Briefing Note: Updated World Health Organisation (WHO) Air Quality Guidelines & Implications for the West Midlands

Summary

- Poor air quality results in short- and long-term health effects and is responsible for ~ 28 - 36,000 premature deaths each year across the UK. The key pollutants of concern in the West Midlands today are nitrogen dioxide gas (NO_2) and fine particles in air ($PM_{2.5}$).

- *Air quality objectives* (AQOs) reflect levels considered to be acceptable in terms of protecting human and environmental health; these are established nationally (as a devolved matter in the UK) and are legally binding.

- The World Health Organisation (WHO) issues *guideline* levels of air pollutants for the protection of human health. The WHO guidelines are effectively the lowest concentration at which there is clear evidence of an increase in risk to health; they do not consider feasibility or cost. WHO guidelines are not legally binding, but are an evidence-informed tool for policymakers, and are referenced in the air quality target setting process in the Environment Bill.

- The WHO guidelines were last set in 2005. Since then, extensive research has found significantly stronger evidence of the impacts of ambient air pollution on human health, including at lower concentrations. WHO updated their Global Air Quality Guidelines on 22 September 2021. The new update includes interim targets intended to guide reduction, as well as revised guideline levels, including (as annual mean concentrations) :

    - $PM_{2.5}$ Interim targets of 35 / 25 / 15 / 10, and a guideline level of 5 $\mu g\ m^{-3}$
    - NO_2 : Interim targets of 40 / 30 / 20, and a guideline level of 10 $\mu g\ m^{-3}$

- When averaged to ward level across the West Midlands, modelled annual mean concentrations of $PM_{2.5}$ and NO_2 are in excess of the new WHO guideline level in all cases, with roughly 60% and 40% of the region's population living in wards with average annual mean concentrations of $PM_{2.5}$ and NO_2 (respectively) above the next interim target level.

- The new WHO guidelines reflect the science evidence that air pollution harms human health even at low levels. They pose a significant challenge for clean air policy in many urban areas of the UK, and are likely to both increase attention on $PM_{2.5}$ levels, and intensify scrutiny on actions to reduce exposure to NO_2, across a wider proportion of the population.

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Air pollution has been recognised as the largest environmental risk to public health. Within the West Midlands, $PM_{2.5}$ exposure causes approximately 1,400 premature deaths annually. In addition to premature deaths, short and long-term exposure to air pollution is strongly linked to several adverse health outcomes including increased risk of cardiovascular and respiratory disease, poor cognitive development and the onset of dementia and related diseases. Those most at risk from impacts of poor air quality are children, pregnant women, the elderly, and those with pre-existing cardiovascular and/or respiratory illnesses.

The UK Government sets national Air Quality Objectives for acceptable levels of pollutants in ambient air (i.e. outdoors), for the protection of human and environmental health. Under the current Local Air Quality Management (LAQM) framework, Local Authorities are responsible for assessing air quality, and for undertaking detailed screening, or developing mitigating action plans, where exceedances of the standards arise in locations where public exposure to pollutants occurs. Many recent initiatives aim to reduce concentrations of NO_2 in urban areas, focussed upon road transport emissions, an objective which will be supported by transport electrification. Reducing concentrations of fine particles (airborne solid and/or liquid materials from human-made and natural sources) is increasingly recognised as the priority for future action. Research evidence suggests it is $PM_{2.5}$ (those particles 2.5 µm or smaller in diameter) which are the main cause of harmful health effects.

Current UK air quality objectives reflect EU air quality directives, translated through the EU withdrawal legislation. In England, these will be updated through the **Environment Bill** (currently in its third reading within the House of Lords), which includes legal obligations for the Secretary of State to set new legally binding air quality targets. The number of targets, their level or format is not specified, but must include long-term targets for $PM_{2.5}$ (and other species, if desired). The government's Clean Air Strategy 2019 set a goal to "*reduce $PM_{2.5}$ concentrations across the UK, so that the number of people living in locations above the WHO guideline level of 10 µg m^{-3} is reduced by 50% by 2025*." The air quality target setting process associated with the Environment Bill will *consider* how $PM_{2.5}$ levels will compare to World Health Organisation (WHO) guideline levels.

The World Health Organisation is the authority within the United Nations responsible for public health of member states. The WHO has published guidance on threshold limits for the pollutants noted above since 1987, with the 2005 update being in force until release of updated WHO Air Quality Guidelines on 22 September 2021. WHO guidelines are set for the protection of human health: including interim targets to facilitate stepwise air quality improvements hence health benefits for the population. In the process of target setting, only evidence relating to health harms is assessed; the guideline levels are the lowest concentration that produces a measurable increase in risk - no consideration is given to whether the levels can be achieved, or at what economic cost. The evidence base for the health effects of air pollution has developed significantly since 2005, and the new guideline levels are considerably reduced - in particular for $PM_{2.5}$ and NO_2.

Table 1 summarises the current key DEFRA Air Quality Objectives for England, and the 2005 and 2021 WHO Guideline levels, for NO_2 and $PM_{2.5}$. There are details regarding target formats and exceedances which cannot be covered here, and further objectives / guidelines for other air pollutant species, and for the protection of ecosystems / vegetation, are also set- see links to the original documentation for full details.

The 2021 WHO guidelines also include *interim targets* (see full table in appendix below), which are intended to provide a framework for assessing stepwise progress; WHO states that they "should be regarded as steps towards ultimately achieving air quality guideline levels in the future, rather than as end targets". For $PM_{2.5}$, the increase in mortality rate [all cause non-accidental mortality] for populations exposed to annual mean concentrations increasing from the guideline level to interim targets 4/3/2/1 is 4, 8, 16 and 25 % respectively. For NO_2, the increase in mortality rate for annual mean concentrations increasing from the guideline level to interim targets 3/2/1 is 2, 4 and 6 % respectively. The interim levels and mortality risk are based upon consideration of individual pollutants only (i.e., neglecting the, likely non-linear, combination of NO_2 and $PM_{2.5}$ effects together).

Table 1: Selected current Air Quality Objectives for England, 2006 and updated 2021 WHO guideline levels. Concentrations in $\mu g\ m^{-3}$

Pollutant	Averaging Time	Air Quality Objectives (England)	WHO Guideline 2005	WHO 2021 Update				
				Interim Targets				Guideline
				1	2	3	4	
Fine Particles, $PM_{2.5}$	Daily (24-hour)mean		25[1]	75	50	37.5	25	15[1]
	Annual mean	**25**	10	35	25	15	10	5
Nitrogen Dioxide, NO_2	Daily (24-hour) mean			120	50			25[1]
	Annual mean	**40**	40	40	30	20		10

1: See links below for precise target definitions and other pollutant targets. This table is simplified.

Figure 1 below shows approximate modelled annual mean concentrations of NO_2 and $PM_{2.5}$ in the West Midlands (WM-Air modelling). These predictions are for 2021 emissions (vehicle fleet), but assume business-as-usual activity patterns (i.e. neglecting Covid impacts). They also exclude effects from the Birmingham Clean Air Zone, and some other recent roadside-NO_2 related interventions.

Model predicted **annual mean levels of $PM_{2.5}$ across the West Midlands** range from approximately 8 to 20 $\mu g\ m^{-3}$ (modelled annual mean concentrations), well within the current air quality objective for England (25 $\mu g\ m^{-3}$) – but with significant areas exceed the 10 $\mu g\ m^{-3}$ limit currently proposed in Lords' amendments to the Environment Bill. When these modelled concentrations are averaged to ward level (a process which will smooth out the highest and lowest concentrations), over half of all wards across the region have average annual mean $PM_{2.5}$ concentrations in excess of 10 $\mu g\ m^{-3}$, located across all 7 of the core West Midlands Local Authority areas. Around 60% of the region's population live in wards where the average annual mean $PM_{2.5}$ concentration is predicted to be above 10 $\mu g\ m^{-3}$. Model predicted **annual mean levels of NO_2 across the West Midlands** range from approximately 12 to over 60 $\mu g\ m^{-3}$, although only a very few areas show these highest levels, in proximity to major transport arteries. Levels above 40 $\mu g\ m^{-3}$ are the focus for a range of current policy interventions. Averaged to ward level, annual mean NO_2 concentrations exceed 20 $\mu g\ m^{-3}$ in 78 wards. Average modelled ward-level annual mean **PM_{10} concentrations** (not shown) meet all the new WHO interim target levels, with approximately 60% of wards exceeding the new guideline level (15 $\mu g\ m^{-3}$); however in the UK both health and policy focus is upon the smaller particles, $PM_{2.5}$ and (although not regulated) ultrafine particles.

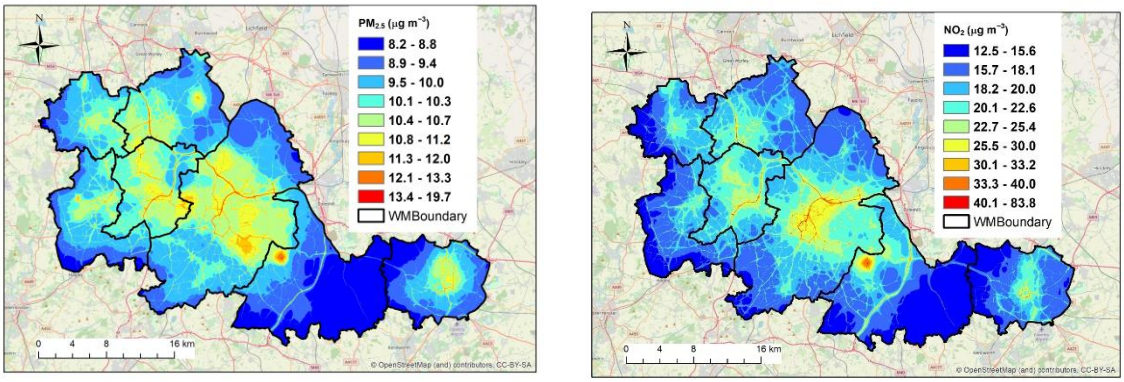

Fig 1: *Modelled annual mean $PM_{2.5}$ (left) and NO_2 (right) concentrations across the West Midlands. These predictions are for 2021, but assume business-as-usual activity patterns (i.e. neglecting Covid impacts). They also exclude effects from the Birmingham Clean Air Zone, and some other recent roadside-NO_2 related interventions.*

Figure 2 shows the percentage of the West Midlands population living in wards whose average modelled annual mean $PM_{2.5}$ or NO_2 concentrations exceed the various WHO interim target levels, and the guideline level. The ward-level average concentrations exceed the 2021 WHO guideline levels in all cases, with roughly 60% ($PM_{2.5}$) and 40% (NO_2) of the region's population living in wards where the average modelled annual mean concentration also exceeds the next interim target level. Using ward-level averages for pollutant concentrations smooths out the highest and lowest concentrations in more localised areas: for example, 2/3 of wards across the region have localised areas where modelled annual mean NO_2 levels exceed interim target 1 (the highest level). A more granular analysis of population distribution vs the WHO interim targets is underway.

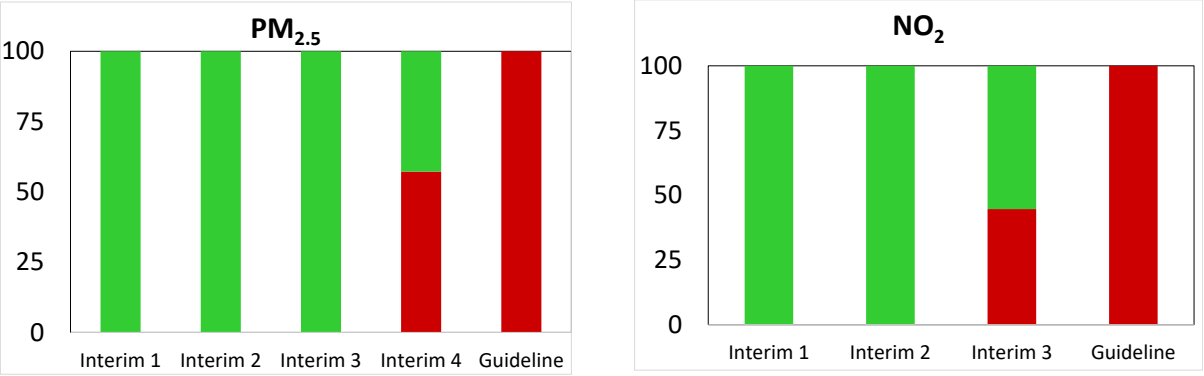

Fig 2*: Approximate proportion of the West Midlands population living in wards whose average annual mean $PM_{2.5}$ (left) and NO2 (right) concentrations are below (green) or above (red) the 2021 WHO interim targets and air quality guideline level.* *Values derived from 2021 simulation under BAU conditions as outlined above. Averaging process will smooth out localised areas with much higher, and lower, pollution levels.*

Opportunities and Challenges

The new WHO guidelines pose a significant challenge for clean air policy in many areas. They are likely to both increase policy attention on $PM_{2.5}$ levels, and intensify scrutiny on actions to reduce NO_2. It remains to be seen how the updated WHO guidelines may influence the air quality target setting process for England associated with the Environment Bill. The government's *Committee on the Medical Effects of Air Pollutants* (COMEAP) recently noted that the health evidence alone is not sufficient to set targets considering the effects seen at very low concentration levels. Rather, and assessment of the costs and benefits of target levels would be required, to help ensure that the investment required to meet targets is proportionate to the benefit gained.

Local and regional responses to new air quality obligations can be informed by quantitative understanding of the clean air benefits achievable for the West Midlands population at different levels (i.e. the health benefit for a given intervention), and a clear understanding of the predominant local pollution sources, and balance between local emissions and wider transport of polluted air from elsewhere (particularly for $PM_{2.5}$). The WM-Air project is supporting provision of this underpinning understanding, drawing upon the wider science evidence base, and developing regional metrics to inform effective environmental public policies which optimise health benefits, reduce inequalities and demonstrate progress towards clean air in the West Midlands.

Reducing $PM_{2.5}$ emissions locally will require a broadening of air pollution policy, with foci beyond road transport – notably to solid fuel combustion, domestically and in industry. It will also require regional and national coordination to tackle imported pollution. Current actions around NO_2 focus on transport sources and roadside exposure, with the transition to electric vehicles likely to deliver significant reductions over the coming 1-2 decades. Lower guideline levels imply greater focus upon wider population exposure, beyond peak areas. For both PM and NO_2, the increased evidence for health impacts at lower levels challenges the existing, compliance-based frameworks (and the levels at which these are set).

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Appendix: Full 2021 WHO Interim Targets and Air Quality Guidelines
(https://www.who.int/publications/i/item/9789240034433)

Table 0.1. Recommended AQG levels and interim targets

Pollutant	Averaging time	Interim target				AQG level
		1	2	3	4	
$PM_{2.5}$, µg/m³	Annual	35	25	15	10	5
	24-hour[a]	75	50	37.5	25	15
PM_{10}, µg/m³	Annual	70	50	30	20	15
	24-hour[a]	150	100	75	50	45
O_3, µg/m³	Peak season[b]	100	70	–	–	60
	8-hour[a]	160	120	–	–	100
NO_2, µg/m³	Annual	40	30	20	–	10
	24-hour[a]	120	50	–	–	25
SO_2, µg/m³	24-hour[a]	125	50	–	–	40
CO, mg/m³	24-hour[a]	7	–	–	–	4

[a] 99th percentile (i.e. 3–4 exceedance days per year).
[b] Average of daily maximum 8-hour mean O_3 concentration in the six consecutive months with the highest six-month running-average O_3 concentration.