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New Air Quality Targets and Interim Goals for Fine Particulate Matter – $PM_{2.5}$: Implications for the West Midlands

A report from the WM-Air project team

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This document provides a comprehensive overview of the implications of more stringent $PM_{2.5}$ targets on air quality and public health in the West Midlands. By examining the sources and levels of $PM_{2.5}$ pollution, exploring potential air quality scenarios and strategies, and estimating the health burden, this document seeks to inform stakeholders and decision makers in their efforts to improve air quality and reduce associated health risks and inequalities. The document is structured as follows:

- Health Risks and Inequalities Associated with Exposure to $PM_{2.5}$ Pollution
- Sources of $PM_{2.5}$ in the West Midlands
- New Air Quality Targets and Interim Goals for $PM_{2.5}$
- Modelled $PM_{2.5}$ Concentrations in the West Midlands
- Air Quality Scenarios for the West Midlands: Potential Impacts of Policy Decisions
- Estimated Health Burden of Air Pollution in the West Midlands
- Opportunities and Challenges
- Strategies and Initiatives for Improving Air Quality and Public Health in the West Midlands

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Health Risks and Inequalities Associated with Exposure to $PM_{2.5}$ Pollution

Air pollution poses a significant health risk, responsible for an estimated 29,000 to 43,000 premature deaths each year in the UK[1]. Of the major air pollutants, Particulate Matter (PM) is a mixture of solid particles and/or liquid droplets that can be harmful to human health. PM is classified according to its diameter and the finest particles, $PM_{2.5}$ with a diameter of 2.5 µm or less, are of particular concern. These tiny particles can penetrate deeply into the lungs and even enter the circulatory system, contributing to a range of adverse health effects, as supported by research evidence.

Exposure to $PM_{2.5}$, both short- and long-term, has recognised negative health impacts. Long-term exposure is linked to increased risk of developing respiratory and cardiovascular diseases such as asthma, coronary heart disease, stroke, and lung cancer[2]. There is also evidence that long-term $PM_{2.5}$ exposure is associated with decline in cognitive functions and onset of dementia[3].

Poor air quality impacts some groups of people more significantly than others. Those particularly at risk include children, pregnant women, the elderly, and individuals with pre-existing cardiovascular and/or respiratory diseases. In addition, those living in socio-economically disadvantaged areas are more vulnerable, therefore air pollution exacerbates existing health and socio-economic inequalities[4].

Sources of $PM_{2.5}$ in the West Midlands

$PM_{2.5}$ comprises both natural components, such as dust and sea salt, and anthropogenic factors, such as soot and emissions from road and tyre wear. Primary emissions, such as soot, are released directly into the atmosphere, while secondary components are formed through chemical transformation and condensation of atmospheric gases, like nitrate, which is formed from nitrogen dioxide (NO_2). $PM_{2.5}$ can be transported from upwind locations and contribute to the $PM_{2.5}$ burden at a given location, in addition to local emissions[5].

In the UK, the contribution of secondary components to total $PM_{2.5}$ varies greatly by location, with around 50% of roadside $PM_{2.5}$ coming from secondary components, rising to around 90% in rural areas[6]. This highlights the complexity of reducing $PM_{2.5}$ concentrations, as the response of secondary pollutants to emissions control measures is more complex than that of primary pollutants.

Under the current Local Air Quality Management (LAQM) framework, local authorities are responsible for assessing air quality and carrying out detailed screening or developing mitigation action plans if air pollutant levels exceed established standards in areas where the public may be exposed. Many recent initiatives aim to reduce NO_2 concentrations in urban areas by focusing on road transport emissions, an objective that will be supported by the electrification of transport[7]. However, developing actions for $PM_{2.5}$ is equally crucial and requires coordinated policy actions.

Fig 1 illustrates the primary $PM_{2.5}$ emissions from sources within the West Midlands Combined Authority (WMCA) area, with solid fuel combustion in households and industries, and transport being the largest contributors. $PM_{2.5}$ emissions from vehicles come from both exhaust and non-exhaust sources, including brakes and tyres. It is noteworthy that non-exhaust sources are significant and often comprise the larger fraction of primary emitted particles for modern vehicles[8].

Further information on $PM_{2.5}$ pollution can be found in the WM-Air briefing note What is $PM_{2.5}$? An introduction to particulate matter in the atmosphere.

Fig 1. Direct emissions of $PM_{2.5}$ from sources within the WMCA region, data drawn from the National Atmospheric Emissions Inventory. The data were simplified by grouping source sectors. © Crown 2022 copyright Defra & BEIS via naei.beis.gov.uk, licenced under the Open Government Licence (OGL).

New Air Quality Targets and Interim Goals for $PM_{2.5}$

The UK government sets National Air Quality Objectives to protect public health and the environment by maintaining acceptable levels of pollutants in ambient air. In December 2022, two new $PM_{2.5}$ targets were set for England to be achieved by 2040, with interim targets to be achieved by 2028, following air quality legislation introduced by the Environment Act 2021:

- **An Annual Mean Concentration Target for $PM_{2.5}$ levels of 10 µg m^{-3} or less by 2040, with an interim target of 12 µg m^{-3} or less by 2028.**
- **A Population Exposure Reduction Target to reduce $PM_{2.5}$ population exposure by 35% by 2040 compared to 2018, with an interim target of at least 22% by 2028.**

Threshold targets drive action to improve air quality in highly polluted areas, often (but not always) associated with the most deprived communities. However, it is important to note that there is no known safe threshold for exposure to $PM_{2.5}$ and reducing exposure to these particles has benefits to improve health outcomes[9]. The population exposure reduction approach aims to reduce $PM_{2.5}$ concentrations in all settings, or at locations where the population density is high. Such approaches offer population-wide benefits and acknowledge the clear research evidence that $PM_{2.5}$ is harmful to health even at levels well below the new long-term threshold target of 10 µg m^{-3}.

Table 1. 2040 $PM_{2.5}$ threshold target (England) set by the Environment Act 2021, UK $PM_{2.5}$ objectives (England) set by the Air Quality Standards Regulations 2010, and WHO 2005 and 2021 global $PM_{2.5}$ (health-based) guidelines for annual mean $PM_{2.5}$ concentrations.

Environment Act 2021 $PM_{2.5}$ Target (µg m^{-3})	Air Quality Standards Regulations 2010 $PM_{2.5}$ Objective (µg m^{-3})	WHO 2005 $PM_{2.5}$ Guideline (µg m^{-3})	WHO 2021 $PM_{2.5}$ Guideline** (µg m^{-3})
10*	20	10	5

Notes: *According to the Environment Act 2021, the new $PM_{2.5}$ threshold target of 10 µg m^{-3} for annual mean concentrations must be attained by 2040. **See also the WM-Air briefing on 2021 WHO air quality guidelines for detailed information on the subject.

The World Health Organization (WHO) provides guidance on levels of air pollutants below which no health impacts have been reported. In 2021, the WHO updated health-based guidelines for annual mean $PM_{2.5}$ concentrations, reflecting new evidence of health harms below the 2005 guideline levels[10]. The WHO health-based guidelines (which are advisory and not legally binding) include an annual mean $PM_{2.5}$ concentration guideline of 5 µg m^{-3} compared to the 2040 $PM_{2.5}$ target for England of 10 µg m^{-3}. Table 1 summarises existing annual mean $PM_{2.5}$ objectives for England[11], the 2040 $PM_{2.5}$ threshold target for England, and the 2005 and 2021 WHO $PM_{2.5}$ health-based guidelines for comparison.

Modelled $PM_{2.5}$ Concentrations in the West Midlands

Assessing the air quality of the West Midlands is crucial to understanding the impact of air pollution on public health. Fig 2a below presents the modelled annual mean concentrations of $PM_{2.5}$ in the WMCA region using WM-Air modelling[12]. These predictions for the 'Present Day' are based on 2021 emissions from the vehicle fleet and assume Business-As-Usual (BAU) activity patterns (e.g. neglecting Covid-19 impacts). This allows for more accurate predictions based on available data.

According to model predictions, the annual mean $PM_{2.5}$ concentrations in the West Midlands for 2021 BAU case range from approximately 8 to 20 µg m^{-3}, which is within the existing air quality objective for England (20 µg m^{-3}), but with significant areas (about 41% at 10 m resolution including hotspots near road sources) exceeding the 2040 threshold target of 10 µg m^{-3} (Fig 2a). When these modelled concentrations are averaged to ward level (a process that smooths out the highest and lowest concentrations), over half of all 192 electoral wards across the region have ward-average annual mean $PM_{2.5}$ concentrations above 10 µg m^{-3} (Table 2). These high concentrations are found across all seven West Midlands Local Authority areas, with around 60% of the region's population living in wards where the ward-average annual mean $PM_{2.5}$ concentration exceeded 10 µg m^{-3} in 2021 (Table 2).

Air Quality Scenarios for the West Midlands: Potential Impacts of Policy Decisions

The WM-Air air quality model was used to estimate $PM_{2.5}$ concentrations in the WMCA region under three different policy scenarios for the year 2030. These scenarios, which are assumed to apply across the UK, offer insight into the potential impact of different policy decisions on air quality. A brief overview of each scenario is provided below.

Table 2. Estimated annual mean $PM_{2.5}$ concentrations in the WMCA region for 'Present Day' (2021, BAU), and 2030 under three different policy scenarios.

Scenario	(I) Estimated annual mean $PM_{2.5}$ ward-level averaged in the WMCA region ($\mu g\ m^{-3}$)			(II) Estimated no. wards where annual mean $PM_{2.5}$ > 10 $\mu g\ m^{-3}$ *	(III) Estimated % population [total 2.9 million] living in wards where annual mean $PM_{2.5}$ > 10 $\mu g\ m^{-3}$ *	(IV) Estimated no. wards where annual mean $PM_{2.5}$ > WHO 2021 (health-based) guidelines (5 $\mu g\ m^{-3}$) *
	Mean	Min	Max			
Present Day (2021, BAU)	10.0	8.4	11.1	104	57	192
Scenario A (2030, NECD)	9.4	7.7	10.4	28	16	192
Scenario B (2030, EV)	9.3	7.7	10.4	26	15	192
Scenario C (2030, Net Zero)	8.9	7.6	9.9	0	0	192

Notes: The values in the table above are a function of the spatial resolution / averaging approach. For the $PM_{2.5}$ levels (I) the figures quoted are estimated from the ward mean values across the WMCA region. For columns (II), (III) and (IV), model outputs are averaged to ward level, and combined with ward population figures. *The ward-level averaging approach significantly smooths out the highest (and lowest) $PM_{2.5}$ values from the original model simulations (which have higher spatial resolution). Segments of the population will be exposed to both higher and lower annual mean concentrations than the ward-level average. The model 2021 BAU scenario does not account for Covid impacts on activity.

Scenario A - National Emission Ceilings Directive (NECD): This scenario assumes emission reductions in line with the actions proposed in the 2019 Air Quality Strategy (including meeting the commitments of the National Emission Ceilings Directive by 2030). This includes for example the ongoing renewal of the vehicle fleet, and agricultural sector actions, but without the larger and faster shifts envisaged in the more recent Net Zero strategy.

Scenario B - Electric Vehicle (EV): This scenario assumes a greater transition to (battery) EVs than Scenario A. The assumed fleet shift to EVs is 24% of the car fleet, 9% of heavy goods vehicles and 25% of buses and coaches (as per the UK Net Zero strategy). Non-exhaust emissions are included as in current emission inventory approaches, with emissions per unit of activity taken from the CERC's EMIT Atmospheric Emissions Inventory Toolkit (see Zhong et al., 2021[12]). The impact of additional electricity production is not considered.

Scenario C - Net Zero: This scenario assumes emission reductions which meet the ambitions of the UK government's Net Zero strategy to 2030. These have been estimated by the WM-Air team with reference to the CO_2 emission reductions determined in the Climate Change Committee assessment of the UK Net Zero Strategy, with adjustments for air pollutant (rather than carbon) emissions, by sector. This analysis indicates that annual mean $PM_{2.5}$ concentration averaged at ward level across the entire West Midlands is estimated to be below 10 $\mu g\ m^{-3}$ for all three scenarios (see Table 2). Figs 2b-d below show the spatial distribution of $PM_{2.5}$ for these scenarios, revealing that while hotspots where $PM_{2.5}$ exceeds 10 $\mu g\ m^{-3}$ are present in some areas, such as city centres and locations adjacent to road sources, these concentrations are below the current standard of 20 $\mu g\ m^{-3}$.

The most conservative scenario (NECD: no additional policies / actions) approach demonstrates a reduction in the percentage of wards where ward-average annual mean $PM_{2.5}$ is above 10 $\mu g\ m^{-3}$ from around 55% for 2021 BAU to 15% (Table 2). Thus, achieving a more ambitious attainment date for the threshold target, such as 2030 rather than 2040, may be feasible for the West Midlands. In fact, extant policies are expected to deliver this (when averaged to ward level) for around 85% of the region's population (Table 2).

Moreover, the Net Zero scenario C demonstrates that annual mean $PM_{2.5}$ concentrations in all wards reach below the 10-$\mu g\ m^{-3}$ threshold. However, all scenarios fail to achieve the WHO 2021 health-based guidelines

of 5 µg m^{-3} (Table 2), indicating that further efforts are needed over longer time scales towards this goal.

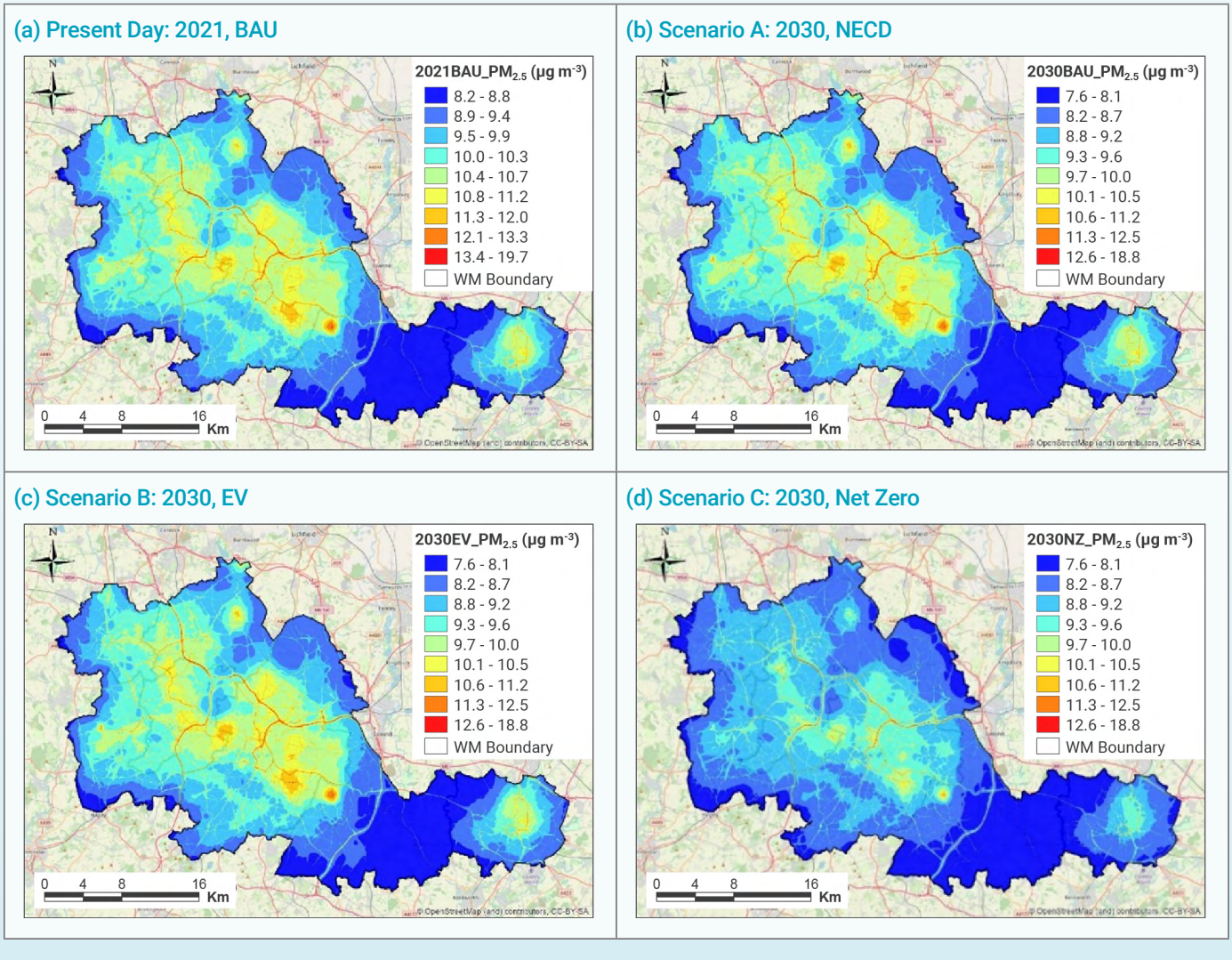
Estimated Health Burden of Air Pollution in the West Midlands

The Air Quality Lifecycle Assessment Tool (AQ-LAT) developed by WM-Air is a useful resource for estimating the health impacts of air pollution at the regional level. By integrating air quality and health data, the AQ-LAT tool was used to estimate the health burden of air pollution exposure in the WMCA region based on the annual mean $PM_{2.5}$ concentrations obtained for BAU 2021 using WM-Air modelling ('Present Day' scenario). The analysis showed that $PM_{2.5}$ pollution exposure is responsible for 2068 early deaths, 1117 asthma, 777 Coronary Heart Disease (CHD), 170 lung cancer, and 657 stroke diagnoses annually in the region in 2021, contributing to an economic burden of £904 million (Table 3). These assessments do not include the impacts of air pollution on cognitive function or dementia.

Meeting the new $PM_{2.5}$ targets in the West Midlands has the potential to make a significant impact on public health. If $PM_{2.5}$ levels in all wards were reduced to below 10 µg m^{-3}, no locations would exceed the 2040 threshold target, which would save 64 lives and prevent 104 diagnoses of associated diseases, with economic benefits of £28 million per year (Table 3) based on WM-Air analysis.

The benefits would be concentrated in the urban centres of Birmingham, Sandwell, Walsall, and Coventry, as these areas currently have higher estimated levels of $PM_{2.5}$ pollution (Fig 3a) and percentage of attributable mortality (Fig 3b). In addition, air pollution reductions would also benefit people living in the most deprived areas, which typically have the highest $PM_{2.5}$ concentrations and therefore greater exposure to harmful pollutants[13].

Fig 2. Spatial distribution of estimated annual mean $PM_{2.5}$ concentrations in the WMCA region for 'Present Day' (2021, BAU) (a) and 2030 under three different policy scenarios (b-d).



WM-Air analysis also suggests that achieving the 35% exposure reduction target, which will also reduce the annual mean $PM_{2.5}$ below 10 μg m^{-3} in all wards, could deliver a greater population level health benefit than just achieving the annual mean target (Table 3). Specifically, achieving the exposure reduction target would save 708 lives, reduce $PM_{2.5}$ attributable mortality by 34%, and prevent 355 asthma, 251 CHD, 58 lung cancer, and 221 stroke diagnoses, with economic benefits of £309 million annually (Table 3).

Although the benefits of reducing $PM_{2.5}$ to the WHO 2021 health-based guidelines are greater (1026 early deaths avoided, 1317 people not developing associated diseases, and £448 million saved annually, see Table 3), achieving the new targets is nevertheless a key step in improving air quality and reducing the health burden of air pollution in the region. It is important to note that even exposure to low levels of air pollution, below WHO guidelines, can have a bearing on health, as air pollution is a complex issue and susceptibility to its effects can vary from person to person.

Opportunities and Challenges

The new Environment Act targets for $PM_{2.5}$ will require increased attention and action by policy makers at local, regional and national levels. To effectively address air pollution, it is important to understand and quantify the health benefits that can be achieved through different interventions, as well as the predominant sources of air pollution in the region and the partition between local emissions and pollution transported from elsewhere. The WM-Air project is developing regional metrics based on scientific evidence to inform effective environmental policies, optimizing health benefits, and reducing inequalities.

Achieving the new, lower $PM_{2.5}$ targets will require clean air policies to broaden actions beyond road transport to include solid fuel combustion in households and industry, and regional and national coordination to address imported pollution. Current actions around NO_2 have primarily focused on transport sources and roadside exposure. The transition to electric vehicles is expected to significantly reduce NO_2 emissions but meeting the new $PM_{2.5}$ targets will require a greater focus on wider population exposure beyond peak areas.

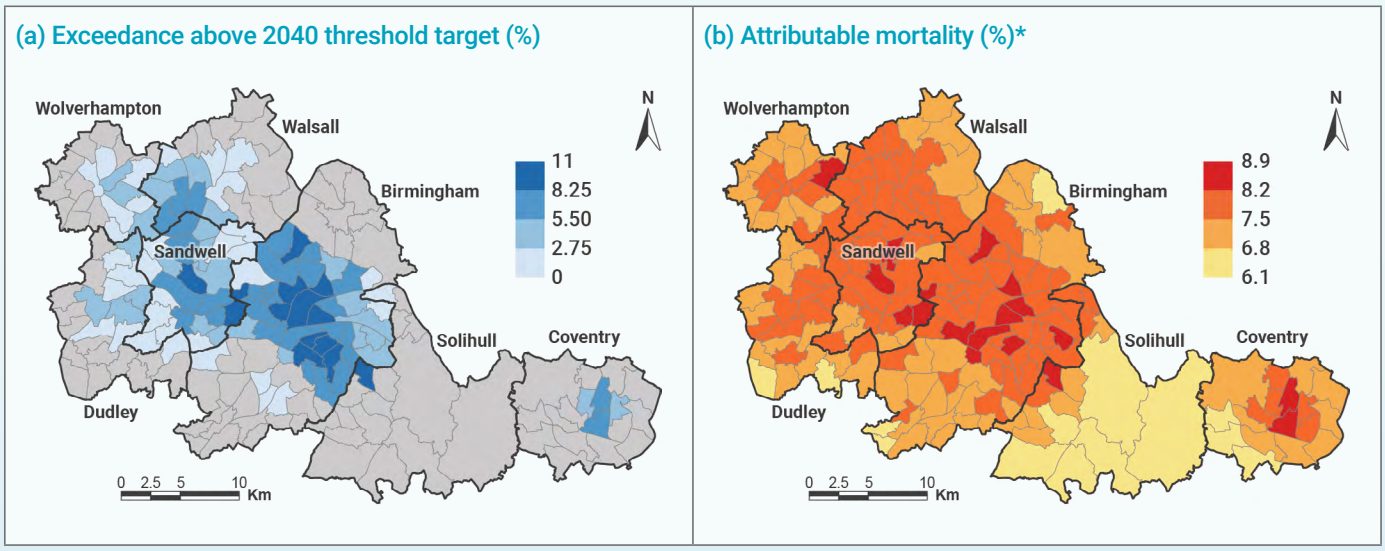
Moreover, the increased evidence of health impacts of even low levels of $PM_{2.5}$ and NO_2 pollution challenges to the current compliance-based frameworks and the thresholds at which they are set. As such, new strategies

Table 3. Assessment of air pollution impacts in the WMCA region and lower limit estimates of benefits of reducing $PM_{2.5}$ to respective annual targets.

Scenario	Health Burden					Economic Burden (£)**
	Early deaths (no.)	Asthma diagnoses (no.)*	CHD diagnoses (no.)	Lung cancer diagnoses (no.)*	Stroke diagnoses (no.)	
Current Health Burden (Present Day: 2021)	2068	1117	777	170	657	£904m
Predicted Health Burden if annual mean $PM_{2.5}$ < 10 μg m^{-3}	2004	1070	752	163	632	£876m
Predicted Health Burden if $PM_{2.5}$ population exposure is reduced by 35%	1360	762	526	112	436	£595m
Predicted Health Burden if annual mean $PM_{2.5}$ < WHO 2021 (health-based) guidelines (5 μg m^{-3})	1042	583	405	85	331	£456m

Notes: Morbidity, mortality and economic burden were calculated individually at the ward level and ward totals summed to produce Birmingham level estimates. This estimate does not include impacts of air pollution on cognitive function / dementia. *Lung cancer and asthma incidence is inelastic with respect to changes in $PM_{2.5}$ as the disease burden becomes driven by NO_2 as the $PM_{2.5}$ reduces. **Economic burden reflects NHS costs, social care costs, and productivity costs associated with disease cases plus monetised value of life years lost to mortality. The burden reflects new annual incident cases not existing prevalence related to air pollution.

Fig 3. Percentage exceedance of the $PM_{2.5}$ threshold target of 10 µg m^{-3} for annual mean concentration (a) and percentage of attributable mortality (b) in the West Midlands wards based on 'Present Day' scenario model estimates.



Notes: *Attributable mortality due to air pollution refers to the number of deaths that can be directly linked to the harmful effects of polluted air. In the map in Fig 3b, it represents the portion of deaths within the WMCA population that can be attributed to exposure to pollutants such as $PM_{2.5}$ and NO_2. Calculations do not include impact of air pollution on cognitive function / dementia.

and policies need to be developed to address these challenges and achieve cleaner air in the West Midlands.

Strategies and Initiatives for Improving Air Quality and Public Health in the West Midlands

The following list of discussion points is intended to guide discussion and help identify opportunities for cleaner air initiatives that align with existing policy priorities in the West Midlands. These cover a range of topics, from monitoring and communication to policy design and implementation, and seek to address key challenges and opportunities for improving air quality and public health in the region. By considering these questions and exploring potential solutions, policymakers, and local communities can work together to promote cleaner air and a healthier environment for everyone:

1. Which cleaner air initiatives could offer the best co-benefits in terms of citizens' health and reducing health inequalities in the West Midlands?
2. How could West Midlands residents be informed about the air quality in their area, and what could be done to encourage them to take actions to improve it?
3. What air quality data is currently available in the West Midlands, and how could monitoring and availability be improved?
4. How can measures be used to inform and track population exposure to air pollution and what strategies can be implemented to reduce exposure levels in communities affected by high levels of pollution?
5. To what extent can the interim targets set for 2028 be achieved in relation to the more stringent $PM_{2.5}$ targets introduced by the Environment Act 2021?
6. What strategies could be employed in collaboration with local communities to identify and address air pollution hotspots?
7. How could Clean Air Zones be designed and implemented to effectively reduce air pollution from road transport, including fine particles?
8. What strategies could be used to reduce emissions of toxic non-exhaust particles from vehicles?
9. What measures could be implemented to encourage more efficient driving behaviour, with the aim of reducing air pollution emissions?
10. What initiatives and incentives should be prioritized to encourage the use of public transport and active travel?
11. What opportunities exist for reducing emissions from industry and other sources of air pollution in the West Midlands, and how can businesses and industry be involved to achieve this?

12. How can local communities collaborate to promote cleaner wood-burning practices and provide resources to help people switch to lower-emission alternatives?
13. What measures can be taken to encourage households to use cleaner and more efficient fuels and appliances?
14. How can resources be made available to local authorities in the West Midlands to effectively tackle air pollution, and how can collaborative efforts support these initiatives?
15. How can we effectively evaluate and analyse the cost-effectiveness of the interventions considered?

Links

Research evidence: **https://www.sciencedirect.com/journal/environment-international/special-issue/10MTC4W8FXJ**

Local Air Quality Management framework: **https://laqm.defra.gov.uk/**

What is $PM_{2.5}$? An introduction to particulate matter in the atmosphere: **http://epapers.bham.ac.uk/4241/1/UoB_WhatIsPM2.5.AW_final.pdf**

New $PM_{2.5}$ targets: **https://questions-statements.parliament.uk/written-statements/detail/2022-12-16/hlws449**

Environment Act 2021: **https://www.legislation.gov.uk/ukpga/2021/30**

WM-Air briefing on 2021 WHO air quality guidelines: **https://wm-air.org.uk/2021/09/24/briefing-note-on-new-air-quality-guidelines/**

2019 Air Quality Strategy: **https://www.gov.uk/government/publications/clean-air-strategy-2019**

National Emission Ceilings Directive: **https://www.legislation.gov.uk/uksi/2018/129**

Net Zero strategy: **https://www.gov.uk/government/publications/net-zero-strategy**

Climate Change Committee assessment of the UK Net Zero Strategy: **https://www.theccc.org.uk/publication/independent-assessment-the-uks-net-zero-strategy**

Air Quality Lifecycle Assessment Tool: **https://wm-air.org.uk/project/health/**

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