Creating a pathway toward the new World Health Organisation guidelines – what are the evidence gaps?

The second meeting of the Clean Air Research Futures Group

Who are the Clean Air Research Futures Group?

Air pollution is an old but constantly evolving research topic. The Clean Air Research Futures Group (CARFuG) is part of the UK Research and Innovation and Met Office Strategic Priorities Fund Clean Air Programme. It is convened by the UK Clean Air Champions to help to shape the future research agenda; to highlight new issues, evidence gaps and research needs.

The group brings together a broad range of participants, including people from industry, government, and NGO communities as well as researchers in fields such as health, transport and urban planning to discuss a defined topic. Members are invited by the Clean Air Champions and vary according to the topic. Membership comprises people who will be tackling these issues in their future careers. For this reason, we are focusing on the inclusion of people at early and mid-career stages

This discussion paper follows the second CARFuG meeting which took place in January 2022.

The new World Health Organisation 2021 Global Air Quality guidelines

Since 1987, the World Health Organisation have been setting guidelines for the quality of our outdoor air. They are designed to offer guidance in reducing the health impacts of air pollution and are based on expert evaluation of current scientific evidence. They are not legally binding, but they do act as a yardstick for governments around the world to help with their own standard setting processes and they help the public to understand the level of ambition that its required.

New guidelines were issued by the WHO in September 2021. This is the first revision since 2005 and included some major changes, reflecting advancements in the evidence base.

For many pollutants the new guidelines are much tighter than the ones that they replaced, as shown in Table 1.

The revision reflects evidence from large-scale epidemiological studies that zero-effects thresholds cannot be identified and that health harms exist at concentrations lower than previously recognised. The new guidelines were therefore based on the 5th percentile (the lowest 5 percent) of concentrations found in health studies. This means that some places in the world already meet the new guidelines, however most of the global population live in areas with air pollution levels considered harmful to human health.

Meeting these new guidelines will be very challenging for the UK and many parts of the world. It would be easy to reject them as unrealistic. Instead, our response should be to map the pathways to

achieving the new guidelines, acknowledging that any reduction in concentration will benefit human health, and to identify the evidence gaps that need to be addressed.

Table 1 Comparison of the 2005 and 2021 air quality guidelines, from https://www.who.int/news-room/feature-stories/detail/what-are-the-who-air-quality-guidelines. The WHO also proposes a system of interim targets for countries to progress towards the guidelines.

Pollutant	Averaging Time	2005 AQGs	2021 AQGs
$PM_{2.5}$, $\mu g/m^3$	Annual	10	5
	24-hour[a]	25	15
PM_{10}, $\mu g/m^3$	Annual	20	15
	24-hour[a]	50	45
O_3, $\mu g/m^3$	Peak season[b]	-	60
	8-hour[a]	100	100
NO_2, $\mu g/m^3$	Annual	40	10
	24-hour[a]	-	25
SO_2, $\mu g/m^3$	24-hour[a]	20	40
CO, mg/m^3	24-hour[a]	-	4

Priority research needs and opportunities

Several priority needs arose in the discussion. These are listed below and briefly discussed in the rest of this document:

- Concentration modelling and measurement systems need to be adapted for future air pollution environments that will have lower concentrations and a greater proportion of volatile PM. At the same time measurement systems need to provide consistent data over decades to inform research on life-course pollution exposure.

- Priority areas for the measurement, modelling and epidemiology communities to work together include addressing the WHO best practice statements on black carbon, ultrafine particles and desert dusts as well as quantifying the health impacts of air pollution mixtures (including characterising multi-pollutant effects) and life-course exposures.

- Attaining the new guidelines will require the regulation of sources that are poorly understood, and many that are not currently regulated. These include brake, tyre and road wear, VOC products used in homes, wood burning, shipping, agriculture and land use. This will require new source-orientated measurement studies and emissions models.

- Further research is needed to evaluate adaptations and changes to our towns and cities and to optimise new forms of urban design. Interdisciplinary work between air pollution scientists, social scientists, public health practitioners, engineers, and urban planners will be essential.

- There is a sparsity of evidence to help us maximise the gains from air pollution policy that could come from optimising actions to protect the most vulnerable people. Development and greater use of systems mapping could support policymaking and help to avoid unintended consequences.

New challenges for measurement and modelling

Tracking the changes in air pollution and air pollution exposure are essential to determine if our policies are working.

Reliable measurement of air pollution will become more challenging as concentrations approach the new guideline values. Many of the measurement methods that we use today were devised to measure concentrations that are were much greater than the new guidelines. This includes the reference methods that are defined to assess legal limits in the EU. Over the last decades substantial improvements in ambient carbon monoxide and sulphur dioxide have reduced concentrations. They now close to the limits of detection for the network instruments. Instruments for measuring future airborne particle concentrations will have to contend with changes in the particle mix which is likely to include a greater proportion of volatile particles.

Measurements are only as good as the calibration chains that connect them to national and international metrological standards. As we approach guideline values, we will need to create new field-deployable instruments and calibration chains to track long-term changes in concentrations and differences between exposure settings. We will therefore need new field-calibration technologies such as stable low-concentration gas mixtures.

Modelling systems and constituent chemical mechanisms and rates were also developed and validated for environments that are more polluted than the new guideline values. More research may be required to validate models in low-concentration environments that include greater proportions of biogenic particles and those from long-range transport. Hemispheric scale issues are likely to play a greater role in determining concentrations, especially for tropospheric ozone.

Air pollution models are also reliant on accurate emissions data. Low concentration environments are likely to be dominated by poorly understood emission sources. Future modelling systems will require better emissions inventories for sources such as wood burning, VOC products used in our homes and tyre, break and road wear.

Towards the new guidelines

Mapping a pathway towards the new guidelines will require the regulation of sources that are poorly understood and many of them are outside the current regulatory domain. These include brake, tyre and road wear, VOC products used in homes, wood burning, shipping and agriculture and land use. We tend to frame air pollution as an urban or industrial issue but changes in land use over the next decades; including afforestation and landscape management need to be understood too.

Tackling these sources requires not just technological solutions but behavioural changes too. Both of these are important future research areas.

Urban design is key to the creation of low-pollution communities and places to live. Solutions such as healthy streets and 15-minute cities all have the potential to reduce air pollution, contribute to net zero and, help with urban noise. These solutions can also help public health by encouraging greater walking and cycling as well as spaces for socialising and community building.

Further research is needed to evaluate adaptations and changes to our towns and cities and to optimise new forms of urban design, requiring interdisciplinary work between air pollution scientists, social scientists, public health practitioners, engineers, and urban planners.

Beyond the new guidelines – new pollutants and mixtures

The new WHO guidelines also contain best practice statements calling for increased measurement and new policy frameworks for black carbon, ultrafine particles and desert dusts. These should be priority areas for the measurement, modelling and epidemiology communities to work together to inform the next guideline iteration. This will require greater measurement of physical and chemical properties of our PM mixture and new modelling systems. The modelling of UFP requires new types of modelling systems.

We do not breathe one pollutant at a time. We breathe a mixture. However, most air pollution epidemiological studies have been based on single pollutant exposures. Understanding pollutant mixtures through measurement and incorporating these within epidemiological studies is a key need to gather evidence for future guideline development. It is also essential that a framework that considers mixtures still links to sources and results that are actionable for policy-makers. The HEI focus on traffic related air pollutants illustrates how a mixtures framework can be linked clearly to source.

Collecting long-term data

New evidence on life course exposure and cognitive and brain health underline the importance of long-term measurement datasets in the future. Collecting long-term datasets raises logistic challenges to maintain consistent measurement networks and calibration chains. Changes in measurement technology can also cause discontinuities. This is especially challenging for PM measurement where many things that we measure are operationally defined by the way in which we measure them. This is a long-standing issue that came to the fore as alternatives to black smoke measurement were developed in the late 20th century but still applies today to PM10, PM2.5 and some components including elemental/black carbon. Testing of new techniques alongside the older ones is part of the solution. Long-term operation of legacy instruments would further reduce uncertainties.

Prioritising the pathways

The CARFuG discussion extended into the factors that could be considered when prioritising policies and actions beyond those from air pollution science alone.

Taking actions on long-term exposure requires setting objectives and targets over decades.

The Environment Act has placed emphasis on setting ambitious but achievable targets. Alternatively setting targets that are beyond those that are currently achievable can act as motivation for change and innovation, even if the pathway is not clear at the outset.

Setting targets based on what is achievable has not produced success over the last decade and has led to some measures with limited population benefit and some measures with unintended adverse consequences. One example is the NO_2 limit value. This should have attained in the UK and EU by 2010, but widespread breaches remain. In this case the policy framework was not sufficiently agile to respond to the poor effectiveness of diesel exhaust controls. An agile policy framework may have tightened standards for these emissions or increased actions on other sources to ensure that the overall trajectory towards attainment was maintained.

Combining the mitigation challenge with an equity challenge is one way forward to optimise policy. Hitherto, there has been little priority attached to social justice in air pollution actions and little emphasis prioritising actions to protect the most vulnerable. Vulnerable people exist outside our communities and country too, and there is a need to ensure international equity to protect against the export of pollution by the offshoring industry and manufacturing to countries with relatively poor environmental controls.

Systems mapping may be a valuable tool to support policy making in this area and for the avoidance of unintended consequences.

Gary Fuller and the Clean Air Champions team, November 2022.

Attendees:

Dr Gary Fuller, Imperial College London (Chair)

Professor Sir Stephen Holgate, Clean Air Champion, University of Southampton

Dr Jenny Baverstock, Clean Air Champion, University of Southampton

Dr Suzanne Bartington, Regional Clean Air Champion, Midlands to North of England

Dr Heather Price, Regional Clean Air Champion, Scotland

Prof Paul Lewis, Regional Clean Air Champion, Wales

Dr Neil Rowland, Regional Clean Air Champion, Northern Ireland

Lucy Saunders, Healthy Streets

Rob Day, AUK-BLF

Ruth Calderwood, City of London

Sarah Legge, EPUK

Dr John Murlis, EPUK Trustee

Simon Ballard, Chichester City Council

Prof Rob Kinnersley, Environment Agency

Dr James Allan, University of Manchester

Dr Matt Loxham, University of Southampton

Larissa Lockwood, Global Action Plan

Prof Stefan Reis, Centre for Ecology & Hydrology, University of Edinburgh

Dr Annalisa Savaresi, University of Stirling

Prof Brian Castellani, Durham University

Prof John Barry, Queens University Belfast

Presenters:

Prof Stefan Reis, CEH, University of Edinburgh

Dr James Allan, University of Manchester

Prof Rob Kinnersley, Environment Agency

Sarah Legge, EPUK

Rob Day, AUK-BLF

Dr Matt Loxham, University of Southampton

Prof Brian Castellani, University of Durham

Lucy Saunders, Healthy Streets

Ruth Calderwood, City of London