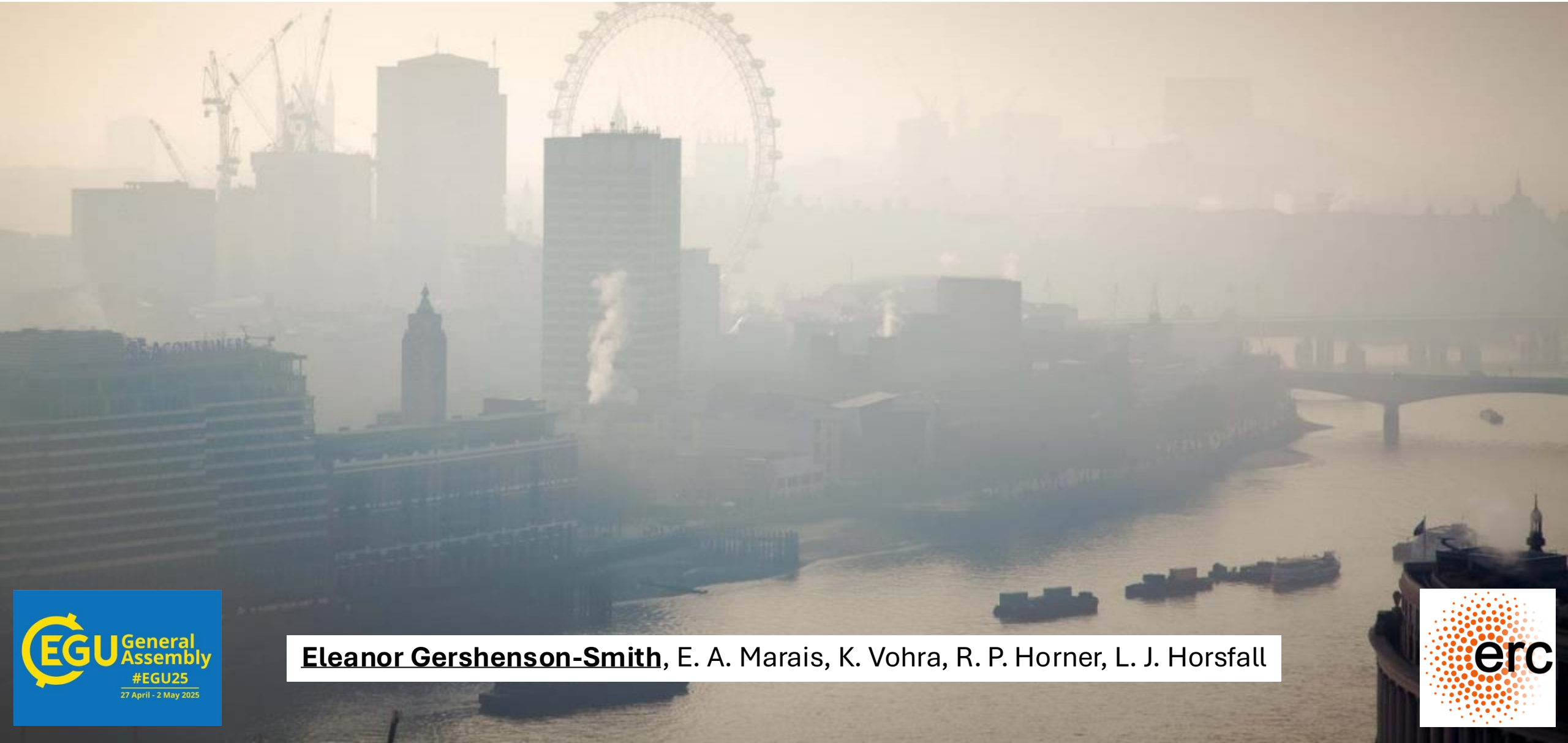
Using high-resolution TROPOMI NO_2 columns to assess health disparities in NO_2 exposure across London



Eleanor Gershenson-Smith, E. A. Marais, K. Vohra, R. P. Horner, L. J. Horsfall

EGU General Assembly #EGU25 27 April - 2 May 2025

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Air quality in London

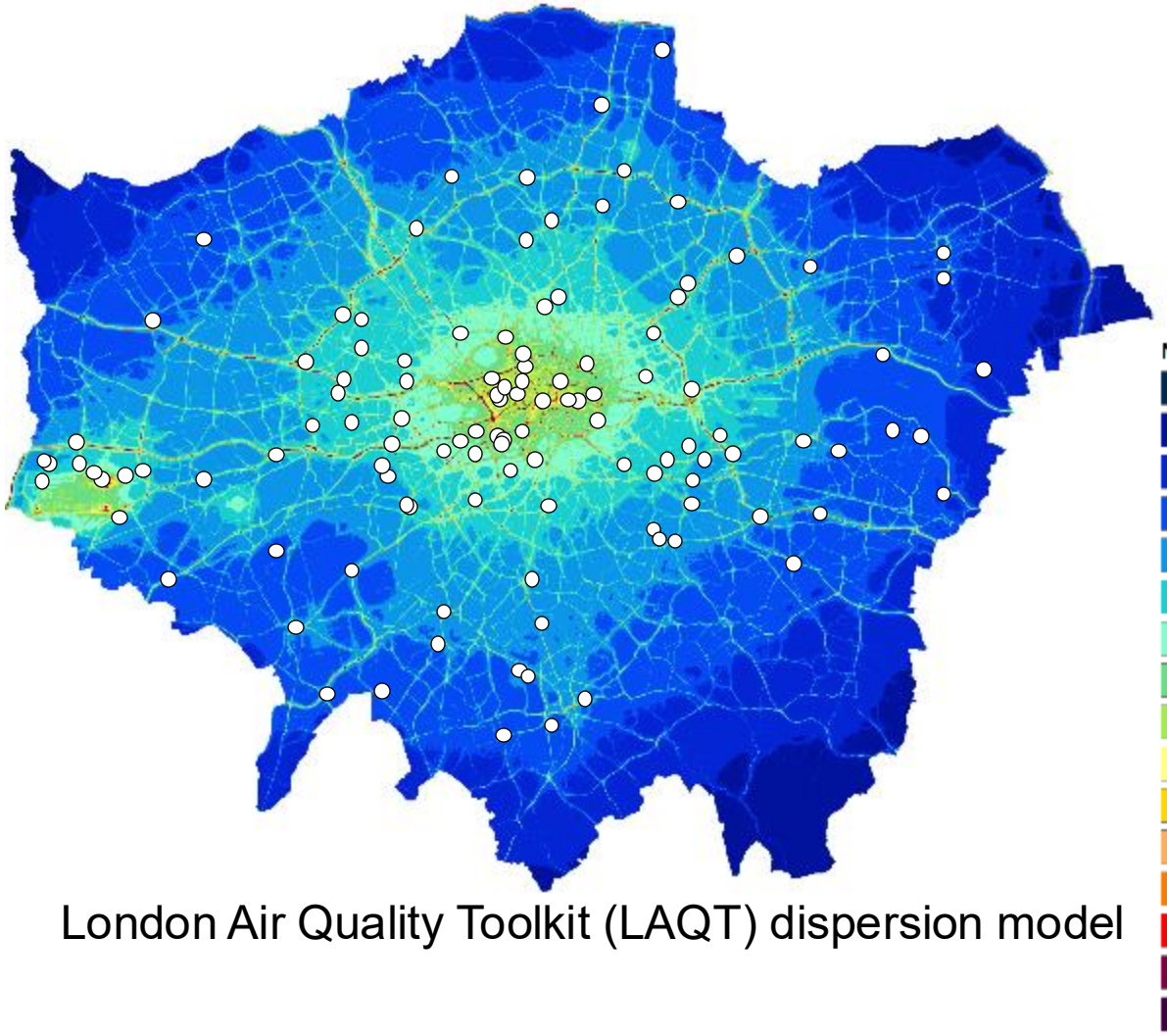
London is in a valley.

It is the most congested city in Europe.

Traffic is the primary source of NO_2.

Air quality monitoring sites are not evenly distributed.

Annual Mean NO_2 Concentrations (2019)



London Air Quality Toolkit (LAQT) dispersion model

TROPOMI observations provide the consistent and extensive coverage needed to assess health disparities and inform air quality policy.

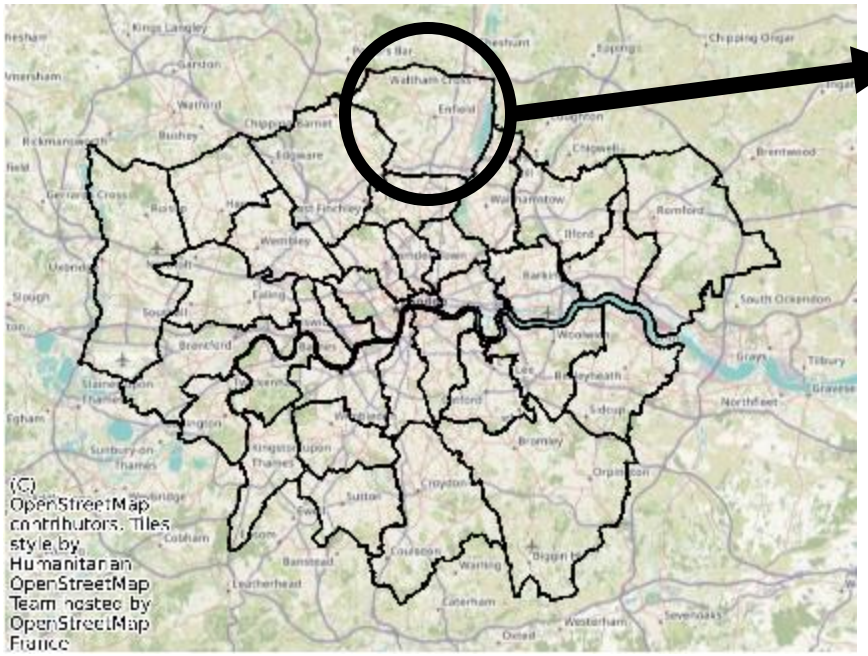
London is the largest and most diverse city in the UK

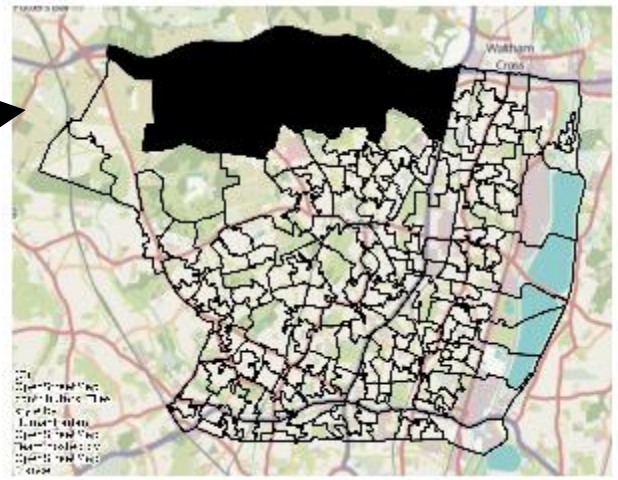
The population of London in 2021 was approximately **8.8 million**.

It is the most ethnically diverse city in the UK.

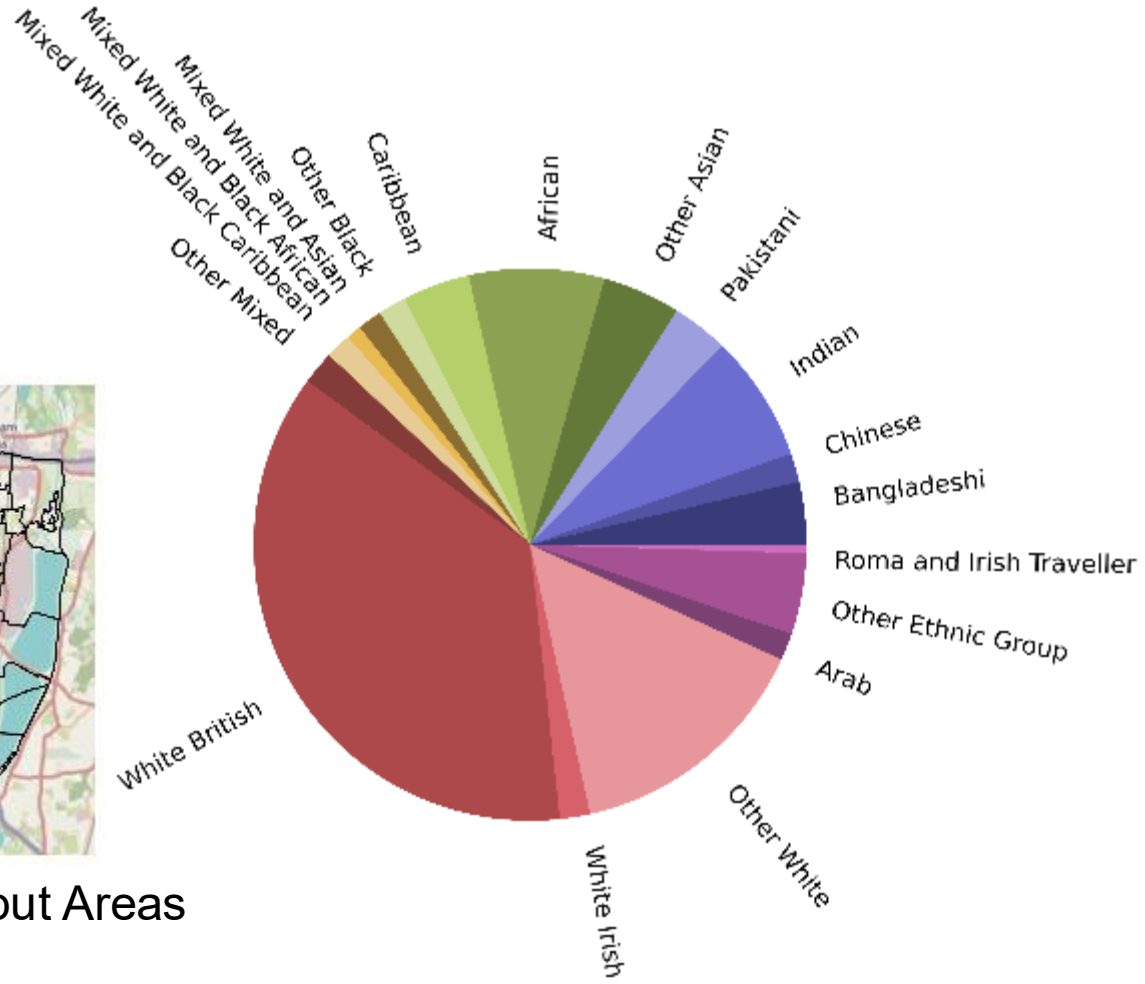
20.7 % Asian, 13.5 % Black, 5.7 % Mixed, 53.8 % % White, 6.3 % Other.

287 ethnic groups and nationalities are represented in the 2021 census.





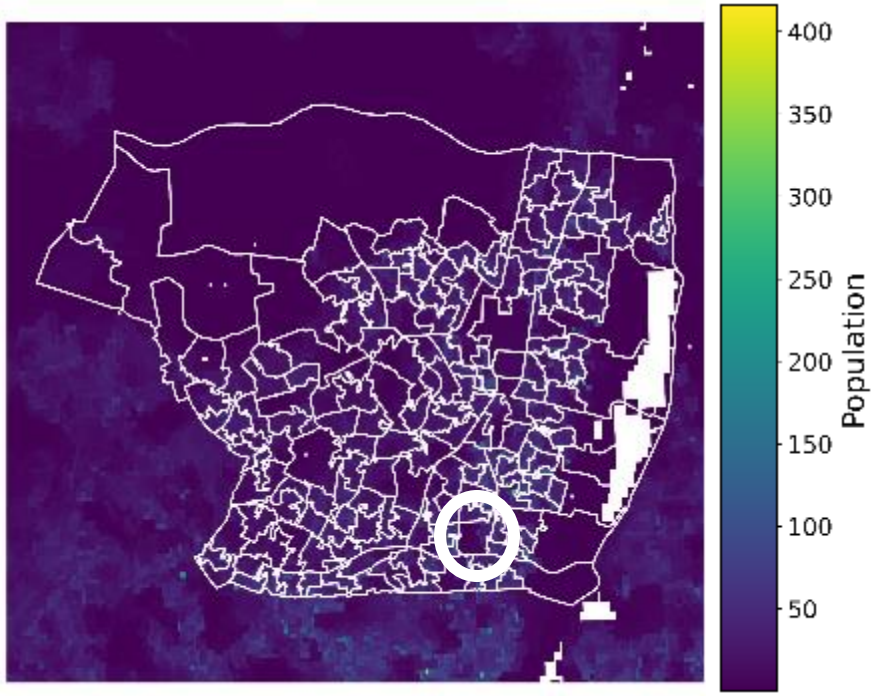
Lower layer Super Output Areas (LSOAs) are census geographies containing between 1,000 and 3,000 persons.



Health disparities at the LSOA level have never been calculated.

Calculating the population-weighted air quality metric

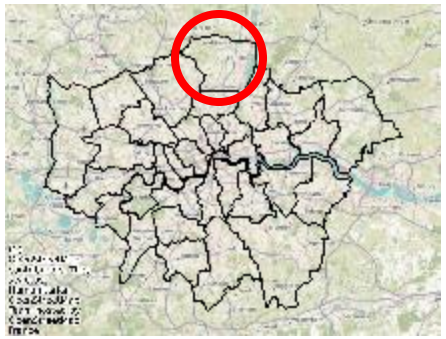
To calculate the population-weighted air quality metric (PW_{NO_2}), we use population data at 100×100 m resolution from WorldPop (2020).

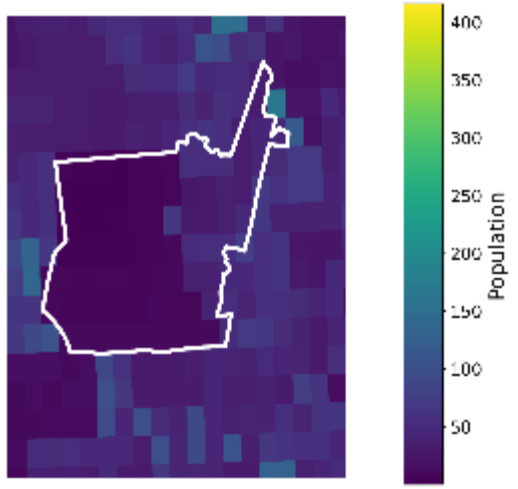


We use data for people aged <20 years.

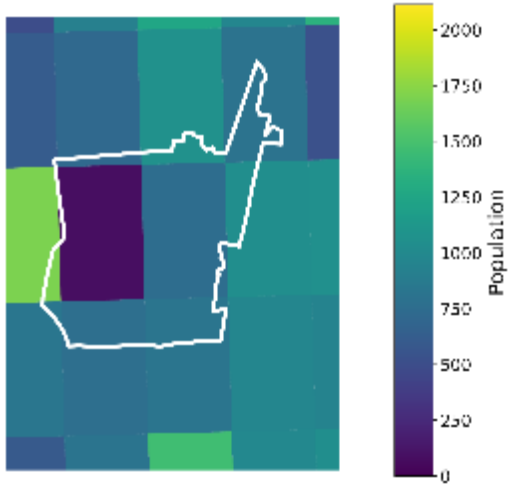
Population data must be re-gridded to 400×400 m resolution for the calculation of PW_{NO_2}.

Calculating the population-weighted air quality metric

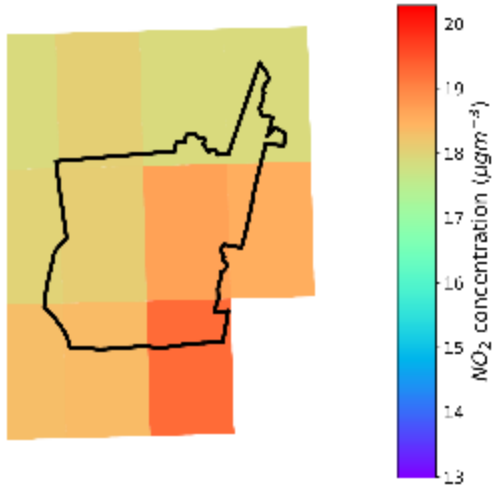




100×100 m



400×400 m



400×400 m

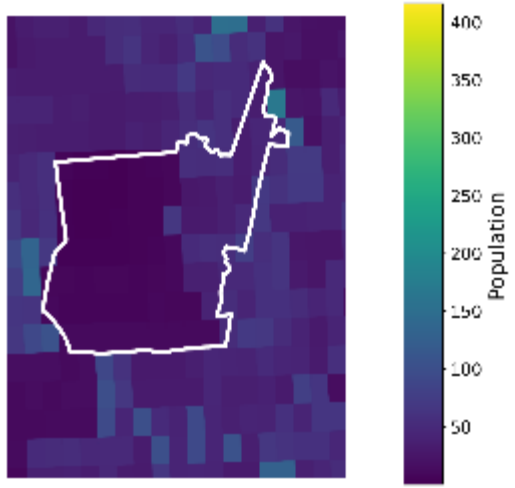
Project 100×100 m populations from WorldPop to the nearest-neighbour 400×400 m TROPOMI pixels and total the populations.

For derivation of TROPOMI derived 400×400 m surface concentrations, please see supplementary slides.

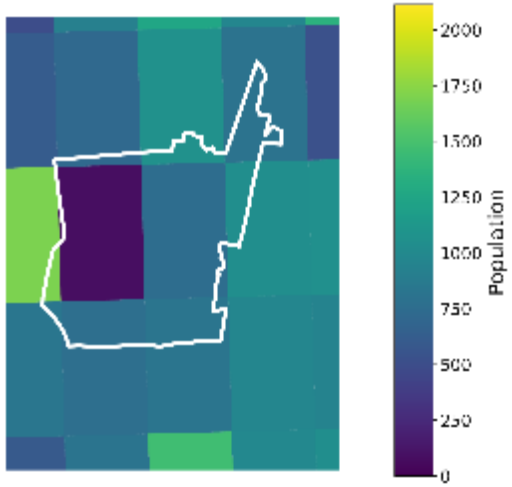
Calculating the population-weighted air quality metric

Assume constant population and NO_2 concentration in a grid cell.

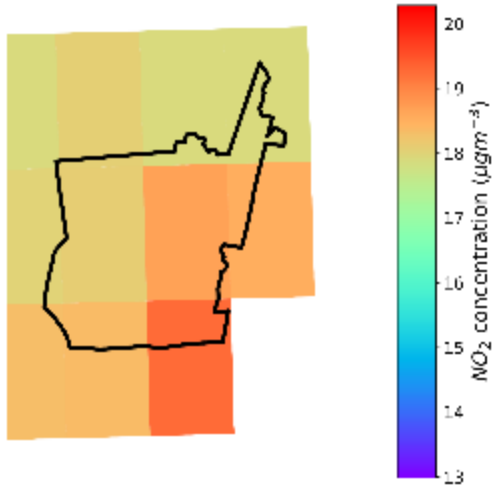
Calculate PW_{NO_2} for an LSOA using the grid cells that overlap LSOA shape.



100×100 m



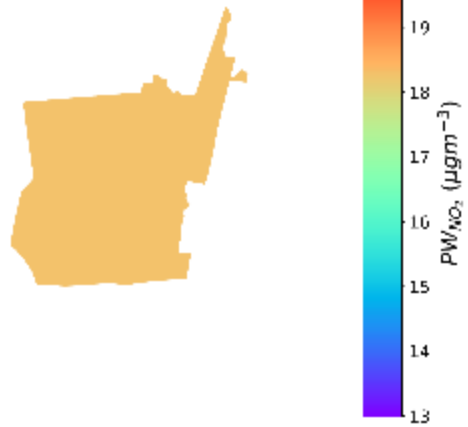
400×400 m



400×400 m

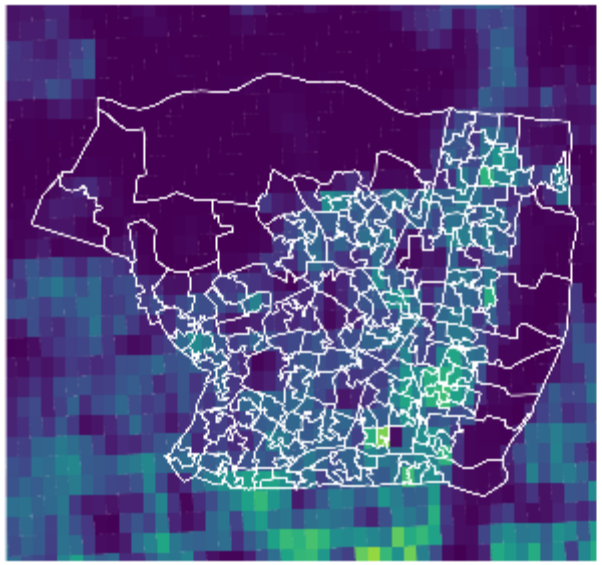
Assume constant population and NO_2 concentration in a grid cell.

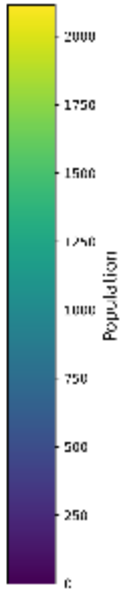
Calculate PW_{NO_2} for an LSOA using the grid cells that overlap LSOA shape.

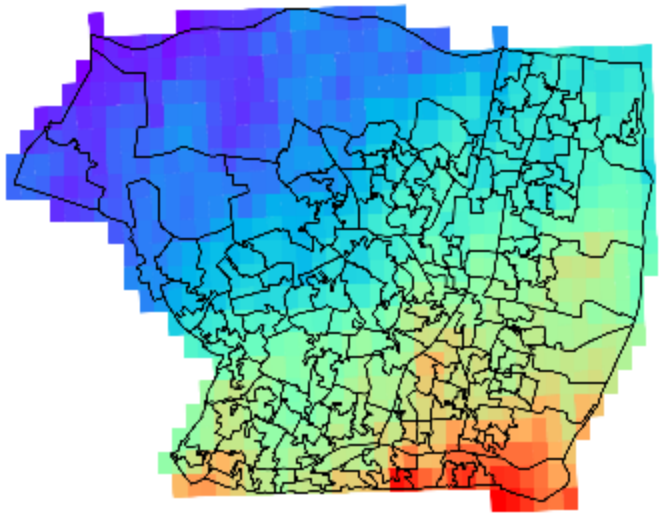


Calculating the population-weighted air quality metric

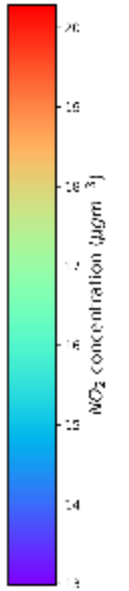
400×400 m



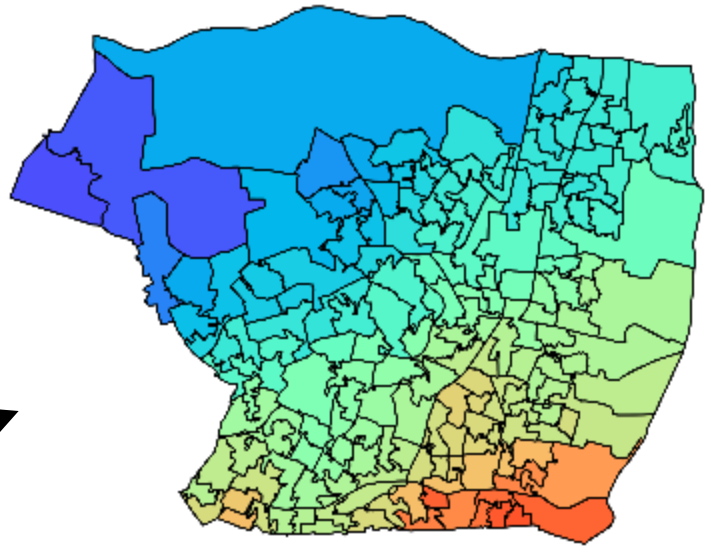


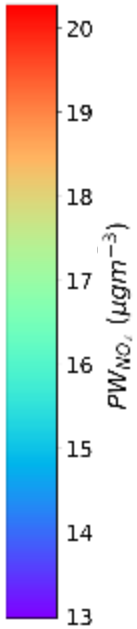


400×400 m



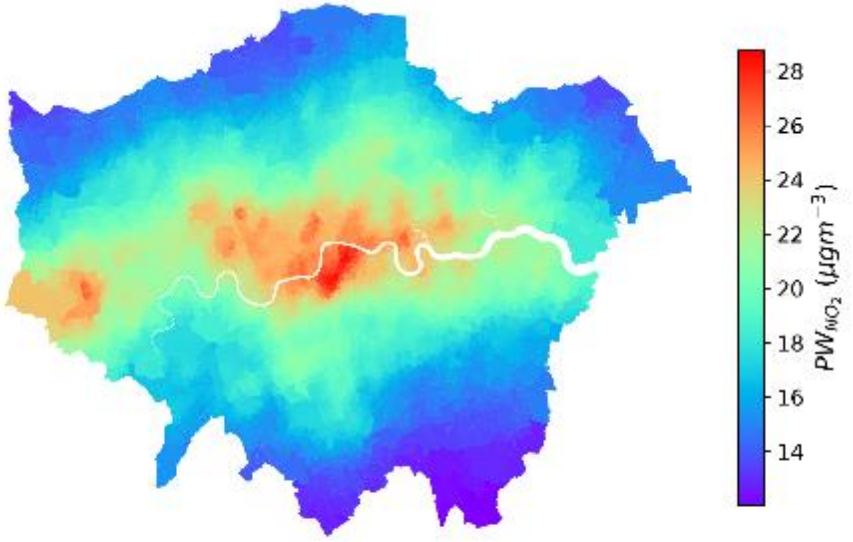
Population-weighted NO_2 for each LSOA



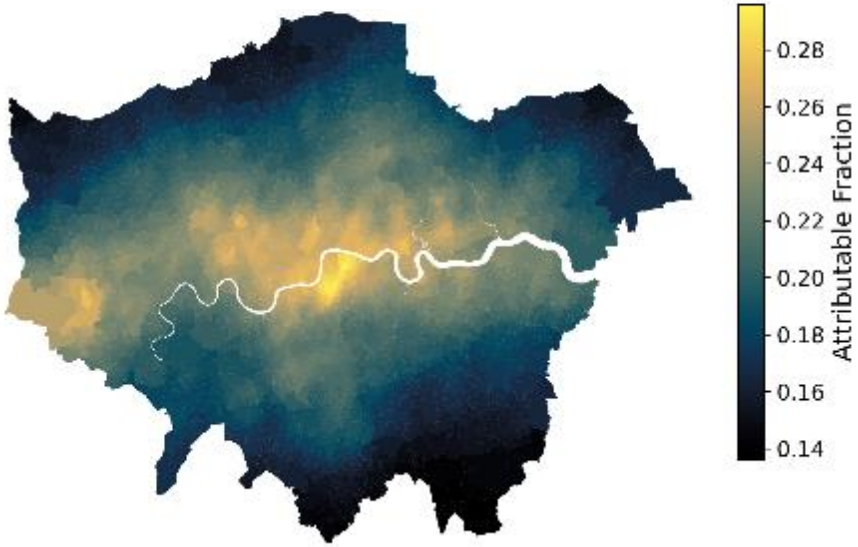


The attributable fraction is greatest in Central London

Population-weighted air pollutant metric (PW_{NO_2})



Attributable fraction (AF)



We calculate attributable fraction following Macintyre et al. (2023).

$\beta = \ln(\text{ERF})$ **Calculate the slope (β) of the exposure response coefficient (ERF).**

ERF = 1.05 per 4 μg m^{-3} annual mean NO_2 (Khreis et al. 2017)

$$RR = \exp\left(\beta \times \frac{PW_{NO_2}}{4}\right)$$ **Calculate the relative risk (RR).**

$$AF = \left(\frac{RR - 1}{RR}\right)$$ **Finally, compute the attributable fraction (AF).**

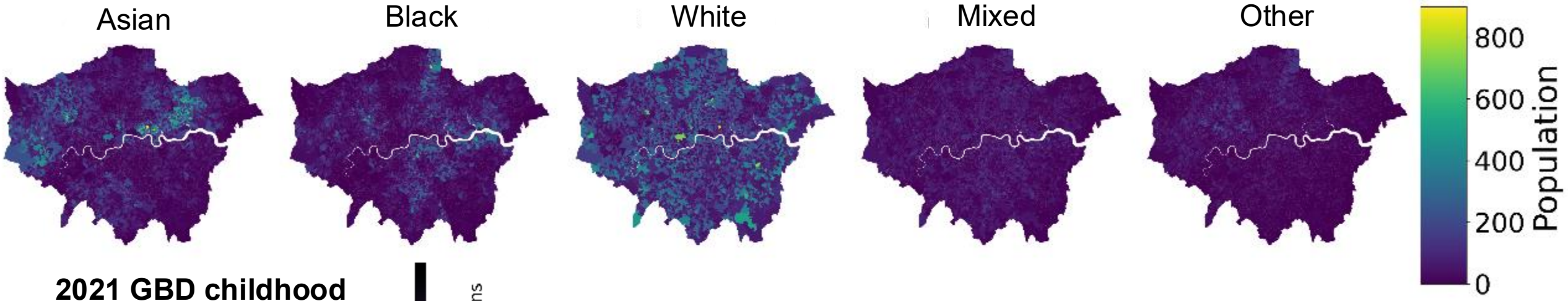
14–29 % of childhood asthma cases are attributable to NO_2 exposure in the Greater London Area.

The attributable fraction is greatest around Central London and Heathrow Airport.

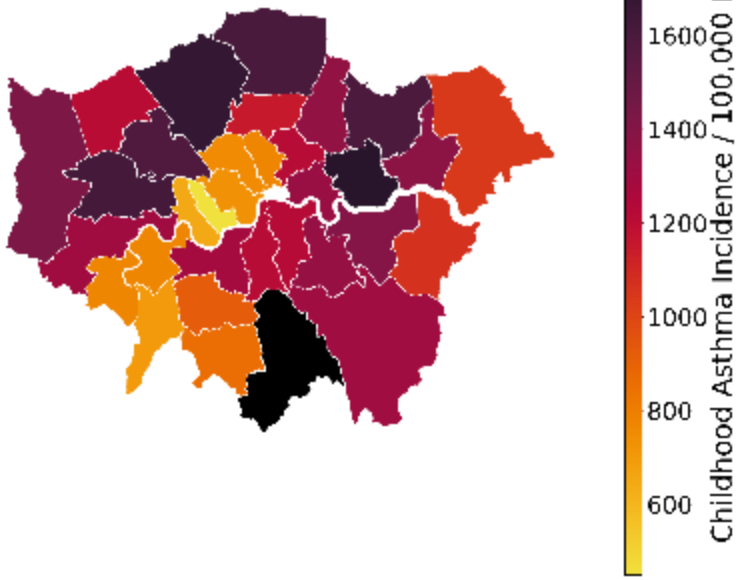
LSOA-level health burden calculations

We use 2021 UK census data for the LSOA-level populations of the five high-level ethnic groups: Asian, Black, White, Mixed and Other.

2021 UK Census Populations



2021 GBD childhood asthma incidence



Borough-level childhood (<20 yrs) asthma incidence from the Global Burden of Disease (GBD).

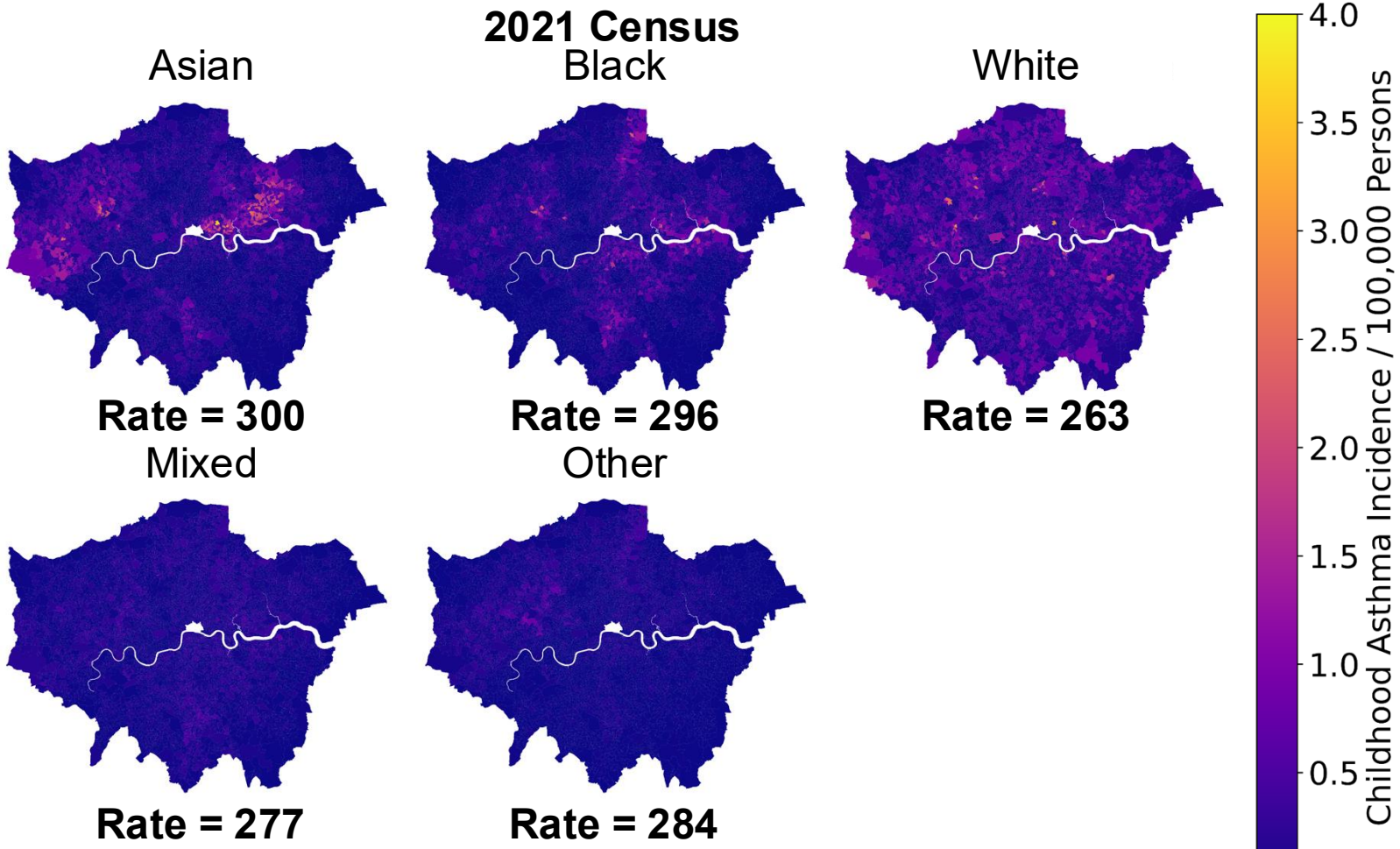
$$Asthma\ burden_{LSOA,\ Ethnic\ group} = AF \times incidence \times population_{LSOA,\ Ethnic\ group}$$

We calculate the burden of childhood asthma incidence for 2021 at the LSOA level for different ethnicities in London.

The same procedure can be applied to calculate the premature mortality burden.

Ethnic disparities in childhood asthma incidence in London

Childhood asthma incidence for high-level ethnicities in UK 2021 Census



Incidence is highest in the White population (1,854 per 100,000 people).

Rates of childhood asthma are highest in the Asian (300), Black (296), Mixed (277) and Other (284) populations.

This reflects the disparities in the literature.

Minoritised ethnic populations are disproportionately burdened by childhood asthma compared to the White population.

The Asian population bears the highest burden in London.

The Tower Hamlets Bangladeshi population experiences the highest asthma burden

The Bangladeshi population has the highest rate of childhood asthma in the Asian census tract.

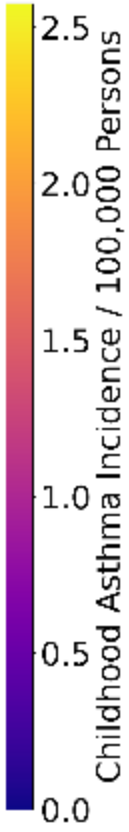
2 in 5 of childhood asthma incidences for the Bangladeshi population are in the London Borough of Tower Hamlets.

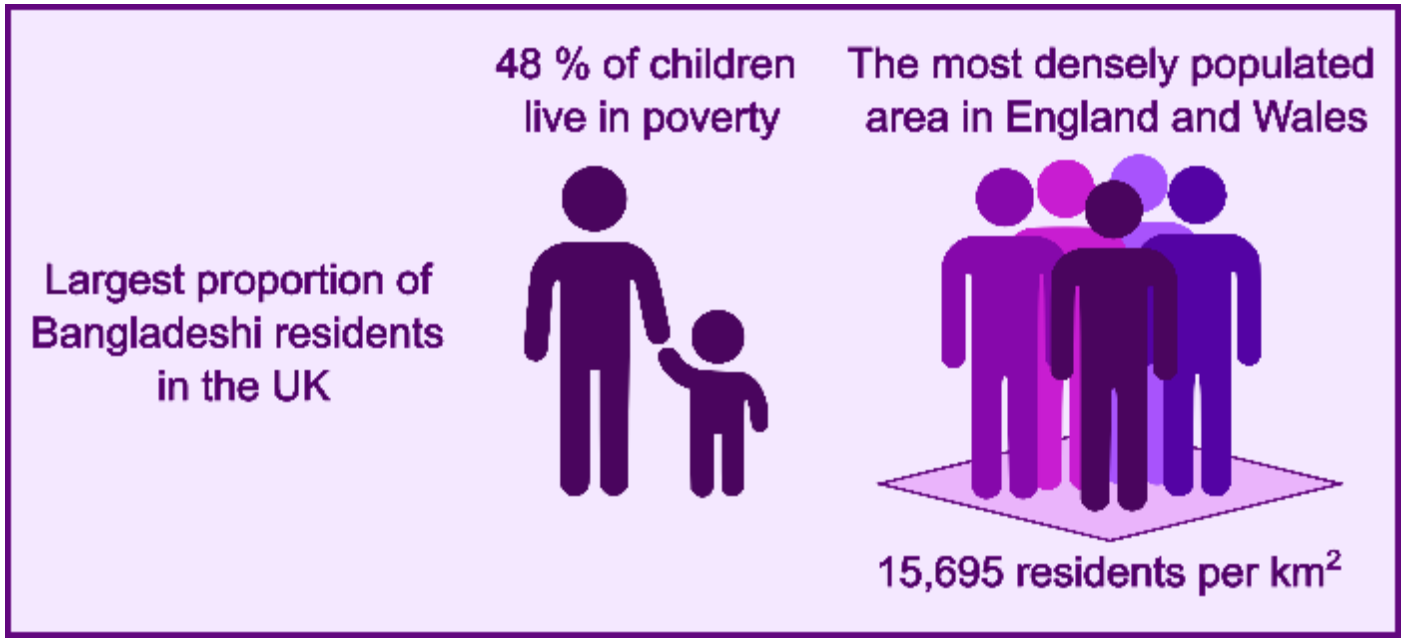
Bangladeshi asthma incidence

Greater London

Tower Hamlets LSOAs

◎ Monitoring site





There are **3 reference-grade monitoring sites** in Tower Hamlets.

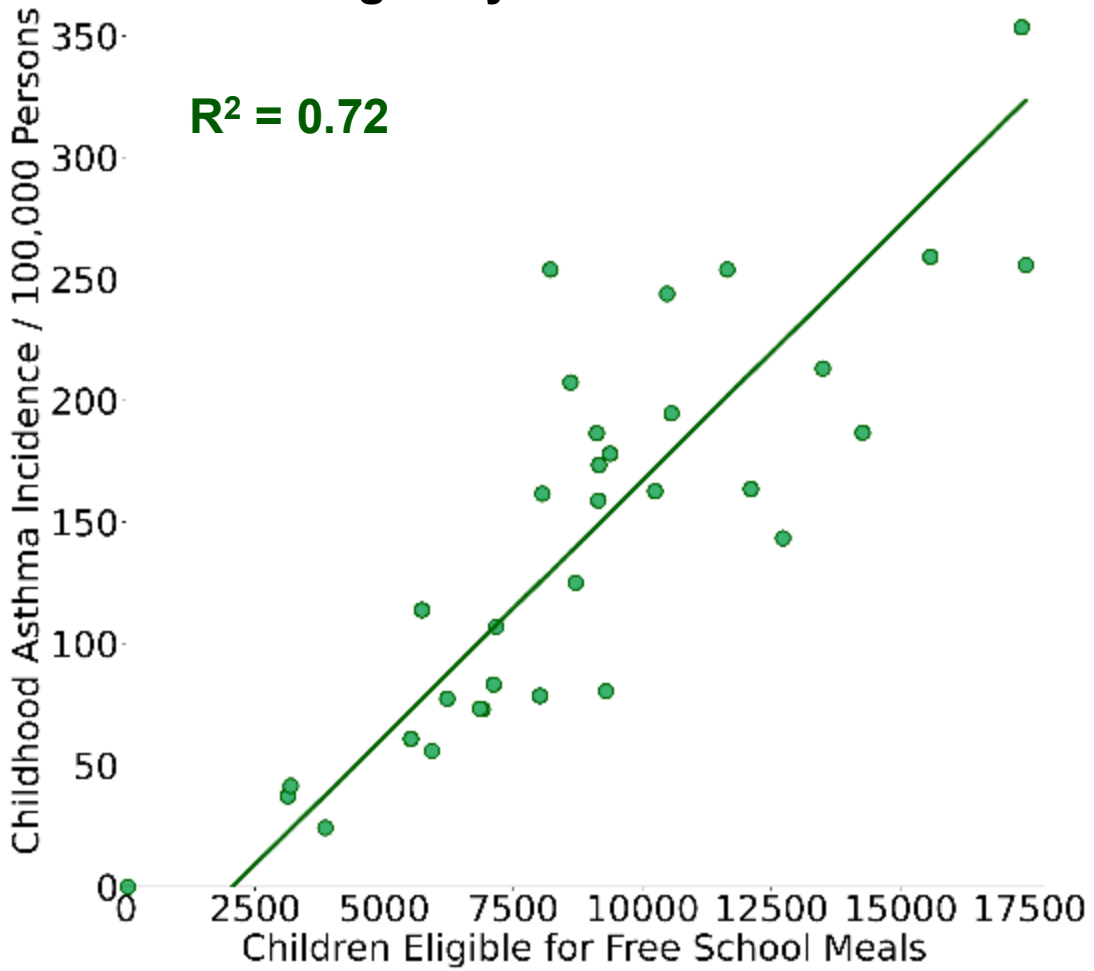
The communities most burdened by NO_2 exposure are not protected by local authorities or current air quality policies.

Deprived children are unequally burdened by asthma

Free school meal (FSM) eligibility is a deprivation indicator for children in the UK.

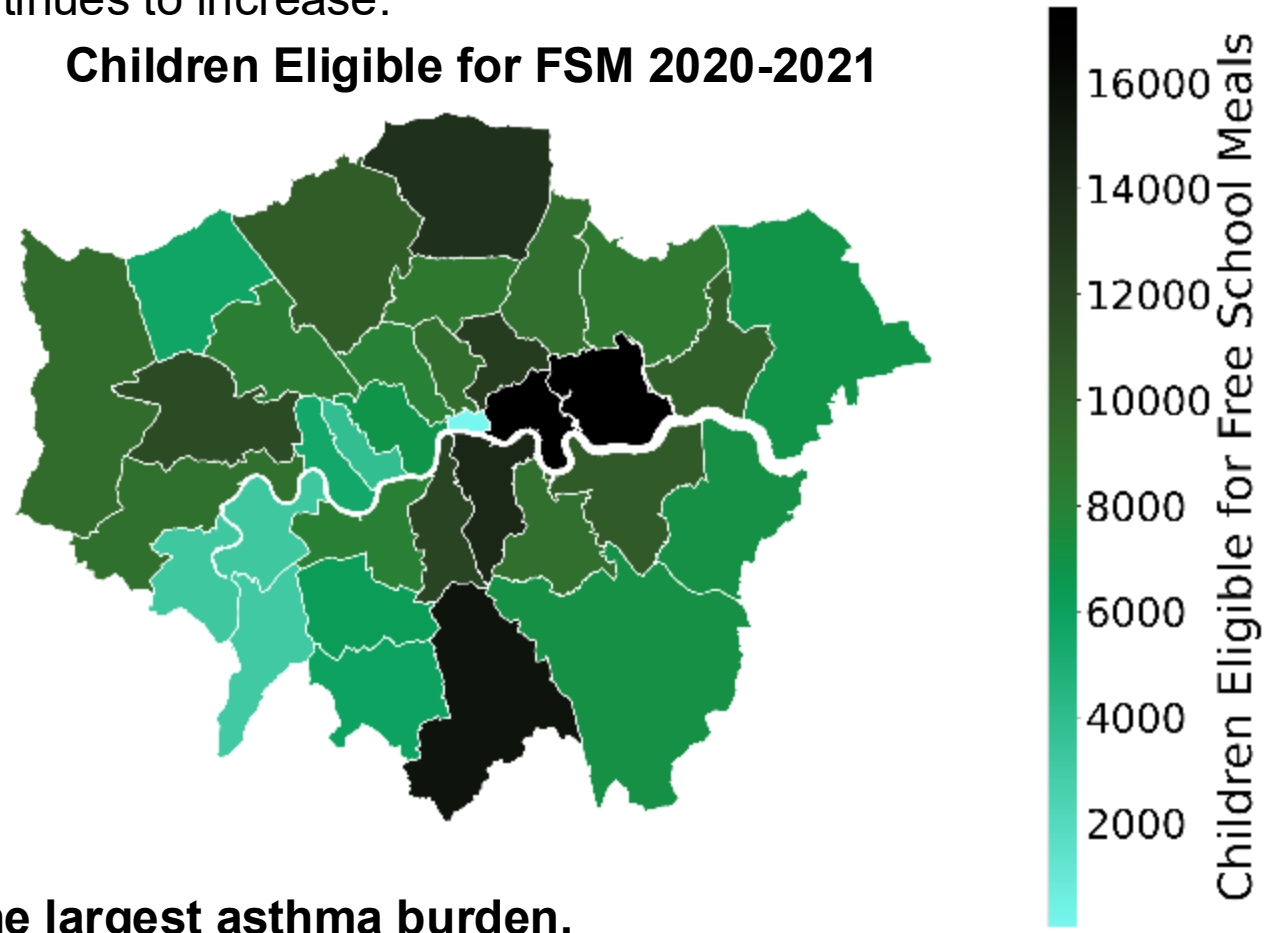
All children in state-funded schools whose parents receive benefits from the government are eligible for FSM.

FSM eligibility and asthma incidence



In 2020-2021 20.8% of pupils were eligible and this number continues to increase.

Children Eligible for FSM 2020-2021



The most deprived children in London experience the largest asthma burden.

Summary and further work

This is the **first calculation** of health disparities at an **LSOA scale** for London using **400 × 400 m TROPOMI derived surface NO_2**.

NO_2 exposure accounts for **14–29 %** of childhood asthma incidences.

The **Asian population is disproportionately burdened by childhood asthma**, followed by Black, Mixed and populations counted as other.

The **Bangladeshi population** in Tower Hamlets is the **most impacted**.

Deprived children experience the largest asthma burden.

Current London air quality policy is insufficient to address these disparities.

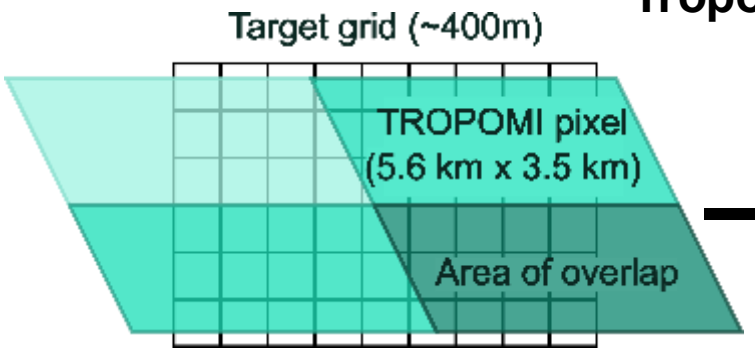
We are continuing to explore the link between deprivation and health disparities due to NO_2 exposure in London.

Ethnic minority groups are unequally burdened by premature mortality, with the **Black population** experiencing the highest burden.

Terrence Koena Sepuru has completed similar calculations for South Africa. **Go visit his poster! X5.106**

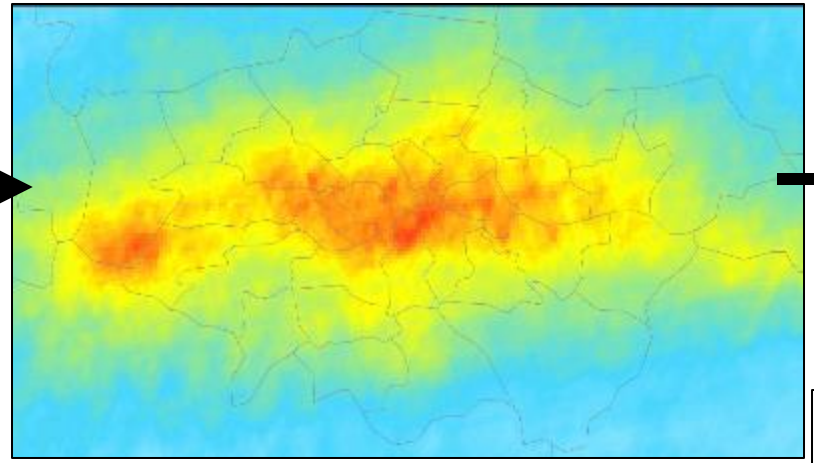
Questions, suggestions, comments, please contact me at: eleanor.smith.18@ucl.ac.uk

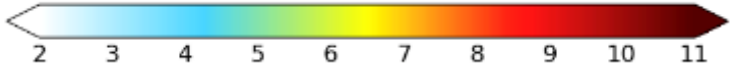
Derivation of NO_2 surface concentrations at 400 x 400 m



Oversample TROPOMI NO_2 columns from its native resolution.

Tropospheric NO_2 (multiyear mean 2018 – 2023)





[10^{15} molecules cm^{-2}]

Subtract uniform free-tropospheric NO_2 column of 50 pptv (cloud-sliced TROPOMI data from Horner et al. 2024).

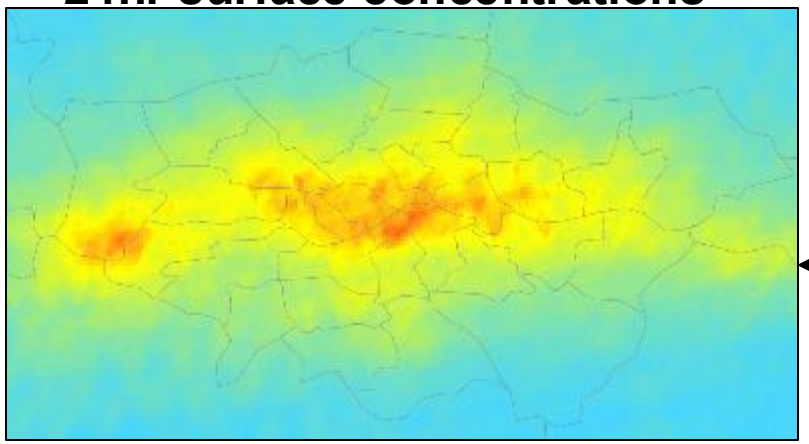
Boundary layer (partial) columns of NO_2

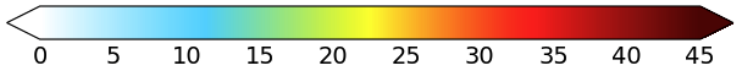
Surface concentration conversion: $\exp(0.21*\Omega) + 0.92$

Midday mean surface concentrations of NO_2

midday-to-24h ratio of 1.30

24hr surface concentrations





[$\mu g\ m^{-3}$]

Comparison of surface sites to TROPOMI derived NO_2