An environmental justice analysis of two decades of air quality change in England in relation to changing deprivation and ethnic group population distributions

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"It's no use carrying on like that, Dad! Atmospheric pollution's at an acceptable level."

Thelwell, 1971

Air Quality Risk

- Air Pollution is the greatest environmental risk to the public's health in the UK with:
  - Between 28,000 and 36,000 deaths each year attributed to human made air pollution
  - Associated with cardiovascular, respiratory disease including lung cancer
  - Possible effects on dementia, low birth weight & diabetes
  - Children in early years at risk, including asthma and poorer lung development
- Air quality research into:
  - NOx Nitrogen Oxides (includes nitric oxide NO & nitrogen dioxide NO_2)
  - **NO_2 Nitrogen Dioxide**
  - PM_{10} Respirable Particulate Matter
  - **$PM_{2.5}$ Fine Particulate Matter**

Public Health England (2019)

Environmental Justice (EJ)

- The environmental justice (EJ) has roots in the USA civil rights movement in the 1980s re association of hazardous (e.g. waste disposal) facilities with race
- In UK EJ has broader environmental considerations; hazards (e.g. flooding, air quality, industrial), salutogenic (e.g. green space)
    - Social focus on deprivation and health inequalities
- UK impetus mainly top-down: central government to meet commitments under the 1992 Rio declaration and UNECE Aarhus convention
    - Government attention declined after 2010 and the outgoing Labour administration
    - Attention persisted amongst health agencies and health equity professionals

Clinton (1994); Black (1980); Acheson (1998); King & Stedman (2000) FoE (2001); Walker *et al*. (2003); Fairburn *et al*. (2005); UNECE (1998)

UK air quality, area deprivation & ethnicity

- Concerns over air quality as analyses demonstrated:
    - **Air pollution burden** fell on more **deprived locations & children** under 10 years old
- Medical research has revealed AQ **health impacts**, especially from **fine particulates**, are worse than previously thought
- Until recently, the deprivation focus meant only a few UK EJ studies examined the distribution of air pollution relative to **ethnicity**
    - National, London & Glasgow analyses reveal that non-White & recent immigrant groups are exposed to greater air pollution
- EJ evidence analyses are dominated by **cross-sectional frameworks**

Barnes et al. (2019); Gray et al. (2023); Brook *et al*. (2023) Catalano (2024) Fecht *et al*. (2014) Gray et al. (2024) Marmot (2010); Mitchell & Dorling (2003); Walker *et al*. (2003b); Manisalidis *et al*. (2020); Schraufnagel (2020); Swift (2022); Mitchell *et al*. (2023)

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- Our previous 2001- 2011 time-series:
  - Air quality **improved** but did so most **slowly** in more **deprived** areas which also bore a disproportionate share of **declining** air quality including **non-compliance** with (then) statutory air quality standards
- With the release of the 2021 Census data …
- For 2021 LSOAs in England, we develop 2001-2021 distributions of:
  - Air quality (NO_2 $PM_{2.5}$)
  - Deprivation using a time-comparable Townsend Index
  - Ethnic group populations (White, South Asian, Black, Mixed, Chinese & Other)

Mitchell et al. (2015); Norman et al. (2024)

Data sources: Air Quality

- Air quality (ambient concentration): England
- Aim for years pooled around the census but data for early years unavailable & later years need to be post-covid lockdown

Air Quality	Definition	Years
Nitrogen Dioxide **NO_2**	Annual mean ambient concentration (µg m^{-3}) Averaged over three years	2001-03 2010-12 2021-23
Particulate Matter **$PM_{2.5}$**	Annual mean ambient concentration (µg m^{-3}) Averaged over three years	2002-04 2010-12 2021-23

- Source: DEFRA: https://uk-air.defra.gov.uk/data/pcm-data grid data estimated for 2021 LSOAs
- µg/m3 = micrograms (one-millionth of a gram) per cubic meter air

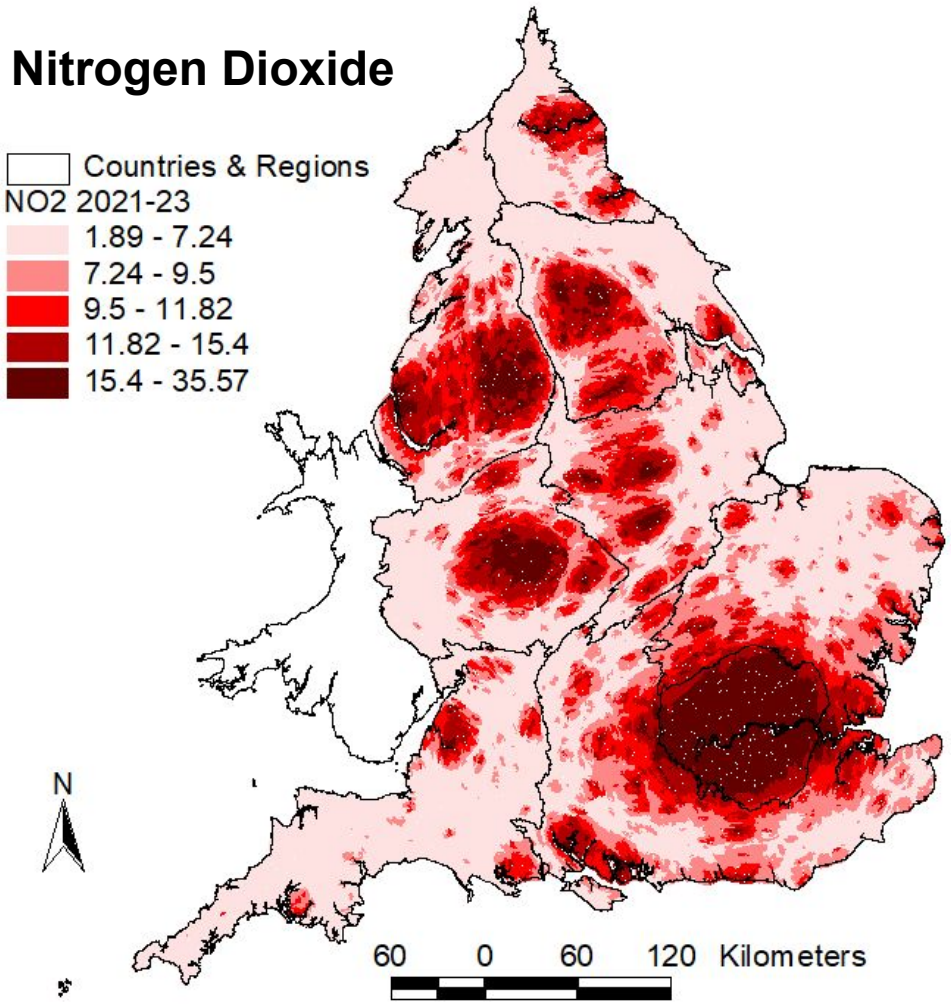
Data sources: Deprivation & Ethnicity

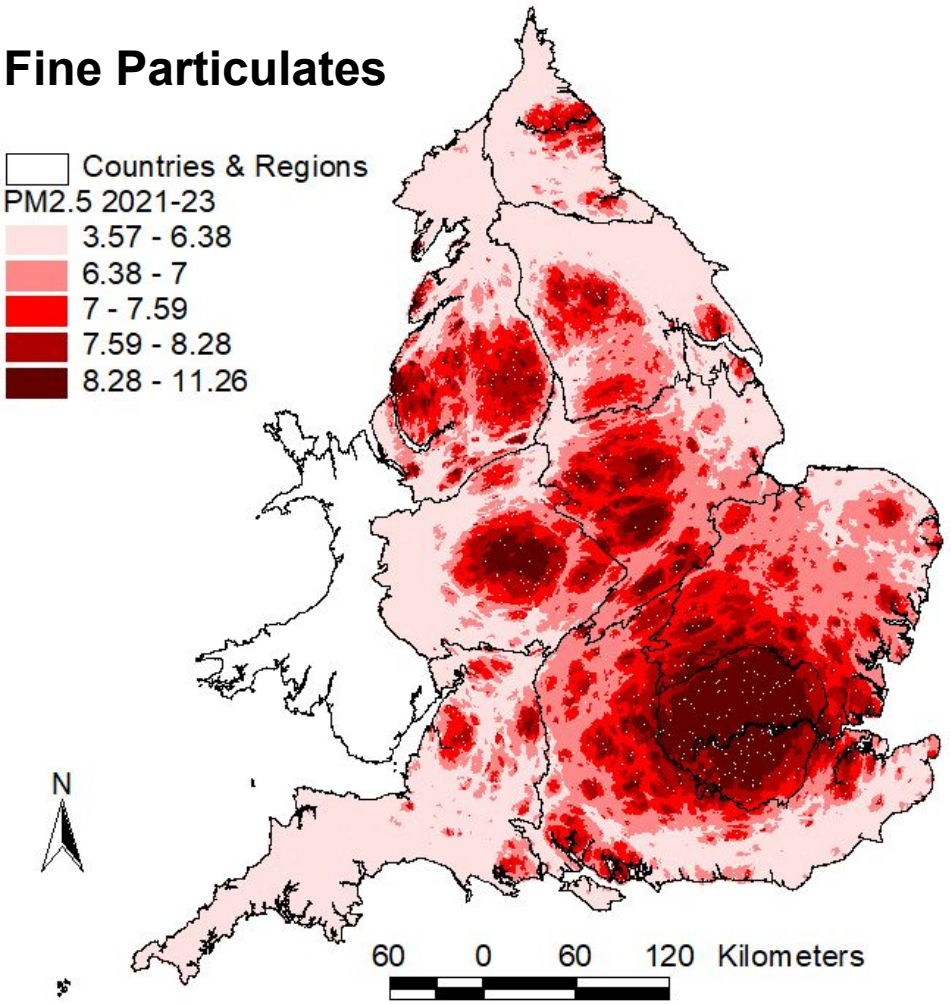
- Deprivation and ethnic group population data: England

Social metric	Definition	Years
Townsend Deprivation Index	Sum the Z-scores of percentages: Unemployment; Household Non-home ownership; No car; and Overcrowding	2001 2011 2021
Count of population by ethnic group	White; South Asian; Black; Mixed; and Chinese & Others	2001 2011 2021

- Source: UK census data at https://www.nomisweb.co.uk/sources/census
- Additional processing to derive the deprivation index (Norman *et al*. 2024) and adjust population counts from previous census geographies to 2021 LSOAs

Results: air quality (2021-23)





Results: air quality national change

- Air quality change in England, 2001-03 to 2021-03

Nitrogen Dioxide NO_2 (ug/m^3)	2001-03	2010-12	2021-23
Mean	**25.80**	**19.30**	**11.51**
Std. Deviation	7.94	7.50	5.10
Minimum	2.62	1.97	1.89
Maximum	61.88	56.61	35.57
Fine Particulates $PM_{2.5}$ (ug/m^3)	**2002-04**	**2010-12**	**2021-23**
Mean	**12.93**	**11.53**	**7.30**
Std. Deviation	1.66	1.87	1.13
Minimum	2.49	2.23	3.57
Maximum	19.15	18.38	11.26

Results: air quality, deprivation & ethnicity

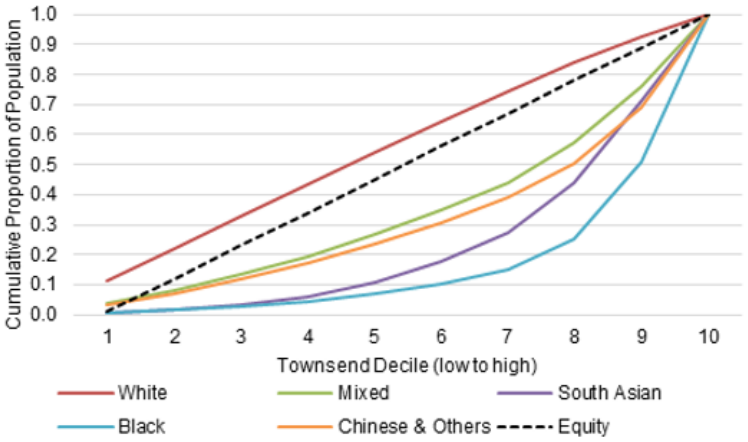
Correlations		**2001**	**2011**	**2021**
Deprivation	**NO_2**	0.499	0.599	0.664
	$PM_{2.5}$	0.385	0.503	0.552
	NO_2			
Ethnic Group	White	-0.423	-0.475	-0.538
	Mixed	0.573	0.607	0.642
	South Asian	0.356	0.429	0.434
	Black	0.471	0.521	0.594
	Chinese & Others	0.445	0.543	0.649
	$PM_{2.5}$			
	White	-0.408	-0.449	-0.484
	Mixed	0.567	0.648	0.590
	South Asian	0.342	0.408	0.407
	Black	0.460	0.573	0.519
	Chinese & Others	0.412	0.528	0.538

Similar relationships between ethnic groups & deprivation

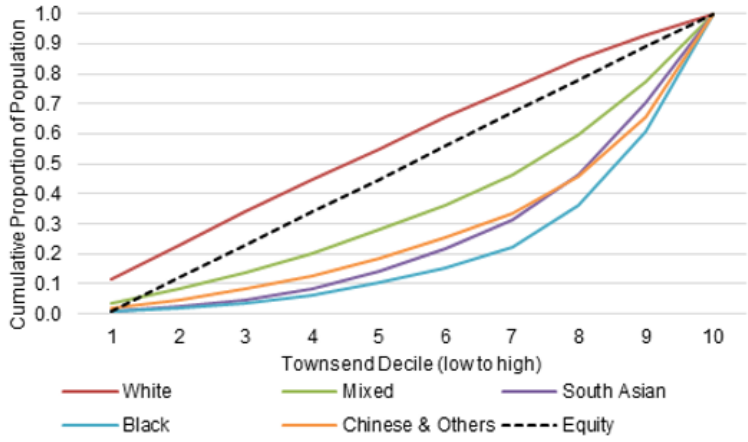
Results: Nitrogen Dioxide Inequalities

Lorenz Curves: Air quality by ethnic group by deprivation decile

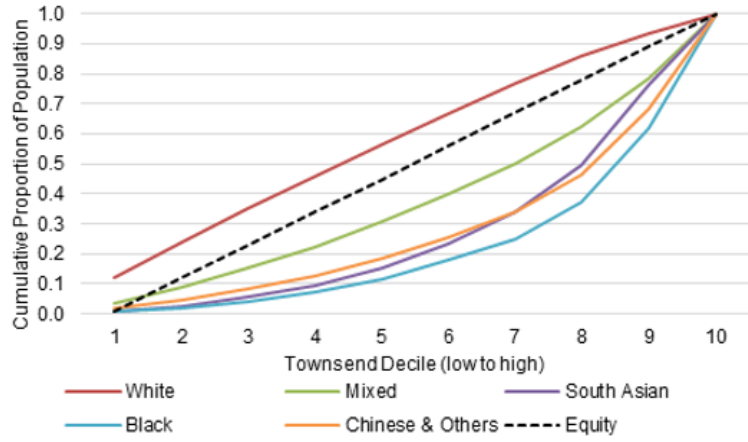
NO_2 2001-03



NO_2 2010-12



NO_2 2021-23



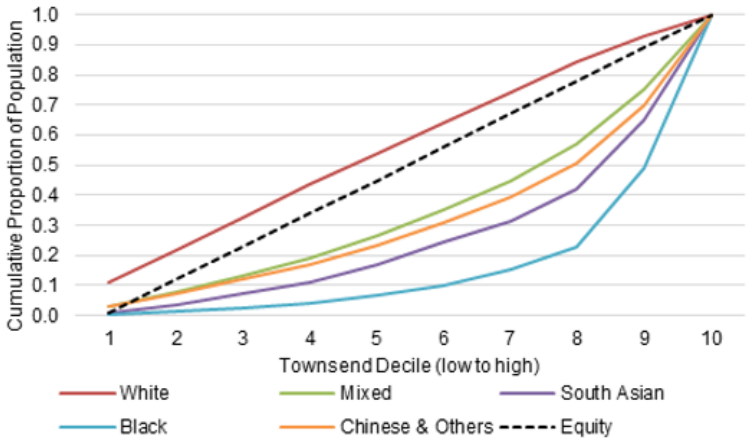
Gini Coefficients

NO_2	**2001-03**	**2010-12**	**2021-23**
White	-0.064	-0.081	-0.102
Mixed ethnicity	0.363	0.343	0.296
South Asian	0.583	0.543	0.502
Black	0.724	0.643	0.610
Chinese & Others	0.421	0.506	0.490

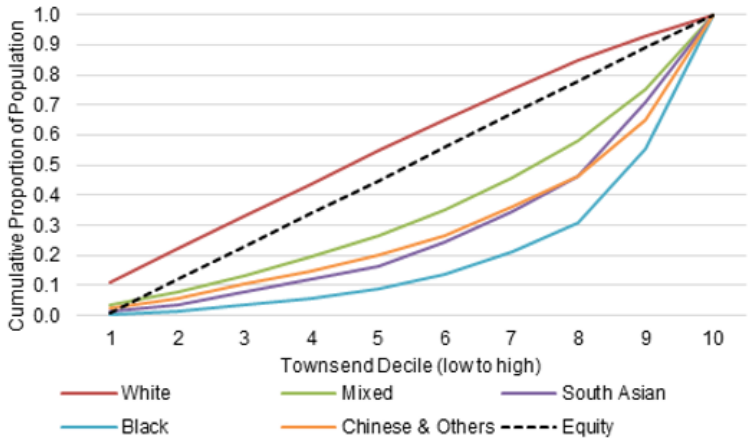
Results: Fine Particulate Matter Inequalities

Lorenz Curves: Air quality by ethnic group by deprivation decile

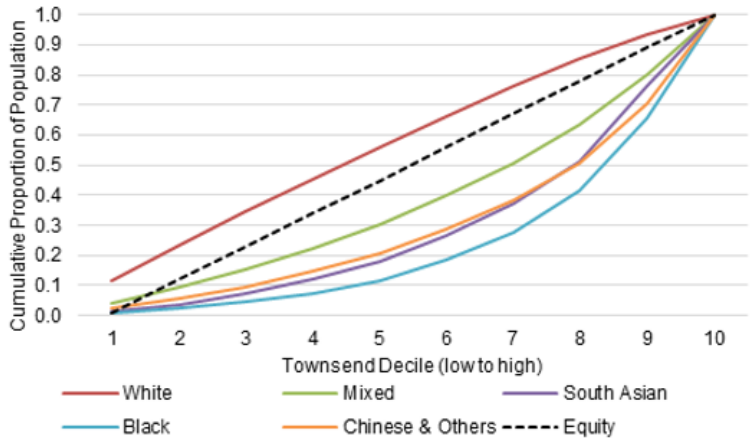
$PM_{2.5}$ 2002-04



$PM_{2.5}$ 2010-12



$PM_{2.5}$ 2021-23

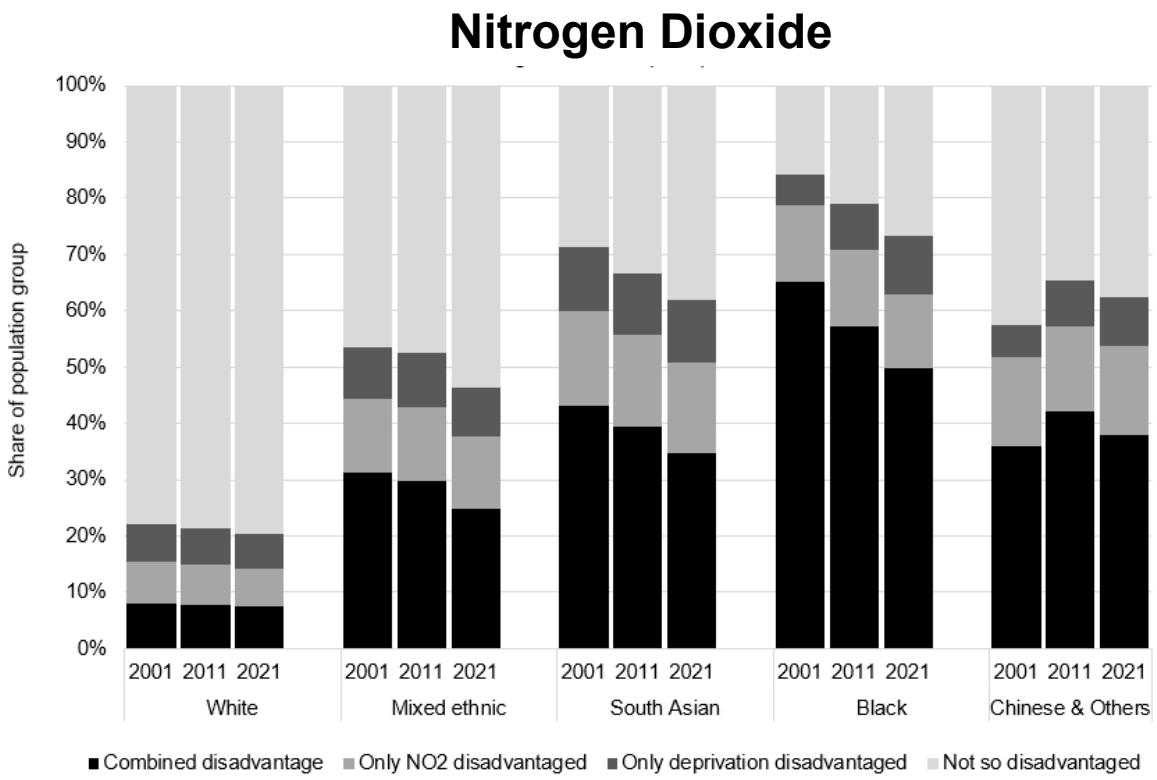


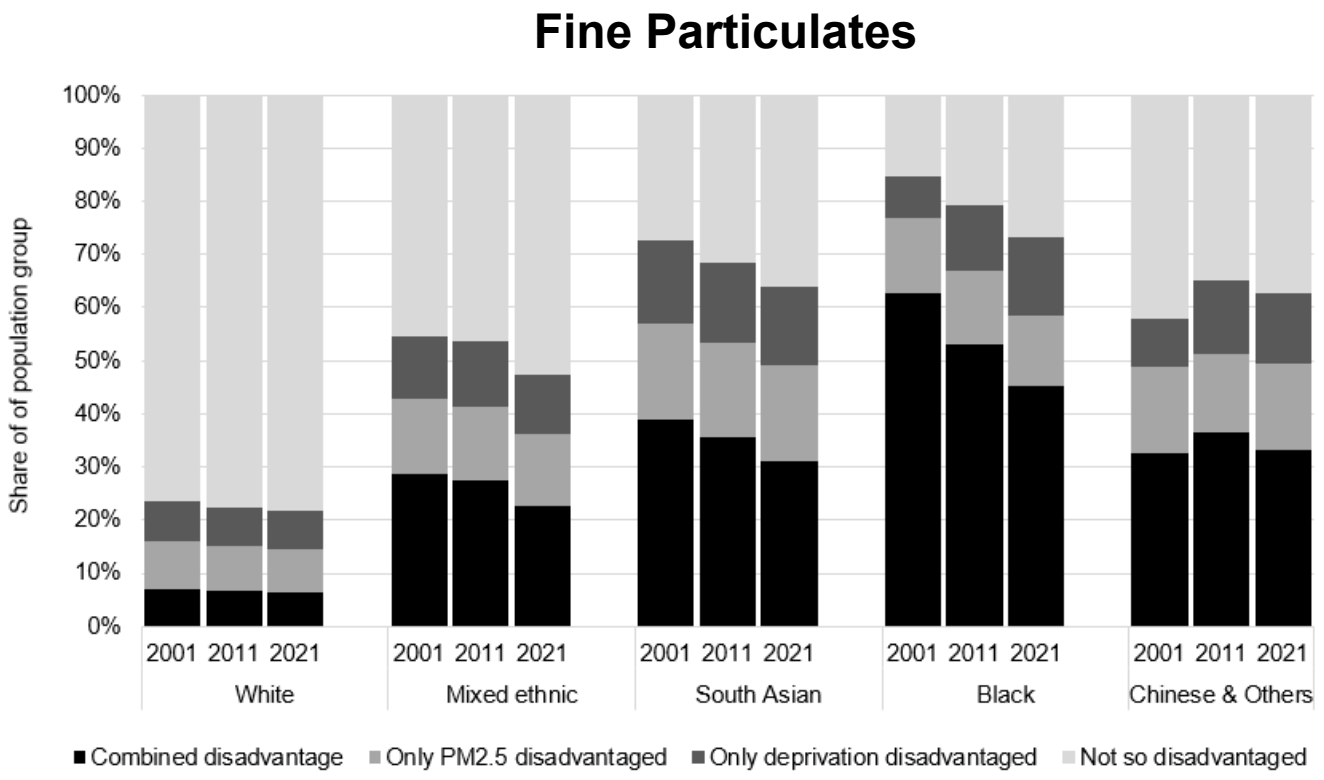
Gini Coefficients

$PM_{2.5}$	**2002-04**	**2010-12**	**2021-23**
White	-0.062	-0.074	-0.094
Mixed ethnicity	0.366	0.359	0.291
South Asian	0.540	0.507	0.473
Black	0.737	0.674	0.594
Chinese & Others	0.419	0.484	0.455

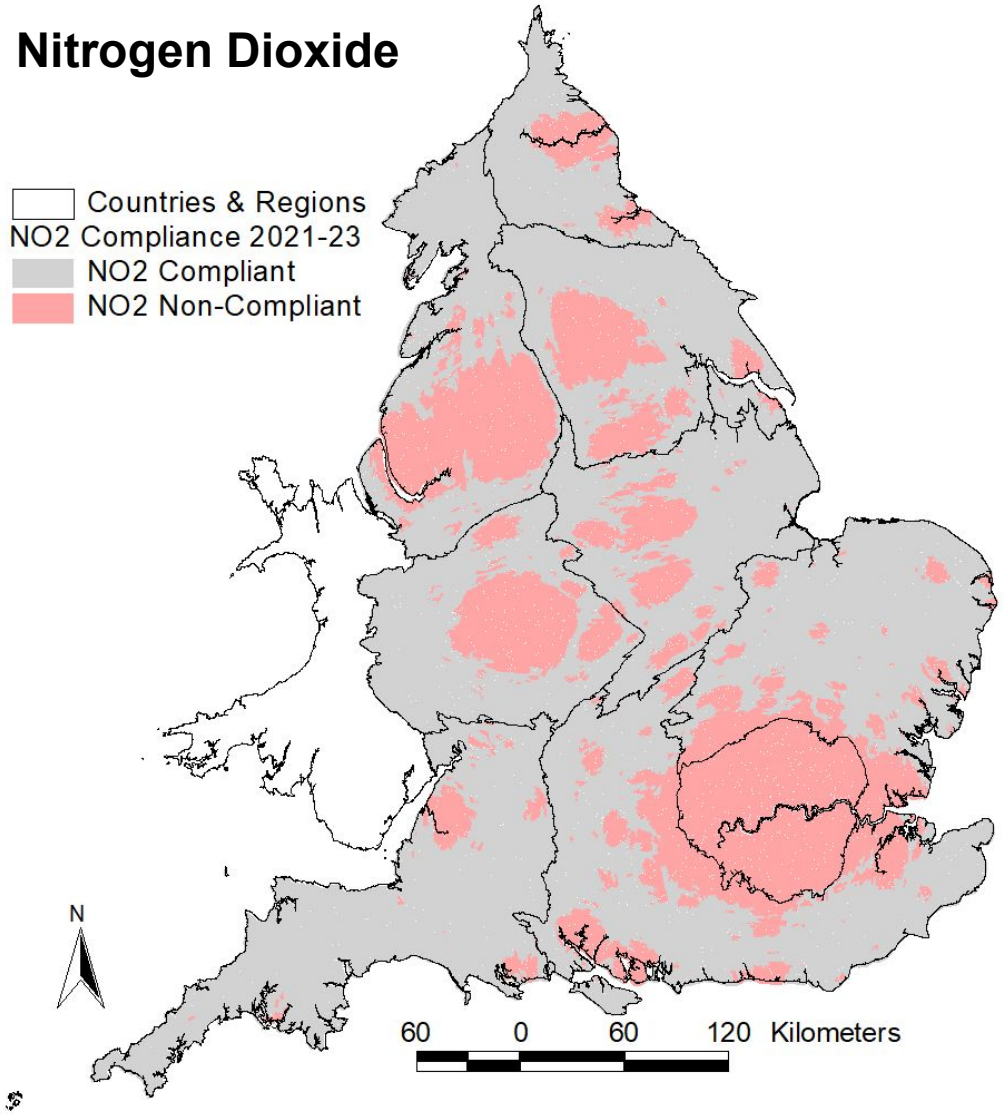
Results: Double Disadvantage?

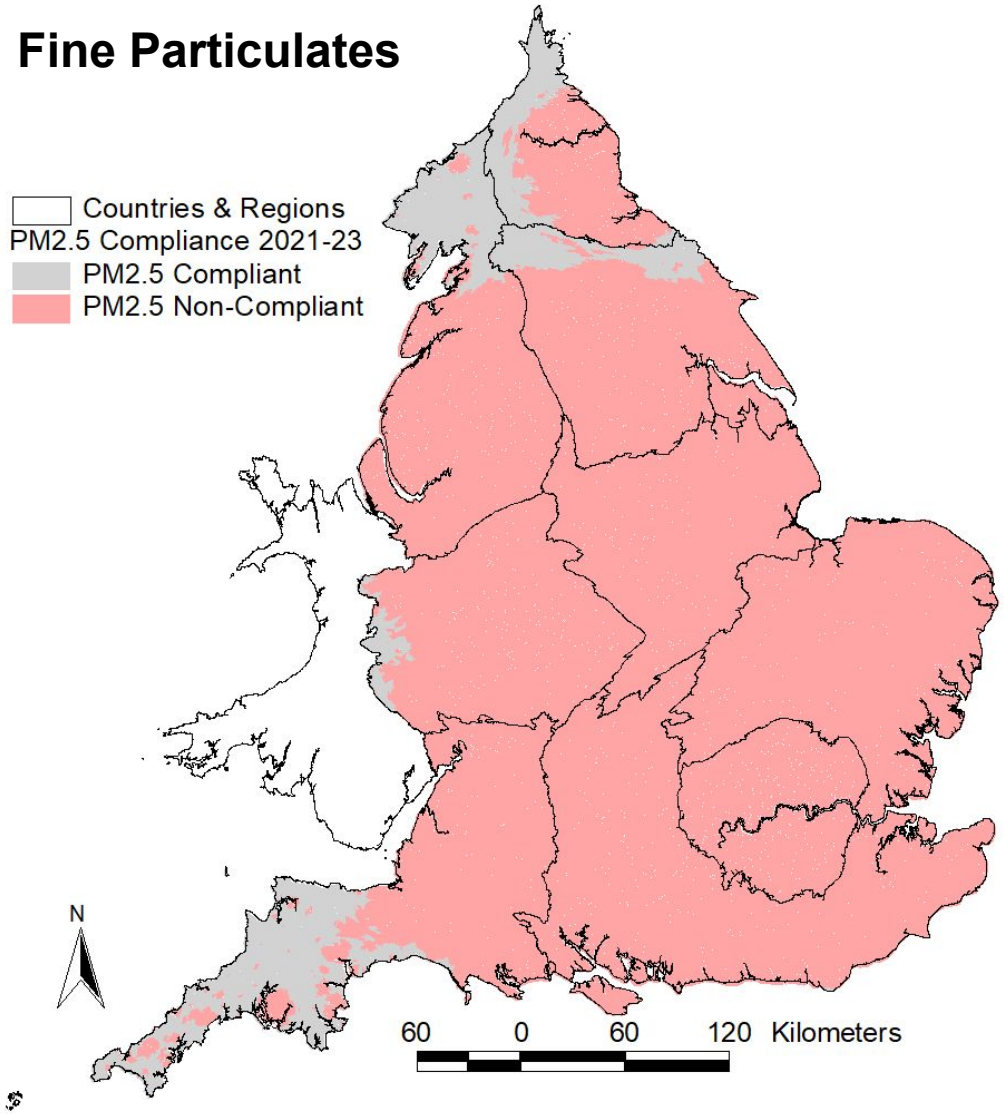
- Most Deprived decile & / or Most Polluted decile





Results: WHO Compliance?





Conclusions

- Deprivation gradients in air pollution previously identified have persisted
- Gradients become less steep as air quality (NO_2 & $PM_{2.5}$) improves, but **more deprived** areas continue to bear a **higher burden** of air pollution and **slowest** rates improvement
- We find strong **ethnic gradients**. As NO_2 and $PM_{2.5}$ increase, the non-White population share increases and the White population declines
- Our **intersectional** analyses (Gini coefficients, quantiles of combined disadvantage) reveal strong differences in combined deprivation / pollution experienced by different ethnic groups. Less than 8% of the White population experience double disadvantage, compared with up to 65% of the Black population
- Multiple disadvantage declines over the last two decades, likely the result of counter-urbanisation of ethnic groups away from the traditional urban centres of immigration
- But declines are modest, with all non-White groups experiencing similar rates of decline, suggesting these ethnic / deprivation differences will persist

Conclusions

- Multiple disadvantage has real implications for public health
- 9 year old Ella Adoo-Kissi-Debrah died of an asthma attack in 2004 and was the first person in the UK to have air pollution **formally listed as a cause of death**. Her multiple disadvantage included air pollution exceeding WHO and EU standards, deprivation and her ethnic status. As a Black person, Ella's genetics made her more susceptible to respiratory disease
- Lewisham (Ella's London borough) is a pollution-poverty-ethnicity hotspot indicating others are similarly at risk
- Application of WHO standards to current air quality in England infers that inequalities will persist unless air quality management adopts a more **socially focussed** approach

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