



Public Health  
England

# Air Quality around Schools

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On behalf of:

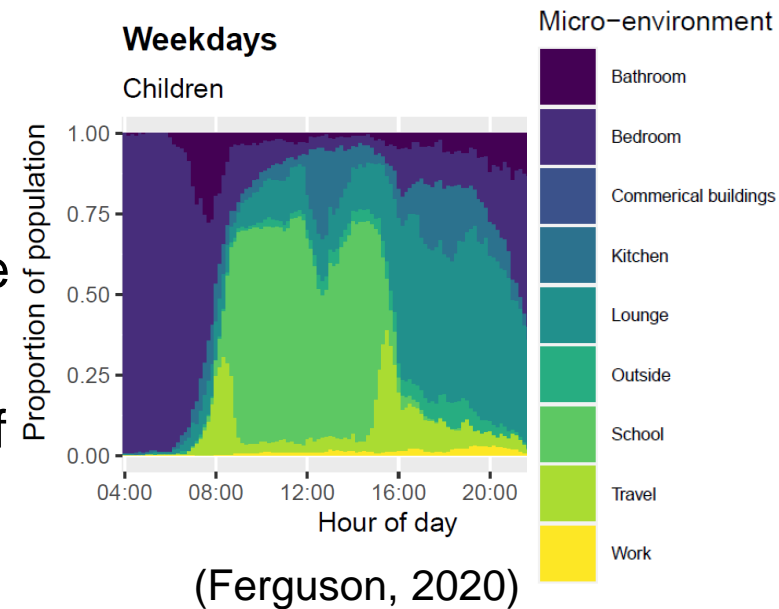
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## Background and Context

- Children are particularly vulnerable to the harmful effects of pollution exposure.
- Children spend a significant proportion of their time at school or commuting to school:
  - in the UK, **time at school is estimated at 25%** (Ferguson, 2020)
  - in England, around **47% of children (aged 5-16) walk or cycle to school, 36% are driven in a car or van** (DfT, 2019).  
UNICEF, 2019





## Current initiatives

In the UK, a number of recent local initiatives have focussed on the problem of poor air quality around schools:

- Installation of green walls and barriers
- ‘School Street’ road closures
- Dedicated school air pollution monitoring campaigns
- Clean air toolkits by local authorities (e.g. Mayor of London, 2018)
- Guidance for schools and communities by the University of Surrey, focussing on exposure mitigation (Kumar et al., 2020)
- Personal exposure studies, detecting real-time pollution exposure and while commuting



# Aims of our work

- The focus of this work was the **air quality around schools**
- **Part I:** Carried out a **literature review** to:
  - identify the key factors affecting air pollutant concentrations and exposure in outdoor school environments across high-income countries, and
  - identify gaps in the knowledge with a view to guide further work.
- **Part II:** **Mapping of school locations** to **air pollution concentrations**; production of **high-resolution air quality maps**; and **linking to inequalities data**



# Part I: Inclusion and Exclusion Criteria

## Included:

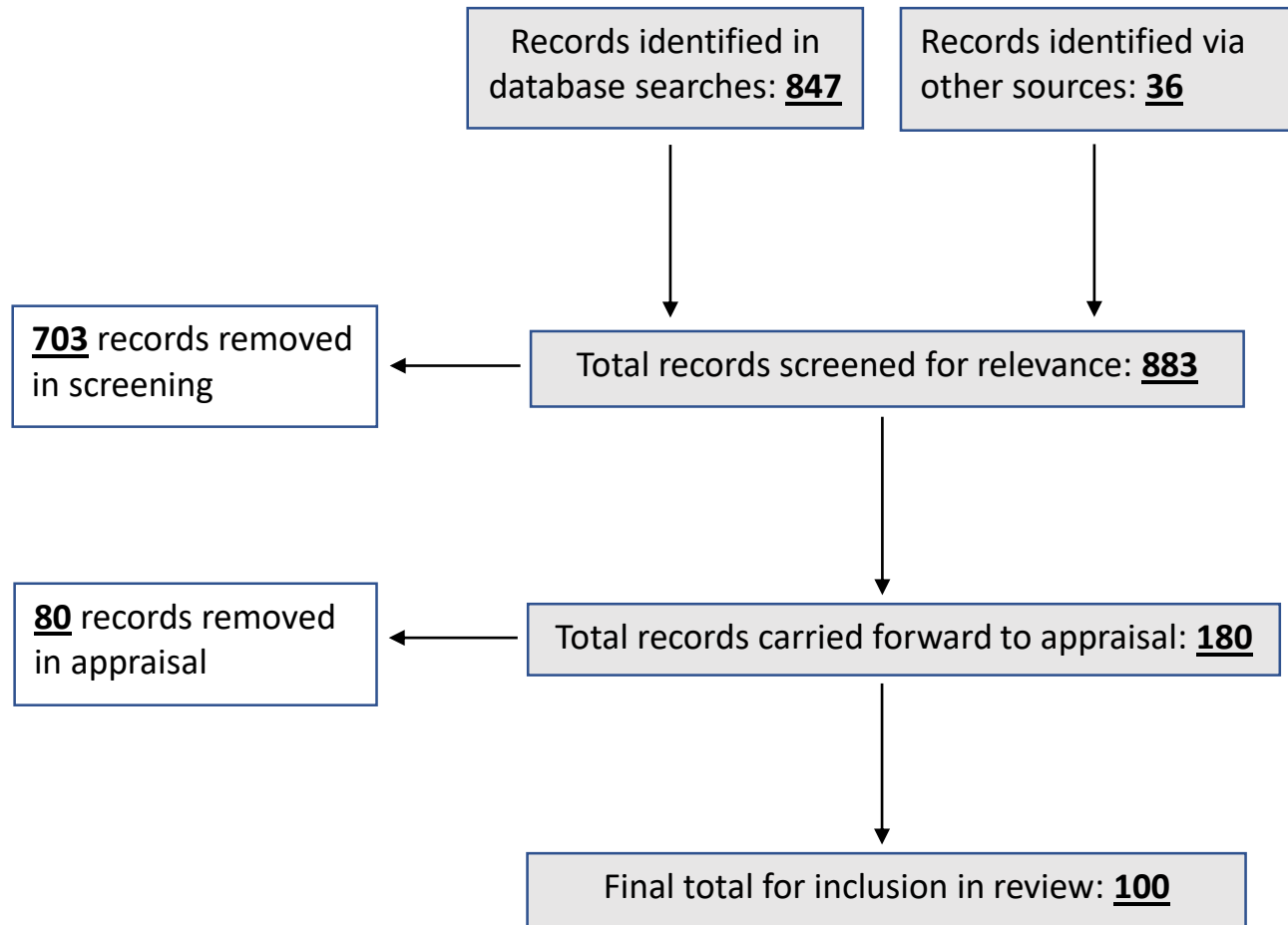
- Studies with **monitored** or **modelled** air pollutant concentrations,
- Studies focussed on **outdoor school environments** (including the commute to school by bus and car)
- Studies taken place in a **high-income country**.

## Excluded:

- Studies reporting **emissions** rather than actual concentrations around schools
- Studies focussed on the **indoor school environment**



# Screening and appraisal





# Summary of results (1/3)

- **Air pollution levels - UK studies:** substantial proportion of schools are in locations where ambient  $PM_{2.5}$  exceeds the WHO guideline of  $10 \mu g m^{-3}$  annual average, and ambient  $NO_2$  breaches the NAQS of  $40 \mu g m^{-3}$
- **Personal monitoring studies - High-income countries:** high exposure peaks while commuting to school commute, as well as in school playgrounds
- **Factors** influencing concentrations on school grounds:
  - **Nearby traffic:** proximity to traffic, traffic volume and traffic flow, bus idling
  - **Sandy** playgrounds and **high density of surrounding buildings** were associated with **high concentrations**
  - **Greenness** in and around school grounds was associated with **lower concentrations**





## Summary of results (2/3)

- Location – urban vs suburban:
  - Higher PM concentrations around urban schools, compared to suburban and rural schools.
  - Higher O<sub>3</sub> concentrations at suburban schools when compared to those in city centres.
- Walking to school:
  - Reduced exposure for children by walking on the quieter side of the road, or taking the back streets
  - Peak exposure for children walking close to traffic
- On school buses - USA Studies:
  - Bus cabins can trap pollutants; opening windows or installing retrofit interventions (e.g. in-cabin filters) can mitigate this build-up.





## Summary of results (3/3)

### ➤ Health effects:

Poor air quality outside schools, and on the commute, may be having a negative effect on children's health:

- particularly respiratory function
- cognitive development



UNICEF, 2019



## Research Gaps (1/2)

- Many studies focus on London (7 of the 14 UK publications)
  - No peer-reviewed study to quantify how many schools are located in **high air pollution** areas **across the country**.
  - No study to investigate how air pollution around schools relates to **socio-economic metrics** of disadvantage at a **national level**.

Osborne, S., Uche, O., Mitsakou, C., Exley, K., & Dimitroulopoulou, S.  
Air quality around schools: Part II - mapping PM2.5 concentrations and  
inequality analysis, *under review*.



## Research Gaps (2/2)

- **Personal monitoring studies** measure children's exposure to pollution throughout the day:
  - **Did not distinguish between outdoor and indoor school environments - reported an aggregate school exposure.**
  - Future personal exposure studies focussing on school environments should aim to separately estimate exposure in **indoor** and **outdoor school environments**, to enable most **effective mitigation strategies** – differ between indoors and outdoors.
- No evaluation of **low cost interventions** (monitoring before / after)
  - **Impact of:** anti-idling measures / landscape features (e.g. greenspace) / pedestrianisation initiatives / road closures / green barriers at schools



## Recommendations to mitigate exposure (1/4)

- **Clean air zones around schools:** through anti-idling campaigns, and the relocation of drop-off and pick-up points:
  - Already action in areas of the UK (Leeds City Council, 2020)
  
- **Green infrastructure:** greening of school grounds and surrounding areas
  - Wider evidence around the positive role that green infrastructure can play, on **ambient air quality** as well as co-benefits including **noise mitigation** and **improved mental health**
  - **Low VOC** and **pollen-releasing species** should be selected
  - Care should be taken to **avoid pollutant trapping** on the source side of the barrier.



## Recommendations to mitigate exposure (2/4)

- **School site selection:** Air quality-conscious selection of new school sites
  - School siting relative to busy roads is crucial when it comes to mitigating children's exposure
  - The anticipated transition to electric vehicles may mitigate it; particulates from traffic are likely to continue to be important, (AQEG, 2019).
  - While guidance on school siting exists from academic work; consideration should be given to be more formalised and standardised in school planning processes.



## Recommendations to mitigate exposure (3/4)

- **Active travel to and from school:** Walking and cycling on the school commute is known to provide health benefits, and reduces the amount of traffic and pollution around the school overall
- **Avoid major roads on the school commute:**
  - Maximise the distance between heavy traffic and those travelling to school
  - Take the back streets, and even just walking along the quieter side of the road
- **Playtime outside of rush hours:** Peaks in ambient pollutant concentrations coinciding with rush-hour traffic, with the morning peak being particularly important
  - Avoid these periods of high potential exposure for outdoor learning and playtime.



# Recommendations to mitigate exposure (4/4)

Follow a holistic approach:

- Measures aiming to reduce **emissions**,
- and those designed to **mitigate exposure** to pollutants already emitted,

should be **tackled simultaneously** using **multiple interventions and strategies** – **will be most effective** (PHE, 2019).



Review article

## Air quality around schools: Part I - A comprehensive literature review across high-income countries

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### ARTICLE INFO

**Keywords**

Outdoor air pollution  
School  
Children  
Exposure  
Commuting

### ABSTRACT

Children are particularly vulnerable to the detrimental health impacts of poor air quality. In the UK, recent initiatives at local council level have focussed on mitigating children's air pollution exposure at school. However, an overview of the available evidence on concentration and exposure in school environments - and a summary of key knowledge gaps - has so far been lacking. To address this, we conducted a review bringing together recent academic and grey literature, relating to air quality in outdoor school environments - including playgrounds, drop-off zones, and the school commute - across high-income countries. We aimed to critically assess, synthesise, and categorise the available literature, to produce recommendations on future research and mitigating actions. Our searches initially identified 883 articles of interest, which were filtered down in screening and appraisal to a final total of 100 for inclusion. Many of the included studies focussed on nitrogen dioxide (NO<sub>2</sub>), and particulate matter (PM) in both the coarse and fine fractions, around schools across a range of countries. Some studies also observed ozone (O<sub>3</sub>) and volatile organic compounds (VOCs) outside schools. Our review identified evidence that children can encounter pollution peaks on the school journey, at school gates, and in school playgrounds; that nearby traffic is a key determinant of concentrations outside schools; and that factors relating to planning and urban design - such as the type of playground paving, and amount of surrounding green space - can influence school site concentrations. The review also outlines evidence gaps that can be targeted in future research. These include the need for more personal monitoring studies that distinguish between the exposure that takes place indoors and outdoors at school, and a need for a greater number of studies that conduct before-after evaluation of local interventions designed to mitigate children's exposure, such as green barriers and road closures. Finally, our review also proposes some tangible recommendations for policymakers and local leaders. The creation of clean air zones around schools; greening of school grounds; careful selection of new school sites; promotion of active travel to and from school; avoidance of major roads on the school commute; and scheduling of outdoor learning and play away from peak traffic hours, are all advocated by the evidence collated in this review.





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# Air quality around schools:

## Part II - Mapping PM<sub>2.5</sub> concentrations and inequality analysis

Part II is currently under review – **unpublished results**



## Aims of Part II

- We used modelled annual mean concentrations of  $PM_{2.5}$  and  $NO_2$ , and monitoring data, to evaluate how many schools in England are co-located with poor air quality.
- We assessed the limitations of our methodology by carrying out a sensitivity analysis using part of high-resolution air pollution data generated using a data extrapolation method.
- We linked the modelled annual mean  $PM_{2.5}$  data at school locations to inequality metrics, to investigate whether pupils with socio-economic disadvantage are more likely to attend school in high pollution areas



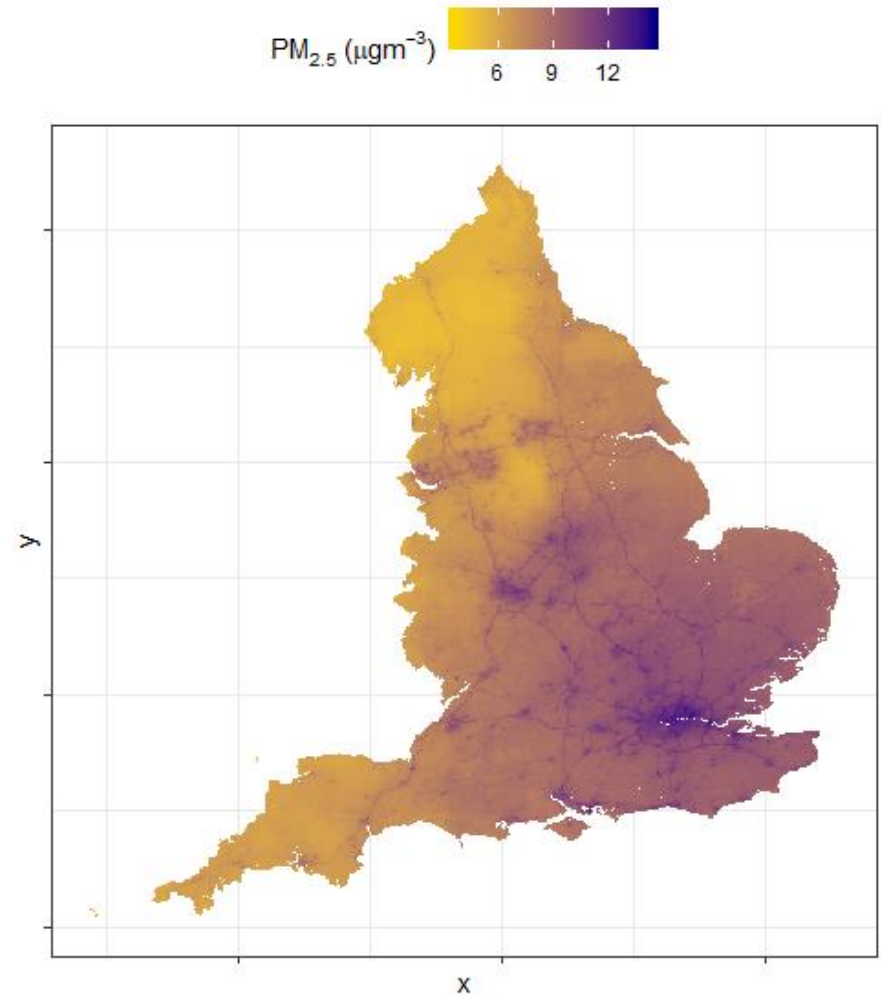
## Mapping of PM<sub>2.5</sub> and NO<sub>2</sub> to school locations

- Maps with annual mean concentrations (1km x 1km) for PM<sub>2.5</sub> and NO<sub>2</sub> for 2017 were downloaded from the UK-Air website (Defra, 2019)
- School coordinates for England, correct as of January 2020 were intersected (DfE, 2020).
- **Definition of school:** state-funded establishments providing education up to the age of 18: incl. special educational needs schools, pupil referral units, state-funded nurseries, and post-16 colleges.
- Pollution concentration maps and school coordinates were intersected in **geospatial packages within R software.**



## Results for England

- Current  $PM_{2.5}$  annual mean national air quality standard of  $25 \mu\text{g m}^{-3}$  was not exceeded by any school
- Maximum annual mean of  $14.4 \mu\text{g m}^{-3}$  (2 primary schools in Solihull)
- 7,801 (out of 22,523) schools representing 3,343,536 pupils were co-located with levels higher than the WHO  $PM_{2.5}$  annual mean of  $10 \mu\text{g m}^{-3}$



*Annual mean  $PM_{2.5}$  ( $\mu\text{g m}^{-3}$ ) concentrations across England at 1km x 1km, for 2017.*

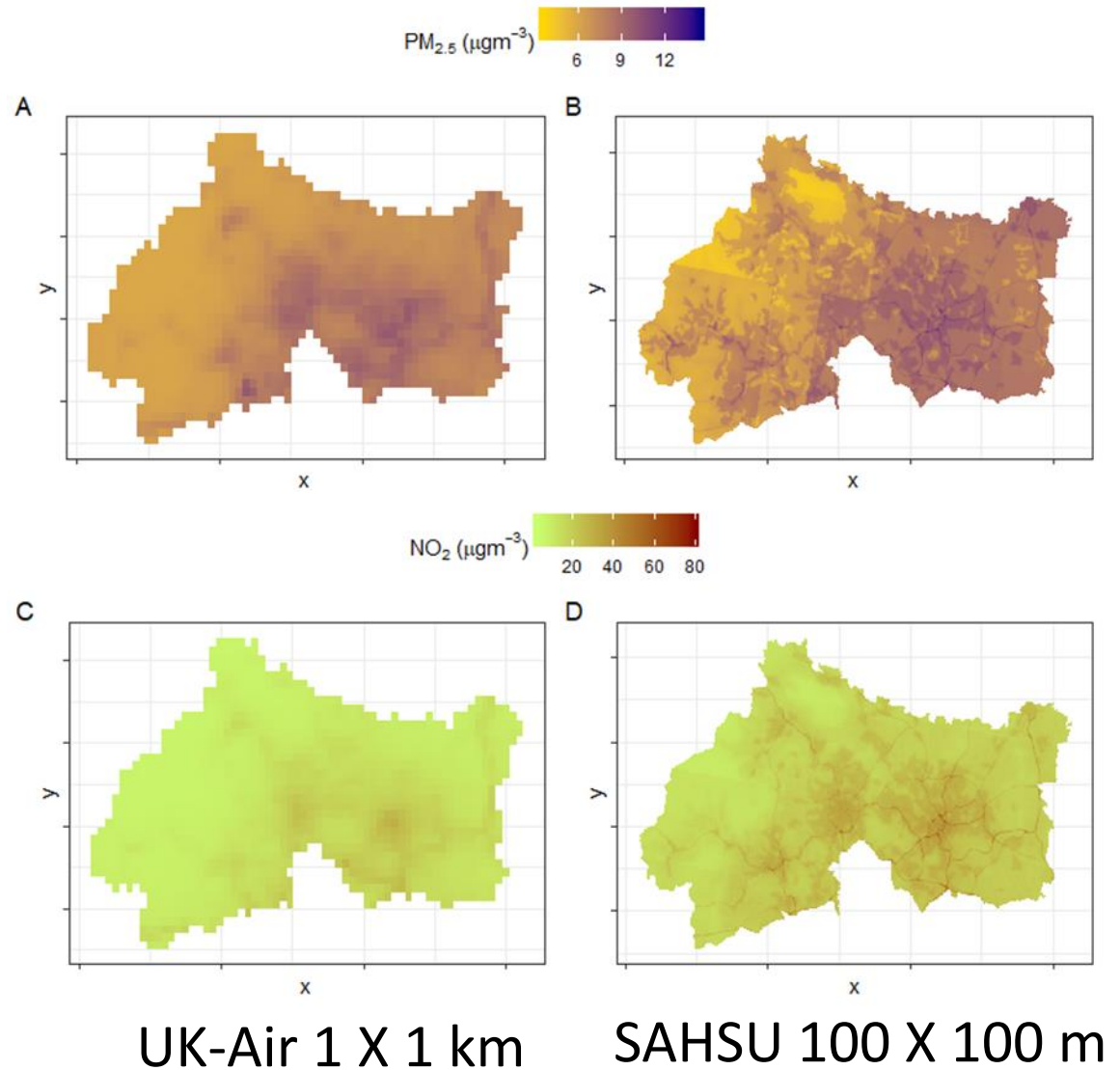


## Sensitivity analysis

- Limitation of maps with annual mean concentrations for  $PM_{2.5}$  and  $NO_2$  is their **relatively low resolution** at 1km x 1km, introducing error into our estimates of school concentrations, by smoothing variation in local concentrations.
- We tested the limitations, comparing UK-Air maps against **high-resolution (100m x 100m)  $NO_2$  and  $PM_{2.5}$**  data published by the Small Area Health Statistics Unit (SAHSU) (De Hoogh, 2019).
- Due to **computational and resource limitations**, we carried out the extrapolation method on three northern local authorities:  
**Leeds, Bradford, and Calderdale.**



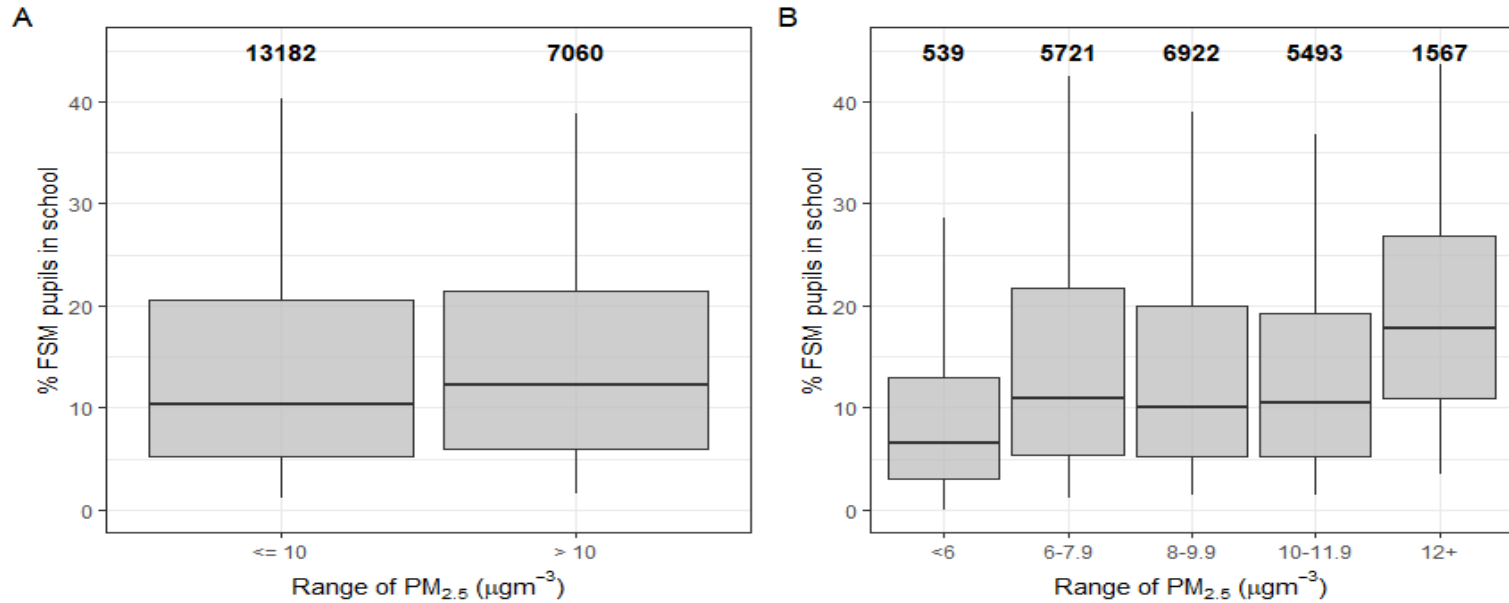
- Modelled  $PM_{2.5}$  maps (1km x 1km) can reasonably estimate concentrations around schools,
- Modelled  $NO_2$  maps (1km x 1km) could substantially underestimate true concentrations around schools
- $PM_{2.5}$  data applied in national mapping



*Modelled air pollution maps for 2017 across  
Leeds, Bradford and Calderdale LAs*



# PM<sub>2.5</sub> around schools and deprivation (1)

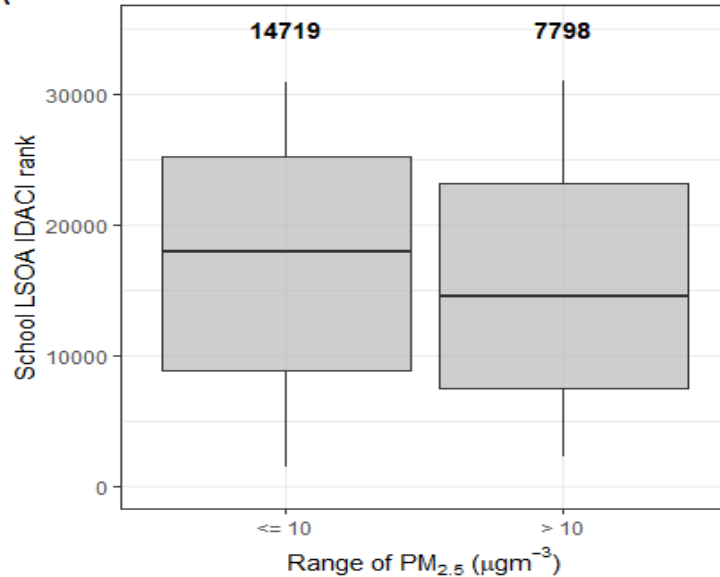


- Schools located at PM<sub>2.5</sub> **below** the WHO annual mean of 10 µgm<sup>-3</sup> have a **lower median %FSM** compared to schools in locations with PM<sub>2.5</sub> above the WHO guideline,
- Schools with the **lowest levels of PM<sub>2.5</sub>** have a **particularly low median %FSM (6.5%)**, while schools with the **highest levels** have a **particularly high median %FSM (17.8%)**, compared to the national median %FSM of 10.9%.

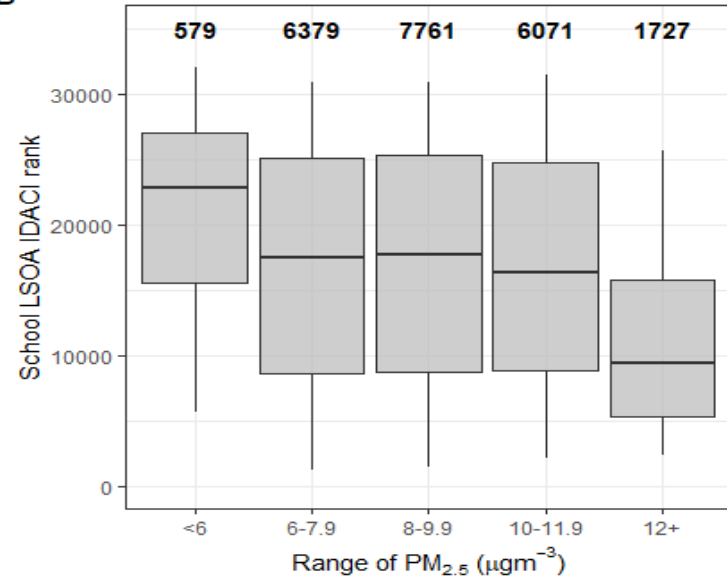


# PM<sub>2.5</sub> around schools and deprivation (2)

A



B

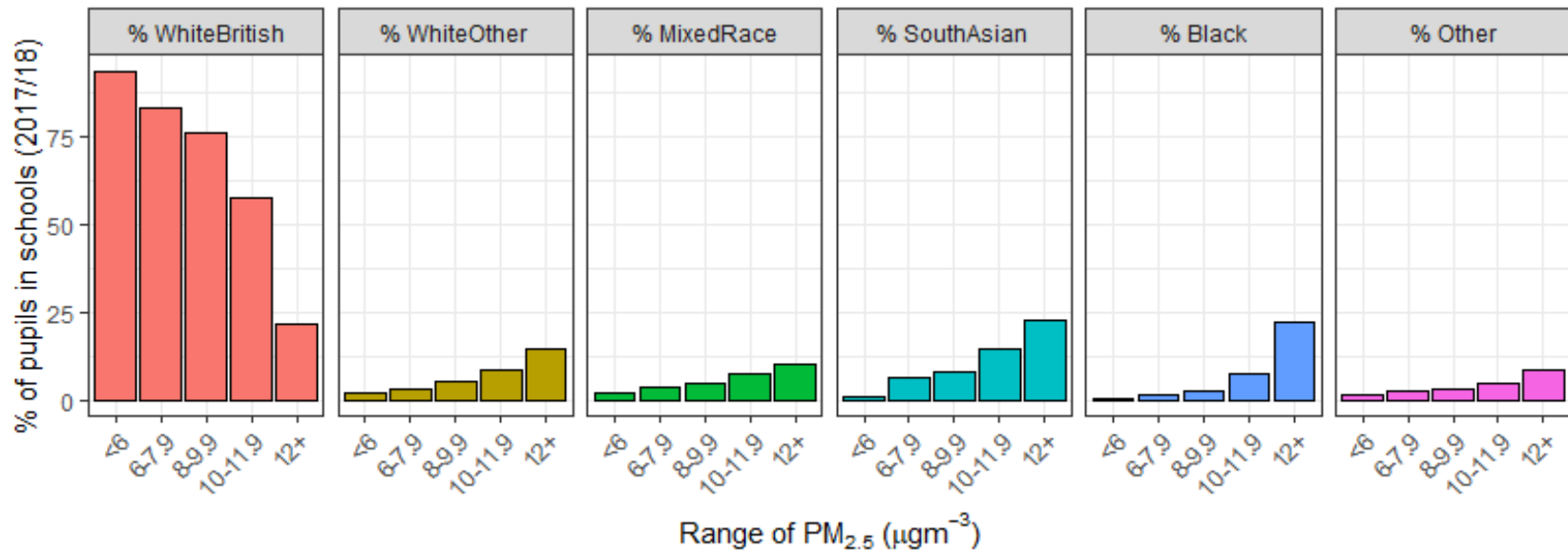


- Schools in higher annual mean PM<sub>2.5</sub> concentrations tend to be in LSOAs with a lower IDACI rank (i.e. higher child deprivation).
- Schools with higher annual mean PM<sub>2.5</sub> concentrations are more likely than low PM<sub>2.5</sub> schools to have a high deprived pupil intake and are more likely to be located in neighbourhoods with high levels of child income deprivation.





# PM<sub>2.5</sub> around schools and ethnicity



- Proportion of pupils with ethnic background (2017/2018):  
*White British (66.8%), White Other (6.7%), Mixed Race (5.8%), South Asian (11.1%), Black (5.7%), and other ethnic backgrounds (5.7%)*
- Schools in low annual PM<sub>2.5</sub> mean concentrations in 2017 tended to have a large majority of white British pupils
- Schools with higher annual mean PM<sub>2.5</sub> concentrations tended to be more ethnically diverse.



## Conclusions

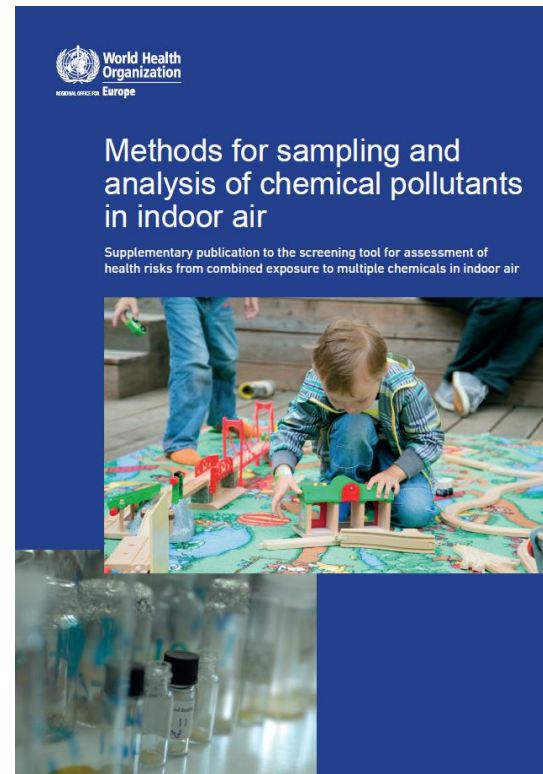
- Part II addressed two key evidence gaps identified in the review:
  - the lack of an **England-wide assessment of air quality outside schools**,
  - the lack of **analysis of air pollution levels in association with inequality metrics**.
- The analysis highlights that:
  - **large number of children** (in approximately one third of schools - 7,801) **in England are experiencing poor air quality outside their school**;
  - **this happens disproportionately for children from low-income families and ethnic minority backgrounds**.
- **The new data may help target resources to schools with poorer air quality and high numbers of socio-economically disadvantaged pupils.**



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# World Health Organisation (WHO)

## Development of a tool to assess the cumulative risks from indoor air pollutants in public settings for children - *on-going project*



<https://apps.who.int/iris/handle/10665/334389>



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***Thank you!***

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