

# Joining Forces to Improve Air Quality and Health Workshop Report

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## **Joining Forces - Key Recommendations**

The following areas of focus were important conclusions identified in the workshop in order to improve the linkages between air pollution measurement, modelling and atmospheric research aimed at improving the health in the UK population:

### **1) Leadership through a National Taskforce/Alliance**

A major concern that emerged at the workshop was a lack of coordination and information exchange between the different partners interested in cleaning up the air we breathe. To address this at a national level, we recommend establishing more coherent associations via a UK overarching body or Alliance that will assess meaningful air pollution levels (including toxicology), bring together the major departments of state leading on air quality with other significant bodies including the UK Health Security Agency (previously part of PHE), local authorities (public health and planning), the medical charities and the Medical Royal Colleges (e.g. UK Health Alliance on Climate Change) and others in the third sector and industry. The Clean Air Alliance would develop a national joined up strategy and be a forum to meet and discuss and would be supported by Regional cross disciplinary champions.

### **2) Communication, Engagement, and Involvement**

There is a need to develop a common language to improve the understanding of air pollution issues and solutions in different professional communities and for the public, to create a more positive narrative on clean air that should have health at its centre, and promote and encourage participation in clean air solutions to improve the health of the nation. Such activities need to especially target vulnerable groups (the young and old, those living with inequalities and chronic diseases). The positive narrative needs to create greater incentives for individuals to take some ownership of air quality issues and encourage involvement in behaviour change for clean air. People will change their behaviour only if they see the new behaviour as easy, rewarding, empowering and normal.

### **3) Engagement with Stakeholders**

There needs to be closer collaboration between the research and industrial development communities to speed up knowledge transfer and accelerate the translation of new ideas into solutions. The air quality field would be greatly enriched if joint positions and secondments between the stakeholder and research communities could be encouraged with a new initiative to roll such a programme out. Another area highlighted was the benefit from closer collaboration within stakeholder groups, particularly within government where improved coordination between the different levels of government (local and national), as well as between different sectors (e.g. transport, housing, planning, public health, and air quality), would result in integrated policies leading to better air quality and improved health outcomes.

A particular stakeholder issue highlighted was for Local Government. Combating poor air quality at the local scale is crucial to the overall improvement of air quality in the UK, and the responsibility for achieving this falls to the local authorities. While they are best placed to address specific locally generated air quality problems, they own a very wide remit of work, and in recent years, endured significant budget reductions. Staff and expertise are a dwindling resource and bringing in new staff is difficult without investment. Apart from the resourcing issues, local

authorities also experience disjointed and competing policies in the departments that are needed to develop holistic and air quality solutions: such as transport, housing, town/city planning and public health. Consequently, interventions frequently lack strategic and operational coordination between these 'siloed' policy areas. Discontinuity between different strata of government further compounds the difficulties. For example, district councils are responsible for air quality management, but responsibilities for transport planning and public health may reside at the county level. It is essential therefore that steps are taken to remove barriers that exist between departments to unifying the development of successful policies for local air quality management.

#### **4) Cross-disciplinary collaboration, funding and capacity building**

Finding solutions to improve air quality and make serious inroads into both outdoor and indoor air pollution requires interdisciplinary science and team working. Funding mechanisms should be put in place that encourage cross-disciplinary research partnerships that deliver sustainable solutions outputs including health solutions. In parallel, for peer review of projects, there is a need to develop appropriate cross disciplinary peer review processes in clean air that recognises the key contributions from different disciplines and the benefit of cross and inter-disciplinary approaches. There remain some important gaps in skills, knowledge and critical mass that require urgent attention including capacity building e.g. air pollutant toxicology and informed and involved health practitioners, as well as interdisciplinary scientists and knowledge translators able to work seamlessly across different specialisms.

#### **5) Data sharing**

Creating better connectivity between scientific, health and administrative data was seen as a major and urgent priority for the clean air community. This would facilitate access to the wealth of data that is already available across different disciplines and magnify the value of the considerable investment in it. It would create the evidence base required for new policy development and stimulate new understanding to close the gap between air pollution exposure and improving human health. Quality metrics on datasets are also required to address standards so that users know that data is fit for purpose.

In order to help take forward these recommendations, the Clean Air SPF is already working towards solutions to a number of these areas: 1) enhancing the toxicology capability; 2) addressing linkages to data sets with a workshop in planned for the autumn of 2021; 3) establishing a network of Regional Clean Air Champions in the four administrations of the UK and; 4) putting in place a Research Futures Group to encourage the creation of new and ambitious approaches to clean air solutions.

## **Introduction**

On 12<sup>th</sup> and 13<sup>th</sup> October 2020 an online workshop "Joining Forces to Improve Air Quality and Health Workshop" was held. The workshop was convened in partnership between the UK Research and

Innovation (UKRI) Strategic Priorities Fund Clean Air Champions, the Met Office and the National Physical Laboratory as one of the knowledge exchange events run by the Strategic Priorities Fund Clean Air programme. The workshop was set up in response to requests for more integration between the health research community and the clean air research community expressed by the during Clean Air Champion stakeholder engagement activities conducted from June 2019-December 2019. More information on the Clean Air Programme and the workshop organisers can be found in Annex 1.

During the planning of the event we sadly and suddenly lost our Clean Air co-Champion Professor Martin Williams. Martin’s passing leaves a large hole at the centre of the clean air research and policy community. We miss his wisdom and extensive knowledge, gained over an extensive and glittering career spanning five decades, and we missed him over the days of the workshop and will continue to do so.

A total of 84 participants registered for the workshop, covering a broad range of sectors and disciplines – as summarised in Table 1. We would like to thank everyone who participated in this forward-looking event who all provided invaluable contributions, particularly acknowledging the speakers, rapporteurs, the conference team and professional facilitators.

**Table 1. Registered participants by sector**

<b>Sector</b>	<b>Number registered (n.)</b>	<b>% Registered delegates</b>
Academic Research Community (multidisciplinary)*	26	31%
Executive Agency / Funder	7	8%
Advisory body	3	4%
Built environment	2	2%
Third Sector	10	12%
Public Sector	3	4%
Research policy and public sector policy	4	5%
Engineering	3	4%
Environment public sector and consulting	4	5%
UKRI	4	5%
Innovate UK	1	1%
Indoor Air quality solutions	3	4%
Health specialists and health public sector	6	7%
PhD student	1	1%
Industry	2	2%
Conference team (including facilitators)	5	6%

\*Disciplines include: atmospheric, social, built environment, child health, data science, environment and health, environmental chemistry (and health); health (including public health), modelling, psychology, respiratory.

## Background

### Event overview

The main objectives for the event were to:

- explain briefly the main aims of the Strategic Priorities Fund Clean Air Programme and its multidisciplinary nature.
- provide a forum to enable discourse between the health outcomes and air quality (AQ) communities, and an opportunity to share experiences, requirements and concerns.
- examine relevant questions and issues that lie at the heart of continued progress in this area.
- identify areas of potential synergies between the health and air quality communities to formulate continued collaborative work that will enable the aims of the Clean Air Programme to be effectively achieved.
- develop key themes and findings that can be formulated into a post-event document to inform others with similar interests and remits.
- produce an informative, forward looking document for publication in an appropriate peer reviewed journal to summarise the main discussion themes and make recommendations for further actions.

To meet the objectives for the conference, nine breakout groups were formed which were constructed to have most sectors represented at each. Each breakout group had a designated rapporteur to facilitate and rapporteurs were drawn from the UKRI, NPL, Met Office and Champions team. The summary and conclusions from these breakout groups form the main body of this report.

The breakout discussions were stimulated by a series of presentations and reflections from invited speakers covering a board range of relevant disciplines and stakeholders. Each speaker provided a short summary of their presentations, and these are given in the following section. A summary of the questions and answers raised during the presentations are given in Annex 3.

### Summary of presentations and reflections from invited speakers

Underpinning concepts concerning air quality in the UK health impacts, public health, behaviour and communication; Matt Hort, Met Office

The Clean Air Programme is a joint UKRI and (Public Sector Research Establishment) PSRE activity. While the UK has made huge strides forward in recent decades in reducing many aspects of air pollution considerable challenges remain. In addition, changes in behaviours and sources of pollution mean that we are entering a transformative period of the causes and solutions of air pollution, where both indoor and outdoor air quality will need to be considered holistically. With increasing understanding of the range of health impacts from air pollution we also continue to have a strong need to reduce air pollution and our exposure to it. Targets such as World Health Organisation (WHO) limits from PM<sub>2.5</sub> must remain a goal.

The aim of the Clean Air Programme is to bring together the UK's world class air quality research base. It supports high quality multi and interdisciplinary research and innovation to develop practical solutions to today's air quality issues and to equip the UK to proactively tackle future air quality issues in order to protect health and support clean growth. The programme has multiple partners (NERC, Met Office, Innovate UK, ESRC, NPL, MRC, EPSRC, STFC, Defra, DHSC, DfT, The Scottish Government and Welsh Government) and interfaces with policy and therefore it is not just about research but about engineering positive policy and societal change with government departments

signed up to the programme. The programme has a diverse approach to funding projects and has also appointed a team of Clean Air Champions who are proving to have a central role (Professor Stephen Holgate, Dr Jenny Baverstock and the late Prof Martin Williams<sup>1</sup>) in realising the challenging aims.

The existing and future activities, funding and collaboration opportunities are all accessible through the SPF Clean Air web site <https://www.ukcleanair.org/>.

Air Quality and atmospheric Science – key issues, future requirements; Alastair C Lewis, University of York

Air pollution is a long-standing issue for the UK, with interventions to limit pollution recorded as long ago as the reign of Edward 1. Over the centuries the nature of air pollution has changed, and the most significant contributors evolve with society and, since the middle of the twentieth century the role of solid fuel combustion and industry has declined in the UK, to be replaced over time by road transport, agriculture, and domestic emissions.

History tells us that air pollution is dynamic and that it is critical to look forwards as well as backwards. The focus of attention is generally on only three pollutants, PM<sub>2.5</sub>, nitrogen dioxide (NO<sub>2</sub>) and ozone (O<sub>3</sub>). This relatively simple picture of pollution hides considerable complexity since both PM<sub>2.5</sub> and O<sub>3</sub> are derived from a much more complex array of emissions of precursor species such as ammonia, organic compounds and sulphur dioxide. Trends in UK emissions since the 1970s show a generally encouraging picture, with substantial reductions in the total emissions of PM, NO<sub>x</sub>, VOCs and SO<sub>2</sub>, although with notably poorer performance and largely static emissions of ammonia. Look more closely however and it is clear that for some species the last decade has seen a plateauing in emissions and improvements have stalled. Trends in national emissions can give a rather flattering view of the position however, since this does not necessarily represent human exposure to pollution – large reductions in emissions of NO<sub>x</sub> can be achieved through the closure of a single coal-fired power station, but that can have only limited impact on UK population exposure to NO<sub>2</sub>.

Atmospheric concentrations of PM<sub>2.5</sub> for example have changed rather little over the last 10 years. Driving concentrations of PM<sub>2.5</sub> down further is challenging since it is increasingly composed of secondary aerosols, and the formation of those can follow non-linear pathways. After a peak around 2010, NO<sub>2</sub> is now falling in the urban environment, due to more effective controls on the emissions from diesel vehicles. One chemical consequence of the reduction in urban NO<sub>x</sub> is a gradual increase in urban ozone, a result of lower titration with primary NO. This highlights how interconnected the atmospheric chemistry of air pollution is and that a holistic view of pollution reduction is required since changing one pollutant emission can feed through in unexpected ways on another. The drivers of the present-day pollution environment differ from some widely held perceptions.

Whilst many people view air pollution as a result of car exhausts, industry and power generation, in reality UK air pollution is now dominated by sectors such as friction and wear from vehicles, agricultural gases arising from our food choices, solvents from domestic products, emissions from our homes such as heating and cooking, and the continued fashion for burning wood in homes. It demands a reframing of some of the debate about how to achieve better air quality, with greater emphasis on personal actions and choices.

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<sup>1</sup> Dr Gary Fuller was appointed to the Champions team in January 2021.

Centre for Climate Change and Social Transformation; Stuart Capstick, CAST Centre

Stuart gave a summary outline of the work of the Centre for Climate Change and Social Transformation (CAST Centre). The CAST Centre began work in May 2019, and it aims to understand and push forward effective responses to climate change, and to identify how to live differently and better while reducing emissions.

The clearest way in which air quality is relevant to the CAST Centre is in terms of mobility as one of four sectors we are focussed on. The reason that we are focussed as a Centre on mobility is that emissions in this sector have hardly budged in recent years. Transport – especially cars, but also other vehicles – is therefore a common cause both of climate change and problems with air quality. At the same time, there are common benefits from acting on it. Reducing emissions from transport addresses climate change and air quality.

Turning to research on public perceptions of climate change: concern about climate change is currently high – in fact, higher than we have seen it for many years. Around three-quarters of people think addressing climate change requires either a high level of urgency, or an extremely high level of urgency. People are also concerned about air quality, although perhaps not to the same degree. Around half the public say they are concerned, and half say they are not concerned about this issue – in their immediate area. This varies by the type of place people live so, tending to increase with population density. Cars and lorries/vans are the main causes of concern; only a small proportion of people are concerned about household sources.

People's perceptions of air quality tend to be grounded in immediate experiences and senses. A range of research shows that physical senses – seeing dirty exhaust fumes, smelling pollution, even taste – are what are memorable and raise concern. The other way that people come to be concerned about air pollution is through having health problems, or concern for family members with health problems.

There seems to be very little research so far on people's perceptions of indoor air pollution. There is some work looking at how SES is connected to indoor pollution, including some behavioural measures such as window opening or cleaning. But this is a topic area that is very under-researched in the environmental social sciences.

In the future, Stuart expressed the hope that we can start to look at behaviour and lifestyle change as if we really mean it. Behaviour in the environmental sphere has so far tended to mean things like doing your recycling or switching your lights off – all good things but typically rather simple and painless and not demanding any real shift in how we live. Stuart and others in CAST have been working on a chapter for the 2020 UN Emissions Gap report on this.

On the back of the recent UK citizens assembly on climate change, there is also an opportunity for ongoing citizen engagement with environmental problems, including air quality.

Health concerns; Dr Mark Miller, University of Edinburgh

We are all aware that air pollution damages our health, yet the scale of the problem is frequently underappreciated. Furthermore, despite the considerable body of scientific evidence, many important questions remain unanswered. Together these issues, and others, slow the desire for, and pace of, change.

Associations between air pollution and health are strongest for particulate matter (PM). PM<sub>2.5</sub> is currently the most relevant metric of airborne particles for epidemiological studies of health



consequences. However, this mass measure inadequately considers factors important for the toxicity of PM, such as reactive surface area, composition, and particle size. In the scientific community, there is a general consensus that the relationship between exposure and health is nonlinear for PM, although there is a need for further work addressing the health effects of PM at high and low concentrations (especially those below WHO guideline levels).

It is widely accepted that certain individuals are likely to be more susceptible to the effects of air pollution: such as the young, the elderly, pregnant mothers and those with pre-existing cardiorespiratory disease. However, we should not overlook the effects on healthy adults where pollutants could be 'silently' promoting the development of disease. Epidemiological studies may focus on the acute (e.g. exacerbation of asthma) and later stages (e.g. hospital admissions, mortality) of air pollutants on health. Toxicological studies have a vital role here by being able to address different stages of disease pathways, reveal underlying mechanisms and investigate specific pollutants in isolation. An interdisciplinary approach across cellular mechanisms, animal models of disease (with clinically relevant endpoints), human exposure studies and epidemiology will be essential for disentangling the complexities of the health effects of air pollution.

Future research needs include; understudied sources of air pollution (e.g. indoor air, agriculture, non-exhaust vehicle emissions and other forms of transport), a fuller investigation of the effects on air pollution on multiple organ systems, identification of key constituents of pollution driving toxicity, the interactions with other environmental factors (e.g. smoking, noise, temperature, heat, infectious diseases) and the implications of current findings for policies and interventions.

[Air-quality as a non-communicable disease: a primary care perspective; Prof Philip Evans, University of Exeter](#)

It was a pleasure to present the primary care perspective on air quality and health. Non-communicable diseases (NCDs) have emerged as a major cause of mortality worldwide and are estimated to cause 71% of all deaths globally. It has been estimated that nearly 2/3<sup>ths</sup> of the 12.6 million deaths caused by the environment each year are due to NCDs. Common NCDs include coronary artery disease, cerebrovascular disease, COPD and cancer (particularly lung cancer). For example, it is estimated that 29% of COPD deaths are attributable to household air pollution, 8% to ambient and 11% to workplace pollution. From a GP perspective, as well as this significant mortality, there is also significant morbidity and major effects on patients' lives and quality-of-life. Air pollution is thought to have both short and long-term effects on patient's health.

Traditionally, the assessment of air quality and its impact on health has not been high on the GP's agenda, despite a third of GP practices being in areas where pollution is above the WHO's limit for PM<sub>2.5</sub>. GPs and their teams are generalists and manage both acute illness and NCDs in their registered patients, most of whom are never referred to specialist care. GPs frequently see the adverse effects of poor air-quality in patients presenting with acute respiratory conditions such as asthma, COPD and hay fever as well as more chronic conditions such as lung cancer.

The challenge in primary care is to identify those 'red flags' that would raise the suspicion of poor air quality both with GPs and their teams; particularly practice nurses. GPs with their ongoing relationship with patients and frequent contact are ideally placed to identify air quality issues. More education however is needed, as well as providing primary care with the tools and opportunities to both diagnose and intervene in cases where air pollution is clearly a major issue. More cross-sector and cross-discipline research is needed in all of these areas, particularly the development of complex interventions (including both diagnosis and intervention) in a primary care setting.

### Air quality: The Charities perspective; Harriet Edwards, British Lung Foundation

Air pollution is a health emergency and the single biggest environmental threat to health. It can increase people's risk of lung disease, make existing lung conditions worse and stunt the growth of children's lungs. We know that children, older people, people from less well-off backgrounds and people living with lung conditions are often the most affected by air pollution but tend to be among those least responsible. Across the UK, air pollution has been linked to up to 36,000 early deaths a year. This is simply unacceptable, and the British Lung Foundation is fighting to change it.

People who live with lung conditions have told us about the far-reaching impacts air pollution is having on their daily lives. People told us it was restricting their mental health, restricting their ability to leave the house and get treatment, socialise, or go to work. For some of them, high air pollution episodes have forced them into hospital. As the pandemic spread across the UK and travel became restricted, levels of air pollution plummeted in many towns and cities. One in six people living with a lung condition reported improvements to their conditions. We had a glimpse of what healthier and traffic-free cities could look like, and surveys showed higher public support for clean air measures than ever before. Worryingly, traffic levels have now returned to near pre-pandemic levels, and it's possible they will rocket even higher given concerns around travel on public transport.

The pandemic has resulted in a new cohort of people with ongoing breathing problems that may be more vulnerable to the harmful effects of air pollution. We know that air pollution contributes to the development and exacerbation of long-term respiratory diseases, which can increase people's risk of severe outcomes from COVID-19, including potential hospitalisation and death. COVID-19 has shaken up existing societal and economic structures, while exposing the harsh realities of health inequality across the UK. Communities living with multiple deprivation are not only exposed to the highest levels of air pollution, but are also being disproportionately impacted by the pandemic, on top of the multitude of other health and social impacts they may face.

Tackling air pollution is therefore critical to help improve the lives of people with a lung condition, reduce asthma attacks, protect the NHS, reduce health inequalities, prevent new lung conditions and improve the resilience of the UK population in the context of COVID-19 recovery. As well as meeting the UK's net zero targets for climate change and aiding an equitable and green economic recovery from COVID-19.

To meet the scale of this health emergency, we need the government to step up and put in place bolder legal targets for fine particulate matter in line with recommendations from the World Health Organisation. We also want to see a specific plan put in place to protect at-risk groups, as well as much more investment in walking, cycling and public transport to move people away from car travel.

### Air quality: The Charities' perspective; Chris Large, Global Action Plan

Global Action Plan was asked to suggest ways that academia and the SPF programme could accelerate the achievement of clean air for all in the UK. We started with a summary of the current state of play among the main actors, before exploring how the research community contribute:

- The public agree there is a problem with air quality and want it solved but are looking to business and government to lead and aren't fully sold on the necessary changes to society.

- Central government largely accepts that reducing pollution levels is important and have stepped in the right direction with funds to boost active travel, curb traffic and end diesel and petrol sales. But many policies that should be joined up have been left to individual local authorities and the government has many more levers it could pull.
- Local government has been most prominent amongst all possible societal leaders, with London's ultra-low emission zone leading to significant improvements. Some local authorities are slower to act and more recently, many clean air zones have been delayed.
- Businesses are becoming more active, with the Business Clean Air Taskforce, and CBI's report on the economic damage of air pollution. But undoubtedly there are many voices lobbying against stricter measures, sometimes with business hiding behind lobby groups that they fund.
- The health sector has some vocal advocates for action and some exemplars such as Great Ormond Street's Clean Air Hospital strategy, but there are no plans in place to roll out provision of air pollution advice by healthcare professionals to vulnerable patients and capacity to reduce the NHS air pollution footprint is severely limited due to funds and COVID-19.

The research community could most accelerate improvement to the air that people breathe by:

- Providing more evidence: on the social injustice, the societal benefits of steps that improve air quality (e.g. how pedestrianisation improves high street trade), emotive stories of the health impact (not just statistics) and the level of public and business backing for government action.
- Uncovering solutions: battery powered transport for all modes (e.g. refrigerated vans), smarter logistics, worker pollution exposure in industrial workplace, and alternatives to woodburning.
- Envisioning the future: how society could be transformed for the better in 20 years' time through progressive transport strategy (roads vs public trans & active travel), remote working and a comprehensive vision of a clean air society.
- Collaboration with NGOs: bringing robust knowledge to NGO campaigns, bolstering energy and enthusiasm for change with rational arguments and well thought out policies and solutions.

#### Air Quality Policy; John Newington, Defra

Defra's role is to design and evaluate effective national policy to improve environmental and human health outcomes resulting from poor ambient air quality. This is delivered using emission and concentration targets which are used to measure success and progress. Leaving the EU and the introduction of the Environment Bill is changing the legislative landscape, and the domestic policy landscape is also changing. Consequently, the evidence that is needed to measure progress and deliver effective policy needs to adapt.

What do you see as the current problems in your sector and what future research/innovation is required to address them?

- a) Precautionary approach vs costed business case - There is a tension between having fit for purpose evidence for establishing a long-term goal verses detailed evidence required at more granular spatial and temporal scales, which are often required in order to understand and apply interventions and maximise impacts at relevant scales. The emphasis on the policy impact at smaller scales from national down to urban and even individuals is becoming more important. Place is becoming central to policy design thinking. Improving the evidence picture to address this challenge over the next decade will grow more imperative, the closer we get to targets like 2030 emission ceilings or 2050 Net Zero ambition. What is "good enough" evidence as there is never perfect evidence?

- b) Data silos - Evidence bases held across government and academia and public health services (for example, atmospheric chemistry and health community data) are not being used to maximum effectiveness. Addressing this will help us improve our understanding of individual exposure, which is growing in importance. To do this it is important to look at all environments along the exposure pathway, both spatially and temporally. This will help us understand how individual's exposure changes during their lifetime and help us understand if that change matters to health outcomes.
- c) Air mixtures – We often focus on individual pollutants but in reality are exposed to air pollutant mixtures. Does that change the health impact? What part of particulates is the most toxic and can that help us prioritise our policy interventions to be more impactful?
- d) Technical innovation - Technological improvements could help us address some of these the evidence challenges and improve abatement options. For example, sensor technologies, industrial abatement equipment, new innovations for brakes and tyres, agricultural emission abatement technology, to name a few.
- e) Concerted and coherent research and development – There is a significant amount of R&D taking place across the UK in all areas relevant to air pollution and it's impacts on human and ecosystem health. There is a real need to join this up and programs like the Strategic Priorities Fund are example of this beginning to happen. This needs to continue and become the norm.

What is the next significant development that you expect to make a difference in your work in this area?

There are a range of evidence base improvements, from the development of new sensors and modelling approaches like personal exposure modelling, that will help us tackle the scale challenges. There is also a recognition that finding a policy home for indoor air will be critical if we are to understand the full exposure pathway and better understand the relevant policy levers available to all tiers of government, industry and individuals. To make the most of these evidence improvements there needs to be a continued emphasis on active engagement across all delivery partners, so we have access to the best available evidence, acknowledge uncertainty and maximise the benefits whilst minimising the unintended consequences.

Which organisation or sector would you most like to collaborate with and why?

There are 3 key areas of engagement that we are looking to enhance and strengthen our existing engagement with: Other Government Departments, academic community through UKRI (especially ESRC and EPSRC) and the charity sector.

[Local Government Policy; Jason Andrews, Merton Council](#)

My perspective is as an 'official' charged with delivering the air quality agenda, in short, an end user. Authorities at every level, local, regional and national have similar duties. It is our role to deliver policy and make changes on-the-ground that will deliver cleaner air. My presentation was aimed at some of the real-world obstacles faced by the deliver arm of regulation and legislation.

Local Authorities' role is to monitor air quality and identify those areas that fail to meet the standards, where necessary declare an Air Quality Management Area and then produce and deliver an action plan to tackle the problem.

My presentation covered the policy drivers, locally and nationally that shape the AQ agenda and highlight the practicalities and difficulties that affect delivery.

What was highlighted is that many Authorities view the air quality agenda differently, monitoring between boroughs often differ greatly and have remained unchanged for many years. Local Authorities have seen a reduction in funding, this impacts on the ability to adequately monitor and deliver projects in some boroughs. Political will is essential to resolving the problem and can sometimes be a barrier.

To plug the funding gap, we have seen the growth of grant funding opportunities, this however can be a lottery and is also dependent upon the resources needed to deliver that particular piece of work. Staff and expertise in Local Authority is a dwindling resource and bringing new staff into the industry is difficult without investment.

On the future of air quality, this is, and has always changed, we need to be able to identify those emerging pollutants and tackle these before they need to be regulated. We need to rethink the established methods of monitoring and be on the 'front foot' in identifying the issues rather than simply reacting.

This is where we need to form strong partnerships with academic, health and policy partners and secure the funding, support and will to coordinate our actions.

It is important to note that there is exceptional and innovative work being carried out across the air quality industry and particularly in regional and local government, this work does contain the resolution to these problems, however implementation can vary between cities and organisations. Best practice needs to spread.

#### Communication Between Disciplines and the Public; Dr Suzanne Bartington, University of Birmingham

Raising public awareness of air quality, including the need to deliver intervention measures is a core challenge and priority in the air quality and health sector. In my capacity as a local councillor, it is apparent that although public awareness of the issue has increased among specific population groups, it does not feature prominently among constituent's everyday concerns raised in "doorstep" discussions. Risk communication is a fundamental challenge in this context given the relatively complex links between air pollution and health; this dialogue could be strengthened by emotive (yet scientifically valid) narratives concerning impacts of poor air quality upon everyday lives.

At the local authority level there exists a significant gap between scientific evidence, policy, and practice, with a pressing need for expertise in knowledge transfer. This could potentially be achieved through scientific advisory roles or by funding mechanisms which incentivise evidence application. Air quality interventions also frequently lack strategic and operational coordination between 'siloes' policy areas (e.g., transport/public health) and would benefit from robust and responsive academic support for evaluation. There exists extensive scope for sharing of best practice for air quality actions within and between local authority areas, thereby improving efficiency and reducing duplication of effort. Similarly, strengthening academic dissemination mechanisms which provide an updated and accessible evidence base for both officers and elected members would be of benefit.

There remain structural challenges for advancing research and innovation within the health professional community, including the relatively inflexible career progression pathways and competing demands for those undertaking clinical academic training. Achieving major progress will require strategic leadership from accreditation and training providers, including embedding air quality knowledge within the undergraduate and postgraduate health professional training curricula.

## Commercial Applications; Mike Bull, ARUP

I was asked to speak from the perspective of any Environmental Consultancy based on my experience of over 30 years in the industry. My presentation considered where I considered improvement was needed in our current modelling tools and areas where new modelling techniques would be useful to address new issues.

There is consistent reporting of under prediction in the models that are frequently applied particularly for prediction of urban nitrogen dioxide (NO<sub>2</sub>) concentrations. As a result, model adjustment through the verification process is frequently applied and it is not unusual to see factors of 4-5 applied. This may simply be an issue with the application of models or the data inputs, but it is clearly an important area to address.

There is increasing interest in ultrafine particles (UFPs). Currently there are no tools available at a consultancy level to examine the impact of this pollutant nor the emission data required. We have noted on several projects that opposing parties are referring to UFPs and wanting an assessment made. It can be anticipated that interest in UFPs will increase further as more information on their health effects becomes available together with monitoring and emission data. This is likely to require new developments in modelling given how UFPs can be formed in the atmosphere as well as being directly emitted.

Finally, it is now more than 25 years since the “new generation” dispersion models such as ADMS and AERMOD became available. They have been subject to continuous development since, so have improved, but is a “second new generation” anywhere on the horizon?!

## Industry; Frédéric Nicholas, Dyson

**What do you see as the current problems in your sector and what future research/innovation is required to address them?** For (very) low cost air quality sensors, there is a lack of test standard and legislation in place to evaluate their ‘quality’. First would be to define what level of sensing should be deemed ‘good enough’ to properly inform people about the level of air quality in their homes. The key is to balance technical accuracy with a cost-effective assessment to persuade the institutions and manufacturers to adopt the standard. This should ideally include fundamental metrics or recognised ways to interpret the air quality data in a scientifically robust way while being communicated in a meaningful manner (layman’s term). The drive behind this is the proliferation of affordable air quality monitoring devices and mitigation of the confusion they can produce when put side-by-side and display different outcomes. This contributes to scepticism around ambient air quality data fuelling disengagement and inconsistent messaging.

**What is the next significant development that you expect to make a difference in your work in this area?** From a technical viewpoint, the recent advances seen in low cost particulate sensing are to be replicated for gaseous monitoring focussing on accuracy, sensitivity and selectivity. In term of the impact of air quality on individual health, a better understanding of toxicity level of pollutants and exposure would be beneficial. For example, what is the difference for the same cumulative exposure between a short high concentration peak and a lower constant background event? Displaying air quality is one aspect, the next step is to translate the information in a meaningful way, to clarify what it means and what one should do about it.

**Which organisation or sector would you most like to collaborate with and why?** Confidentiality and Intellectual Property (IP) are paramount for our industries and for us especially as we constantly innovate. So, any involvement and collaboration would need to satisfy these two key parameters.

As a business we have made perennial investment with some key partners on tactical technologies. For example, with Imperial College London we have developed a state-of-the-art robotic lab and at the University of Cambridge we have funded a chair with the Dyson Professor of Fluid Dynamics. For exposure and air quality science we need to pivot towards knowledge generation to advise and guide us on the impact on health and existing conditions linked to air quality, what the problems are. Translating this knowledge to people in a meaningful and engaging way to capture their interest is an essential aspect for our future communication. By better understanding what people breathe and the impact it is having on each individual, it would make the messaging more pertinent and relevant and would drive desired behavioural changes.

#### Workshop summary; Dr William Bird, GP

Getting the linkages clearer between health and air pollution is important: 7-9 million lives are curtailed due to air pollution worldwide and we need to improve this. This impact is not evenly distributed across the world with some areas worse than others. The issue for me as a GP is that I do not know anyone who has “died from air quality”, but we know in general practice of people who have died from complications of obesity or lung cancer from smoking, but these extra deaths worldwide related to air quality cannot be pinned on particular events. For example, how much did poor air quality contribute to those patients in my practice or family who died from a heart attack, stroke or cancer? Air pollution is invisible, you can’t smell, taste or see it unless it is very obvious like the Californian wildfires or bush fires in Australia. In modern times in the UK we don’t even have poor visibility as a problem, apart from the occasional haze, and we have no access to measuring air quality personally, whereas we can measure inactivity through step counts and obesity through BMI and can hear and see excess traffic. Therefore, democratisation of both an understanding and measurement of air quality is important.

The other factor is that it is all very confusing: as a population do we travel by car and get exposed to VOCs or do we cycle and inhale exhaust fumes and which route will reduce this load. Do we walk in London alongside stationary traffic or do we go on the underground and inhale particulates? These comparisons may reveal which exposes us to more particulates or NO<sub>x</sub> but in the big scheme of things does that difference really matter. Unpacking the detail of science and the toxicology is difficult and our knowledge is evolving but with so many uncertainties remaining scientists often debate these uncertainties creating further confusion.

A particular quote from the meeting: “we always live in a world of mediocre because we give people a third best solution to get on with and then a second best solution but it is too late. We never get to the first best solution because it is too difficult”. Ideally, we need to get the second best solution but in time.

Looking at the air pollution levels: currently the graphs look good, the levels have come down and are levelling off in some areas but we can do better - it has got to come down.

This then leads to the question “what are we trying to do?” A lot of the issues that came out at the workshop were around our targets: when do we know we have achieved success? ...is it zero particulates, zero NO<sub>2</sub>, zero ozone, zero ammonia (which will probably not happen because of background) or is it the WHO levels? Or is it more individual e.g. someone who is vulnerable (with heart disease or COPD)? For that person their target will be very different to another individual. So, we have to define what success looks like in 10-15 years’ time.

There were suggestions that we need to draw together an institution, with funding, with major stakeholders from industry, academia, health professionals, policy and the public to deliver the plan. Speaking as a GP, I would love to get training about air quality, but what do GPs do when they have a consultation and have to make a decision, knowing that the air quality is bad where their patients live. GPs will need to share with that patient the actions they can take just like we do when we talk about physical activity, smoking or obesity. What can GPs share with patients? They might be confused: they may live on a busy main road, do they exercise outside or not, etc.? We need very clear advice, not just to GPs but to teachers, parents, planners, council and employers. It is an education right from beginning to end. Monitors in schools that give accuracy and not pseudoscience is key to let the public explore and make air quality relevant for themselves. This approach can engender social movement and cultural change.

We covered modelling and the science behind it: the workshop discussions were around accuracy and whether we are using models properly. We could go for that extra percentage improvement but perhaps the effort and money involved to do that would be better directed to other developments that would have far greater impact on reduction or mitigation of air pollution?

The attachment to climate change is an important focus; when I worked on physical activity with patients and hitched it to obesity it worked because Obesity was the main talking point so rather than compete for air time we added physical activity to the obesity debate.

For our purposes, let's attach it to climate change initially (without a big costly campaign), for example, if you are going carbon neutral/zero you are going to help air quality. There are 57 interventions for zero carbon (Ally Lewis presentation) and only three or four have a negative impact on air quality AND all of these can be mitigated. Therefore, we already have 57 interventions attached to zero carbon that will improve air quality. We have reached a juncture here where this work can be translated into action with all the pieces in place.

COVID-19 is another global issue that has been catastrophic and some researchers have calculated that air quality has contributed to 19% of all COVID-19 deaths in Europe.<sup>2</sup>

The Governments levelling up which aligns with Marmot's health inequalities agenda is another main policy area in which poor air quality contributes.

Who is more susceptible to poor air quality? Would the effort be best spent in the interim period to identify genetic and pathological factors and focus on these high-risk patients (including children)?

We all agreed that we have made great progress over the past 50 years in improving air quality but it remains a totally man made problem that targets those in poorer areas with poor health so we have a duty to eliminate the problem.

This creates opportunities for us to create a bold plan for a big problem and the next step is to set up the multidisciplinary institution that was discussed at this workshop.

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<sup>2</sup> Pozzer, A., Dominici, F., Haines, A., Witt, C., Münzel, T. and Lelieveld, J., 2020. Regional and global contributions of air pollution to risk of death from COVID-19. *Cardiovascular research*, 116(14), pp.2247-2253.





A summary of the key points raised around each theme are presented in the following sections.

## Communication

The problems of air quality and health are complex, comprising numerous components with different health impacts, sources and behaviour in the atmosphere. Communicating important issues at this level of complexity can be difficult between sectors. Different sections of the community use different terminology, which introduces barriers. This is compounded by the limited opportunity for interactions and communication (workshops/conferences etc) that involve the whole air quality and health impacts community. Although there will be overlapping areas of interest, there is a lack of commonly held objectives across the community.

As evidenced during the COVID-19 pandemic, communicating the science to the wider public remains problematic. There was an acknowledgement that scientists need to improve how they explain concepts so that they are accepted by the public. If this can be achieved, it could be instrumental in fostering behavioural changes regarding lifestyle choices that result in poor air quality (e.g. use of domestic open fires as a form of secondary heating). It does not help that messages from the general media is still very pro-car ownership. Effective communication was therefore also highlighted as a potential enabler. Over complicated messages can serve as a distraction to potential solutions.

The primary requirement here is for coherent, positive messaging that links the key metrics for different end users. This messaging needs to be tailored for specific stakeholders and provided at the appropriate level of detail for those users. Engagement with other disciplines such as social/behavioural scientists and the arts would help design and target this messaging, with air quality visualisation tools being key elements to this. The metrics themselves need to be consistent with the clear use of 'statistics' when communicating information.

The objective from this positive messaging is to improve the awareness and understanding of air quality issues, impacts and solutions at all levels within society:

- at the individual level, bringing greater public recognition of the links between AQ and health, and individual knowledge of what we as individuals can do about it (what can 'we' do, not what should 'they' do).
- at the community level with greater engagement with communities to support them taking ownership of their local spaces and feeling empowered to make change.
- for local health care, supporting GPs/primary health care providers to proactively manage environmental health effects, e.g. providing early warning of air pollution episodes to GPs to manage patients with respiratory illness.
- in schools, raising awareness of the both the general and specific AQ issues in each school.
- at the local authority level to support local air quality planning and management activities.
- at the national level to support appropriate AQ policy development, provide clear and consistent public communications campaigns, and awareness at the policy design stage about what the implications for AQ are of policies that are not ostensibly about AQ (e.g. retrofitting houses to improve insulation).

Meeting the objective requires improved communication with messaging that conveys positive health and wellbeing rather than putting obstacles in the way. A new mind-set is required to convey such positive messaging since most public discourse on issues relating to air pollution is couched in negative terms. Put simply, is air pollution a negative thing to be controlled, or is a healthy environment a positive target to aim for? Such positive messaging needs to be adopted by the NHS

budget as a driver for improved health. It is worth noting, however that framing communication in terms of human health can sometimes get more leverage than general environmental health, although when possible both should be used together especially when effects on the natural environment reinforce health messaging ( for example: <https://www.tecamgroup.com/effects-air-pollution-environment/>) .

As a counterpoint to the positive messaging, more use should also be made of medical case studies that clearly demonstrate the adverse influence of outdoor and indoor air pollution on human health. The recent inquest on the death of Ella Kissi-Debrah establishing a causal role of air pollution exposure in her asthmatic illness and death is one example. The improvement in health of a Parisian teenager with asthma when she moved from a highly polluted area to one with much cleaner air is another (<https://www.bbc.co.uk/news/world-europe-48762911> ). Health professionals need to identify such case studies since real life stories are powerful tools for communicating often complex messages. The Medical Royal Colleges (RCPCH and RCP), Professional bodies and the third sector could do much in this area with “telling the story” to the health sector in their own language. Anecdotal evidence is also strong as health charities hear from their supporters all the time.

### Engagement with stakeholders

A crucial element of the challenge for AQ and health researchers is to effectively engage with the wider stakeholder community. A number of key stakeholder groupings were identified such as the policy developers and implementors within national government and local authorities. A similar issue of needing both national and local involvement was highlighted for effective engagement with the public, with pressure groups and the charity sector providing important linkages. Industrial involvement was also key in terms of providing technological solutions but also sectors such as the insurance industry that are taking an increasing interest in this area. Some of the specific points raised across the different stakeholder sectors are discussed below.

A general point was made that it is often difficult to understand who, or which organisation is responsible for various aspects of air quality and health concerns. This is especially important when looking to forge collaborative relationships and developing real sustainable solutions that normally require inputs from multiple organisations (and sectors).

### National Government and Policy Development

Achieving clean air for all requires clear and ambitious government and regulator policy in addition to the previously highlighted individual responsibility, industry engagement and research excellence. The multi-faceted nature of air quality also has important implications for Departmental led policy. To achieve clean air, policy needs to be clear and constructed in a holistic sense and cut across traditional departmental rolls. Devolution of solutions offers the flexibility to adapt to local pressures, but air quality does not respect boundaries and so ambitious centrally defined minimum requirements on data gathering, sharing and targets are required to ensure both adequate evidence and also to ensure joined up approaches.

It is important that AQ moves up as a priority area in the political arena. While there are lots of bodies involved there is a tendency for each to work separately rather than together. Better links need to be made between the Government Departments and their advisory committees and activities promoting clean air outside government. Air pollution policy making requires interdepartmental working. At present Defra holds to responsibility for air quality but it is really important that other central government departments especially DHSC, DfT, Ministry of Housing, Communities & Local Government, Department for Business, Energy & Industrial Strategy have well-

oiled communications and input into Defra Policy making. It was questioned as to whether Defra was the most appropriate department to handle air quality, particularly with regard to indoor air quality.

Transport was identified as a particular focus for national policy in this area. Since a high proportion of polluting particles and gases are derived from transport (road vehicles, trains and ships) a key win would be for government to do more to promote a real shift to active travel by taking a wider public health approach. This will require strong public information and local authority health focused educational campaigns linked to the multiple health gains associated with reduced traffic, increased exercise, improved mental health and wellbeing with a greater societal appreciation of green spaces and corridors in urban environments. The last year of COVID-19 has reinforced the importance of active travel and the benefits of the wider urban and natural environment (e.g. blue and green gyms).

One important policy and research interaction that was highlighted was the linkage between air quality and climate change. It is critical that promotion of activities to clean up the air are distinguished from the carbon agenda, so not to be viewed simply as an “add-on” but an integral component where both action on climate change and cleaner air are working synergistically together. At present, the climate and cleaner air objectives sometimes work against each other e.g. sealing of homes to conserve heat but at the expense of reduced ventilation and accumulation of indoor pollutants and moisture. Air pollution and climate change: should be considered as two sides of the same coin. Focussing on reducing emissions will allow those concerned with air quality improvements (indoor and outdoor) to work more closely with the climate sector and to further develop synergies for policy. This would be greatly helped if there was easier access to data right across the board to enable better use for analysis and for public information. Cabinet level representation covering both Air Quality and Climate Change would demonstrate the national importance of the combined challenge.

In terms of driving policy development forwards, while legal pressure helps to override political resistance, lots of bodies e.g. AQEG, COMEAP, PHE, medical and environmental charities need to be brought together and help create a joined-up national clean air strategy which embraces health at its core rather than focusing on achieving air quality limit values. Put simply there needs to be a joined-up plan where all the stakeholders are pulling in the same direction. Maybe the proposed new Office for Environment Protection (<https://deframedia.blog.gov.uk/2019/10/16/new-office-for-environmental-protection-will-ensure-governments-maintain-green-credentials/>) will help create a more ambitious collaborative agenda to bridge and pull together information on air pollution and linking this with health planning. While new policy changes are in train, such as Clean Air Zones, facilitating uptake of electric vehicles etc. researchers outside government have the power to help hone evidence in order to strengthen messaging, or respond to challenges from the public.

#### Local Authorities (LA)

The LA remit is very broad and has undergone significant budget reductions in recent years. Many have dwindling resources with some under pressure to further reduce posts. In-house expertise will vary widely, with some authorities having to outsource their air quality assessments to consultants, while others are totally reliant on key individuals who will act as a single point of expertise and driving force for addressing air quality issues. It was felt that most LA air quality work is tuned to the prime objective of satisfying statutory responsibilities, which tends to be focussed on driving down emissions everywhere (as guided by central government) and are therefore not always directly health focussed.

It was acknowledged that the connectivity between local and national policy providers was perhaps better in Scotland, but in England strong relationships between the two were patchy. There are some good examples in England but in the main this was not the case. It was noted, for example, that although the level of technical guidance offered to the LAs by central government was good, guidance regarding intervention strategies to improve air quality was poor. The extent to which LAs feel able to engage closely with government seems to depend on the size of the LA, the larger ones appearing to have more resources to build closer working relations. This situation could be improved through a forum for LAs to share good practice. Although there is an annual event that tries to get most LAs to attend, many cannot make the meeting as their resources will not stretch that far. It is possible that with the on-line conference now quite popular, that many will now be able to attend.

Another strong influencing factor is public perception and how much key air quality concerns reach the attention of the elected official, who may then urge for the LA to act. However, with many other prominent and competing concerns (such as pot-hole repairs, social care matters, local crime figures, education etc.) air quality will not always feature as a priority. There was a view expressed that if the public were more aware of poor air quality and its impacts, these concerns may become higher priorities. There is indication that this is beginning to occur in some LA areas.

There is a major issue to ensure that LAs have adequate funding dedicated specifically for air quality work, linked to a need to ring-fence environmental budgets for the LAs. It is not effective for them to rely solely on short-term grants for specific projects. Guaranteed long-term budgets will enable LAs to plan more strategically, train up their in-house staff and perhaps retain staff for a longer period resulting in more consistent handling of the problem.

Siloed working is also a problem at local government level when attempting to carry out interventions for cleaner air. So, for example, air quality needs to be more effectively embedded in local planning systems and protocols, supported by advice on air quality-friendly new builds and how effectively to retro-fit existing housing stock. There also is an urgent need to get better at sharing good practice and to encourage good links between local authorities and local industry to jointly develop solutions to local problems. There remains a fear in some industry sectors that cleaning up the air will threaten jobs in industry and impose unaffordable costs. The ULEZ in London is an example where such barriers have been overcome. Local government could benefit from working with wider stakeholders with aid of central government (example: ensuring feasible infrastructure required to achieve a transition to electric vehicles). Collaborative taskforce efforts convening the right actors around manageable issues (e.g. ensuring hospitals have clean air) would be very helpful.

#### Engaging and enabling the public

While public awareness is higher than it was, and there is also the media, and they are more interested now often through campaigns (e.g. the Times, the Guardian and the Evening Standard), there is still much to do in getting appropriate communication to the public for understanding the health impacts of poor air quality and what, as individuals and organisations, they can do to improve the situation. Bringing the public into the debate could prove to be influential especially if they communicate their concerns to elected officials at the local level. More use should be made of citizens' assemblies to both inform of current situations and to learn more about their experiences. As a general comment, education is the key to getting people involved and aware early in schools and local communities, and making sure people have information of air quality in their local area so that they can be informed and demand improvements. Once the public are really demanding change then this will drive political motivation to make change.

A key change would be to empower individuals, community groups and schools with the knowledge of air quality in their localities by making available reliable and affordable air quality sensor devices for house/personal use and what wearable devices would be suitable for personal exposure monitoring. Such information has the potential of being collected together and then used to inform the wider local community. In addition, apps for AQ health warnings e.g. via primary care would be very empowering as would knowledge about hyperlocal monitoring as demonstrated in the Breathe London project.

Considering recent publicity and the increasing profile that air pollution issues are generating, it is surprising that many people still don't understand AQ issues. Part of the problem here is that there has been little attempt to coordinate reliable health information/air quality messaging across the country. This means that while there are pockets of good practice, this is by no means common. PHE have produced evidence based interventions that have been assembled and sent to local government (<https://www.gov.uk/government/publications/improving-outdoor-air-quality-and-health-review-of-interventions>), but there has been little or no follow-through as to whether such information is being acted upon or reaching the public. Bringing the public on board via citizen assemblies might act as a good way to help educate the public but also as a vehicle to getting air quality issues prioritised more at local and national policy levels.

The charity sector has an important role to play alongside pressure groups to provide information to the public and other stakeholders in the air pollution space. The medical charities and Royal Medical Colleges as well as professional societies need to raise the profile of air pollution and encourage engagement to seek and implement solutions. There is also an opportunity to grab public interest and piggyback on the momentum already generated by pressure groups such as Extinction Rebellion and the work surrounding Greta Thunberg as an environmental activist. Pressure groups such as ClientEarth also play an important role not only in raising air pollution as a key issue for action but also in the scrutiny of any new or proposed legislation.

#### Industrial involvement

It was noted that the level of partnering with industry varies considerably across the country, but the landscape is changing as IT and tech-companies get more involved. Some LAs, such as in Oxford, have very good working relationships with locally based industry, encouraging them to contribute to the development of locally based solutions. More generally though, industry tends to only get involved if there is a clear business opportunity and the perceived benefits may be realised in the shorter-term. Local businesses will analyse the market" and decide (usually in isolation) how and in what capacity to become involved. In doing so, they will not always contact LAs. Clear guidance on the requirements and accepted methods to deliver AQ solutions would assist both the suppliers and users of these products. As a specific example, a formal standard for low cost AQ sensors, as is the case for other air quality instruments, would be of value.

Another important area of industrial involvement is data handling and analytics. If large data companies could get involved then they would be able to help with their expertise in handling large datasets but companies such as Google and Facebook also hold a lot of data that could be really useful for things like health studies in order to map exposure pathways of people.

Due to Covid-19, actuaries are taking greater interest in the impact of this tragic pandemic on life expectancy, especially with the recognition of long-term consequences (long-Covid - <https://www.bmj.com/content/371/bmj.m4470>). Such predictive opportunities equally apply to indoor and outdoor air pollution exposure where there are both acute and chronic impacts. The

untimely death of Ella Kissi-Debrah from asthma and the inception and progression of her disease has, for the first time, laid blame on air pollution that she was exposed to across her short life as being causal (<https://www.newscientist.com/article/2263165-landmark-ruling-says-air-pollution-contributed-to-death-of-9-year-old/>). Attaching risk estimates linked to air pollution exposure requires robust science in order to underpin such calculations and open up the market for mitigation action. A point raised was that, if in the UK our health systems were privatised, there would be more interest from insurers on environmental exposures and likelihood of health conditions, as occurs currently in flood risk. Creating an environment that drove insurance needs would open opportunities for insurers to help drive environmental changes required to reduce pollutant exposures.

### Cross-disciplinary collaboration and funding

It was acknowledged that a number of funding mechanisms do exist and, for example, those from the research councils are good for academic research within the scope of a single research council, however, there is significant room for improvement. The current mechanisms and funding structures for research are not ideally suited to support cross-disciplinary collaboration with eligibility for non-academic organisations not always clear. Better integration is needed across all relevant disciplines and organisation types, including social and behavioural science (social practice theorists and transitions researchers not just behavioural change research) and the arts. There is also a need to break down negative perceptions of industry involvement, highlighting that such collaborations can bring significant benefit and faster impact, not trying to steal ideas for commercial use.

Stimulating such collaboration requires the relevant governance structures and joint funding calls to stimulate co-ordinated research to fill research gaps. There also needs to be upfront openness from all sides about the motivations and unique interests of the different sectors to help identify areas for collaboration and build trust, and it should be recognised that it takes time to develop such relationships. This could be supported by encouragement of discipline-hopping and cross-discipline training and education, e.g. epidemiology for environmental scientists and vice versa (similar approaches have already been done by EPSRC for ICT, for instance), as well as means of rapid communication and policy dissemination between sectors. Similarly there need to be close links and understanding between the research community and the public sector, possibly through fellowships for public sector workers to go out into academia or other sectors for a period of time as well as for researchers and others to go into the public sector. Another important element required to support internal and external communication is evidence synthesis and translation into plain English, which should be a skills base that is actively funded and developed rather than a piecemeal addition at the end of individual projects.

In all cases such collaboration needs to be driven by a shared vision with common goals and priorities, with a clear view of the positive impacts that can be achieved through collaboration rather than focussing on the challenges and complexity of interdisciplinary research. This can be supported through solutions-focussed funding calls with wide inclusivity through cross sector involvement in programme and project development and funding availability for the wide range of relevant partners/stakeholders. Designing such collaborative programmes should consider what solutions have worked previously both within AQ and in other areas.

A point was raised about the recognition of the wider impact of research. Generally, there is a pervading culture among higher education institutes (HEIs) on publication outputs rather than on translating research into policy and public benefit. Reducing air pollution and improving public

health would provide strong impact case studies in exercises such as the REF2021. Hopefully the increased weighting given to research impact in REF2021 of 25% compared to 20% in the REF2014 will further encourage this behaviour change within the HEIs.

A number of specific needs for future collaborative funding were identified with a particular focus on the linkage between indoor and outdoor AQ. These included the need to provide new research that integrates indoor and outdoor exposures for health impact assessments, since air pollution exposure occurs continuously but variably in different settings (home, travel, outdoor, schools, workplaces etc).

There is a marked lack of understanding of the importance of the indoor environment as a source of air pollution (ingress from outside, and both primary and secondary sources inside) both in terms of the air pollutant mix, the importance of ventilation (especially with emphasis on energy conservation) and importantly, acute and long term effects on health. Promotion of a virtuous circle of clean AQ outdoors and natural ventilation (open windows) to save energy e.g. fresh air produced by intelligent window ventilation (<https://www.geze.com/en/discover/topics/natural-ventilation> and <https://www.windowmaster.com/expertise/natural-ventilation-and-mixed-mode-ventilation/natural-ventilation-strategies/>). Such activity will require cross-sectoral collaboration including strong engagement with industry, the construction sector, planning policy and building regulations and embracing indoor/outdoor air quality in the round rather than just looking at each in isolation.

The Clean Air Programme is attempting to address some of these issues. It has been clear from the outset that to advance knowledge and its uptake for change to cleaner air both outside and inside requires greater interdisciplinary working in the form of interdisciplinary groups, workshops, conferences etc. that would allow increased discussion between the air quality and health communities, allowing networking and connections to be established and to enable sharing of research. This approach is also critical to encourage the “end user” in a meaningful way and industry participation. COVID-19 has shone a strong light on how powerful interdisciplinary interactions can produce rapid results e.g. the rapid creation of diagnostic tests, drugs and vaccines. Better use needs to be made of recognising the importance of air pollution as a target to improve people’s health by the NHS and they themselves through their hospitals and GP Practices should be setting an example as is now happening with the zero carbon agenda and climate change (<https://www.england.nhs.uk/2020/01/greener-nhs-campaign-to-tackle-climate-health-emergency/>). Again, the complementarity of reducing pollution emissions and meeting climate objectives is striking.

The linkage to climate change and mitigation policies was also highlighted by the late Professor Martin Williams who described how policies to help the UK meet its climate change carbon emissions mitigation obligations will as a result change the types of pollutants we see outdoors over the lifetime of much of our housing stock. For instance, in the period 2030-50, incentivising biomass energy production could lead to an increase in exposure to primary PM combustion products, including carcinogens. However, he also made the point that if air quality and energy efficiency measures are considered together, the Climate Change Act target could provide an opportunity for the biggest air quality and public health improvements since the Clean Air Act of 1956. The COP26 event being hosted in the UK later in 2021 is creating opportunities for major announcements on climate action, and an opportunity to highlight the strong links between climate and air quality.

A key element to improve future research cooperation would be through targeted training to improve interdisciplinarity. Early career researchers, particularly in Doctoral Training Partnerships



(DTPs) and Centres for Doctoral Training (CDTs) with access to cross disciplinary thinking need to be incentivised to help break down traditional departmental barriers (silo working) in HEIs. Effort needs to be made in training up scientists to network across the other disciplines. Bringing in social scientists is increasing and is a huge positive that needs further encouragement since communication is so closely linked to behaviour change. Similarly, an important route to build the links with the industrial sector is through methods such as jointly funded PhD studentships or industrial partners having academic appointments. One area that requires particular attention is the language used by different specialist fields that creates barriers to understanding and knowledge transfer. Social scientists have a major role to play in helping simplify language and communication especially in creating much needed positive messaging.

Although the focus of the workshop was on UK requirements, the international nature of the challenge was acknowledged. Air pollutants know no borders, which is why international coordination of air pollution policy remains indispensable. International engagement, e.g. under the UNECE Air Convention (<https://unece.org/convention-and-its-achievements>) embraces cross-disciplinary research and has developed robust science-policy interfaces and is providing a platform for scientists and policymakers to exchange information which has led to innovative approaches in air pollutant abatement and creating mutual trust and learning. Air pollution affects all of us: it harms human health, affects food security, hinders economic development, contributes to climate change and degrades the environment upon which our very livelihoods depend. The Convention provides a platform to discuss these interconnections and take actions to prevent negative impacts.

### Data sharing

There is a wealth of data concerning air quality and health outcomes. In order to maximise the usefulness of this data it should be easily accessible to those working to improve air quality and health. There is currently a lack of easily accessible good quality data available, particularly regarding health outcomes. Part of the problem with health outcomes data is related to matters of confidentiality, although it is possible to obtain anonymised data. For both air quality and health sectors the problems of accessing spatially and temporally relevant data in the right format is seen as a major barrier to continued work as well as preventing meaningful collaborations. Even just knowing what relevant data is available would be a good start.

Access to large data sets is also a crucial component for providing strong messaging underpinned by evidence. This will require better communication between the air quality and health communities so that we know what information or data is required and so that this can be made easily available e.g. we have large amounts of air quality data being produced from the SPF Clean Air Programme that will be open access but if it doesn't include the data, metrics, etc. that the health community need for their work then it will not be used. Clearly there needs to be more attention given to identify people's data requirements in advance so that appropriate interfaces can be established. In order to communicate our science to the general public better we could involve social scientists who understand case studies and public experiences and who can help to present the science in a way that the general public can understand and engage with. One good example of this is the HDRUK/UKRI BREATHE project hosted by the Usher Institute in Edinburgh that aims to make respiratory health better by changing the way the NHS, researchers, industry and charities use data (<https://www.ed.ac.uk/usher/breathe>).

Measurement data is always spatially discreet and cannot provide advance information on effectiveness of policy and/or action. Models compliment and go beyond measurements. Access to measurement and model data for wider analysis and use is needed but often presents challenges

due to provenance, representivity, validation, uncertainty and suitability. There is a need for meta-data guidance and good practice to support open and inter-operability of modelled and measured data.

Key to making progress on the communication and collaboration areas is the development of common approaches to data and information sharing. This should include AQ and health metrics that are useful to researchers and meaningful to the public supported by quality metrics for both the underlying data and conclusions drawn from it. Ideally this would be linked to a common platform to share data, best practise and knowledge as well as information about calls and opportunities. Such a platform should be designed to support the needs of and provide information for research, industry and government stakeholders. This should also be supported through more attention to knowledge synthesis and exchange across different organisations in different sectors and sharing of best practice as there is a wealth of previous experience and information that currently has limited visibility. For example, organisations such as the Turing Institute and data focused organisations such as Microsoft and Google have huge experience in this area and should be engaged with as a matter of priority.

Meeting the challenge of clean air requires change across a huge array of activities. The above points outline several actions that if undertaken would support the solving of the air quality challenge. However, we need to also recognise that for change to become imbedded that many of these activities need to happen in unison and in combination. Evidence and data need to be shared and provided in forms that are usable by different groups and individuals. These activities, many of which have joint data and social science dimensions, are as important as the more easily recognised research and policy activities.

### [Leadership through a National TaskForce](#)

A common theme that the participants thought was needed to facilitate a co-ordinated approach to meeting the air quality and health challenges was the establishment of a National Taskforce. This would provide leadership and structure to connect the stakeholders and the suppliers of innovation and change, as well as a focus for the implementation of national schemes. This could be based around a national forum of leading figures and key representatives to make decisions and shape the future, linked to a network of local/sectoral/institutional champions who would be the 'flag-bearers' for cross-disciplinary solutions to AQ challenges.

Dynamic and engaging leadership has been shown to be an important element of stimulating awareness and understanding and then in driving change in key societal and environmental challenges e.g. wildlife preservation, climate change, use of pesticides. This can include individuals, political leaders/parties and organisations/corporations. Air quality as a largely unseen and invisible problem would significantly benefit from highly visible and aspiration leadership. Such champions provide the charismatic leadership (the 'Attenborough Affect') needed to energise and empower people.

## Workshop Conclusions

The Joining Forces to Improve Air Quality and Health Workshop was a unique event that brought together 84 representatives from across the diverse range of disciplines and stakeholders involved in Air Quality and Health issues. These included academic and public sector researchers, health practitioners, national and local government, industrial innovators and environmental consultants, and third sector representatives.

Following some scene setting from invited speakers across the different sectors, the challenge set to the workshop participants was to identify the current barriers to these sectors working better together and what should be done to break down these barriers to find solutions that have full sector involvement. During the wide-ranging and open discussions that followed a wealth of ideas, information and suggestions were captured that could be grouped around a clear set of common, closely linked, themes.

Improved and more inclusive communication was identified as a primary area of immediate need both internally within the research community and externally to the wider set of stakeholders. The internal communication is crucial to facilitate the understanding of the differing research needs and challenges that would then lead to effective cross-disciplinary collaboration, supported by appropriate funding mechanisms. The external communication needs to be tailored to the differing requirements of the diverse set of stakeholders in this area including: policy developers and implementors within national and local government; the general public, often through links with pressure groups and the charity sector; and industrial suppliers of technological and data solutions as well as the insurance industry.

Access to large data sets is a crucial component for facilitating joint research and strong messaging on air quality and health underpinned by evidence. There is a wealth of air quality and health data available, but it will require close interaction between the research communities to develop common approaches to information sharing, so that there is widespread awareness of what is required and so it can be easily accessed. A key element of this data provision is that the primary data is supported by meta-data and quality metrics to ensure it meets the different user requirements.

There was general agreement that a key next step to facilitate a co-ordinated approach to meeting the air quality and health challenges was the establishment of a National Taskforce, based around a national forum of leading figures and key representatives to guide decisions and shape the future, linked to a network of local/sectoral/institutional champions who would be the 'flag-bearers' for cross-disciplinary solutions to AQ challenges.

## Annex 1 – Workshop process

The facilitated workshop was a two day event online. The meeting was an invite only event with delegates selected from a wide range of sectors. Registrants were required to register via Eventbrite from a link emailed from the Met Office. Registration data was taken before the event and information supplied on attendees is taken from that date. There was some variation on the day with delegates unable to attend both days or only partial sections of the meeting. The data on delegates is cleaned to represent 15 sectors.

The meeting was conducted via Zoom and the first part of day one was plenary with scene setting speakers. A further two sessions of scene setting plenary speakers were also provided for day two. Speakers were asked to address the following in their presentations:

- **What do you see as the current problems in your sector and what future research/innovation is required to address them?**
- **What is the next significant development that you expect to make a difference in your work in this area?**
- **Which organisation or sector would you most like to collaborate with and why?**

Speakers who were not necessarily full experts in the field were also asked to provide their perspectives on air quality and engagement with the issue from their perspective.

There was time built in for questions and these were captured from delegates via Mentimeter. Mentimeter enabled delegates to vote (or rank) the questions that were raised. The facilitator conducted short Q&A sessions with the highest ranked questions being asked live with the speaker after each plenary session. Additional questions raised were captured and the questions were taken forward with speakers to answer post workshop. Summaries of the question and answer sessions with the invited speakers can be found in Annex 3.

**Table 2: Agenda:**

### Day 1

TIME	SESSION OVERVIEW
09:50	Pre-registered participants admitted
10:00	<p><b>Formal Welcome and Introduction</b></p> <p><b>Explanation of underpinning concepts concerning air quality in the UK, health impacts, public health, behaviour and communication.</b></p> <ul style="list-style-type: none"> <li>• Welcome by Matt Hort</li> <li>• Remembering Martin Williams</li> <li>• Purpose and aims of the workshop</li> <li>• Agenda – (facilitator)</li> </ul>

<b>10:10</b>	<b>Guest Speakers</b> <ul style="list-style-type: none"> <li>• <b>10.15</b> Atmospheric Science - Ally Lewis</li> <li>• <b>10.25</b> Public behaviour - Stuart Capstick</li> <li>• <b>10.35</b> Health concerns - Mark Miller</li> <li>• <b>10.45</b> Air Quality as a Non-Communicable Disease: a primary care perspective - Phil Evans</li> </ul>
<b>10:55</b>	<b>Questions and Answers</b> Speakers respond to most “up-voted” questions by participants
<b>11:10</b>	<b>Breakout Groups Briefing (Facilitator)</b>
<b>11:15</b>	<b>BREAK</b>
<b>11:25</b>	<b>Breakout Group Sessions</b>
<b>12:10</b>	<b>LUNCH</b>
<b>12:40</b>	<b>Feedback from breakout groups in plenary</b>
<b>13:00</b>	<b>Guest Speakers</b> Perspectives from the Charities sector <ul style="list-style-type: none"> <li>• <b>13.05</b> Harriet Edwards - AUK BLF</li> <li>• <b>13.15</b> Chris Large - Global Action Plan</li> </ul>
<b>13:25</b>	<b>Questions and Answers</b> Speakers respond to most “up-voted” questions by participants
<b>13:40</b>	<b>Day 1 Summary - Stephen Holgate</b>
<b>14:00</b>	<b>Close Day 1</b>

## Day 2

<b>TIME</b>	<b>SESSION OVERVIEW</b>
<b>09:50</b>	Pre-registered participants admitted
<b>10:00</b>	<b>Formal Welcome and Introduction</b> <ul style="list-style-type: none"> <li>• Welcome by Stephen Holgate</li> <li>• Recap of previous day’s highlights</li> <li>• Purpose and aims of the workshop</li> </ul>

	<ul style="list-style-type: none"> <li>• Agenda (facilitator)</li> </ul>
<b>10:10</b>	<p><b>Guest Speakers</b></p> <p>Sector representatives speak about significant developments, current problems influencing future research and innovation, and sector collaboration.</p> <ul style="list-style-type: none"> <li>• <b>10.15</b> Defra Policy - John Newington</li> <li>• <b>10.25</b> Local Government Policy - Jason Andrews</li> <li>• <b>10.35</b> Communication between disciplines and the public - Suzanne Bartington</li> </ul>
<b>10:45</b>	<p><b>Questions and Answers</b></p> <p>Speakers respond to most “up-voted” questions by participants</p>
<b>10:55</b>	<b>Breakout Groups Briefing (Facilitator)</b>
<b>11:00</b>	<b>BREAK</b>
<b>11:10</b>	<b>Breakout Group Sessions</b>
<b>11:55</b>	<b>Feedback from breakout groups in plenary</b>
<b>12:10</b>	<p><b>Guest Speakers</b></p> <p>Sector representatives speak about significant developments, current problems influencing future research and innovation, and sector collaboration.</p> <ul style="list-style-type: none"> <li>• <b>12.10</b> Applications - Michael Bull, ARUP</li> <li>• <b>12.20</b> Industry - Fredric Nicolas, Dyson</li> </ul>
<b>12:35</b>	<p><b>Questions and Answers</b></p> <p>Speakers respond to most “up-voted” questions by participants</p>
<b>12:45</b>	<p><b>Briefing (Facilitator)</b></p> <p>A look ahead to the afternoon agenda and questions to reflect on over lunch</p>
<b>12:50</b>	<b>LUNCH</b>
<b>13:20</b>	<b>Breakout Group Sessions</b>
<b>14:05</b>	<b>Feedback from breakout groups in plenary</b>
<b>14:20</b>	<p>Independent summary of the two days by Dr William Bird (introduced by Matt Hort)</p> <p><b>Workshop Summary – William Bird</b></p> <p><b>Next Steps and Wrap Up – Matt Hort</b></p>

14:40	Close
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## Annex 2 – Event funding and organisers

### Strategic Priority Fund Clean Air Programme

Funding for the Clean Air programme is provided through the UKRI Strategic Priorities Fund (SPF), which has been set up to build upon the vision of a ‘common research fund’ set out in Sir Paul Nurse’s independent review of the Research Councils. The fund will drive an increase in high-quality multi- and interdisciplinary research and innovation, ensure that UKRI’s investment links up effectively with Government departments’ research priorities and opportunities, and ensure that the system is able to respond to strategic priorities and opportunities.

More information about all SPF programmes, including Wave 1 and Wave 2 Clean Air programmes, can be found through the links below:

[www.ukri.org/research/themes-and-programmes/strategic-priorities-fund](http://www.ukri.org/research/themes-and-programmes/strategic-priorities-fund)

[www.ukcleanair.org/](http://www.ukcleanair.org/)

### The Met Office

The Met Office is the national meteorological service for the UK providing critical weather services and climate science that is used to inform a range of important decisions of society. Since their foundation in 1854, the Met Office has pioneered the science of meteorology and its many applications making them one of the world’s most trusted weather forecasters. As well as the public weather services, the Met Office has a variety of international and political responsibilities acting as a key provider of valuable information to help government, emergency responders and the public to make informed decisions. The Met Office also collaborates closely with other organisations, forming partnerships that extend beyond the UK, contributing to science and research throughout the world.

[www.metoffice.gov.uk/research/approach/collaboration/spf/spf-opportunities](http://www.metoffice.gov.uk/research/approach/collaboration/spf/spf-opportunities)

### National Physical Laboratory (NPL)

The National Physical Laboratory (NPL) is the UK’s national measurement institute and is a world-leading centre of excellence in developing and applying the most accurate measurement standards, science and technology available. For more than a century NPL has developed and maintained the nation’s primary measurement standards. These standards underpin an infrastructure of traceability throughout the UK that ensures accuracy and consistency of measurement.

NPL has a long history in the measurement of atmospheric pollutants. This work covers the development of high accuracy calibration standards and novel measurement technologies; tools for the laboratory and field validation of monitoring techniques; the use of such techniques in research, industrial and regulatory applications; and leadership of international standardisation in this area.

[www.npl.co.uk/environment](http://www.npl.co.uk/environment)

### SPF Clean Air Champions

The Champions: Professor Stephen Holgate, Dr Jenny Baverstock and Dr Gary Fuller (who has replaced the late Prof Martin Williams) bring together outstanding researchers across atmospheric, medical and social science to develop practical solutions for air quality issues, and then ensure that

these interdisciplinary communities are connected to the public and wider policy and business environment to maximise the impact of their research.

The Champions will also look to work wider, working with other national and international stakeholders to facilitate joint working, identifying areas of common interest and ensuring no duplication.

Please find more information at <https://www.ukcleanair.org/about-us/clean-air-champions/>



## Annex 3 – Invited Speaker Q & A

### Questions for Ally Lewis

*Q. Surprisingly we do have SOME control re weather! Possible (and happens) to modulate emissions according to the weather. Of course longer term we need to understand impact of changing climate*

A. I would stand by the answer given verbally, which is that in terms of control levers emissions is the parameter that can be controlled, not weather, in the same way as one cannot manipulate chemical rate constants. The impacts of a changing climate are possibly significant on the timescales of perhaps 20 years plus, but there is nothing in those predictions for the future that would significantly change decision-making on air quality improvement now or over the next decade.

*Q. Has domestic use of solvents increased in absolute terms? Relative to transport I appreciate it may well gone up, but in absolute terms it may have gone down.*

A. Yes it has increased in absolute terms. The Inventories haven't been updated particularly well since ~2005 in terms of reflecting consumer patterns, but even assuming consumption per head hasn't changed, the growth in UK population means absolute emissions are estimated to be higher now than 20 years ago. It seems likely that per capita consumption has increased as well, evidenced for example by increases in individual VOC sources reported by industry in areas like aerosol fills, car care products and so on.

*Q. Is there a 'hit list' of the VOCs of most concern, to enable targeting of action?*

A. In terms of absolute amount, ethanol, methanol and butane dominate UK emissions. All are associated with emission sources that could plausibly be reduced, easier than for example ethane from low level fugitive gas leakage.

*Q. How easy is it to get a picture of how much of a particular VOC we use in the home via use of various products?*

A. Not very easy based on a bottom up examination of the products themselves, since there is no labelling or assessment of emissions. Labelling was proposed however in the Defra CAS, so we wait to see on that. France has a proposed system that would extend a traffic light VOC labelling to all products in a way similar to the labelling on paints (the globe with the smelly fumes rising up).

*Q. Ammonia emissions are likely to increase (use a fuel and used for energy storage). Do you think this issue is being addressed or will we wait for it to be an issue before acting?*

A. Huge quantities of ammonia are already shipped around the world and there is little evidence that its production or fugitive losses is a major air pollution emissions problem. It is currently well managed simply because pure ammonia is so toxic. A personal opinion is that ammonia as a fuel would be similarly tightly controlled in terms of loss and leakage since its potential to kill the user is much greater than similar mass emission losses of gasoline or natural gas.

*Q. Ally, how can academics tackle the pseudo solutions (Ikea's curtain, canned fresh air, anti-pollution shower gel) and free-market think-tank efforts to rubbish science? Should they set up a watchdog?*

A. There are already routes to challenge clearly ridiculous or baseless claims through sale of goods misrepresentation and advertising standards laws. But as yet few people have challenged the claims made on AQ. It may be that academics can help support those challenges using experimental and data skills available to that community. Once suspects that a number of embarrassing retractions for some high profile companies, or the costs of defending claims for smaller ones, could go a long way to reducing misinformation.

*Q. Indoor Air quality hasn't been mentioned as much as outdoor air quality. With limited bandwidth and resource should we focus on outdoor air quality?*

A. Use of the available bandwidth is often driven by public pressure which in turn is often a consequence of regulatory or legal pressures. This trickles down even to the academic community - many funding sources are highly directed and these are often based on the external environment surrounding the topic. The lack of obvious standards in the indoor space, and owner of the problem, means inevitably it receives less attention. This makes no sense from a public health perspective of course, but the whole ecosystem of research and evidence tends to follow the external drivers. There is a case to be made that the high profile given to outdoor air, has in a way dragged indoor air further into the spotlight.

### Questions for Mark Miller

*Q. Is the measure for particulate (PM2.5) the best one to use to link to toxicity?*

A. From an epidemiology perspective, PM2.5 is currently the best metric we have to study the health effects of particulates in ambient air pollution (I should note though that PM10 may be a better metric if looking at specific sources of coarse particles). Ideally, we would be able to look in more detail at the characteristics of the particles within PM2.5 (such as smaller particles, chemical make-up of the particles, reactivity of these constituents) but that is not currently possible with the technology and practicalities of current monitoring networks. These features and specific pollutant sources can be addressed in experimental work (e.g. lab assay, cell cultures, animal models and controlled exposures in human volunteers). At present my feeling is that there is a general consensus between laboratory studies and epidemiological studies using PM2.5, although undoubtedly some of the inconsistencies in findings will be due to the lack of ability to focus on more specific aspects of PM2.5. This is where toxicology studies play a vital role in identifying which features of PM2.5 we should focus on as pollutant monitoring advances.

*Q. Do we understand which aspect of the pollutants are toxic to us? For example, is it particle number/size/shape/composition or all of the above?*

A. We have a reasonable understanding of which aspects of pollutants have the capacity to be more toxic than others. For PM2.5 in urban environments, characteristics such as the size of the particle and the content of redox-active metals and organic carbon molecules are likely to play important roles. However, it is very unlikely that a single particle chemical/feature is mediating the harmful

actions of PM – it will surely be a complex interaction of multiple chemicals/features that drives their biological activity, and this will likely vary depending on which effects and organ systems you are looking at.

*Q. Should we be including epidemiology of air pollution in the school curriculum?*

A. I personally would like to see some discussion of air pollution (not necessarily the epidemiology alone), although I appreciate there will be lots of topics rivalling for attention in the school curriculum. I take reassurance that, from my own discussion with both primary and high school pupils, that there is actually a good general awareness of this issue, and it is heartening to see pupils speaking about this topic with their friends, teachers and families. I know of several high schools that have had projects on air pollution where pupils carry an air quality monitor around their school environment, and even look at levels before and after an 'intervention' such as opening/closing classroom windows or putting in hedging around their school yards. Children tend to be really engaged in these projects and make compelling advocates for the issue.

*Q. Which messages on health are most effective in influencing the large-scale change we need? Is it the long-term or acute effects, everyone's health or those on vulnerable people?*

A. Overall, the weight of epidemiological evidence suggests, perhaps intuitively, that long-term exposure to air pollution is more significant for health than acute periods of exposure. However, a number of studies have shown that acute exposure can have rapid and long-lasting effects on the way our body functions, or could even trigger an event such as an asthma attack. It is the sum of these exposures of a course of a lifetime that ultimately governs the overall impact on our health. It is important that vulnerable groups (such as the elderly or though with cardiorespiratory disease) are given a degree of priority, as they are the ones most at risk of sudden events such as a heart attack or stroke (or on their development, in the case of young children). However, I feel it is very important to emphasise that air pollution harms the health of everyone, and can have measurable effects on the way our bodies function in young healthy adults. However, this is often 'silent' in that there is a cumulative damage to our body over many years that may only cause symptoms as the condition gets more severe.

*Q. How strong is the evidence about air quality impacting things like cognitive development in children and a role in 'unhealthy' ageing and poor mental health?*

A. I have not personally looked into this area in any great detail, but I am aware that there is now a very large body of evidence saying that air pollution can impair cognitive development/ability and is associated with conditions such as depression or neurodegenerative disease. I believe there is still considerable uncertainty in the field given the infancy of this research topic and the complex biological processes governing such conditions. However, I would expect that the evidence for links between air pollution and cognition/neurological conditions will grow over the next decade.

*Q. What about the contribution of biological exposure? much focus seems to be only on chemicals?*

A. I agree that biological exposures are important to the detrimental health effects of air pollutants. This may especially be the case with certain health conditions (e.g. asthma) or specific sources of pollution (e.g. indoor air pollution or occupational settings). Additionally, there are suggestions that biological and 'chemical' exposures could have synergistic actions (e.g. particulates carrying allergens, or converging biological pathways for these pollutants) so it is important that researchers consider biological exposures.

### Questions for Phil Evans

*Q. Should air pollution exposure/assessment be a part of the standard respiratory medical history (in both primary and secondary care)?*

A. Yes indeed, although this does raise the issue of how we inculcate AQ assessments into routine undergraduate medical training

*Q. Do GPs generally receive air quality forecasts for their areas do you know?*

A. Not that I'm aware of, there were a number of met office pilots but these have now stopped

*Q. Do you have some data to show the increase in prescribed Salbutamol? This might help to give evidence for the health effects on PM0.1 and PM2.5 to councils*

A. Yes the paper is available at <https://academic.oup.com/jpubhealth/article/35/4/502/1686918>

*Q. Can we weave in AQ as part of QOF?*

A. Although this would be ideal, it is highly unlikely. QOF inclusion needs evidence based guidelines and appropriate metrics

*Q. How can GPs nationally be supported to incorporate air pollution related health advice in to their practice with patients? What are the interventions to upskill GPs?*

A. This is an extremely good question. Engagement is needed as well as education and the provision of appropriate information which is easily digestible by the GP and the practice team and of practical use. Interventions that are context-specific e.g. respiratory disease may have more traction than generic education

*Q. What sort of material (static or dynamic) would support GPs in identifying and communicating AQ issues?*

A. See response above- GPs are very pragmatic and hence any intervention will need to be kept simple and easy-to-use. A trigger from the GP computer systems often a helpful way to facilitate GP education and interventions.

## Questions for Stuart Capstick

*Q. Stuart - do we think it acceptable to 'export' our air pollution (i.e. resell dirty vehicles to other parts of the world)?*

A. Personally, I would respond with a strong 'no' to this question. There may be economic or industry arguments for being able to sell vehicles on, but a reasonable rule of thumb to me would be: if a vehicle is too polluting to meet the UK's regulations, it shouldn't be sold abroad. In a related way, if we do have ban on diesel and petrol vehicles from 2030, as now seems likely, then no I don't think we should see it as OK to sell these to places that don't. This is of course part of a much bigger issue: we export our pollution in many ways, either convolutedly through emissions share allocations, or directly by shipping physical waste elsewhere in the world. We have as much of an ethical responsibility to people living elsewhere as we do to people living down the road, and the international nature of commerce doesn't change that!

*Q. Stuart how can we communicate that indoor air quality is an issue? If people do not understand the issue they will not act.*

A. This is a tricky one, and I'd suggest a good starting point would be some detailed research on this. In the early days of research on public perceptions of climate change in the late 1980s and early 1990s, work was done to uncover how people were beginning to think about and understand these issues. This revealed that for many people, a mix-up with the ozone hole was common (e.g. that a hole in the ozone layer lets in more heat, that leads to global warming). I would guess that in a similar way there is not much awareness of indoor air pollution issues, and that where people are aware, there may be confusion about which aspects are important or impactful, and what can be done about it. (Saying this though, it is probably fair to say that passive smoking is on people's radar, and that those with asthma or another illness are also likely to be more aware.) So-called 'mental models' research - e.g. see <http://dx.doi.org/10.1088/0952-4746/36/2/S102> for an example - can help here. When we know what people do and don't understand, that then enables us to communicate better. If there are particular things that practitioners want people to \*do\* this is best said clearly and simply; too often information details all the facts and figures but isn't clear on how to reduce risks - for example, perhaps there is a need to state that certain cleaning products should be avoided because they are harmful? (The govt's 'Stay Home, Protect the NHS, Save lives' was a good example of a clear and direct message from COVID-19 of a sort that I think communicates well what was needed.) This said, we have learned the hard way through many health campaigns and on other environmental problems, that information and awareness alone are often ineffective, or at least only useful in comparison with other measures. There's a need as well to understand what aspects of people's daily lives and circumstances - beyond their intentional choices and awareness - mean they do things that are not ideal, in order to address these too.

*Q. Stuart, we've seen recently that it may be hard for government and science to bring the population along with them to achieve positive outcomes in such a complex area. What are the best ways to do so?*

A. In many ways I think that the nation's response to COVID-19 has shown precisely that people \*will\* take action - even very inconvenient measures or action that constitutes a real personal

sacrifice - if they feel there is an important reason to do so. Part of this is of course to do with wanting to protect the health of yourself and others, but also - for a time at least - we experienced in our usually rather individualistic culture the sense that we had shared and collective responsibility for an issue. Of course, the urgency of the situation demanded this - and this makes it much harder to replicate for slow-burner and messier problems like air pollution from transport - but it does illustrate that people aren't necessarily as recalcitrant as you might expect when it comes to dealing with the problems we face, if there is very clear leadership and a sense of shared responsibility. Some of this has been outlined in a report from Climate Outreach that I contributed to (in relation to climate change and COVID-19, but some generalisable findings):

<https://climateoutreach.org/reports/communicating-climate-during-covid-19/> Another answer to the question is to recognise that often public opposition to something can be overcome through simply doing it! That is maybe not the ideal way to bring the public along with you/us, but has been shown time and again to work - e.g. the London congestion charge was much opposed before it was introduced, and then much supported after it was. Low-traffic neighbourhoods seem to be going this way. A lot of resistance and opposition from some, but once things settle down then a sense that actually this is better. To give another example, some people opposed many of the measures to restrict smoking in public spaces - but would we ever go back now? I can't imagine being able to smoke in a restaurant as used to be the case!

*Q. Stuart - I found the concept of 15min cities very interesting. Could you say a little more about them please?*

A. As I understand it, this has been an initiative driven by the mayors of some cities around the world, to design urban infrastructure in a way that means most things you need to access and do can be accessed within a 15 minute walk or cycle. The idea being that we can live well without having to constantly be in our cars to get to work, shop, take children to school etc. This is aspirational in many ways (i.e. easier said than done) but does prompt a different way of thinking about urban design: for example, it is completely at odds with the idea of out-of-town megastores which kill off local shops and mean we end up driving places to buy things. There's a good article in the Financial Times on this, including a comment from Sustrans (who talk of a 20 minute principle) that

""It's not that everything needs to be within 20 minutes and you're stuck within it, but it's trying to ensure that people don't hop in their car to get a pint of milk. That doesn't limit you, it takes away some of the unnecessary journeys; it opens up a more accessible world"" . See

<https://www.ft.com/content/c1a53744-90d5-4560-9e3f-17ce06aba69a> (this article also looks at the downsides of this principle). See also <https://www.c40knowledgehub.org/s/article/How-to-build-back-better-with-a-15-minute-city/> .

*Q. Stuart - How would the balance of economic arguments go further towards benefits >> costs if (when?) evidence for air pollution effects on brain health (dementia, Alzheimers disease, etc.) strengthens?*

A. I probably don't need to say to anyone working in this field that 'externalities' are one of the most difficult things to deal with. We know that air pollution has these costs to people's health and quality of life, but no one is accountable to picking up the tab. I'm always a little sceptical of assigning economic costs to things like dementia - but if this is to be done, then I would suggest the

appropriate mechanisms for this to be met would be for producers of products that cause this, are required to pay for them. Adding costs to fuel duty seems to be politically impossible, but I see no reason that larger companies that sell petrol and diesel products should avoid paying upstream. This would be fair, and could also hasten their inevitable transition to renewable energy and/or ultimate demise.

### Questions for Jason Andrews

*Q. Jason - with such a wide remit of competing duties, how do local authorities prioritise Air Quality given their available resources?*

A. Funding/resourcing of the air quality agenda does directly affect what can be delivered/achieved, as does political will. Local councils have seen many years of austerity, which has directly affected all services. I must say that in the boroughs I represent there has been no decrease in funding, however a huge increase in the interest and demand relating to air quality, sometimes makes the scales unbalanced, and staff can feel overwhelmed.

*Q. It is important to note that air quality is not just for the traditional pollution teams but should be for all departments to contribute to, including transport, procurement, public health, schools etc. This 'joint' resource, if focused, can be considerable.*

A. Air quality initiatives are also heavily subsidised by Grant Funding, however this can sometimes be a lottery and take a lot of resourcing and effort, often without success. We also need to remember that you need staffing revenue to deliver grants projects, often a 'catch 22' for many authorities.

The prioritising of resources and projects are normally set out in Air Quality Action Plans, and it will be for individual boroughs to focus on areas of concern. As indicated above, we need to be able to tap into these areas and partners to deliver change. The downside is that not all local authorities have the same priorities and we know that pollution does not respect boundaries. In theory, you can have a borough doing everything humanly possible to tackle the problem and their neighbour doing the bare minimum.

*Q. Jason - Do local authorities engage with the public regarding Air Quality issues?*

A. Many do, and many have now started to realise that if you want to change behaviour and get the message across then you need to work with people and active groups. Air quality is the responsibility of us all and we need to be aware of our own contribution and what we can do to change. Air quality is not simply a problem for the Government, it's in everything we do.

In the areas I represent we have citizen science projects and community forums, we actively engage with those that have traditionally been seen as our critics. Obviously, care needs to be taken as pollution can, and is, weaponised for individual campaigns rather than the greater good.

Engagement also includes official consultations around air quality, which is invariably linked to other areas of local Government. So for instance a Parking Policy Review will need to include Air Quality. My view is that we need to include and involve the public to get the best outcome.

*Q. Jason - local authorities seem to choose to be oblivious to Air Quality issues as this allows them to ignore the issue and therefore their responsibilities. How can they be forced to recognise this?*

A. I would say that this is changing, especially in London. The health issues surrounding pollution have become a major public health and political concern. We saw that Client Earth challenged the Government on its approach to air quality - it is important to note that the same challenge can be made against any Local Authority, so ignoring the issue is, to me, extremely unwise and probably a dereliction of responsibility.

Pressure can be put on Authorities through public, political and perhaps even legal challenge. The difficulty here is that boroughs need to be aware of the pollution in their areas and to have actively monitored it. We do have reporting processes for those boroughs subject to Air Quality Management Areas, but not all areas in the country are covered.

*Q. Jason - Do you require additional guidance from Central Government regarding advice on monitoring etc.?*

A. I would say no, advice exists from DEFRA. The cost of monitoring is either very cheap or very expensive, and the cost can prohibit boroughs from having many automated monitoring stations.

What could be useful is standardising the monitoring in boroughs. Boroughs choose where and what they monitor, with some (my boroughs) being extremely thorough, others not so much. Perhaps some obligations on boroughs to monitor and a programme of peer challenge would be a good starting point - and then perhaps regulation.

*Q. Jason - AQMAs have been a mixed success - how does remit (and resource) need to change in the future Env Bill framework for Air Quality improvements to be realised?*

A. All of the answers above apply. I think the mixed success has been down to local commitment. There is some excellent work going on in many areas, locally and regionally, and the solutions are out there, but the resourcing, commitment and expertise varies dramatically across the country. We need to take the best examples, the projects and approaches that work, and emulate them where needed. Perhaps the new legislation needs to be more imposing, but its enactment would also need to be properly resourced.

*Q. Jason/ John - Are there concerns about the impact of Brexit on Air Quality legislation where we are no longer implementing EU Directives? How will you ensure no long term negative impact?*

A. There are many facets to this question. From my understanding the Government has committed to the transfer of legislation for Air Quality and I do not think it would be politically or publicly palatable to water this down. There will be challenges over time and I am sure legislation will change. I would like to think we could change it to be more positive and become one of the most proactive countries in the world.

*Q. Jason - is there good connectivity between the Air Quality sections of local authorities and their Transport and Planning departments? This seems like a crucial requirement.*



A. It varies between local authorities: all of the key partners need to be invested and play their part. Good relations with colleagues, the connections and joint benefits all need to be understood. Boroughs need a champion (whether this be an individual or a team) to pull these partners together. That said, we have seen vast improvements in joint working with key partners over the past few years

*Q. Jason - how can we get Planning departments to take Air Quality into account consistently?*

A. The best way is to embed air quality into the Local Plan and produce a Supplementary Planning Document (SPD). This sets out what is expected of the council, what the local needs are and what we want from new development. Embed this in formal processes and it cannot be ignored. We have a number of great examples of a local SPD's. Failing that, education of, and training to planners, committees and departments around their contribution and actions to tackle the problem...oh and keep badgering them.

*Q. Suzanne/Jason - Public health in local authorities - will they have any real influence?*

A. Of all of our partners, yes. Communication, messaging, health links, influencing are all skills they have in abundance. Just need a focus sometimes...speaking from experience...no criticism on my Public Health colleagues, they are all great!

*Q. With Public Health embedded in local authorities how do they link into community health/CCGs/GP?*

A. Probably a question best responded to by my Public Health colleagues.

### Questions for Chris Large

*Q. Chris; who are the exemplar countries that have a proven track record in mitigating some of the negative health, environmental and economic impacts of air pollution and from whom we may learn from?*

A. We recently asked this question of the WHO, and they couldn't report many good recent examples of efforts to tackle NOx and PM2.5 around the globe. There have been environmental successes, typically from policy interventions in the banning of CFCs which has seen a positive improvement in repairing the Ozone layer, and the banning of lead in petrol. More recent air pollution steps that I think have had some effect are Beijing's controls using the number plate to limit car usage, and Singapore's road pricing policy, which changes in real time to financially deter people from using congested routes and has been in place for over a decade. Pollution would likely be higher without these measures.

*Q. Chris - In the NHS what are the exemplar methods for informing the public and clinicians from your perspective?*

A. There is no programme in place to mobilise clinicians to provide air quality advice to patients, even in very related disciplines such as respiratory medicine. GAP and the UKHACC are running pilots testing the feasibility of respiratory and paediatric clinicians providing health advice to patients. Similarly, there is no public health campaign in the way that the public is educated about other health issues - smoking, diet, alcohol, drunk driving - which each have millions spent on public campaigns each year. Some campaigns are running (with completely inadequate funding) run by health charities like the British Lung Foundation and British Heart Foundation, some local NHS trusts and councils and campaigns like Clean Air Day.

*Q. Chris and Harriet - Do you think we need the different charities to come together to host a high profile event/initiative to galvanise public awareness and add political pressure?*

A. Charities will like to do more, but can't without significantly more funding. The Healthy Air Campaign convened by ClientEarth and supported by around 30 charities is very active, and is keeping pressure up for the right policies as we speak in the environment bill. We would like to shine a light on more voices who support clean air policies (the vast majority of the public from our polling data), and lobby more politicians more frequently, and compete the voices campaigning against clean air policies (car manufacturers, freight lobby groups, taxpayers alliance).

*Q. Chris - do you consider COVID-19 has further sensitised public conscience/opinion regarding the importance of air quality?*

A. Yes, in both a greater appreciation that what is in the air (pollution or virus) can be harmful, and how much better life is when cities have less traffic and cleaner air. The public says it is now more important to tackle air pollution than before lockdown, and a majority of people think that business, central govt and local govt need to do more than they are currently doing towards clean air. <https://www.globalactionplan.org.uk/build-back-cleaner-air> is our report summing up public attitudes to air pollution in light of coronavirus.

*Q. Chris - The public tend to be very wedded to car culture and lots of employment in transport sector - those employed are very vocal. What positive messages are there that can overcome this?*

A. The lockdown increased cycling and walking, and a decent percentage of people said they planned to walk or cycle more, and drive less permanently (fingers crossed). Details in <https://www.globalactionplan.org.uk/build-back-cleaner-air> .

To encourage people to move away from car ownership / use we need to focus on the positives of active travel and working from home, and negatives of car ownership. More exercise, feel fitter, save money, save time (not stuck in traffic), more time with family, or to yourself. Car ownership means an asset that wastes money most of the time while it is sitting on the drive doing nothing, which needs care and maintenance, which could be stolen, which needs to be parked etc.

Regarding the economy, I think that Green Alliance produced a report that showed 80%+ of existing automotive jobs are directly transferable when a factory switches to manufacturing electric cars (that's without thinking about jobs to install chargers, research in to better battery tech etc). Also, a number of local authorities have recently reported that local shop takings have increased when they

have increased cycling and walking, which is studied deeply by Living Streets  
<https://www.livingstreets.org.uk/media/3890/pedestrian-pound-2018.pdf>

*Q. Chris - What is your view on the relative importance, now and in the future, of long-range transboundary air pollution? What can be done by academia, third sector, government to influence / change?*

A. I'm not an expert on this, but it seems it can only be tackled through international government cooperation.

*Q. Chris and Harriet, the charity sector spans a number of roles-supporting patients and lobbying for change. Where do you think the balance lies between individual and policy change to have the best impact?*

A. We won't get clean healthy air unless we have policies that force change (in the types of cars sold, the amount of car use, the wood burning products sold, the use of diesel in construction etc). And we are more likely to get those policies if the public support them. So the best bet is to have an engaged and caring public, pushing for change alongside health professionals, NGOs, academics and enlightened politicians. Businesses can also be a campaign force for good, with Climate Group, ClientEarth and GAP all leading business groups which push for clean air.

*Q. Both CAS are solutions to local NO2 problems, and advocated for in the charity sector., but may not be particularly effective to deliver PM2.5 reductions - does this create a messaging dilemma?*

A. We just need to be careful to explain the full picture to the public whenever we talk about air pollution. There are a multitude of sources, and tackling one source or one sector cannot solve the problem (e.g. if we converted all cars to electric tomorrow, we still wouldn't have clean air because of agriculture, industry, wood burning, particulates from car tyres etc).

*Q. Chris - are there plans for the Manchester study to be submitted for peer-review publication?*

A. Yes. An early summary can be found here: <https://www.globalactionplan.org.uk/news/clean-air-day-2020reducing-air-pollution-levels-by-20could-improve-children-s-ability-to-learn-by-one-month-per-year-0>

*Q. Chris - How would the balance of economic arguments go further towards benefits >> costs if (when?) evidence for air pollution effects on brain health (dementia, Alzheimers disease, etc.) strengthens?*

A. I guess this would just further strengthen an already compelling case. The Environmental Audit Committee already accepts that air pollution costs the country around £20bn a year, and the CBI recently calculated a £1.6bn benefit to the economy of getting pollution down to WHO recommended limits. These benefits would already validate an investment in creating clean air,

which any evidence about Alzheimers would strengthen, but perhaps make no difference if the current business case is not leading to the action we want.

*Q. Do EVs fit with overall sustainability? Aren't they resource intensive?*

A. I believe in most scenarios (dependent on how they were made, and how the electricity to power them is generated) EVs produce less carbon in their entire life-cycle than ICE vehicles. T&E have analysed this subject. <https://www.transportenvironment.org/news/how-clean-are-electric-cars>

*Q. Do you know why David Cameron did not make 'idling your engine' unlawful? I believe that was the plan?*

A. I hadn't ever heard this was a policy position for David Cameron so can't provide any insight, sorry.

### Questions for Harriet Edwards

*Q. Is there a graph to show the number of people developing asthma over the last 20 years or so (perhaps regionally)?*

A. You can find our stats and graphs on asthma here - <https://statistics.blf.org.uk/asthma>

*Q. There are many contaminates/pollutants that have many different levels of effects on different people even if for example a family living in the same conditions each can have different reactions.*

A. Absolutely, I think this is an area that needs much more research too.

*Q. Do we know about other environmental stresses that might exacerbate sufferer's conditions such as pollen or spores etc?*

A. Pollen and mould are certainly other environmental triggers, particularly for asthma. You can read more about triggers on our health advice - <https://www.asthma.org.uk/advice/triggers/>

*Q. Countries like USA and Australia recognise mould as a major indoor contaminate and it appears both Insurance and Government wish to bury their heads, why do you think it is ignored.*

A. I think indoor air pollution is a tricky one in terms of responsibility and variability across properties. I think it's also a difficult thing to enforce, particularly when it comes to the way the housing market is structured. It's certainly something that many of our supporters have contacted us about.

*Q. Do you think we need the different charities to come together to host a high profile event/initiative to galvanise public awareness and add political pressure?*

A. There is a huge amount of work coming out of the charity sector already. We've been working on this issue for many years alongside charities like the British Heart Foundation and ClientEarth. We all work closely together in the Healthy Air Campaign coalition and have spearheaded a number of the air pollution campaigns that have delivered policy change in recent years. I think what's really exciting is the new collaborations emerging, such as those in the Clean Air Programme, where policy experts, lived experience and researchers are coming together in networks. These programmes have the capacity to really help drive forward the evidence base and put pressure on policymakers.

*Q. The charity sector spans a number of roles-supporting patients and lobbying for change. Where do you think the balance lies between individual and policy change to have the best impact?*

A. I think this is a really critical point. We think that system change at the population level is crucial for air pollution. That much more ambition is needed from central government to deliver change in order to support individuals to change their behaviour. Of course, we also need everyone to make individual changes to their lives that reduce their contribution. But ultimately, the level of change required to lower air pollution levels is needed at government level.

*Q. CAS are solutions to local NO2 problems, and advocated for in the charity sector., but may not be particularly effective to deliver PM2.5 reductions - does this create a messaging dilemma?*

A. Yes, it is a challenge that not all pollutants are being dealt with at the same time. We would prefer to see regional clean air plans that set out policies to tackle all harmful pollutants across regional areas, rather than local plans that are just focussing on putting a clean air zone in place to comply with legal limits. However, it's also important to remember that CAZs will go a long way in tackling NO2 and their introduction has taken a lot of hard work from campaigners and policy makers alike. So I think we should celebrate the progress that is happening and work with local areas to strengthen CAZ plans and urge them to bring in regional clean air policies.

### Questions for Suzanne Bartington

*Q. Suzanne - what taskforce or institution should we set up to lead national public communications? Or should it be completed by one existing organisation?*

A. My original answer to this was that it would best suited for the new body arising from PHE with air quality and health remit – e.g. the National Institute for Health Protection, however appreciate there is still some uncertainty over how this will operate. There could be advantages for commissioning a third sector organisation, such as Global Action Plan, given the extensive experience of public engagement and communications. Targeted messaging, utilising social media and other mechanisms for dissemination (e.g. TV/radio/poster billboards) have been effective in previous public health campaigns such as HIV, drink-driving)

*Q. Suzanne/Jason - Public health in local authority - will they have any real influence?*

A. This is very dependent upon available resource – although the PH budget has been ring-fenced since transfer to Local Government there are still multiple competing pressures on LA public health teams and COVID-19 has placed them under additional pressure amidst wider budget uncertainty.

Influence can depend upon the internal structures operating at authority level, political balance and willpower for public health empowerment and support among key elected members and officers. This is still an evolving process but there is potential for harnessing the position in local government to strengthen links between different teams (e.g. health/planning/transport/communities) and link air quality to statutory responsibility for air quality. A designated section of each Director of Public Health Annual report dedicated to environment/air quality could also be helpful to further raise the profile of the issue at a local level, alongside input to planning and development processes.

*Q. Suzanne - what are the main obstacles going into politics from a career in science? Do you have sage words of advice for scientists to campaign with politicians?*

A. Public health is a very helpful grounding for politics as it provides a broad perspective at a population level and delivers key skills in interpretation of key facts and figures and communication to diverse stakeholders. However, there are major challenges with regard to objectivity and handling of evidence which as a scientist operating in a political context I find frustrating. In terms of engagement and campaigning, politicians receive large volumes of correspondence and persuasive lobbying from different angles. What I have witnessed to be most effective in terms of techniques, is framing the narrative around tangible events or life stories, and effective visualisation. Demonstrating the wider benefit and being mindful of public perceptions, geopolitical context and electoral timelines is also important – particularly at local Government level.

### Questions for John Newington

*Q. How does Defra facilitate a concerted approach (i.e. including atmospheric science, behavioural science and health research) to tackle these challenges?*

A. It's one of the biggest challenges and I'm not saying we've got it right. One of the things we've done is to work really closely with UKRI and work with Stephen and the Champions of the Strategic Priorities Fund so that we can start to bring together some of these different disciplines. We also have close links with local authorities... I've got a local authority background, so I'm very aware of some of those challenges, so we're working really closely with some of our local authority colleagues to bridge some of those gaps. It's really interesting to hear what Suzanne was just saying around the communication aspects and the key role that local authorities could play and we're very minded of that. We also run various consultations on some of the changes we're putting forward and that's a way that we can gather information not only from some of the usual professionals or everyday engagement with other government departments and experts but also with the public. So, I think there's various mechanisms. Whether we get that right all the time or whether we could be doing more, I'm sure we could but time and resources are limited as we all know and if anyone's got any suggestions on what we could be doing more of then I'm happy to take that on board and we'll try and do better.

*Q. John - Is Defra also looking at indoor air pollution? This has not been included in Defra's remit in the past.*

A. Defra has instigated two indoor air quality round tables this year and continue to work closely with the Chief Medical Officer, the Department of Health and Social Care, our independent air

quality expert group (AQEG) and Chief Scientific Advisor. The Department is working hard to bring together relevant expertise and disciplines with policy officials to address indoor air quality and the interplay between ambient and indoor air quality. AQEG are working with the Committee on Medical Effects of Air Pollution to write a report on indoor air quality and the relationships with the outdoor environment. Defra also sit on the Steering group for the Clean Air Strategic Priorities fund which has a strong focus on indoor air. Defra's remit continues to focus on ambient air quality and we will continue to work with all departments and relevant parties to deliver improvements that reduce human exposure to air pollutants across the exposure pathway.

*Q. John - what is being done to investigate synergies between air quality issues and climate change?*

A. Earlier in the year we ran a workshop between our independent air quality expert group and the committee on climate change looking at some of the synergies and some of the trade-offs and that's online so it's publicly available. We used that as the basis to inform a Defra wide net zero steering group which is feeding in to BEIS, so there's a lot of activity going on to try to bring these two agendas together and ensure we don't get any of these unintended consequences. In the main, if it's done well, there's lots of benefits but we need to be mindful we don't have another diesel issue.

*Q. John - Exposure to mixtures of pollutants are challenging to address with pollutant-focused policies, what is Defra's thinking around addressing multi-pollutant risks?*

A. Defra has developed a list of Areas of Research Interest and the role and importance of mixtures is one of those components that we recognise as an area where more research is needed.

*Q. John - given that air quality issues don't respect national boundaries, how are you working with the devolved nations to ensure a coherent approach across the UK as a whole?*

A. Defra works closely with the Devolved Administrations and support each other as we develop a cohesive range of strategies and work towards meeting the UK's Emission Ceilings.

*Q. John - In many areas UK Government use technical agencies to lead on scientific/technical coordination rather than doing this from departments. AQ is notable in not doing this. Any thoughts?*

A. In Air Quality, we use a mixed model approach of scientific. Technical delivery. The monitoring network is managed and delivered by the Environment Agency with expert advice delivered by the department's independent Air Quality Expert Group (AQEG) and DHSC's Committee on Medical Effects of Air Pollutants (COMEAP) as well as close co-operation with UKRI through programmes like the Clean Air Strategic Priorities Fund. There are pros and cons for adopting different delivery models but the main benefit for delivering this within the department is that the evidence expertise is close to the policy area. This is an advantage for the challenge of air quality which is complex to understand and requires co-ordination across a range of delivery partners which central government is well placed to influence.

*Q. Is Government planning a public health campaign on air quality to raise public awareness? If not why not?*

A. Public Health Campaigns are the remit of DHSC and PHE. Defra is working closely with a number of stakeholders including PHE and their expert advisory group (the Committee on Medical Effects of Air Pollution) as well the Defra independent Air Quality Expert Group (AQEG) and the Clean Air Hub to better understand the ways in which the public but also specific end users with certain needs might be best communicated with to not only reduce their exposure but also reduce the emissions that they have the ability to reduce both directly and indirectly (for example, through the businesses that they are part of). Any health campaign needs to be carefully targeted and carefully planned to deliver the desired outcomes.

*Q. Jon - what happens in interregnum between Brexit and Environment bill?*

A. Existing legislation has been transferred into UK law. The Environment Bill will build on and improve on that existing legislation.

*Q. Jason/ John - Are there concerns about the impact of Brexit on Air Quality Legislation where we are no longer implementing EU Directives. How will you ensure no long term negative impact?*

A. Jason covered that really well. I think there were fears but I honestly believe we put in place some measures to demonstrate that we're still committed to continuing on this journey and in fact the environment bill is going to build on it and then it's about how we gage everyone so, thinking about what Suzanne was saying about who drives the agenda, let's make sure we're all driving the agenda. It's not national government on its own, actually local government has a role to play as do individuals.

### Questions for Frédéric Nicolas

*Q. Frederic - do you know the most dangerous compositions of PM?*

A. PM is a term including many substances originated from different sources. In our case our PM sensor does not differentiate between the multiple constituents. Interestingly our PM sensor was evaluated outdoor both in London and Beijing against reference measurements and performed well despite diverse environments. For the dangerousity, it's probably referring to toxicity level, so you would have to refer to known literature on this subject and research is active. PM2.5 concentration (mass) privilege the bigger size range and so focus and attention should also consider the lower range like PM0.1 which research is showing impact on our health.

*Q. We have 8 air purifiers in one open plan office in the post-covid world. They read (just now) between 3 and 54 ug/m3 is that type of data really useful to anyone?*

A. This is the challenge we need to address on educating and changing the way we share air quality data with the wider population. What is useful to people? Are there any actions required, is the air purifier doing something or should do something, could we tell the person to change their behaviour. if the open plan office having such a large variation in levels of particulate matter, what



does it say about the ventilation system? The display is about concentration levels, what about exposure, it is worth reading the WHO advice, as well as your local AQI (in the UK it is Defra) as they will share further detail on advised activity level based on the concentrations and a person's sensitivity/risk. We are back to the topic on educating people on the impact of AQ and why it matters, we need to enable behaviour changes where required.

*Q. Frederic - what do you think is the relative balance / importance of public education about meaning of AQ figures vs. data visualisation/actionable advice?*

A. Educating the general public is a key aspect for people to understand what air quality means to them and what they can do to mitigate their own exposure. Understanding the sources of air pollution is an initial step so it can be reduced and ideally eliminated. Some of these sources are outside people's control so making them aware is a required step. As we have seen with our participation earlier in the year with the RCPCH in the release of the report on how the indoor air quality impacts children health, the knowledge and evidence is there so how can we translate them in a meaningful way. When you can capture people's interest on air quality and educate them on the importance, they do take meaningful action to lower their exposure as seen with the Breathe London Wearable project and school children changing their commute to school by using less busy street.

*Q. Frederic - is the data from commercial measurements (in homes or industry) available? Could owners sign up to share?*

A. In terms of Dyson devices, each owner could request access to their own data beyond the visualisation provided through the APP, but as yet we do not share the data from the network externally.

*Q. How are Dyson purifiers assessed for air quality performance?*

A. There is an industry standard for indoor portable air cleaner called Clean Air delivery Rate (CADR). We do not see this standard representative enough of a domestic indoor environment and on how a product performance would translate from this standard to the home. For example, the air quality sensors are not used in the test to detect a pollution event and an external air movement device is included in the test to support the air cleaner which would obviously not be present in your home. We have derived an alternative test method including the above to offer a truer performance representation. We think it's important to assess the ability of a purifier to respond to the pollution in a room automatically because we cannot see these pollutants, so the sensors can help with tackling pollution events more effectively. Filtration performance is also very important of course, and here we are considering the HEPA standard which assesses the efficiency of filtration targeting 99.95% of particles as small as PM0.1 for example.

*Q. Frederic; given Dyson inter alia are responsible for household appliances, is it not incumbent upon you to also inform the public about indoor pollutants and dedicate more research and funding to it?*

A. We are working with a number of external partners mostly in the UK on the topic of air quality beyond product development. As an example, we financially supported the RCPCH in the latest report on the impact of indoor air quality on children health with the aim to raise awareness of the issue and educate people.

*Q. Frederic how far away are we from patients having a portable monitor meeting high standards and using it in the same way as a step counter or pair of scales*

A. Over the past few years we have seen sudden improvement in sensor quality especially for PM2.5 with associated miniaturisation and cost reduction. It is difficult to predict when the technology is going to be ready for non-intrusive personal exposure monitoring but it would require another technology step change especially in the form factor. One challenge beyond the technology is providing users with useful metrics and actions, whereas with a pedometer if you have not achieved your goal you can go for a walk, with an air quality monitor some of the solutions are beyond our control as individuals.

*Q. To what degree is the tension between open publicly funded research and private (for profit) IP a challenge?*

A. From the UK you might not see the true commercial challenge we face in specific countries where some of the international trade agreements especially around IP are not fully respected and enforced. Not only patents but also trade names and now the way some businesses are being setup making enforcement lengthy and difficult, rendering any potential actions challenging. So publicly funded research helps to correctly protect the longer term research, whether it is for fundamental technology or a focus on knowledge growth and understanding.

### Questions for Mike Bull

*Q. Can models predict the PM of other pollutants generated by the utterly complex world of VOCs?*

A. Yes

*Q. Do we even have the monitoring data for UFPs?*

A. Yes

*Q. How do the concerns of the public manifest themselves to drive the sort of work you perform as a consultant?*

A. Yes

*Q. What are the gaps in the understanding of health impacts for UFPs?*

A. There are no air quality standards available to compare predicted concentrations or particle numbers, we don't have any relationships between exposure and health effects as yet, there's very little information on existing concentrations either.

*Q. Following the age old saying all models are wrong some models are useful, do you not feel that the current models are useful?*

A. I do feel that current models are very useful but there is a tendency for users to consider that they are 100% accurate and possibly discount other evidence.

*Q. Is one issue the need to run models at very high spatial resolutions but the models and computing power needed are either hard to come by or not available to consultancies?*

A. There's an element of truth here - consultancies have to use tools that are fit for purpose but represent a reasonable balance between accuracy and usability

*Q. Michael - do consultant get involved in health impact assessments as well as environmental impact assessments? If so, what information do you consider?*

A. Yes frequently - but AQ practitioners are generally just passing their modelling results onto Health professional to allow them to undertake the assessment. There are models around that will predict exposure and risk from different pathways of exposure and some consultants use these.

*Q. "Model" was not defined- assume air pollution rather than health modelling. A range of models are used to simulate air quality and complexity vs resolution. Specific model you are referring to?*

A. The models we use most frequently are ADMS and AERMOD, occasionally CALPUFF.