Socio-economic impacts of air quality

IAPSC

The Priory Rooms, Birmingham

Presentation by

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OR
Environmental Injustice and Social Inequalities of Air Pollution Exposure and Generation

Highlights

- A 16-year update on the first UK environmental justice air quality study (Mitchell & Dorling, 2003)
- Emissions for private vehicles are attributed to census area of registered keeper
- Social inequalities in traffic-related pollution exposure are clearer and stronger
- Young children, adults, and households in poverty have highest levels of exposure
- A strong inverse relationship was found between poverty and emissions generation

Introduction

Mitchell & Dorling (2003)

- Mitchell G, Dorling D, 2003, An environmental justice analysis of British air quality, *Environment and Planning A*, 35(5) 909 – 929
- First EJ and AQ study in the UK
- Ward level analysis of NO_2 concentrations (1999) and NOx emissions against:
  - Age deciles
  - Poverty (Breadline Britain Index – BBI (Gordon & Pantazis, 1997))
  - Car ownership
- 1991 Census

EPSRC award EP/K000438/1, 2012-15,
http://gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=EP/K000438/1

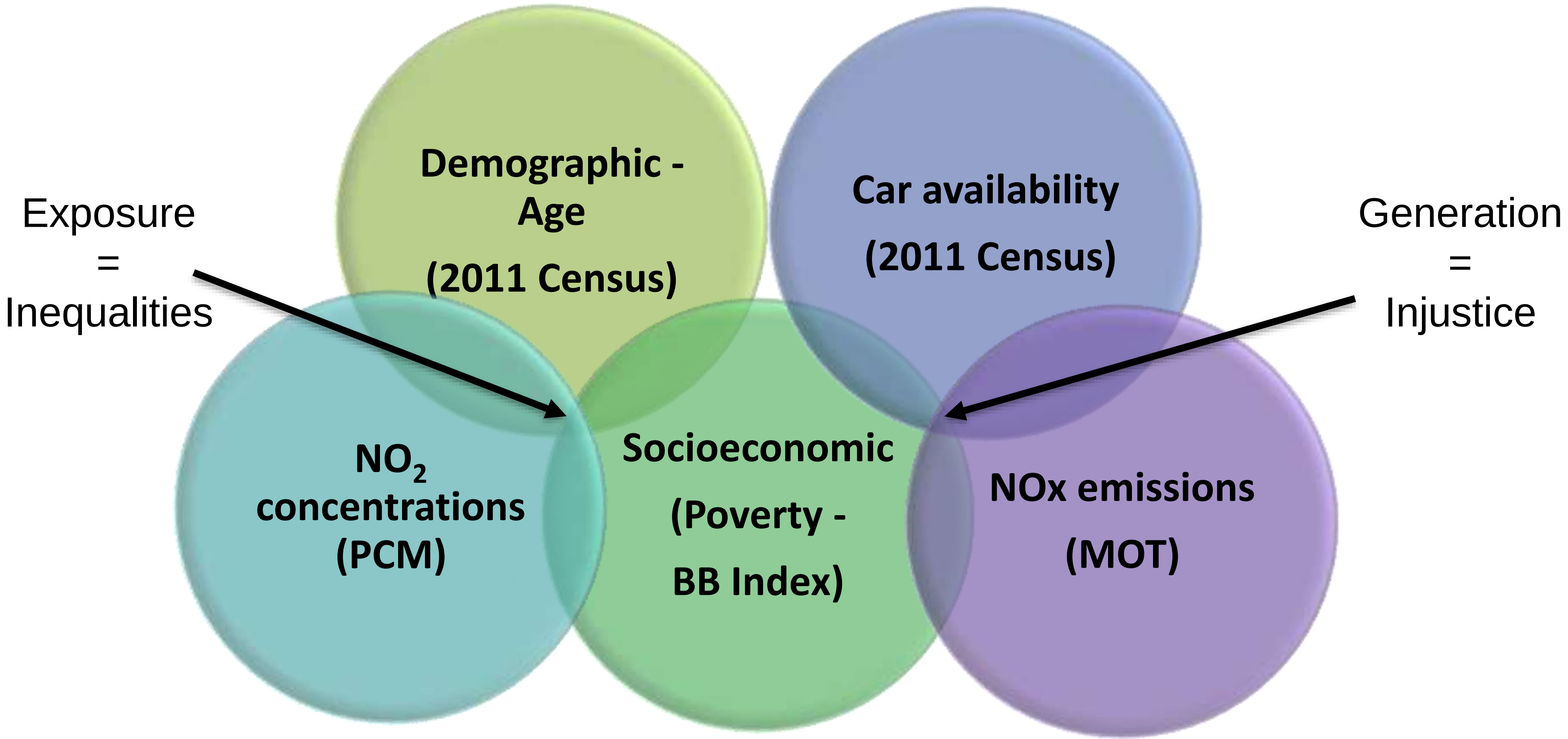
MOT

Motoring and Vehicle Ownership Trends in the UK

MOT (Ministry of Transport) test

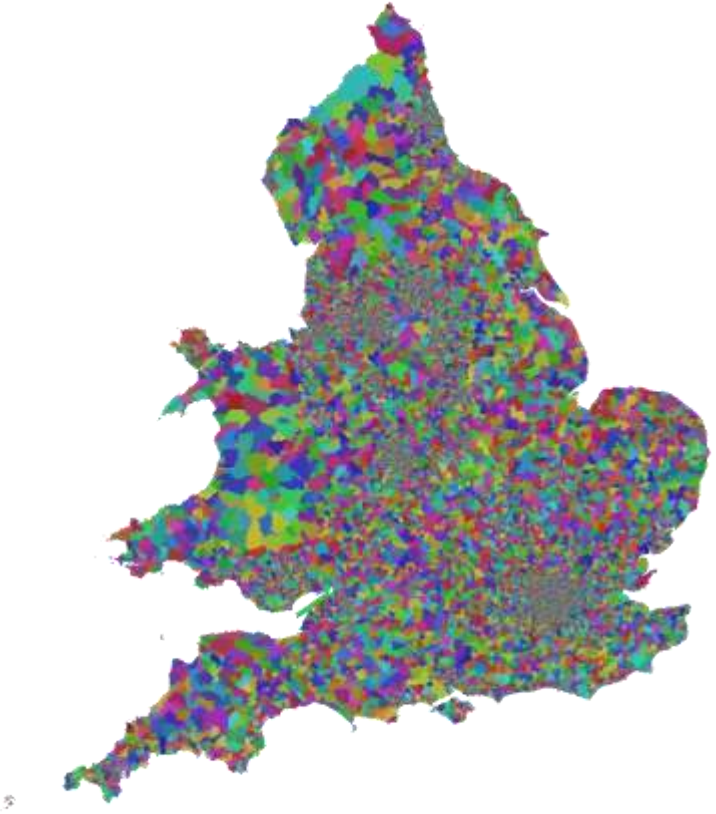
- UK’s annual safety inspection for all road vehicles >3 years old
- Since 2005 results have been captured and stored digitally
- In November 2010, Department for Transport published the first 5 years of this data online
- 35,000,000 vehicle tests each year
- >160 million data points!

Methodology


Exposure
=
Inequalities
Demographic -
Age
(2011 Census)
Car availability
(2011 Census)
Generation
=
Injustice
NO_2
concentrations
(PCM)
Socioeconomic
(Poverty -
BB Index)
NOx emissions
(MOT)

Study area & scale of analysis

- England and Wales
- Lower Super Output Areas (LSOAs)
  - 34,753 LSOAs
    - ~700 households (range 400-1200)
    - ~1600 residents (range 1000-3000)
  - ~ consistent population size
  - uniformity of socioeconomic characteristics



Calculation of Emissions/Fuel Use

MOT Dataset

- Odometer Reading and Date of Test
- Calculate annual mileage using straddle dates (Wilson et al. 2013)
- Engine size/Fuel type/Date of first registration

Fuel Usage

- Figures by year and engine size from www.cso.ie
- Alt. fuel from www.carfueldata.gov

Emission Factors

- UWE ECOstars project (Barnes and Bailey, 2013)
- Copert 4 (v8.1), TRL (2009) for petrol and diesel
- NAEI (2013), EMEP/EEA (2013) for alt. fuel

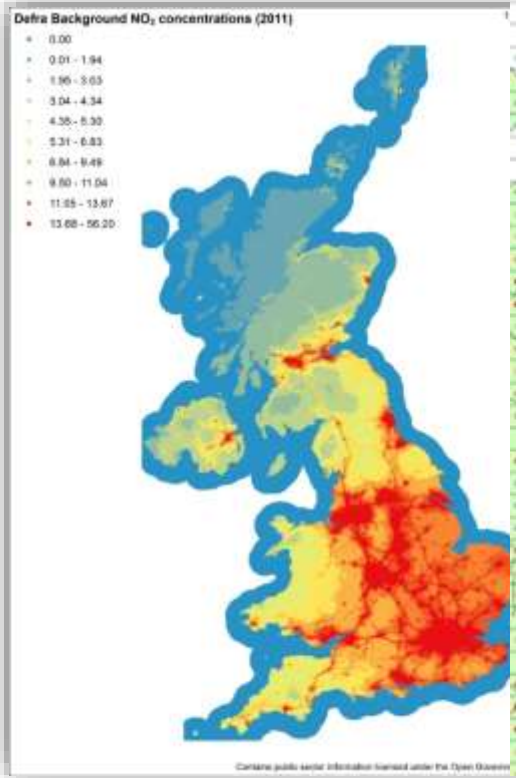
Vehicles <3 years old (7.8% private vehicles) interpolated from distance driven between date of first registration and recorded mileage at first test

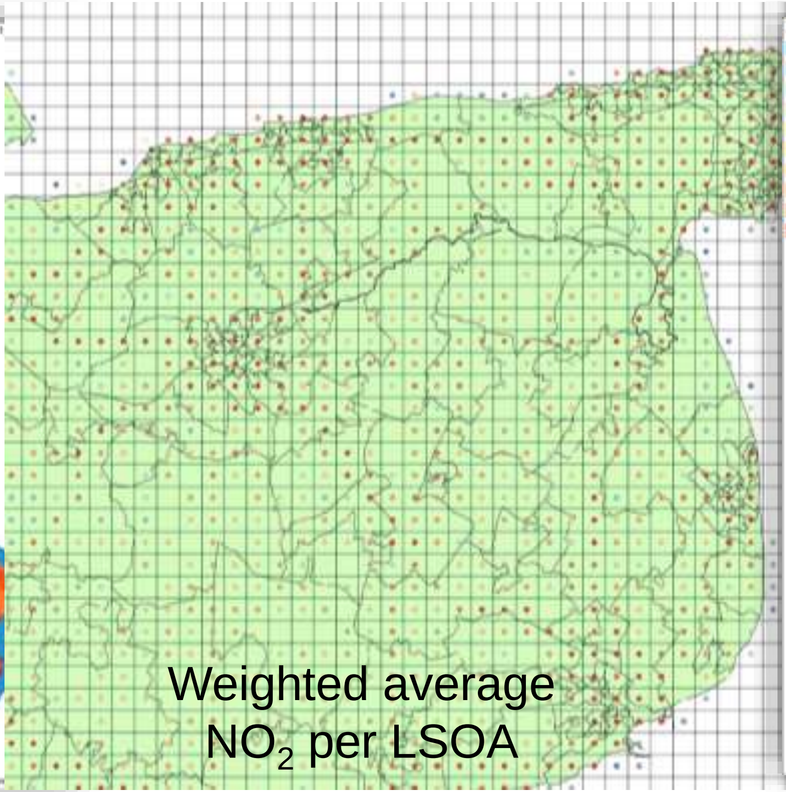
Chatterton et al. (2015)

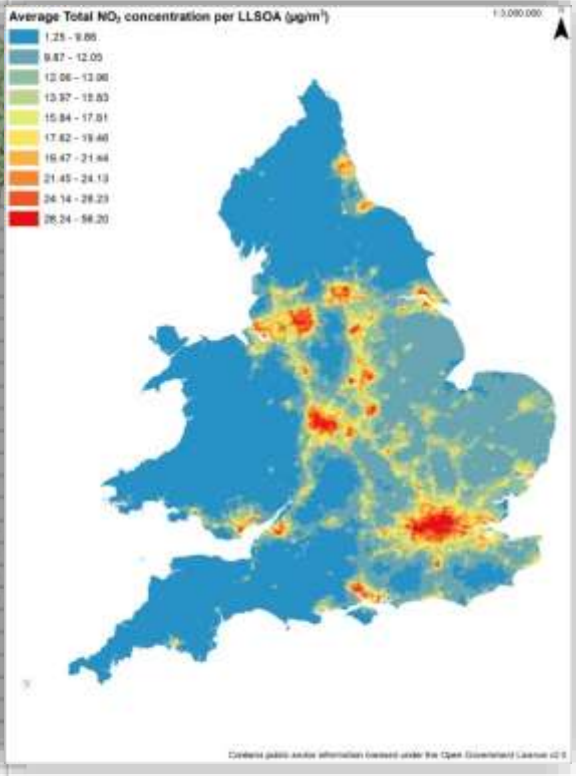
Emissions methodology

- Date of first registration was used to estimate specific emission factors for each and every vehicle
- Multiplied by the annual distance driven by that vehicle (recorded mileage)
- Vehicles located by the LSOA of the registered keeper so a profile for an average car within each LSOA was generated
- Data on household car ownership (2011 Census) used
- NO_x and PM_{10} emissions (total and average) calculated for all privately-owned vehicles (up to 3.5 tonnes) in each LSOA in the UK ($n \approx 27$ million)

NO_2 concentrations by LSOA







Exposure vs. Emissions

- Average NO_2 concentrations per LSOA are used to estimate exposure of households within those areas, i.e. *who* is being exposed.

- MOT-derived emissions from private vehicles are used to attribute vehicle emissions to the location of the driver (or more precisely the registered vehicle keeper) i.e. *who* is generating the emissions, not *where* these emissions happen.

Poverty by LSOA (Breadline Britain Index)

- 21.7% of Households with access to no car/van*
- 20.3% of total HHs not in owner-occupied housing
- 16.0% of Lone-parent HHs
- 15.9% of the total HHs whose head was in social classes IV & V.
  - Household Reference Person in NS-SeC categories equivalent to Social Classes IV (semi-skilled) (L11.2, L12.2, L12.4, L12.5, L12.7,L 13.1, L13.2, L13.5) and V (unskilled) (L13.4)
- 9.4% of HHs headed by unemployed workers (NS-SeC category 8)
- 10.8% of total HHs with person with long-term limiting illness

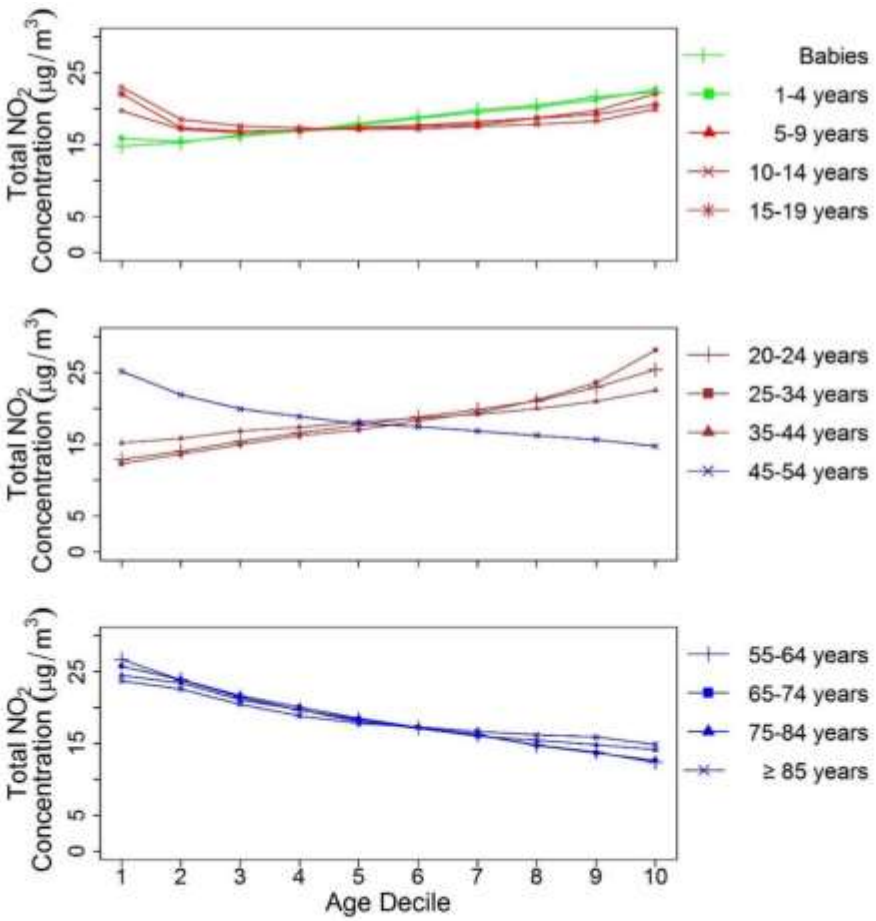
** "the weakest direct relationship with car ownership of any of the common deprivation measures"* (Mitchell & Dorling, 2003)

[adapted from Gordon & Pantazis (1997)]

Results

Exposure vs. Age

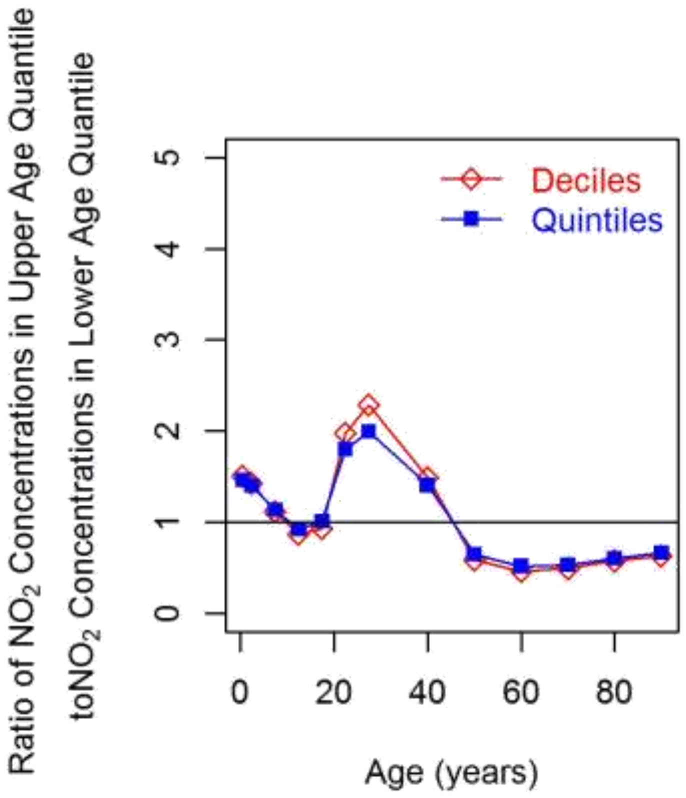
- Average annual mean NO_2 concentrations by age profile.
- Age decile 1 = 10% LSOAs with the lowest proportion of an age group.
- Age decile 10 = 10% LSOAs with the highest proportion of an age group.
- Under-fives and adults aged 20 to 44 have higher NO_2 concentrations.
- Areas with more over-45s tend to have better air quality.



UWE Bristol University of the West of England

Exposure vs. Age

- Ratio of NO_2 concentrations between highest and lowest quantiles in each age band
- If ratio >1, exposure is higher than average for the population
- Younger children (<5 years) and adults (in their 20s and 30s) have higher NO_2
- Older children (10-20) and adults (>50) are associated with lower NO_2
- NO_2 concentrations in areas with more young adults are two times the average



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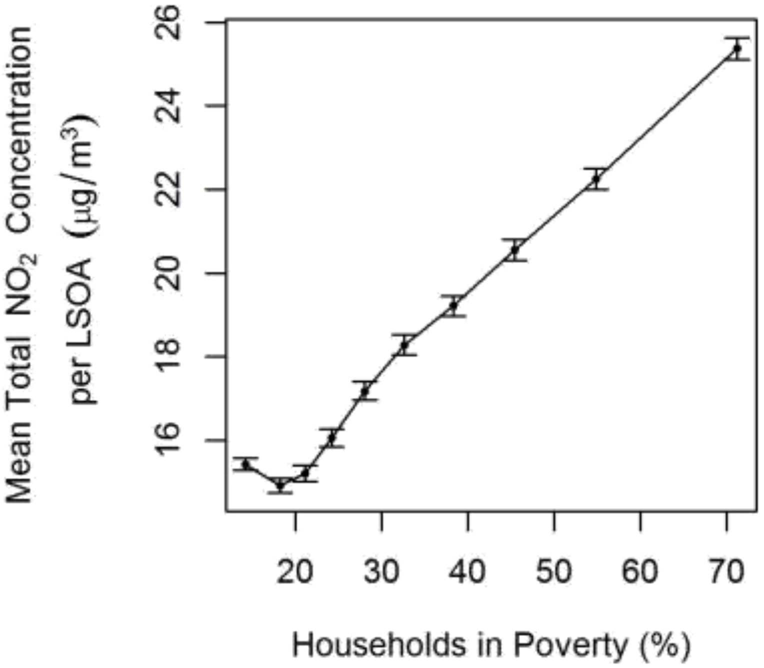
Exposure vs. Poverty

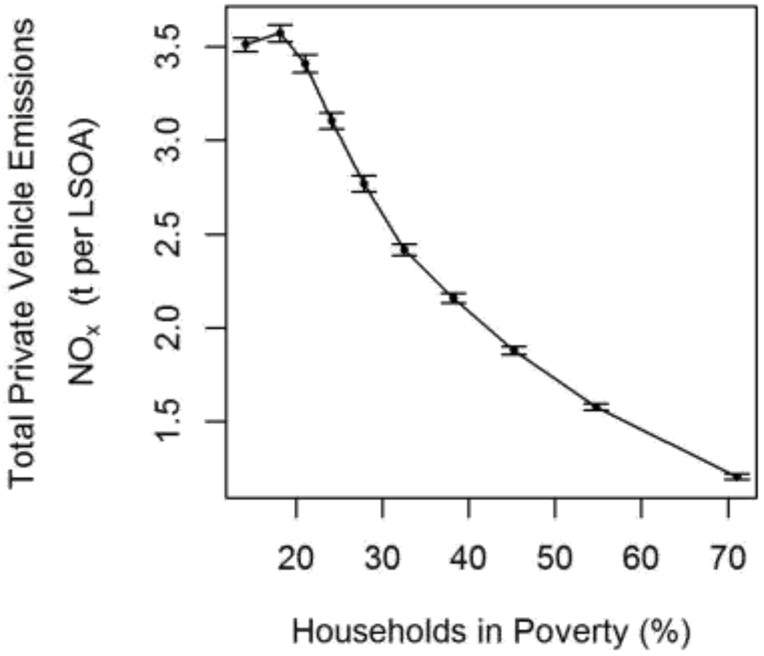
- Exposure to NO_2 concentrations against % households in poverty within an LSOA
- In lowest decile (i.e. 10% LSOAs with the lowest proportion of households in poverty) average concentrations are <16 μg/m³
- In highest decile (i.e. 10% LSOAs with the highest proportion of households in poverty) average concentrations are >25 μg/m³
- Clear social inequality in exposure to NO_2 (>50% difference) - same relationship for PM_{10}



Error bars = 95% confidence intervals (CIs).

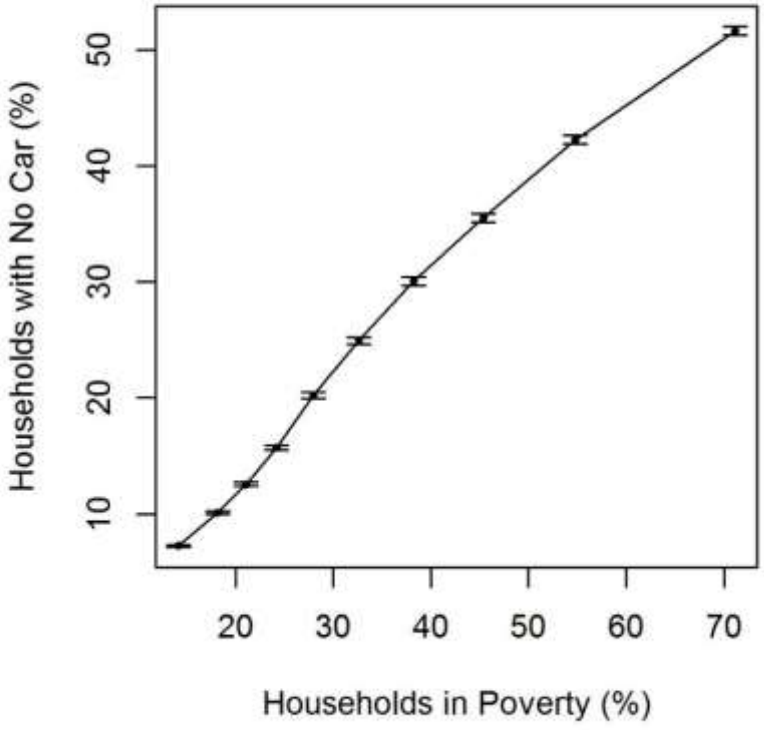
Generation vs. Poverty

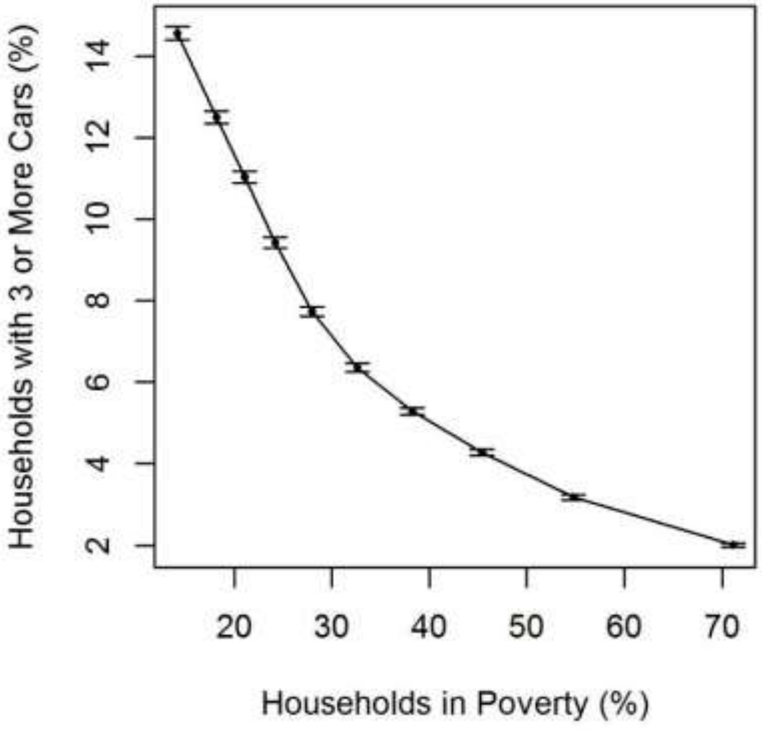
- NO_x emissions from private vehicles against % households in poverty within an LSOA
- In lowest decile (i.e. 10% LSOAs with the lowest proportion of households in poverty) average private vehicle emission per household are ~3.5 t per LSOA
- In highest decile (i.e. 10% LSOAs with the highest proportion of households in poverty) average private vehicle emission per household are ~1 t per LSOA
- Households in the poorest areas emit the least NO_x (and PM), whilst HHs in the least poor areas emitted the most



Error bars = 95% confidence intervals (CIs).

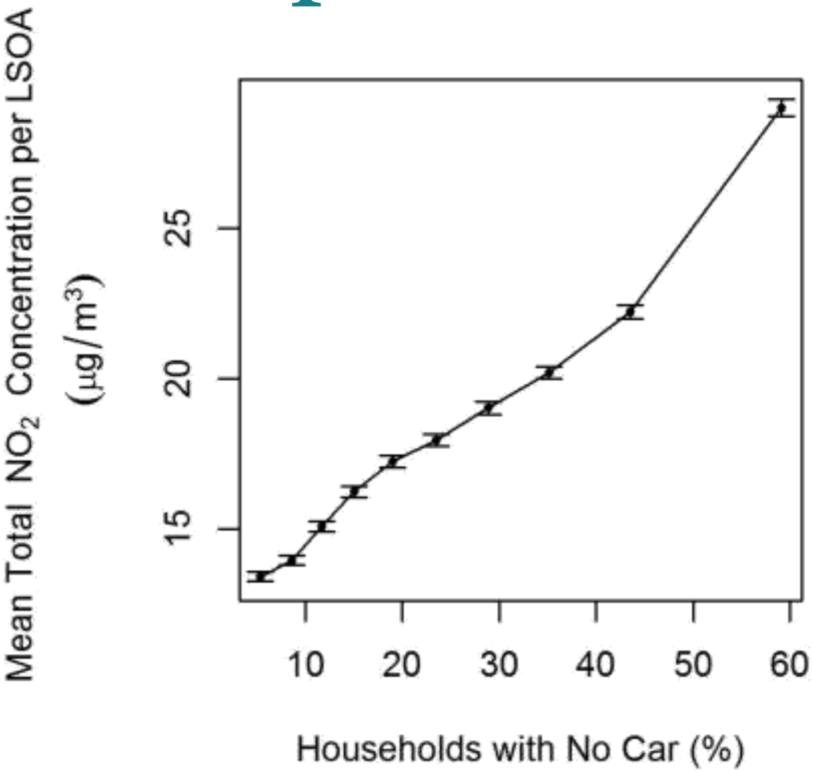
Access to a car vs. Poverty

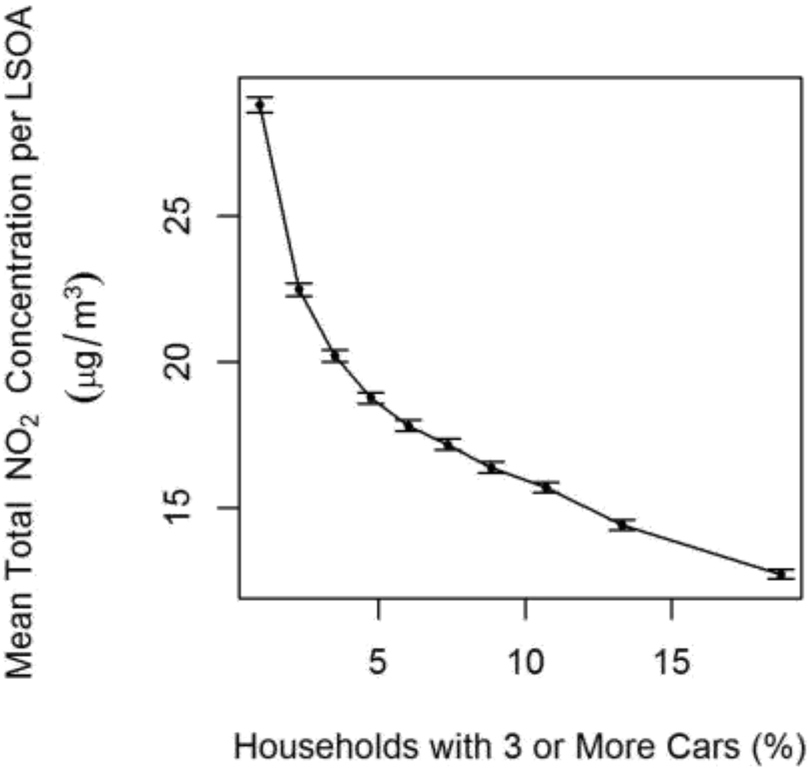




Error bars = 95% confidence intervals (CIs).

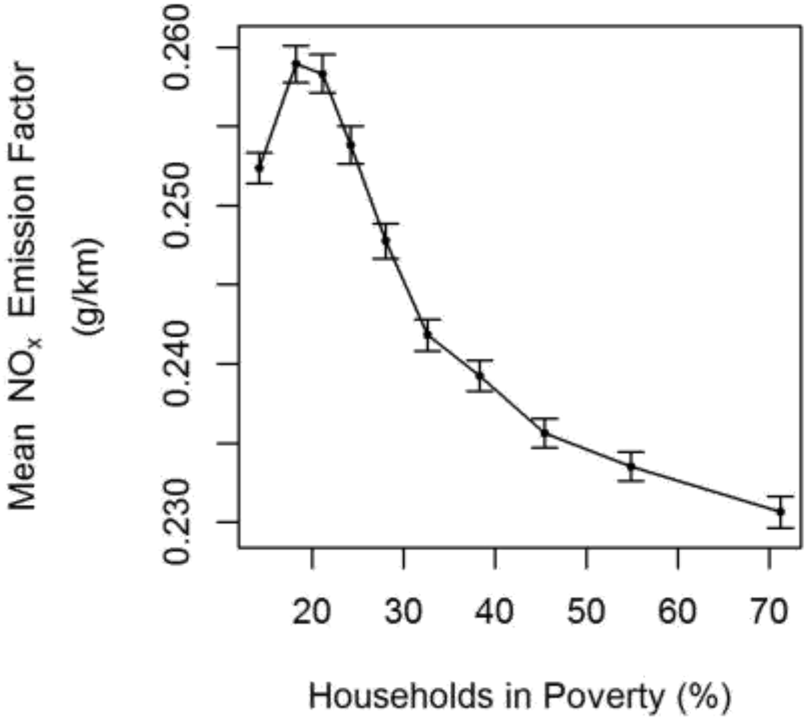
Exposure vs. Access to a car

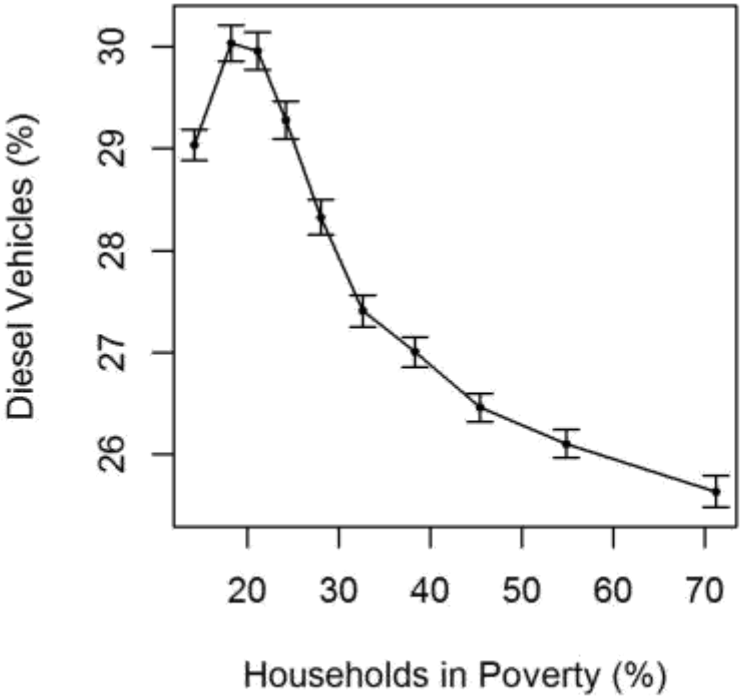




Error bars = 95% confidence intervals (CIs).

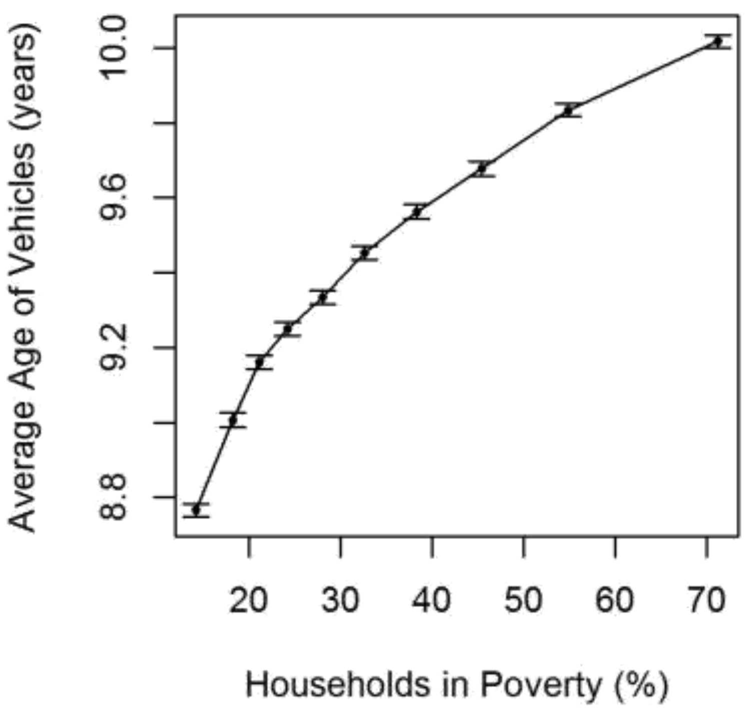
EFs/Diesel ownership vs. Poverty

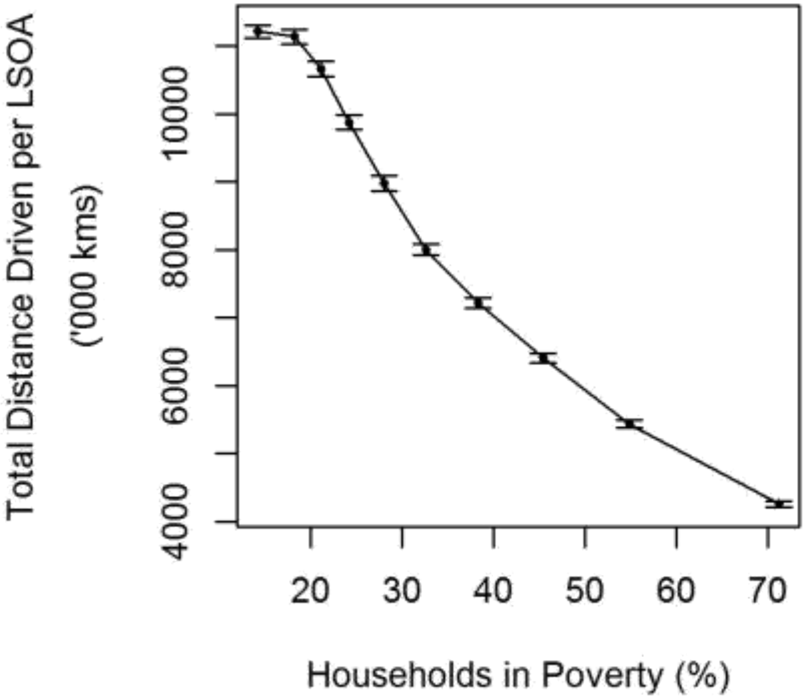




Error bars = 95% confidence intervals (CIs).

Vehicle age/Distance driven vs. Poverty





Error bars = 95% confidence intervals (CIs).

Summary & Conclusions

Summary

- LSOAs with higher proportions of young families and households in poverty (as opposed to the converse) have higher concentrations of NO_2

- LSOAs with more households in poverty also have:
  - lower total private vehicle emissions per household
  - higher levels of non-car ownership /fewer multiple-car households
  - lower average NOx emission factor per household
  - fewer diesel vehicles per household
  - drive less
  - have vehicles on average only just over a year older than households in the least poor areas

Conclusions

- The most elevated levels of NO_2 and other pollutants occur in LSOAs containing the poorest households.
- These households contribute significantly less to air pollution than the least poor households.
- Furthermore, the economic circumstances of those living in the poorest households means that they are less capable of altering their situation, i.e. by moving to a less polluted area or purchasing newer, less polluting vehicles.
- Despite more than a decade of air quality policy, environmental injustice of air pollution exposure has worsened.
- New evidence regarding the responsibility for generation of road traffic emissions provides a clear focus for policy development and targeted implementation.

Acknowledgements

- This work has been undertaken under EPSRC Grant EP/K000438/1
- Contains National Statistics and Ordnance Survey data © Crown copyright and database right 2012. MOT Project website www.MOTproject.net. An earlier version of this research was published by WIT Press (Barnes, J. and Chatterton, T. (2017). An environmental justice analysis of exposure to traffic-related pollutants in England and Wales. WIT Transactions on Ecology and the Environment, 210 (12). pp. 431-442. ISSN 1743-3541)
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