for many people. We have the protocol from other successful overseas studies relevant to this which we are able to provide to others. (Catherine Sutton | May 28, 2020, 10:04 BST)
 - I am now working as a freelance consultant, so happy to join up with teams taking projects forwards to contribute my air quality experience. (Duncan Laxen | May 20, 2020, 15:44 BST)