Modelling the Health Burden of Air Pollution in the UK using Updated Exposure-risk Relationships

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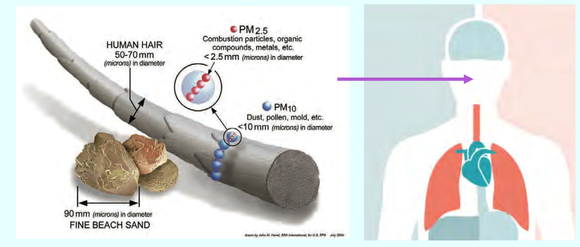
1. Fine particulate matter ($PM_{2.5}$) air pollution and disease burden

- Long-term exposure to ambient $PM_{2.5}$ is a leading cause of global premature mortality.
- In the UK, $PM_{2.5}$, dominated by agricultural emissions of ammonia (Kelly et al., 2023), is linked to **29,000-34,000** adult early deaths a year, estimated using models that relate exposure to health risk (Gowers et al., 2014, Macintyre et al., 2023).
- Recent cohort studies have identified a supralinear relationship between exposure and risk at relatively low $PM_{2.5}$ concentrations typical of the UK (5-12 μg m^{-3}) (Brauer et al., 2022).
- Here we use this new knowledge to estimate adult premature mortality in the UK for present day (2019) and future (2030).



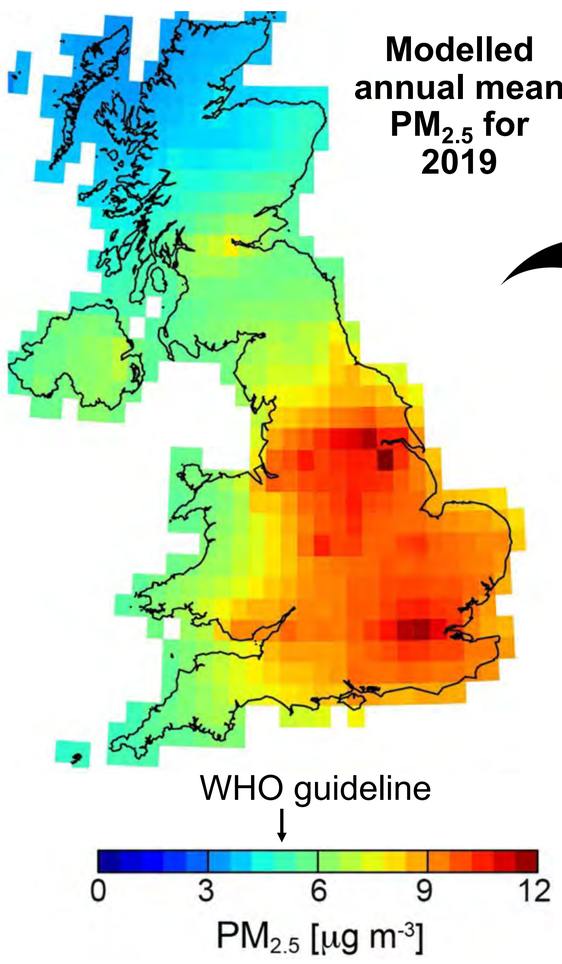
Fine particles or $PM_{2.5}$ cause **respiratory** and **cardiovascular** **diseases** when inhaled

2. Methodology

A four-step approach to estimate premature mortality from long-term (annual) exposure to $PM_{2.5}$

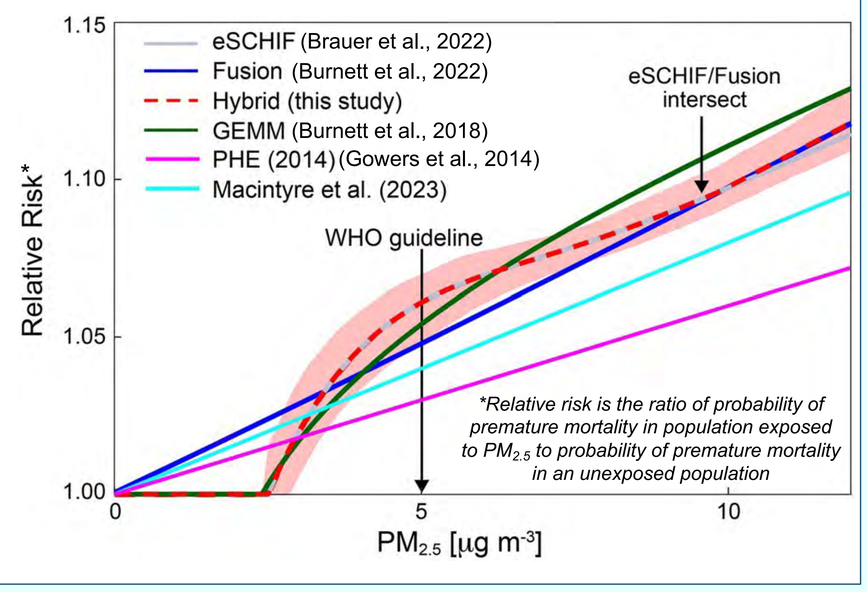
2.1. Simulate UK annual mean $PM_{2.5}$

- We use the ***GEOS-Chem*** atmospheric chemistry model to simulate ambient $PM_{2.5}$ concentrations in 2019.
- We also use emission projections for 2030 to assess the efficacy of legally binding and best available measures for reducing precursor emissions of $PM_{2.5}$.
- Modelled $PM_{2.5}$ is validated against the UK surface monitoring network (Kelly et al., 2023).
- 79% UK exceeds WHO $PM_{2.5}$ guideline.



2.2. Relative risk (RR) from updated exposure-harm relationships

- We use the hybrid health risk assessment model combining **Fusion** (combines best of 3 well-established curves) and **eSCHIF** (Canadian cohort, provides RR at low $PM_{2.5}$) with transition at their intersection (Fusion > 9.8 μg m^{-3} and eSCHIF for 2.5-9.8 μg m^{-3}) *[Approach motivated by Weichenthal et al. (2022)]*
- Updated RR above 1.06 (PHE) and 1.08 (Macintyre et al., 2023) at 10 μg m^{-3} previously used for the UK



2.3. Estimate Population Attributable Fraction (PAF)

PAF is proportion of premature mortality attributed to long-term exposure to $PM_{2.5}$

$$\mathbf{PAF} = 1 - \frac{\mathbf{1}}{\boldsymbol{RR}}$$

Standard approach as in Vohra et al. (2021), Burnett et al. (2018)

2.4. Calculate premature deaths

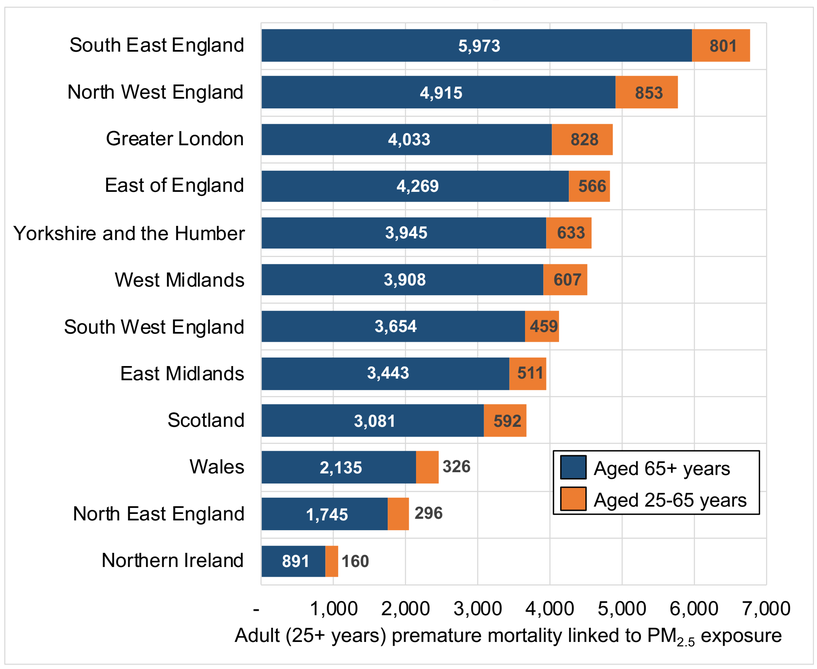
Premature death is estimated using PAF, adult population (Pop) from WorldPop and baseline mortality rates (BMR) from ONS

$PM_{2.5}$-attributable mortality
$= \mathbf{PAF} \times \boldsymbol{Pop} \times \boldsymbol{BMR}$

3. Results

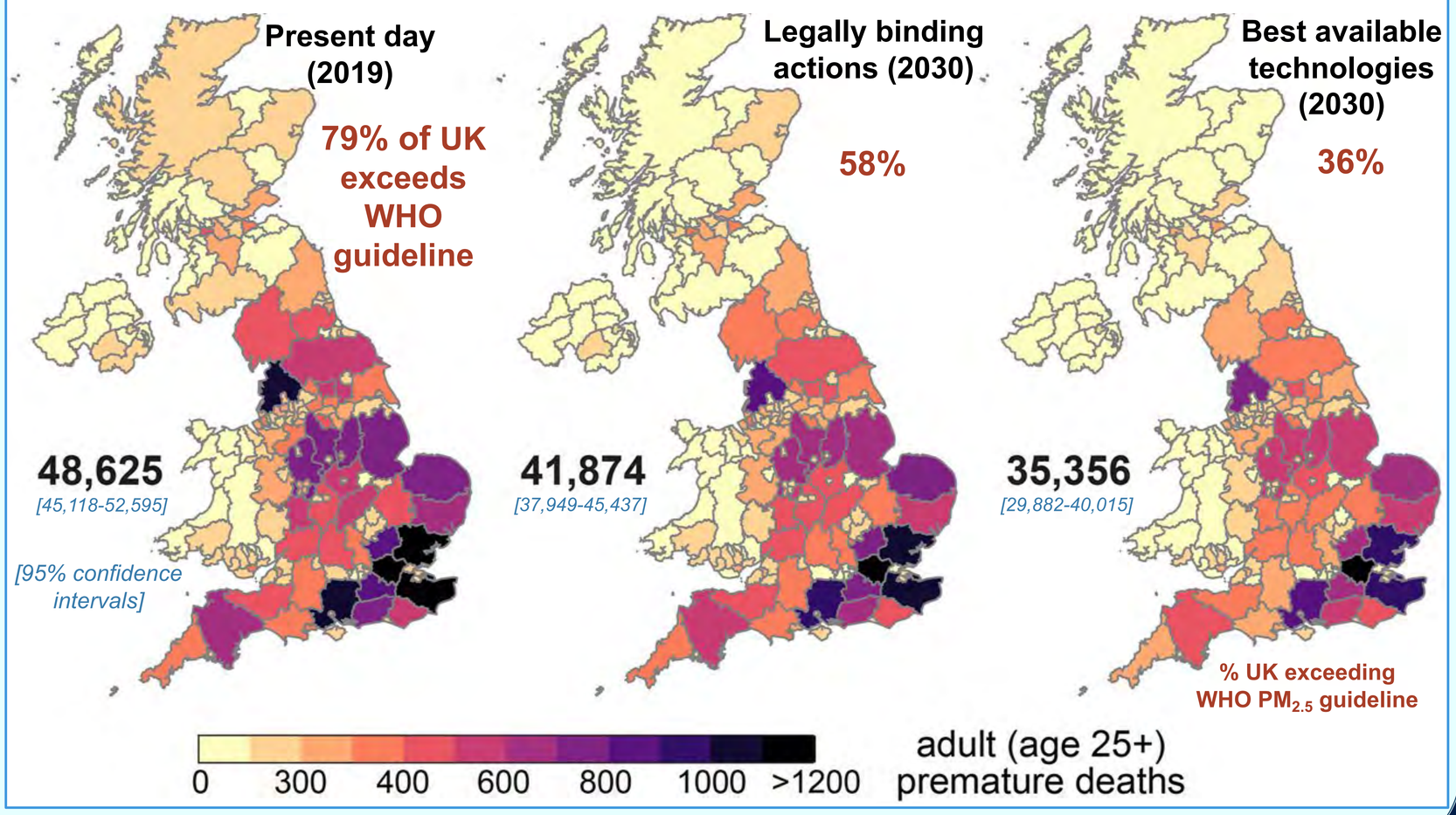
Severe health burden of $PM_{2.5}$ pollution persists in the UK despite adopting best available technologies

1. We estimate 48,625 adult premature mortality attributable to exposure to ambient $PM_{2.5}$ in the UK in 2019;15,000-20,000 more than estimates using outdated health-risk assessment models.
2. The elderly (65+ years) account for most (86%) UK deaths. 89% in South West England, 83% in London.



3. All adult (25+ years) premature mortality in Greater London exceeds that in Scotland, Wales and Northern Ireland.

4. Decline in precursor emissions of $PM_{2.5}$ by adopting currently legislated measures results in 41,874 premature deaths by 2030 or 6,751 avoided early deaths. By adopting best available technologies, these total 35,356 premature deaths or 13,269 avoided deaths, twice that achieved with current legislation.



4. Key findings

- $PM_{2.5}$ is more hazardous to UK adults than previously reported
- Elderly population is most affected (83-89%) by $PM_{2.5}$ pollution across the UK
- A supralinear exposure-response curve also suggests there are substantial public health gains in targeting dominant source contributors to $PM_{2.5}$, in particular the unregulated agricultural sector. This is likely to be offset by the increase in an aging population by 2030.

Check out Marais et al. (2023) for more details

References

1) *Braur et al., url:https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9556709/pdf/hei-2022-212.pdf, 2022.*
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5) *Kelly et al., doi:10.1016/j.cacint.2023.100100, 2023.*
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9) *Weichenthal et al., doi:10.1126/sciadv.abo3381, 2023.*

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